PERFORMANCE EVALUATION PARAMETERS FOR SIGNALIZED ROAD INTERSECTIONS UNDER HETEROGENEOUS TRAFFIC CONDITION

By
M.M.A. KADER CHOWDHURY

MASTER OF SCIENCE IN ENGINEERING
(CIVIL AND TRANSPORTATION)

DEPARTMENT OF CIVIL ENGINEERING

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DHAKA, BANGLADESH.

NOVEMBER, 2016

PERFORMANCE EVALUATION PARAMETERS FOR SIGNALIZED ROAD INTERSECTIONS UNDER HETEROGENEOUS TRAFFIC CONDITION

BY
M.M.A. KADER CHOWDHURY

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

Masters of Science in Engineering
(Civil & Transportation)

The Thesis Titled **"Performance Evaluation Parameters for Signalized Road Intersections under Heterogeneous Traffic Condition"**, submitted by: **M.M.A. Kader Chowdhury**, Roll No: 0412042442F, Session: April/2012; has been accepted as satisfactory in partial fulfillment of the requirement for the degree of **Master of Science in Civil Engineering (Transportation)** on **26, November, 2016.**

BOARD OF EXAMINERS

Dr. Md. Shamsul Hoque Professor Department of Civil Engineering BUET, Dhaka-1000.	Chairman (Supervisor)
Dr. Abdul Muqtadir Professor and Head Department of Civil Engineering BUET, Dhaka-1000.	Member (Ex-Officio)
Dr. Md. Mizanur Rahman Professor Department of Civil Engineering BUET, Dhaka-1000.	Member
Dr. Saiyid Hassan Sikder Joint Chief Planning Commission Bangladesh.	Member (External)

DECLARATION

This is to certify that the thesis entitled **"Performance Evaluation Parameters for Signalized Road Intersections under Heterogeneous Traffic Condition"**, submitted to the Department of Civil Engineering, Bangladesh University of Engineering and Technology, (BUET) in partial fulfillment of the requirement for the degree of Master of Science in Civil Engineering (Transportation) is a record of original research work done by me (M.M.A. Kader Chowdhury) under the supervision of Dr. Md. Shamsul Hoque , Professor, Department of Civil Engineering, BUET. It is hereby declared that this thesis or any part of it has not been submitted elsewhere for any award/degree/diploma/fellowship or for any other purpose.

M.M.A. Kader Chowdhury
November 26, 2016

ACKNOWLEDGEMENTS

Thanks to Almighty Allah for His graciousness, unlimited kindness and with the blessings of whom the good deeds are fulfilled.

I would like to express my deepest sincere gratitude to my supervisor Prof. Dr. Md. Shamsul Hoque, for giving me a unique opportunity to work on such an important topic. His continuous guidance, invaluable suggestions, affectionate encouragement, generous help and invaluable acumen are greatly acknowledged. His keen interest on this topic and enthusiastic support on my effort was a source of inspiration for me to carry out the study. I consider myself fortunate to work under his supervision.

I am grateful to Engr. Md. Aminul Islam, Transport Specialist, DTCA Clearing House Project and Engr. Md. Abdullah al Mamun, Research Engineer, BUET for their directions and suggestions regarding this study. Also, I am indebted to Engr. Md. Anisur Rahman, Traffic Engineer (Deputy Secretary), DTCA, Engr. Md. Tajul Islam Chowdhury, Consultant, DDC and Arch. Tariqul Islam, Managing Director, AECL for letting me use various studies BRT Line 3 Feasibility Study Report, DUTP Study report, CASE Study Traffic Signal Synchronization Report, etc.

Special thanks go to my friend Mr. Romeo Angelo and his team member for their tiresome efforts of collecting field data. I would also like to thank Engr. Md. Aminul Islam, S.M. Rezaul Karim and Engr. Md. Siddique Ahmed, Director (Technical), AECL for helping me in writing this thesis paper, without their help I could not accomplish this work.

I am expressing my especial thanks to my father, Engr. Md. Nurul Islam Chowdhury, for his inspiration and cordial help in this research work, without his mental support I could not move forward.

Last but not the least; I want to convey my deep gratefulness to all members of Traffic Police Division, DMP for their cordial support in this study.

ABSTRACT

A study was carried out to evaluate the performance of the intersection in terms of delay based Level of Service (LOS), Accident Records and based on that appropriate countermeasures are recommended to improve the performance.

In order to achieve the objectives of this study / research, at first a preliminary survey was organized around the Dhaka Metropolitan City area. In Dhaka Metropolitan City, there are ninety eight (98) major intersections, out of which sixty one (61) intersections were surveyed in this preliminary survey. From the preliminary survey, seven (7) important intersections were selected among the entire road network of Dhaka Metropolitan City on the basis of site selection criteria, focusing on their importance and geometric classification.

After the finishing of preliminary survey of those selected intersections, the final field survey was performed. Detail data collection of various characteristics of intersections were done, such as geometric and operating condition, vehicular flow, pedestrian flow, side friction, traffic control devices, queue length, delay, accident record (reported), etc. Finishing this data collection, analysis of data was done. From this analysis, a delay based level of service (LOS) of different approaches of selected intersections was calculated as per standard stated in Highway Capacity Manual (HCM) and American Association of State Highway and Transport Officials (AASHTO). The overall LOS of those intersections was found out by following a statistical method named Average Method s was established based on LOS. From this ranking, the worst and best performing intersections were identified.

This study incorporated with the reported accident data. Accident data was obtained from Accident Research Institute (ARI) of BUET for the period of sixteen (16) years (from 1998 to 2014).

Finally evaluation of parameters for signalized / un signalized road intersections under heterogeneous traffic condition of Dhaka City, a delay based LOS and as well as ranking were established with respect to accident data.

Table of Contents

List of Figures

List of Tables

LIST OF ABBREVIATION

AASHTO	American Association of State Highway and Transport Officials
AECL	Associate Engineers and Consultants Ltd
AWSC	All Way Stopped Control
BRTA	Bangladesh Road Transport Authority
BRT	Bus Rapid Transit
BUET	Bangladesh University of Engineering and Technology
CAD	Computer Aided Drafting
CASE	Clean Air and Sustainable Environment
CBD	Commercial Business District
DDC	Development Design Consultants Ltd.
DMP	Dhaka Metropolitan Police
DNCC	Dhaka North City Corporation
DSCC	Dhaka South City Corporation
DTCA	Dhaka Transport Coordination Authority
DUTP	Dhaka Urban Transport Planning
HCM	Highway Capacity Manual
ICT	Information Communication Technology
ITE Manual	Institute of Transport Engineers Manual
LOS	Level of Service
MVC	Motor Vehicle Collision
NAM Bhaban	Non Aligned Movement Bhaban
NMV	Non Motorized Vehicle
PCU	Passenger Car Unit
RAJUK	Rajdhani Unnayan Kartripakkha
TAZ	Traffic Analysis Zone
TCD	Traffic Control Device
TWSC	Two Way Stopped Controls
UK	United Kingdom
USA	United States of America
VMS	Variable Massage Sign

Chapter One

INTRODUCTION

1.1 Background of the Problem

Intersections are one of the important bottlenecks, which interrupt the smooth flow of traffic which cause delay. In spite of being a very small area, the intersection is a very important one as it dictates the overall capacity of road network *(Alam, M.S. 1997)*. For avoiding this unnecessary delay or to get an efficient traffic flow movement, these intersections need to be planned and designed properly and carefully. Along with the appropriate road network and geometry, the necessary traffic control devices (TCD) also need to be applied wisely. So, the performance of intersection is very significant to get an efficient road network *(Hoque, M.S. 1994)*.

In the developed countries, like USA, UK, Australia, Canada, etc. to obtain orderly movement of vehicles through intersections, they have strict traffic control rules, regulations and well established planning, designing methodology for geometric design of road intersections and as well as standard guidelines for the application for geometric design of road intersection and the proper application of traffic control devices. Because of these practice, clear pattern in queue formation and discharging can be seen from road intersections of these countries.In order to achieve the optimum productivity from the intersection, these countries have been adopting the traffic engineering tools since early stage *(Hoque, M.S. 1994)*.

Especially, signalized intersections are among the most complex locations in urban road network. The operational conditions of such intersections profoundly affect the well-being of the surface transportation of goods and passengers in cities; whose social, economic, recreational, and other activities depend on an efficient road system. As the operational quality of urban road systems gradually deteriorates due to increase in traffic volume and a higher level of service (LOS) is required, a well planned and efficient improved scheme is necessary to assure a satisfactory condition of road transportation at all times. The evaluation of the current status and performance of road intersections is one of the important tasks in the management and improvement of traffic systems. Based on assessment results, the authorities can isolate those strategies and plans that make both the improvement measures and the allocation of limited funds more rationally *(J. Li. et al. 2004)*.

1.2 Present Status of the Problem

The road traffic system of Dhaka Metropolitan City is in the worst phase now. All major signalized intersections (presently controlled manually through

responsive signal system in field condition) within this city have got severe traffic congestion producing long delay and untold sufferings of the road users. This is happening mainly because of -inappropriate / ill planned road network, faulty layout configuration of the intersections, inappropriate synchronization of traffic signal, arbitrary setting of signal time and phasing, poor enforcement in signal control and many other factors. However, from the field observation, it is clear that intersections act as serious bottleneck and in general cause traffic congestion in the Dhaka Metropolitan City road network *(Signal Synchronization Study, 2013).*

Field observation revealed the faulty geometric condition of the intersections; illegal encroachment and random pedestrian crossing are mainlyresponsible for intersection delay. Moreover, improper turning radius, absence of medians and signs, markingsand faulty operation of police, absence of following the lane system, etc. are some factors which are causing delay, making intersection inoperative, degrading the overall performance of intersection. As such, to augment overall capacity of entire road network, it is necessary to improve the performance of intersection / junction *(Alam, M.S. 1997).* This research attempts to investigate the selected intersections of Dhaka Metropolitan City, to evaluate them with the ideal condition and ranks them according to their performance following their LOS and Accident Records (reported only).

1.3 Objectives with Specific Aims and Possible Outcomes

This research is aimed at performance evaluation of selected road intersections of Dhaka Metropolitan City. It will help the City Authority and Government to evaluate the present condition of Dhaka Metropolitan City road network comparing with the ideal condition, help them to find out the appropriate solution of the present ill operated condition and to give a conceptual idea of economic loss due to present operation of intersections. Moreover, the probable ranking system of road intersection inside Dhaka Metropolitan City can be found by it. The main objectives of this research are presented here in Figure 1.3.1.

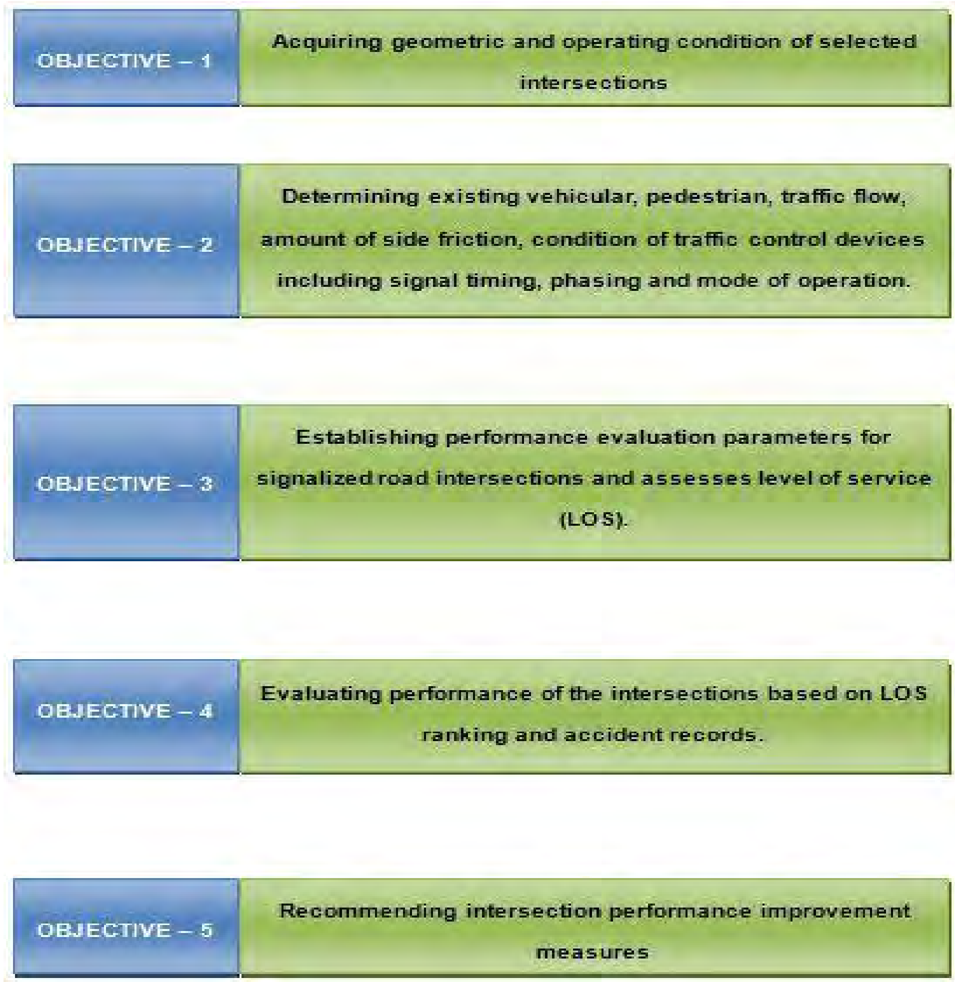


Figure 1.3.1: Objectives of the Research.

It is expected that the outcome of this research will help city authorities, policy makers as well as professionals to understand the real problems of Dhaka City road intersections and take appropriate policy for improving the current deteriorating situation and to make it a livable city.

1.4 Study Plan of the Thesis

In order to achieve the above objectives, at first a comprehensive literature review conducted, which gave a foundation of understanding of ideal intersections and its facilities; after that, existing problems of different intersections of Dhaka Metropolitan City were found out; collection of various data of these intersections were done; quantitative observation of various problems in these intersections were done; analysis of gathered data was done for finding out the LOS of these intersections and ranked them sequentially according to their LOS and accident record; at last, planning and construction of intersections in the road network of Dhaka Metropolitan City area were recommended.The plan of this research work is schematically presented in Figure 1.4.1 which also outlines the general structure of this thesis.

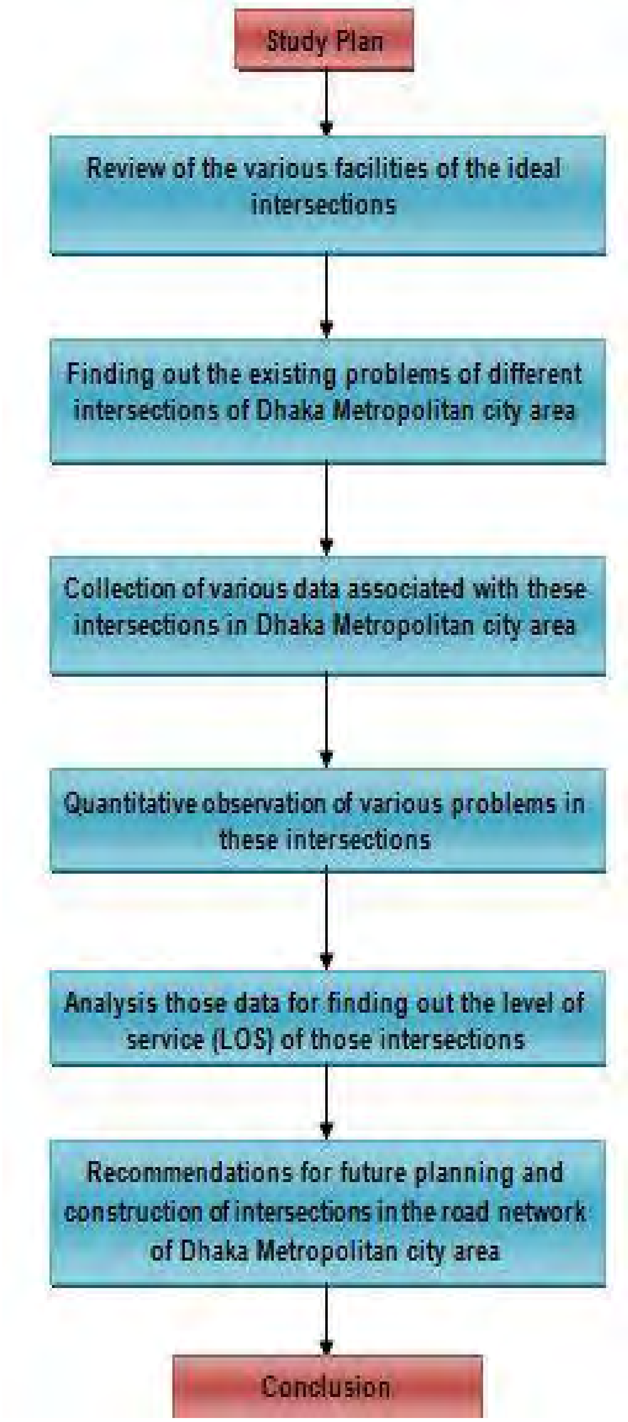


Figure 1.4.1: Study Plan of the Research.

1.5 Thesis Organization

The contents of this thesis are arranged into five (5) chapters. These are summarized as follows:

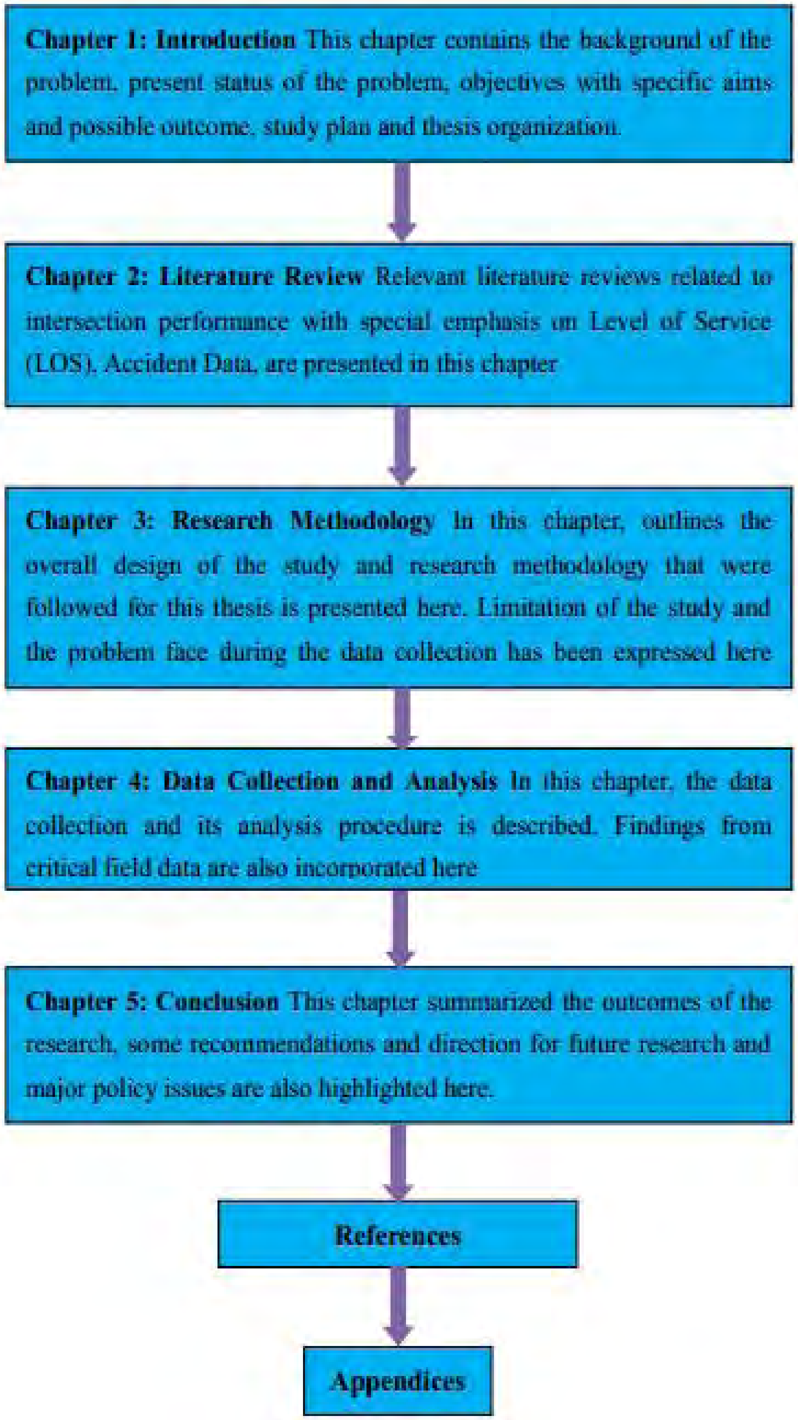


Figure 1.5.1: Organization of the Thesis Paper.

1.6 Overview

In this chapter intersection related problem has been identified and emphasized the need for undertaking a comprehensive study. Here, specific objectives of the study are also set out with expected outcome. To understand the road intersection problems in details, in the next chapter d further. It has also been delineated the way out of the road intersections problems to augment the overall network productivity.

Chapter Two

LITERATURE REVIEW

2.1 Introduction

Performance of an intersection depends on many factors, such as: geometry of intersection and it is only controlled through priority basis, police control or signal control; side friction, behavior of drivers, crossing of pedestrians, etc. Geometry of an intersection affects its performance to a greater extent. It includes layout of the intersection, channelization for right and left - turning vehicles, islands, and refuges for pedestrians, legal intersection area, etc. *(Alam, M.S. 1997).*So, it can be found out easily that planning of intersection, construction, control, maintenance, and overall performance enhancement is vital works for the improvement of LOS of intersection.

But no comprehensive / brief study has been performed for detailed investigation of road intersection / junction and its performance evaluation of Dhaka Metropolitan City so far *(Signal Synchronization Study, 2013).* So a brief literature review relating to detailed investigation and performance evaluation of intersection depending on developed countries has been outlined in the following articles. Focusing on the objectives of this study a) detailed investigation of intersection and b) finding out of performance evaluating parameters / LOS of intersection of Dhaka Metropolitan City area, and their relevant literature reviews are as followed.

2.2 City Development

A developed urban area, which creates sustainable economic development and high quality of life by excelling in multiple key areas; such as: economy, mobility, environment, people, living, and government. Besting in these key areas can be done so through strong human capital, social capital, and/or ICT infrastructure *(Wikipedia, Urban Planning).*

2.2.1 Capital City

A capital city is the municipality, enjoying primary status in a state, country, province or other region as it is the seat of government. A capital city that physically encompasses the office and meeting places of its respective government and normally fixed by its law or constitution. In some jurisdictions, including several countries, the different branches of government is located in different settlements *(Wikipedia, Capital City).*

2.2.2 Dhaka City

Dhaka city, being the administrative, commercial and cultural capital of Bangladesh and the nation ow been turned into 26th Mega City and 10th most populous city of the world *(Habib et al., 2005).* The city experiences the proliferation of scattered development without appropriate guidance resulting in urban system difficulties. The lack of integration between land use planning and transportation system has resulted in uncontrolled and unplanned developments, non-compliances and poor mixing of land use leading to in-efficiencies in the Dhaka

based network system has weakened potentials and appeal of other types of transportation system like rail or water transport. Indeed, the amount of road network (only 6 percent), accessibility, and efficiency is far fewer than the minimum requirement (about half of the area has reasonable accessibility). The unplanned and haphazard orientation of road network also leads to emerge problems on the operational and management aspects of the transportation system and functionally weakens the entire road network performance *(Mahmud, S.M. Sohel, 2009).*

2.2.3 Development of Dhaka City

Immense densification and mushrooming development of residential, commercial and other infrastructure, trim down the opportunity to construct new road infrastructure or introduce modern system for taming overall transportation system. Incomplete understanding of the inherent weakness of the city, the authority are providing piecemeal solution without a long term vision which is becoming an extra burden on the overall system of the city and the city is developing without a decent growth *(Mahmud, S.M. Sohel, 2009).*

To have an idea about the evolutionary development of Dhaka City in the sight of urban planning, it is presented in brief in this chapter and which is important for better understanding of the urban transport problems today we have. It will provide a conceptual idea of evolvement of Dhaka city from various stages of time from past.

2.3 Transportation Infrastructure

Transport is vital to the well-functioning of economic activities and a key to ensure social well-being and cohesion of populations. Transport ensures everyday mobility of people and is crucial to the production and distribution of goods. Adequate infrastructure is a fundamental precondition for transport systems. In their endeavor to facilitate transport, however, decision-makers in governments and international organizations face difficult challenges. These include the existence of physical barriers or hindrances, such as: insufficient or inadequate transport infrastructures, bottlenecks and missing links, as well as lack of funds to remove them. Solving this problem is not easy. It requires action on the part of the governments concerned, actions that are coordinated with other governments at international level *(Mahmud, S.M. Sohel, 2009).*

2.3.1 History of Road

Travelled way on which people, animals or wheeled vehicles move. The earliest roads developed from paths and trails and appeared with the invention of wheeled vehicles,

around 3000 B.C. Road systems developed to facilitate trade in early civilizations; the first major road extended 1,775 mile (2,857 Km) from the Persian Gulf to the Aegean Sea and was used in 3500-300 B.C. The Romans used roads to maintain, control and extend of their empire, with over 53,000 mile (85,000 Km) of roadways extending across its lands; Roman construction techniques and design remained the most advanced until the late 1700 th century invention of Macadam road construction provided a quick and durable method to construct roads and asphalt and concrete also began to be used. Motorized traffic in the 20th century led to limited access highway, the first of which was a Parkway in New York City (1925). Superhighways also appeared in Italy and Germany in the 1930
to link the country cities *(Wikipedia, History of Road Transport).*

2.3.2 Road Network

A road network is a system of interconnecting lines and points representing a system of streets or roads for a given area. A road network provides the foundation for network analysis; for example, finding the best route or creating service areas. Road network can be very complex in city area. Road network is very often localized, because there is little non highway transportation from one place to another place *(Hoque, M.S. Class Lecture, 2012).*

2.3.3 Road Network Classification

Roadway patterns are very essential in the development of the settlement of a city. However recent development in cities does not give emphasis on the study of the road patterns that give rise to numerous roads that are not interconnected, housing schemes and commercial developments built far away where roads are very distant from the center of the town. The increasing distance between the residential and commercial hub of the city increases dependency on cars for the daily travel chores each household members make frequently. The roadway patterns also increase the response time, the emergency response vehicles take to reach a certain place *(Wikipedia, Road Network).*

There are so many types of road network pattern, they are: (a) Rectangular / block / grid pattern; (b) Radial pattern, (i) Radial and block pattern, (ii) Radial and circular pattern, (iii) Radial and grid pattern; (c) Hexagonal pattern; (d) Linear road pattern; (e) Cul de sac pattern; (f) Pattern less road network. Among all of the classification of road network pattern, Dhaka city has pattern less road network *(Hoque, M.S. Class Lecture, 2012).*

2.3.4 Road Network Element

By analyzing the road network, two (2) elements are found (a) cross element / junction / intersection, (b) linear element / road / approach *(Hoque, M.S. Class Lecture, 2012).*

2.3.5 Road Intersection / Junction / Cross Element

When two or more roads join together, transport may have to distribute in different direction, this place can be defined as a nodal point. This place is also called as intersection. This thing is handled as a point in a road network. This is vital in the network as an element of road network. An intersection is defined as the general area where two or more roads / highways join or cross, within which include the roadway and roadside facilities for traffic movements. Intersections are the modal points of road network where vehicles are distributed and redirected towards desired destination and pedestrians are moved in a safe and systematic way. It is not the wide roads that increase the roadway capacity, rather it is intersection that reduces congestion, increases roadway capacity and promotes safety for vehicles and pedestrians *(Kadiyali, L.R. 1983)*.

2.3.6 Intersection

The intersections can be classified by two (2) options, (a) geometry wise and (b) operation wise.

Depending upon the geometry, intersection can be classified in following categories- (a) cross junction, (b) tee junction, (c) wye junction, (d) staggered junction, (e) roundabout and (f) multi legged junction.

Depending upon the operation, intersections are classified into two (2) categories- (a) un-controlled intersection and (b) controlled intersection *(Hoque, M.S. Class Lecture, 2012)*.

2.3.7 Link / Road / Approach

The connecting element between two (2) adjacent nodal points / junctions is named as a link. This is also a straight element and road *(Hoque, M.S. Class Lecture, 2012)*.

2.3.8 Link / Road / Approach Classification

In a road network, roadway / road / approach can be classified under some characteristics. Such as-

a) **Geographical area or location wise** (i) rural road, (ii) urban road, (iii) sub-urban road;

b) **Function wise** (i) rural road national highway, regional highway, Zilla (district) road, (ii) urban road arterial road, primary road, secondary road, local road;

c) **Standard wise** (i) full access control super highway, express highway, (ii) partial / limited access, (iii) no access control;

d) **Usage wise** (i) all-purpose road, (ii) commuter road, (iii) driveway, (iv) feeder / collector road, (v) slip road, (vi) service road, (vii) frontage road, (viii) by pass road, (ix) distributor / ring / orbital road, (x) link road;

e) **Operation wise** (i) earthen road, (ii) all weathered road block pavement, flexible pavement, and rigid pavement;

f) **Investment wise** (i) public road, (ii) private road *(Hoque, M.S. Class Lecture, 2012).*

2.3.9 Road Hierarchy

The hierarchy of roads categorize according to their function and capacities. While source differ on the exact nomenclature, the basic hierarchy comprises with freeway, arterials, collectors and local roads *(Hoque, M.S. Class Lecture, 2012).*

For this research purpose, it is paramount to know the ideal road hierarchical template which will give a clear idea on road pattern of Dhaka city.

2.4 Functional Intersection Area

An intersection is defined by both its functional and physical areas. The functional area in an intersection extends both upstream and downstream from the physical intersection area and includes any auxiliary lanes and their associated channelization. The functional area on the approach to an intersection or driveway consists of three (3) basic elements: (a) perception reaction distance, (b) maneuver distance and (c) queue storage distance. The distance traveled during the perception reaction time will depend on the vehicle speed, driver alertness and driver familiarity with the location. Where there is a left or right- turn lane, the maneuver includes the length needed for both braking and lane changing. In absence of turning lanes, it involves braking to a comfortable stop. The storage length should be sufficient to accommodate the longest queue expected *(Hoque, M.M. Class Lecture, 2012).*

Functional intersection area which is also known as

2.5 Geometric Design of the Junction / Intersection

Geometry of a junction is the prime factor that affects performance of the junction significantly. Removing other affecting factors but geometry performance of a junction must be very low than that of another properly designed junction. Although it is possible to change the existing geometry of a junction in rural areas but it may be regarded as a permanent fault for a built up if it is not designed properly. So a junction layout of three or more approaches has to be designed sensibly to get maximum performance. For these, some standard factors have been exercised in the developed countries *(Alam, M.S. 1997*).

2.5.1 Approach

Because signals permit traffic movement from any approach for only a proportion of the time, is sometimes necessary for the intersection approaches, where queuing takes place, to be wider than the roads, which feed these approaches to pass the required flow. If the intersection already exists, the timing of the signals can be adjusted for a given flow pattern to make the best use of the existing layout. If the intersection is in its design stage, or if some changes can be made to the layout of an existing intersection, then a choice of approach width may be available, after selecting the green time that can be adjusted to give the correct capacities for those approaches *(Alam, M.S. 1997).*

2.5.2 Lane Width

It is normal practice all over the world for lanes to be 10 ft. wide at an intersection, though occasionally 9 ft. lanes have to be accepted at some existing intersections. Some countries have found that in certain cases having very narrow lanes (down to 7 ft.) even though drivers of wider vehicle are unable to keep within them increases capacity. With queuing lanes wider than 10 ft. is likely that capacity would be wasted though these depends on traffic composition, for example, if there is a high proportion of bi cycles, or of wide vehicles, it may be beneficial to have a wider nearside lane.

Some traffic engineers recommend of having the same number of lanes on the exit side of the intersection as there are straight through lanes (partly or exclusively used by straight - through traffic) on the approach side. If, however site conditions make it necessary to have fewer lanes on the exist sides of the intersection, a distance of about 300 ft. on that side should be allowed for merging to take place, though this could be reduced if there are many turning vehicles at the intersection, i.e. fewer vehicles going straight ahead. It is most desirable that vehicles travelling in through lanes should not be obstructed by either parked vehicles or waiting right turners, and the later should wherever possible have their own lane or lanes *(Alam, M.S. 1997).*

2.5.3 Layout for Right Turning Vehicles

Opposing right turners can turn on either the offside or the near side of each other. In the former case they have good visibility and can see an approaching gap in the opposing stream to complete the turn. On other hand, if there are too many turners from the two directions for the storage space within the intersection, the two streams may interlock causing congestion in the intersection. With the near side method locking cannot occur but visibility is often restricted, and drivers usually have to wait until the end of the green period before turning to be sure about opposing straight through traffic. If the near side method of turning right is used, there may be advantages in offsetting the centerline (or the central reserve) to allow more space available to traffic approaching the intersection than to traffic leaving it. In some cases, it may be desirable to place the opposing right turners opposite each other *(Alam, M.S. 1997).*

2.5.4 Channelization

Channelization by means of road markings, raised curb, traffic islands and bollards can be used to guide vehicles along specific paths on the approach to and or exit from an intersection. The benefits of these are that movements are specified, less confusion arises and the number of conflict points is minimized. Effectively, the number of decisions required of a driver at any time is reduced, allowing him to concentrate more on gaps in the opposing stream. Traffic islands have the additional benefit of providing a refuse for pedestrians crossing the road. They also provide a convenient location for street furniture such as signs, street lighting and drainage covers. Urban channelization schemes can be relatively complex, dealing with large traffic volumes. In rural areas concerned is usually focused on protecting turning vehicles from faster moving traffic and to position vehicles correctly on the road. Channelization of intersections is generally considered for one or more of the following factors- (a) The paths of vehicles are confined by channelization so that not more than two paths cross at any one point; (b) The angle and location at which vehicles merged, diverged or cross are controlled; (c) The amount of paved area is reduced and there by decreases vehicle wander and narrows area of conflict between vehicles; (d) Clearer indications are provided for the proper path in which movements are to be made; (e) The predominant movements are giving priority; (f) Areas are provided for pedestrian refused; (g) Separate storage lanes permit turning vehicles to wait clear of through-traffic lanes; (h) Space is provided for traffic control devices, so that they can be more readily perceived; (i) Prohibited turns are controlled. The speeds of vehicles are restricted to some extent *(Khisty, C.J. and Lal, B.K. 2003).*

2.5.5 Pedestrian Crossing

A pedestrian refuse is usually placed at or near the center of a single carriageway if the widths remaining to traffic in the two (2) directions are sufficient, where the pedestrians have to cross a very wide approach, it is desirable to place the stop line well back from the crossing (about 20 ft.) so that when the vehicular phase begins, drivers can easily see if pedestrians have not completed their crossing and can delay their start accordingly. It is desirable in some cases to restrict the crossing of pedestrians to certain approaches at an intersection and guard rails can be used to prevent pedestrians crossing at unmarked place (e.g. where filter streams may be moving at times unexpected by the pedestrians). On one way streets pedestrian can be signaled to cross without any interference from turning traffic and without reducing the green times items to traffic. On two way streets it is sometimes necessary to allocate a special phase to pedestrian if they are numerous. Subways and footbridges provide safer method of crossing the road, but pedestrians do not always use them unless the alternative suffrage level path is such that it takes more time to cross. Guard rails are often used to make the surface path less convenient. It should be noted that the effort involved in using subways and foot bridges is often not considered, particularly women and old people, have a reluctance to use subways at night *(Alam, M.S. 1997).*

2.6 Traffic Control Devices (TCD)

Performance of a signalized junction depends largely to traffic control devices that include all signs, markings, and signals placed at the junction to regulate, warned, or guide traffic movement. To improve performance of junction, traffic control devices should be properly designed.

But to get maximum performance of well-designed traffic control devices they should be placed and operated in a uniform, consistent manner. In this way, motorist can be expected to respond properly to the devices on the basis of previous exposure to similar traffic situations. A control device should be placed within the user
reasonable proximity to the point, object, or situation to which it applies. Its location and eligibility should be such that a driver travelling at normal speed has enough time to respond appropriately.

It is important that devices should be maintained to high standards to ensure that legibility and visibility are retained. When no longer needed, traffic control devices should be removed *(Alam, M.S. 1997).*

2.6.1 Traffic Sign

There are three (3) functional classes of traffic signs: (i) regulatory, (ii) warning, and (iii) guide signs. Regulatory signs give users notice of traffic laws or regulations. Such signs designate right of way (e.g. STOP, YIELD), indicate speed controls (e.g. SPEED LIMIT 50, SPEED ZONEAHEAD), control movements (e.g. NO RIGHT TURN, KEEP RIGHT, ONE WAY), regulate parking (e.g. NO PARKING), control pedestrian movements (e.g. CROSS ONLY AT CROSS WALKS), and regulate traffic in various other ways. Warning signs need direct attention conditions on or adjacent to a street or highway that are potentially hazardous to traffic operations. Such signs require motorists to exercise caution, reduce, speed, or make some maneuver in the interest of their own safety or that of other motorists or pedestrians. Examples of warning signs are curve signs (shown curved arrow). STOP AHEAD signs, PAVEMENT ENDS signs and advisory speed plates. The letter sign consist of other types of warning signs too. Warning signs have a black legend and border placed on a yellow background. With but few exceptions, warning signs have a diamond shape. Guide signs indicate route designations, directions, point of interest, and other geographic or cultural information. Examples of guide signs include JUNCTION signs, DETOUR signs, REST AREA signs, and service signs (food, gas, lodging, etc.) *(Alam, M.S. 1997)*

2.6.2 Traffic Markings

Markings consist of paint or some other material placed on the pavement, curb, or object to convey traffic regulations and warnings to drivers. Markings may be used alone or in combination with traffic signs or signals. Although markings are effective and essential means of traffic control, they tend to be difficult to see in rainy weather and may be obliterated altogether by bad weather *(Alam, M.S. 1997).*

2.6.3 Traffic Signals

Traffic control signals are primarily used to control the movements of vehicular and pedestrian traffic at intersection. It is used to avoid vehicle conflicts and to reduce the number and severity of accidents at intersections. There are essentially two (2) types of signals in general using; fixed time and vehicle actuated. An intermediate type, semi vehicle actuated signals, with detectors on the side roads *(Alam, M.S. 1997).*

2.6.4 Pedestrian Signals

Normally intersections are controlled by signals; the requirements of pedestrians are created in two (2) ways. One method is to provide a crossing marked out in studs in front of the stop line used by pedestrians during normal signal timings, i.e. no special phases are given for them. This arrangement is normally used at intersections where turning traffic is not heavy. In the second method pedestrians
separate signals during special phase. This is a more positive method as well as traffic is halted before the pedestrian phase is given, but it causes greater delay to vehicles *(Alam, M.S. 1997).*

2.6.5 Signal Cycle Time

Cycle length is composed of the total signal time to serve all of the signal phases including the green time plus any change interval. Longer cycles will accommodate more vehicles per hour but that will also produce higher average delays. The best way is to use the shortest practical cycle length that will serve the traffic demand. Vehicles at a signal installation do not instantaneously enter the intersection. Early studies by Greenshields found that the first vehicle had a starting delay of 3.7 seconds to enter the intersection with subsequent vehicles requiring an average of 2.1 seconds each. Generally, vehicles will pass over an approach detector with headway of 2 to 2.5 seconds. For general calculation purposes, an average time of 2.5 seconds per vehicle to enter the intersection is a conservative value. This value can be used to estimate signal timing for planning purposes. The cycle length includes the green time plus the vehicle signal change interval for each phase totaled to include all signal phases and the signal cycle time should be greater than 120 seconds according to Webster A number of methods have been used to determine cycle lengths as outlined in the Highway Capacity Manual, ITE Manual on Traffic Signal Design, and ITE Transportation and Traffic Engineering Handbook. Webster provided the basic empirical formula that would minimize intersection delay as follows:

C = (1.5*L + 5) / (1.0 -

Where:

C = Optimum Cycle Length in seconds adjusted usually to the next highest 5 second interval. Cycle lengths in the range of 0.75C to 1.5C do not significantly increase delay.

L = Unusable Time per Cycle in seconds usually taken as a sum of the vehicle signal change intervals.

= Critical Lane Volume each phase/Saturation Flow.

The saturation flow will be between 1,500 and 1,800 vehicles per hour. Refer to HCM. The "Y" value should be computed for each phase and totaled to arrive at phases *(Alam, M.S. 1997).*

2.6.6 Signal Coordination

Traffic signal coordination is normally implemented to improve the LOS of a road or a network of roads, where the spacing of signals is such that isolated signal operation would cause excessive delays, stops and loss of capacity. The popular concept is that coordinating traffic signals is simply to provide green-wave progression whereby a motorist travelling along a road receives successive green signals. While this is one of the aims, the principal purpose of coordination is to minimize overall delay and/or number of stops. This can be achieved using fixed-timing plans or using adaptive technology.

The three (3) main components of coordinated timings are:

- **Cycle time**, the time to complete all phases in a timing plan (a phase is any period in a cycle where non-conflicting traffic movements may run);
- **Stage splits**, the amount of time allocated to a phase in a cycle;
- **Offsets**, green signals at adjacent intersections are set to occur at a given time, relative to that at a reference intersection. It depends on the distance between signals, the progression speed along the road between the signals and the queues of vehicles waiting at red signals *(Signal Synchronization Study, 2013).*

2.7 Performance Evaluation Parameters of Intersection

2.7.1 Delays in Intersection

The delays experienced on the arterial signalized streets are mainly associated with the intersection where conflicting movements are separated and controlled by traffic signals. These traffic signals can be operated under an isolated control strategy; with the signal settings of each signal can be set independently according to the settings of adjacent signals. The delay is defined as the difference in travel time when a vehicle is unaffected by the controlled intersection and when a vehicle is affected by the controlled intersection.

This delay includes lost time due to deceleration and acceleration as well as stopped delay. Thus, intersection delay estimates are directed toward estimating total delay or simply stopped delay *(Kadiyali, L.R. 1983)*.

2.7.2 Queue Length

In transportation systems, queues are formed whenever the number of arrivals at a given location exceeds the maximum rate at which vehicles can go through the location. When such a situation occurs, the excess vehicles are stored upstream of the bottleneck or service area and their departure is delayed to a later time period. Depending on the type of service provided, the queues that are formed may be either moving or completely stopped. Typically, moving queues are formed at locations where the flow of vehicles across the bottleneck or service area is never completely stopped. Stopped queues occur, when there is completely interruption of service for a significant amount of time *(Kadiyali, L.R. 1983)*.

According to the research outcome of *J. Li et al, 2004*, the ultimate level of queue length of an intersection is considered as 100 meter, but in Dhaka City the common phenomenon of the intersection queue length is over 200 meter.

2.7.3 Level of Service of Intersection

Level of service (LOS) is a qualitative measure that describes the operating conditions within an intersection or roadway section, and the perception of those conditions by the facility

facility, might include any or all of the following: (a) User comfort; (b) Convenience; (c) Travel time; (d) Maneuverability; (e) Interruptions in traffic; (f) Speed; (g) Cost; (h) Number of stops; (i) Fuel consumption. Every type of facility (intersection, freeway segment, arterial, or pedestrian) has different operating parameters that are used to determine its level of service. For intersections, the primary operating parameter is average control delay per vehicle defined in units of seconds per vehicle. There are six (6) levels of service defined for each facility type. Each level has a letter identification from A to F with LOS A representing the best operating conditions and LOS F the worst *(Kadiyali, L.R. 1983)*.

2.7.3.1 Signalized Intersection

The delay experienced by motorists in a signalized intersection is affected by a number of factors related to geometrics, traffic, control, and incidents. The total delay is defined as the difference between the actual travel time and travel time that would result from ideal conditions. An ideal signalized intersection has 10-ft. lane widths, level grade, no curb parking, only passenger cars in the traffic stream, no turning movements, green signal available all the time, and is located outside the central business district. For signalized intersections, only the portion of the total delay associated with signal control device is measured. This delay is referred to as control delay and includes the following: initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. Table 2.7.1summarizes the Highway Capacity Manual (6) LOS s for a signalized intersection *(HCM, 2010)*.

Table 2.7.1: Level of Service for Signalized Intersection.

LOS	Average Delay Per Vehicle
A	Very low control delay 10 or less seconds per vehicle; progression is very favorable; most vehicle arrive during green signal; most vehicles do not stop. Short cycle lengths may also contribute to low delay.
B	Control delay greater than 10 and up to 20 seconds per vehicle; progression is good and / or cycle lengths are short. More vehicles stop than for LOS A, causing higher levels of average delay.
C	Control delay greater than 20 and up to 35 seconds per vehicle; progression is fair and / or cycle lengths are longer. Individual cycle failures may begin to appear at this level. The number of vehicles stopping is significant, though many vehicles still pass through without stopping.
D	Control delay greater than 35 and up to 55 seconds per vehicle; progression is unfavorable and / or cycle lengths are long or has a high flow ratio to capacity ratio. Many vehicles stop and the proportion of vehicles not stopping diminishes. Individual cycle failures are obvious.
E	Control delay greater than 55 up to 80 seconds per vehicle; progression is poor, cycles lengths are long, and has a high flow rate to capacity ratio. Individual cycle failures are frequent occurrences.
F	Control delay greater than 80 seconds per vehicle; progression is very poor, cycle lengths are long. Many individual cycle failures. Arrival flow rates exceed the capacity of intersection. This level is considered unacceptable to most drivers.

2.7.3.2 Un - signalized Intersection

The two (2) types of un signalized intersections include two-way stop-controlled (TWSC) and all-way stop-controlled (AWSC) intersections. The LOS for a TWSC intersection is defined by control delay for each minor approach and major street left-turn movement rather than the overall intersection. The LOS for an AWSC intersection is defined by control delay for the intersection as a whole. The delay range for un signalized intersections is different from those for signalized intersections primarily due to driver expectation. The expectation is that signalized intersections are designed to carry higher volumes of traffic and therefore higher levels of delay are acceptable. Table 2.7.2summarizes the Highway Capacity Manual (6) LOS s for a un - signalized intersection *(HCM, 2010)*.

Table 2.7.2: Level of Service for Un - signalized Intersection.

LOS	Average Delay Per Vehicle
A	Very low control delay 10 or fewer seconds per vehicle. All drivers find freedom of operation. Very rarely more than one vehicle in queue.
B	Control delay greater than 10 and up to 15 seconds per vehicle. Some drivers begin to consider the delay troublesome. Seldom there is more than on vehicle in queue.
C	Control delay greater than 15 and up to 25 seconds per vehicle. Most drivers feel restricted, but tolerably so. Often there is more than one vehicle in queue.
D	Control delay greater than 25 and up to 35 seconds per vehicle. Drivers feel restricted. Most often, there is more than one vehicle in queue.
E	Control delay greater than 35 and up to 50 seconds per vehicle. Drivers find delays approaching intolerable levels. There is frequently more than one vehicle in queue. This level denotes a state in which the demand is close or equal to the probable maximum number of vehicles that can be accommodated by the movement.
F	Control delay in excess of 50 seconds per vehicle. Very constrained flow. Represents an intersection failure situation that is caused by geometric and / or operational constraints external to the intersection.

Adjoining the both condition, summary table stands like this

Table 2.7.3: Summary Table of LOS.

LOS	Un - signalized Intersections (sec)	Signalized Intersections (sec)
A		
B	> 10 and	> 10 and
C	> 15 and	> 20 and
D	> 25 and	> 35 and
E	> 35 and	> 55 and
F	> 50	> 80

2.7.4 Intersection Accident

A traffic collision, also known as a motor vehicle collision (MVC), traffic accident, motor vehicle accident, car accident, automobile accident, road traffic collision, road traffic accident, wreck, car crash, or car smash, it occurs when a vehiclecollides with another vehicle, pedestrian, animal, road debris, or other stationary obstruction, such as a tree or utility pole. Accident / collision may occur in intersection area, important part of a road network and this collision of intersection area occurring injury, death and property damage. A number of factors contribute to the risk of collision, including vehicle design, speed of operation, road design, road environment, and driver skill, impairment due to alcohol or drugs, and behavior, notably speeding and street racing. Worldwide, motor vehicle collisions lead to death and disability as well as financial costs to both society and the individuals involved. Road injuries resulted in 1.4 million deaths in 2013, up from 1.1 million deaths in 1990. About 68,000 of these occurred in children less than five years old.Almost all high-income countries have decreasing death rates, while the majority of low-income countries having increasing death rates due to traffic collisions. Middle-income countries have the highest rate with 20 deaths per 1, 00,000 inhabitants, 80% of all road fatalities by only 52% of all vehicles. While the death rate in Africa is the highest (24.1 per 1, 00,000 inhabitants), the lowest rate is to be found in Europe (10.3). Accidents in intersection area generally fall into one of four (4) common types:

- Lane departure crashes, which occur when a driver leaves the lane they are in and collide with another vehicle or a roadside object. These include head on collisions and run-off-road collisions.
- Collisions at junctions include rear-end collision and angle or side impacts.
- Collisions involving pedestrians and cyclists.
- Collisions with animals.

Although other types of collision do occur. Rollovers are not very common, but lead to greater rates of severe injury and death. Some of these are secondary events that occur after a collision with a run-off-road crash or a collision with another vehicle. If several vehicles are involved, the term 'serial crash' is often used. If many vehicles are involved, the term 'major incident' may be used. Crashes at intersections (road junctions) are a very common type of road collision types. Collisions may involve head-on impact when one vehicle crosses an opposing lane of traffic to turn at an intersection, or side impacts when one vehicle crosses the path of an adjoining vehicle at an intersection. The risk of intersection collisions differs on rural and urban roads, with around 50% of urban crashes and 30% of rural crashes occurring at junctions. In urban areas the likelihood of an intersection collision occurring is high as they typically have a higher density of junctions. On rural roads while the likelihood of a collision may be lower; (because of fewer intersections) the outcome of the collision is often significantly worse because of the increased speeds involved. Because intersection collisions often result in side-impacts they are therefore often fatal because people are seated close to the part of the car that provides little protection. Although expensive to implement, roundabouts are an effective way of reducing the speed of traffic at intersections reducing the likelihood of high speed right-angle collisions. Clear road markings and signing are low cost methods of improving safety at intersections *(Road Safety Manual on Low Cost Engineering Countermeasures, 1990).*

2.8 Overview

From the thorough literature review, it is found that there are many factors that affect the urban road intersections capacity. Moreover, it is revealed that though various traffic control measures are being used in abroad, but a few of them applied in local traffic control measure to optimize the intersection capacity.Considering our city traffic condition, composition of traffic stream and road users application of traffic rules and regulation, traffic management, intersection , etc., level of service of selected intersections were found out under this study. It is also revealed that though many researches have undertaken in abroad, a very little study had so far been carried out to improve the intersection capacity and quantify the intersection performance evaluation in the context of local traffic conditions. It is to be noted here that not the link capacity but the intersection capacity that dictate the whole transport network capacity. Therefore, how to identify the junction related problems as well as to evaluate and to determine level of service and eventually the different ways of augmenting the intersection capacity and thereby to enhance the network productivity are described in the next chapter.

RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the techniques for the collection of data and the procedures applied to accomplish / carry out the study. Its methodology expresses a systematic way through which any study can be done in fruitful way. This chapter delineates the overall design of the study and research mythologies that have been followed to achieve the objectives set out in Chapter 1. It also describes data collection procedures and techniques. Eventually, the difficulties or problems faced during data collection process and limitation of the study has been illustrated.

3.2 Outline of the Research Methodology

Basically, the study is aimed at performance evaluation of selected intersections of Dhaka Metropolitan City. It will help the City Authority and Government to evaluate the present condition of Dhaka Metropolitan City road network, also help them for finding appropriate solution of the present ill operated condition and give a conceptual idea of economic loss due to present operation of intersections. Moreover, it will help to find out a probable ranking system of road intersectionsinside Dhaka Metropolitan City.

Following process / methods are applied for achieving the target which is set out as objective in the opening chapter.

- At the very outset of the research work, an extensive literature review had been carried out to know the condition, types, nature, limitations, recommendations, etc. of previous research, project reports conducted in home and abroad on LOS and accident data of intersections for acquiring knowledge for the basic understanding on that topics.
- After finishing the gathering of knowledge about the research topic, trying to find out the existing qualitative problems of intersections of whole Dhaka Metropolitan City through a preliminary survey. Observing the result of the preliminary survey, seven (7) suitable road intersections (Mirpur 1, Shishu Mela, Agargaon, Bangla Motor, Mirpur 10, Shapla Chattar and Science Laboratory intersections) of Dhaka Metropolitan City had been shortlisting according to their classification and importance of them in the Dhaka City road network. Later those intersections were finalized for detail field study of the research.
- After finishing the final selection, a detail survey plan of those intersections was done. A detail allocation of the surveyors for different surveys (vehicular survey,

pedestrian survey, side friction related survey, condition survey of traffic control devices including signal timing and mode of operation, approach wise queue length survey, delay / road occupancy survey, intersection accident data collection, etc.) as per objectives of this research was done. A qualitative and quantitative analysis of these survey results was done later on.

- From the quantitative analysis of these survey result, LOS of those intersection was calculated. After this, ranking of those intersections was done according to their LOS and accident data (reported only).
- Latterly recommendation for future planning and construction of intersections in the road network of Dhaka Metropolitan City was done.

In bird t is seems that the study area and topics covered a wide range area and in depth evaluation to fulfill the objectives in this topics is a complicated and difficult issue within the limited amount of manpower, resource, expertise and time in a M. Sc. Engineering research project. To overcome these difficulties, the study elaborated in breadth but in depth it is shallow.

The methodology followed is outlined in the Figure 3.2.1 and described subsequently. The relevant review on previous literature from home and abroad have been carried out before conducting detailed review and study to identify the relevant sectors and field. These also pointed out the required study area and from where data or information will have to be collected. The literature review also assist to select the type and nature of data required for this study, to outline the method of data collection and time for data collection also. Data or information has been collected, formatted and analyzed to identify the performance of intersections of Dhaka Metropolitan City.

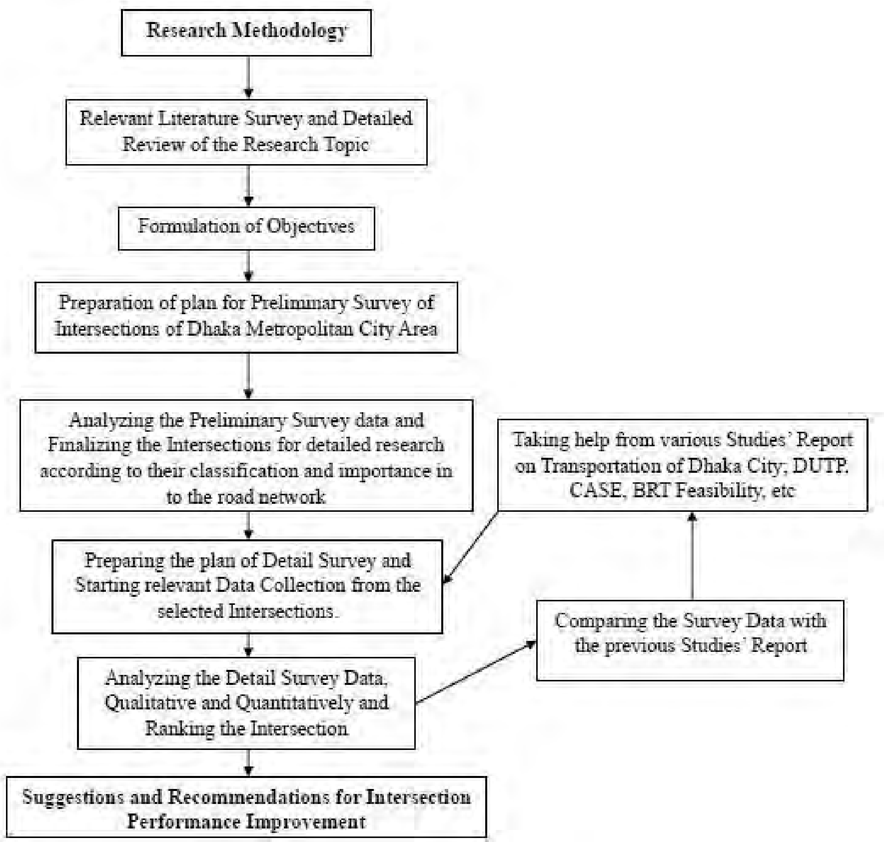


Figure 3.2.1: Flow Chart of the Research Methodology.

In order to get the basic understanding on the topic, in depth literature review was undertaken and information was collected from published and unpublished sources to broaden the knowledge in this respect. Different journals, thesis (published and unpublished), project reports, papers, booklets were studied for gathering knowledge and information. Different published articles, evaluations and reports were deeply observed to collect the news and views about the performance of intersection of Dhaka Metropolitan City, its management and operation and to point out the opinion of the professionals, policymakers, and experts in different sectors of home and abroad. Various books on transportation engineering and different rules and regulation were widely consulted throughout the study.

Comprising the basic understanding on the research topic, to know the further study requirements, limitations of previous initiation / study and to collect secondary information literature survey has been conducted from the various institution, centers, and libraries. Some of the libraries and related survey literature are listed in Table 3.2.1.

Table 3.2.1: List of Literature Survey.

Serial Number	Sources / Libraries	Key Features
1	BUET Central Library	Basic transportation planning and traffic engineering journal
2	Civil Departmental Library	Previous studies for M.Sc. and B.Sc. degree on performance of intersection and different project reports on Dhaka city.
3	Traffic Engineering Laboratory	Recent studies and previous studies for M.Sc. and B.Sc. degree on performance of intersection.
4	Urban and Regional Planning (URP) Library	Previous studies for MURP and BURP on Dhaka City transportation and its intersection.
5	Accident Research Institute (ARI)	Accident data road intersections of Dhaka Metropolitan City Area.
6	Bangladesh Road Transport Authority (BRTA)	Bangladesh Road Sign Manual Part 1 and Part 2.
7	Dhaka Transport Coordination Authority (DTCA)	Strategic Transport Planning (STP), 2004.
8	Development Design Consultants Ltd. (DDC)	Report of DUTP project, 1997 1999.
9	Associate Engineers and Consultants Ltd. (AECL)	Project Report on Signal Synchronization, CASE Study 2013 *(World Bank Funded)*.

Besides this, a lot of information, such as: international studies international standard, planning, online journal paper, etc. were collected through internet.

Objective is that which helps us to form a complete structure of the study with providing sufficient guidelines. So, at the first stage, objectives have been formulated. The objectives in the study are related to the performance of intersections in Dhaka Metropolitan City area, its determination and ranking of intersections according to their LOS and accident records. Detail study of literature review; various studies intellectual report, theses of recent and previous; their findings, application and scope of development are also the main objectives of this research. Some objectives are also related to the proposals or recommendations that help to achieve the goals.

3.3 Study Area

The scope of area under this research is Dhaka Metropolitan Area (DMA). This study area can be defined as the geographical area encompasses by river Buriganga at the South side, river Turag at West and North side, and river Balu at the east side. The area of the DMA is about 1,353 square kilometers, of which Dhaka City Corporation (DCC) occupied 276 square kilometers at the 2001 census. The relevant map is given in Figure 3.3.1

Figure 3.3.1: Location Map of the Study Area

Source: *(DHUTS Study, 2009)*

After formulating the objectives of research, a decision of conducting a preliminary survey within Dhaka Metropolitan City was taken. The main purpose of this preliminary survey was for the selection of suitable intersection for research. There are about ninety eight (98) major intersections in Dhaka Metropolitan city, out of which sixty one (61) intersections were surveyed in this preliminary survey. The position of major 98 intersections inside Dhaka Metropolitan Area is given below through a map in Figure 3.3.2

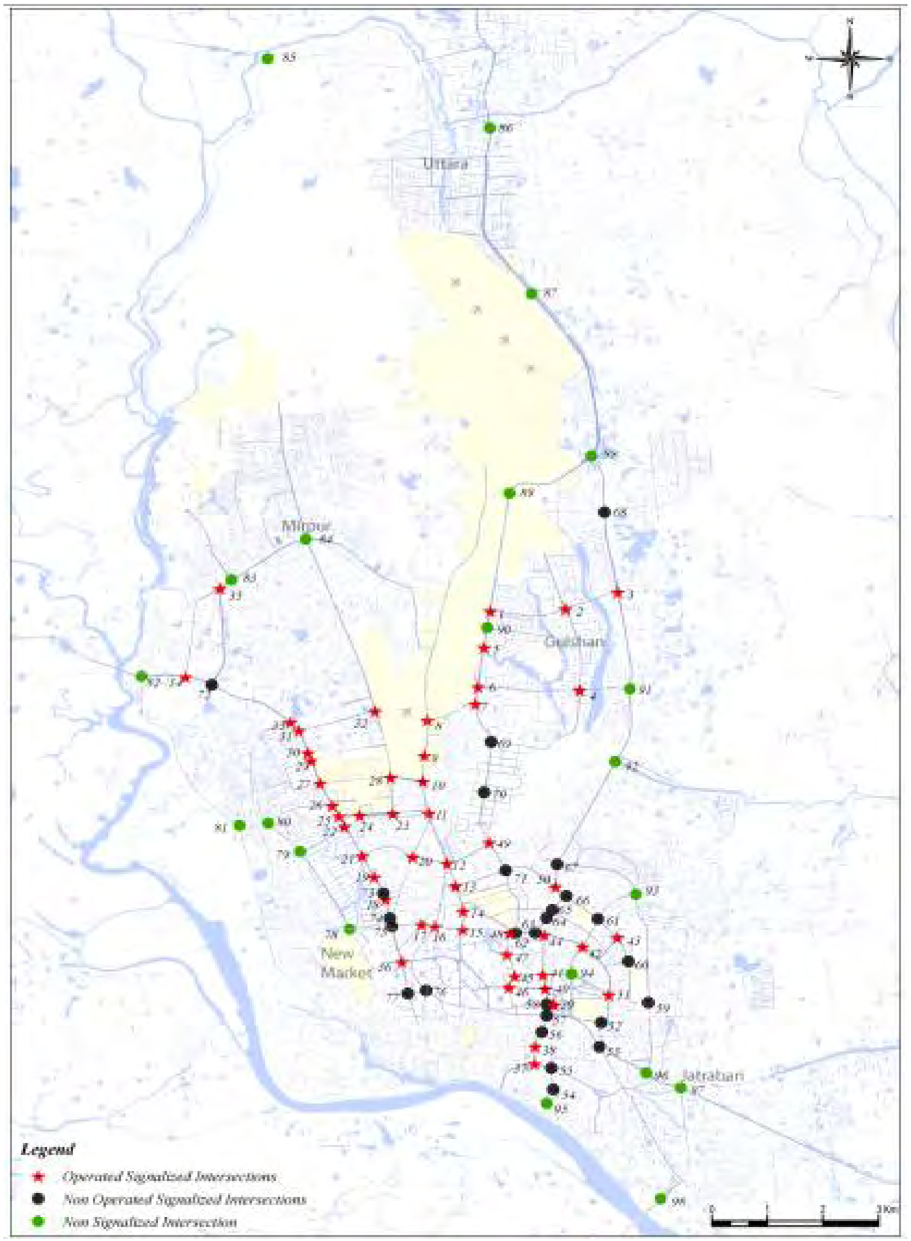


Figure 3.3.2: Locations of Major Intersections of Dhaka City.

Source: DHUTS Study, 2009

The list of those sixty one (61) intersections are given below in Table 3.3.1

Table 3.3.1: List of Preliminary Surveyed Intersections.

Sl. No.	Location / Intersection	Sl. No.	Location / Intersection
1.	Mirpur 1.	32.	Topkhana Intersection.
2.	Mirpur Mazar Road.	33.	Zero Point.

3.	Dar us Salam.	34.	Golap Shah Mazar.
4.	Agargaon.	35.	Zahir Raihan Intersection.
5.	Bijoy Sarani (Aeroplane).	36.	Bangshal Road Intersection.
6.	Khamar Bari.	37.	English Road Intersection.
7.	Parliament Intersection.	38.	Mirpur 10.
8.	Shishu Mela.	39.	Sadarghat Road Intersection.
9.	Tejgaon Rangs Link Road.	40.	Ittefaq Intersection.
10.	Jahangir Gate.	41.	Gulisthan Square Intersection.
11.	Front of Prime Minister Office.	42.	Shapla Chattar Intersection.
12.	Bijoy Sarani (Rangs).	43.	Kamlapur Railway Station.
13.	Hotel Sonargaon.	44.	Kamlapur Container Terminal.
14.	Bangla Motor.	45.	Rajarbagh Intersection.
15.	Bata Signal.	46.	Fakirapul Intersection.
16.	New Market.	47.	Kakrail (Rajmoni) Intersection.
17.	Azimpur.	48.	Shanti Nagar Intersection.
18.	Palashi.	49.	Malibagh Intersection.
19.	Curzon Hall	50.	Mouchak Intersection.
20.	Kadom Chattar.	51.	Mogbazar Intersection.
21.	Malibag Rail Gate Intersection.	52.	Kakrail Mosque Intersection.
22.	Basundhara Intersection.	53.	Bijoy Nagar Intersection.
23.	Mujib Avenue.	54.	Peerjongi Majar Intersection.
24.	Gulshan 2.	55.	Shah bag.
25.	Gulshan 1.	56.	Hotel Sheraton.
26.	Kakoli.	57.	Bangla Motor.
27.	Chairman Bari.	58.	Farmgate.
28.	Mohakhali Amtoli.	59.	Dhanmondi Road 10.
29.	Mohakhali Rail Crossing.	60.	Dhanmondi Road 6.
30.	Tongi Diversion Intersection.	61.	Science Lab Intersection.
31.	Matshaw Bhaban.		

After having done the preliminary survey of 61 major intersections of Dhaka Metropolitan City and analyzing the findings of preliminary survey, seven (7) intersections has been shortlisted; they are as follows

1. Mirpur 1 Tee Intersection / Wye Intersection,
2. Shishu Mela Tee Intersection,
3. Agargaon Cross Intersection,
4. Bangla Motor Cross Intersection,
5. Mirpur 10 Round About,
6. Shapla Chattar Round About, and
7. Science Laboratory Multi legged Compound Intersection.

After this shortlisting, a detail attention is being taken in those intersections. The geometric and traffic characteristics of those sites were observed, the basic properties are given below in Table 3.3.2.

Table 3.3.2: Geometric and Traffic Characteristics of Sites Shortlisted.

Intersection Name	**Approach***	**Type of Roads****	**Turning Movements*****	**Vehicle Mix******
Mirpur 1.	Mazar Road (E)	Two way, DC	A	With NMV
	Mirpur 10 (W)	Two way, DC	A, L	With NMV
	Dar us Salam (S)	Two way, DC	L, RO	With NMV
Sishu Mela.	Shyamoli (N)	Two way, DC	A, L	With NMV
	Agargaon (E)	Two way, DC	L, RO	With NMV
	College Gate (S)	Two way, DC	A, RO	With NMV
Agargaon.	Mirpur 10 (N)	Two way, DC	A, L, RO	With NMV
	Prime Minister Office (E)	Two way, DC	A, L, RO	Without NMV
	Farmgate (S)	Two way, DC	A, L	With NMV
	Shishu Mela (W)	Two way, DC	A, L, RO	With NMV
Bangla Motor.	Farmgate (N)	Two way, DC	A, L	Without NMV
	Moghbazar (E)	Two way, DC	A, L, RO	With NMV
	Sonargaon (W)	Two way, DC	A, L, RO	With NMV
	Sheraton (S)	Two way, DC	A, L	Without NMV
Mirpur 10	Mirpur 12 (N)	Two way, DC	A, L, RO	With NMV
	Mirpur 14 (E)	Two way, DC	A, L, RO	With NMV
	Agargaon (S)	Two way, DC	A, L, RO	With NMV
	Mirpur Thana (W)	Two way, DC	A, L, RO	With NMV
Shapla Chattar.	Fakirapul (N)	Two way, DC	A, L	With NMV
	Kamlapur Bazar (E)	Local Road	A	With NMV
	Tikatuli (S)	Two way, DC	A, L	With NMV

	Baitul Mukarram	Two way, DC	L	With NMV
Science Laboratory Intersection.	Kalabagan (N)	Two way, DC	A, L, RO	With NMV
	Green Road (N)	Two way, DC	A, L	With NMV
	Shahbag (E)	Two way, DC	L, RO	With NMV
	New Market (S)	Two way, DC	A	With NMV
	Dhanmondi Road 2 (W)	Two way, DC	L	With NMV
	Dhanmondi Road 3 (W)	Two way, DC	A, L, RO	With NMV

Note:*N = North, S = South, E = East, W = West;

** DC = Dual Carriageway;

*** A = Ahead, L = Left, RO = Right Opposed;

**** NMV = Non-Motorized Vehicle.

3.4 Finalizing Intersection for Detail Survey

3.4.1 Site Selection Criteria

The main criteria for selecting the sites were

1) To find the availability of visibility for manual counting in the field survey of these intersections.
2) To consider the importance of these intersections in the overall road network in the Dhaka Metropolitan City area.
3) To get both vehicular and pedestrian movements, those are high, according to intersections
4) To include wide verities of vehicles types and traffic conditions such as with / without non motorized vehicles (NMV), crossing reinforcement measures viz. with / without median barriers, foot over bridge location near / away from junction / none.
5) To include wide varieties of Traffic Analysis Zone (TAZ), example: residential, commercial, official zone, Commercial Business District (CBD), etc.
6) To find out the scope of permission from the Dhaka Metropolitan Police (DMP), Traffic Division.

It was, therefore, essential to select sites based on the above requirements. The aim was to identify the sites which were most suitable for the final survey.

3.4.2 Objectives of Data Collection

The objectives of the data collection from detail field survey were

1) To acquire the information about the geometric and operating condition of selected intersections, (namely: Mirpur 1 intersection, Shishu Mela intersection, Agargaon intersection, Bangla Motor intersection, Mirpur 10 intersection, Shapla Chattar intersection, and Science Laboratory intersection).

2) To obtain comprehensive information / data from selected intersections. These include basic data such as existing vehicular and pedestrian flow collected at different times of the day covering from pre peak to off peak periods; amount of side friction; condition of traffic control devices including signal timing and mode of operation, etc.
3) To obtain vital parametric information, such as approach wise queue length, delay / road occupancy, saturation flow would also be collected from primary and secondary sources and would be analyzed along with roadway capacity to establish a LOS based performance evaluation approach for signalized intersections under non lane indiscipline heterogeneous traffic condition.
4) To collect reported accident data from Accident Research Institute (ARI) of Bangladesh University of Engineering and Technology (BUET).

3.4.3 Method of Data Collection

Keeping eye on the objectives of data collection, observing the findings of data collection the following methods were used in detail data collection from the field. Data collection procedure was classified in three (3) methods. They were

1) **Qualitative observation** of geometric and operating condition of selected intersections.
2) **Manual counting** for upstream classified vehicle counts and pedestrian flow data for finding out the vehicle classification, degree of saturation each approach of the intersection, turning movement / directional distribution at peak hour and off peak hour of the intersection, approach wise queue length and delay / road occupancy.
3) **Collection of accident records** of these selected intersections from ARI of BUET.

The following key parameters were selected for investigation of those selected intersections

- Classified vehicle count.
- Pedestrian count inside the intersection.
- Counting of Diverted Non-Motorized vehicles from intersection.
- Para-transit vehicle count.
- Signal Cycle time.
- Queue length.
- Delay.
- Numbers of accident.

For gathering those data from detail survey, two (2) types of data was gathered from field. They are

Table 3.4.1: Summery of Methods of Data Collection.

Parameters	Method of data collection
Classified vehicle count	Primary Data
Pedestrian counting	Primary Data
Counting of Diverted Non-Motorized vehicles from intersection	Primary Data
Para transit vehicle counting	Primary Data
Signal cycle time counting	Primary Data
Determination of queue length	Primary Data
Counting of delay in intersection	Primary Data
Collection of accident numbers (reported only)	Secondary Data

The method of data collection is described below

3.4.3.1 Classified Vehicle Count

To carry out traffic volume counts by hand tally the observer required suitable clip board, watch, pencils and forms (tally sheet). Detailed forms were designed to allow swift and accurate recording of all desired details of direction of movement, turning movements and type of vehicles. A separate sheet is generally used for each 15 minutes interval counting period. Summary forms and diagrams are prepared on a single sheet or diagram; values obtained for each elementary unit of counting period and total values for the entire period of observations.

3.4.3.2 Pedestrian Counting Manual Counting Method

In order to get a comprehensive data of pedestrian movement inside the intersection, it is decided to count the number of pedestrian movement in different approach of intersection passing through a strip of one meter length at a certain interval of time. To make pedestrian counting by hand tally, the observer is equipped with suitable clipboard, watch, pencils and forms. The detailed forms were designed to allow swift and accurate recording of all desired details of pedestrian movements. A separate sheet is generally used for each counting period. Summery forms and diagrams are employed on a single sheet of diagram; values obtained for each elementary unit of counting period and total values for the entire period of observation.

3.4.3.3 Counting of Diverted Non-Motorized Vehicles from Intersection-Manual Counting Method

To reduce the traffic load and making fast circulation of motorized vehicles at the intersection most of the non-motorized vehicles are diverted from the main approach of the intersection to the internal connecting road. To make volume counts of non-motorized vehicles by hand tally. A number of enumerators need to be engaged, who are familiar with work especially. They are equipped with full of necessary materials needed for this purpose. Detailed forms should be designed to allow swift and accurate recording of all desired details. A separate sheet is generally used for each counting period. Summery forms are prepared on a single sheet; values obtain for each elementary unit of counting period and total values for the entire period of observation.

3.4.3.4 Para - Transit Vehicle Counting Manual Counting Method

In Dhaka Metropolitan City some para transit vehicles are engaged for carrying short distanced passengers from the nearest point of intersections. These para transit vehicles are illegally running their service and they do not follow the traffic rules and regulation. Moreover, their movement activities are completely hazardous. It slows down the flow of main traffic at the intersections.

To make Para transit vehicle counting manually the observer is engaged with their necessary materials needed for counting. Detailed forms were designed to allow for swift and accurate recording. A separate sheet is generally used for its counting period. Summery forms are prepared on a single sheet, volumes obtained for each elementary unit of counting period and total values for entire period of observation.

3.4.3.5 Signal cycle time counting Manually

At any intersection the time taken to complete one cycle of all approach phases is called signal cycle time. Cycle length is composed of the total signal time to serve all of the signal phases including the green time plus any change interval.

To count the signal cycle time manually the observer is engaged with necessary materials, such as clip board, watch, pencils and a supply of detailed forms for these purpose. Detailed forms were designed to allow swift and accurate recording of all desired data.

3.4.3.6 Queue Length Survey Manually

Queue length surveys are essential to calibrate traffic models and provide evidence of congestion and delays. Traffic Data Collection ensure that queue length surveys are carried out for each approach of each junction
vehicle numbers, or in meters / yards.

To measure the queue length manually the approach is marked with color paint at a distance of 10 ft interval starting from the intersection vehicle stop line initially. The observer is equipped with suitable clip board, watch, pencil and a supply of detailed forms. Detailed forms were designed to allow swift and accurate recording of all desired data.

3.4.3.7 Counting of Delay in Intersection- Manually

The Intersection Delay Study is used to evaluate the performance of intersections in allowing traffic to enter and pass through, or to enter and turn onto another route. This study will effectively provide a detailed evaluation of stopped time delay at the intersection.

To perform the study, the first observer counts and records the number of vehicles stopped on the approach for each sampling interval. A stop watch used to provide the observer with the proper intervals for counting the stopped vehicles. A vehicle is counted more than once in the delay determination if it is stopped during more than one sampling time. That is, a particular vehicle will continue to be counted in all sample time periods during which it remains stopped on the intersection approach.

Alternatively, by accumulating the amount of time spent by each vehicle in the queue and counting all vehicles (moving and stationary), a true measurement of delay can be achieved.

3.4.3.8 Collection of Accident Data in Intersection

In Dhaka Metropolitan city, the traffic roadway system context is more complex where a mixed road user environment prevails and greater perceptual and cognitive demands are placed on the road users. Particularly at the intersections, the signalized ones that are problematic locations and have been identified as among the most hazardous locations on the roads which account for a substantial portion of traffic accidents. The heterogeneity of traffic, plying of modes with varying speed and maneuvering time makes the intersections of Dhaka city even more complex.

The Accident Research Institute (ARI) at Bangladesh University of Engineering & Technology (BUET) essentially uses the MAAP (Microcomputer Accident Analysis Package) database. Accident reporting database was transferred to ARI through an institutional collaboration with the Road Safety Cell (RSC) of the Bangladesh Road Transport Authority (BRTA) and the Police Department. The current road safety research and investigation works is based on this database. Road accident data at intersections of Dhaka Metropolitan City are collected from ARI.

For understanding the real scenario of Dhaka city, the accident record was collected from ARI.

3.5 Overview

In this chapter, detail methodologies followed in the study are presented sequentially. Besides, the methods of data collection and analysis for different parameters related to the objectives are drawn up elaborately. All these gathered data and information would form the basis of subsequent analysis conducted later, whichare presented and analyzed in the following chapter viz. Chapter 4.

DATA COLLECTION AND ANALYSIS

4.1 Introduction

The study is aimed at performance evaluation of selected intersections of Dhaka Metropolitan City. It will help the City Authority and Government to evaluate the present condition of Dhaka Metropolitan City road network, also help them for finding out the appropriate solution of the present ill operated condition and give a conceptual idea of economic loss due to present operation of intersections. Moreover, it will help to find out the probable ranking system of road intersection inside Dhaka Metropolitan City.

It is, therefore, necessary that the results are carefully assessed using information from actual traffic situations. In order to do that, data (degree of saturation of traffic flow, side friction, queue length and delay) from the study sites were collected and analyzed. Flow for each approaches of the selected junctions i.e. Mirpur 1, Shishu Mela, Agargaon, Bangla Motor, Shapla Chattar and Science Laboratory; the vehicle had been counted for eleven (11) hours (from 07.00 A.M. to 06.00 P.M.). Various parameters which are related to these intersections / junctions had been analyzed for the evaluation of the performance. Finally the intersections had been ranked down according to their level of service (LOS) and past accident record.

Thus this chapter deals with the data collection and analysis process of this study elaborately.

4.2 Data Collection and Analysis

Data were collected from the selected sites to obtain the important variables, such as classified vehicle counts, saturation flow calculation; pedestrian counting; condition of traffic control device, signal timing, phasing, mode of operation; queue length collection from the approach; delay / road occupancy of vehicle; evidence documenting for side friction; accident record, etc. which can be used for finding out the LOS of the Dhaka City intersection. The characteristics of the sites survey can be seen from Table 3.3.2.

i. **Traffic Flow Based Data:**

   Classified vehicle count (with Motorized and Non Motorized), saturation flow counting, pedestrian counting (entire flow and crossing facility users)

ii. **Traffic Control Data:**

   Condition of traffic control device, signal timing, phasing, mode of operation, queue length collection, delay / road occupancy of vehicle determination

iii. **Intersection Based Data:**

Evidence documentation for side friction, accident data of the intersection

The field data were analyzed for finding out the other relevant data of this research later on.

4.3 Observations of Heterogeneous Traffic Behavior

The vehicle composition in the western countries is mainly car dependent. But in Bangladesh there are thirteen (13) different types of vehicles starting from heavy trucks to push carts. In Dhaka city road network, ten (10) types of vehicle were found in this research (*Signal Synchronization Study, 2013*). No single vehicle type dominates in the traffic stream. In order to get a detailed and comprehensive picture of such heterogeneous traffic behavior, it was decided to use manual data collection method, which has the advantage of providing a permanent and comprehensive data record of traffic movements. It can be used repeatedly to obtain the field picture of Dhaka city road intersections. An added advantage of this type of data is that, one may obtain many sets of information regarding heterogeneous stream characteristics from this collected data.

In this research, the collected data was more detailed and accurate regarding the flow of vehicles through intersection, especially for the classified vehicles count of the total approach, pedestrian counting of the intersection, the traffic control device data of the intersections, queue length and delay data of the approach properties. Moreover, the extraction of data in workable format was also a tedious and time consuming occupation.

In order to obtain a better understanding of the nature of mixed traffic behavior, this accumulated data analysis was done qualitatively as well as quantitatively.

4.4 Qualitative Analysis of Survey Data

This was done by observing the field condition critically at preliminary survey and main field survey. To summarize the findings, the following is a list of points describing the behavior of the traffic, which would be considered in the measurement of performance evaluation and LOS of signalized intersections under heterogeneous traffic condition.

i. At upstream a clear segregation of motorized and non-motorized vehicles is observed. In general motorized vehicle occupied the right part, whereas non motorized vehicles took left part of road.

ii. Queue is built up based on the optimum road space utilization criterion i.e. when a vehicle join with the queue, main stimulus is the front gap irrespective of the lane in which it is available. As a result, it has been observed that straight ahead vehicles / through traffic, regardless of the type whether motorized or not, occupy any position across the road based on the available space. Consequently, the maximum interactions between the motorized and non-motorized vehicles are observed during the subsequent discharge process. Note also that due to the arbitrary position of the vehicles across the road width, not all the space can be filled up during the queue formation. Another feature of the queue formation is that the smaller sized vehicles such as bi cycles and motor cycles use inter vehicular space to come in front of the queue. Sometimes the smaller vehicles do not try to follow the traffic signal.

iii. At most of the approaches, traffic signals have been placed too far away from the edge of the cross road and thereby leaving a large road space between the signal or stop line and the edge of the cross road and thereby leaving a large road space between the signal or stop line and the edge of the cross road. In reality, this acts as a big stimulus for the drivers and indulges to cross the stop line during the formation of the queue at red signal time. because of this, during the subsequent discharge operation the following problems arise

- The leader of the stopped vehicle could not see the signal / police and as such discharge operation start with confusion.
- Usually drivers start to move off sometimes by intuition, hearing horn from its trailing vehicles and seeing slowing discharge process from the cross road.
- The delayed and confused starting operation from the current phase encourage drivers from the previous phase to violet red at change of signal that causes unnecessary vehicular conflicts within the intersections and increase accident potential substantially. Sometimes the red jumper from previous phase trapped inside the intersection by the oncoming vehicles from the current phase of the side road and reduces the start off and reduces junction performance greatly.
- Causes disorderly movement of vehicles through junctions and no clear pattern could be seen during the start off and stopping operation at the change of signal.

iv. From the observation, it is learnt that when the proportion of right turners and as well as flow is low, the right turning maneuvers follow the gap acceptance criteria. But when the proportion of right turning vehicle is high and at the same time opposing flow is also high, right turning maneuvers follow a very complex negotiation process with the opposite straight ahead / through vehicles instead of gap acceptances criteria.

v. Another interesting observation is the performance of the non motorized vehicles at the end of green period. As the intersection of Dhaka City are quite wide in nature and the non motorized vehicles (NMV) take more time than the motorized vehicles (MV) to clear the junctions, the slow moving NMVs that violate the red signal become trapped at the end of green period. For making the junction clear, it demands a special all red period in signaling phase.

vi. Another striking observation is the pedestrian crossing, though every intersections of Dhaka city have some crossing facilities, such as grade separated facility: over bridge, underpass, etc. at grade facility zebra crossing, pedestrian refuge, pedestrian signal, etc. But pedestrian cross through this intersection through road interrupting the traffic flow. Illegal encroachment of footpath and road side, illegal parking, bus stoppage, rickshaw stoppage, etc. increase the side friction, that delayed the traffic flow, decrease the performance of intersection, as well as reduces the level of service (LOS).

Based on these above findings, the data was collected from field, evaluated and found out the LOS.

4.5 Quantitative Analysis of Survey Data

Concentrating on the objective of this investigation / research work, the existing information of the selected intersections were found out as per findings of preliminary survey of those intersections; Mirpur 1, Shishu Mela, Agargaon, Bangla Motor, Mirpur 10, Shapla Chattar and Science Laboratory intersections. These information included peak hour time of the intersection, classified vehicle of these intersections / composition of vehicle according to directional distribution / movement wise, highest carried vehicle movement in the intersection and its percentage, percentage of Non Motorized Vehicle (NMV) and Motorized Vehicle (MV), total vehicle nos., combination percentage in the intersection, approach wise flow ratio of the intersection, total pedestrian in the intersections, availability of pedestrian crossing facilities and users and overall percentage, side friction at different position inside the intersection, signal cycle time at peak period, identification of queue length / delay at different approach all through the day, calculation of LOS of intersections, collection of past accident records from ARI of BUET.

Referring that information of intersections, the LOS based performance evaluation approach was established for signalized intersections under non-lane disciplined heterogeneous traffic conditions.

4.5.1 Peak Hour

A rush hour / peak hour is a part of the day during which traffic volume on roads is at its highest. Normally, this happens twice every general weekday; once in the morning and other in the afternoon-evening, the duration of time of day when the most people commute. The term is often used for a period of peak congestion that may last for one hour or more.

The term is very broad, but often refers specifically to private automobile transportation traffic, even when there is a large volume of cars on a road but not a large number of people, or if the volume is normal but there is some disruption of speed. Mainly it effects the in the intersection most.

4.5.2 Vehicle Combination

This term is generally used for the vehicle collection / group of vehicles on the road. It includes all type of traffic on the road. In the road network of Dhaka Metropolitan City, the combination of Motorized and Non motorized vehicle was observed. Basically, this vehicle combination can be called heterogeneous traffic, which is previously stated in section 4.3.

4.5.3 Classified Vehicle Count and PCU Values

Classified vehicle count means the counting of vehicle on the road according to their classification. Usually, in Dhaka Metropolitan City, there are two (2) main classification of traffic; Motorized vehicle and Non motorized vehicle. This Classified vehicle counts data are converted to passenger car unit (PCU) for comparison purpose later. Passenger Car Equivalent factors for different types of vehicles are taken from *Signal Synchronization Study, 2013, CASE Study.*

Table 4.5.1: PCU Value of Different Vehicles.

Vehicle Type	Serial No.	Classified Vehicle	PCU Value
Motorized Vehicle	1.	Car / Taxi	1.00
	2.	Utility	1.00
	3.	CNG / Mishuk	0.60
	4.	Micro bus / Ambulance	1.00
	5.	Mini bus	2.00
	6.	Large bus	3.00
	7.	Motor cycle	0.33
	8.	Truck	3.00
Non motorized Vehicle	9.	Rickshaw	0.80
	10.	Bi cycle	0.25

4.5.4 Flow

Flow is the number of vehicles expressed in passenger cars passing a specified point on the road (or an approach at an intersection) in unit time, usually in an hour.

4.5.5 Saturation Flow

The saturation flow should be directly measured from the field and not from empirical relationships which is the case for developed countries. As it would be obtained from direct field measurement, there is no need for reduction of its value due to road side friction.

4.5.6 Flow Ratio (v/c Ratio)

The v/c ratio is the ratio of current flow rate to capacity of the facility.It is an indicator of the quality of the operations at an intersection.

v/c = rate of flow / capacity

v/c ratio is a part of the design criteria and the value which is followed at the time of traffic signaldesign.To test this value at an existing intersection, we can get the flow rate from traffic counts and capacity can be calculated based on the signal timing plan.A ratio that is greater than 1.00 predicts that the facility will fail; because it is unable to discharge the demand arriving at the section.It should be less than 0.95.

4.5.7 Conflict

Conflict is undue interference between vehicles that usually occur at the beginning or the end of a signal phase. This various type of conflicts at an intersection are crossing conflicts, merging conflicts and diversion conflicts on right angle.

4.5.8 Side Friction

Side friction means the reason of disturbing of traffic flow in the intersection area; illegal bus stoppage, rickshaw stand, human hauler / Laguna stand, pedestrian movement, passenger boarding and alighting, various repair work of road, etc.

4.5.9 Signal Cycle Time

Cycle length is composed of the total signal time to serve all of the signal phases including the green time plus any change interval. Longer cycles will accommodate more vehicles per hour but that will also produce higher average delays. The best way is to use the shortest practical cycle length that will serve the traffic demand *(Webster, Delay vs. Cycle Time)*.

4.5.10 Queue Length

In transportation systems, queues are formed whenever the number of arrivals at a given location exceeds the maximum rate at which vehicles can go through the location. When such a situation occurs, the excess vehicles are stored upstream of the bottleneck or service area and their departure is delayed to a later time period. Depending on the type of service provided, the queues that are formed may be either moving or completely stopped. Typically, moving queues are formed at locations where the flow of vehicles across the bottleneck or service area is never completely stopped. Stopped queues occur on the other hand when there is completely interruption of service for a significant amount of time.In those observed intersection, the queue length was measured (*Papacostas, C.S. and Prevedorous, P.D. 2001*).

4.5.11 Delay in Intersection

The delays experienced on the arterial signalized streets are mainly associated with the intersection where conflicting movements are separated and controlled by traffic signals. These traffic signals can operate under an isolated control strategy, with the signal settings of each signal set independently of the settings of adjacent signals. The delay is defined as the difference in travel time when a vehicle is unaffected by the controlled intersection and when a vehicle is affected by the controlled intersection. This delay includes lost time due to deceleration and acceleration as well as stopped delay. Thus, intersection delay estimates are directed toward estimating total delay (*Papacostas, C.S. and Prevedorous, P.D. 2001*).

4.5.12 Level of Service (LOS) of Intersection

Level of service (LOS) is a qualitative measure that describes the operating conditions within an intersection or roadway section, and the perception of those conditions by the facility LOS provided by any given facility, might include any or all of the following:

- User comfort.
- Convenience.
- Travel time.
- Maneuverability.
- Interruptions in traffic.
- Speed.
- Cost.
- Number of stops.
- Fuel consumption.

Every type of facility (intersection, freeway segment, arterial, or pedestrian) has different operating parameters that are used to determine its level of service. For intersections, the primary operating parameter is average control delay per vehicle defined in units of seconds per vehicle. There are six (6) LOS defined for each facility type. Each level has a letter identification from A to F with LOS A representing the best operating conditions and LOS F the worst *(HCM, 2010)*.

4.5.13 Accident Data of Intersection

In road network, accident is a very common phenomenon. In this research, the accident data was collected from ARI of BUET; data was analyzed as per intersection and joined with LOS data of intersection. Finally, these intersections were ranked by analyzing both LOS data and accident data separately. In this way a procedure of ranking of intersection was established inside the Dhaka City Metropolitan Area. The detail has been described in Appendix A.

Detail qualitative analyses of those intersections are given below through appropriate table and graphs.

4.6 Quantitative Data Analysis of Mirpur 1 Intersection

A. Site Investigation of Mirpur 1 Intersection

1

10 round about oads in Northern part of Dhaka City. It is situated inside the Dhaka North City Corporation (DNCC) area. All type of development in this area had been done by focusing this intersection. This intersection is the development hub of this area. According to classification of intersection, Mirpur 1 is a ee Intersection / Wye intersection intersection point from three different directions. This intersection is now performing as a principal commercial heart of Mirpur area.

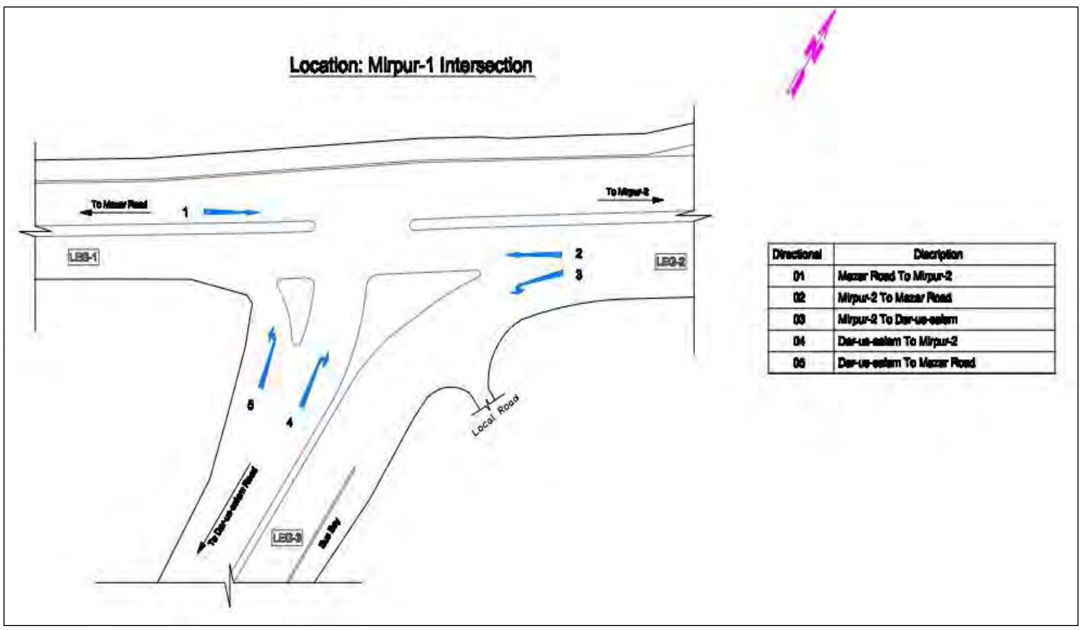


Figure 4.6.1: Layout of Mirpur 1 Intersection.

Source: (Signal Synchronization Study, 2013)

From preliminary survey of this selected intersection, the three (3) approaches are divided by lanes with necessary marking. Table 4.6.1 describing the lane division of different approaches is given below.

Table 4.6.1: Approach of Mirpur 1 Intersection with Lane Division

Serial No.	Approach with direction	Lane number
Leg 1.	Mazar Road to Mirpur 1 intersection.	2 lanes both direction.
Leg 2.	Mirpur 10 Round about intersection to Mirpur 1 intersection.	2 lanes both direction.
Leg 3.	Dar us Salam Road to Mirpur 1 junction.	2 lanes both direction.

The main carriageway of this intersection is flexible pavement in all direction. Due to regular maintenance work, we found a lot of digging works in various places of this intersection. But in lack of proper finishing, the excavating places had not been filled up well. For this lot of problems occurred in the rainy season.

Observing the vehicular flow of this intersection, we found two (2) distinct peak hours of this intersection around from 08.00 AM to 12.00 P.M. and from 04.00 PM to 06.00 PM and further more. In this preliminary survey period we found out the flow ratio on every approach of this intersection for assessing the vehicular characteristics. A lot of traffic used this intersection all throughout the day. A lot of pedestrian movement was found in this intersection. There were some pedestrian facilities for movement, such as footpath, crossing facilities, such as - over bridge. But this footpath was illegitimately invaded by the hawkers, traders, hotels, road side market, etc. There were a lot of side frictions in the approaches of this intersection.

There was the provision of automatic traffic signal for traffic control, but this was not practiced in field. So, all of the signals were as showpiece in a showcase. Traffic police tried to control the traffic of this intersection manually. Signal timing, phasing was not consistent for this. They tried to operate this intersection responding as per demand. So a lot of delay occurred here and queue length originated in peak period too.

B. Geometric and Operating Conditions of Selected Intersection (Mirpur 1)

After finishing the detail survey of selected intersection, Mirpur 1; analysis of collected data about the intersection geometry and operating condition was done. The findings of this analysis are tabulated in Table 4.6.2 below.

Table 4.6.2: Geometric and Operating Condition of Mirpur 1 Intersection.

Sl. No.	Items.	Description.
1.	**Number of Approaches.**	There are three (3) approaches namely; from Mirpur 1 to Mazar road, Mirpur 1 to Mirpur 2 and Mirpur 1 to Dar us Salam.
2.	**Carriageway.**	All three (3) approaches of this intersection are made of flexible pavement in structural point of view and having dual carriageway.
3.	**Footpath Coverage**	Footpaths for pedestrian are found existing here, by the both of the side of all the three (3) approaches of this intersection, which is illegally occupied by purveyors, building materials, parked vehicle, etc. Mirpur 1 intersection has 100% footpath coverage.
4.	**Channelization**	Here, on the mouth of Dar us Salam to Mirpur -1

		approach, there are channelization for left turning, which are giving direction to vehicles towards from Mirpur 1 to Mazar Road and receiving vehicles from Mirpur 2 to Dar us Salam. But straight moving vehicle as usually try to block the entry in this channel. Besides this, there is a dedicated lane for NMV in this intersection; it is located at the front of Mukto Bangla Shopping Complex. But it is not used by NMV properly, it is also illegally occupied.
5.	**Divider**	All approaches of this intersection are alienated by the non - engineering divider, which is not related with velocity profile of vehicle of this intersection.
6.	**Pedestrian Crossing Facility**	There is a three (3) legged over bridge, which is located in the center of this intersection, which is providing pedestrian crossing facility as a grade separated service.
7.	**Side Road**	From preliminary survey of Mirpur 1 intersection and its surrounding area; eight (8) side roads were found, which are coming from neighboring residential and commercial area of this intersection and exposed in this intersection directly. It was containing maximum NMV on them.

C. Determining the Existing Vehicular, Pedestrian Flow, Amount of Side Friction, and Condition of Traffic Control Devices including Signal Timing, Phasing and Mode of Operation at Mirpur 1 Intersection:

In detail survey of Mirpur 1 intersection; existing vehicular flow, pedestrian flow was observed, furthermore amount of side friction was exposed and condition of traffic signal, signal timing, phasing and mode of operation was recorded and which analyzed later.

i. Existing Vehicular Flow

Analyzing the existing vehicular flow of Mirpur 1 intersection, an 11 hours vehicular survey (from 07.00 A.M. to 06.00 P.M.) was organized, the result of this survey and its analysis are presented here in Figure 4.6.2 a) and b), this figure is presenting a general graph accompanying with a pie chart, which is presenting the data of vehicular survey of this intersection and expressing the characteristics of vehicular flow through this intersection.

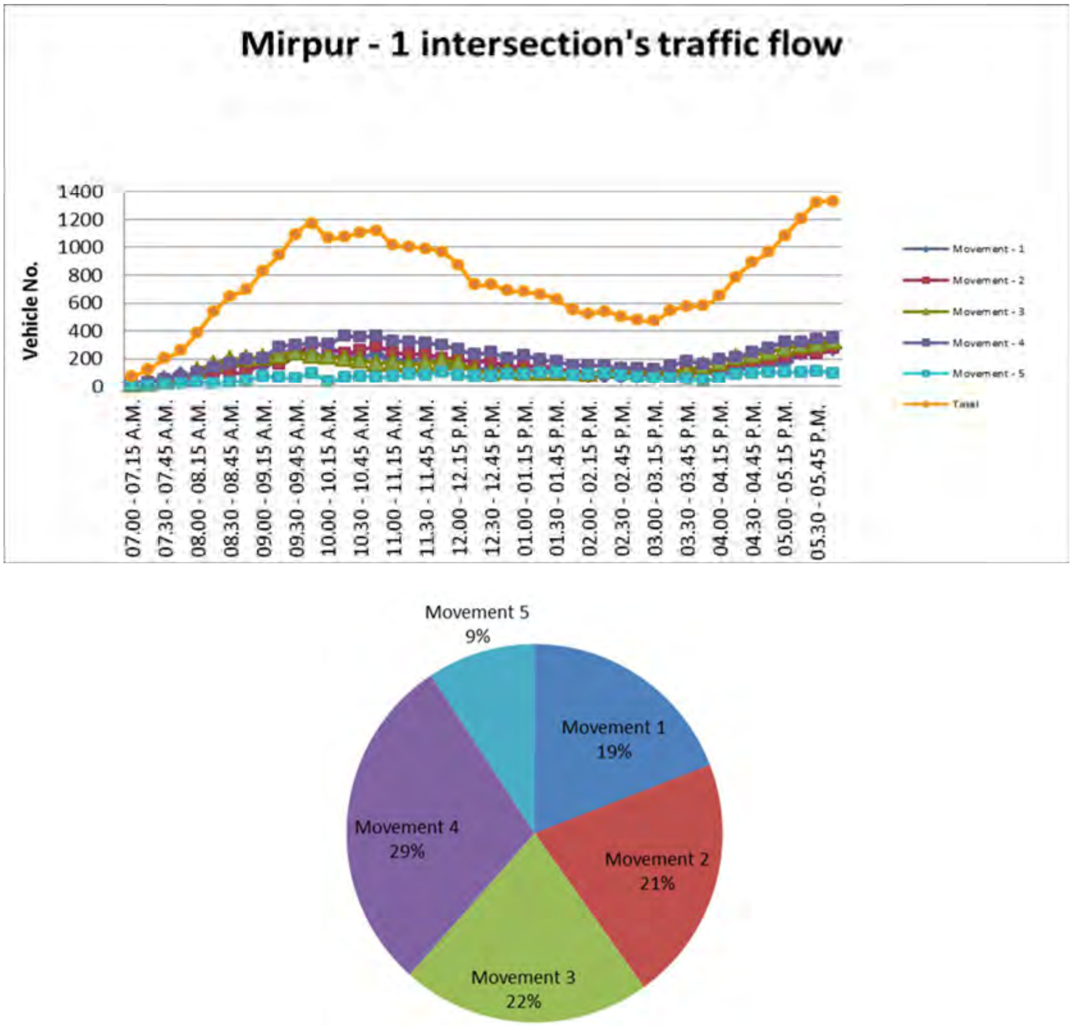


Figure 4.6.2: a) Vehicular Flow Data of Mirpur 1 Intersection; b) Vehicle Movement Contribution of Mirpur 1 Intersection.

Analyzing the vehicular survey data of this intersection, five (5) individual movements were found and among of them Movement 4 (from Dar us Salam to Mirpur 2) was maximum, which contained 29% of entire traffic flow of this intersection on the day of survey. From the entire 11 hour vehicular survey, two (2) distinct peak hours were found in traffic flow; one was in the morning period from 08.00 A.M. to 12.00 P.M. and another was in the evening from 04.30 P.M. to 06.00 P.M. and furthermore (beyond the survey time), total peak period of the entire survey time was 5.5 hours, which was 50% of total survey time of that day.

After analyzing the vehicular flow of this intersection, assessment of the vehicular combination of this intersection was done. The result of this analysis is presented here in Figure 4.6.3 a) and b), this figure is presenting a pie chart accompanying with a general graph.

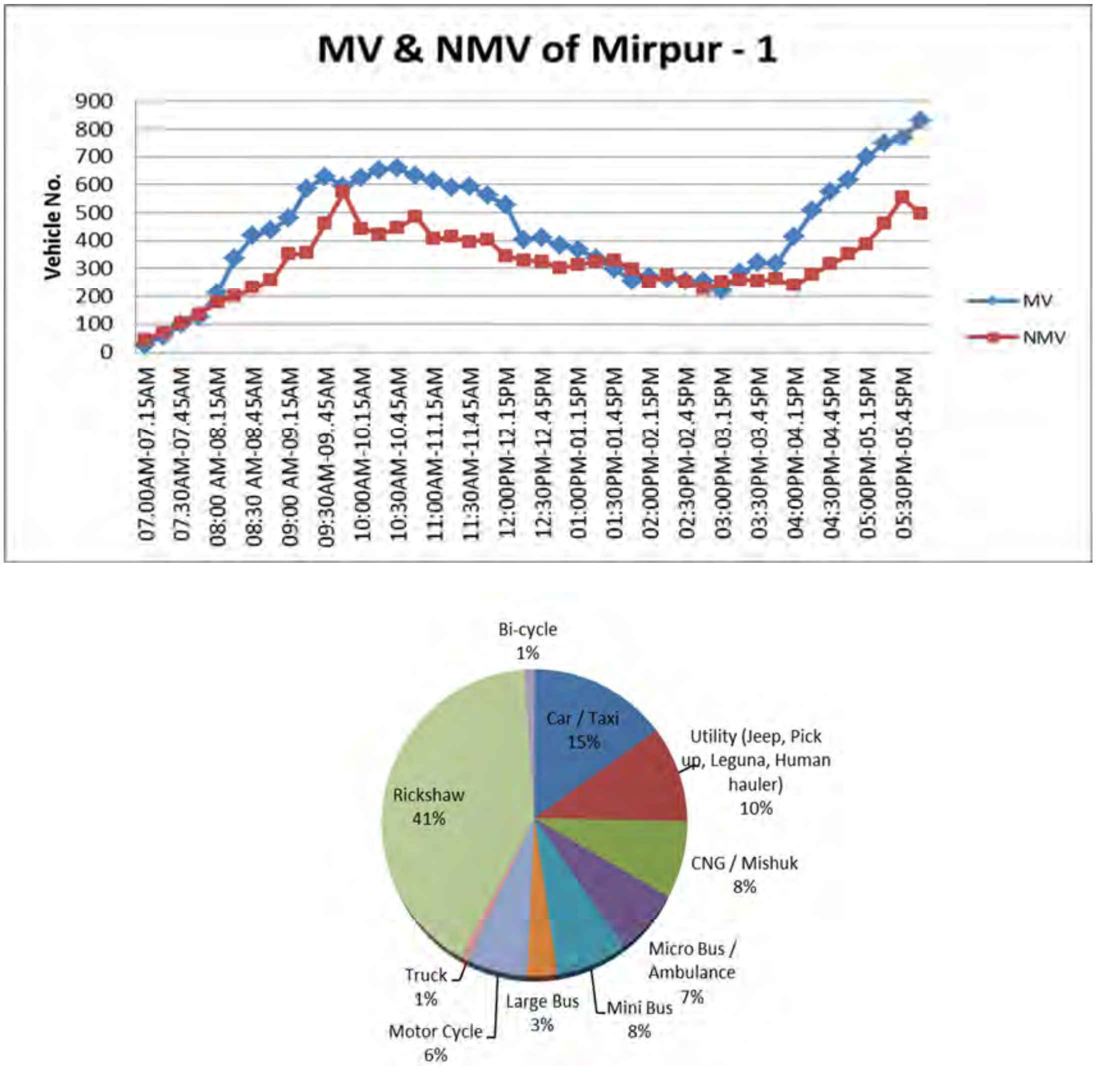


Figure 4.6.3: a) Individual flow of MV and NMV in Mirpur 1 Intersection; b) Classified Vehicle in Mirpur 1 Intersection.

In Figure 4.6.3 a), a general graph is shown, which is showing the individual flow of MV and NMV through this intersection. Analyzing this general graph, two (2) distinct peak hours are found for both MV and NMV; for MV it was observed from 08.00 A.M. to 12.00 P.M. at morning peak and from 04.00 P.M. to 06.00 P.M and further at evening peak and for NMV it was observed from 08.00 A.M. to 12.00 P.M. at morning peak and from 04.00 P.M. to 06.00 P.M. and further at evening peak. In Figure 4.6.3 b), a pie chart is shown, which is expressing the vehicular composition of this intersection. The dominancy of NMV is found out from here, which was 42% of total vehicular flow of that day; among the vehicular flow, rickshaw was the mostly governed vehicle type in this intersection, which was 41% of total flow and 58% of total vehicular flow, was MV.

After finding out the vehicular composition, the saturation flow of every approach of this intersection was calculated from the vehicular survey data. The result of this analysis is presented here through a tabular format in Table 4.6.3 below.

Table 4.6.3: Saturation Flow of Different Approach of Mirpur 1 Intersection.

Sl. No.	Intersection Name	Intersection Classification	Approach Name	Saturation Flow (PCU/Hour)
1.	Mirpur 1	Tee intersection / Wye Intersection	Mazar Road to Mirpur 1	1065.08
2.			Mirpur - 2 to Mirpur 1	2601.76
3.			Dar - us - Salam to Mirpur 1	1804.64

Later, the usages of road space of every approaches of this intersection were calculated. The result of this calculation is presented here through Figure 4.6.4 a), b), and c) with individual general graph, which is expressing the flow ratio with respect to saturation flow of the every individual approach of this intersection of 11 hours (from 07.00 A.M. to 06.00 P.M.).

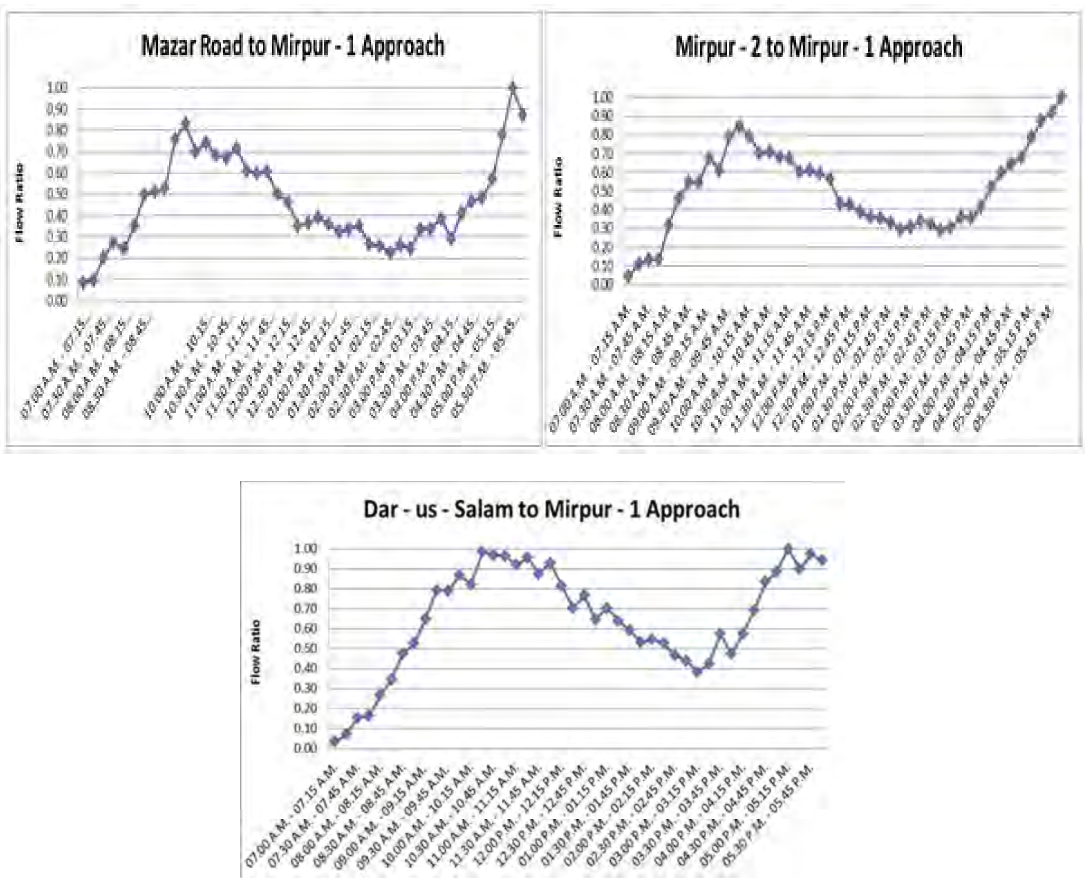


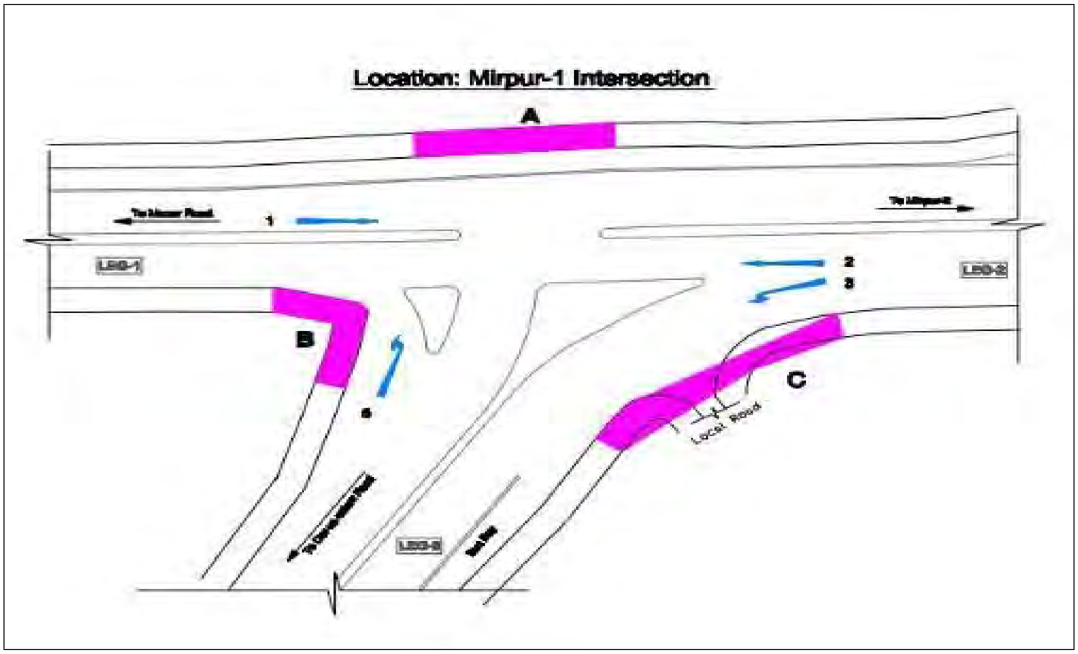
Figure 4.6.4: a) Flow Ratio of Mazar Road to Mirpur 1 Approach; b) Flow Ratio of Mirpur 2 to Mirpur 1 Approach; c) Flow Ratio of Dar us Salam to Mirpur 1 Approach.

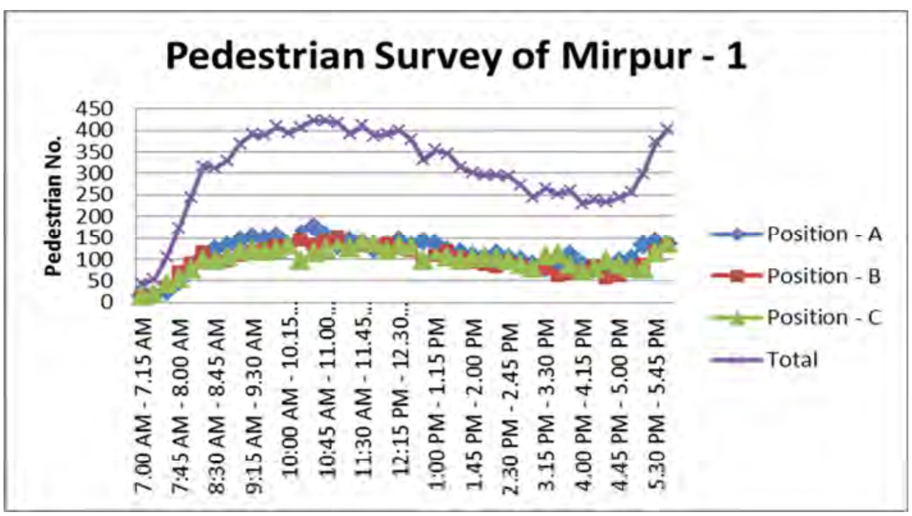
From Figure 4.6.4, it is observed that, two (2) peak hours were found in every approach of this intersection in vehicular flow; one in the morning and other in the evening.

ii. Pedestrian Flow

As per set out objectives of this research, the pedestrian flow through this intersection was also observed. In preliminary survey, two (2) types of pedestrian flow were observed; one was at grade and other was grade separated.

In this intersection, detail 11 hours (from 07.00 A.M. to 06.00 P.M.) pedestrian survey was organized for finding out the scenario of at grade pedestrian flow. After analyzing the result of this, it is presented here in Figure 4.6.5 a), b) and c), through a general graph accompanying with a CAD drawing and pie chart.





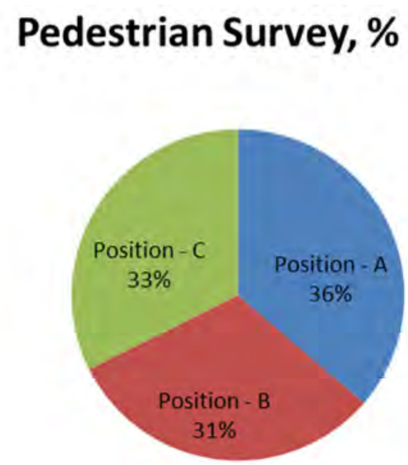
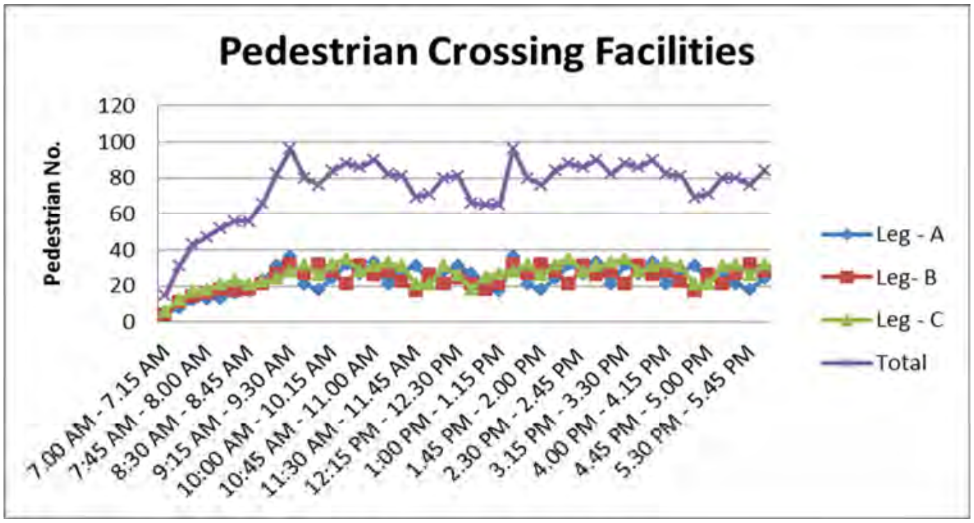


Figure 4.6.5: a) Pedestrian Survey Position inside Mirpur-1 Intersection; b) Pedestrian Flow; c) Pedestrian Flow Contribution among three (3) Positions.

From the preliminary survey, the three (3) positions were selected for detail field survey according to the availability of pedestrian in these points. The positions of those three (3) points are shown here in Figure 4.6.5 a). From Figure 4.6.5 b) at grade pedestrian flow through this intersection is presented, two (2) peak hours were found, one in the morning from 09.30 A.M. to 11.00 A.M. and other in the evening from 04.30 P.M. to 06.00 P.M. Among the three (3) positions, maximum at grade pedestrian flow was observed in position A, which is at the front of Mukto Bangla Shopping Complex, 36% percent of entire at grade pedestrian flow took place in this position which is presented here in Figure 4.6.5

A three (3) legged over bridge is situated inside this intersection as a grade separated crossing facilities for pedestrian. For finding out the scenario of grade separated pedestrian crossing facility of this intersection, an 11 hours (from 07.00 A.M. to 06.00 P.M.) pedestrian crossing survey was organized in this over bridge. After analyzing the result of this pedestrian survey, it is presented here in Figure 4.6.6 a), b) and c), through a general graph accompanying with a Google map and pie chart.



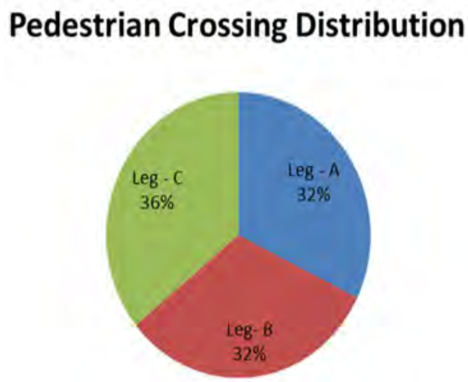


Figure 4.6.6: a) Position of Foot Over Bridge at Mirpur-1 Intersection; b) Grade Separated Pedestrian Flow; c) Pedestrian Flow Contribution among three (3) Legs.

From Figure 4.6.6 a), b) and c), from 11 hours survey it was observed that total 3, 277 nos. of pedestrian used this over bridge as a crossing facility through this intersection, the three (3) legs of the over bridge is indicated by Leg A, Leg B and Leg C in Google map. With respect to total pedestrian flow only 24 % pedestrian used this facility on that day. Among the three legs of this over bridge, about 36% of total crossing pedestrian of this intersection was being passed through Leg C which is at the corner of Capital Tower Shopping Mall.

iii. Side Friction

As per set out objectives of this research, the amount of side friction in this intersection was also determined. For this, in preliminary survey four (4) points were found out according to the site analysis.

From the preliminary survey of this intersection the three (3) specified reasons of side friction were found here Illegal rickshaw stand, human hauler / Laguna stand and bus stand. For finding out the scenario of side friction, an 11 hour nting survey (from 07.00 A.M. to 06.00 P.M.) was organized. The result of this counting survey is presented here inFigure 4.6.7 a), b), c) and d).

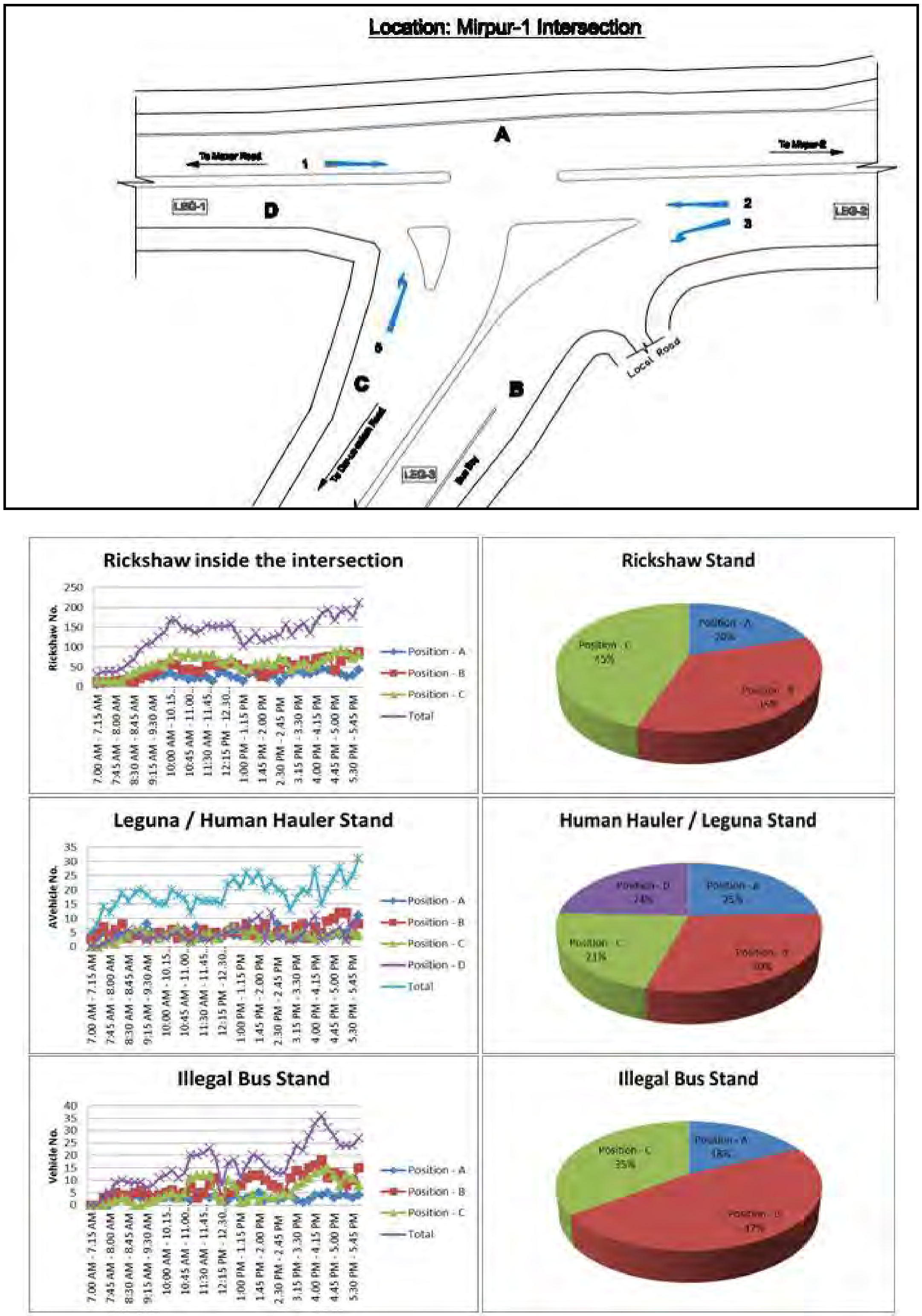


Figure 4.6.7: a) Side Friction Survey Position inside the Mirpur-1 Intersection; b) Contribution of Illegal rickshaw Stand; c) Contribution of Illegal Human Hauler Stand; d) Contribution of Illegal Bus Stand.

Analyzing Figure 4.6.7 a), b), c) and d); For rickshaw stand, it was observed that the position C (45% of total illegally standee rickshaw) contained maximum, for Laguna / Human hauler stand, it was found that, the position B (30% of total illegally standee Laguna / human hauler) contained maximum and for Illegal bus stand, it was found that, the position B (47 % of total illegally standee bus) contained maximum among the four (4) positions. Generally the combined effect of side friction was observed in the traffic flow of this intersection. 60% of total road width at the mouth of approach of this intersection was blocked by this side friction in the peak hour. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing day by day.

iv. Traffic Control Devices

From the preliminary survey of this intersection, a condition survey of traffic control devices was organized. The outputs of this condition survey are given below in a tabular format, in Table 4.6.4.

Table 4.6.4: Signal Accessories of Mirpur 1 Intersection.

Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Light Operation	Pedestrian Signal Light Operation
SP-1	OK	OK	Yes	-
SP-2	OK	OK	Yes	-
SP-3	OK	OK	No	-
SP-4	OK	OK	Yes	-
SP-5	OK	OK	Yes	-
MAP 1	OK	OK	Yes	-
TSC	OK	Shutter Missing	-	-

Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

Inthis intersection, for traffic control there was no use of traffic signal; instead of this, police controlled the traffic movement of this intersection manually based on traffic flow demands among three (3) approaches which is considered to be as c demand responsive signal system

controlling system (one road

stopped), which was the most inefficient method of traffic control. The traffic signal cycle time in this method is not consistent. The variation of signal cycle time in Mirpur 1 intersection at peak periods are given in the following Figure 4.6.8.

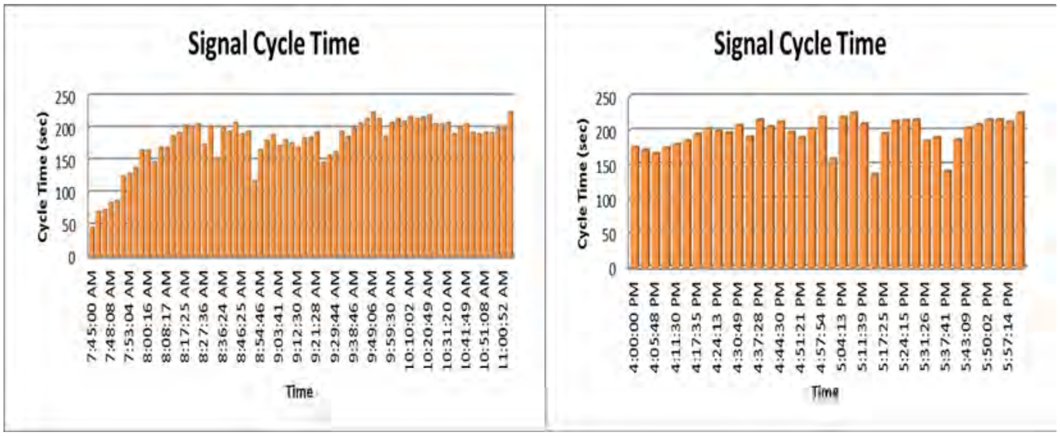


Figure 4.6.8: Signal Cycle Time at Peak Periods a) from 07.45 A.M. to 11.00 A.M.; b) from 04.00 P.M. to 05.57 P.M.

From the signal cycle time counting, it was observed that, 98.11% of total observation time was more than 120 sec, which is increasing the delay of the intersection as per research of *J. Li et al. (2004)*.

From the preliminary survey of this Mirpur 1 intersection, the information about mode of operation of this intersection was observed. In the detail analysis of this information, it is tabulated in Table 4.6.5.

Table 4.6.5: Existing Traffic Control System and Time of Operation of Mirpur -1 Intersection.

Sl. No.	Description	Duration of operation
1	Automatic signal lighting system	(08.00 PM 08.00 AM)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(08.00 AM 11.00 AM) (05.00 PM 08.00 PM)
4	Mixed	(11.00 AM 05.00 PM)

Analyzing the Table 4.6.5, it is found that Mirpur 1 intersection is operated in three (3) methods and different hours; automatic signal lighting system 12 hours of the total time of the day, automatic signal system (control by traffic police demand responsive) 6 hours and mixed (both automatic and controlled by police) 6 hours. In peak period this intersection is controlled by police manually.

The flow ratio of the three (3) approaches of this intersection at peak period is calculated, it is tabulated in Table 4.6.6. This is given below

Table 4.6.6: Flow Ratio of Different Approaches Mirpur 1 Intersection.

Time	Mazar Road to Mirpur 1, y_1	Mirpur 2 to Mirpur 1, y_2	Dar us Salam to Mirpur 1, y_3	Summation, Y
08.00 A.M. - 08.15 A.M.	0.24	0.32	0.27	0.83

08.15 A.M. - 08.30 A.M.	0.35	0.46	0.35	1.16
08.30 A.M. - 08.45 A.M.	0.50	0.55	0.47	1.52
08.45 A.M. - 09.00 A.M.	0.51	0.54	0.53	1.58
09.00 A.M. - 09.15 A.M.	0.53	0.68	0.65	1.86
09.15 A.M. - 09.30 A.M.	0.76	0.61	0.79	2.16
09.30 A.M. - 09.45 A.M.	0.83	0.79	0.79	2.41
09.45 A.M. - 10.00 A.M.	0.70	0.85	0.87	2.42
10.00 A.M. - 10.15 A.M.	0.74	0.79	0.82	2.35
10.15 A.M. - 10.30 A.M.	0.68	0.70	0.98	2.36
10.30 A.M. - 10.45 A.M.	0.67	0.71	0.97	2.35
10.45 A.M. - 11.00 A.M.	0.72	0.68	0.96	2.36
11.00 A.M. - 11.15 A.M.	0.61	0.67	0.92	2.20
11.15 A.M. - 11.30 A.M.	0.60	0.60	0.96	2.16
11.30 A.M. - 11.45 A.M.	0.60	0.61	0.88	2.09
11.45 A.M. - 12.00 P.M.	0.50	0.59	0.93	2.02
04.30 P.M. - 04.45 P.M.	0.47	0.64	0.83	1.94
04.45 P.M. - 05.00 P.M.	0.48	0.68	0.89	2.05
05.00 P.M. - 05.15 P.M.	0.57	0.78	1.00	2.35
05.15 P.M. - 05.30 P.M.	0.78	0.87	0.90	2.55
05.30 P.M. - 05.45 P.M.	1.00	0.92	0.97	2.89
05.45 P.M. - 06.00 P.M.	0.87	1.00	0.94	2.81

By analyzing the Table 4.6.6 it is found that the traffic operation system by automatic signal of this intersection will not work in peak period, because the summation of the flow ratio is greater than 1.00 all throughout the peak period of this intersection as per signal design theory.

D. Establishing Performance Evaluation Parameters for Signalized Road Intersections and Assesses Level of Service (LOS)

As per setout objectives of this research for finding out the LOS of the individual approach, queue length, delay was found out in detail survey of this intersection.

For finding out the effect of inefficiency in traffic control, queue length determination survey at peak period was organized in this intersection. The result of this survey is tabulated through the Table 4.6.7andTable 4.6.8 below.

Table 4.6.7: Queue Length at Different Approach of Mirpur 1 Intersection (Morning Peak).

Observation No.	**Time**	**Queue Length (in meter)**		
		Mazar Road to Mirpur 1 Approach	**Dar us Salam to Mirpur 1 Approach**	**Mirpur 2 to Mirpur 1 Approach**
1.	07.45 A.M. 08.00 A.M.	0	0	86.3

2.	08.00 A.M. - 08.15 A.M.	0	0	122.31
3.	08.15 A.M. - 08.30 A.M.	0	0	165.59
4.	08.30 A.M. - 08.45 A.M.	0	0	151.90
5.	08.45 A.M. - 09.00 A.M.	0	78.91	165.21
6.	09.00 A.M. - 09.15 A.M.	0	124.56	188.34
7.	09.15 A.M. - 09.30 A.M.	156.55	154.33	190.93
8.	09.30 A.M. - 09.45 A.M.	187.33	188.77	227.91
9.	09.45 A.M. - 10.00 A.M.	213.33	211.32	211.32
10.	10.00 A.M. - 10.15 A.M.	219.88	224.35	221.46
11.	10.15 A.M. - 10.30 A.M.	218.32	238.26	209.90
12.	10.30 A.M. - 10.45 A.M.	222.32	289.77	208.96
13.	10.45 A.M. - 11.00 A.M.	234.25	311.44	228.32
14.	11.00 A.M. - 11.15 A.M.	238.23	324.55	218.33
15.	11.15 A.M. - 11.30 A.M.	300.54	331.22	226.44
16.	11.30 A.M. - 11.45 A.M.	267.54	327.44	224.59
17.	11.45 A.M. - 12.00 P.M.	249.33	302.22	226.77

Table 4.6.8: Queue Length at Different Approach of Mirpur 1 Intersection (Evening Peak).

Observation No.	Time	Queue Length (in meter)		
		Mazar Road to Mirpur 1 Approach	**Dar us Salam to Mirpur 1 Approach**	**Mirpur 2 to Mirpur 1 Approach**
1.	04.00 P.M. 04.15 P.M.	0	145.67	0
2.	04.15 P.M. 04.30 P.M.	0	165.77	0
3.	04.30 P.M. 04.45 P.M.	143.66	197.54	145.44
4.	04.45 P.M. 05.00 P.M.	167.87	226.78	187.77
5.	05.00 P.M. 05.15 P.M.	227.55	309.88	221.00
6.	05.15 P.M. 05.30 P.M.	275.66	332.76	235.66
7.	05.30 P.M. 05.45 P.M.	288.94	345.67	221.33
8.	05.45 P.M. 06.00 P.M.	328.43	331.22	227.89
9.	06.00 P.M. 06.15 P.M.	342.56	342.00	228.21

Analyzing the result of the queue length survey, queue was measured on three (3) approaches of this intersection; two (2) peak queue formation were found in this survey period that at morning peak from 07.45 A.M. to 11.15 A.M. and evening peak from 04.00 P.M. to 06.15 P.M. Maximum queue length was found in this intersection at different approach, at Mazar Road to Mirpur 2 approach 300.54 m at morning peak and 342.56 m at evening peak, Dar us Salam to Mirpur 1 approach 331.22 m at morning peak and 345.67 m at evening peak and Mirpur 2 to Mirpur 1 approach 228.32 m at morning peak and 235.66 m at evening peak. Among them, all throughout the day the queue length of this intersection was increased in peak hour, 56.42% of total observation time, the queue length was over 200 m, which was very worst as per research of *J. Li et al. (2004).*

After that, another parameter for determination of LOS, delay was found out through a delay determination survey. This survey had two parts; one was determination of travel time at free flow condition and other was determination of travel time in field condition. Firstly the free flow travel time in every approach of this intersection was counted. The free flow condition travel time of this Mirpur 1 intersection is presented here in a tabular format in Table 4.6.9.

Table 4.6.9: Travel Time at Free Flow Condition of Mirpur 1 Intersection (sec).

Observation No.	Time	Sony Cinema Hall to Mirpur 1 (sec)	Panir Tanki to Mirpur 1 (sec)	Shah Ali Mazar to Mirpur 1 (sec)
1.	07.00 A.M. 07.30 A.M.	4	11	8

After this, for finding out the delay of this intersection, a travel time counting survey in field condition was organized; from here travel time was collected on every approaches of this intersection from 07.00 A.M to 06.00 P.M. After getting this travel time of every approach, deducting the free flow time from surveyed travel time, delay was found from every approaches all throughout the day. The delays of these approaches are shown below from 07.00 A.M. to 06.00 P.M. in Table 4.6.10.

Table 4.6.10: Delay at Different Approach of Mirpur 1 Intersection.

Observation No.	Time	Delay (Sony Cinema Hall to Mirpur 1) sec	Delay (Panir Tanki to Mirpur 1) sec	Delay (Shah Ali Mazar to Mirpur 1) sec
1.	07.00 A.M. 07.30 A.M.	1	1	6
2.	07.30 A.M. 08.00 A.M.	1	5	7
3.	08.00 A.M. 08.30 A.M.	3	11	10
4.	08.30 A.M. 09.00 A.M.	4	7	7
5.	09.00 A.M. 09.30 A.M.	61	23	9
6.	09.30 A.M. 10.00 A.M.	52	30	13
7.	10.00 A.M. 10.30 A.M.	73	45	26
8.	10.30 A.M. 11.00 A.M.	61	56	29
9.	11.00 A.M. 11.30 A.M.	51	67	36
10.	11.30 A.M. 12.00 P.M.	63	70	45
11.	12.00 P.M. 12.30 P.M.	39	80	58
12.	12.30 P.M. 01.00 P.M.	41	95	69
13.	01.00 P.M. 01.30 P.M.	41	78	78
14.	01.30 P.M. 02.00 P.M.	40	101	64
15.	02.00 P.M. 02.30 P.M.	39	121	59

16.	02.30 P.M. 03.00 P.M.	57	134	60
17.	03.00 P.M. 03.30 P.M.	72	121	59
18.	03.30 P.M. 04.00 P.M.	68	111	104
19.	04.00 P.M. 04.30 P.M.	52	76	102
20.	04.30 P.M. 05.00 P.M.	108	123	115
21.	05.00 P.M. 05.30 P.M.	152	132	127
22.	05.30 P.M. 06.00 P.M.	183	145	124

Analyzing the Table 4.6.10, the delay at different approach of Mirpur 1 intersection was found increased as the progress of the day time. Approach wise comparison of delay time is shown in Figure 4.6.9 below.

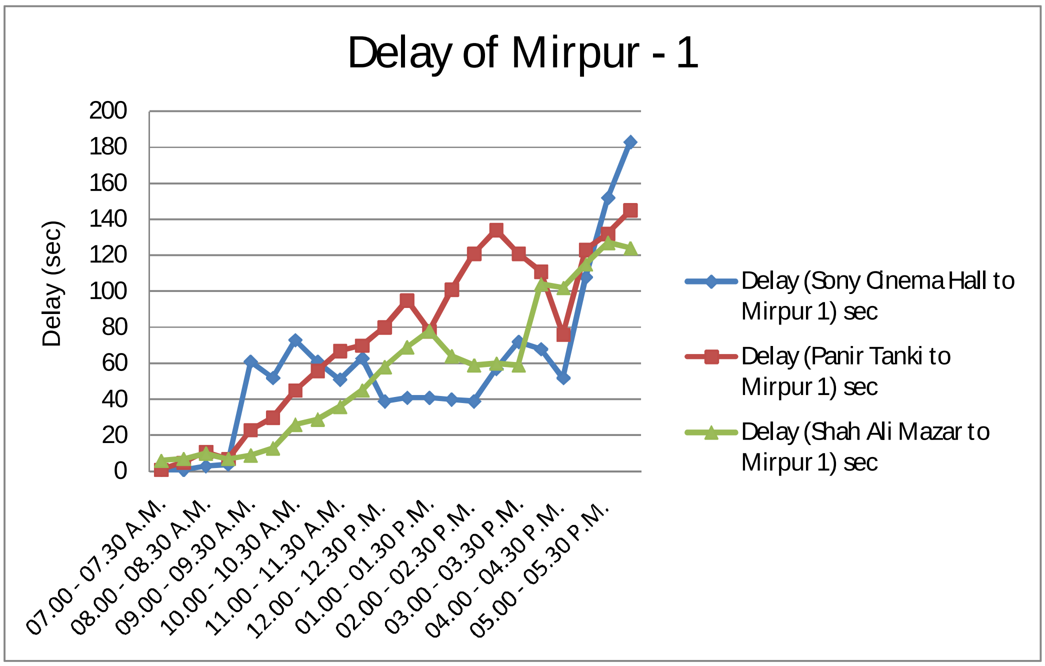


Figure 4.6.9: Comparison of Delay at Different Approach of Mirpur 1 Intersection.

Analyzing the Figure 4.6.9, maximum delay was found in Sony Cinema Hall to Mirpur 1 approach of this intersection.

E. Evaluation Performance of The Intersections Based on LOS Ranking.

Finally, based on the delay on every approach of this intersection, LOS of three (3) approaches was calculated for Mirpur 1 intersection (*HCM, 2010*). In the following Table 4.6.11 and Figure 4.6.10 the LOS of this intersection is presented below, the detailed calculation of LOS given in Appendix A

Table 4.6.11: LOS of Different Approaches of Mirpur 1 Intersection.

Observation No.	**Time**	**LOS (Sony Cinema Hall to Mirpur 1)**	**LOS (Panir Tanki to Mirpur 1)**	**LOS (Shah Ali Mazar to Mirpur 1)**
1.	07.00 A.M. 07.30 A.M.	A	A	A
2.	07.30 A.M. 08.00 A.M.	A	A	A

3.	08.00 A.M.	08.30 A.M.	A	B	A
4.	08.30 A.M.	09.00 A.M.	A	A	A
5.	09.00 A.M.	09.30 A.M.	F	C	A
6.	09.30 A.M.	10.00 A.M.	F	D	B
7.	10.00 A.M.	10.30 A.M.	F	E	D
8.	10.30 A.M.	11.00 A.M.	F	F	D
9.	11.00 A.M.	11.30 A.M.	F	F	E
10.	11.30 A.M.	12.00 P.M.	F	F	E
11.	12.00 P.M.	12.30 P.M.	E	F	F
12.	12.30 P.M.	01.00 P.M.	E	F	F
13.	01.00 P.M.	01.30 P.M.	E	F	F
14.	01.30 P.M.	02.00 P.M.	E	F	F
15.	02.00 P.M.	02.30 P.M.	E	F	F
16.	02.30 P.M.	03.00 P.M.	F	F	F
17.	03.00 P.M.	03.30 P.M.	F	F	F
18.	03.30 P.M.	04.00 P.M.	F	F	F
19.	04.00 P.M.	04.30 P.M.	F	F	F
20.	04.30 P.M.	05.00 P.M.	F	F	F
21.	05.00 P.M.	05.30 P.M.	F	F	F
22.	05.30 P.M.	06.00 P.M.	F	F	F

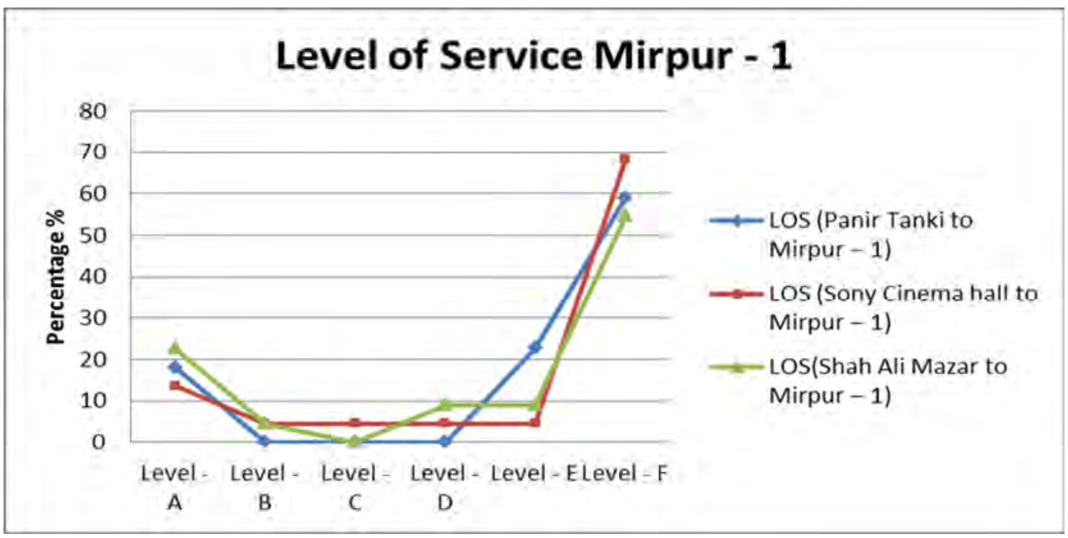


Figure 4.6.10: Percentage of Various LOS at Different Approaches of Mirpur 1 Intersection.

By analyzing the Table 4.6.11 and Figure 4.6.10 the LOS of different approaches of this intersection, it was found that during 11 hours survey period for Panir Tanki to Mirpur 1 approach, the LOS level A, B, C, D, E and F were observed to be 18.18%, 4.5%, 4.5%, 4.5%, 4.5% and 68.18% of survey time respectively. Similarly for approach Shah Ali Mazar to Mirpur 1 the LOS level A, B, C, D, E and F were observed to be 22.72%, 4.5%, 0.0%, 9%, 9% and 54.54% and for approach Sony Cinema Hall to Mirpur 1 the

LOS level A, B, C, D, E and F were observed to be 18.18%, 0.0%, 0.0%, 0.0 %, 22.72% and 59.09% of survey time respectively. The LOS of every approach of this intersection was retaining at Level F mostly. For present Dhaka Metropolitan City, it is a curse.

4.7 Quantitative Data Analysis of Shishu Mela Intersection

A. Site Investigation of Shishu Mela Intersection:

intersection site is situated on Mirpur Road in between Shyamoli intersection to the north and Gonovaban intersection to the south. At this intersection a link road from the Agargaon intersection to the east, namely Syed Mahbub Morshed Avenue is joined. Syed Mahbub Morshed Avenue was built as a link road between two primary roads: Mirpur road and Begum Rokeya Avenue. Basically, this intersection is inside the official area. This intersection is the entry gate of official area of Agargaon. In this intersection, by the side of the roads Asian Development Bank (ADB), World Bank (WB), Government Hospitals (Shahid Suhrawardi Hospital, National Cancer Institute, National Heart Disease Institute, National Kidney Foundation, National Trauma Hospital, and National Eye Hospital), Passport office, LGED office, Radio Center, Sher-e-Bangla Agricultural University, different schools, etc. important offices and staff quarters are built up. According to the classification of intersection, the Shishu Mela intersection is a ee - intersection (3) different directions. This intersection has an importance in Dhaka City road network. At first it was used as a shortcut road between Mirpur Road and Begum Rokeya Avenue. But now it acts as a linking road from Agargaon intersection to Prime Minister Office, which invites a lot of traffic flow in Shishu Mela intersection. On the other hand, major traffic flow from Gabtoli moves towards the south passing through this intersection. So this intersection is very busy throughout the day.

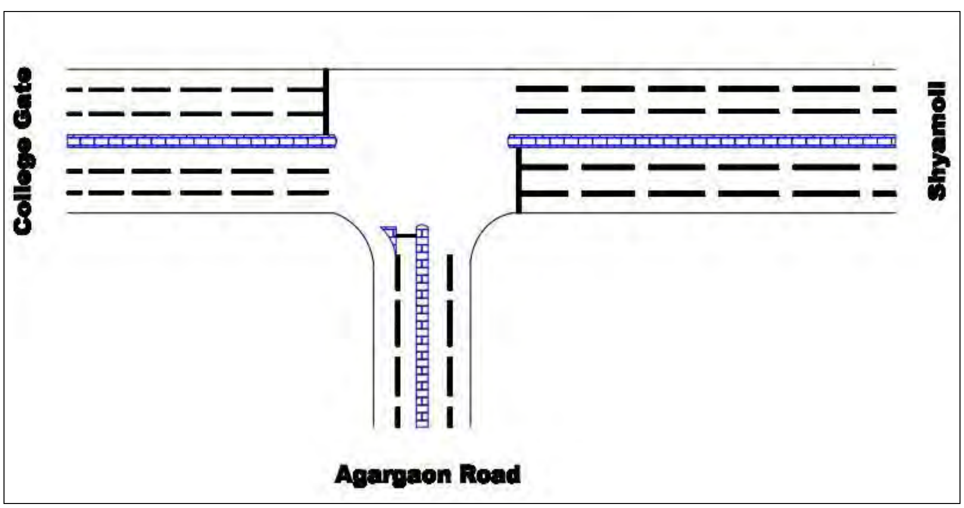


Figure 4.7.1: Layout of Shishu Mela Intersection.

Source: (Signal Synchronization Study, 2013.

From preliminary survey of this selected intersection, the three (3) approaches are divided by lanes with necessary marking. Table 4.7.1 describing the lane division of different approaches is given below

Table 4.7.1: Approach of Shishu Mela Intersection with Lane Division.

Serial No.	Approach with direction	Lane number
Leg 1.	Shyamoli to Sishu Mela Intersection.	3 lanes both direction.
Leg 2.	Agargaon to Sishu Mela Intersection.	2 lanes both direction.
Leg 3.	College Gate to Sishu Mela Intersection.	3 lanes both direction.

The main carriageway of this intersection is flexible pavement in all approaches. Due to regular maintenance work, a lot of digging works in various places of this intersection were found in preliminary survey. But in lack of proper finish, the constructed places had not filled up well. This type of carelessness hampers the traffic flow in this intersection during rainy season.

Noticing the vehicular flow of this intersection, we could not detect the distinct peak hour for this intersection. An increased constant vehicle flow was found all throughout the day in this intersection. A lot of traffic uses this intersection throughout the day. A lot of pedestrian movement was found in this intersection. But there is no road crossing facilities in this intersection, people tried to cross the road through suitable gap between the busy vehicular flows with cent percent chance of accidents. There was footpath in all approaches of the intersection; however this footpath was dishonestly invaded by the hawkers, traders, hotels, construction material, medical dispensaries etc. So, there was a lot of side friction in the approaches of this intersection.

There was the provision of automatic traffic signal for traffic control, but this was not practiced in field. So, all of the signals were as showpiece in a showcase. Traffic police tried to control the traffic of this intersection manually. Signal timing, phasing was not consistent for this. They tried to operate this intersection responding as per demand. So a lot of delay occurred here and queue length originated in peak period too.

B. Geometric and Operating Conditions of Selected Intersection (Shishu Mela)

After finishing the detail survey of selected intersection, Shishu Mela; analysis of collected data about the intersection geometry and operating condition was done. The findings of this analysis are tabulated in Table 4.7.2.

Table 4.7.2: Geometric and Operating Condition of Shishu Mela Intersection.

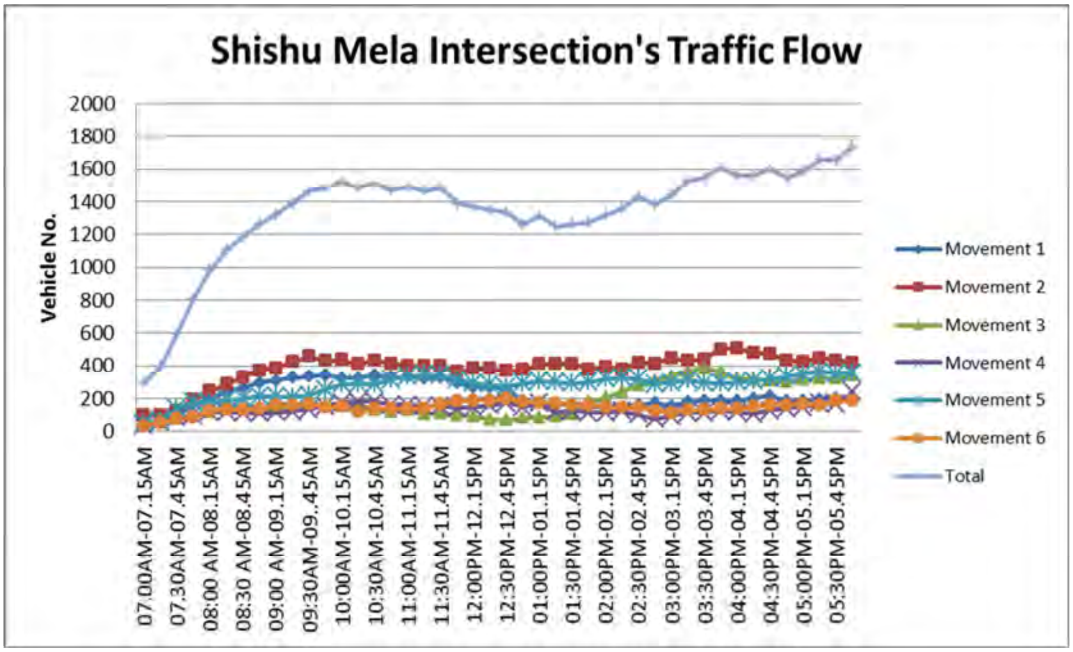
Serial No.	Items	Description
1.	**Number of Approaches**	There are three (3) approaches namely Shishu Meal to Shyamoli, Shishu Mela to Agargaon and Shishu Mela to College Gate.
2.	**Carriageway**	All three (3) approaches of this intersection are flexible pavement in structural point of view and dual carriageway.
3.	**Footpath Coverage**	Footpaths for pedestrian are found existing here, by the both of the side of all the three (3) approaches of this intersection, which is illegally occupied by purveyors, building materials, parked vehicle, etc. Shishu Mela intersection has 100% footpath coverage.
4.	**Channelization**	Here, on the mouth of Shishu Mela to Agargaon approach, there is channelization for exclusive left turning, which is giving direction to vehicles towards College Gate from Shishu Mela intersection. But through vehicle as usually try to block the entry in this channel.
5.	**Divider**	All approaches of this intersection are alienated by the non - engineering divider, which is not related with velocity profile of vehicle of this intersection.
6.	**Pedestrian Crossing Facility**	There is no grade separatedor at grade pedestrian crossing facility inside this intersection.Pedestrians try to cross the road by finding suitable gap between vehicular flows.
7.	**Side Road**	From preliminary survey of Shishu Mela intersection and its surrounding area; one (1) side road was found, which is coming from neighboring residential of this intersection, exposed in this intersection directly, containing maximum NMV on it.

C. Determining the Existing Vehicular, Pedestrian Flow, Amount of Side Friction, and Condition of Traffic Control Devices including Signal Timing, Phasing and Mode of Operation at Shishu Mela Intersection:

In detail survey of Shishu Mela intersection; existing vehicular flow, pedestrian flow was observed, furthermore amount of side friction was exposed and condition of traffic signal, signal timing, phasing and mode of operation was documented and which was analyzed later.

i. Existing Vehicular Flow

Analyzing the exiting vehicular flow of Shishu Mela intersection, an eleven (11) hours vehicular survey (from 07.00 A.M. to 06.00 P.M.) was organized, the result of this survey and its analysis are presented here in Figure 4.7.2 a) and b), this figure is presenting a general graph accompanying with a pie chart, which is presenting the data of vehicular survey of this intersection and expressing the characteristics of vehicular flow through this intersection.



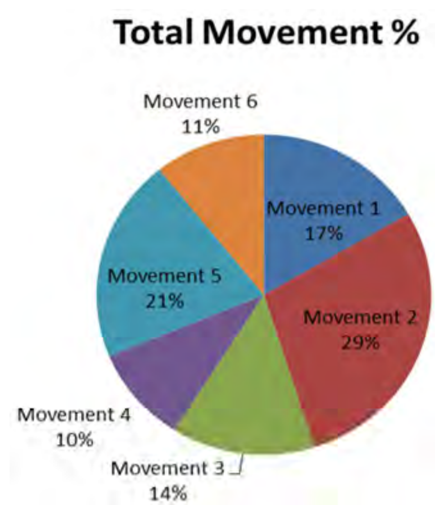
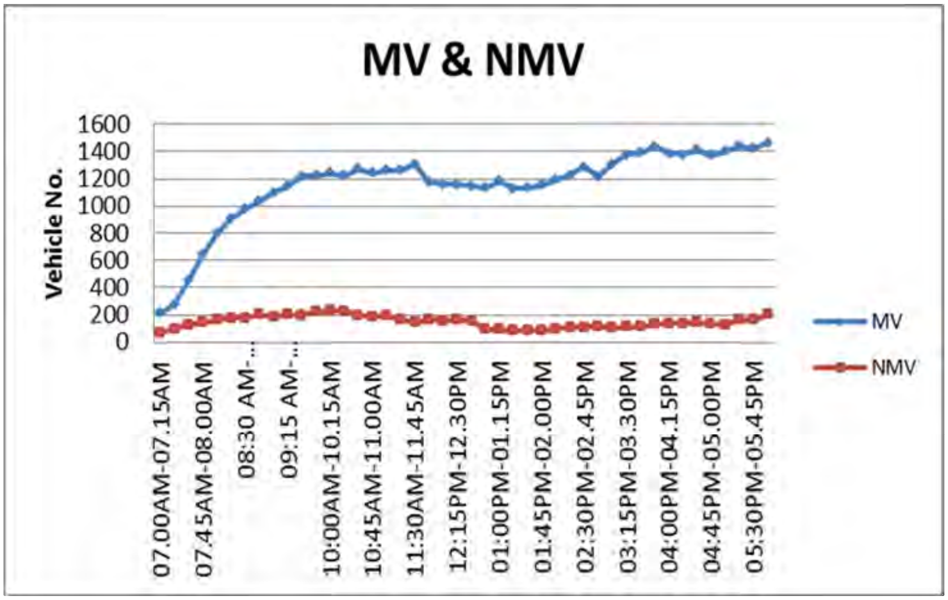


Figure 4.7.2: a) Vehicular Flow Data of Shishu Mela Intersection; b) Vehicle Movement Contribution of Shishu Mela Intersection.

Analyzing the vehicular survey data of this intersection, six (6) individual movements were found and among them movement 2 (from Shyamoli to College gate) was maximum, which contained 29% of entire traffic flow of this intersection on the day of survey. From the entire 11 hour vehicular survey, no distinct peak hour was found in this intersection, an increased constant vehicle flow all throughout the day was observed. This situation was continuing from 09.00 A.M. to 06.00 P.M. that was 81.81% of total survey time of that day.

After analyzing the vehicular flow of this intersection, assessment of the vehicular combination of this intersection was done. The result of this analysis is presented here in Figure 4.7.3 a) and b), this figure is presenting a pie chart accompanying with a general graph.



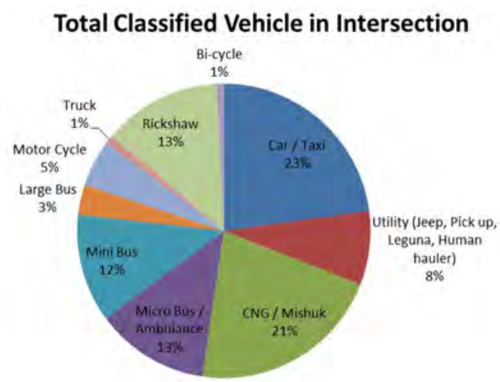


Figure 4.7.3: a) Individual Flow of MV and NMV in Shishu Mela Intersection; b) Classified Vehicle in Shishu Mela Intersection.

In Figure 4.7.3 a), a general graph is shown, which is showing the individual flow of MV and NMV through this intersection. Analyzing this general graph, no distinct peak hours are found for both MV and NMV; an increased constant flow all throughout the day was observed on both. In Figure 4.7.3 b), a pie chart is shown, which is expressing the vehicular composition of this intersection. The dominancy of MV is found out from here, which was 86% of total vehicular flow; among the vehicular flow car / taxi was the mostly governed vehicle type in this intersection, which was 23% of total flow and only 14% of total vehicular flow was NMV.

After finding out the vehicular composition, the saturation flow of every approach of this intersection was calculated from the vehicular survey data. The result of this analysis is presented here through a tabular format in Table 4.7.3.

Table 4.7.3: Saturation Flow of Different Approach of Shishu Mela Intersection.

Serial No.	Intersection Name	Intersection Classification	Approach Name	Saturation Flow (PCU / Hour)
1.	Shishu Mela	Tee intersection	Shyamoli to Shishu Mela	3230.88
2.			Agargaon to Shishu Mela	2335.60
3.			College Gate to Shishu Mela	3762.60

After that the usages of road space of every approaches of this intersection were calculated. The result of this calculation is presented here through Figure 4.7.4 a), b), and c) with individual general graph, which is expressing the flow ratio with respect to saturation flow of the every individual approach of this intersection of 11 hours.

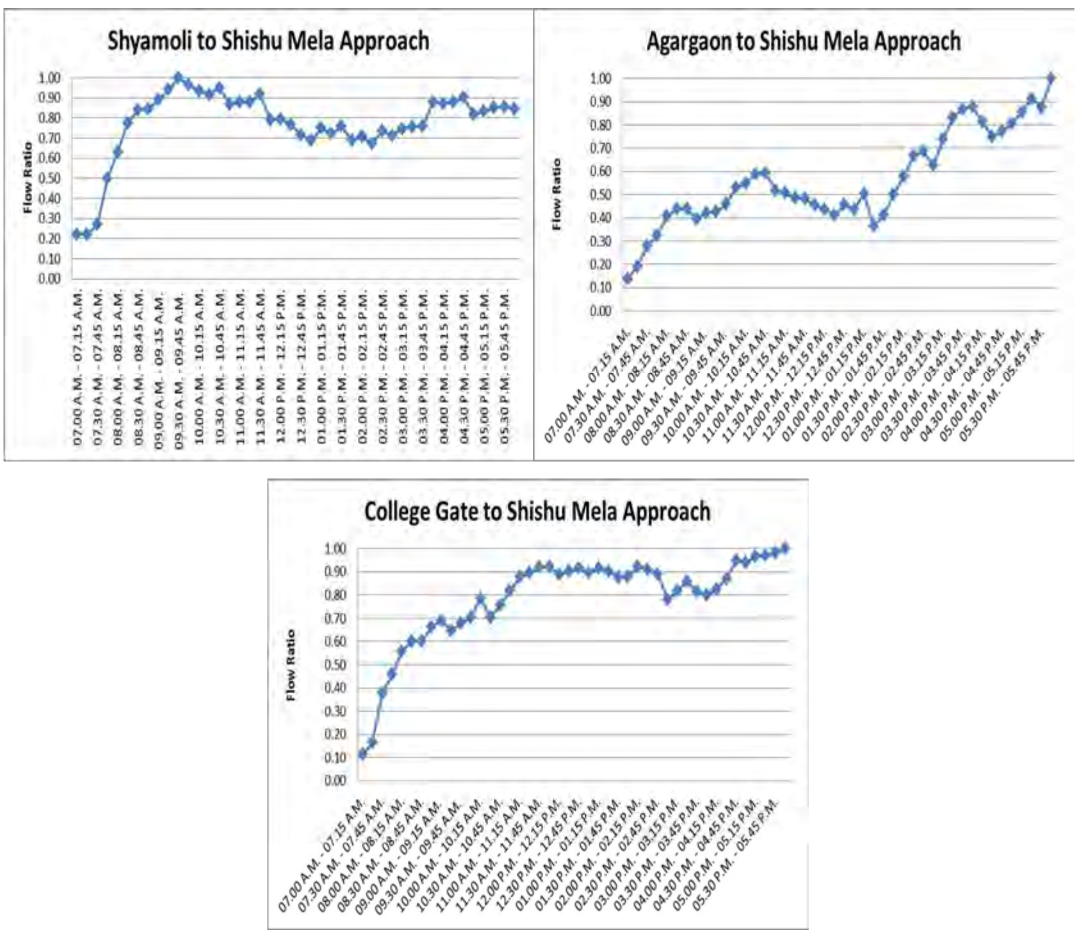


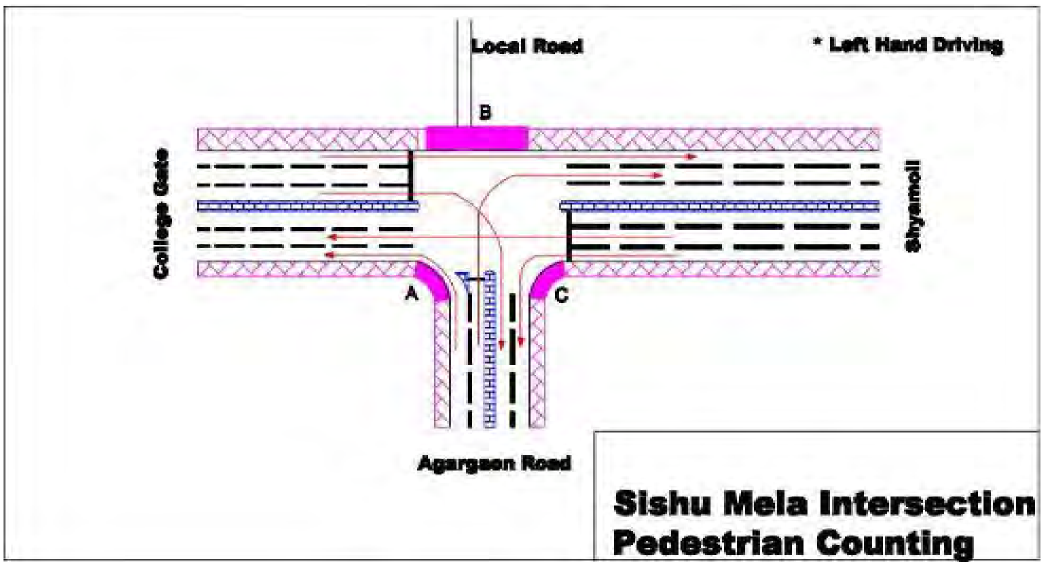
Figure 4.7.4: a) Flow Ratio of Shyamoli to Shishu Mela Approach; b) Flow Ratio of Agargaon to Shishu Mela Approach; c) Flow Ratio of College Gate to Shishu Mela Approach.

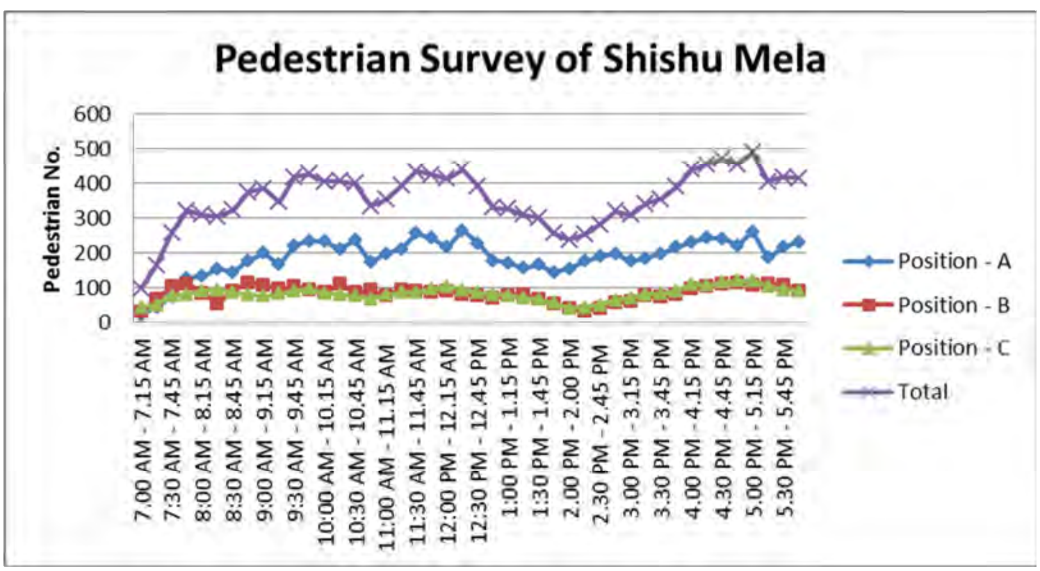
From Figure 4.7.4, it is observed that, every approach of this intersection a constant increasing flow ratio all throughout the day. Maximum flow ratio on these three (3) approaches is seen in the evening. As usually in this time, this intersection is experienced a worst situation by MV.

ii. Pedestrian Flow

As per set out objectives of this research, the pedestrian flow through this intersection was also observed. For finding out the present scenario of pedestrian movement through this intersection an 11 hour

was organized. The result of this survey is presented here through Figure 4.7.5 a), b) and c) through a general graph accompanying with a CAD drawing and pie chart.





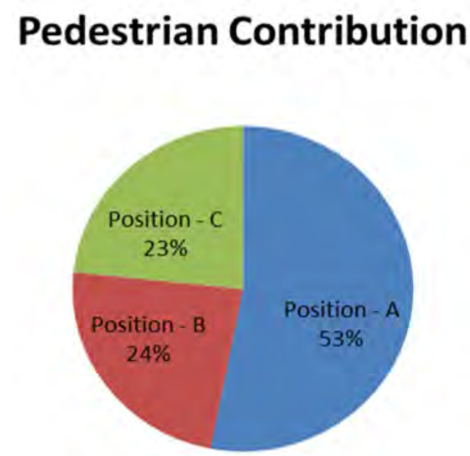


Figure 4.7.5: a) Pedestrian Survey Position inside Shishu Mela Intersection; b) Pedestrian Flow; c) Pedestrian Flow Contribution among three (3) Positions.

From the preliminary survey, the three (3) positions were selected for detail field survey according to the availability of pedestrian in this intersection. The positions of those three (3) points are shown here in Figure 4.7.5 a). From Figure 4.7.5 b) pedestrian flow through this intersection is presented; no distinct peak was found all throughout the day. Among the three (3) positions, maximum pedestrian flow was found in position A, which is at the corner of Shishu Mela Park. 53% of entire pedestrian flow of this intersection took place in this position, which is presented in Figure 4.7.5 c).

In this intersection, no grade separated pedestrian crossing facilities is found in preliminary survey, such as over bridge, underpass etc. Instead of these, pedestrians are crossing this intersection through at grade. As usually, the pedestrian of this intersection try to cross the road in between the gap of moving vehicles.

iii. Side Friction

As per set out objectives of this research, the amount of side friction in this intersection was also determined. For this, in preliminary survey four (4) points were found out according to the site analysis.

From the preliminary survey of this intersection the three (3) specified reasons of side friction were found here rickshaw diversion, illegal human hauler stand and illegal bus stand. For finding out the scenario of side friction, an 11 hour
07.00 A.M. to 06.00 P.M.) was organized. The result of this counting survey is presented here in Figure 4.7.6 a), b) and c).

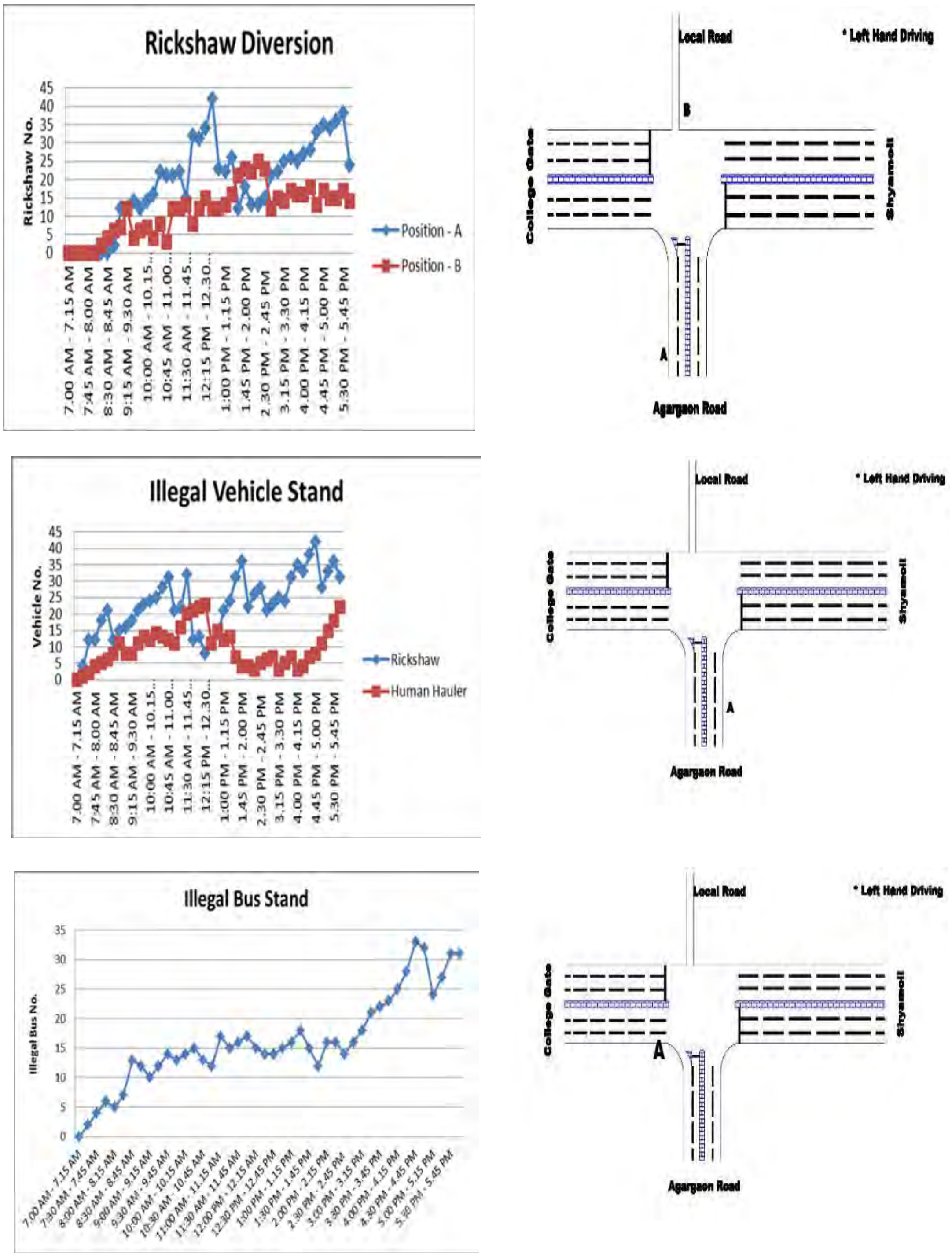


Figure 4.7.6: a) Contribution of Rickshaw Diversion; b) Contribution of Illegal Vehicle Stand; c) Contribution of Illegal Bus Stand.

Analyzing Figure 4.7.6 a), b) and c); For Rickshaw diversion, two (2) points were found inside this intersection, beside Shishu Mela Park and on the mouth of Khilji road. Among the two places, 63% diversion of total diverted rickshaw was done beside the Shishu Mela Park. For this diversion, a huge jam was created on the mouth of the Agargaon to Shishu

Mela approach. For Illegal Rickshaw and Human Hauler stand was found beside the wall of SOS Shishu Polli. A lot of rickshaw and human hauler (1, 432 in number) stood in this place all throughout the day, which blocked the mouth of Shishu Mela to Agargaon approach. For illegal Bus stand at the corner of Shishu Mela Park, a lot of bus illegally stood there (413 in number) all throughout the day. The Shyamoli to College Gate approach was blocked by this. Generally the combined effect of side friction was observed in the traffic flow of this intersection. 70% of total road width at the mouth of approach of this intersection was blocked by these side frictions in the peak hour. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing day by day.

iv. Traffic Control Devices

From the preliminary survey of this intersection, a condition survey of traffic control devices was organized. The outputs of this condition survey are given below in a tabular format, in Table 4.7.4.

Table 4.7.4: Signal Accessories of Shishu Mela Intersection.
Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Light Operate	Pedestrian Signal Light Operate
SP-1	OK	OK	Yes	-
SP-2	OK	OK	Yes	-
SP-3	OK	OK	No	-
SP-4	OK	OK	Yes	-
SP-5	OK	OK	Yes	No
MAP-1	OK	One Shed Missing	Yes	-
MAP-2	OK	OK	Yes	-
MAP-3	OK	OK	Yes	-
TSC	OK	OK	-	-

Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

In this intersection, for traffic control there was no use of traffic signal; instead of this, police controlled the traffic movement of this intersection manually based on traffic flow demands among three (3) approaches which is considered to be as ic demand responsive signal system

controlling system (one road
stopped), which was the most inefficient method of traffic control. The traffic signal cycle time in this method is not consistent. The variation of signal cycle time in Shishu Mela intersection at peak periods are given in the following Figure 4.7.7.

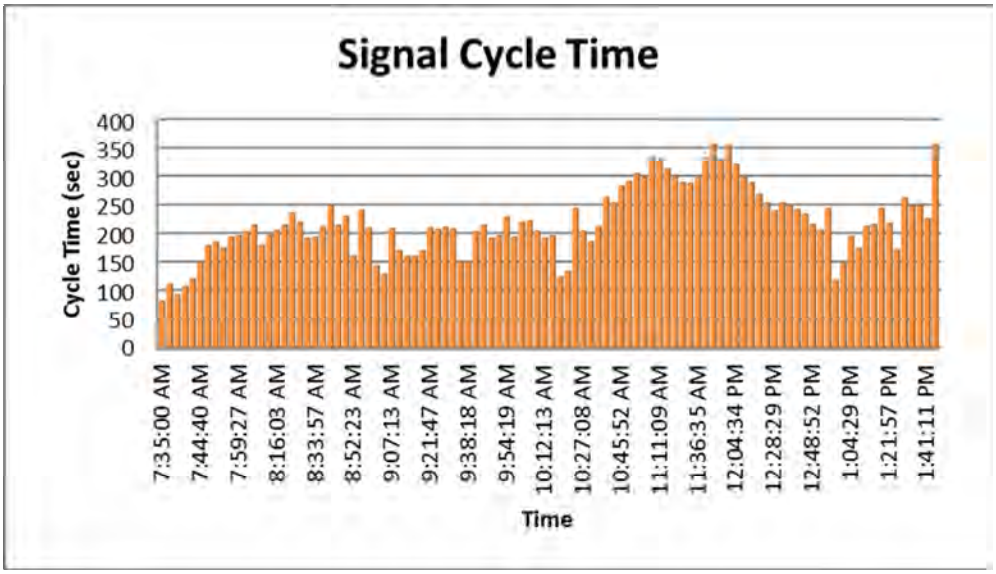


Figure 4.7.7: Signal Cycle Time at Peak Periods from 07.35 A.M. to 01.41 P.M.

From the signal cycle time counting, it was observed that, 95.09 % of total observation time was more than 120 sec, which is increasing the delay of the intersection as per research of *J. Li et al. (2004)*.

From the preliminary survey of this Shishu Mela intersection, the information about mode of operation of this intersection was observed. In the detail analysis of this information, it is tabulated in Table 4.7.5 below.

Table 4.7.5: Existing Traffic Control System and Time of Operation of Shishu Mela Intersection.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(08.00 PM 08.00 AM)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(08.00 AM 11.00 AM) (05.00 PM 08.00 PM)
4	Mixed	(11.00 AM 05.00 PM)

Analyzing the Table 4.7.5 it is found that Shishu Mela intersection is operated in three (3) methods and different hours; automatic signal lighting system 12 hours of the total time of the day, automatic signal system (control by traffic police demand responsive) 6 hours and mixed (both automatic and controlled by police) 6 hours. In peak period this intersection is controlled by police manually.

The flow ratio of the three (3) approaches of this intersection at peak period is calculated, it is tabulated in Table 4.7.6 below.

Table 4.7.6: Flow Ratio of Different Approaches Shishu Mela Intersection.

Time	Shyamoli to Shishu Mela, y_1	Agargaon to Shishu Mela, y_2	College Gate to Shishu Mela, y_3	Summation, Y
07.00 A.M. - 07.15 A.M.	0.22	0.14	0.11	0.47
07.15 A.M. - 07.30 A.M.	0.22	0.19	0.16	0.58
07.30 A.M. - 07.45 A.M.	0.27	0.28	0.38	0.93
07.45 A.M. - 08.00 A.M.	0.50	0.32	0.46	1.28
08.00 A.M. - 08.15 A.M.	0.63	0.41	0.56	1.60
08.15 A.M. - 08.30 A.M.	0.78	0.44	0.60	1.82
08.30 A.M. - 08.45 A.M.	0.84	0.44	0.60	1.88
08.45 A.M. - 09.00 A.M.	0.84	0.40	0.66	1.90
09.00 A.M. - 09.15 A.M.	0.89	0.42	0.69	2.00
09.15 A.M. - 09.30 A.M.	0.94	0.43	0.65	2.01
09.30 A.M. - 09.45 A.M.	1.00	0.46	0.68	2.14
09.45 A.M. - 10.00 A.M.	0.97	0.53	0.70	2.20
10.00 A.M. - 10.15 A.M.	0.93	0.55	0.78	2.27
10.15 A.M. - 10.30 A.M.	0.92	0.59	0.70	2.21
10.30 A.M. - 10.45 A.M.	0.95	0.59	0.76	2.30
10.45 A.M. - 11.00 A.M.	0.87	0.52	0.82	2.20
11.00 A.M. - 11.15 A.M.	0.88	0.51	0.88	2.26
11.15 A.M. - 11.30 A.M.	0.88	0.49	0.90	2.26
11.30 A.M. - 11.45 A.M.	0.92	0.48	0.92	2.32
11.45 A.M. - 12.00 P.M.	0.79	0.45	0.92	2.17
12.00 P.M. - 12.15 P.M.	0.80	0.44	0.89	2.12
12.15 P.M. - 12.30 P.M.	0.77	0.41	0.90	2.08
12.30 P.M. - 12.45 P.M.	0.72	0.46	0.92	2.09
12.45 P.M. - 01.00 P.M.	0.69	0.44	0.89	2.02
01.00 P.M. - 01.15 P.M.	0.75	0.50	0.92	2.17
01.15 P.M. - 01.30 P.M.	0.72	0.36	0.90	1.99
01.30 P.M. - 01.45 P.M.	0.76	0.41	0.88	2.05
01.45 P.M. - 02.00 P.M.	0.69	0.50	0.88	2.07
02.00 P.M. - 02.15 P.M.	0.71	0.58	0.92	2.21
02.15 P.M. - 02.30 P.M.	0.67	0.67	0.91	2.25
02.30 P.M. - 02.45 P.M.	0.73	0.69	0.89	2.31
02.45 P.M. - 03.00 P.M.	0.71	0.63	0.78	2.12
03.00 P.M. - 03.15 P.M.	0.75	0.74	0.82	2.30
03.15 P.M. - 03.30 P.M.	0.76	0.83	0.86	2.45

03.30 P.M. - 03.45 P.M.	0.76	0.87	0.81	2.44
03.45 P.M. - 04.00 P.M.	0.88	0.88	0.80	2.56
04.00 P.M. - 04.15 P.M.	0.87	0.81	0.82	2.51
04.15 P.M. - 04.30 P.M.	0.88	0.75	0.87	2.50
04.30 P.M. - 04.45 P.M.	0.90	0.77	0.95	2.62
04.45 P.M. - 05.00 P.M.	0.82	0.81	0.94	2.57
05.00 P.M. - 05.15 P.M.	0.83	0.86	0.97	2.65
05.15 P.M. - 05.30 P.M.	0.85	0.91	0.97	2.73
05.30 P.M. - 05.45 P.M.	0.86	0.87	0.98	2.71
05.45 P.M. - 06.00 P.M.	0.84	1.00	1.00	2.84

By analyzing the Table 4.7.6, it is found that the traffic operation system by automatic signal will not work here, because the summation of the flow ratio is greater than 1.00 all throughout the day in this intersection as per signal design theory.

D. Establishing Performance Evaluation Parameters for Signalized Road Intersections and Assesses Level of Service (LOS)

As per setout objectives of this research for finding out the LOS of the individual approach; queue length, delay was found out in detail survey of this intersection.

For finding out the effect of inefficiency in traffic control; queue length determination survey at peak period was organized in this intersection. The result of this survey is tabulated through the Table 4.7.7 below.

Table 4.7.7: Queue Length of Different Approach of Shishu Mela Intersection.

Observation No.	**Time**	**Queue Length (in meter)**		
		Agargaon to Shishu Mela Approach (m)	**College Gate to Shishu Mela Approach (m)**	**Shyamoli to Shishu Mela Approach (m)**
1.	07.45 A.M. 08.00 A.M.	145.54	155.22	125.32
2.	08.00 A.M. - 08.15 A.M.	178.65	176.22	145.54
3.	08.15 A.M. - 08.30 A.M.	202.34	145.54	178.65
4.	08.30 A.M. - 08.45 A.M.	225.54	178.65	202.34
5.	08.45 A.M. - 09.00 A.M.	278.66	202.34	225.54
6.	09.00 A.M. - 09.15 A.M.	224.55	225.54	145.54
7.	09.15 A.M. - 09.30 A.M.	312.33	276.22	178.65
8.	09.30 A.M. - 09.45 A.M.	354.88	245.34	202.34
9.	09.45 A.M. - 10.00 A.M.	378.88	296.33	225.54
10.	10.00 A.M. - 10.15 A.M.	425.65	306.67	201.34
11.	10.15 A.M. - 10.30 A.M.	478.77	312.32	198.77
12.	10.30 A.M. - 10.45 A.M.	422.56	332,32	186.78
13.	10.45 A.M. - 11.00 A.M.	432.77	345.63	296.33

14.	11.00 A.M. - 11.15 A.M.	397.77	376.00	306.67
15.	11.15 A.M. - 11.30 A.M.	354.66	402.34	312.32
16.	11.30 A.M. - 11.45 A.M.	405.77	389.77	332,32
17.	11.45 A.M. - 12.00 P.M.	378.66	416.77	345.63
18.	12.00 P.M. 12.15 P.M.	322.66	422.83	354.88
19.	12.15 P.M. 12.30 P.M.	389.65	395.45	378.88
20.	12.30 P.M. 12.45 P.M.	405.23	412.34	425.65
21.	12.45 P.M. 01.00 P.M.	411.23	435.22	312.32
22.	01.00 P.M. 01.15 P.M.	411.66	389.67	332.32
23.	01.15 P.M. 01.30 P.M.	367.23	438.00	345.63
24.	01.30 P.M. 01.45 P.M.	392.23	451.12	376.00
25.	01.45 P.M. 02.00 P.M.	402.55	419.21	389.77

Analyzing the result of the queue length survey, it was measured on three (3) approaches of this intersection. Maximum queue length was found in this intersection at different approach with the progress of the time. The queue length was observed in Agargaon to Shishu Mela approach 478.77 m, College Gate to Shishu Mela approach 451.12 m and Shyamoli to Shishu Mela approach 425.65 m. Among them, the queue length of this intersection was increasing all throughout the day, 82.67% of total observation time, the queue length was over 200 m, which was very worst as per research of *J. Li et al. (2004).*

After that, another parameter for determination of LOS, delay was found out through a delay determination survey. This survey had two parts; one was determination of travel time at free flow condition and other was determination of travel time in field condition. Firstly the free flow travel time in every approach of this intersection was counted. The free flow condition travel time of this Shishu Mela intersection is presented here in a tabular format in Table 4.7.8.

Table 4.7.8: Travel Time at Free Flow Condition of Shishu Mela Intersection (sec).

Observation No.	**Time**	**Shyamoli to Shishu Mela Approach (sec)**	**Agargaon to Shishu Mela Approach (sec)**	**College Gate to Shishu Mela Approach (sec)**
1.	07.00 A.M. 07.30 A.M.	4	28	6

After this, for finding out the delay of this intersection, a travel time counting survey in field condition was organized; from here travel time was collected on every approaches of this intersection from 07.00 A.M to 06.00 P.M. After getting this travel time of every approach, deducting the free flow time from surveyed travel time, delay was found from every approaches all throughout the day. The delays of these approaches are shown below from 07.00 A.M. to 06.00 P.M. in Table 4.7.9.

Table 4.7.9: Delay at Different Approach of Shishu Mela Intersection.

Observation No.	Time	Delay (Shyamoli to Shishu Mela) sec	Delay (Agargaon to Shishu Mela) sec	Delay (College Gate to Shishu Mela) sec
1.	07.00 A.M. 07.30 A.M.	2	7	1
2.	07.30 A.M. 08.00 A.M.	4	26	11
3.	08.00 A.M. 08.30 A.M.	12	41	50
4.	08.30 A.M. 09.00 A.M.	83	48	181
5.	09.00 A.M. 09.30 A.M.	308	64	143
6.	09.30 A.M. 10.00 A.M.	224	89	222
7.	10.00 A.M. 10.30 A.M.	343	117	270
8.	10.30 A.M. 11.00 A.M.	455	161	321
9.	11.00 A.M. 11.30 A.M.	550	209	446
10.	11.30 A.M. 12.00 P.M.	650	259	433
11.	12.00 P.M. 12.30 P.M.	763	270	581
12.	12.30 P.M. 01.00 P.M.	572	284	637
13.	01.00 P.M. 01.30 P.M.	641	311	762
14.	01.30 P.M. 02.00 P.M.	330	309	881
15.	02.00 P.M. 02.30 P.M.	319	450	961
16.	02.30 P.M. 03.00 P.M.	428	540	950
17.	03.00 P.M. 03.30 P.M.	512	650	978
18.	03.30 P.M. 04.00 P.M.	428	661	1061
19.	04.00 P.M. 04.30 P.M.	328	717	1038
20.	04.30 P.M. 05.00 P.M.	219	839	1137
21.	05.00 P.M. 05.30 P.M.	250	858	1217
22.	05.30 P.M. 06.00 P.M.	183	893	1332

Analyzing the Table 4.7.9, the delay at different approach of Shishu Mela intersection is increasing as the progress of the day time was found. Approach wise comparison of delay time is shown in Figure 4.7.8.

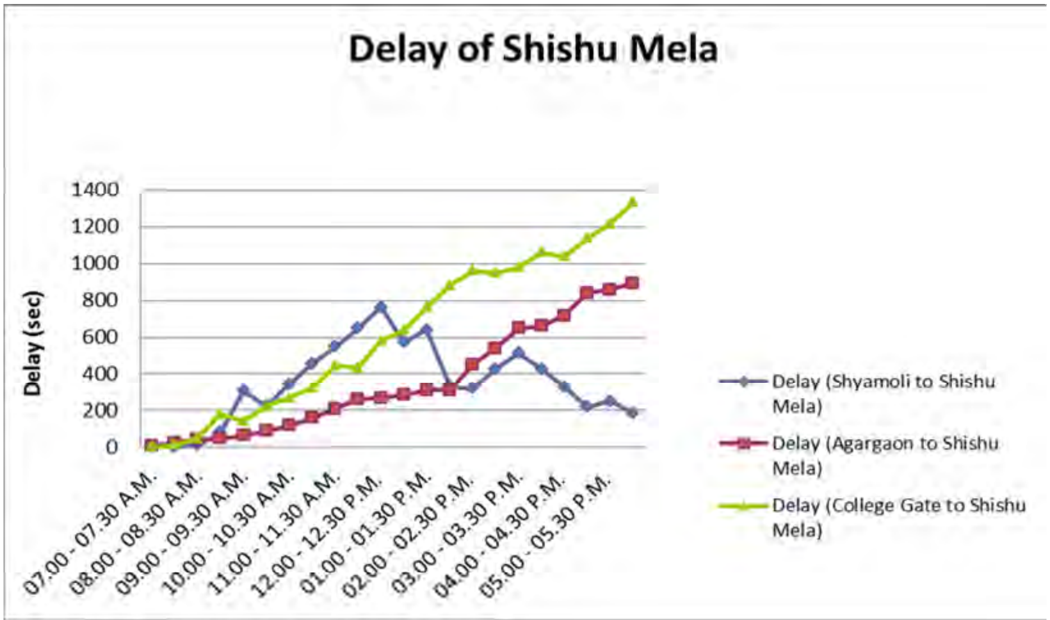


Figure 4.7.8: Comparison of Delay at Different Approach of Shishu Mela Intersection.

Analyzing the Figure 4.7.8 the maximum delay was found in College Gate to Shishu Mela approach of this intersection.

E. Evaluation Performance of the Intersections Based on LOS Ranking.

Finally, based on the delay on every approach of this intersection, LOS of three (3) approaches was calculated for Shishu Mela intersection. In the following Table 4.7.10 and Figure 4.7.9 the LOS of this intersection is presented below, the detailed calculation of LOS given in Appendix A

Table 4.7.10: LOS of Different Approaches of Shishu Mela Intersection.

Observation No.	Time	LOS (Shyamoli to Shishu Mela)	LOS (Agargaon to Shishu Mela)	LOS (College Gate to Shishu Mela) sec
1.	07.00 A.M. 07.30 A.M.	A	A	A
2.	07.30 A.M. 08.00 A.M.	A	D	B
3.	08.00 A.M. 08.30 A.M.	B	E	E
4.	08.30 A.M. 09.00 A.M.	F	E	F
5.	09.00 A.M. 09.30 A.M.	F	F	F
6.	09.30 A.M. 10.00 A.M.	F	F	F
7.	10.00 A.M. 10.30 A.M.	F	F	F
8.	10.30 A.M. 11.00 A.M.	F	F	F
9.	11.00 A.M. 11.30 A.M.	F	F	F
10.	11.30 A.M. 12.00 P.M.	F	F	F
11.	12.00 P.M. 12.30 P.M.	F	F	F
12.	12.30 P.M. 01.00 P.M.	F	F	F

13.	01.00 P.M.	01.30 P.M.	F	F	F
14.	01.30 P.M.	02.00 P.M.	F	F	F
15.	02.00 P.M.	02.30 P.M.	F	F	F
16.	02.30 P.M.	03.00 P.M.	F	F	F
17.	03.00 P.M.	03.30 P.M.	F	F	F
18.	03.30 P.M.	04.00 P.M.	F	F	F
19.	04.00 P.M.	04.30 P.M.	F	F	F
20.	04.30 P.M.	05.00 P.M.	F	F	F
21.	05.00 P.M.	05.30 P.M.	F	F	F
22.	05.30 P.M.	06.00 P.M.	F	F	F

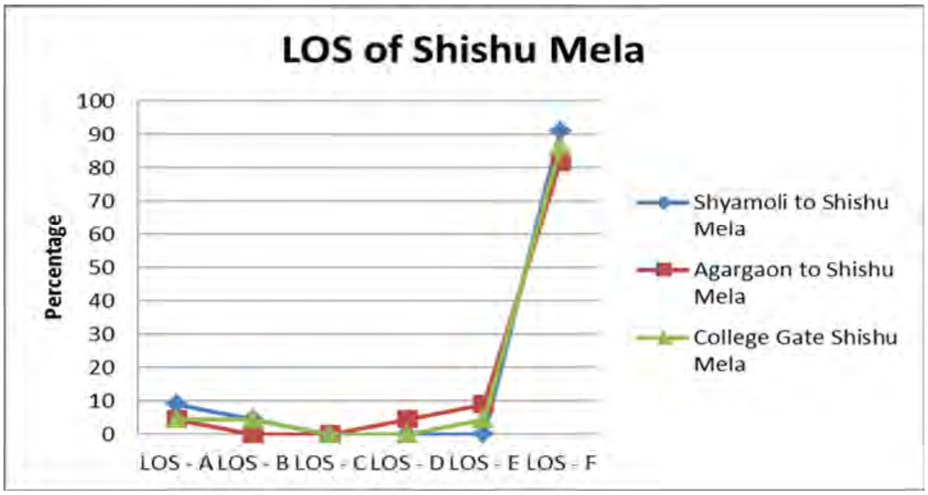


Figure 4.7.9: Percentage of Various LOS at Different Approaches of Shishu Mela Intersection.

By analyzing the Table 4.7.10 and Figure 4.7.9 the LOS of different approaches of this intersection, it was found that during 11 hours survey period for Shyamoli to Shishu Mela approach, the LOS level A, B, C, D, E and F were observed to be 9%, 4.5%, 0.0%, 0.0%, 0.0% and 86.36%of survey time respectively. Similarly for approach Agargaon to Shishu Mela the LOS level A, B, C, D, E and F were observed to be 4.5%, 0%, 0%, 4.5%, 9%, and 81.81% and for approach College Gate to Shishu Mela the LOS level A, B, C, D, E and F were observed to be 4.5%, 4.5%, 0%, 0%, 0% and 91.0% of survey time respectively. The LOS of every approach of this intersection was retaining at Level F consistently. For present Dhaka Metropolitan City, it is a curse.

4.8 Quantitative Data Analysis of Agargaon Intersection

A. Site Investigation of Agargaon Intersection:

intersection is situated on primary road, Begum Rokeya Avenue in north to south connecting with Syed Mahbub Morshed Avenue to west coming from Shishu Mela intersection and Bir Uttom Major General Azizur Rahman Road to the east meeting with the Tejgaon Airport Road. This is a very busy as well as wide four (4) legged (cross) intersection. Among all of the intersections of Dhaka city, this intersection is much disciplined. This intersection is also situated in the official area, government residential area too. Now a day this intersection becomes so important for Tejgaon Airport going vehicle. This intersection is an example of traffic engineered among all of the intersections of Dhaka city. According to classification of intersection, the Agargaon intersection is four (4) legged / cross junction. Two (2) important roads cross in this intersectional point. One road is a primary road named Begum Rokeya Avenue and other road is a link road named Syed Mahbub Morshed Avenue   Bir Uttom Major General Azizur Rahman Road. In the Dhaka city road network there is a very few number of linking road between east and west part, among them these two roads are very important and this Agargaon intersection is playing a very important role too. This is the entry point of Mirpur area. A lot of Government and Non-Government offices, Government residential area, Museum of Air Force are situated around this intersection. Some are IDB Bhaban, LGED office, Passport office, Islamic Foundation, Jakat Board, World Bank (WB), Asian Development Bank (ADB), etc.

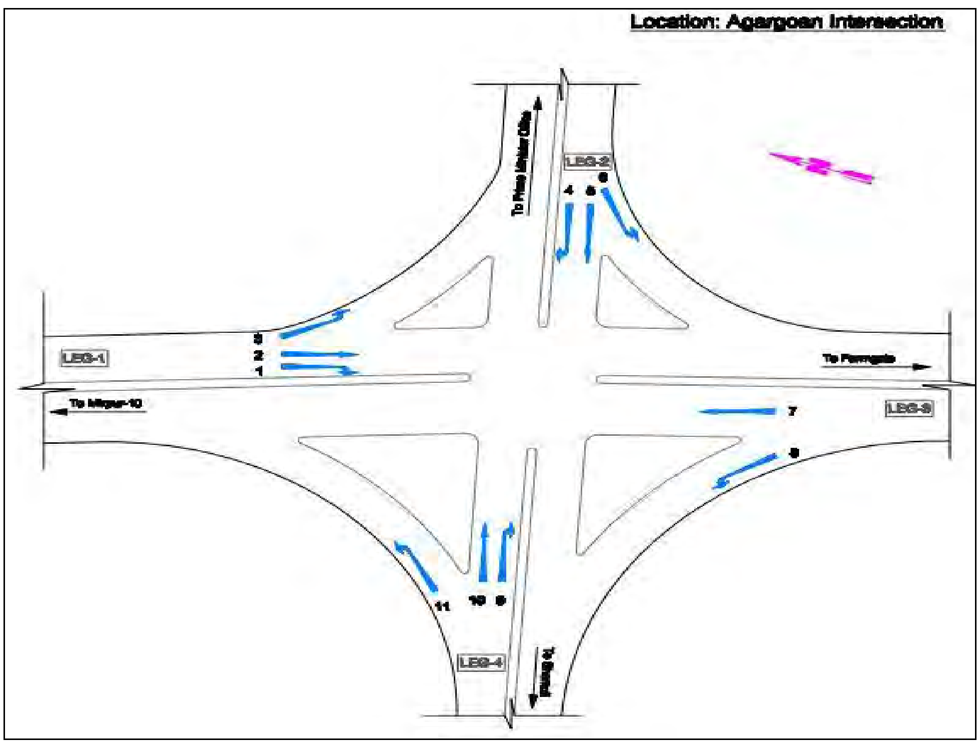


Figure 4.8.1: Layout of Agargaon Intersection.

Source: (Signal Synchronization Study, 2013).

From preliminary survey of this selected intersection, the four (4) approaches are divided by lanes with necessary marking. A table describing the lane division of different approaches is given below

Table 4.8.1: Approach of Agargaon Intersection with Lane Division.

Serial No.	Approach with direction	Lane number
Leg 1.	Agargaon to Mirpur 10.	3 lanes both direction
Leg 2.	Agargaon to Prime Minister Office.	2 lanes both direction
Leg 3.	Agargaon to Farmgate.	3 lanes both direction
Leg 4.	Agargaon to Shishu Mela intersection.	2 lanes both direction

The main carriageway of this intersection is flexible pavement in all direction. Comparing with this intersection; one in morning period from 08.00 AM to 11.30 AM and other is in evening period from 04.30 PM to 06.00 PM and furthermore. In this preliminary survey period we found out the flow ratio on every approach of this intersection for assessing the vehicular characteristics. A lot of traffic uses this intersection all throughout the day. A lot of pedestrian movement was found in this intersection. But there is no grade separated road crossing facilities in this intersection, such as over bridge, people try to cross the road through suitable gap between the busy vehicular flows with cent percent chance of accidents. There was footpath in all approaches of the intersection.

There was the provision of automatic traffic signal for traffic control, but this was not practiced in field. So, all of the signals were as showpiece in a showcase. Traffic police tried to control the traffic of this intersection manually. Signal timing, phasing was not consistent for this. They tried to operate this intersection responding as per demand. So a lot of delay occurred here and queue length originated in peak period too.

A. Geometric and Operating Conditions of Selected Intersection (Agargaon)

After finishing the detail survey of selected intersection, Agargaon; analysis of collected data about the intersection geometry and operating condition was done. The findings of this analysis are tabulated in Table 4.8.2 below.

Table 4.8.2: Geometric and Operating Condition of Agargaon Intersection.

Serial No.	Items	Description
1.	**Number of Approaches**	There are four (4) approaches namely from Agargaon to Mirpur 10, Agargaon to Prime Minister Office, Agargaon to Farmgate and Agargaon to Shishu Mela.
2.	**Carriageway**	All four approaches of this intersection are flexible pavement in structural point of view and dual carriageway.
3.	**Footpath Coverage**	Footpaths for pedestrian are found existing here, by the both of the side of two (2) approaches among the four (4) approaches of this intersection, which is illegally

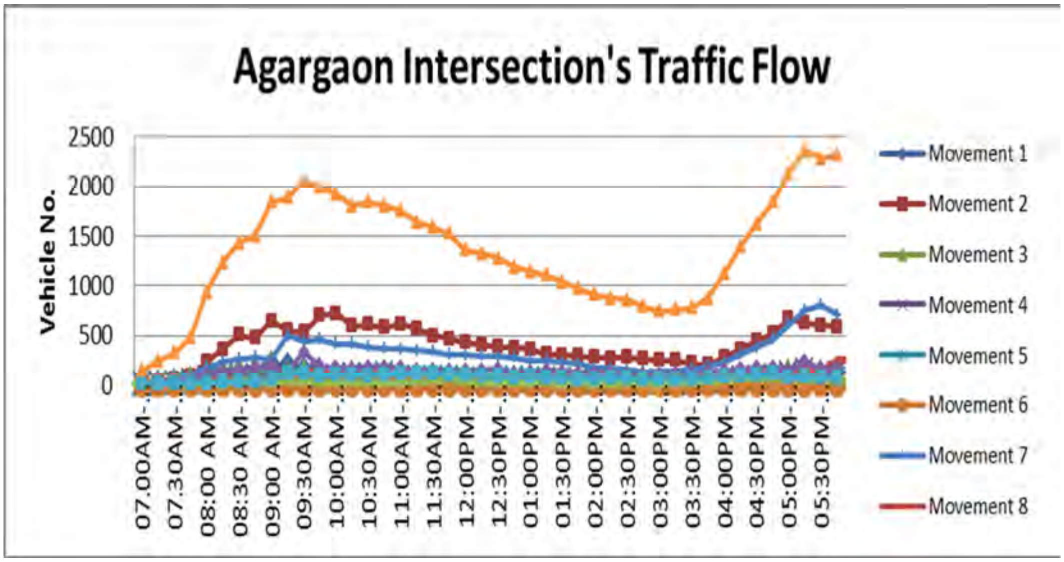
		occupied by purveyors, vegetable market, parked vehicle, nursery, etc. Agargaon intersection has 100% footpath coverage.
4.	**Channelization**	On the mouth of approach Prime Minister Office to Agargaon and Shishu Mela to Agargaon, there arechannelization for left turning, which are giving direction to vehicles towards Prime Minister Office from Mirpur 10 and Mirpur 10 from Shishu Mela.
5.	**Divider**	All approaches of this intersection are alienated by the non - engineering divider, except one approach contains engineering median (from Agargaon to Prime Minister Office). This non engineering divider is not related with velocity profile of vehicle of this intersection.
6.	**Pedestrian Crossing Facility**	There is no grade separated pedestrian crossing facility inside this intersection, such as over bridge, under pass, etc., but there is some road crossing facilities at grade, such as Zebra crossing.
7.	**Side Road**	From preliminary survey of Agargaon intersection surrounding area; it was found out that, four (4) side roads, which is coming from neighboring residential area of this intersection, exposed in this intersection directly, which are containing MV and NMV on it.

B. Determining the Existing Vehicular, Pedestrian Flow, Amount of Side Friction, and Condition of Traffic Control Devices including Signal Timing, Phasing and Mode of Operation at Agargaon Intersection:

In detail survey of Agargaon intersection; existing vehicular flow, pedestrian flow was observed, furthermore amount of side friction was exposed and condition of traffic signal, signal timing, phasing and mode of operation was documented and which was analyzed later.

i. Existing Vehicular Flow

Analyzing the exiting vehicular flow of Agargaon intersection, an eleven (11) hours vehicular survey (from 07.00 A.M. to 06.00 P.M.) was organized, the result of this survey and its analysis are presented here in Figure 4.8.2 a) and b), this figure is presenting a general graph accompanying with a pie chart, which is presenting the data of vehicular survey of this intersection and expressing the characteristics of vehicular flow through this intersection.



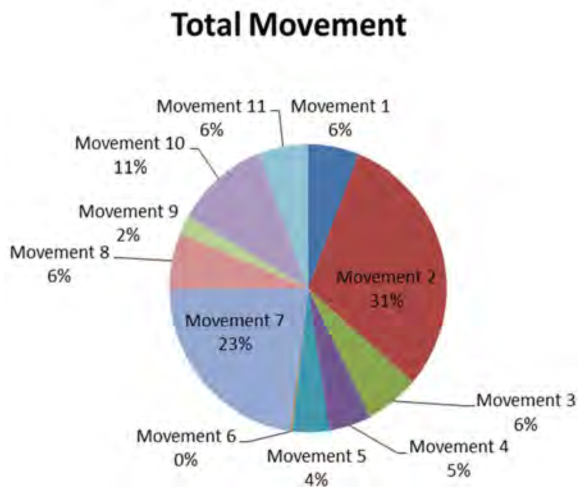
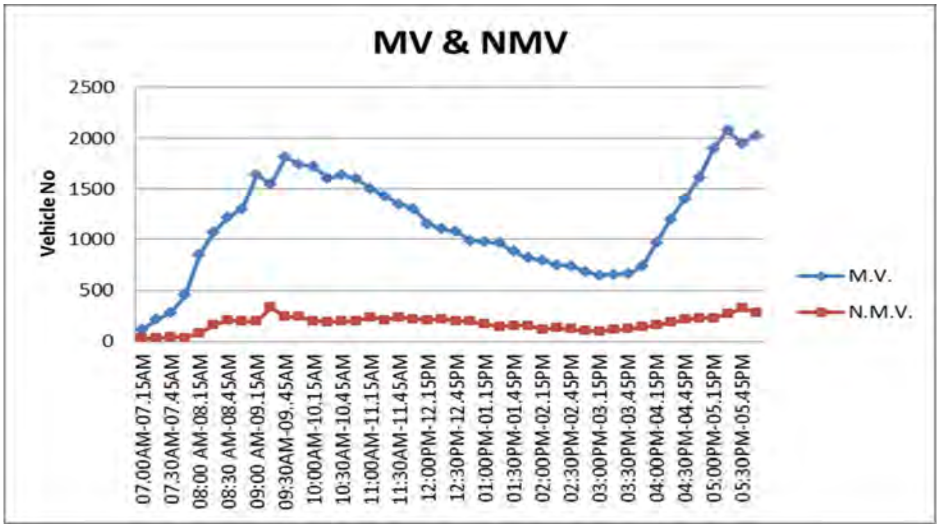


Figure 4.8.2: a) Vehicular Flow data of Agargaon Intersection; b) Vehicle Movement Contribution of Agargaon Intersection.

Analyzing the vehicular survey data of this intersection, eleven (11) individual movements were found and among them movement 2 (from Mirpur 10 to Farmgate) was maximum, which contained 31% of entire traffic flow of this intersection on the day of survey. From the entire 11 hour vehicular survey, two (2) distinct peak hours were found in traffic flow; one was in the morning period from 08.00 A.M. to 11.30 A.M. and another was in the evening from 04.30 P.M. to 06.00 P.M. and further (beyond the survey time), total peak period of the entire survey time was 5 hours, which was 45.45% of total survey time of that day.

After analyzing the vehicular flow of this intersection, assessment of the vehicular combination of this intersection was done. The result of this analysis is presented here in Figure 4.8.3 a) and b), this figure is presenting a general graph accompanying with a pie chart.



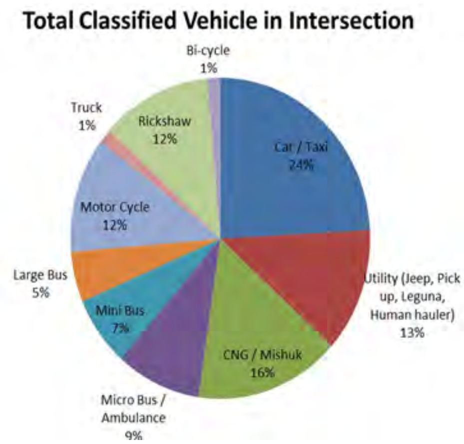


Figure 4.8.3: a) Individual Flow of MV and NMV in Agargaon Intersection; b) Classified Vehicle in Agargaon Intersection

In Figure 4.8.3 a), a general graph is shown, which is showing the individual flow of MV and NMV through this intersection. Analyzing this general graph, two (2) distinct peak hours are found for both MV and NMV; for both MV and NMV it was observed from 09.00 A.M. to 01.00 P.M. at morning and from 04.30 P.M. to 06.00 P.M. and further at evening period. In Figure 4.8.3 b), a pie chart is shown, which is expressing the vehicular composition of this intersection. The dominancy of MV is found out from here, which was 87% of total vehicular flow; among the vehicular flow car / taxi was the mostly governed vehicle type in this intersection, which was 24% of total flow.

After finding out the vehicular composition, the saturation flow of every approach of this intersection was calculated from the vehicular survey data. The result of this analysis is presented here through a tabular format in Table: 4.8.3 below.

Table 4.8.3: Saturation Flow of Different Approach of Agargaon Intersection.

Serial No.	Intersection Name	Intersection Classification	Approach Name	Saturation Flow (PCU / Hour)
1.	Agargaon	Cross / Four Legged Junction	Mirpur 10 to Agargaon	4151.76
2.			PM Office to Agargaon	979.60
3.			Farmgate to Agargaon	4411.92
4.			Shyamoli to Agargaon	1856.64

Later, the usages of road space of every approaches of this intersection were calculated. The result of this calculation is presented here through Figure 4.8.4 a), b), c) and d) with individual general graph, which is expressing the flow ratio with respect to saturation flow of the individual approach of this intersection of 11 hours (from 07.00 A.M. to 06.00 P.M.).

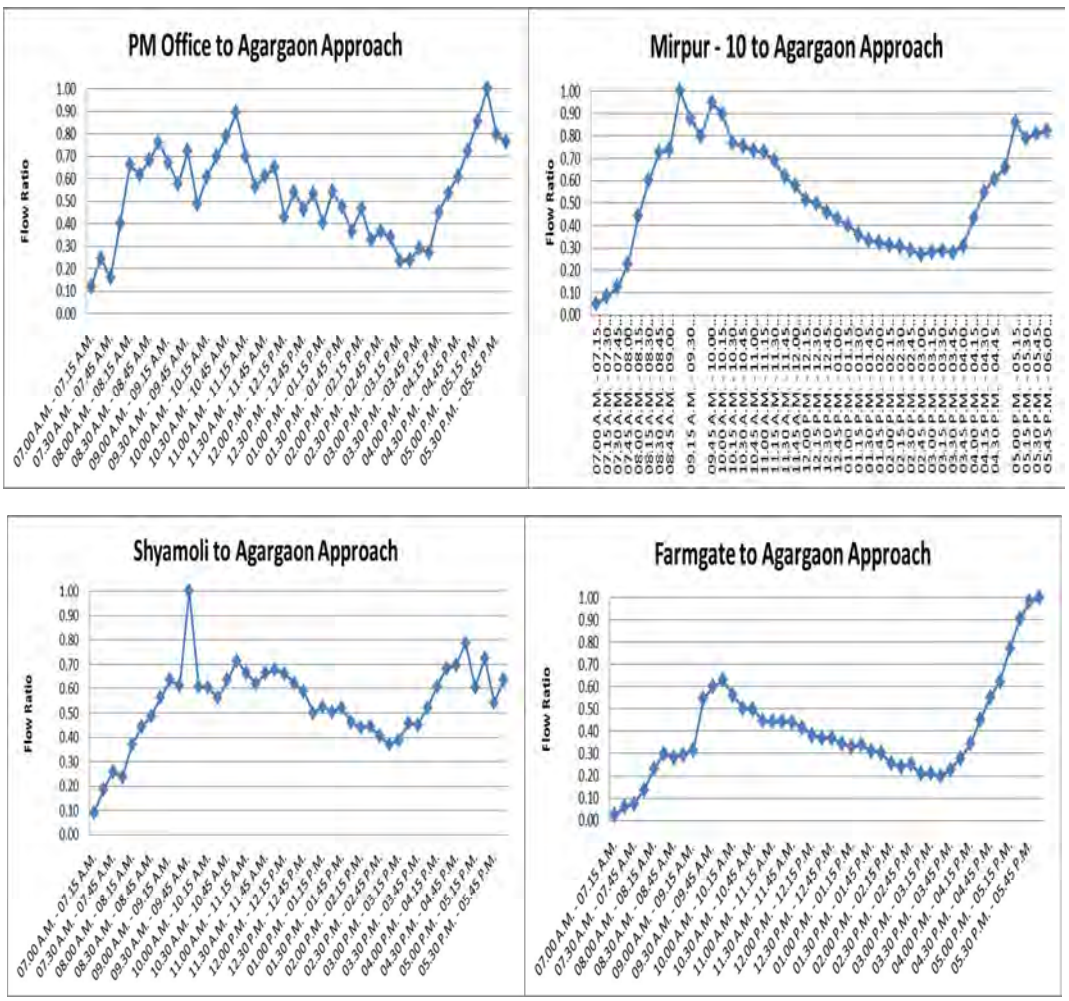
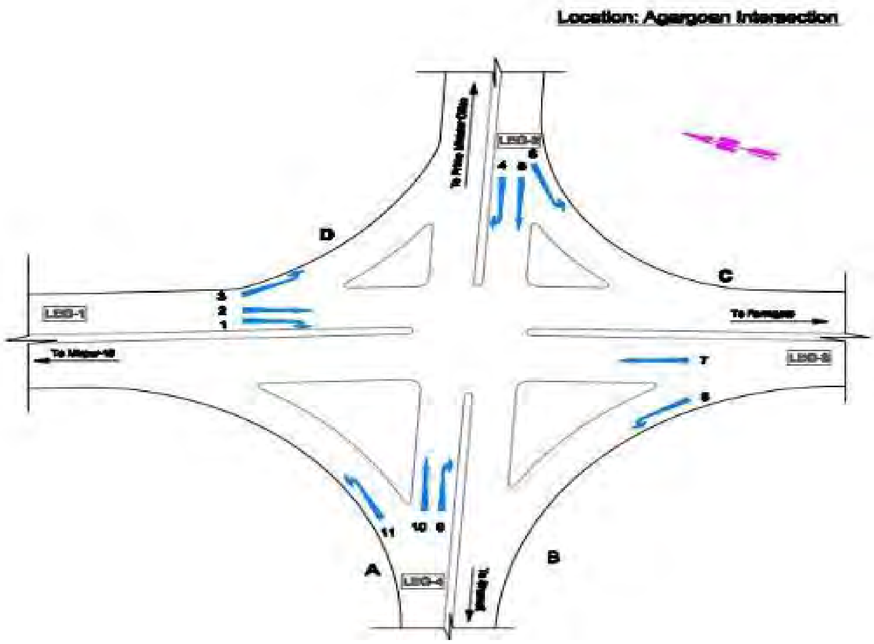


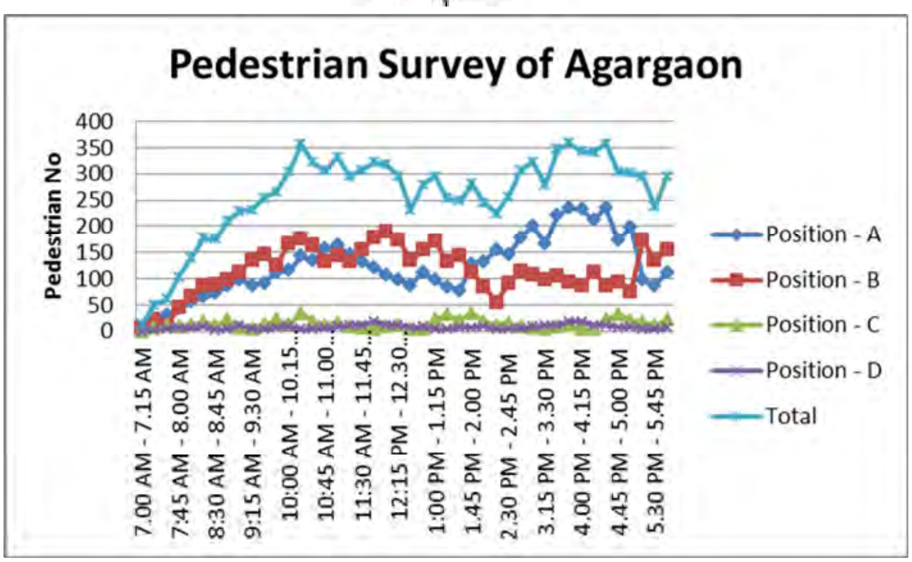
Figure 4.8.4: a) Flow Ratio of PM Office to Agargaon Approach; b) Flow Ratio of Mirpur 10 to Agargaon Approach; c) Shyamoli to Agargaon Approach; d) Flow Ratio of Farmgate to Agargaon Approach.

From Figure 4.8.4, it is observed that, every approach of this intersection were containing in two (2) peak hours in vehicular flow; one in the morning and other in the evening.

ii. Pedestrian Flow

As per set out objectives of this research, the pedestrian flow through this intersection was also observed. For finding out the present scenario of pedestrian movement through this intersection an 11 hour .00 A.M. to 06.00 PM) pedestrian counting survey was organized. The result of this survey is presented here through Figure 4.8.5 a), b) and c) a CAD drawing accompanying with general graph and pie chart.





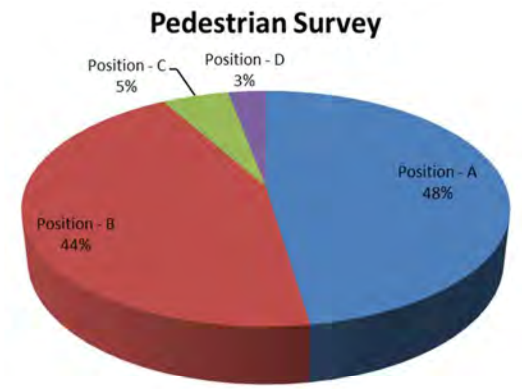


Figure 4.8.5: a) Pedestrian Survey Position inside Agargaon Intersection; b) Pedestrian Flow; c) Pedestrian Flow Contribution among four (4) Positions.

From the preliminary survey, the four (4) positions were selected for detail field survey according to the availability of pedestrian in this intersection. The positions of those four (4) points are shown here in Figure 4.8.5 a). From Figure 4.8.5 b) pedestrian flow through this intersection is presented, a constant rate of pedestrian flow was found here. Among the four (4) positions, maximum pedestrian flow was occurred in position A, which was at the corner of Passport Office, 48% percent of entire pedestrian flow took place in this position, which is presented here in Figure 4.8.5 c).

In this intersection, no grade separated pedestrian crossing facilities is found in preliminary survey, such as over bridge, underpass, etc. Instead of these, pedestrians are crossing this intersection through at grade. As usually, the pedestrian of this intersection try to cross the road in between the gap of moving vehicles.

iii. Side Friction

As per set out objectives of this research, the amount of side friction in this intersection was also determined. For this in preliminary survey of this intersection the three (3) specified reasons of side friction were found here illegal rickshaw stand, human hauler stand and bus stand, for finding out the present scenario of this side friction, an 11 hour (from 07.00 A.M. to 06.00 P.M.) counting survey was organized here also. The result of this counting survey is presented here through Figure 4.8.6 a) and b).

From the preliminary survey of this intersection, it was observed that, there were three (3) distinct points inside the intersection, where rickshaw and human hauler illegally stood. For understanding the real scenario of this illegal standee a counting survey was organized in the final survey. The result of this survey is presented here in Figure 4.8.6 a) and b).

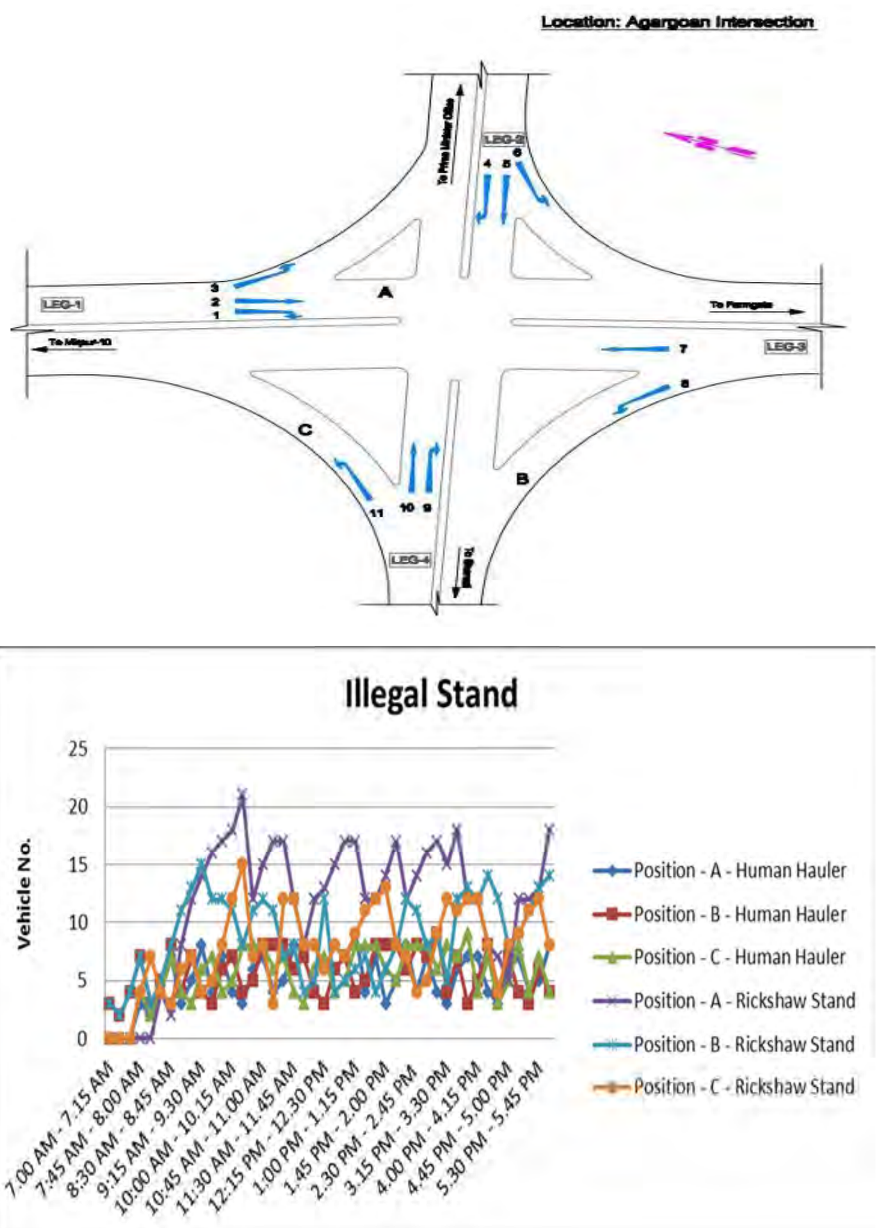


Figure 4.8.6: a) Position of Side Friction inside Agargaon Intersection; b) Contribution of Illegal Vehicle (Human Hauler and Rickshaw Stand).

Analyzing the Figure 4.8.6 it is found that, the rickshaw and human hauler do not follow a continuous characteristic in there standing. Very small amount of rickshaw and human hauler stood on these points, which interrupt the traffic flow of through this intersection. Among the three (3) points 42% of these type of vehicle stood in position A, on the mouth of Agargaon to Prime Minister Office

the mostly planned intersection in the Dhaka Metropolitan City. The effect of side friction is very negligible in the traffic flow of this intersection.

iv. Traffic Control Devices

From the preliminary survey of this intersection, a condition survey of traffic control devices was organized. The outputs of this condition survey are given below in a tabular format, in Table 4.8.4.

Table 4.8.4: Signal Accessories of Agargaon Intersection.
Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP).

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Light Operate	Pedestrian Signal Light Operate
SP-1	OK	OK	Yes	No
SP-2	OK	OK	Yes	-
SP-3	OK	OK	Yes	No
SP-4	OK	Two lamp missing	Yes	No
SP-5	OK	One lamp missing	Yes	No
SP-6	OK	OK	Yes	-
SP-7	OK	OK	Yes	No
SP-8	OK	OK	Yes	-
SP-9	OK	Two lamp missing	Yes	No
SP-10	OK	One lamp missing	-	No
MAP-1	OK	Two lamp missing	Yes	No
MAP-2	OK	OK	Yes	-
TSC	OK	OK	-	-

Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

In this intersection, for traffic control there was no use of traffic signal; instead of this, police controlled the traffic movement of this intersection manually based on traffic flow demands among three (3) approaches which is considered to be as ic demand responsive signal system
controlling system (one road
stopped), which was the most inefficient method of traffic control. The traffic signal cycle time in this method is not consistent. The variation of signal cycle time in Agargaon intersection at peak periods are given in the following Figure 4.8.7.

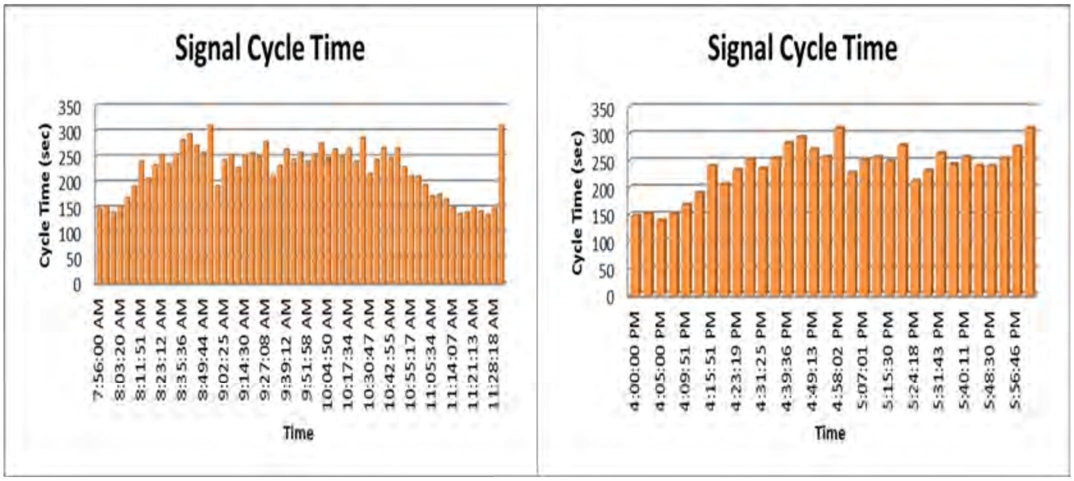


Figure 4.8.7: Signal Cycle Time at Peak Periods a) from 07.56 A.M. to 11.28 A.M.; b) from 04.00 P.M. to 05.56 P.M.

From the signal cycle time counting, it was observed that, 100.00% of total observation time was more than 120 sec, which is increasing the delay of the intersection as per research of *J. Li et al. (2004)*.

From the preliminary survey of this Agargaon intersection, the information about mode of operation of this intersection was observed. In the detail analysis of this information, it is tabulated in Table 4.8.5 below

Table 4.8.5: Existing Traffic Control System and Time of Operation of Agargaon Intersection.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(08.00 PM 08.00 AM)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(08.00 AM 11.00 AM) (05.00 PM 08.00 PM)
4	Mixed	(11.00 AM 05.00 PM)

Analyzing the Table 4.8.5 it is found that Agargaon intersection is operated in three (3) methods and different hours; automatic signal lighting system 12 hours of the total time of the day, automatic signal system (control by traffic police demand responsive) 6 hours and mixed (both automatic and controlled by police) 6 hours. In peak period this intersection is controlled by police manually.

The flow ratio of the four (4) approaches of this intersection at peak period is calculated, it is tabulated in Table 4.8.6. This is given below

Table 4.8.6: Flow Ratio of Different Approaches of Agargaon Intersection.

Time	Mirpur 10 to Agargaon, y_1	PM Office to Agargaon, y_2	Farmgate to Agargaon, y_3	Shyamoli to Agargaon, y_4	Summation, Y
08.00 A.M. - 08.15 A.M.	0.44	0.66	0.23	0.37	1.70
08.15 A.M. - 08.30 A.M.	0.60	0.62	0.30	0.44	1.96
08.30 A.M. - 08.45 A.M.	0.73	0.68	0.28	0.49	2.18
08.45 A.M. - 09.00 A.M.	0.74	0.76	0.29	0.56	2.36
09.00 A.M. - 09.15 A.M.	1.00	0.67	0.31	0.63	2.62
09.15 A.M. - 09.30 A.M.	0.88	0.57	0.55	0.61	2.61
09.30 A.M. - 09.45 A.M.	0.80	0.72	0.60	1.00	3.12
09.45 A.M. - 10.00 A.M.	0.95	0.49	0.63	0.61	2.67
10.00 A.M. - 10.15 A.M.	0.90	0.61	0.56	0.60	2.67
10.15 A.M. - 10.30 A.M.	0.77	0.70	0.50	0.56	2.53
10.30 A.M. - 10.45 A.M.	0.75	0.79	0.50	0.64	2.68
10.45 A.M. - 11.00 A.M.	0.74	0.89	0.45	0.71	2.79
11.00 A.M. - 11.15 A.M.	0.73	0.70	0.44	0.66	2.53
11.15 A.M. - 11.30 A.M.	0.69	0.57	0.44	0.62	2.32
04.30 P.M. - 04.45 P.M.	0.61	0.61	0.55	0.70	2.47
04.45 P.M. - 05.00 P.M.	0.66	0.72	0.62	0.79	2.79
05.00 P.M. - 05.15 P.M.	0.86	0.85	0.77	0.60	3.09
05.15 P.M. - 05.30 P.M.	0.79	1.00	0.90	0.72	3.42
05.30 P.M. - 05.45 P.M.	0.81	0.80	0.98	0.54	3.13
05.45 P.M. - 06.00 P.M.	0.82	0.76	1.00	0.64	3.22

By analyzing the Table 4.8.6, it is found that the traffic operation system by automatic signal will not work, because the summation of the flow ratio is greater than 1.00 all throughout the day in this intersection as per signal design theory.

C. Establishing Performance Evaluation Parameters for Signalized Road Intersections and Assesses Level of Service (LOS)

As per setout objectives of this research for finding out the LOS of the individual approach; queue length, delay was found out in detail survey of this intersection.

For finding out the effect of inefficiency in traffic control; queue length determination survey at peak period was organized in this intersection. The result of this survey is tabulated through the Table 4.8.7 and Table 4.8.8 below.

Table 4.8.7: Queue Length of Different Approach of Agargaon Intersection (Morning Peak).

Observation No.	Time	Queue Length (in meter)			
		Mirpur - 10 to Agargaon Approach (m)	**Shyamoli to Agargaon Approach (m)**	**Farmgate to Agargaon Approach (m)**	**PM Office to Agargaon Approach (m)**
1.	08.00 A.M. - 08.15 A.M.	0	0	0	0
2.	08.15 A.M. - 08.30 A.M.	0	155.22	0	0
3.	08.30 A.M. - 08.45 A.M.	135.34	176.22	0	0
4.	08.45 A.M. - 09.00 A.M.	165.77	145.54	0	0
5.	09.00 A.M. - 09.15 A.M.	187.33	178.65	0	0
6.	09.15 A.M. - 09.30 A.M.	245.32	202.34	125.99	145.22
7.	09.30 A.M. - 09.45 A.M.	255.34	225.54	155.66	176.67
8.	09.45 A.M. - 10.00 A.M.	278.34	276.22	145.54	212.33
9.	10.00 A.M. - 10.15 A.M.	323.44	245.34	178.65	202.34
10.	10.15 A.M. - 10.30 A.M.	297.66	296.33	202.34	225.54
11.	10.30 A.M. - 10.45 A.M.	305.33	306.67	225.54	276.22
12.	10.45 A.M. - 11.00 A.M.	275.77	312.32	276.22	245.34
13.	11.00 A.M. - 11.15 A.M.	315.44	342.46	255.66	235.00
14.	11.15 A.M. - 11.30 A.M.	344.21	305.73	221.37	295.66

Table 4.8.8: Queue Length of Different Approach of Agargaon Intersection (Evening Peak).

Observation No.	Time	Queue Length (in meter)			
		Mirpur - 10 to Agargaon Approach (m)	**Shyamoli to Agargaon Approach (m)**	**Farmgate to Agargaon Approach (m)**	**PM Office to Agargaon Approach (m)**
1.	04.00 P.M. 04.15 P.M.	185.88	112.45	143.55	112.67
2.	04.15 P.M. 04.30 P.M.	276.00	122.56	136.58	98.76
3.	04.30 P.M. - 04.45 P.M.	321.00	245.78	155.75	115.78
4.	04.45 P.M. - 05.00 P.M.	334.67	332.67	187.76	187.78
5.	05.00 P.M. - 05.15 P.M.	342.22	312.67	145.67	177.86
6.	05.15 P.M. - 05.30 P.M.	375.22	302.66	152.34	185.56
7.	05.30 P.M. - 05.45 P.M.	411.76	287.78	187.98	209.87
8.	05.45 P.M. - 06.00 P.M.	427.44	297.66	376.88	334.57

Analyzing the result of the queue length survey, it was measured on four (4) approaches of this intersection. Maximum queue length was found in this intersection at different approach with the progress of the time. The queue length was observed in Mirpur 10 to

Agargaon approach at morning peak 344.21 m and at evening peak 427.44 m, Shyamoli to Agargaon approach at morning peak 342.46 m and at evening peak 332.67 m, Farmgate to Agargaon approach at morning peak 276.22 m and at evening peak 376.88 m and PM Office to Agargaon approach at morning peak 295.66 m and at evening peak 334.57 m. Among them, the queue length of this intersection was increasing with the progress of time, 50.00% of total observation time, the queue length was over 200m, which was very worst as per research of *J. Li et al. (2004).*

After that, another parameter for determination of LOS, delay was found out through a delay determination survey. This survey had two parts; one was determination of travel time at free flow condition and other was determination of travel time in field condition. Firstly the free flow travel time in every approach of this intersection was counted. The free flow condition travel time of this Agargaon intersection is presented here in a tabular format in Table 4.8.9 below.

Table 4.8.9: Travel Time at Free Flow Condition of Agargaon Intersection (sec).

Observation No.	Time	Taltola to Agargaon	Shishu Mela to Agargaon	Planning Commission to Agargaon	Prime Minister Office to Agargaon
1.	07.00 A.M. 07.30 A.M.	5	28	6	31

After this, for finding out the delay of this intersection, a travel time counting survey in field condition was organized; from here travel time was collected on every approaches of this intersection from 07.00 A.M to 06.00 P.M. After getting this travel time of every approach, deducting the free flow time from surveyed travel time, delay was found from every approaches all throughout the day. The delay of these approaches are shown below from 07.00 A.M. to 06.00 P.M. in Table 4.8.10

Table 4.8.10: Delay at Different Approach of Agargaon Intersection.

Observation No.	Time	Delay (Taltola to Agargaon) sec	Delay (Shishu Mela to Agargaon) sec	Delay (Planning Commission to Agargaon) sec	Delay (Prime Minister Office to Agargaon) sec
1.	07.00 A.M. 07.30 A.M.	1	0	2	5
2.	07.30 A.M. 08.00 A.M.	7	11	6	13
3.	08.00 A.M. 08.30 A.M.	17	26	16	22
4.	08.30 A.M. 09.00 A.M.	40	39	18	35
5.	09.00 A.M. 09.30 A.M.	53	46	28	27
6.	09.30 A.M. 10.00 A.M.	64	49	19	25
7.	10.00 A.M. 10.30 A.M.	87	50	59	31

8.	10.30 A.M.	11.00 A.M.	123	49	61	36
9.	11.00 A.M.	11.30 A.M.	248	84	38	42
10.	11.30 A.M.	12.00 P.M.	322	93	28	43
11.	12.00 P.M.	12.30 P.M.	282	195	106	56
12.	12.30 P.M.	01.00 P.M.	218	200	118	65
13.	01.00 P.M.	01.30 P.M.	182	303	126	81
14.	01.30 P.M.	02.00 P.M.	149	208	215	93
15.	02.00 P.M.	02.30 P.M.	82	196	218	97
16.	02.30 P.M.	03.00 P.M.	109	160	217	68
17.	03.00 P.M.	03.30 P.M.	123	144	219	56
18.	03.30 P.M.	04.00 P.M.	111	90	272	58
19.	04.00 P.M.	04.30 P.M.	73	86	219	56
20.	04.30 P.M.	05.00 P.M.	119	198	250	54
21.	05.00 P.M.	05.30 P.M.	117	193	221	85
22.	05.30 P.M.	06.00 P.M.	127	269	248	97

Analyzing the Table 4.8.10 the delay at different approach of Agargaon intersection is increasing as the progress of the day time was found. Approach wise comparison of delay time is shown in Figure 4.8.8below

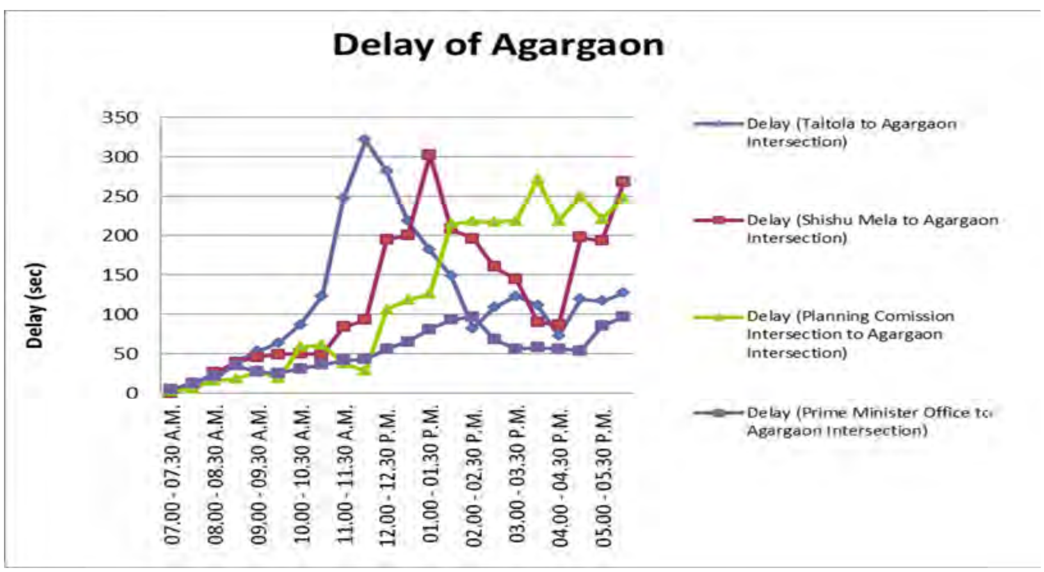


Figure 4.8.8: Comparison of Delay at Different Approach of Agargaon Intersection.

Analyzing the Figure 4.8.8, the maximum increasing delay was found in Planning Commission to Agargaon intersection.

D. Evaluation Performance of the Intersections Based on LOS Ranking.

Finally, based on the delay on every approach of this intersection, LOS of four (4) approaches was calculated for Agargaon intersection. In the following Table 4.8.11 and Figure: 4.8.9 the LOS of this intersection is presented below, the detailed calculation of LOS given in Appendix A

Table 4.8.11: LOS of Different Approaches of Agargaon Intersection.

Observation No.	Time	LOS (Taltola to Agargaon)	LOS (Shishu Mela to Agargaon)	LOS (Planning Commission to Agargaon)	LOS (Prime Minister Office to Agargaon)
1.	07.00 A.M. 07.30 A.M.	A	A	A	A
2.	07.30 A.M. 08.00 A.M.	A	B	A	B
3.	08.00 A.M. 08.30 A.M.	C	D	C	C
4.	08.30 A.M. 09.00 A.M.	E	E	C	D
5.	09.00 A.M. 09.30 A.M.	F	E	D	D
6.	09.30 A.M. 10.00 A.M.	F	E	C	C
7.	10.00 A.M. 10.30 A.M.	F	E	F	D
8.	10.30 A.M. 11.00 A.M.	F	E	F	E
9.	11.00 A.M. 11.30 A.M.	F	F	E	E
10.	11.30 A.M. 12.00 P.M.	F	F	D	F
11.	12.00 P.M. 12.30 P.M.	F	F	F	F
12.	12.30 P.M. 01.00 P.M.	F	F	F	F
13.	01.00 P.M. 01.30 P.M.	F	F	F	F
14.	01.30 P.M. 02.00 P.M.	F	F	F	F
15.	02.00 P.M. 02.30 P.M.	F	F	F	F
16.	02.30 P.M. 03.00 P.M.	F	F	F	F
17.	03.00 P.M. 03.30 P.M.	F	F	F	F
18.	03.30 P.M. 04.00 P.M.	F	F	F	F
19.	04.00 P.M. 04.30 P.M.	F	F	F	F
20.	04.30 P.M. 05.00 P.M.	F	F	F	F
21.	05.00 P.M. 05.30 P.M.	F	F	F	F
22.	05.30 P.M. 06.00 P.M.	F	F	F	F

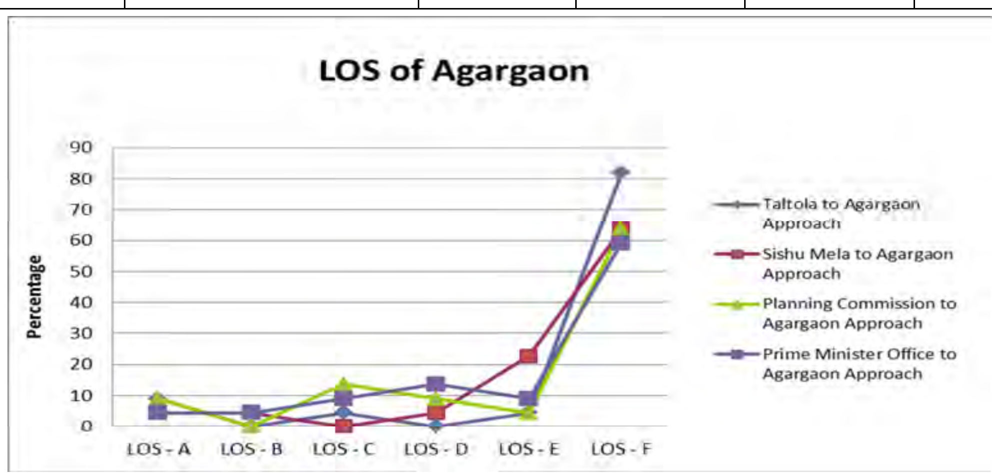


Figure 4.8.9: Percentage of Various LOS at Different Approaches of Agargaon Intersection.

By analyzing the Table 4.8.11 and Figure: 4.8.9 the LOS of different approaches of this intersection, it was found that during 11 hour for Taltola to Agargaon approach, the LOS level A, B, C, D, E and F were observed to be 9%, 0.0%, 4.5%, 0.0%, 4.5% and 81.81% of survey time respectively. Similarly for approach Shishu Mela to Agargaon approach the LOS level A, B, C, D, E and F were observed to be 4.5%, 4.5%, 0.0%, 4.5%, 22.72%, and 63.63%, for approach Planning Commission to Agargaon the LOS level A, B, C, D, E and F were observed to be 9.0%, 4.5%, 13.63%, 9%, 4.5% and 63.63% and for approach of Prime Minister Office to Agargaon the LOS level A, B, C, D, E and F were observed to be 4.5%, 4.5%, 9%, 13.63%. 9% and 59.1% of survey time respectively. The LOS of every approach of this intersection was retaining at Level F consistently. For present Dhaka Metropolitan City, it is a curse.

4.9 Quantitative Data Analysis of Bangla Motor Intersection

A. Site Investigation of Bangla Motor Intersection:

intersection is situated on a primary road, Kazi Nazrul Islam Avenue in north to south connecting with New Eskaton Road to east coming from Mouchak intersection and short road connecting Bir Uttam C.R. Dutta Road to the west. It is a four (4) legged / cross intersection. All time of the day, this intersection contains a huge traffic. This is the busiest intersection of Dhaka City. According to the classification of road, in this intersection one primary road and one secondary road cross to each other. The name of primary road is Kazi Nazrul Islam Avenue (north south direction) and the name of secondary road is New Eskaton Road Sonargaon Road (east west direction). This intersection is being positioned in the commercial area and important VIP road of Dhaka city. A lot of bank, shopping center, high rise commercial building, market, shops, show rooms etc. are located in this intersection.

From preliminary survey of this selected intersection, the four (4) approaches are divided by lanes with necessary marking. A table describing the lane division of different approaches is given below.

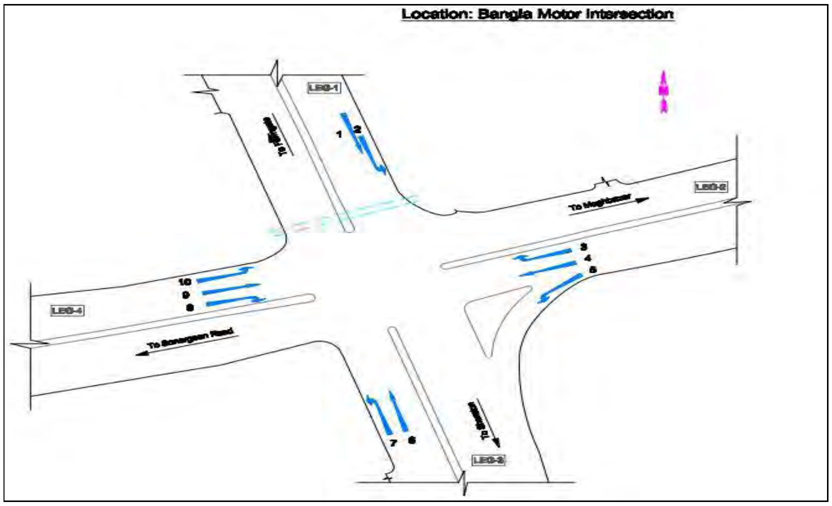


Figure 4.9.1: Layout of Bangla Motor Intersection.

Source: (Signal Synchronization Study, 2013).

Table 4.9.1: Approach of Bangla Motor Intersection with Lane Division.

Serial No.	Approach with direction	Lane number
Leg 1.	Farmgate to Bangla Motor Intersection.	3 lanes both direction
Leg 2.	Bangla Motor Intersection to New Eskaton Road.	2 lanes both direction
Leg 3.	Bangla Motor Intersection to Sheraton.	3 lanes both direction
Leg 4.	Bangla Motor to Sonargaon Road.	2 lanes both direction

The main carriageway of this intersection is flexible pavement in all direction. But frequent road digging is found here for regular maintenance work. In the preliminary survey time, we found the construction work of Mogbazar Mouchak Flyover work, in the New Eskaton road. So the traffic flow disturbed due to this construction work on this approach.

Noticing the vehicular flow of this intersection, two (2) distinct peak hours were found in traffic flow; one was in the morning period from 08.00 A.M. to 01.00 P.M. and another was in the evening from 03.30 P.M. to 06.00 P.M. and furthermore (beyond the survey time). A lot of traffic uses this intersection all throughout the day. A lot of pedestrian movement was found in this intersection. There is an over bridge for crossing the junction, it is a two (2) legged over bridge. There was footpath in all approaches of the intersection; however this footpath was invaded by the hawkers, traders, hotels, construction material, rickshaw stand, etc. There was a lot of side friction in the approaches of this intersection.

There was the provision of automatic traffic signal for traffic control, but this was not practiced in field. So, all of the signals were as showpiece in a showcase. Traffic police tried to control the traffic of this intersection manually. Signal timing, phasing was not consistent for this. They tried to operate this intersection responding as per demand. So a lot of delay occurred here and queue length originated in peak period too.

In future it will be the entry gate of Mogbazar flyover. It will play an important role in Dhaka City road network.

B. Geometric and Operating Conditions of Selected Intersection (Bangla Motor)

After finishing the detail survey of Bangla Motor; analysis of collected data about the intersection geometry and operating condition was done. The findings of this analysis are tabulated in Table 4.9.2 below.

Table 4.9.2: Geometric and Operating Condition of Bangla Motor Intersection.

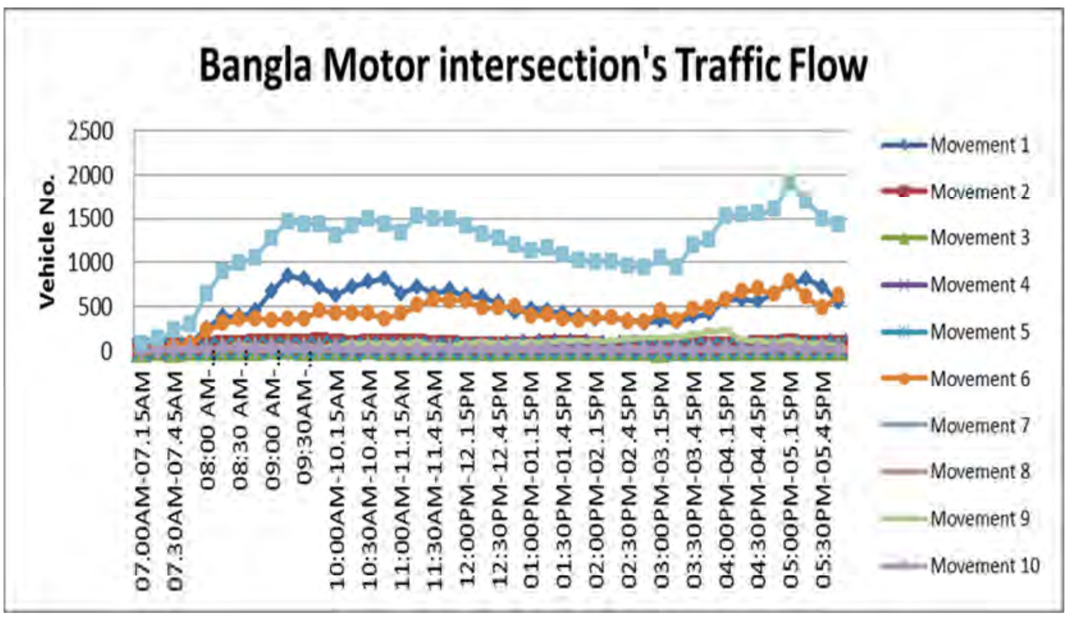
Serial No.	Items	Description
1.	**Number of Approaches**	There are four (4) approaches namely from Farmgate to Bangla Motor, Bangla Motor to New Eskaton Road, Bangla Motor to Sheraton and Bangla Motor to Sonargaon. But vehicular flow was interrupted in Bangla Motor to New Eskaton road approach due to construction of Mogbazar Mouchak flyover.
2.	**Carriageway**	All four (4) approaches of this intersection are flexible pavement in structural point of view and dual carriageway.
3.	**Footpath Coverage**	Footpaths for pedestrian are found existing here, by the both of the side of all the four approaches of this intersection, which is illegally occupied by purveyors, building materials, parked vehicle, etc. Bangla Motor intersection has 100% footpath coverage.
4.	**Channelization**	On the mouth of New Eskaton Road to Bangla Motor approach, there is a channelization of left turning traffic, which is giving direction to vehicles towards Sheraton from Malibag Mouchak.
5.	**Divider**	All approaches of this intersection are alienated by the non - engineering divider. This non engineering divider is not related with velocity profile of vehicle of this intersection.
6.	**Pedestrian Crossing Facility**	There is a two legged over bridge for pedestrian crossing facility inside this intersection on the mouth of Bangla Motor to Farmgate approach, but pedestrians try to cross the intersection through the busy road at grade as usually.
7.	**Side Road**	From preliminary survey of Bangla Motor intersection surrounding area; five (5) side roads were found out, which are coming from neighboring residential area / business area of this intersection. They are exposed in this intersection directly, which are containing MV and NMV both in it.

C. Determining the Existing Vehicular, Pedestrian Flow, Amount of Side Friction, and Condition of Traffic Control Devices including Signal Timing, Phasing and Mode of Operation at Bangla Motor Intersection:

In detail survey of Bangla Motor intersection; existing vehicular flow, pedestrian flow was observed, furthermore amount of side friction was exposed and condition of traffic signal, signal timing, phasing and mode of operation was documented and which was analyzed later.

i. Existing Vehicular Flow

Analyzing the exiting vehicular flow of Bangla Motor intersection, an 11 hours vehicular survey (from 07.00 A.M. to 06.00 P.M.) was organized, the result of this survey and its analysis are presented here in Figure 4.9.2 a) and b), this figure is presenting a general graph accompanying with a pie chart, which is presenting the data of vehicular survey of this intersection and expressing the characteristics of vehicular flow through this intersection.



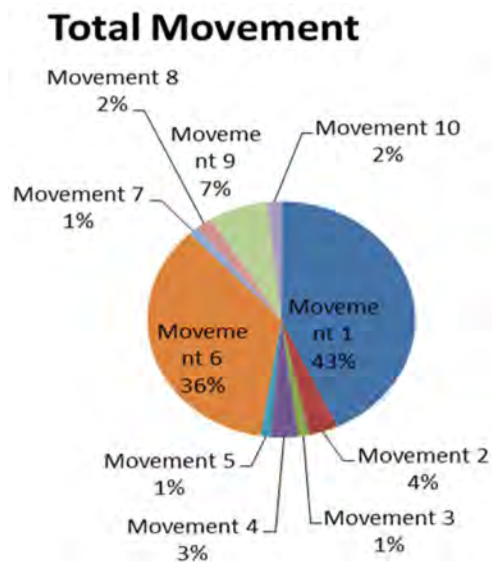
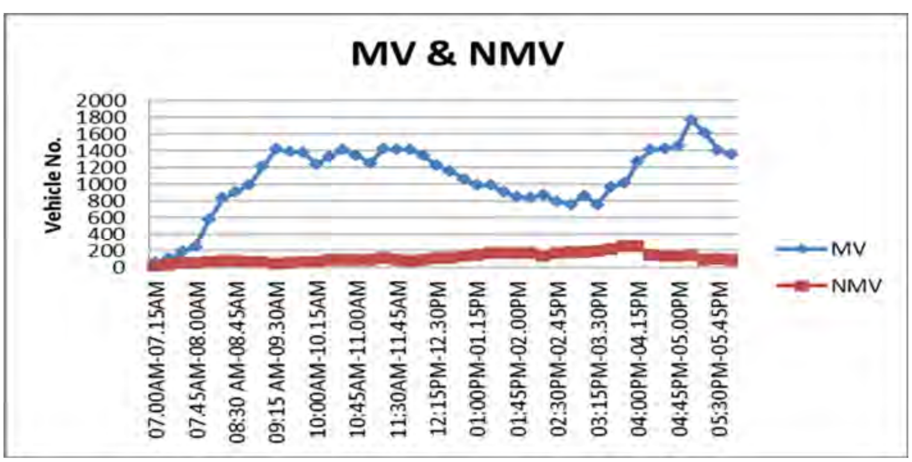


Figure 4.9.2: a) Vehicular Flow Data of Bangla Motor Intersection; b) Vehicle Movement Contribution of Bangla Motor Intersection.

Analyzing the vehicular survey data of this intersection, ten (10) individual movements were found and among them movement 1 (from Farmgate to Sheraton) was maximum, which contained 43% of entire traffic flow of this intersection on the day of survey. From the entire 11 hour vehicular survey, two (2) distinct peak hours were found in traffic flow; one was in the morning period from 08.00 A.M. to 01.00 P.M. and another was in the evening from 03.30 P.M. to 06.00 P.M. and furthermore (beyond the survey time), total peak period of the entire survey time was 7.5 hours, which was 68.18% of total survey time of that day.

After analyzing the vehicular flow of this intersection, assessment of the vehicular combination of this intersection was done. The result of this analysis is presented here in Figure 4.9.3 a) and b), this figure is presenting a general graph accompanying with a pie chart.



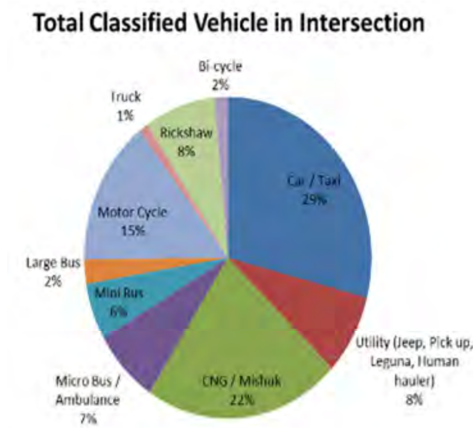


Figure 4.9.3: a) Individual flow of MV and NMV in Bangla Motor intersection; b) Classified Vehicle in Bangla Motor intersection.

In Figure 4.9.3 a), a general graph is shown, which is showing the individual flow of MV and NMV through this intersection. Analyzing this general graph, two (2) distinct peak hours are found for MV, it was observed from 09.00 A.M. to 01.00 P.M. at morning peak and from 04.30 P.M. to 06.00 P.M. and furthermore at evening peak period. A constant rate of flow was followed by the NMV of this intersection all throughout the day, because NMV only flow through two (2) approaches; Moghbazar to Bangla Motor approach and Sonargaon to Bangla Motor approach. In Figure 4.9.3 b), a pie chart is shown, which is expressing the vehicular composition of this intersection. The dominancy of MV is found out from here, which was 90% of total vehicular flow; among the vehicular flow car / taxi was the mostly governed vehicle type in this intersection, which was 29% of total flow.

After finding out the vehicular composition, the saturation flow of every approach of this intersection was calculated from the vehicular survey data. The result of this analysis is presented here through a tabular format in Table 4.9.3 below.

Table 4.9.3: Saturation Flow of Different Approach Bangla Motor Intersection.

Serial No.	Intersection Name	Intersection Classification	Approach Name	Saturation Flow (PCU / Hour)
1.	Bangla Motor	Cross / Four Legged Junction	Farmgate to Bangla Motor	3291.16
2.			Sheraton to Bangla Motor	3079.88

At the time of field survey of this intersection the traffic flow was interrupted in these Moghbazar to Bangla Motor and Sonargaon to Bangla Motor approach due to construction of Moghbazar Mouchak flyover.

Later, the usages of road space of approaches of this intersection were calculated. The result of this calculation is presented here through Figure 4.9.4 a) and b) with individual general graph, which is expressing the flow ratio with respect to saturation flow of the individual approach of this intersection of 11 hours.

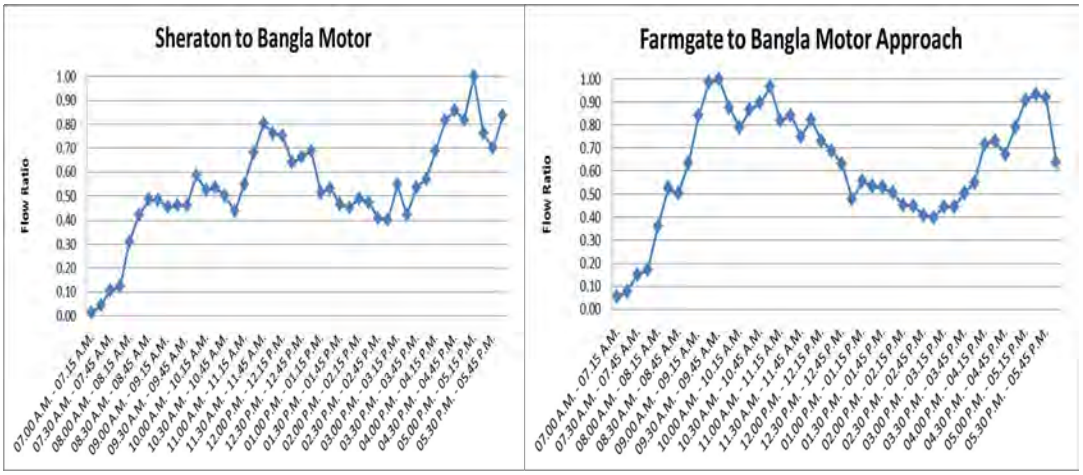


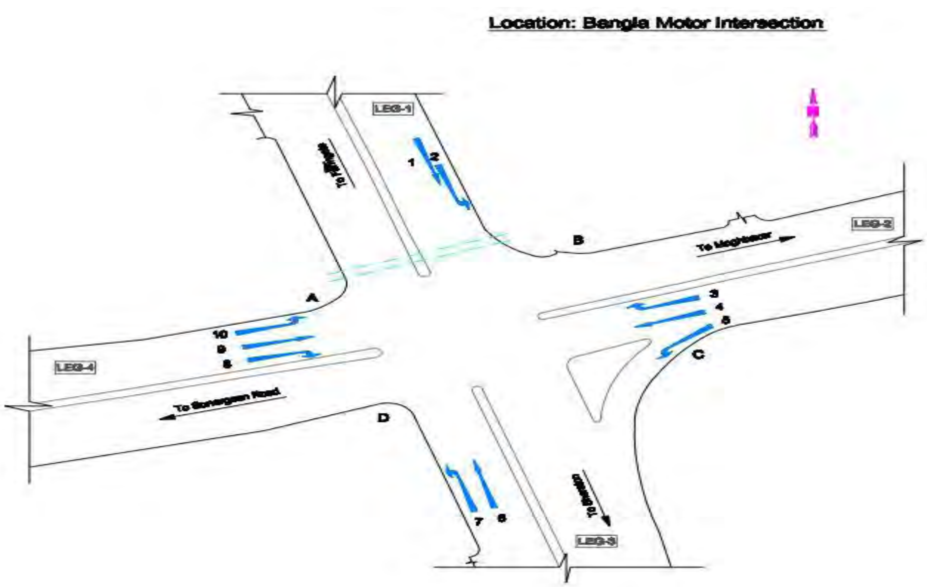
Figure 4.9.4: a) Flow Ratio of Sheraton to Bangla Motor Approach; b) Flow Ratio of Farmgate to Bangla Motor Approach.

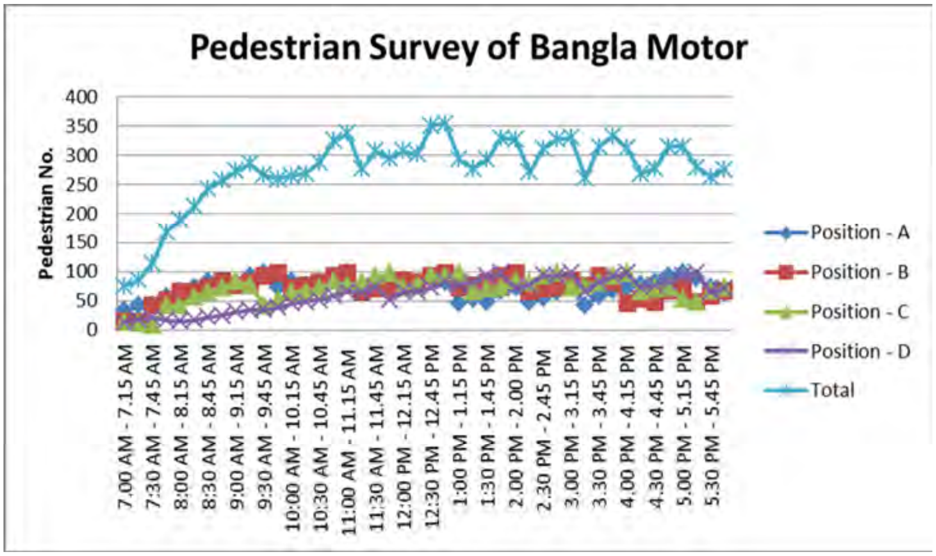
From Figure 4.9.4 it is observed that, the two (2) approach of this intersection were containing in two (2) peak hours in vehicular flow; one in the morning and other in the evening.

ii. Pedestrian Flow

As per set out objectives of this research, the pedestrian flow through this intersection was also observed. In preliminary survey, two (2) types of pedestrian flow were observed; one was at grade and other was grade separated.

In this intersection, detail 11 hours (from 07.00 A.M. to 06.00 P.M.) pedestrian survey was organized for finding out the scenario of at grade pedestrian flow. After analyzing the result of this survey, it is presented here in Figure 4.9.5 a), b) and c), through a general graph accompanying with a CAD drawing and pie chart.





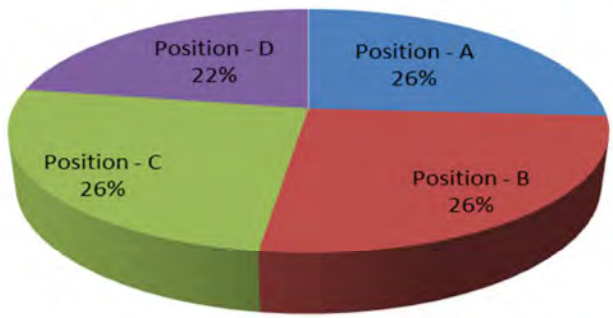


Figure 4.9.5: a) Pedestrian Survey Position inside Bangla Motor Intersection; b) Pedestrian Flow; c) Pedestrian Flow Contribution among four (4) Positions.

From the preliminary survey, the four (4) positions were selected for detail field survey according to the availability of pedestrian in this intersection. The positions of those four (4) points are shown here in Figure 4.9.5 a). From Figure 4.9.5 b) at grade pedestrian flow through this intersection is presented, a constant increased pedestrian flow all throughout the day was found here. Maximum at grade pedestrian flow was in position A, B and C which were at the corner of Sonargaon Road, Moghbazar Road and Sheraton approaching Road, 26% percent of entire at grade pedestrian flow took place in those positions, which are presented here in Figure 4.9.5 c).

A two (2) legged over bridge is situated inside this intersection as a grade separated crossing facilities for pedestrian. For finding out the scenario of grade separated pedestrian crossing facility of this intersection, an 11 hours (from 07.00 A.M. to 06.00 P.M.) pedestrian crossing survey was organized in this over bridge. After analyzing the result of this pedestrian survey, it is presented here in Figure 4.9.6 a), b) and c), through a general graph accompanying with a Google map and pie chart.

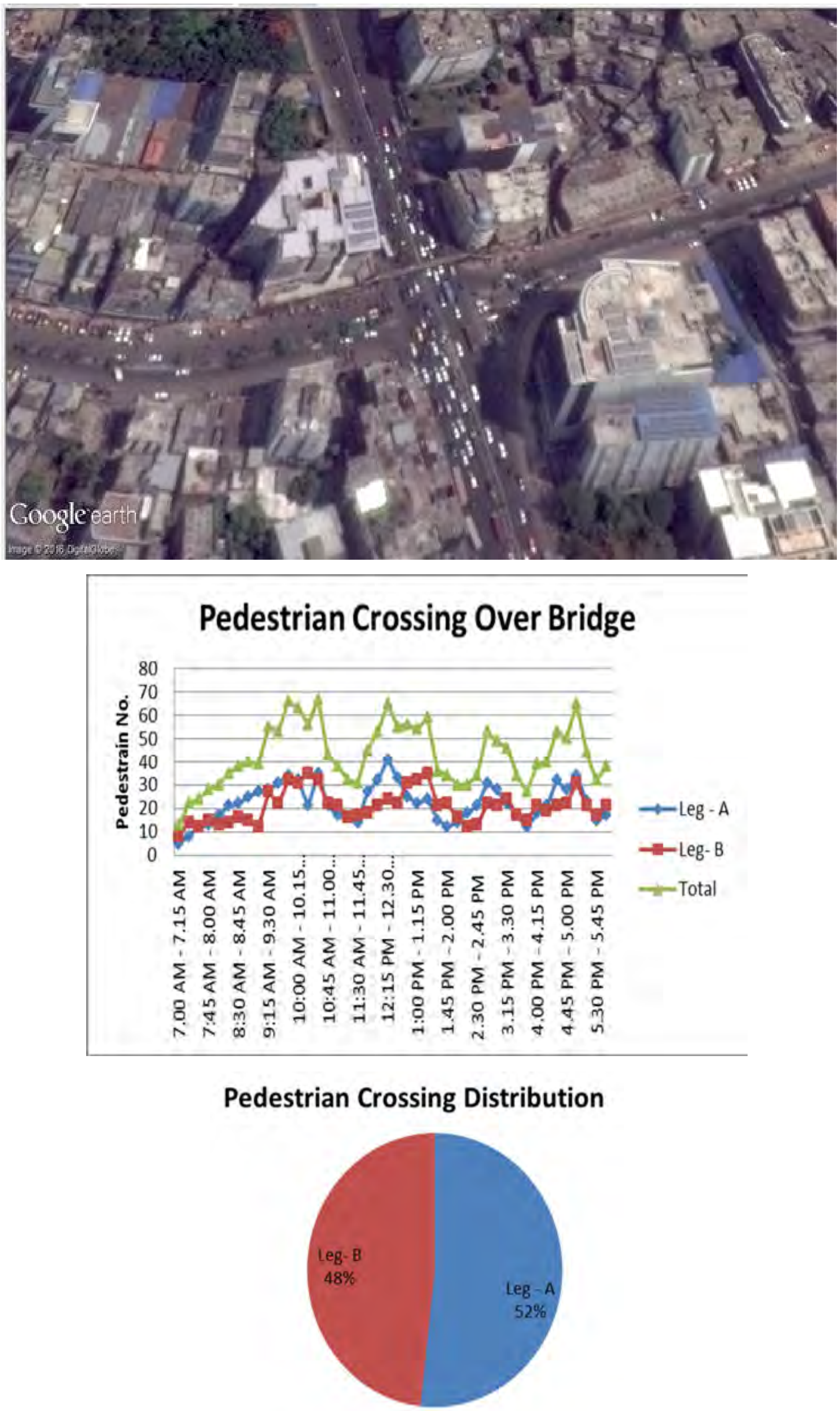


Figure 4.9.6: a) Position of Foot Over Bridge at Bangla Motor Intersection; b) Grade Separated Pedestrian Flow; c) Pedestrian Flow Contribution among two (2) Legs.

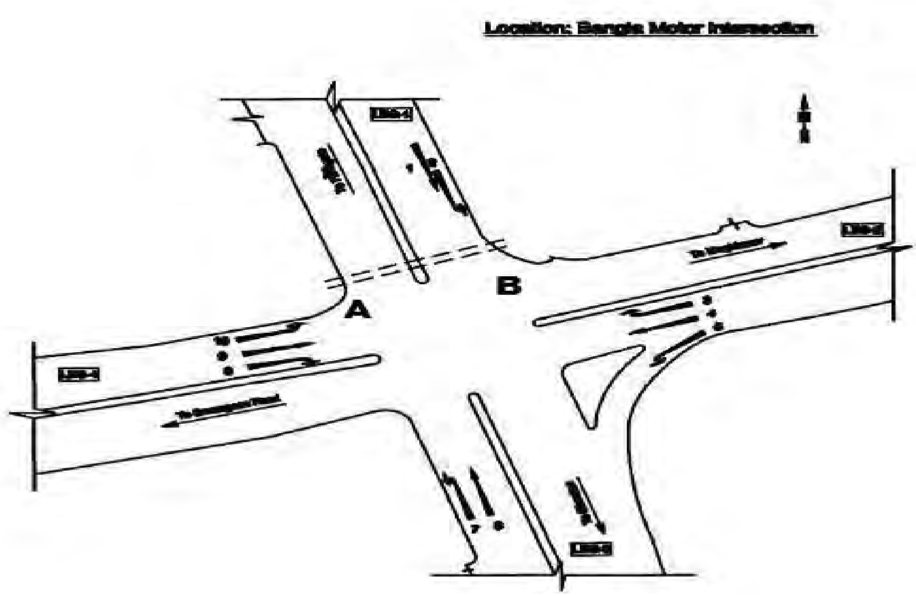
From Figure 4.9.6 a), b) and c) , from 11 hours survey it was observed that total 1,894 nos. of pedestrian used this over bridge as a crossing facility through this intersection, the two legs of the over bridge is indicated by Leg A and Leg B in picture. With respect to total pedestrian flow only 16 % pedestrian were using this facility on that day. Between the two legs of this over bridge, about 52% of crossing pedestrian was in Leg A which is at the corner of Sonargaon Road.

iii. Side Friction

As per set out objectives of this research, the amount of side friction in this intersection was also determined. For this, in preliminary survey two (2) points were found out according to the site analysis.

From the preliminary survey of this intersection the two (2) specified reasons of side friction were found here illegal rickshaw stand and bus stand. For finding out the scenario of side friction, an 11 hour

was organized. The result of this counting survey is presented here in Figure 4.9.7 a), b) and c).



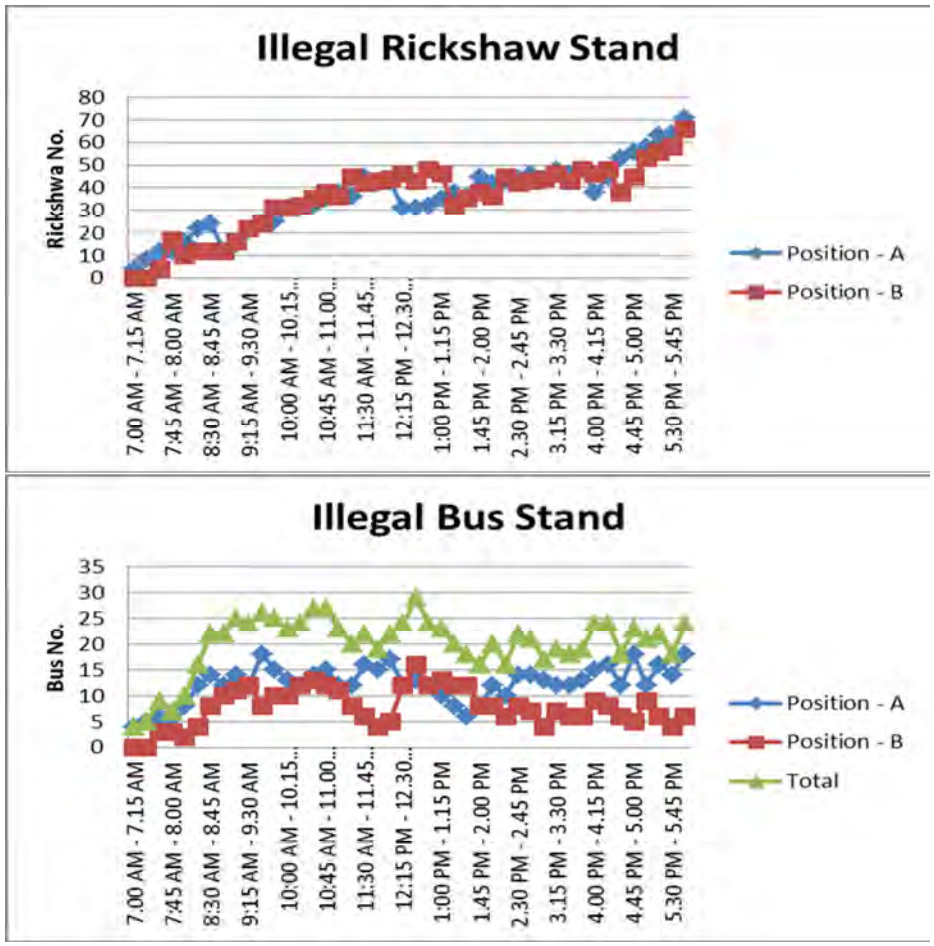


Figure 4.9.7: a) Position of Side Friction inside Bangla Motor Intersection; b) Contribution of Illegal Rickshaw Stand; c) Contribution of Illegal Bus Stand.

Analyzing Figure 4.9.7 a), b) and c); for illegal rickshaw stand, same two (2) points were found at same place of illegal bus stand under the over bridge also. 3, 135 nos. of rickshaw illegally stood in those two (2) points, which were interrupted the as usual flow of traffic through this intersection. For illegal bus stand, two (2) points were found underneath the over bridge both side of the road. 882 nos. of bus illegally stood these points on that day. They interrupted the natural flow of traffic by blocking the width of the approach. Generally, the combined effect of side friction was observed in the traffic flow of this intersection. 50% of total road width at the mouth of approach of this intersection was blocked by this side friction in the peak hour and the vehicular flow of primary road interrupted. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing as the progress of time.

iv. Traffic Control Devices

From the preliminary survey of this intersection, a condition survey of traffic control devices was organized. The outputs of this condition survey are given below in a tabular format, in Table 4.9.4.

Table 4.9.4: Signal Accessories of Bangla Motor Intersection.
Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP).

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Light Operate	Pedestrian Signal Light Operate
SP-1	OK	Two lamp missing	Yes	No
SP-2	OK	Broken	Yes	No
SP-3	OK	Two lamp missing	Yes	No
SP-4	OK	One lamp missing	-	No
MAP-1	OK	OK	Yes	-
MAP-2	OK	One lamp missing	Yes	No
MAP-3	OK	One lamp missing	Yes	-
TSC	OK	OK	-	-

Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

In his intersection, for traffic control there was no use of traffic signal; instead of this, police controlled the traffic movement of this intersection manually based on traffic flow demands among three (3) approaches which is considered to be as c demand responsive signal system

controlling system (one road er three road

stopped, which was the most inefficient method of traffic control. The traffic signal cycle time in this method is not consistent. The variation of signal cycle time in Bangla Motor intersection at peak periods are given in the following Figure 4.9.8.

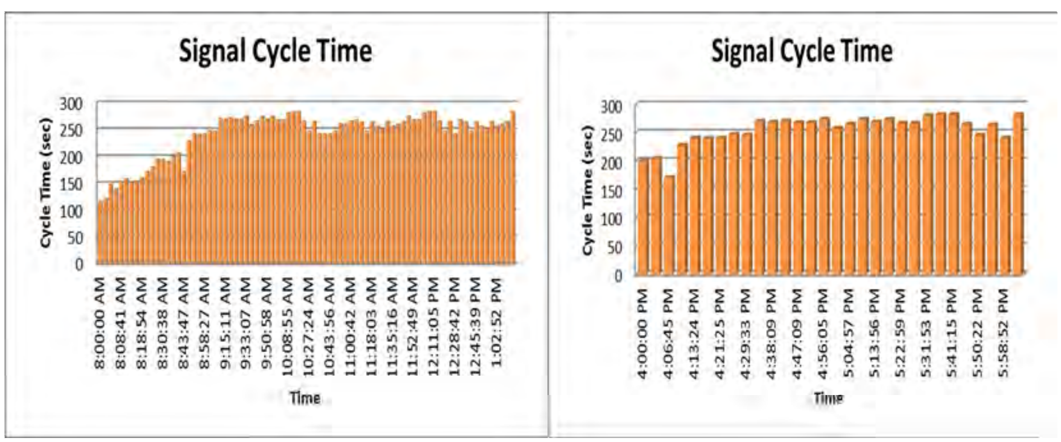


Figure 4.9.8: Signal Cycle Time at Peak Period (a) from 08.00 A.M. to 01.11 P.M.; (b) from04.00 P.M. to 05.58 P.M.

From the signal cycle time counting, it was observed that, 100.00% of total observation time was more than 120 sec, which is increasing the delay of the intersection as per research of *J. Li et al. (2004)*.

From the preliminary survey of this Bangla Motor intersection, the information about mode of operation of this intersection was observed. In the detail analysis of this information, it is tabulated in Table 4.9.5 below.

Table 4.9.5: Existing Traffic Control System and Time of Operation of Bangla Motor Intersection.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(08.00 PM 08.00 AM)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(08.00 AM 11.00 AM) (05.00 PM 08.00 PM)
4	Mixed	(11.00AM 05.00 PM)

Analyzing the Table 4.9.5, it is found that Bangla Motor intersection is operated in three (3) methods and different hours; automatic signal lighting system 12 hours of the total time of the day, automatic signal system (control by traffic police demand responsive) 6 hours and mixed (both automatic and controlled by police) 6 hours. In peak period this intersection is controlled by police manually.

The flow ratio of the two (2) approaches of this intersection at peak period is calculated, it is tabulated in Table 4.9.6, which is given below

Table 4.9.6: Flow Ratio of two approaches Bangla Motor Intersection.

Time	Farmgate to Bangla Motor, y_1	Sheraton to Bangla Motor, y_2	Summation, Y
08.00 A.M. - 08.15 A.M.	0.36	0.31	0.67
08.15 A.M. - 08.30 A.M.	0.53	0.42	0.95
08.30 A.M. - 08.45 A.M.	0.50	0.49	0.99
08.45 A.M. - 09.00 A.M.	0.63	0.49	1.12
09.00 A.M. - 09.15 A.M.	0.84	0.45	1.30
09.15 A.M. - 09.30 A.M.	0.99	0.46	1.45
09.30 A.M. - 09.45 A.M.	1.00	0.46	1.46
09.45 A.M. - 10.00 A.M.	0.88	0.59	1.46
10.00 A.M. - 10.15 A.M.	0.79	0.52	1.31
10.15 A.M. - 10.30 A.M.	0.87	0.53	1.40
10.30 A.M. - 10.45 A.M.	0.90	0.50	1.40
10.45 A.M. - 11.00 A.M.	0.97	0.44	1.41
11.00 A.M. - 11.15 A.M.	0.82	0.55	1.37
11.15 A.M. - 11.30 A.M.	0.84	0.68	1.52
11.30 A.M. 11.45 A.M.	0.75	0.80	1.55

11.45 A.M. 12.00 P.M.	0.82	0.76	1.59
12.00 P.M. 12.15 P.M.	0.73	0.75	1.48
12.15 P.M. 12.30 P.M.	0.69	0.64	1.33
12.30 P.M. 12.45 P.M.	0.63	0.66	1.29
12.45 P.M. 01.00 P.M.	0.48	0.69	1.17
03.30 P.M. 03.45 P.M.	0.51	0.54	1.04
03.45 P.M. 04.00 P.M.	0.55	0.57	1.12
04.00 P.M. 04.15 P.M.	0.72	0.69	1.41
04.15 P.M. 04.30 P.M.	0.73	0.82	1.55
04.30 P.M. - 04.45 P.M.	0.67	0.86	1.53
04.45 P.M. - 05.00 P.M.	0.79	0.82	1.61
05.00 P.M. - 05.15 P.M.	0.91	1.00	1.91
05.15 P.M. - 05.30 P.M.	0.93	0.76	1.69
05.30 P.M. - 05.45 P.M.	0.92	0.70	1.62
05.45 P.M. - 06.00 P.M.	0.64	0.84	1.48

By analyzing the Table 4.9.6 it is found that the traffic operation system by automatic signal will not work, because the summation of the flow ratio is greater than 1.00 all throughout the day in this intersection as per signal design theory.

D. Establishing Performance Evaluation Parameters for Signalized Road Intersections and Assesses Level of Service (LOS)

As per setout objectives of this research for finding out the LOS of the individual approach; queue length, delay was found out in detail survey of this intersection.

For finding out the effect of inefficiency in traffic control; queue length determination survey at peak period was organized in this intersection. The result of this survey is tabulated through the Table 4.9.7 and Table 4.9.8 below.

Table 4.9.7: Queue Length of Two approaches of Bangla Motor Intersection (Morning Peak).

Observation No.	Time	Queue Length (in meter)	
		Farmgate to Bangla Motor Approach (m)	Sheraton to Bangla Motor Approach (m)
1.	08.00 A.M. - 08.15 A.M.	0	0
2.	08.15 A.M. - 08.30 A.M.	116.26	0
3.	08.30 A.M. - 08.45 A.M.	187.34	0
4.	08.45 A.M. - 09.00 A.M.	221.34	0
5.	09.00 A.M. - 09.15 A.M.	278.34	123.57
6.	09.15 A.M. - 09.30 A.M.	328.92	134.56
7.	09.30 A.M. - 09.45 A.M.	309.69	176.63
8.	09.45 A.M. - 10.00 A.M.	345.67	217.34

9.	10.00 A.M. - 10.15 A.M.	355.45	265.77
10.	10.15 A.M. - 10.30 A.M.	378.97	298.23
11.	10.30 A.M. - 10.45 A.M.	393.43	312.23
12.	10.45 A.M. - 11.00 A.M.	412.21	332.43
13.	11.00 A.M. - 11.15 A.M.	354.44	342.22
14.	11.15 A.M. - 11.30 A.M.	385.33	328.92
15.	11.30 A.M. 11.45 A.M.	392.23	309.69
16.	11.45 A.M. 12.00 P.M.	404.44	345.67
17.	12.00 P.M. 12.15 P.M.	408.22	355.45
18.	12.15 P.M. 12.30 P.M.	394.56	378.97
19.	12.30 P.M. 12.45 P.M.	407.21	393.43
20.	12.45 P.M. 01.00 P.M.	401.59	432.22

Table 4.9.8: Queue Length of two Approaches of Bangla Motor Intersection (Evening Peak).

Observation No.	**Time**	**Queue Length (in meter)**	
		Farmgate to Bangla Motor Approach (m)	**Sheraton to Bangla Motor Approach (m)**
1.	04.00 P.M. 04.15 P.M.	355.45	278.44
2.	04.15 P.M. 04.30 P.M.	378.97	312.43
3.	04.30 P.M. - 04.45 P.M.	393.43	356.78
4.	04.45 P.M. - 05.00 P.M.	412.21	378.53
5.	05.00 P.M. - 05.15 P.M.	354.44	412.33
6.	05.15 P.M. - 05.30 P.M.	385.33	443.66
7.	05.30 P.M. - 05.45 P.M.	392.23	392.23
8.	05.45 P.M. - 06.00 P.M.	404.44	412.23
9.	06.00 P.M. 06.15 P.M.	408.22	422.32

Analyzing the result of the queue length survey, it was measured on two (2) approaches of this intersection. Maximum queue length was found in this intersection at different approach with the progress of the time. The queue length was observed in Farmgate to Bangla Motor approach at morning peak 412.21 m and at evening peak 412.21 m, and Sheraton to Bangla Motor approach at morning peak 432.22 m and at evening peak 443.66 m. Among them, the queue length of this intersection was increasing with the progress of time, 81.03% of total observation time, the queue length was over 200 m, which was very worst as per research of *J. Li et al. (2004).*

After that, another parameter for determination of LOS, delay was found out through a delay determination survey. This survey had two parts; one was determination of travel time at free flow condition and other was determination of travel time in field condition. Firstly the free flow travel time in every approach of this intersection was counted. The free flow condition travel time of this Bangla Motor intersection is presented here in a tabular format in Table 4.9.9.

Table 4.9.9: Travel Time at Free Flow Condition of Bangla Motor Intersection (sec).

Observation No.	Time	SAARC Fowara to Bangla Motor (sec)	Paribagh to Bangla Motor (sec)
1.	07.00 A.M. - 07.30 A.M.	4	7

After this, for finding out the delay of this intersection, a travel time counting survey in field condition was organized; from here travel time was collected on every approaches of this intersection from 07.00 A.M to 06.00 P.M. After getting this travel time of every approach, deducting the free flow time from surveyed travel time, delay was found from every approaches all throughout the day. The delays of these approaches are shown below from 07.00 A.M. to 06.00 P.M. in Table 4.9.10.

Table 4.9.10: Delay at Different Approach of Bangla Motor Intersection.

Observation No.	Time	Delay (SAARC Fowara to Bangla Motor) sec	Delay (Paribagh to Bangla Motor) sec
1.	07.00 A.M. 07.30 A.M.	4	4
2.	07.30 A.M. 08.00 A.M.	10	11
3.	08.00 A.M. 08.30 A.M.	14	22
4.	08.30 A.M. 09.00 A.M.	24	42
5.	09.00 A.M. 09.30 A.M.	52	38
6.	09.30 A.M. 10.00 A.M.	72	60
7.	10.00 A.M. 10.30 A.M.	121	106
8.	10.30 A.M. 11.00 A.M.	266	121
9.	11.00 A.M. 11.30 A.M.	321	160
10.	11.30 A.M. 12.00 P.M.	781	288
11.	12.00 P.M. 12.30 P.M.	830	360
12.	12.30 P.M. 01.00 P.M.	928	441
13.	01.00 P.M. 01.30 P.M.	994	537
14.	01.30 P.M. 02.00 P.M.	980	771
15.	02.00 P.M. 02.30 P.M.	963	860
16.	02.30 P.M. 03.00 P.M.	872	758
17.	03.00 P.M. 03.30 P.M.	659	661
18.	03.30 P.M. 04.00 P.M.	883	732
19.	04.00 P.M. 04.30 P.M.	967	819
20.	04.30 P.M. 05.00 P.M	1039	987
21.	05.00 P.M. 05.30 P.M.	980	980
22.	05.30 P.M. 06.00 P.M.	241	966

Analyzing the Table 4.9.10 the delay at two (2) approaches of Bangla Motor intersection is increasing as the progress of the day time was found. Approach wise comparison of delay time is shown in Figure 4.9.9 below.

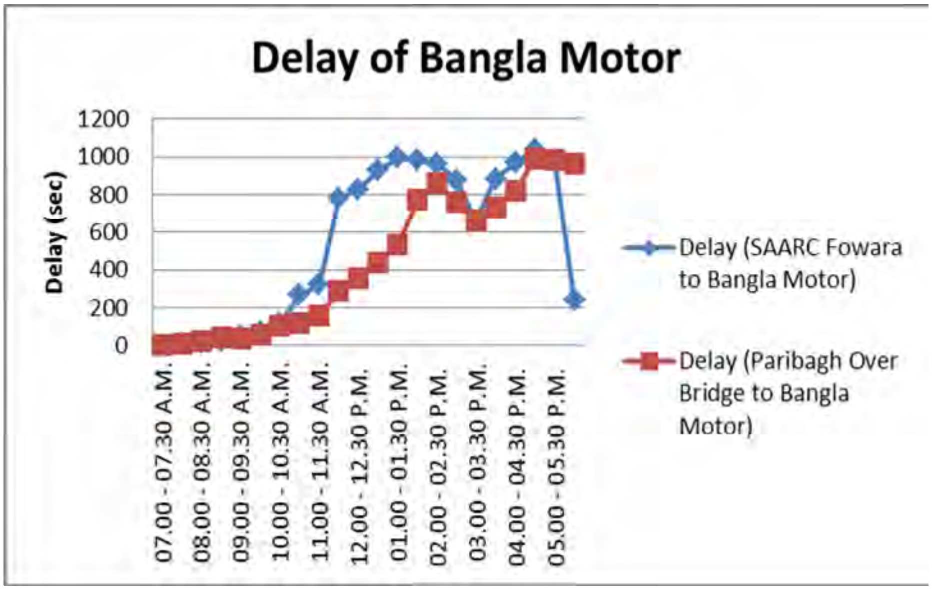


Figure 4.9.9: Comparison of Delay at Different Approach of Bangla Motor Intersection.

Analyzing the Figure 4.9.9, the maximum delay was found in both two (2) approaches.

E. Evaluation Performance of the Intersections Based on LOS Ranking

Finally, based on the delay on two (2) approaches of this intersection, LOS was calculated for Bangla Motor intersection. In the following Table 4.9.11 and Figure 4.9.10 the LOS of this intersection is presented below, the detailed calculation of LOS is given in Appendix A

Table 4.9.11: LOS of Different Approaches of Bangla Motor Intersection.

Observation No.	Time	LOS (SAARC Fowara to Bangla Motor)	LOS (Paribagh to Bangla Motor)
1.	07.00 A.M. 07.30 A.M.	A	A
2.	07.30 A.M. 08.00 A.M.	A	B
3.	08.00 A.M. 08.30 A.M.	B	C
4.	08.30 A.M. 09.00 A.M.	C	E
5.	09.00 A.M. 09.30 A.M.	F	E
6.	09.30 A.M. 10.00 A.M.	F	F
7.	10.00 A.M. 10.30 A.M.	F	F
8.	10.30 A.M. 11.00 A.M.	F	F
9.	11.00 A.M. 11.30 A.M.	F	F
10.	11.30 A.M. 12.00 P.M.	F	F
11.	12.00 P.M. 12.30 P.M.	F	F
12.	12.30 P.M. 01.00 P.M.	F	F
13.	01.00 P.M. 01.30 P.M.	F	F

14.	01.30 P.M. 02.00 P.M.	F	F
15.	02.00 P.M. 02.30 P.M.	F	F
16.	02.30 P.M. 03.00 P.M.	F	F
17.	03.00 P.M. 03.30 P.M.	F	F
18.	03.30 P.M. 04.00 P.M.	F	F
19.	04.00 P.M. 04.30 P.M.	F	F
20.	04.30 P.M. 05.00 P.M.	F	F
21.	05.00 P.M. 05.30 P.M.	F	F
22.	05.30 P.M. 06.00 P.M.	F	F

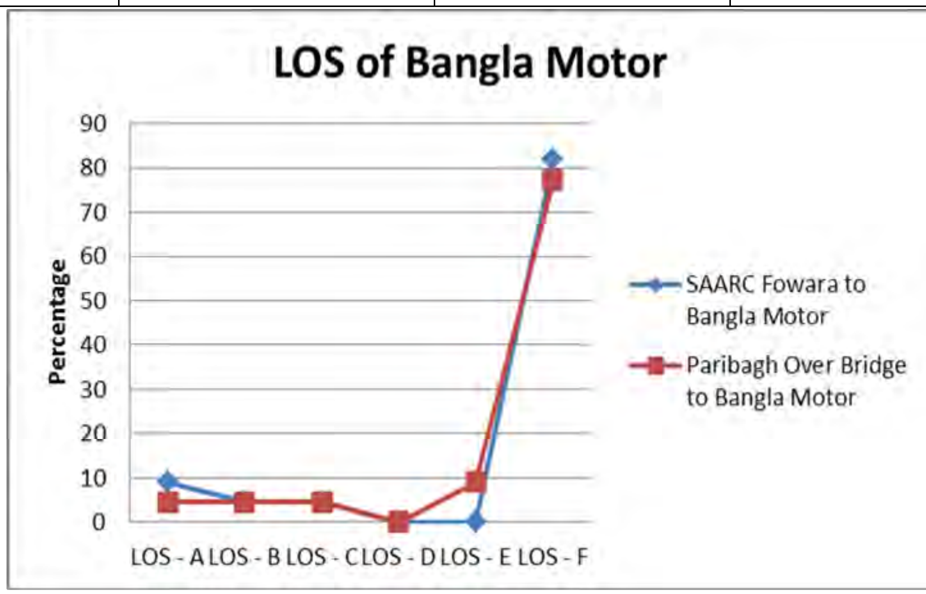


Figure 4.9.10: Percentage of Various LOS at Different Approaches of Bangla Motor Intersection.

By analyzing the Table 4.9.11 and Figure 4.9.10 the LOS of different approaches of this intersection, it was found that during 11 hours survey period for SAARC Fowara to Bangla Motor approach, the LOS level A, B, C, D, E and F were observed to be 9%, 4.5%, 4.5%, 0%, 0% and 81.81% of survey time respectively. Similarly for approach Paribagh Over Bridge to Bangla Motor approach the LOS level A, B, C, D, E and F were observed to be 4.5%, 4.5%, 4.5%, 0%, 9.0%, and 77.27%. The LOS of two (2) approaches of this intersection was retaining at Level F consistently. For present Dhaka Metropolitan City, it is a curse.

4.10 Quantitative Data Analysis of Mirpur - 10 Intersection

A. Site Investigation of Mirpur 10 Intersection:

According to the classification of intersection the 10 intersection is a roundabout intersection with four (4) approaches. In this intersection point one primary road and one secondary road cross with each other. The name of the primary road is Begum Rokeya Avenue (north - south) and the name of secondary road is Mirpur Road (east west, coming from Mirpur 1 to Mirpur - 14). There are so many land use activity such as shopping malls, market, banks, schools, indoor stadium, health clinic, garments factory, Cantonment area, residential area by both of the sides in northern part. To the south approach (towards Agargaon intersection) there are residential areas, shopping mall, government / non-government office, super markets, banks, private school and college, clinic, commercial areas built up both of the sides. To the east approach towards Mirpur 14, there are police barrack, NAM Vaban, BRTA office, renowned schools and colleges, Cantonment area, health clinic, residential area built up both of the sides. To the west approach, towards Mirpur 1 intersection, Sher-e-Bangla National Cricket Stadium, Swimming pool, BTCL office, National Heart Foundation, National Kidney Foundation, Bank Training Institute (BTI), Grameen Bank Office, university, college, schools, technical institutes, City Corporation office, Markets, Shopping malls, residential area, etc. These land use activities generate huge pedestrian and vehicular flow which creates a tremendous thrust on this round about intersection throughout the day.

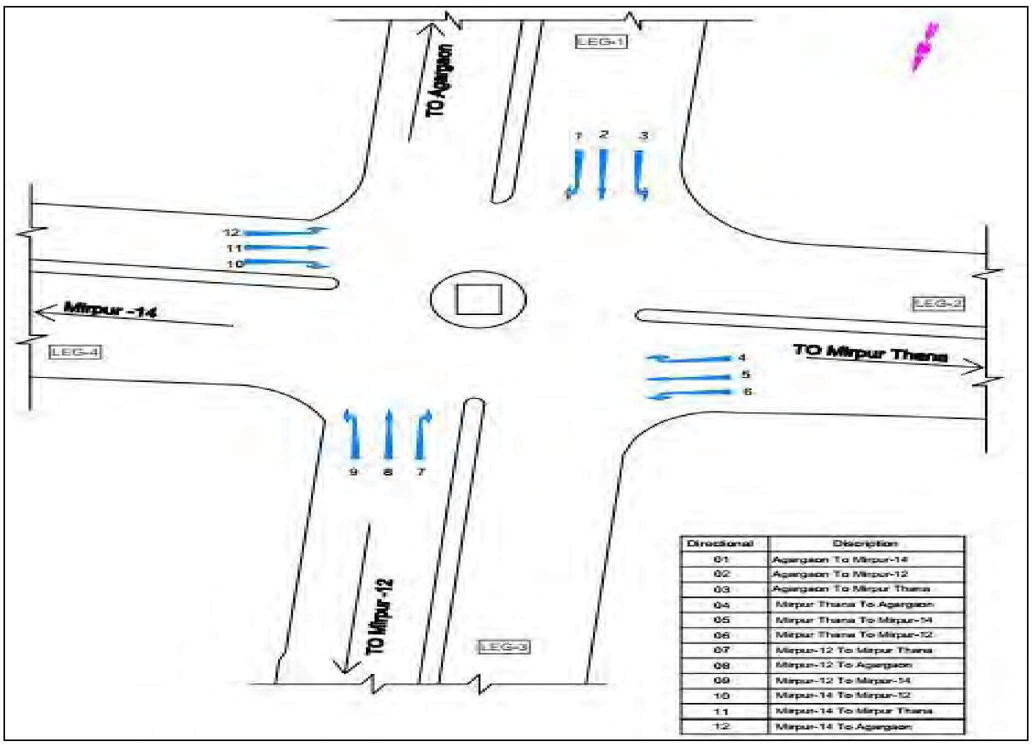


Figure 4.10.1: Layout of Mirpur 10 Intersection.

Source: (Signal Synchronization Study, 2013)

From preliminary survey of this selected intersection, the four (4) approaches are found lane divided with necessary marking. A table describing the lane division of different approaches is given below.

Table 4.10.1: Approach of Mirpur 10 Intersection with Lane Division.

Serial No.	Approach with Direction	Lane Number
Leg 1	Mirpur 10 Intersection to Mirpur 12	2 lanes both direction
Leg 2	Mirpur 10 Intersection to Mirpur 14	2 lanes both direction
Leg 3	Mirpur 10 Intersection to Agargaon	2 lanes both direction
Leg 4	Mirpur 10 Intersection to Mirpur 1	2 lanes both direction

The main carriageway of this intersection is flexible pavement in all direction. But frequent road digging is found in the four (4) approaches for regular maintenance. In the preliminary survey time, the road lane extension work in two approaches, Leg 1, towards Mirpur 12 and Leg 2, towards Mirpur 14 was found.

By observing the preliminary condition of traffic flow, two (2) distinct peak hours were found in this intersection; one, in the morning from 08.30 A.M. to 12.00 P.M. and other, in the evening from 03.30 P.M. to 06.00 P.M. and furthermore (beyond the survey time), which is higher than the morning peak. In morning hour the traffic flow started to increase in this intersection and mid of the day the vehicular flow rate became steady and at end part of the day the traffic flow increased once again.

There was the provision of automatic traffic signal for traffic control, but this was not practiced in field. So, all of the signals were as showpiece in a showcase. Traffic police tried to control the traffic of this intersection manually. Signal timing, phasing was not consistent for this. They tried to operate this intersection responding as per demand. So a lot of delay occurred here and queue length originated in peak period too.

In near future, this intersection will be the entry place of Banani Flyover. It will play an important role in Dhaka City road network. It will be a link for keeping connection between east and west part of Dhaka city, shortening travel time.

B. Geometric and Operating Conditions of Selected Intersection (Mirpur - 10)

After finishing the detail survey of selected intersection, Mirpur 10; analysis of collected data about the intersection geometry and operating condition was done. The findings of this analysis are tabulated in Table 4.10.2 below.

Table 4.10.2: Geometric and Operating Condition of Mirpur 10 Intersection.

Serial No.	Items	Description
1.	**Number of Approaches**	There are four (4) approaches namely from Mirpur 12 to Mirpur 10 approach, from Mirpur 14 to Mirpur 10 approach, from Agargaon to Mirpur 10 approach and from Mirpur 1 to Mirpur 10 approach.

2.	**Carriageway**	All four (4) approaches of this intersection are flexible pavement in structural point of view and dual carriageway.
3.	**Footpath Coverage**	Footpaths for pedestrian are found existing here, by the both of the side of all the four approaches of this intersection, which is illegally occupied by purveyors, building materials, parked vehicle, etc. Mirpur 10 intersection has 100% footpath coverage.
4.	**Channelization**	There are no channels for left turning in any approach of this intersection.
5.	**Divider**	All approaches of this intersection are alienated by the non - engineering divider. This non engineering divider is not related with velocity profile of vehicle of this intersection. The non engineering divider is replaced by the engineering divider now.
6.	**Pedestrian Crossing Facility**	There is a four (4) legged over bridge, which is at the center of this intersection, providing pedestrian crossing facility as a grade separated service, but pedestrians try to cross the intersection through the busy road at grade as usually.
7.	**Side Road**	From preliminary survey of Mirpur 10 intersections surrounding area; eight (8) side roads, which are coming from neighboring residential / commercial area of this intersection, exposed in this intersection directly, containing maximum NMV on it.

C. Determining the Existing Vehicular, Pedestrian Flow, Amount of Side Friction, and Condition of Traffic Control Devices including Signal Timing, Phasing and Mode of Operation at Mirpur - 10 Intersection:

In detail survey of Mirpur 10 intersection; existing vehicular flow, pedestrian flow was observed, furthermore amount of side friction was exposed and condition of traffic signal, signal timing, phasing and mode of operation was documented and which was analyzed later.

i. Existing Vehicular Flow

Analyzing the exiting vehicular flow of Mirpur 10 intersection, an 11 hours vehicular survey (from 07.00 A.M. to 06.00 P.M.) was organized, the result of this survey and its analysis are presented here in Figure 4.10.2 a) and b), this figure is presenting a general graph accompanying with a pie chart, which is presenting the data of vehicular survey of this intersection and expressing the characteristics of vehicular flow through this intersection.

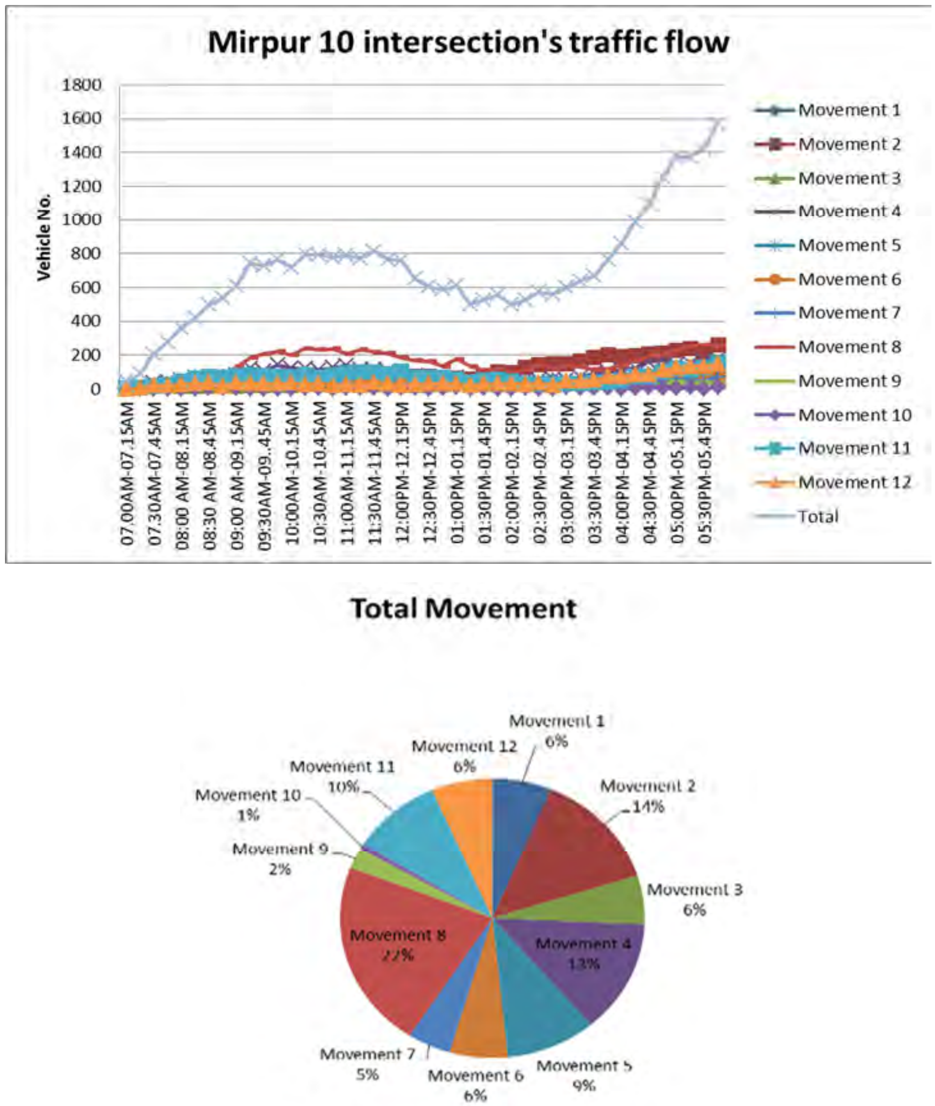
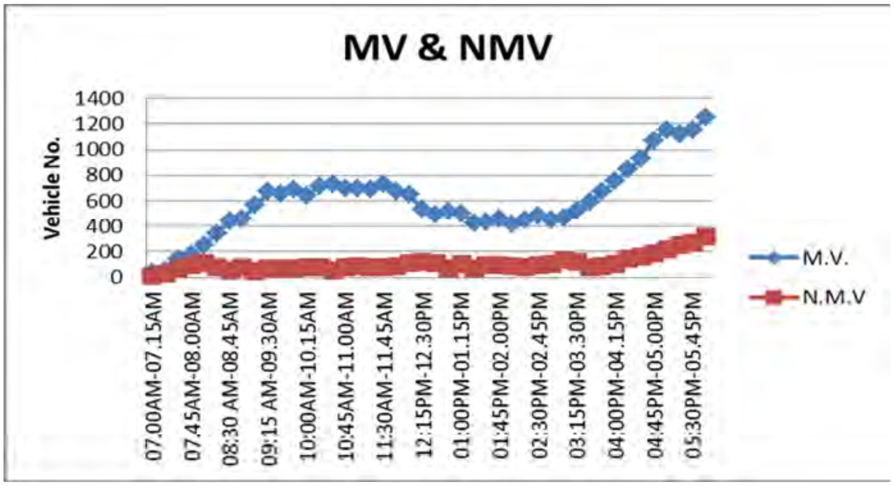


Figure 4.10.2: a) Vehicular Flow Data of Mirpur - 10 Intersection; b) Vehicle Movement Contribution of Mirpur - 10 Intersection.

Analyzing the vehicular survey data of this intersection, twelve (12) individual movements were found and among them movement 8 (from Mirpur 12 to Agargaon) was maximum, which contained 22% of entire traffic flow of this intersection on the day of survey. From the entire 11 hour vehicular survey, two (2) distinct peak hours were found in this intersection, one, in the morning from 08.30 A.M. to 12.00 P.M. and other, in the evening from 03.30 P.M. to 06.00 P.M. and furthermore (beyond the survey time), which is higher than the morning peak, total peak hour of the survey time was 5.5 hours, which was 54.54 % of total survey time.

After analyzing the vehicular flow of this intersection, assessment of the vehicular combination of this intersection was done. The result of this analysis is presented here in Figure 4.10.3 a) and b), this figure is presenting a general graph accompanying with a pie chart.



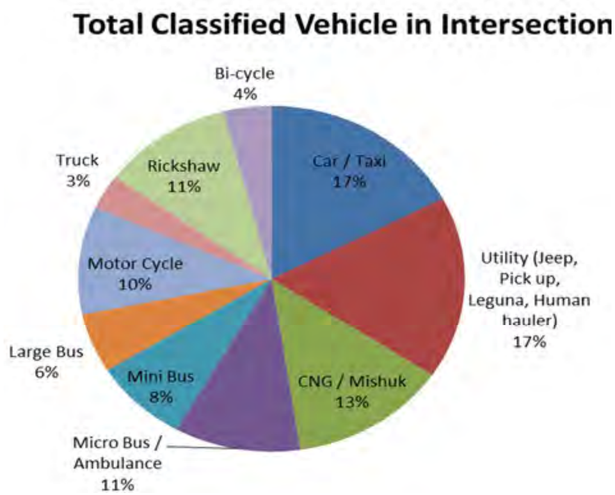


Figure 4.10.3: a) Individual Flow of MV and NMV in Mirpur 10 Intersection; b) Classified Vehicle in Mirpur 10 Intersection.

In Figure 4.10.3 a), a general graph is shown, which is showing the individual flow of MV and NMV through this intersection. Analyzing this general graph, two (2) distinct peak hours are found for MV; it was observed from 08.30 A.M. to 12.30 P.M. at morning and from 03.30 P.M. to 06.00 P.M. and furthermore at evening period. A constant rate of NMV flow was found through this intersection all throughout the day. In Figure 4.10.3 b), a pie chart is shown, which is expressing the vehicular composition of this intersection. The dominancy of MV is found out from here, which was 85% of total vehicular flow; among the vehicular flow car / taxi and utility were the mostly governed vehicle type in this intersection, which were 17% of total flow for both.

After finding out the vehicular composition, the saturation flow of every approach of this intersection was calculated from the vehicular survey data. The result of this analysis is presented here through a tabular format in Table 4.10.3 below.

Table 4.10.3: Saturation Flow of Different Approach of Mirpur - 10 Intersection.

Serial No.	**Intersection Name**	**Intersection Classification**	**Approach Name**	**Saturation Flow (PCU / Hour)**
1.	Mirpur - 10	Round About	Agargaon to Mirpur 10	2054.84
2.			Mirpur Thana to Mirpur 10	1613.44
3.			Mirpur 12 to Mirpur 10	1633.24
4.			Mirpur 14 to Mirpur 10	1085.72

Later, the usages of road space of every approaches of this intersection were calculated. The result of this calculation is presented here through Figure 4.10.4 a), b), c) and d) with individual general graph, which is expressing the flow ratio with respect to saturation flow of the individual approach of this intersection of 11 hours (from 07.00 A.M. to 06.00 P.M.).

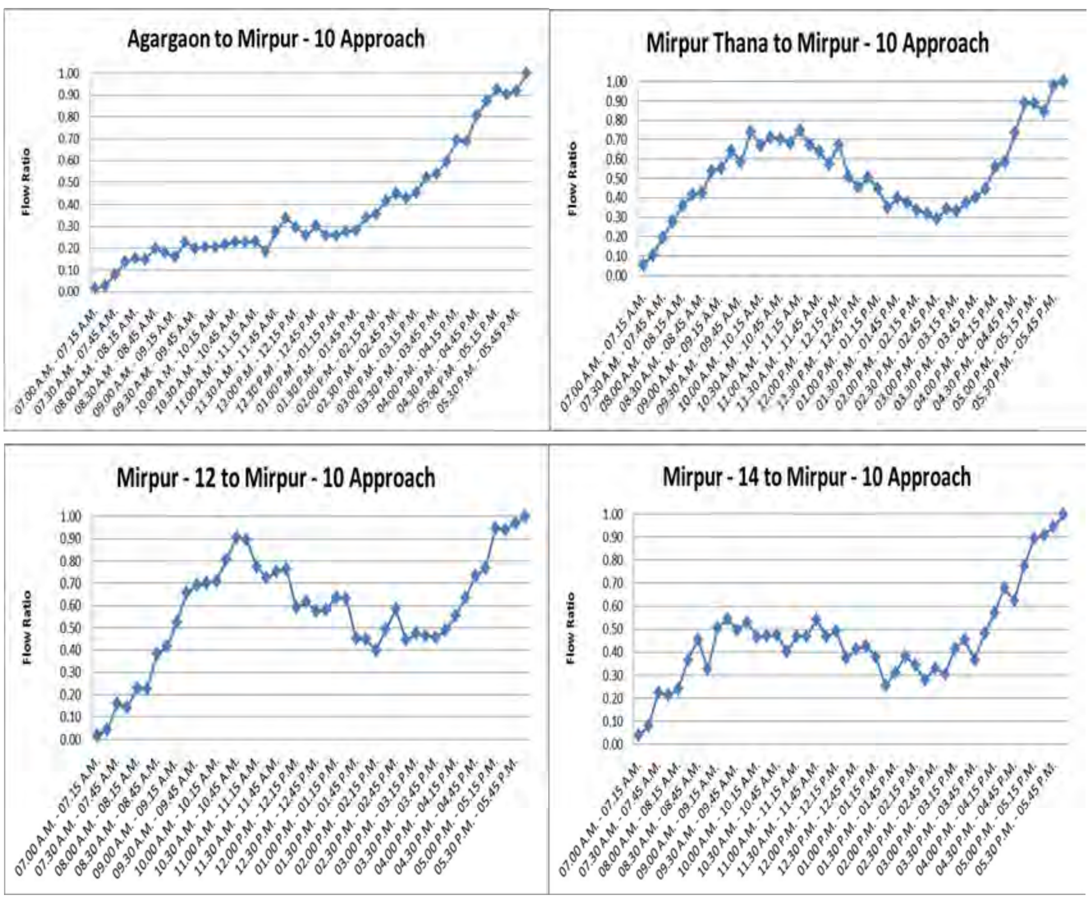


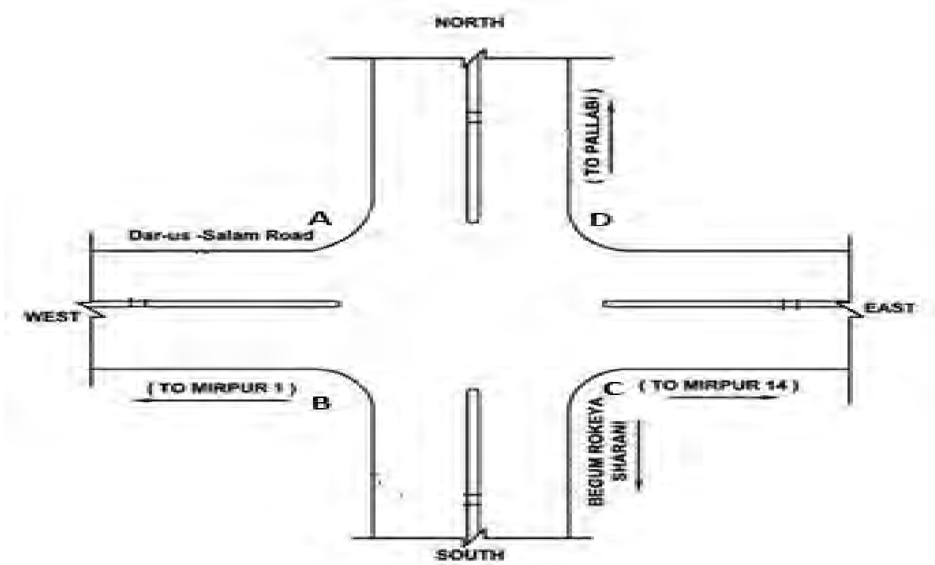
Figure 4.10.4: a) Flow Ratio of Agargaon to Mirpur 10 Approach; b) Flow Ratio of Mirpur Thana to Mirpur - 10 Approach; c) Flow Ratio of Mirpur 12 to Mirpur 10 Approach; d) Flow Ratio of Mirpur 14 to Mirpur 10 Approach.

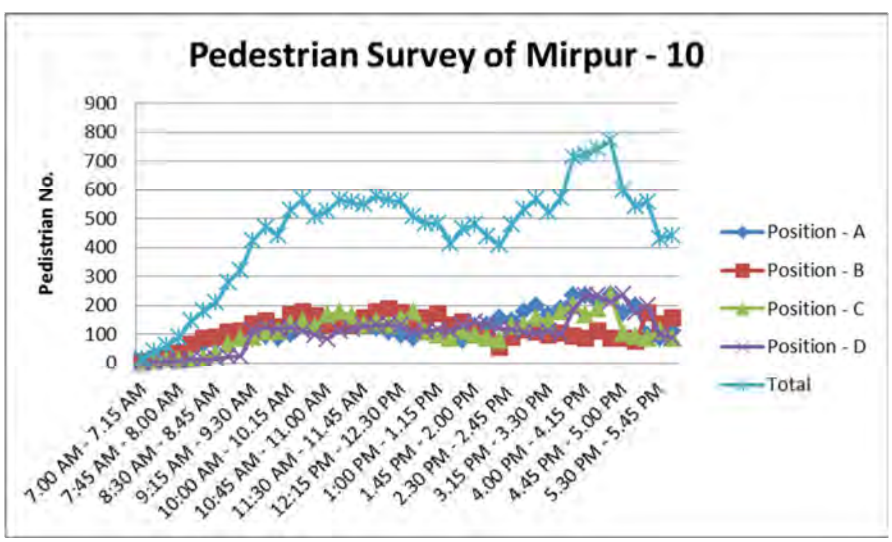
From Figure 4.10.4, it is observed that, every approach of this intersection were containing in two (2) peak hours in vehicular flow; one in the morning and other in the evening.

ii. Pedestrian Flow

As per set out objectives of this research, the pedestrian flow through this intersection was also observed. In preliminary survey, two types of pedestrian flow were observed; one was at grade and other was grade separated.

In this intersection, detail 11 hours (from 07.00 A.M. to 06.00 P.M.) pedestrian survey was organized for finding out the scenario of at grade pedestrian flow. After analyzing the result of this, it is presented here in Figure 4.10.5 a), b) and c), through a general graph accompanying with a CAD drawing and pie chart.





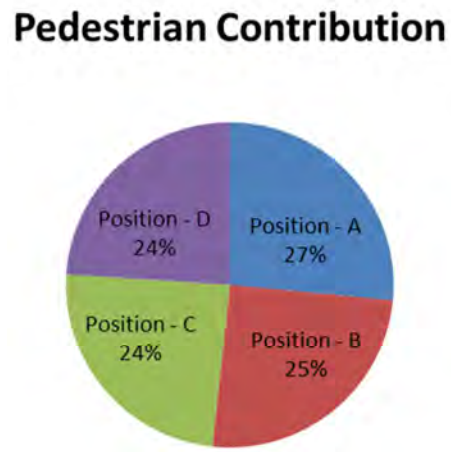
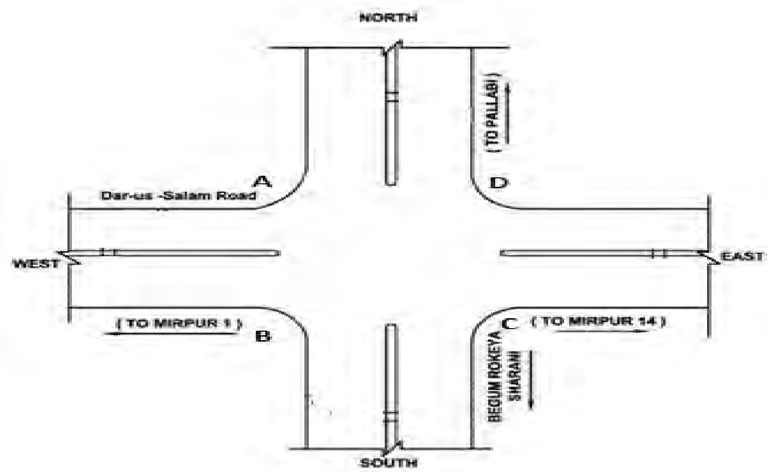
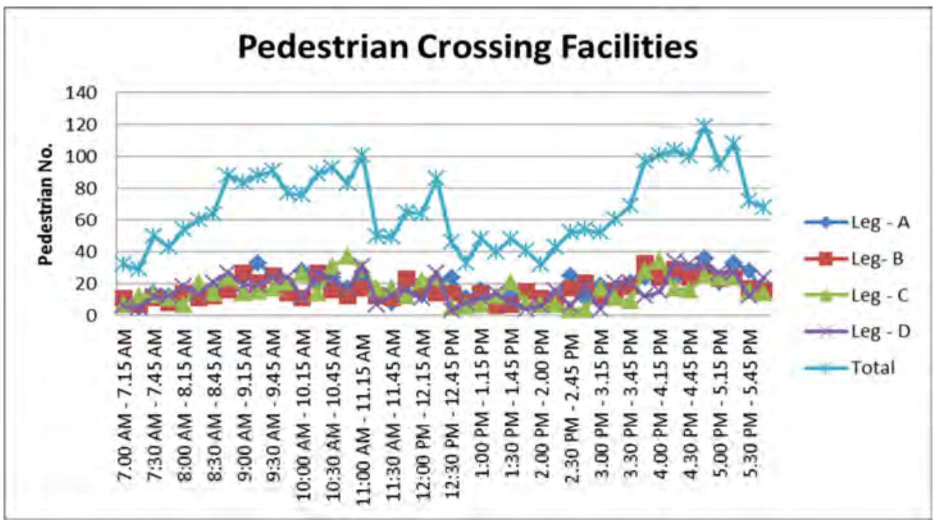


Figure 4.10.5: a) Pedestrian Survey Position inside Mirpur 10 Intersection; b) Pedestrian Flow; c) Pedestrian Flow Contribution among four (4) Positions.

From the preliminary survey, the four (4) positions were selected for detail field survey according to the availability of pedestrian in this intersection. The positions of those four (4) points are shown here in Figure 4.10.5 a). From Figure 4.10.5 b) at grade pedestrian flow through this intersection is presented, two (2) peak hours is found from it, one in the morning from 09.30 A.M. to 01.00 P.M. and other in the evening from 04.00 P.M. to 06.00 P.M and further beyond the survey time. Among the four (4) positions, maximum at grade pedestrian flow was occurred in position A, which is at the corner of Fire Brigade and Civil Defense, 27% percent of entire at grade pedestrian flow took place in this position which is presented here in Figure 4.10.5 c).

A four (4) legged over bridge is situated inside this intersection as a grade separated crossing facilities for pedestrian. For finding out the scenario of grade separated pedestrian crossing facility of this intersection, an 11 hours (from 07.00 A.M. to 06.00 P.M.) pedestrian crossing survey was organized in this over bridge. After analyzing the result of this pedestrian survey, it is presented here in Figure 4.10.6 a), b) and c), through a general graph accompanying with a CAD drawing and pie chart.





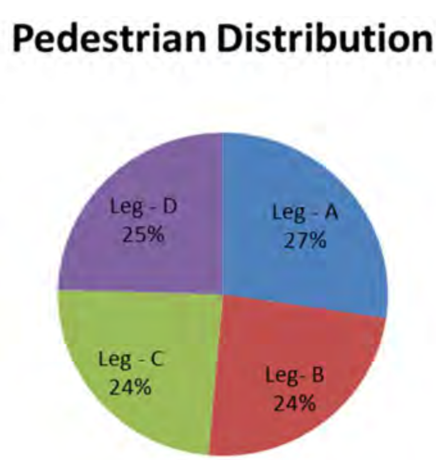


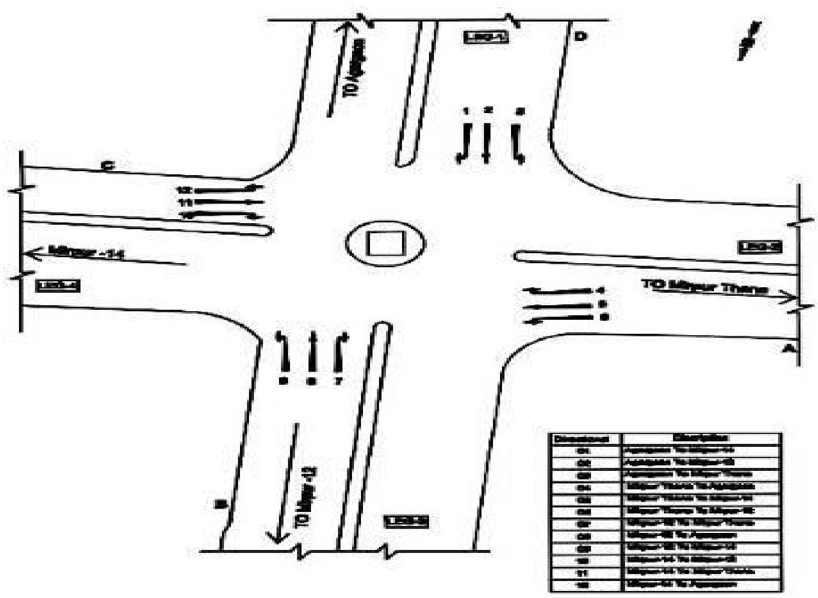
Figure 4.10.6: a) Position of Foot Over Bridge at Mirpur - 10 Intersection; b) Grade Separated Pedestrian Flow; c) Pedestrian Flow Contribution among four (4) Legs.

From Figure 4.10.6 a), b) and c) , from 11 hours survey it was observed that total 2, 999 nos. of pedestrian used this over bridge as a crossing facility through this intersection, the legs of the over bridge is indicated by Leg A, Leg B, Leg C and Leg D in CAD drawing. With respect to total pedestrian flow only 15 % pedestrian used this facility on that day. Among the four legs of this over bridge, about 27% of intersection crossing pedestrian was found in Leg A, which is at the corner of Fire Brigade and Civil Defense.

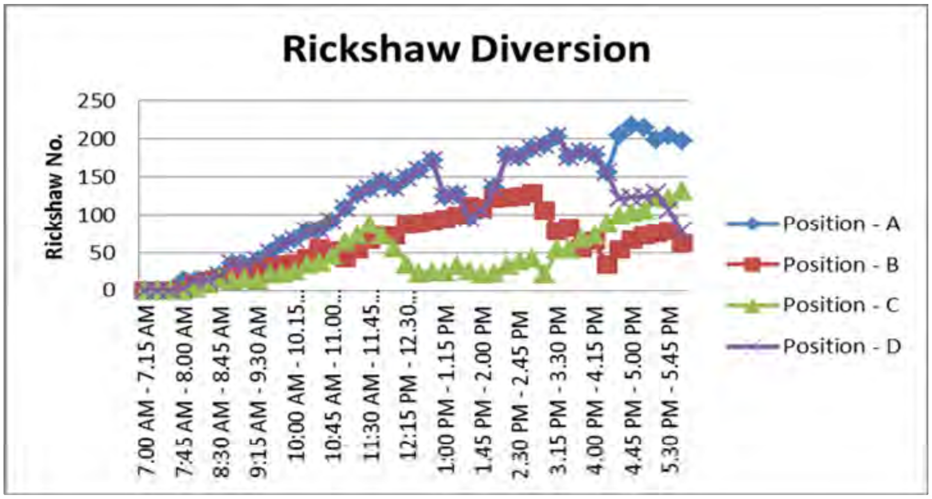
iii. Side Friction

As per set out objectives of this research, the amount of side friction in this intersection was also determined. From the preliminary survey of this intersection the four (4) specified reasons of side friction were found rickshaw diversion, illegal human hauler stand, bus stand and rickshaw stand. For finding out the scenario of side friction, an 11 hour . to 06.00 P.M.) was organized.

From the preliminary survey of this intersection, it was observed that, there were four (4) distinct points inside the intersection (Abdul Baten Sarak, REX er goli, behind the Shah Ali Plaza and S.A. paribahan road), from where rickshaw / NMV were diverted by the community police, which created a lot of jam on these approaches. For understanding the real scenario of this rickshaw diversion, a counting survey was organized in the final survey of this intersection. The result of this survey is presented here in Figure 4.10.7 a), b) and c).



Mirpur-10 Intersection



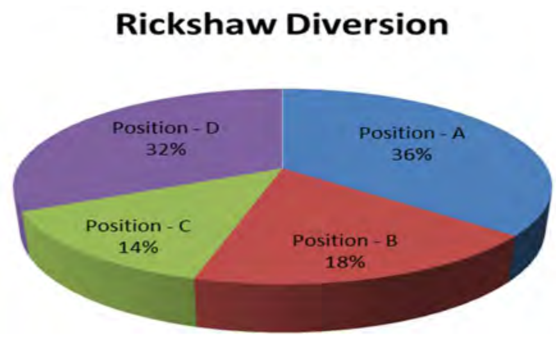
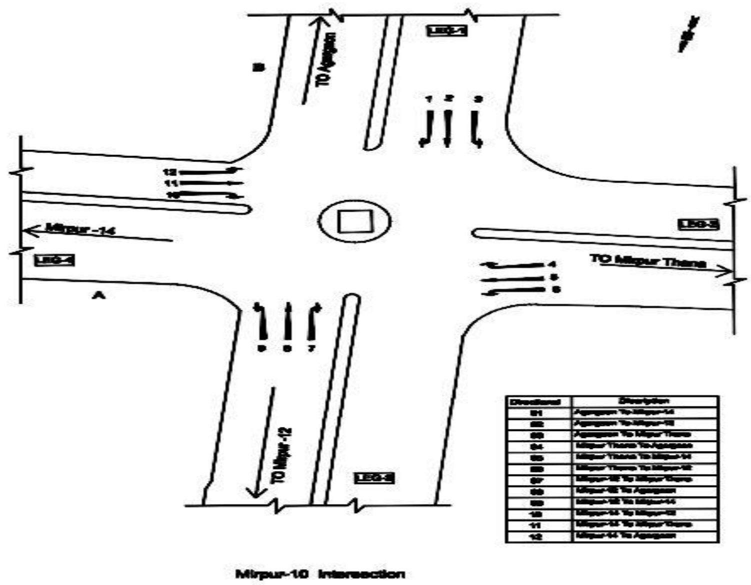
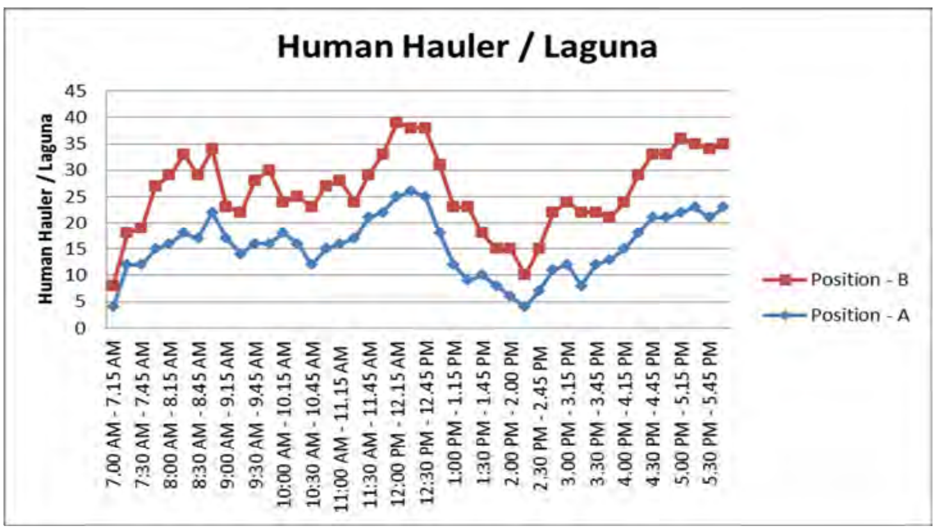


Figure 4.10.7: a) Position of Rickshaw Diversion inside Mirpur - 10 Intersection; b) Rickshaw Diversion All Throughout the Day; c) Contribution of Rickshaw Diversion.

From the above Figure 4.10.7 a), b) and c); analyzing the 11 hours survey result, a huge amount of rickshaw were diverted from these points on the main approach of this intersection. Among the four (4) points the most amount of rickshaw were diverted from Abdul Baten Sarak, it is situated on the Mirpur Thana to Mirpur - 10 approach. Though the rickshaw diversion is a continuing process in this intersection, but rickshaw was found in the vehicle count of this intersection.

From the preliminary survey of this intersection, it was observed that, there were two (2) distinct points inside the intersection (at the corner of Shah Ali Plaza, on the mouth of Mirpur 10 to Mirpur 14 approach), illegal human hauler and Laguna was found. They stood in these two (2) points haphazardly and interrupt the general traffic flow through this intersection. For finding out the scenario of this an 11 hours counting survey was arranged. The result of this counting survey is presented here through Figure 4.10.8 a), b) and c).





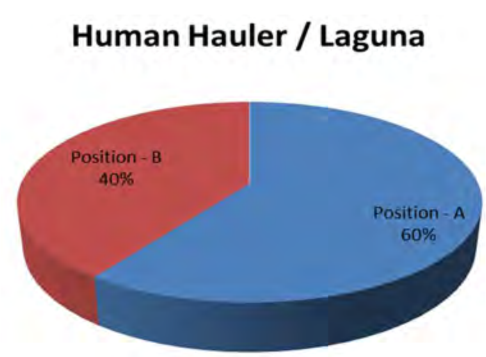
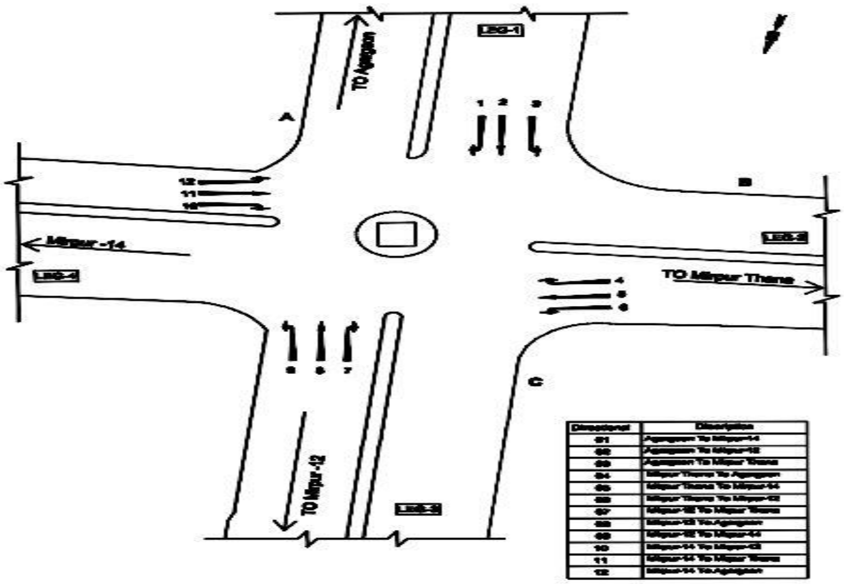


Figure 4.10.8: a) Position of Human Hauler inside Mirpur - 10 Intersection; b) Human Hauler all throughout the Day; c) Contribution of Human Hauler.

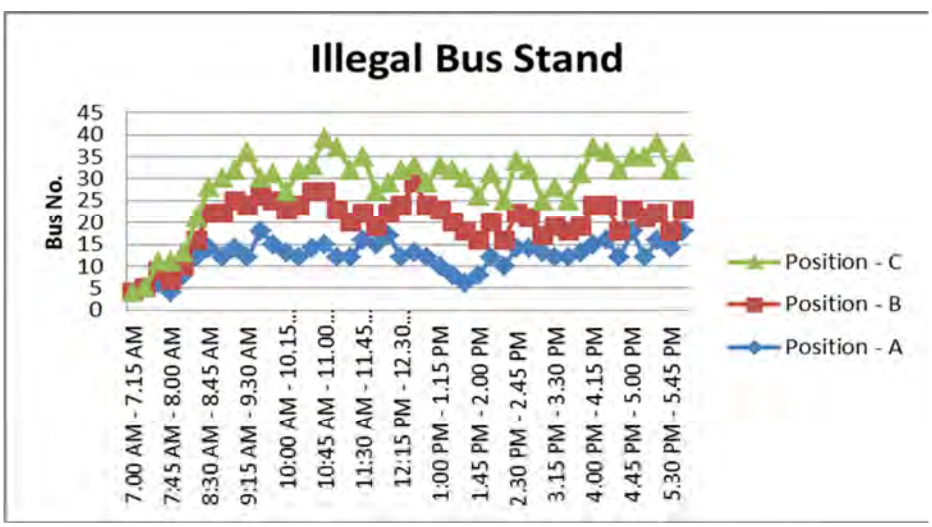
From the above Figure 4.10.8 a), b) and c); analyzing the 11 hours survey result, a huge amount of human hauler / Laguna were stood in these two (2) points on the main approach of this intersection. Among the two (2) points the most amount of human hauler

/ Laguna were stood on the mouth of Mirpur 10 to Mirpur 14 approach. Around 60% of total illegal standee stood in this point.

From the preliminary survey of this intersection, it was observed that, there were three (3) distinct points inside the intersection (at the corner of Shah Ali Plaza, on the mouth of Mirpur 10 to Mirpur Thana approach and on the mouth of Mirpur 10 to Mirpur 12 approach), illegal bus stand were found. They stood in these three (3) points haphazardly and interrupted the general traffic flow through this intersection. For finding out the scenario of this an 11 hours counting survey was arranged. The result of this counting survey is presented here through Figure 4.10.9 a), b) and c).



Mirpur-10 Intersection



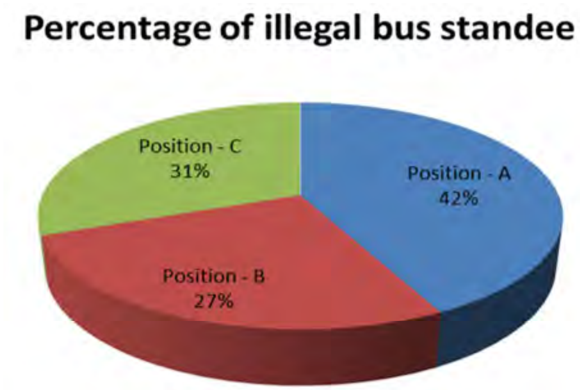


Figure 4.10.9: a) Position of Illegal Bus inside Mirpur - 10 Intersection; b) Illegal Bus all throughout the Day; c) Contribution of Illegal Bus.

From the above Figure 4.10.9 a), b) and c); analyzing the 11 hours survey result, a huge amount of bus were stood in these three (3) points on the main approach of this intersection. Among the three points the most amount of bus were stood on the mouth of Mirpur 10 to Mirpur 12 approach. Around 42% of total illegal standee stood in this point.

Generally the combined effect of side friction was observed in the traffic flow of this intersection. 60% of total road width at the mouth of approach of this intersection was blocked by this side friction in the peak hour. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing day by day.

iv. Traffic Control Devices

From the preliminary survey of this intersection, a condition survey of traffic control devices was organized. The output of this condition survey is given below in a tabular format, in Table 4.10.4.

Table 4.10.4: Signal Accessories of Mirpur 10 Intersection.

Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Operate	Pedestrian Signal Operate
SP-1	OK	Rotated	Yes	No
SP-2	OK	OK	-	No
SP-3	OK	OK	-	No
SP-4	OK	All missing	-	-
SP-5	OK	OK	No	No
SP-6	OK	Rotated	-	No
SP-7	OK	Rotated	Yes	No
SP-8	OK	Missing	-	No
SP-9	Signal	Missing	Yes	No

	lights hidden			
SP-10	OK	Missing	-	No
MAP-1	Signal lights hidden	Missing	Yes	No
MAP-2	OK	OK	-	-
MAP-3	OK	Rotated	-	No
MAP-4	OK	Missing	No	-
MAP-5	One side signal light hidden	OK	Yes	No
TSC	OK	OK	-	-

Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

In this intersection, for traffic control there was no use of traffic signal; instead of this, police controlled the traffic movement of this intersection manually based on traffic flow demands among four approaches which is considered to be as mand responsive signal system

system (one road

was the most inefficient method of traffic control. The traffic signal cycle time in this method is not consistent. The variation of signal cycle time in Mirpur 10 intersection at peak periods are given in the following Figure 4.10.10.

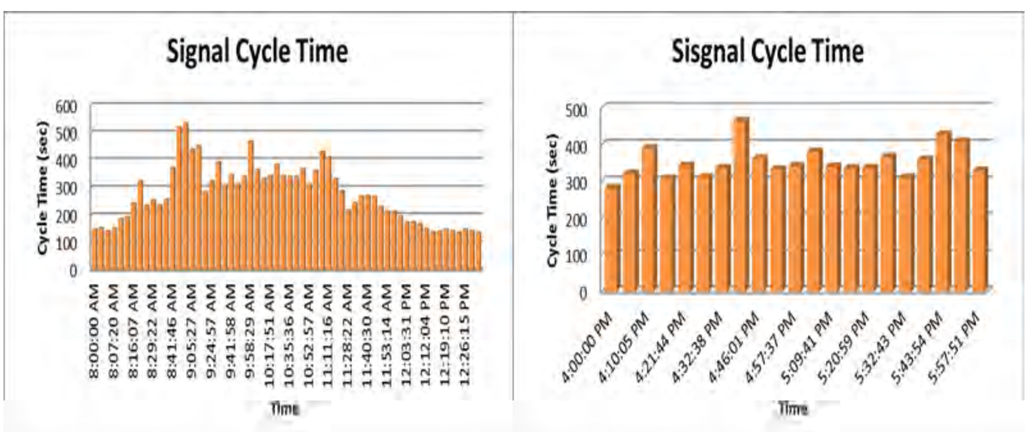


Figure 4.10.10: Signal Cycle Time at Peak Periods a) from 08.00 A.M. to 12.31 P.M.; b) from 04.00 P.M. to 05.57 P.M.

From the signal cycle time counting, it was observed that, 100.00% of total observation time was more than 120 sec, which is increasing the delay of the intersection as per research of *J. Li et al. (2004)*.

From the preliminary survey of this Mirpur 10 intersection, the information about mode of operation of this intersection was observed. In the detail analysis of this information, it is tabulated in Table 4.10.5 below.

Table 4.10.5: Existing Traffic Control System and Time of Operation of Mirpur 10.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(08.00 PM 08.00 AM)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(08.00 AM 11.00 AM) (05.00 PM 08.00 PM)
4	Mixed	(11.00AM 05.00 PM)

Analyzing the Table 4.10.5, it is found that Mirpur 10 intersection is operated in three (3) methods and different hours; automatic signal lighting system 12 hours of the total time of the day, automatic signal system (control by traffic police demand responsive) 6 hours and mixed (both automatic and controlled by police) 6 hours. In peak period this intersection is controlled by police manually.

The flow ratio of the four (4) approaches of this intersection at peak period is calculated, it is tabulated in Table 4.10.6. This is given below

Table 4.10.6: Flow Ratio of Different Approaches of Mirpur 10 Intersection.

Time	Agargaon to Mirpur - 10, y_1	Mirpur Thana to Mirpur - 10, y_2	Mirpur - 12 to Mirpur - 10, y_3	Mirpur - 14 to Mirpur - 10, y_4	Summation , Y
08.30 A.M. - 08.45 A.M.	0.20	0.43	0.38	0.46	1.46
08.45 A.M. - 09.00 A.M.	0.18	0.54	0.42	0.33	1.46
09.00 A.M. - 09.15 A.M.	0.16	0.55	0.53	0.51	1.74
09.15 A.M. - 09.30 A.M.	0.23	0.64	0.66	0.54	2.07
09.30 A.M. - 09.45 A.M.	0.20	0.59	0.69	0.50	1.97
09.45 A.M. - 10.00 A.M.	0.20	0.74	0.70	0.53	2.18
10.00 A.M. - 10.15 A.M.	0.20	0.67	0.71	0.46	2.04
10.15 A.M. - 10.30 A.M.	0.22	0.71	0.81	0.47	2.21
10.30 A.M. - 10.45 A.M.	0.23	0.70	0.91	0.47	2.31
10.45 A.M. - 11.00 A.M.	0.23	0.68	0.90	0.40	2.21
11.00 A.M. - 11.15 A.M.	0.23	0.75	0.78	0.47	2.22
11.15 A.M. - 11.30 A.M.	0.18	0.67	0.72	0.47	2.05
11.30 A.M. 11.45A.M.	0.27	0.64	0.75	0.54	2.21
11.45 A.M. 12.00P.M.	0.34	0.57	0.76	0.47	2.14
03.30 P.M. 03.45P.M.	0.54	0.40	0.46	0.37	1.76
03.45 P.M. 04.00P.M.	0.60	0.45	0.49	0.48	2.01
04.00 P.M. 04.15P.M.	0.69	0.56	0.55	0.57	2.38
04.15 P.M. 04.30P.M.	0.69	0.59	0.64	0.68	2.59

04.30 P.M. - 04.45 P.M.	0.81	0.74	0.73	0.62	2.90
04.45 P.M. - 05.00 P.M.	0.87	0.89	0.77	0.77	3.30
05.00 P.M. - 05.15 P.M.	0.93	0.89	0.95	0.89	3.65
05.15 P.M. - 05.30 P.M.	0.90	0.84	0.94	0.91	3.60
05.30 P.M. - 05.45 P.M.	0.92	0.98	0.97	0.95	3.82
05.45 P.M. - 06.00 P.M.	1.00	1.00	1.00	1.00	4.00

By analyzing the Table 4.10.6, it is found that the traffic operation system by automatic signal of this intersection will not work in peak period, because the summation of the flow ratio is greater than 1.00 all throughout the peak period of this intersection as per signal design theory.

D. Establishing Performance Evaluation Parameters for Signalized Road Intersections and Assesses Level of Service (LOS)

As per setout objectives of this research for finding out the LOS of the individual approach, queue length, delay was found out in detail survey of this intersection.

For finding out the effect of inefficiency in traffic control, queue length determination survey at peak period was organized in this intersection. The result of this survey is tabulated through the Table 4.10.7 and Table 4.10.8 below.

Table 4.10.7: Queue Length of Different Approach of Mirpur 10 Intersection (Morning Peak).

Observation No.	**Time**	**Queue Length (in meter)**			
		Agargaon to Mirpur - 10 Approach, m	**Mirpur 14 to Mirpur - 10 Approach, m**	**Mirpur 12 to Mirpur - 10 Approach, m**	**Mirpur Thana to Mirpur - 10 Approach, m**
1.	08.00 A.M. 08.15 A.M.	0	0	125.67	0
2.	08.15 A.M. 08.30 A.M.	95.7	0	145.44	0
3.	08.30 A.M. - 08.45 A.M.	142.05	67.83	212.33	112.32
4.	08.45 A.M. - 09.00 A.M.	162.05	87.23	245.21	142.33
5.	09.00 A.M. - 09.15 A.M.	185.49	74.56	279.32	162.05
6.	09.15 A.M. - 09.30 A.M.	211.06	91.23	282.31	185.49
7.	09.30 A.M. - 09.45 A.M.	214.77	88.34	311.33	211.06
8.	09.45 A.M. - 10.00 A.M.	239.81	101.45	323.33	214.77
9.	10.00 A.M. - 10.15 A.M.	176.76	103.56	344.32	239.81
10.	10.15 A.M. - 10.30 A.M.	188.98	112.34	287.22	176.76
11.	10.30 A.M. - 10.45 A.M.	221.77	98.33	322.32	188.98
12.	10.45 A.M. - 11.00 A.M.	204.46	87.97	311.22	212.33
13.	11.00 A.M. - 11.15 A.M.	243.78	106.45	309.76	245.21
14.	11.15 A.M. - 11.30 A.M.	245.76	105.78	312.56	279.32

15.	11.30 A.M. 11.45A.M.	252.77	144.78	332.22	282.31
16.	11.45 A.M. 12.00P.M.	231.23	132.56	307.92	311.33
17.	12.00 P.M. 12.15 P.M.	228.98	167.76	282.33	323.33
18.	12.15 P.M. 12.30 P.M.	232.67	202.33	266.55	312.33

Table 4.10.8: Queue Length of Different Approach of Mirpur   10 Intersection (Evening Peak).

Observation No.	**Time**	**Queue Length (in meter)**			
		Agargaon to Mirpur - 10 Approach, m	**Mirpur 14 to Mirpur - 10 Approach, m**	**Mirpur 12 to Mirpur - 10 Approach, m**	**Mirpur Thana to Mirpur - 10 Approach, m**
1.	04.00 P.M. 04.15P.M.	311.33	124.45	279.32	322.32
2.	04.15 P.M. 04.30P.M.	323.33	127.41	282.31	311.22
3.	04.30 P.M. - 04.45 P.M.	352.33	118.00	311.33	309.76
4.	04.45 P.M. - 05.00 P.M.	287.22	134.67	323.33	312.56
5.	05.00 P.M. - 05.15 P.M.	322.32	154.78	348.32	332.22
6.	05.15 P.M. - 05.30 P.M.	311.22	207.89	287.22	307.92
7.	05.30 P.M. - 05.45 P.M.	309.76	245.67	322.32	282.33
8.	05.45 P.M. - 06.00 P.M.	312.56	255.67	311.22	266.55

Analyzing the result of the queue length survey, queue was measured on three approaches of this intersection; two peak queue formation were found in this survey period that at morning peak from 08.00 A.M. to 12.30P.M. and evening peak from 04.00 P.M. to 06.00 P.M.Maximum queue length was found in this intersection at different approach, at Aargaon to Mirpur   10approach 252.77 m at morning peak and 352.33 m at evening peak, Mirpur   14 to Mirpur   10 approach 202.33 m at morning peak and 255.67 m at evening peak, Mirpur   12 to Mirpur   10approach 344.32 m at morning peak and 348.32 m at evening peak and Mirpur Thana to Mirpur   10 approach 323.33 m at morning peak and 332.22 m at evening peak. Among them, all throughout the day the queue length of this intersection was increasing in peak hour. The queue length was over 200m 70.19% of total observation time, which was very worst as per research of *J. Li et al. (2004).*

After that, another parameter for determination of LOS, delay was found out through a delay determination survey. This survey had two (2) parts; one was determination of travel time at free flow condition and other was determination of travel time in field condition. Firstly the free flow travel time in every approach of this intersection was counted. The free flow condition travel time of this Mirpur   10 intersection is presented here in a tabular format in Table 4.10.9.

Table 4.10.9: Travel Time at Free Flow Condition of Mirpur 10 Intersection (sec).

Observation No.	Time	Benarasi 1 No. Gate to Mirpur 10, sec	Al-Helal Hospital to Mirpur 10, sec	Mirpur 2 to Mirpur 10, sec	DWASA training Center to Mirpur 10, sec
1.	07.00 A.M. - 07.30 A.M.	4	7	5	8

After this, for finding out the delay of this intersection, a travel time counting survey in field condition was organized; from here travel time was collected on every approaches of this intersection from 07.00 A.M to 06.00 P.M. After getting this travel time of every approach, deducting the free flow time from surveyed travel time, delay was found from every approaches all throughout the day. The delays of these approaches are shown below from 07.00 A.M. to 06.00 P.M. in Table 4.10.10.

Table 4.10.10: Delay at Different Approach of Mirpur 10 Intersection.

Observation No.	Time	Benarasi 1 No. Gate to Mirpur 10, sec	Al-Helal Hospital to Mirpur 10, sec	Mirpur 2 to Mirpur 10, sec	DWASA training Center to Mirpur 10, sec
1.	07.00 A.M. 07.30 A.M.	4	4	2	0
2.	07.30 A.M. 08.00 A.M.	14	7	7	8
3.	08.00 A.M. 08.30 A.M.	21	27	9	24
4.	08.30 A.M. 09.00 A.M.	241	26	8	36
5.	09.00 A.M. 09.30 A.M.	481	21	127	81
6.	09.30 A.M. 10.00 A.M.	742	27	139	113
7.	10.00 A.M. 10.30 A.M.	861	58	208	213
8.	10.30 A.M. 11.00 A.M.	880	120	327	279
9.	11.00 A.M. 11.30 A.M.	751	216	441	120
10.	11.30 A.M. 12.00 P.M.	652	349	543	81
11.	12.00 P.M. 12.30 P.M.	164	436	552	221
12.	12.30 P.M. 01.00 P.M.	52	551	669	359
13.	01.00 P.M. 01.30 P.M.	39	662	773	470
14.	01.30 P.M. 02.00 P.M.	51	435	826	590
15.	02.00 P.M. 02.30 P.M.	83	328	551	651
16.	02.30 P.M. 03.00 P.M.	128	480	428	871
17.	03.00 P.M. 03.30 P.M.	183	545	334	990
18.	03.30 P.M. 04.00 P.M.	217	480	282	1070
19.	04.00 P.M. 04.30 P.M.	483	769	440	937
20.	04.30 P.M. 05.00 P.M.	781	880	553	988
21.	05.00 P.M. 05.30 P.M.	873	971	771	979
22.	05.30 P.M. 06.00 P.M.	912	1031	909	879

Analyzing the Table 4.10.10, the delay at different approach of Mirpur 10 intersection is increasing as the progress of the day time was found. Approach wise comparison of delay time is shown in Figure 4.10.11below.

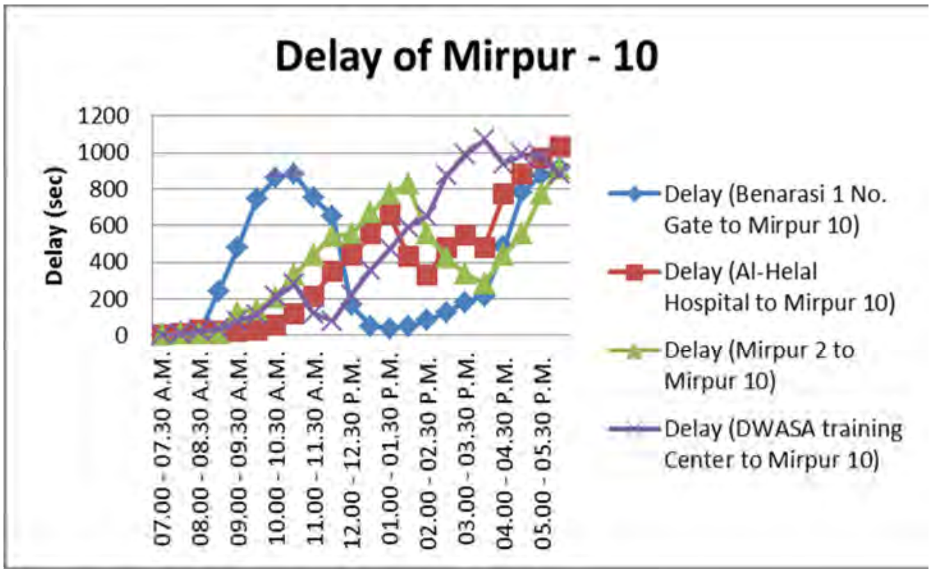


Figure 4.10.11: Comparison of Delay at Different Approach of Mirpur 10 Intersection.

Analyzing the Figure 4.10.11 it was observed that, all the approaches of this intersection experienced maximum delay in traffic flow at the time of evening peak hour mostly; it was seen those 3 hours in the evening peak delay occurred maximum.

E. Evaluation performance of the intersections based on LOS ranking

Finally, based on the delay on every approach of this intersection, LOS of four (4) approaches was calculated for Mirpur 10 intersection. In the following Table 4.10.11 and Figure 4.10.12 the LOS of this intersection is presented below, the detailed calculation of LOS given in Appendix A

Table 4.10.11: LOS of Different Approaches of Mirpur - 10 Intersection.

Observation No.	Time	LOS (Benarasi 1 No. Gate to Mirpur - 10)	LOS (Al-Helal Hospital to Mirpur 10)	LOS (Mirpur 2 to Mirpur 10)	LOS (DWASA training Center to Mirpur 10)
1.	07.00 A.M. 07.30 A.M.	A	A	A	A
2.	07.30 A.M. 08.00 A.M.	B	A	A	A
3.	08.00 A.M. 08.30 A.M.	C	D	A	C
4.	08.30 A.M. 09.00 A.M.	F	D	A	E
5.	09.00 A.M. 09.30 A.M.	F	C	F	F
6.	09.30 A.M. 10.00 A.M.	F	D	F	F
7.	10.00 A.M. 10.30 A.M.	F	E	F	F

8.	10.30 A.M.	11.00 A.M.	F	F	F	F
9.	11.00 A.M.	11.30 A.M.	F	F	F	F
10.	11.30 A.M.	12.00 P.M.	F	F	F	F
11.	12.00 P.M.	12.30 P.M.	F	F	F	F
12.	12.30 P.M.	01.00 P.M.	F	F	F	F
13.	01.00 P.M.	01.30 P.M.	E	F	F	F
14.	01.30 P.M.	02.00 P.M.	F	F	F	F
15.	02.00 P.M.	02.30 P.M.	F	F	F	F
16.	02.30 P.M.	03.00 P.M.	F	F	F	F
17.	03.00 P.M.	03.30 P.M.	F	F	F	F
18.	03.30 P.M.	04.00 P.M.	F	F	F	F
19.	04.00 P.M.	04.30 P.M.	F	F	F	F
20.	04.30 P.M.	05.00 P.M.	F	F	F	F
21.	05.00 P.M.	05.30 P.M.	F	F	F	F
22.	05.30 P.M.	06.00 P.M.	F	F	F	F

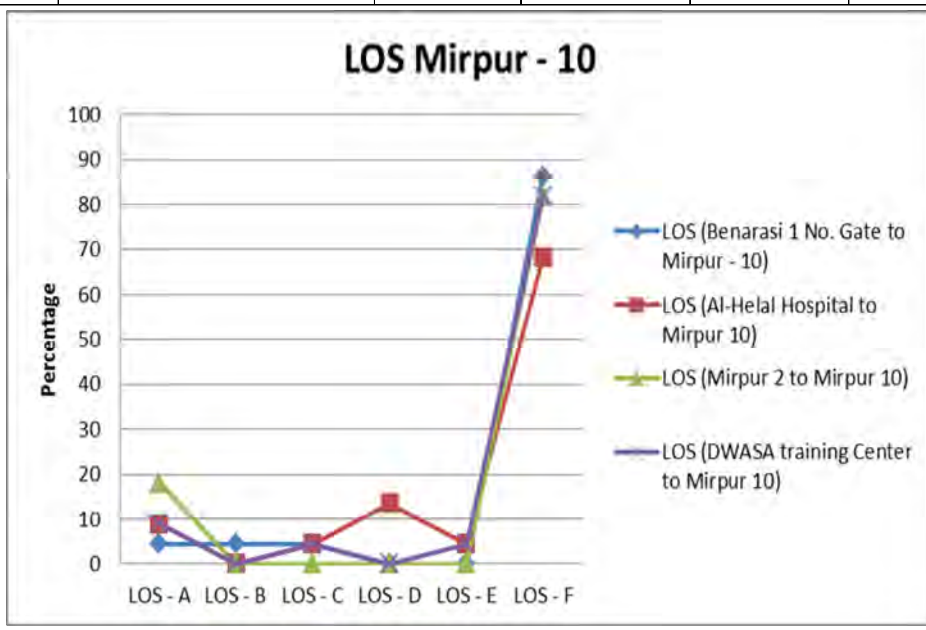


Figure 4.10.12: Percentage of Various LOS at Different Approaches of Mirpur 10 Intersection.

By analyzing theTable 4.10.11 andFigure 4.10.12 the LOS of different approaches of this intersection, it was found that during 11 hours survey period for Benarasi 1 No. Gate to Mirpur 10 approach, the LOS level A, B, C, D, E and F were observed to be 4.5%, 4.5%, 4.5%, 0.0%, 0.0% and 86.36% of survey time respectively. Similarly for approach Al Helal Hospital to Mirpur 10 the LOS level A, B, C, D, E and F were observed to be 9.0%, 0.0%, 4.5%, 13.63%, 4.5% and 68.18%, for approach Mirpur 2 to Mirpur 10 the LOS level A, B, C, D, E and F were observed to be 18.18%, 0.0%, 0.0%, 0.0%, 0.0% and 81.81% of survey time respectively and DWASA training center to Mirpur 10 the LOS level A, B, C, D, E and F were observed to be 9.0%, 0.0%, 4.5%, 0.0%, 4.5% and

81.81% of survey time respectively. The LOS of every approach of this intersection was retaining at Level F consistently. For present Dhaka Metropolitan City, it is a curse.

4.11 Quantitative Data Analysis of Shapla Chattar Intersection

A. Site Investigation of Shapla Chattar Intersection:

The roundabout intersection is situated at the central part of the Dhaka Metropolitan City at Motijheel in front of Bangladesh Bank. This is a busy intersection as well as wide roundabout junction. This is a major three (3) legged round about junction. Among the three (3) approaches, the north approaches towards Toyenbee road, to the south approach meeting with Ram Krishno (R.K.) Mission Road and to the west approach towards High Court Intersection. There are so many land use activity such as shopping malls, market, banks, schools, colleges, business complex, high rise office building, health clinic, government staff quarter, government / non-government office, Dhaka Stock Exchange (DSE), etc. built up both of the sides of the road. Moreover there are Bangabandhu Stadium, Baitul Mukarram Mosque, renowned hotel, Bank
BaFF (Bangladesh Football Federation), Mohammadan Football Club, Baitul Mukarram market, Secretariat, GPO, Press Club, etc. built up both of the sides of the road and inside the intersection. These land use activities generate huge pedestrian and vehicular flow which creates a tremendous thrust on this round about.

From preliminary survey of this intersection, the three (3) main approaches are divided by lanes with marking and the other minor approach does not have lane division. A table describing the lane division of different approaches is given below.

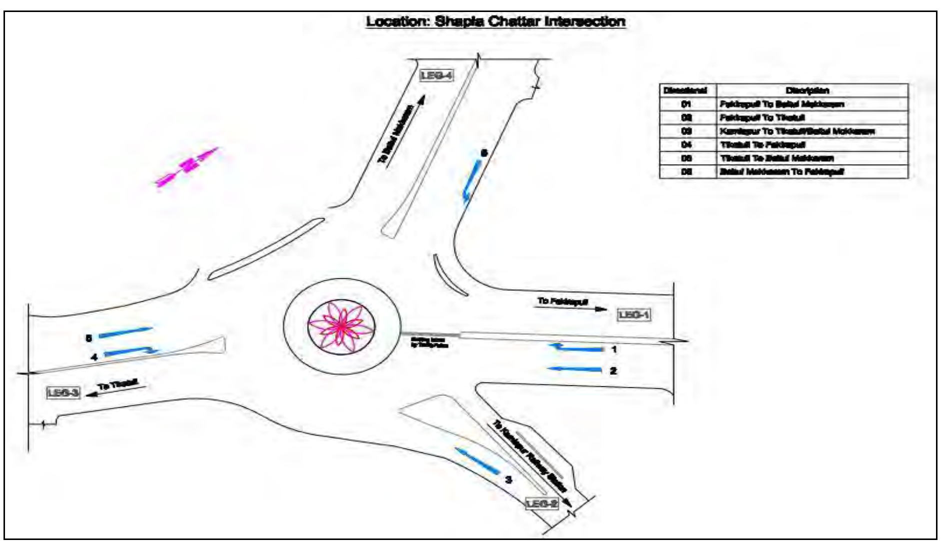


Figure 4.11.1: Layout of Shapla Chattar Intersection.

Source: (Signal Synchronization Study,2013).

Table 4.11.1: Approach of Shapla Chattar Intersection with Lane Division.

Serial No.	**Approach with direction**	**Lane number**
Leg 1.	Shapla Chattar Intersection to Fakirapul.	3 lanes both direction
Leg 2.	Shapla Chattar Intersection to Kamlapur Bazar Road.	No lane division.
Leg 3.	Shapla Chattar Intersection to Tikatuli.	3 lanes both direction
Leg 4.	Shapla Chattar Intersection to Baitul Mukarram.	3 lanes both direction

The main carriageway of this intersection is flexible pavement in all direction. Here we did not find any lack in the maintenance work of intersection. We found here smooth carriageway in this intersection.

By reviewing the preliminary survey of this intersection, two (2) distinct peak hours were found in this intersection, one, in the morning from 09.00 A.M. to 12.30 P.M. and other, in the evening from 04.30 P.M. to 06.00 P.M. and furthermore (beyond the survey time). A lot of traffic used this intersection all throughout the day. A lot of pedestrian movement was found in this intersection. There is an over bridge for crossing the junction, it is a two (2) legged over bridge. There was footpath in all approaches of the intersection; however this footpath was dishonestly invaded by the hawkers, traders, hotels, construction material, rickshaw, Laguna stand, bazar, illegal parking, bus stand, etc. There was a lot of side friction in the approaches of this intersection. Effective road width of the intersection was reduced by this type of activities and circulation of traffic was decreased.

There was the provision of automatic traffic signal for traffic control, but this was not practiced in field. So, all of the signals were as showpiece in a showcase. Traffic police tried to control the traffic of this intersection manually. Signal timing, phasing was not consistent for this. They tried to operate this intersection responding as per demand. So a lot of delay occurred here and queue length originated in peak period too.

Generally, there is no provision for using traffic signal in round about worldwide.

B. Geometric and Operating Conditions of Selected Intersection (Shapla Chattar)

After finishing the detail survey of selected intersection, Shapla Chattar; analysis of collected data about the intersection geometry and operating condition was done. The findings of this analysis is tabulated in Table 4.11.2 below

Table 4.11.2: Geometric and Operating Condition of Shapla Chattar Intersection

Serial No.	**Items**	**Description**
1.	**Number of Approaches**	There are four(4) approaches (namely from Shapla Chattar to Fakirapul approach, from Shapla Chattar to Kamlapur Bazar approach, from Shapla

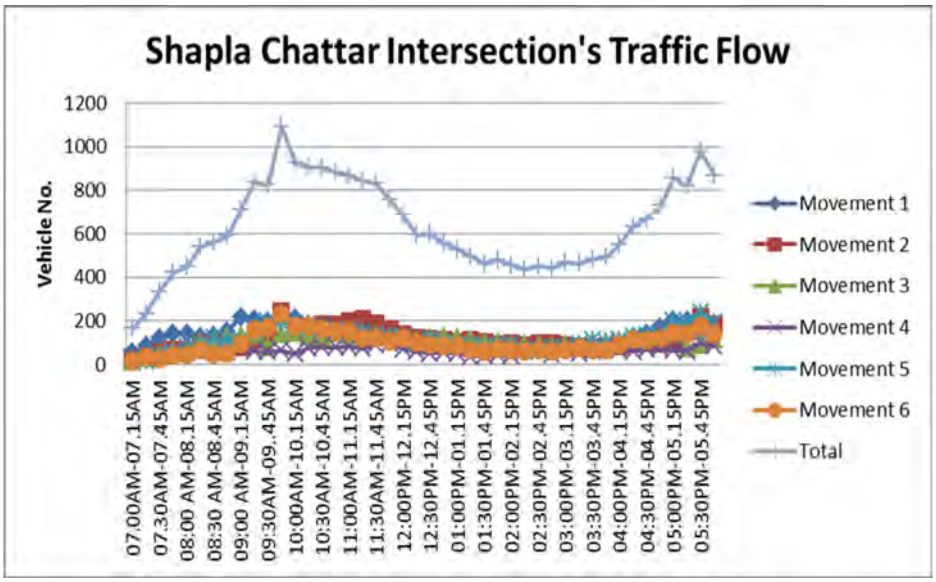
		Chattar to Tikatuli approach and from Shapla Chattar to Baitul Mukarram approach)
2.	**Carriageway**	All four (4) approaches of this intersection are flexible pavement in structural point of view and dual carriageway.
3.	**Footpath Coverage**	Footpaths for pedestrian are found existing here, by the both of the side of all the four approaches of this intersection, which is illegally occupied by purveyors, building materials, parked vehicle, etc. Shapla Chattar intersection has 100% footpath coverage.
4.	**Channelization**	There is channelization for left turning exclusive lane on the mouth of Baitul Mukarram to Shapla Chattar approach, which is giving direction to vehicles towards Fakirapul from Baitul Mukarram approach.
5.	**Divider**	All approaches of this intersection are alienated by the non - engineering divider. This non engineering divider is not related with velocity profile of vehicle of this intersection.
6.	**Pedestrian Crossing Facility**	There is a two legged over bridge, which is at the inside of this intersection, on the mouth of Shapla Chattar to Fakirapul approach providing pedestrian crossing facility as a grade separated service, but pedestrians try to cross the intersection through the busy road at grade as usually.
7.	**Side Road**	From preliminary survey of Shapla Chattar intersection surrounding area; researcher team found ten (10) side roads, which are coming from neighboring residential / commercial area of this intersection. They are exposed in this intersection directly, which are containing MV and NMV both in it.

C. Determining the Existing Vehicular, Pedestrian Flow, Amount of Side Friction, And Condition of Traffic Control Devices including Signal Timing, Phasing and Mode of Operation at Shapla Chattar Intersection:

In detail survey of Shapla Chattar intersection; existing vehicular flow, pedestrian flow was observed, furthermore amount of side friction was exposed and condition of traffic signal, signal timing, phasing and mode of operation was documented and which was analyzed later.

i. Existing Vehicular Flow

Analyzing the exiting vehicular flow of Shapla Chattar intersection, an eleven (11) hours vehicular survey (from 07.00 A.M. to 06.00 P.M.) was organized, the result of this survey and its analysis are presented here in Figure 4.11.2 a) and b), this figure is presenting a general graph accompanying with a pie chart, which is presenting the data of vehicular survey of this intersection and expressing the characteristics of vehicular flow through this intersection.



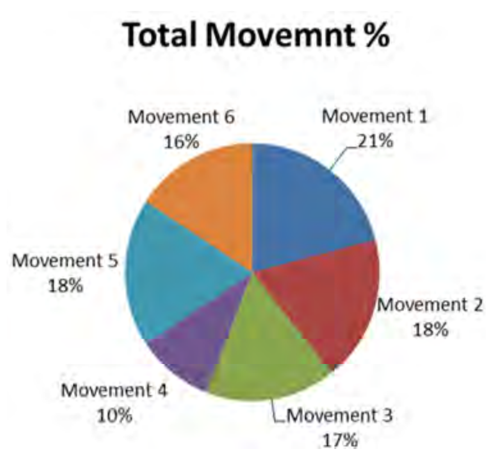
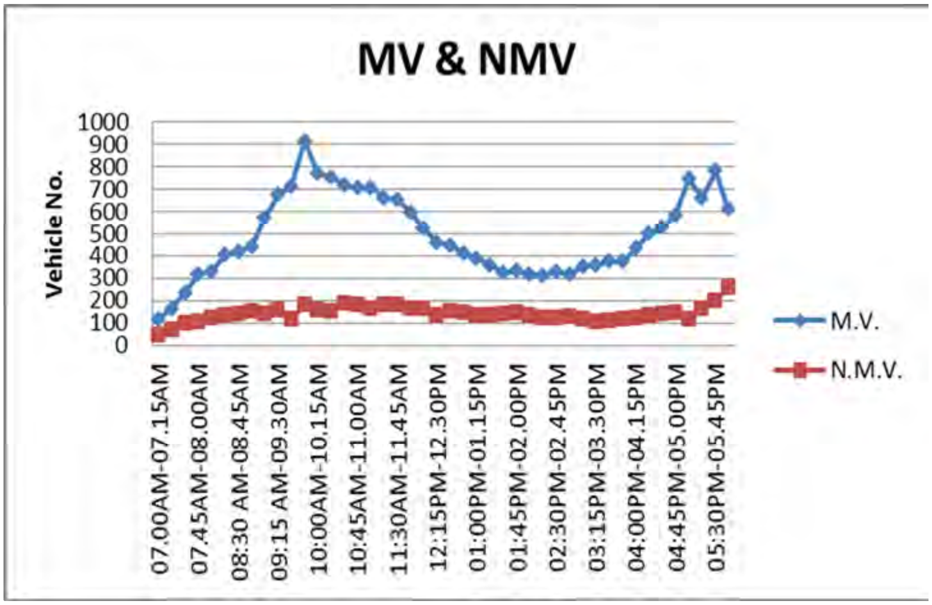


Figure 4.11.2: a) Vehicular Flow Data of Shapla Chattar; b) Vehicle Movement Contribution of Shapla Chattar.

Analyzing the vehicular survey data of this intersection, six (6) individual movements were found and among them movement -1 (Fakirapul to Baitul Mukarram) was maximum, which contained 21% of entire traffic flow of this intersection on the day of survey. From the entire 11 hour vehicular survey, two (2) distinct peak hours were found in this intersection, one, in the morning from 09.00 A.M. to 12.30 P.M. and other, in the evening from 04.30 P.M. to 06.00 P.M. furthermore (beyond the survey time), total peak hour of the survey time was 5 hours, which was 45.45% of total survey time.

After analyzing the vehicular flow of this intersection, assessment of the vehicular combination of this intersection was done. The result of this analysis is presented here in Figure 4.11.3 a) and b), this figure is presenting a general graph accompanying with a pie chart.



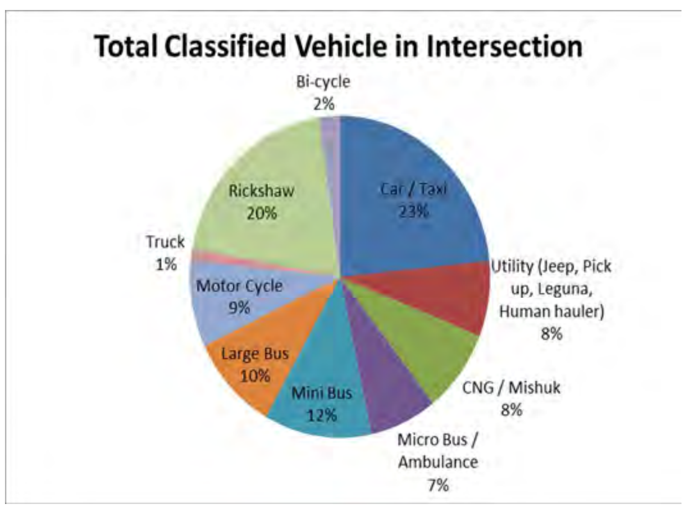


Figure 4.11.3: a) Individual Flow of MV and NMV in Shapla ChattarIntersection; b) Classified Vehicle in Shapla Chattar Intersection.

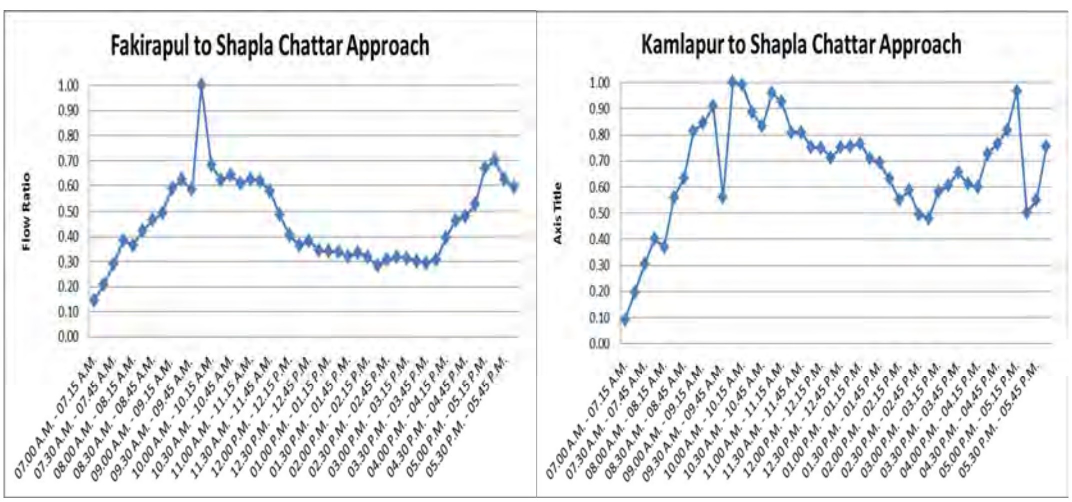
In Figure 4.11.3 a), a general graph is shown, which is showing the individual flow of MV and NMV through this intersection. Analyzing this general graph, two (2) distinct peak hours are found for MV; it was observed from 09.00 A.M. to 12.00 P.M. at morning and from 04.00 P.M. to 06.00 P.M. and furthermore at evening peak period. A constant rate of NMV flow was found through this intersection all throughout the day.

In Figure 4.11.3 a), a pie chart is shown, which is expressing the vehicular composition of this intersection. The dominancy of MV is found out from here, which was 78% of total vehicular flow; among the vehicular flow car / taxi were the mostly governed vehicle type in this intersection, which was 23% of total flow. After finding out the vehicular composition, the saturation flow of every approach of this intersection was calculated from the vehicular survey data. The result of this analysis is presented here through a tabular format in Table 4.11.3 below.

Table 4.11.3: Saturation Flow of Different Approach of Shapla Chattar Intersection.

Serial No.	**Intersection Name**	**Intersection Classification**	**Approach Name**	**Saturation Flow (PCU / Hour)**
1.	Shapla Chattar	Round About	Fakirapul to Shapla Chattar	2630.80
2.			Kamlapur to Shapla Chattar	504.00
3.			Tikatuli to Shapla Chattar	1768.44
4.			Baitul Mukarram to Shapla Chattar	1652.00

Later, the usages of road space of every approaches of this intersection were calculated. The result of this calculation is presented here through Figure 4.11.4 a), b), c) and d) with individual general graph, which is expressing the flow ratio with respect to saturation flow of the individual approach of this intersection of 11 hours.



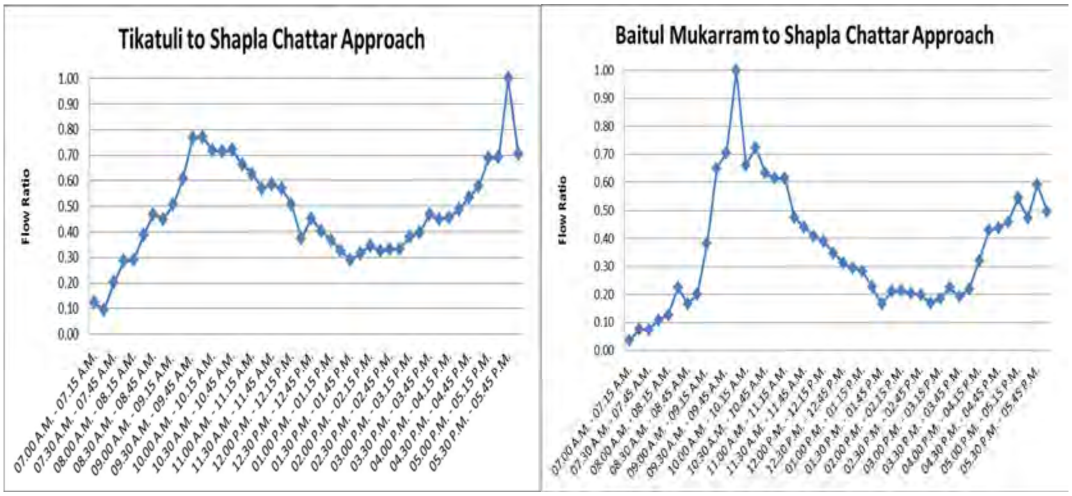


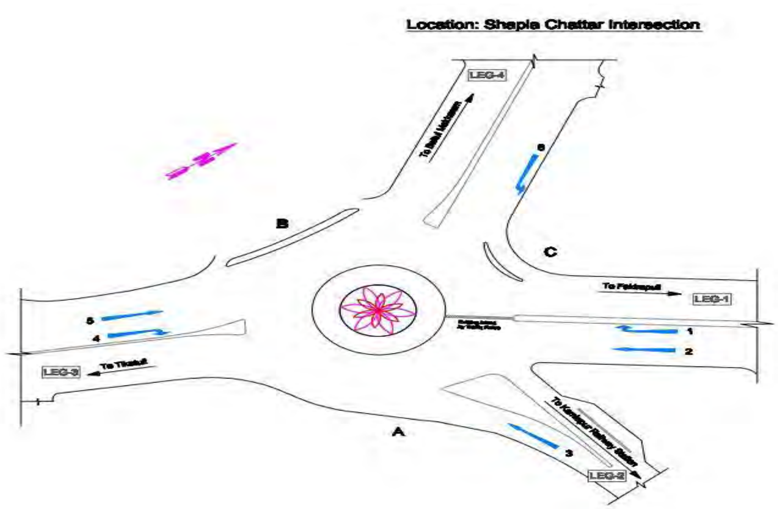
Figure 4.11.4: a) Flow Ratio of Fakirapul to Shapla Chattar Approach; b) Flow Ratio of Kamlapur to Shapla Chattar Approach; c) Flow Ratio of Tikatuli to Shapla Chattar Approach; d) Flow Ratio of Baitul Mukarram to Shapla Chattar Approach.

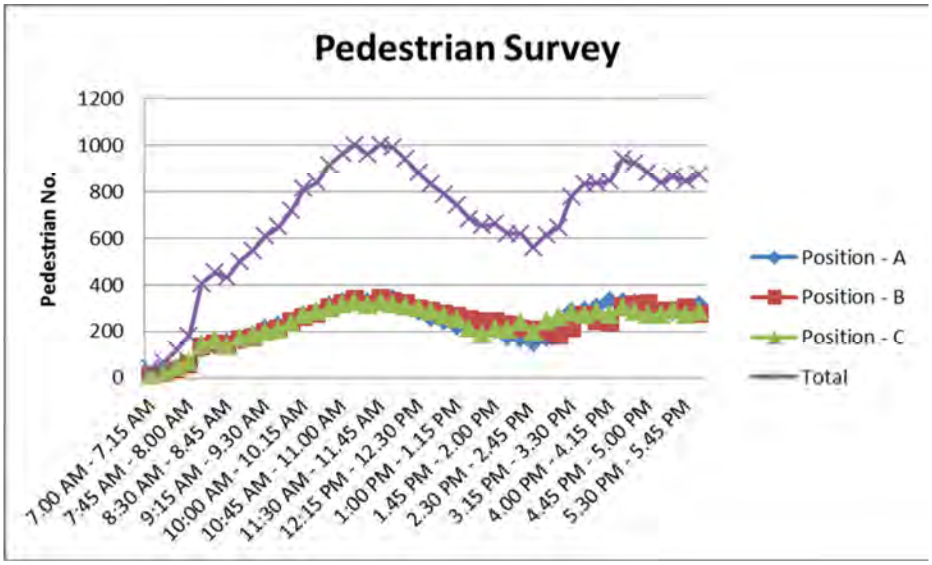
From Figure 4.11.4, it is observed that, every approach of this intersection were containing two (2) peak hours in vehicular flow; one in the morning and other in the evening.

ii. Pedestrian Flow

As per set out objectives of this research, the pedestrian flow through this intersection was also observed. In preliminary survey, two (2) types of pedestrian flow were observed; one was at grade and other was grade separated.

In this intersection, detail 11 hours (from 07.00 A.M. to 06.00 P.M.) pedestrian survey was organized for finding out the scenario of at grade pedestrian flow. After analyzing the result of this, it is presented here in Figure: 4.11.5 a), b) and c), through a general graph accompanying with a CAD drawing and pie chart.





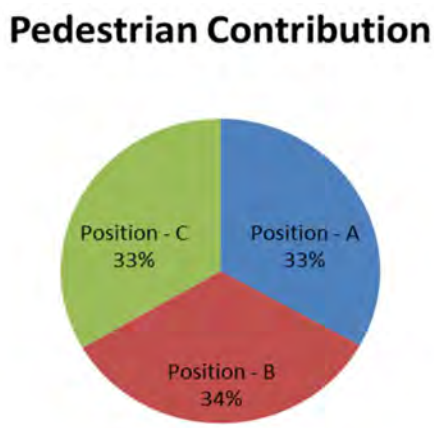


Figure 4.11.5: a) Pedestrian Survey Position inside Shapla Chattar Intersection; b) Pedestrian Flow; c) Pedestrian Flow Contribution among three (3) Positions

From the preliminary survey, the three (3) positions were selected for detail field survey according to the availability of pedestrian in this intersection. The positions of those three (3) points are shown here in Figure 4.11.5 a). From Figure 4.11.5 b) at grade pedestrian flow through this intersection is presented, two (2) peak hours is found from it, one in the morning from 10.00 A.M. to 01.00 P.M. and other in the evening from 03.30 P.M. to 06.00 P.M and further beyond the survey time. Among the three (3) positions, maximum at grade pedestrian flow was occurred in position B, which is at the front of Sonali Bank 34% percent of entire at grade pedestrian flow took place in this position which is presented here in Figure 4.11.5 c).

A two legged over bridge is situated inside this intersection as a grade separated crossing facilities for pedestrian. For finding out the scenario of grade separated pedestrian crossing facility of this intersection, an 11 hours (from 07.00 A.M. to 06.00 P.M.) pedestrian crossing survey was organized in this over bridge. After analyzing the result of this pedestrian survey, it is presented here in Figure 4.11.6 a), b) and c), through a general graph accompanying with a Google Map photo and pie chart.

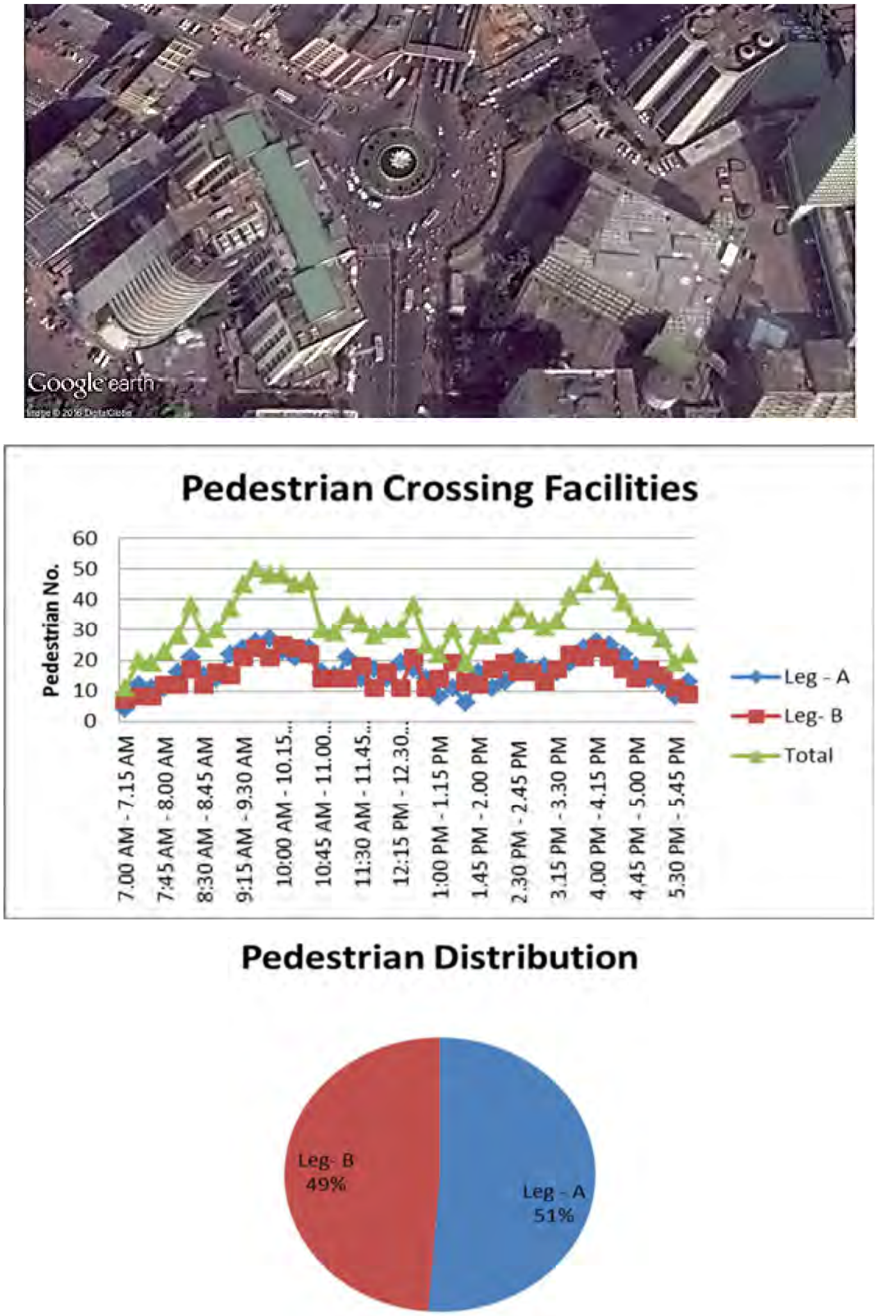


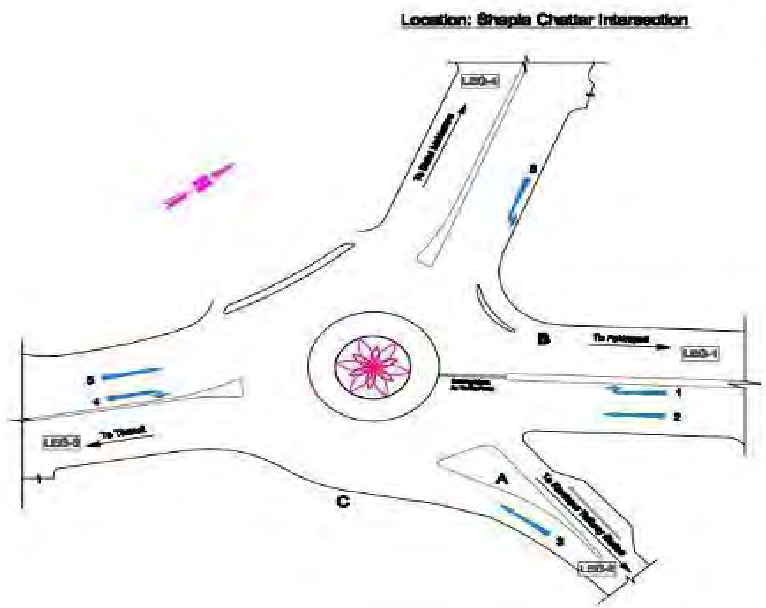
Figure 4.11.6: a) Position of Foot Over Bridge at Shapla Chattar Intersection; b) Grade Separated Pedestrian Flow;c) Pedestrian Flow Contribution among two (2) Legs.

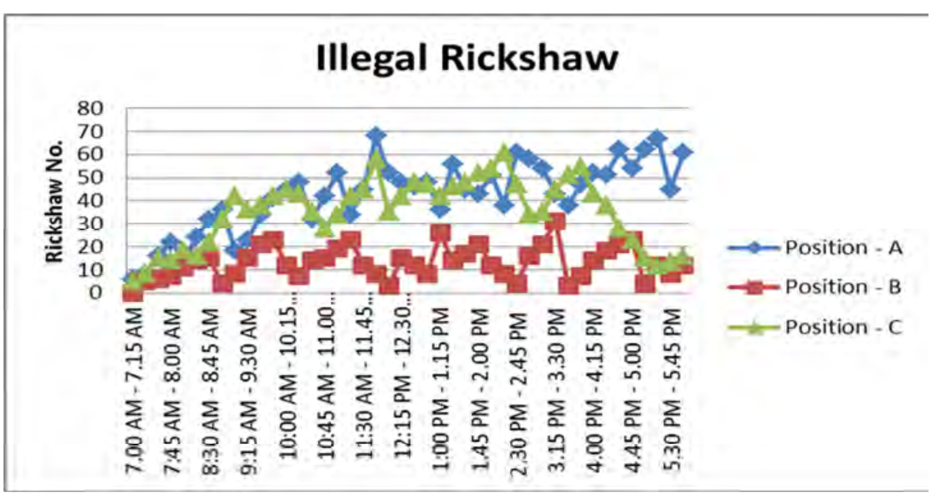
From Figure 4.11.6 a), b) and c) , from 11 hours survey it was observed that total 2, 874 nos. of pedestrian used this over bridge as a crossing facility through this intersection, the legs of the over bridge is indicated by Leg A and Leg B in Google Map drawing. With respect to total pedestrian flow only 9 % pedestrian used this facility on that day. Among the two legs of this over bridge, it was found that, about 51% of intersection crossing pedestrian were in Leg A, which is at the corner of Bangladesh Bank.

iii. Side Friction

As per set out objectives of this research, the amount of side friction in this intersection was also determined. From the preliminary survey of this intersection the two (2) specified reasons of side friction were found illegal rickshaw and bus stand. For finding out the scenario of side friction, an 11 hour . to 06.00 P.M.) was organized.

From the preliminary survey of this intersection, it was observed that, there were three (3) distinct points inside the intersection; rickshaws were stood there illegally, which created a lot of jam on the approaches. For understanding the real scenario of this rickshaw stand, a counting survey was organized in the final survey of this intersection. The result of this survey is presented here in Figure 4.11.7 a), b) and c).





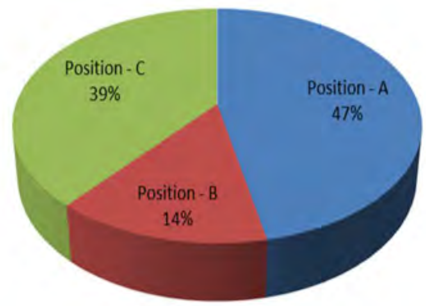


Figure 4.11.7: a) Position of Illegal Rickshaw Stand inside Shapla Chattar Intersection; b) Illegal Rickshaw all throughout the Day; c) Contribution of Illegal Rickshaw.

From the above Figure 4.11.7 a), b) and c); analyzing the 11 hours survey result, a huge amount of rickshaw stood these points on the main approach of this intersection. Among the three points the most amount of rickshaw stood on position A, on the mouth of Shapla Chattar to Kamlapur approach, 47% of total illegal standee was found here.

Beside this, in front of Sonali Bank, some illegal buses were found for collection of passenger inside this intersection. It obstructed the smooth flow of traffic through this intersection. For understanding the real scenario of this illegal bus stand, a counting survey was organized in the final survey of this intersection. The result of this survey is presented here in Figure 4.11.8 a) and b).

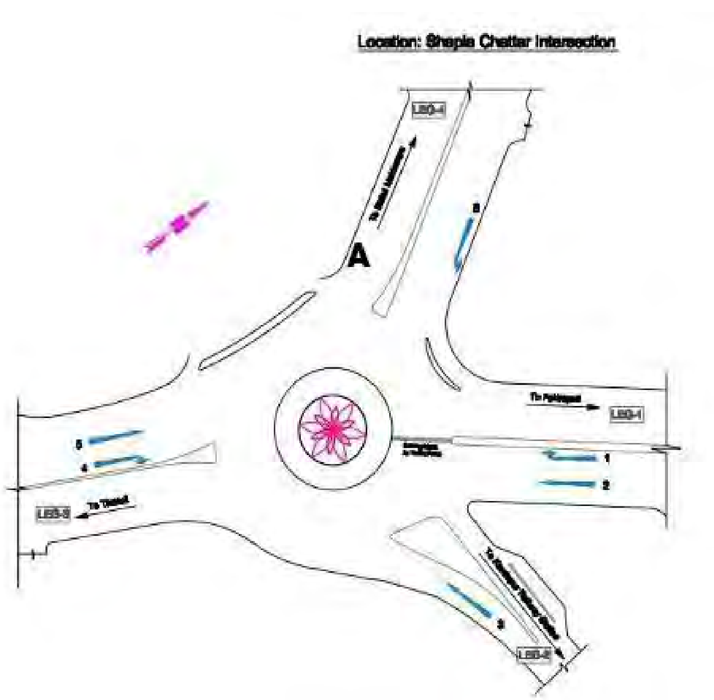


Figure 4.11.8: a) Position of Illegal Bus Stand inside Shapla Chattar Intersection; b) Illegal Bus all throughout the Day.

From the above Figure 4.11.8 a) and b); analyzing the 11 hours survey result, a huge amount of bus stood this point on the main approach of this intersection. Around 621 nos. of buses were found in this place. As usually they were created obstacle in the circulation of vehicle inside this roundabout intersection. It stopped the flow of vehicle through this intersection intermittently.

Generally the combined effect of side friction was observed in the traffic flow of this intersection. 50% of total road width at the mouth of approach of this intersection was blocked by these side frictions in the peak hour. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing day by day.

iv. Traffic Control Devices

From the preliminary survey of this intersection, a condition survey of traffic control devices was organized. The outputs of this condition survey are given below in a tabular format, in Table 4.11.4**.**

Table 4.11.4: Signal Accessories of Shapla Chattar Intersection.

Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Operate	Pedestrian Signal Operate
SP-1	OK	Rotated	Yes	No
SP-2	OK	OK	-	No
SP-3	OK	OK	-	No
SP-4	Hidden	All missing	-	-
SP-5	OK	OK	No	No
SP-6	OK	Rotated	-	No

SP-7	OK	Rotated	Yes	No
SP-8	OK	Missing	-	No
SP-9	Signal lights hidden	Missing	Yes	No
SP-10	OK	Missing	-	No
MAP-1	Signal lights hidden	Missing	Yes	No
MAP-2	OK	OK	-	-
MAP-3	OK	OK	-	No
MAP-4	Signal lights hidden	OK	No	-
MAP-5	One side signal light hidden	OK	Yes	No
TSC	OK	OK	-	-

Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

In this intersection, for traffic control there was no use of traffic signal; instead of this, police controlled the traffic movement of this intersection manually based on traffic flow demands among four (4) approaches which is considered to be as responsive signal system re a two (2) phase traffic controlling system (one road which was the most inefficient method of traffic control. The traffic signal cycle time in this method is not consistent. The variation of signal cycle time in Shapla Chattar intersection at peak periods are given in the following Figure: 4.11.9.

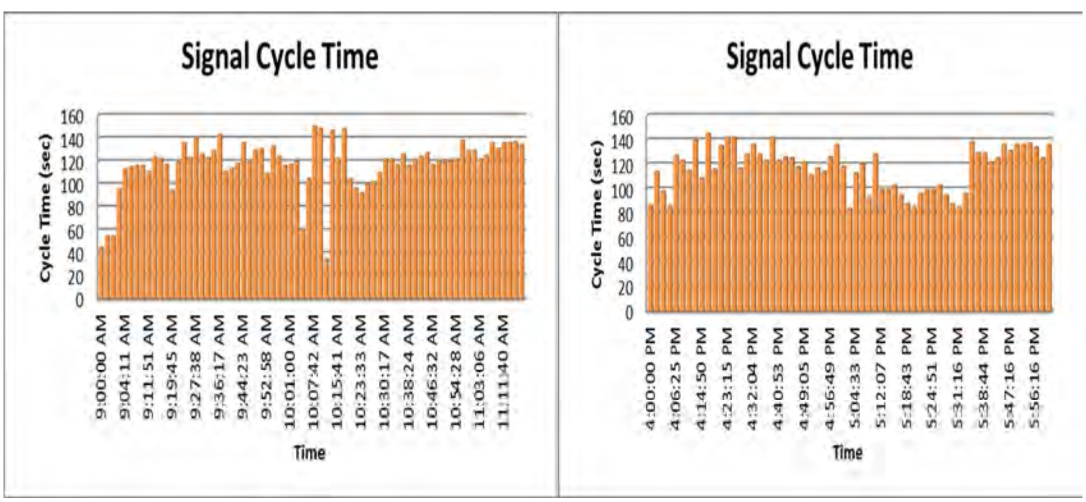


Figure 4.11.9: Signal Cycle Time at Peak Periods a) from 09.00 A.M. to 11.18 A.M.; b) from 04.00 P.M. to 06.00 P.M.

From the signal cycle time counting, it was observed that, 54.56% of total observation time was more than 120 sec, which is increasing the delay of the intersection as per research of *J. Li et al. (2004)*.

From the preliminary survey of this Shapla Chattar intersection, the information about mode of operation of this intersection was observed. In the detail analysis of this information, it is tabulated in Table 4.11.5 below

Table 4.11.5: Existing Traffic Control System and Time of Operation of Shapla Chattar.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(07.30 P.M 07.30 A.M.)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(09.00 AM 11.00 AM) (04.30 PM 07.30 PM)
4	Mixed	(11.00 AM 04.30 PM) (07.30 AM 09.00 AM)

Analyzing the Table 4.11.5, it is found that Shapla Chattar intersection is operated in three (3) methods and different hours; automatic signal lighting system 12 hours of the total time of the day, automatic signal system (control by traffic police demand responsive) 5 hours and mixed (both automatic and controlled by police) 7 hours. In peak period this intersection is controlled by police manually.

The flow ratio of the four (4) approaches of this intersection at peak period is calculated, it is tabulated in Table 4.11.6. This is given below

Table 4.11.6: Flow Ratio of Different Approaches of Shapla Chattar Intersection.

Time	Fakirapul to Shapla Chattar, y_1	Kamlapur to Shapla Chattar, y_2	Tikatuli to Shapla Chattar, y_3	Baitul Mukarram to Shapla Chattar, y_4	Summation, Y
09.00 A.M. - 09.15 A.M.	0.59	0.84	0.51	0.38	2.32
09.15 A.M. - 09.30 A.M.	0.62	0.91	0.61	0.65	2.79
09.30 A.M. - 09.45 A.M.	0.58	0.56	0.77	0.71	2.62
09.45 A.M. - 10.00 A.M.	1.00	1.00	0.77	1.00	3.77
10.00 A.M. - 10.15 A.M.	0.68	0.99	0.72	0.66	3.05
10.15 A.M. - 10.30 A.M.	0.62	0.88	0.71	0.72	2.95
10.30 A.M. - 10.45 A.M.	0.64	0.83	0.72	0.63	2.83
10.45 A.M. - 11.00 A.M.	0.61	0.96	0.66	0.61	2.85

11.00 A.M. - 11.15 A.M.	0.63	0.92	0.63	0.61	2.79
11.15 A.M. - 11.30 A.M.	0.62	0.81	0.57	0.48	2.47
11.30 A.M. 11.45 A.M.	0.58	0.81	0.59	0.44	2.41
11.45 A.M. 12.00 P.M.	0.49	0.75	0.57	0.41	2.22
12.00 P.M. 12.15 P.M.	0.40	0.75	0.51	0.39	2.05
12.15 P.M. 12.30 P.M.	0.37	0.71	0.37	0.35	1.80
04.30 P.M. - 04.45 P.M.	0.48	0.76	0.53	0.44	2.22
04.45 P.M. - 05.00 P.M.	0.53	0.82	0.58	0.46	2.38
05.00 P.M. - 05.15 P.M.	0.67	0.97	0.69	0.54	2.87
05.15 P.M. - 05.30 P.M.	0.70	0.50	0.69	0.47	2.37
05.30 P.M. - 05.45 P.M.	0.62	0.55	1.00	0.59	2.76
05.45 P.M. - 06.00 P.M.	0.59	0.75	0.70	0.50	2.55

By analyzing the Table 4.11.6, it is found that the traffic operation system by automatic signal of this intersection will not work in peak period, because the summation of the flow ratio is greater than 1.00 all throughout the peak period of this intersection as per signal design theory.

D. Establishing Performance Evaluation Parameters for Signalized Road Intersections and Assesses Level of Service (LOS)

As per setout objectives of this research for finding out the LOS of the individual approach, queue length, delay was found out in detail survey of this intersection.

For finding out the effect of inefficiency in traffic control, queue length determination survey at peak period was organized in this intersection. The result of this survey is tabulated through the Table 4.11.7 and Table 4.11.8 below.

Table 4.11.7: Queue Length of Different Approach of Shapla Chattar Intersection (Morning Peak).

Observation No.	Time	Queue Length (in meter)	
		Shapla Chattar to Fakirapul approach (m)	Shapla Chattar to Tikatuli (m)
1.	09.00 A.M. - 09.15 A.M.	0	0
2.	09.15 A.M. - 09.30 A.M.	0	0
3.	09.30 A.M. - 09.45 A.M.	121.33	0
4.	09.45 A.M. - 10.00 A.M.	145.47	132.22
5.	10.00 A.M. - 10.15 A.M.	212.33	156.67
6.	10.15 A.M. - 10.30 A.M.	257.64	212.87
7.	10.30 A.M. - 10.45 A.M.	264.47	256.75
8.	10.45 A.M. - 11.00 A.M.	312.32	288.65
9.	11.00 A.M. - 11.15 A.M.	334.21	312.00
10.	11.15 A.M. - 11.30 A.M.	298.56	342.54

11.	11.30 A.M. 11.45A.M.	323.45	365.00
12.	11.45 A.M. 12.00P.M.	316.57	342.22
13.	12.00 P.M. 12.15 P.M.	332.32	311.23

Table 4.11.8: Queue Length of Different Approach of Shapla Chattar Intersection (Evening Peak).

Observation No.	Time	Queue Length (in meter)	
		Shapla Chattar to Fakirapul approach (m)	Shapla Chattar to Tikatuli (m)
1.	04.00 P.M. 04.15 P.M.	212.33	212.87
2.	04.15 P.M. 04.30 P.M.	257.64	256.75
3.	04.30 P.M. - 04.45 P.M.	264.47	288.65
4.	04.45 P.M. - 05.00 P.M.	312.32	312.00
5.	05.00 P.M. - 05.15 P.M.	328.67	342.54
6.	05.15 P.M. - 05.30 P.M.	298.56	312.33
7.	05.30 P.M. - 05.45 P.M.	323.45	342.22
8.	05.45 P.M. - 06.00 P.M.	316.57	311.23
9.	06.00 P.M. 06.15 P.M.	333.12	346.72

Analyzing the result of the queue length survey, it was measured on two (2) approaches of this intersection. Maximum queue length was found in this intersection at different approach with the progress of the time. The queue length was observed in Shapla Chattar to Fakirapul approach at morning peak 334.21 m and at evening peak 333.12 m and Shapla Chattar to Tikatuli approach at morning peak 365.00 m and at evening peak 346.72 m. Among them, the queue length of this intersection was increasing with the progress of time; the queue length was over 200 m79.54% of total observation time, which was very worst as per research of *J. Li et al. (2004).*

After that, another parameter for determination of LOS, delay was found out through a delay determination survey. This survey had two parts; one was determination of travel time at free flow condition and other was determination of travel time in field condition. Firstly the free flow travel time in every approach of this intersection was counted. The free flow condition travel time of this Shapla Chattar intersection is presented here in a tabular format in Table 4.11.9.

Table 4.11.9: Travel Time at Free Flow Condition of Shapla Chattar Intersection (sec)

Observation No.	Time	R.K. Road to Shapla Chattar, sec	Arambagh Mor to Shapla Chattar, sec
1.	07.00 A.M. - 07.30 A.M.	10	8

After this, for finding out the delay of this intersection, a travel time counting survey in field condition was organized; from here travel time was collected on every approaches of this intersection from 07.00 A.M to 06.00 P.M. After getting this travel time of every approach, deducting the free flow time from surveyed travel time, delay was found from every approaches all throughout the day. The delay of these approaches are shown below from 07.00 A.M. to 06.00 P.M. in Table 4.11.10

Table 4.11.10: Delay at Different Approach of Shapla Chattar Intersection.

Observation No.	**Time**	**Delay (R.K. Road to Shapla Chattar) sec**	**Delay (Arambagh Mor to Shapla Chattar) sec**
1.	07.00 A.M. 07.30 A.M.	12	26
2.	07.30 A.M. 08.00 A.M.	22	36
3.	08.00 A.M. 08.30 A.M.	46	40
4.	08.30 A.M. 09.00 A.M.	57	47
5.	09.00 A.M. 09.30 A.M.	68	69
6.	09.30 A.M. 10.00 A.M.	113	81
7.	10.00 A.M. 10.30 A.M.	124	113
8.	10.30 A.M. 11.00 A.M.	116	127
9.	11.00 A.M. 11.30 A.M.	128	155
10.	11.30 A.M. 12.00 P.M.	235	159
11.	12.00 P.M. 12.30 P.M.	290	270
12.	12.30 P.M. 01.00 P.M.	368	337
13.	01.00 P.M. 01.30 P.M.	416	452
14.	01.30 P.M. 02.00 P.M.	536	670
15.	02.00 P.M. 02.30 P.M.	526	726
16.	02.30 P.M. 03.00 P.M.	713	868
17.	03.00 P.M. 03.30 P.M.	732	970
18.	03.30 P.M. 04.00 P.M.	869	979
19.	04.00 P.M. 04.30 P.M.	968	980
20.	04.30 P.M. 05.00 P.M.	1024	1068
21.	05.00 P.M. 05.30 P.M.	768	866
22.	05.30 P.M. 06.00 P.M.	555	560

Analyzing the Table 4.11.10, the delay at different approach of Shapla Chattar intersection is increasing as the progress of the day time was found. Approach wise comparison of delay time is shown in Figure: 4.11.10 below.

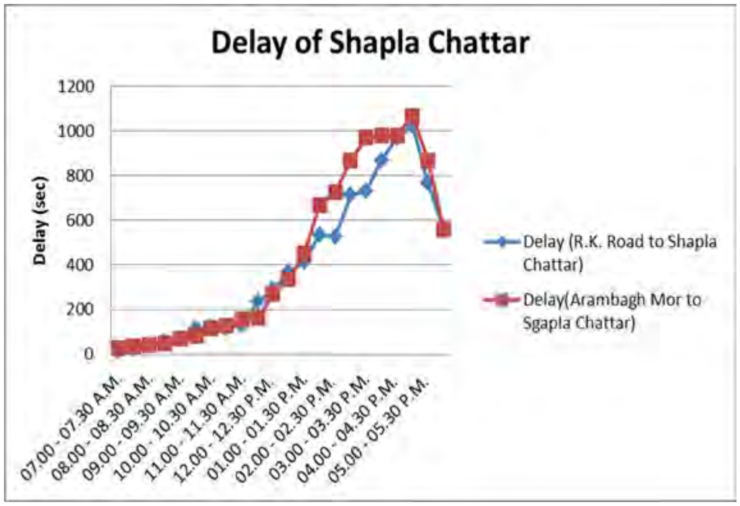


Figure 4.11.10: Comparison of Delay at Different Approach of Shapla Chattar Intersection.

Analyzing the Figure 4.11.10, it was observed that, all the approaches of this intersection experienced maximum delay in traffic flow at the time of evening peak hour mostly.

E. Evaluation Performance of the Intersections Based on LOS Ranking

Finally, based on the delay on every approach of this intersection, LOS of four (4) approaches was calculated for Shapla Chattar intersection. In the following Table 4.11.11 Figure: 4.11.11 the LOS of this intersection is presented below, the detailed calculation of LOS given in Appendix A

Table 4.11.11: LOS of Different Approaches of Shapla Chattar Intersection.

Observation No.	Time	LOS (R.K. Road to Shapla Chattar)	LOS (Arambagh Mor to Shapla Chattar)
1.	07.00 A.M. 07.30 A.M.	A	C
2.	07.30 A.M. 08.00 A.M.	C	D
3.	08.00 A.M. 08.30 A.M.	E	E
4.	08.30 A.M. 09.00 A.M.	F	E
5.	09.00 A.M. 09.30 A.M.	F	F
6.	09.30 A.M. 10.00 A.M.	F	F
7.	10.00 A.M. 10.30 A.M.	F	F
8.	10.30 A.M. 11.00 A.M.	F	F
9.	11.00 A.M. 11.30 A.M.	F	F
10.	11.30 A.M. 12.00 P.M.	F	F
11.	12.00 P.M. 12.30 P.M.	F	F
12.	12.30 P.M. 01.00 P.M.	F	F
13.	01.00 P.M. 01.30 P.M.	F	F
14.	01.30 P.M. 02.00 P.M.	F	F
15.	02.00 P.M. 02.30 P.M.	F	F

16.	02.30 P.M. 03.00 P.M.	F	F
17.	03.00 P.M. 03.30 P.M.	F	F
18.	03.30 P.M. 04.00 P.M.	F	F
19.	04.00 P.M. 04.30 P.M.	F	F
20.	04.30 P.M. 05.00 P.M.	F	F
21.	05.00 P.M. 05.30 P.M.	F	F
22.	05.30 P.M. 06.00 P.M.	F	F

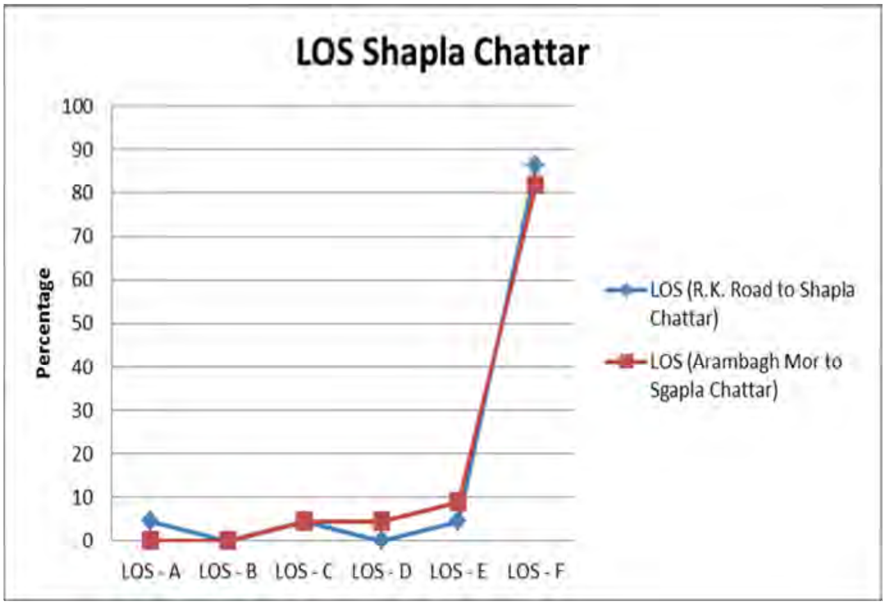


Figure 4.11.11: Percentage of Various LOS at Different Approaches of Shapla ChattarIntersection.

By analyzing the Table 4.11.11 and Figure: 4.11.11 the LOS of different approaches of this intersection, it was found that during 11 hours survey period for R.K. Road to Shapla Chattar approach, the LOS level A, B, C, D, E and F were observed to be 4.5%, 0.0%, 4.5%, 0.0%, 4.5% and 86.36% of survey time respectively and similarly for approach Arambagh Mor to Shapla Chattar the LOS level A, B, C, D, E and F were observed to be 0.0%, 0.0%, 4.5%, 4.5%, 9.0% and 81.81% of survey time respectively. The LOS of every approach of this intersection was retaining at Level F consistently. For present Dhaka Metropolitan City, it is a curse.

4.12 Quantitative Data Analysis of Science Laboratory Intersection

A. Site Investigation of Science Laboratory Intersection:

The Intersection is situated on a primary road (Mirpur road). This intersection contains a huge area for traffic operation. Green roads, Elephant road, New Market road, Dhanmondi road 1, 2, 3, Mirpur road are joining in this intersection. This is a busy place of Dhaka city. In every approach of this intersection contain markets, shopping mall, offices, schools, colleges, restaurants, private universities, etc. according to classification of intersection; the Science Laboratory Intersection is a multi - legged compound intersection. In this intersection, there is a combination of one four (4) legged / cross junction, two (2) Tee intersection.

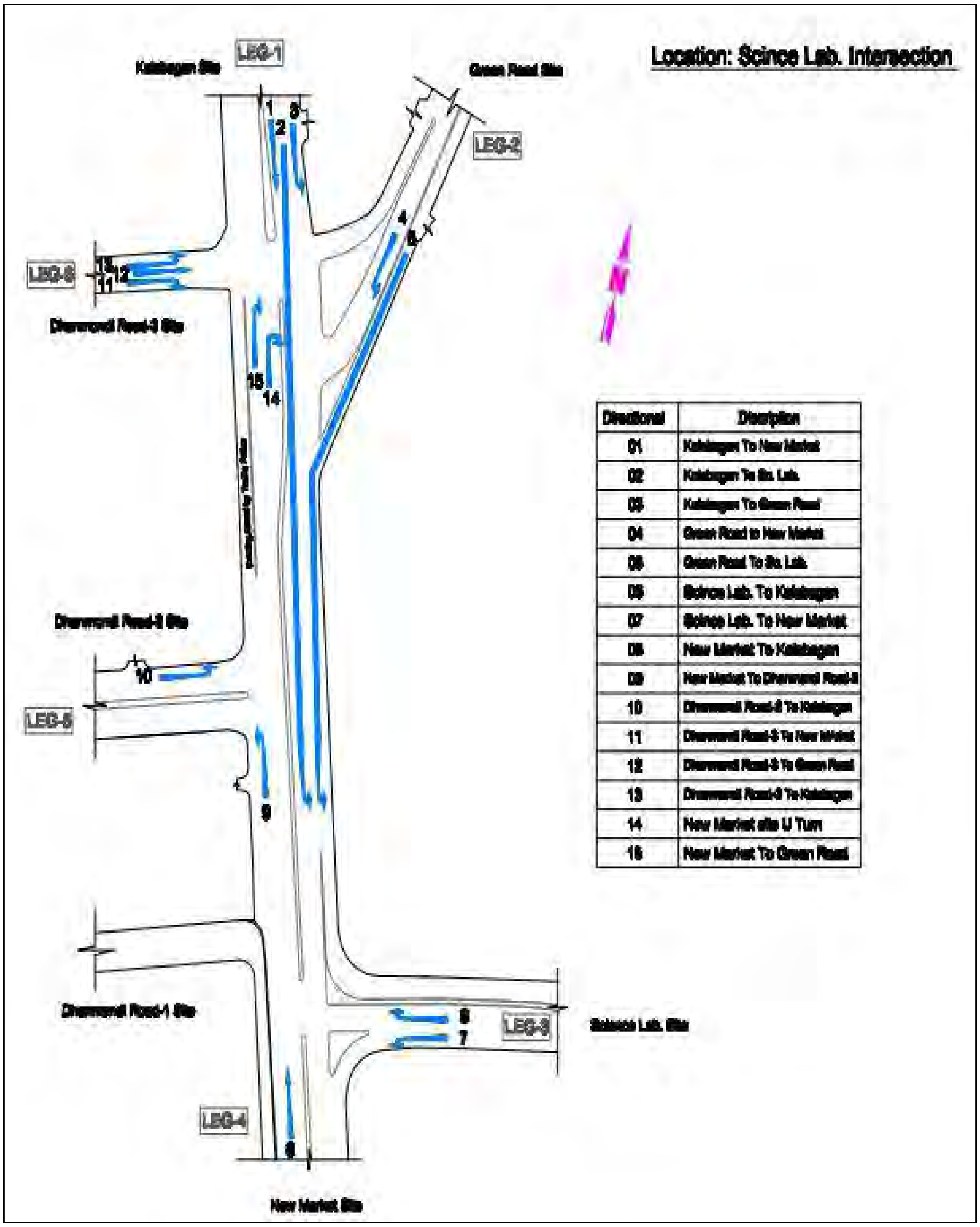


Figure 4.12.1: Layout of Science Laboratory intersection.

Source: (Signal Synchronization Study, 2013).

From preliminary survey of this shortlisted intersection, the main approaches are divided by lanes with marking and the one minor approach does not have lane division. A table describing the lane division of different approaches is given below

Table 4.12.1: Approach of Science Laboratory Intersection with Lane Division.

Serial No.	Approach with Direction	Lane Number
Leg 1.	Science Laboratory Intersection to Kalabagan	3 lanes both direction
Leg 2.	Science Laboratory Intersection to Green Road	2 lanes both direction
Leg 3.	Science Laboratory Intersection to Shahbag Road	2 lanes both direction
Leg 4.	Science Laboratory Intersection to New Market	3 lanes both direction
Leg 5.	Science Laboratory Intersection to Dhanmondi Road 2	2 lanes both direction
Leg 6.	Science Laboratory Intersection to Dhanmondi Road 3	No lane Division

The main carriageway of this intersection is flexible pavement in all direction. In this intersection, no lack of maintenance work was found here. We found here smooth carriageway in this intersection.

By reviewing the preliminary survey of this intersection, two (2) distinct peak hours were found in this intersection, one, in the morning from 08.30 A.M. to 12.00 P.M. and other, in the evening from 03.30 P.M. to 06.00 P.M. and furthermore (beyond the survey time). A lot of traffic used this intersection all throughout the day. A lot of pedestrian movement was found in this intersection. There is an over bridge having for crossing the junction, it is a four (4) legged over bridge. But a negligible amount of pedestrian uses this crossing facility. Pedestrians cross the junction matching with their desire paths under risk. Pedestrian would hardly find the suitable gaps within the moving traffic stream to perform the crossing maneuver. There was footpath in all approaches of the intersection; however this footpath was dishonestly invaded by the hawkers, traders, hotels, construction material, rickshaw, Laguna stand, illegal parking, bus stand, etc. The footpath facilities for pedestrian movements are completely blocked by the street hawkers, forcing pedestrian on to the roadway. NMV is not allowed in this intersection, a separate lane is provided in this intersection. There was a lot of side friction in the approaches of this intersection. A parts of the road space always remain block with parked vehicle. At the vicinity of this intersection approaches, almost all the approaches are provided with illegal stoppage, where the vehicles stand haphazardly. Effective road width of the intersection was reduced by this type of activities.

There was the provision of automatic traffic signal for traffic control, but this was not practiced in field. So, all of the signals were as showpiece in a showcase. Traffic police tried to control the traffic of this intersection manually. Signal timing, phasing was not consistent for this. They tried to operate this intersection responding as per demand. So a lot of delay occurred here and queue length originated in peak period too.

B. Geometric and Operating Conditions of Selected Intersection (Science Laboratory Intersection)

After finishing the detail survey of selected intersection, Science Laboratory intersection; analysis of collected data about the intersection geometry and operating condition was done. The findings of this analysis is tabulated in Table: 4.12.2 below

Table 4.12.2: Geometric and Operating Condition of Science Laboratory Intersection.

Serial No.	Items	Description
1.	**Number of Approaches**	There are six (6) approaches namely from Science Laboratory to Kalabagan approach, from Science Laboratory to Green Road approach, from Science Laboratory to Shah bag approach, from Science Laboratory to New Market approach, from Science Laboratory to Dhanmondi Road 2 approach and from Science Laboratory to Dhanmondi Road 3 approach.
2.	**Carriageway**	All six (6) approaches of this intersection are flexible pavement in structural point of view and dual carriageway.
3.	**Footpath Coverage**	Footpaths for pedestrian are found existing here, by the both of the side of all the four approaches of this intersection, which is illegally occupied by purveyors, building materials, parked vehicle, etc. Science Laboratory intersection has 100% footpath coverage.
4.	**Channelization**	On the mouth of Shahbag and Green road approach there are channelizations for left turning

		vehicle.
5.	**Divider**	All approaches of this intersection are alienated by the non - engineering divider. This non engineering divider is not related with velocity profile of vehicle of this intersection.
6.	**Pedestrian Crossing Facility**	There is a four (4) legged over bridge, which is at the inside of this intersection, providing pedestrian crossing facility as a grade separated service. But pedestrians try to cross the intersection through the busy road at grade as usually.
7.	**Side Road**	From preliminary survey of Science Laboratory intersection area eight (8) side roads were found, which are coming from neighboring residential / commercial area of this intersection, exposed in this intersection directly, containing maximum NMV and MV on it.

C. Determining the Existing Vehicular, Pedestrian Flow, Amount of Side Friction, and Condition of Traffic Control Devices including Signal Timing, Phasing and Mode of Operation at Science Laboratory Intersection:

In detail survey of Science Laboratory intersection; existing vehicular flow, pedestrian flow was observed, furthermore amount of side friction was exposed and condition of traffic signal, signal timing, phasing and mode of operation was documented and which was analyzed later.

i. Existing Vehicular Flow

Analyzing the exiting vehicular flow of Science Laboratory intersection, an 11 hours vehicular survey (from 07.00 A.M. to 06.00 P.M.) was organized, the result of this survey and its analysis are presented here in Figure 4.12.2 a) and b), this figure is presenting a general graph accompanying with a pie chart, which is presenting the data of vehicular survey of this intersection and expressing the characteristics of vehicular flow through this intersection.

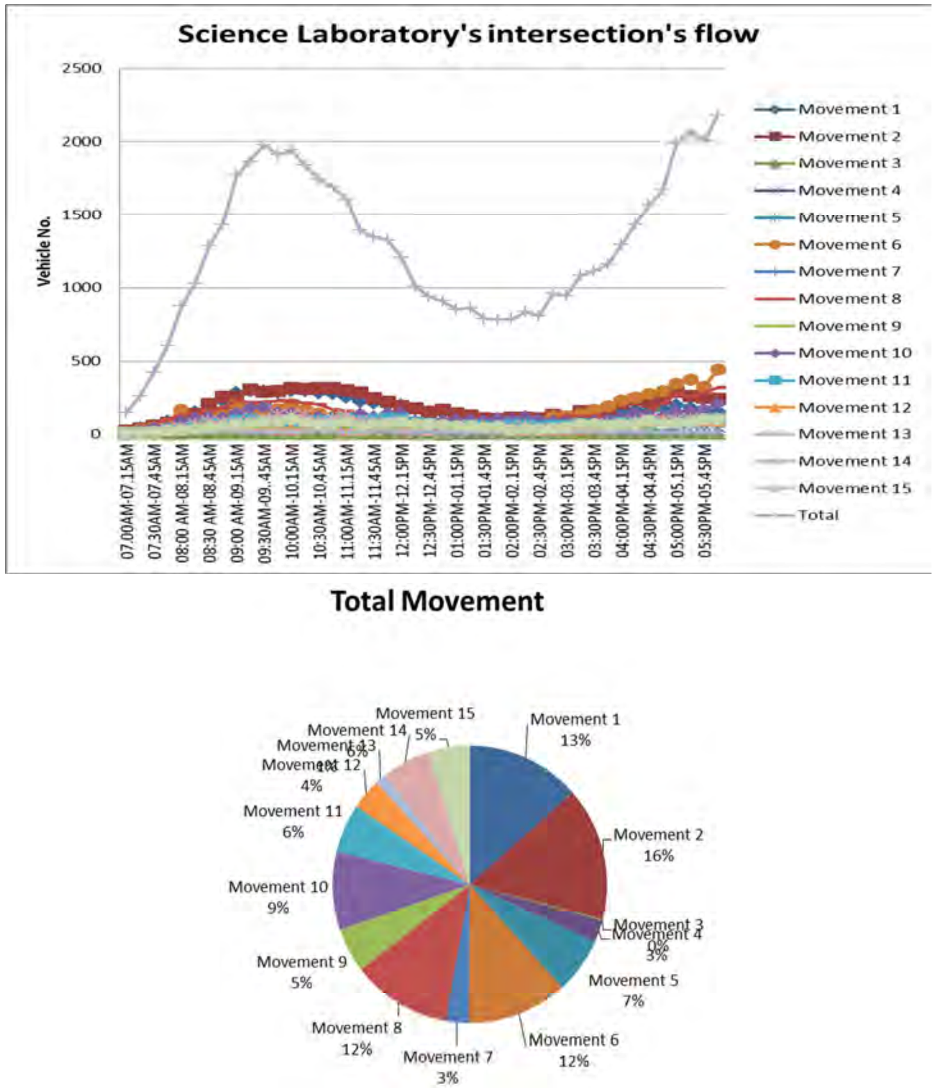
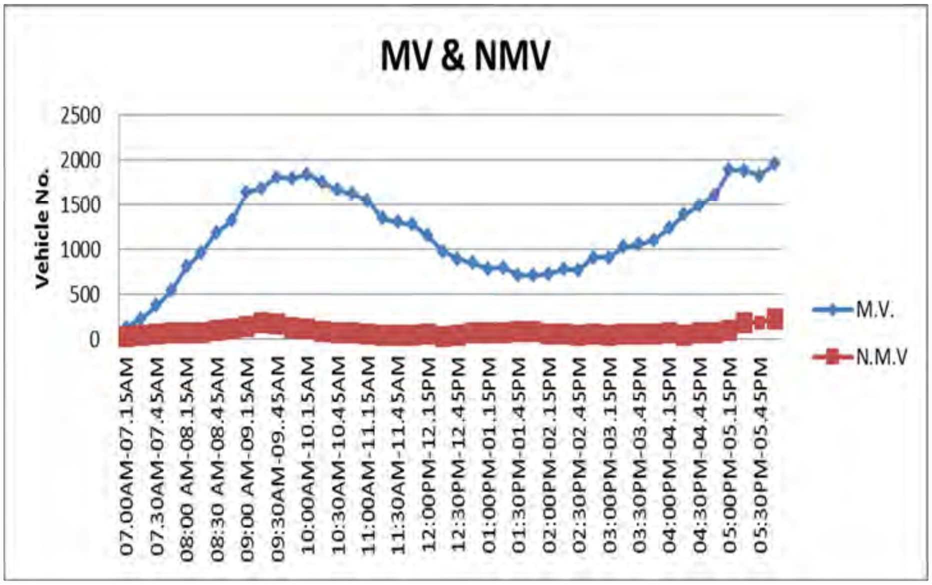


Figure 4.12.2: a) Vehicular Flow Data of Science Laboratory Intersection; b) Vehicle Movement Contribution of Science Laboratory Intersection.

Analyzing the vehicular survey data of this intersection, fifteen (15) individual movements were found and among them Movement -2 (Kalabagan to Science Laboratory) was maximum, which contained 16% of entire traffic flow of this intersection on the day of survey. From the entire 11 hour vehicular survey, two (2) distinct peak hours were found in this intersection, one, in the morning from 08.30 A.M. to 12.00 P.M. and other, in the evening from 03.30 P.M. to 06.00 P.M. and furthermore (beyond the survey time), which is higher than the morning peak, total peak hour of the survey time was 6 hours, which was 54.54% of total survey time.

After analyzing the vehicular flow of this intersection, assessment of the vehicular combination of this intersection was done. The result of this analysis is presented here in Figure 4.12.3 a) and b), this figure is presenting a general graph accompanying with a pie chart.



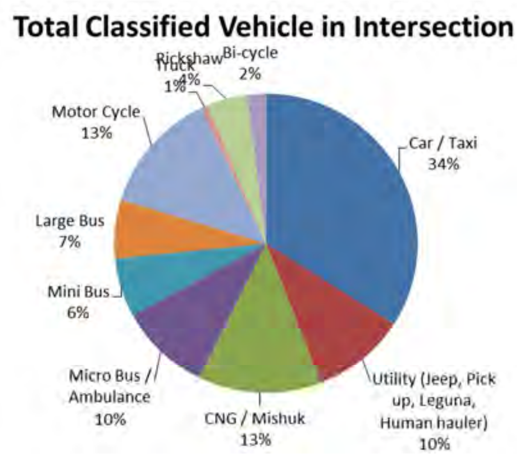


Figure 4.12.3: a) Individual Flow of MV and NMV in Science LaboratoryIntersection; b) Classified Vehicle in Science Laboratory Intersection;

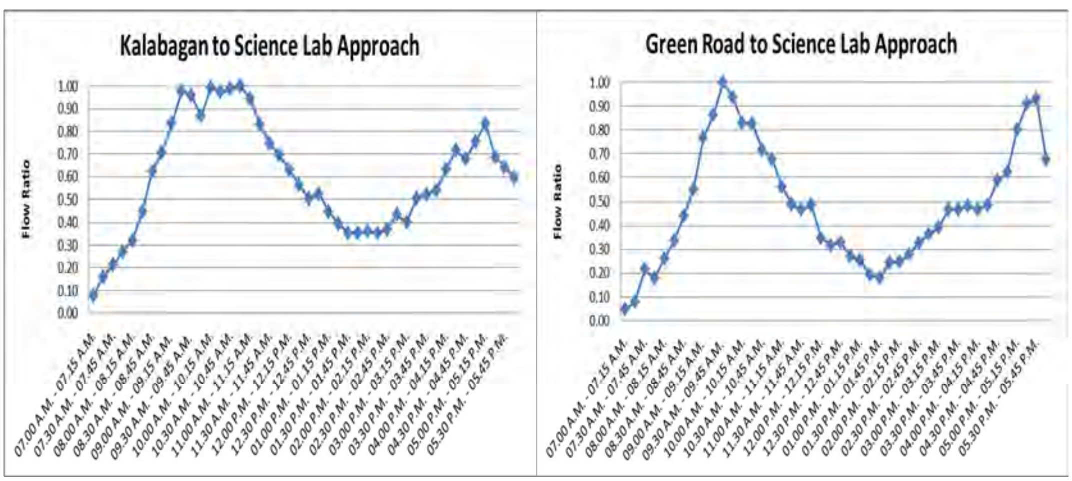
In Figure 4.12.3 a), a general graph is shown, which is showing the individual flow of MV and NMV through this intersection. Analyzing this general graph, two (2) distinct peak hours are found for MV; it was observed from 08.30 A.M. to 12.00 P.M. at morning and from 03.30 P.M. and 06.00 P.M. and furthermore at evening period. A constant rate of NMV flow was found through this intersection all throughout the day. In Figure 4.12.3 b), a pie chart is shown, which is expressing the vehicular composition of this intersection. The dominancy of MV is found out from here, which was 94% of total vehicular flow; among the vehicular flow car / taxi were the mostly governed vehicle type in this intersection, which was 34% of total flow.

After finding out the vehicular composition, the saturation flow of every approach of this intersection was calculated from the vehicular survey data. The result of this analysis is presented here through a tabular format in Table 4.12.3 below.

Table 4.12.3: Saturation Flow of Different Approach of Science Laboratory Intersection.

Serial No.	Intersection Name	Intersection Classification	Approach Name	Saturation Flow (PCU / Hour)
1.	Science Laboratory intersection	Multi - legged Compound Intersection.	Kalabagan to Science Lab Intersection.	2852.56
2.			Green Road to Science Lab Intersection.	804.08
3.			Elephant Road to Science Lab Intersection.	2039.24
4.			New Market Road to Science Lab Intersection.	2736.96
5.			Dhanmondi Road 2 to Science Lab Intersection.	1158.84
6.			Dhanmondi Road 2 to Science Lab Intersection.	503.48

Later, the usages of road space of every approaches of this intersection were calculated. The result of this calculation is presented here through Figure 4.12.4 a), b), c), d), e) and f) with individual general graph, which is expressing the flow ratio with respect to saturation flow of the individual approach of this intersection of 11 hours.



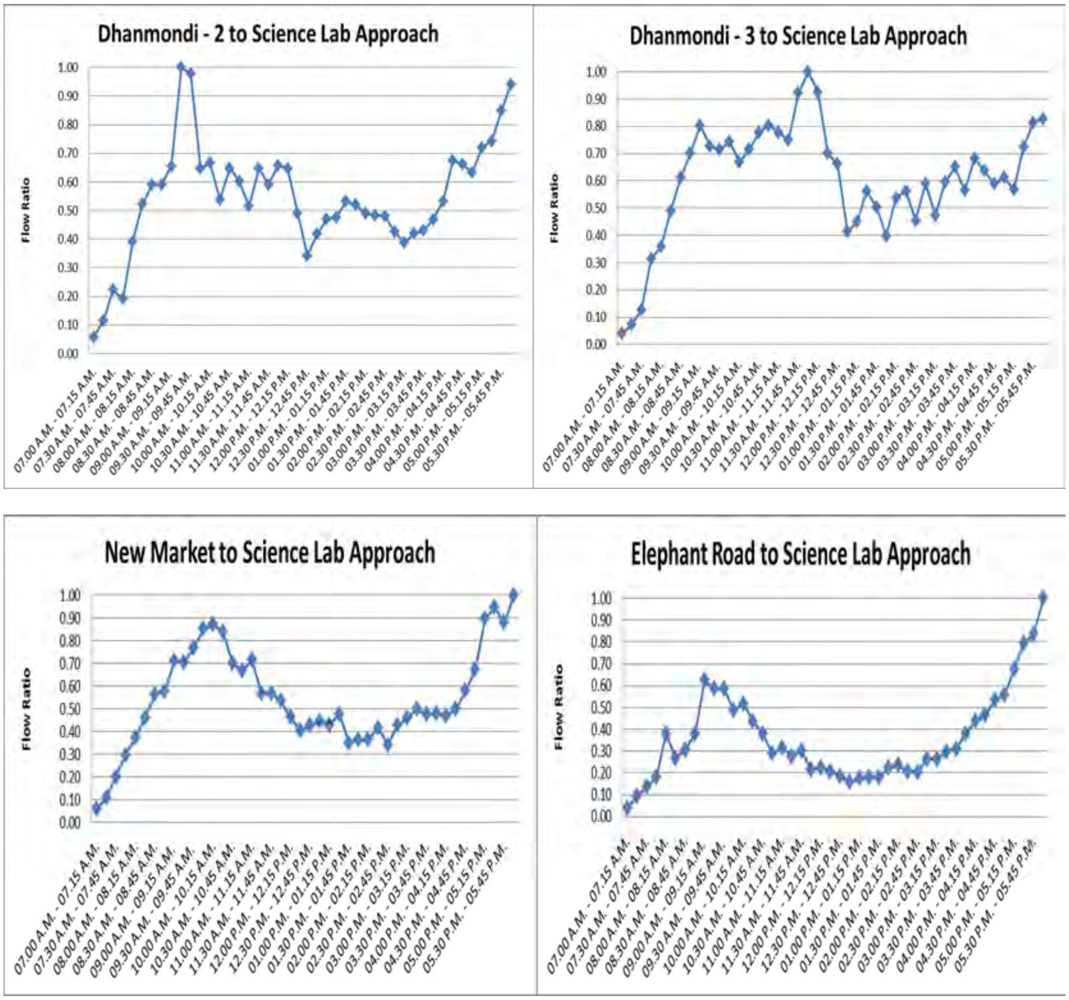


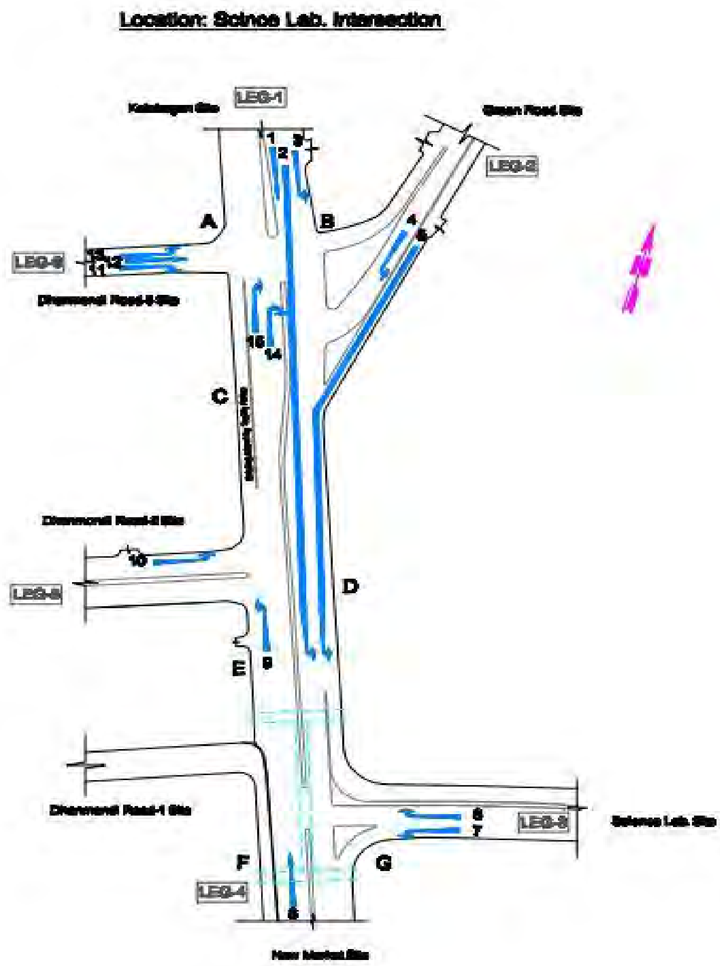
Figure 4.12.4: a) Flow Ratio of Kalabagan to Science Lab. Approach; b) Flow Ratio of Green Road to Science Lab approach; c) Flow Ratio of Dhanmondi 2 to Science Lab approach; d) Flow Ratio of Dhanmondi 3 to Science Lab approach; e) Flow Ratio of New Market to Science Lab approach; f) Flow Ratio of Elephant Road to Science Lab approach.

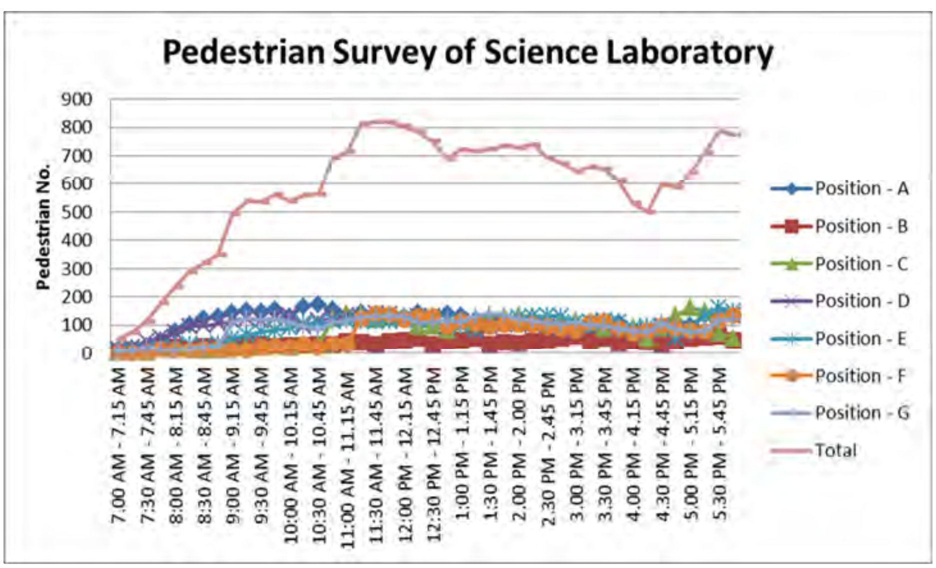
From Figure 4.12.4, it is observed that, every approach of this intersection were containing in two (2) peak hours in vehicular flow; one in the morning and other in the evening.

ii. Pedestrian Flow

As per set out objectives of this research, the pedestrian flow through this intersection was also observed. In preliminary survey, two (2) types of pedestrian flow were observed; one was at grade and other was grade separated.

In this intersection, detail 11 hours (from 07.00 A.M. to 06.00 P.M.) pedestrian survey was organized for finding out the scenario of at grade pedestrian flow. After analyzing the result of this, it is presented here in Figure 4.12.5 a), b) and c), through a general graph accompanying with a CAD drawing and pie chart.





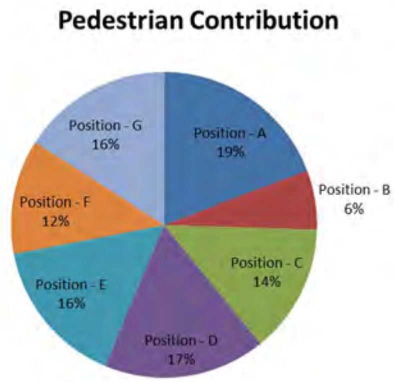
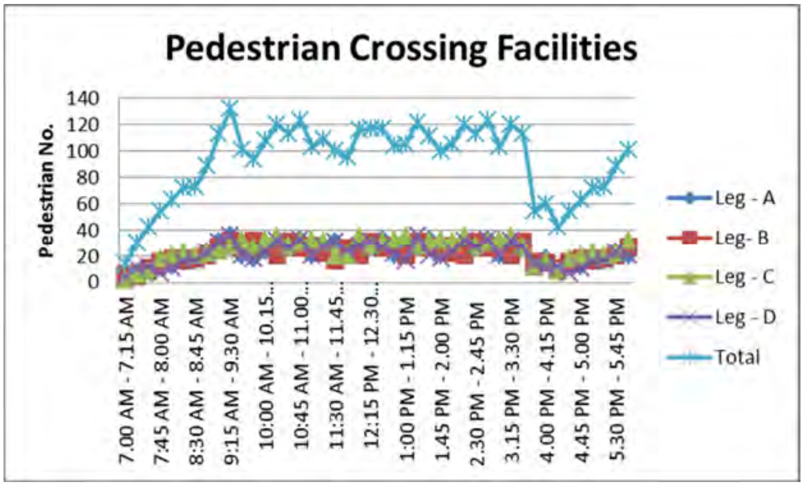


Figure 4.12.5: a) Positions of Pedestrian Survey inside the Science Laboratory Intersection; b) Pedestrian Flow through Selected Positions of Pedestrian Survey; c) Percentage of Contribution of Pedestrian among the seven Positions.

From the preliminary survey, the seven (7) positions were selected for detail field survey according to the availability of pedestrian in this intersection. The positions of those seven points are shown here inFigure 4.12.5 a). From Figure 4.12.5 b) at grade pedestrian flow through this intersection is presented, the pedestrian flow through this intersection was increased at 10.00 A.M. and later the rate of this was remained constant all throughout the day. Among the seven (7) positions, maximum at grade pedestrian flow was found in position A, which is at the corner of Dhanmondi road 3 and in front of Alliance Francaise, 19% percent of entire at grade pedestrian flow took place in this position which is presented here in Figure 4.12.5 c).

A four legged over bridge is situated inside this intersection as a grade separated crossing facilities for pedestrian. For finding out the scenario of grade separated pedestrian crossing facility of this intersection, an 11 hours (from 07.00 A.M. to 06.00 P.M.) pedestrian crossing survey was organized in this over bridge. After analyzing the result of this pedestrian survey, it is presented here in Figure 4.12.6 a), b) and c) through a general graph accompanying with a Google Map and pie chart.



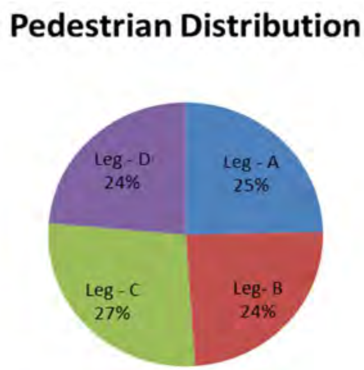


Figure 4.12.6: a) Position of Over Bridge inside Science Laboratory Intersection; b) Grade Separated Pedestrian Crossing Facilities Users c) Percentage of Pedestrians, who Crossed Using Over Bridge.

From Figure 4.12.6 a), b) and c) , from 11 hours survey it was observed that total 4, 045 nos. of pedestrian used this over bridge as a crossing facility through this intersection, the legs of the over bridge is indicated by Leg A, Leg B, Leg C and Leg D in Google Map. With respect to total pedestrian flow only 15.72% pedestrian used this facility on that day. Among the four legs of this over bridge, it was found that, about 27% of intersection crossing pedestrian were in Leg C, which is at the corner of Science Laboratory Masjid.

iii. Side Friction

As per set out objectives of this research, the amount of side friction in this intersection was also determined. From the preliminary survey of this intersection the three (3) specified reasons of side friction were found rickshaw diversion, illegal human hauler and bus stand. For finding out the scenario of side friction, an 11 hour (from 07.00 A.M. to 06.00 P.M.) was organized.

From the preliminary survey of this intersection, it was observed that, there was one (1) distinct point inside the intersection; rickshaws were diverted from this place, which created a lot of jam on the approaches. For understanding the real scenario of this rickshaw stand, a counting survey was organized in the final survey of this intersection. The result of this survey is presented here in Figure 4.12.7 a) and b).

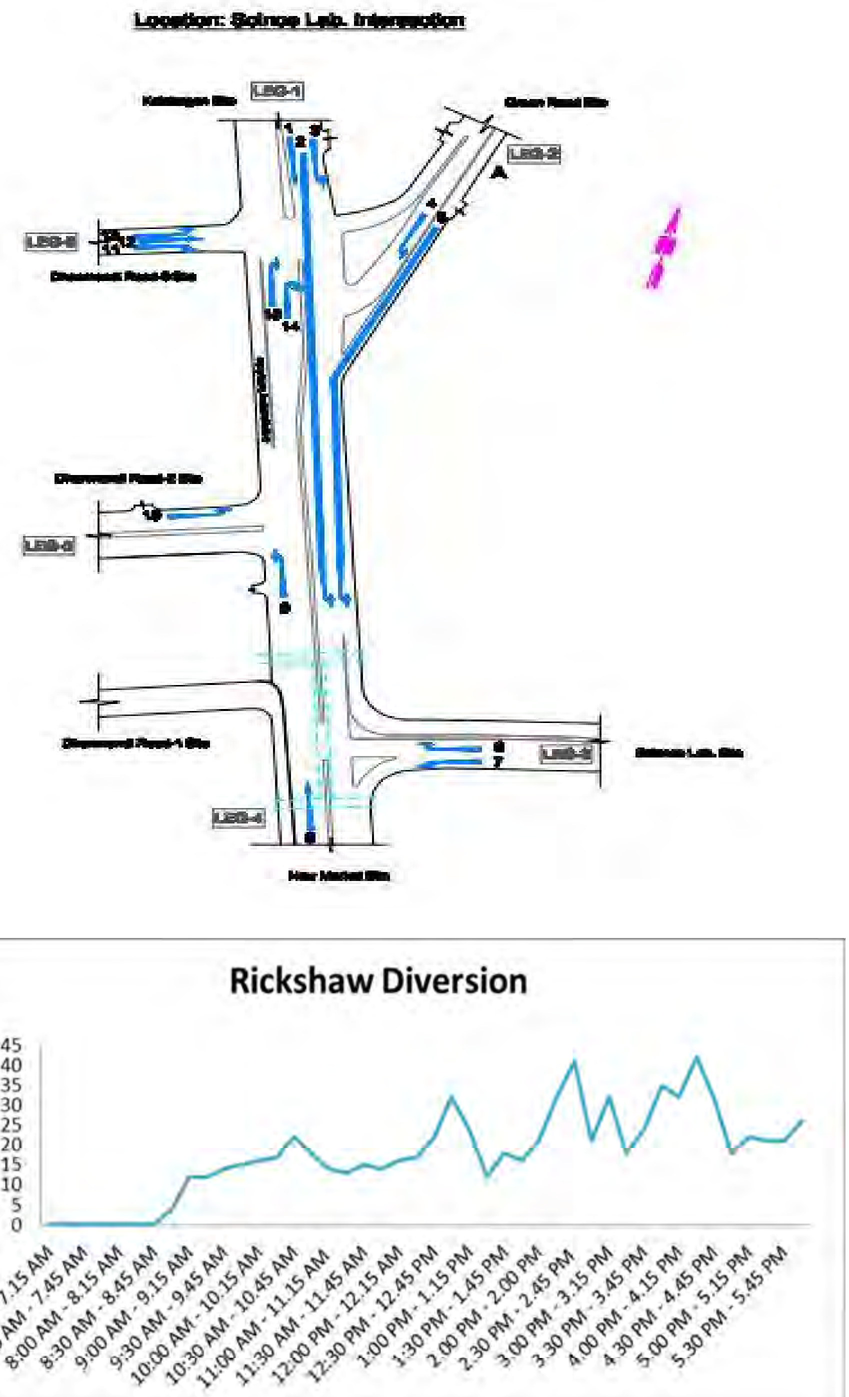


Figure 4.12.7: a) Position of Rickshaw Diversion Point of Science Laboratory Intersection; b) Counting Survey of Rickshaw Diversion from Science Laboratory Intersection.

From the above Figure 4.12.7 a) and b) analyzing the 11 hours survey result, a huge amount of rickshaw were diverted from this point on the main approach of this intersection, on the mouth of Science Lab to Green Road approach. It disturbed the smooth flow of the vehicle through this intersection. Though the rickshaw diversion is continuing process in this intersection, but rickshaw was found in the vehicle count inside this intersection too.

From the preliminary survey of this intersection, it was observed that, there was one (1) distinct point inside the intersection; human hauler illegally stood there, which created a lot of jam on the approaches. For understanding the real scenario of this rickshaw stand, a counting survey was organized in the final survey of this intersection. The result of this survey is presented here in Figure 4.12.8 a) and b).

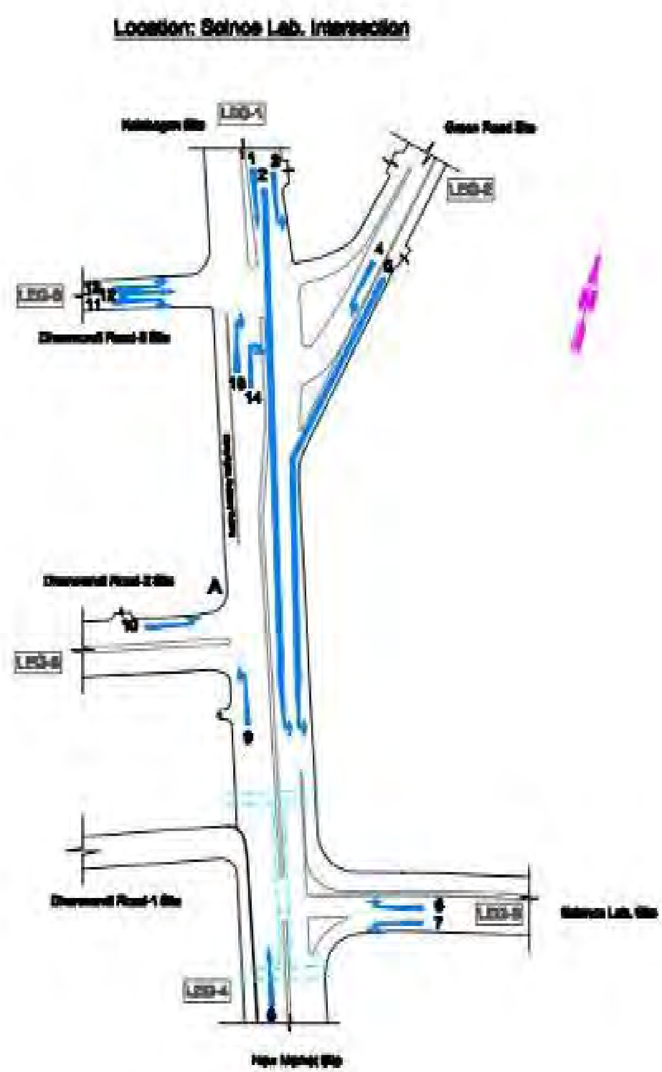
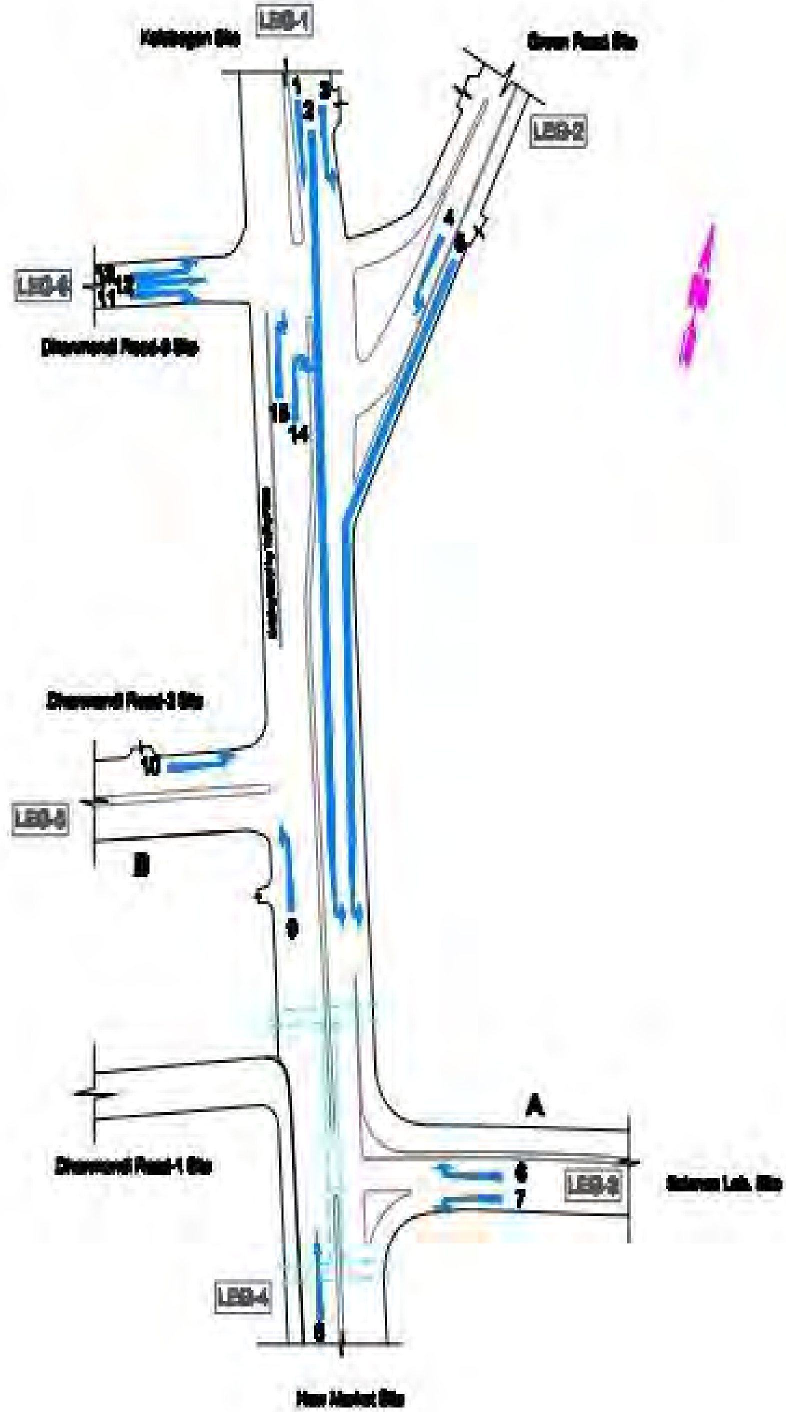


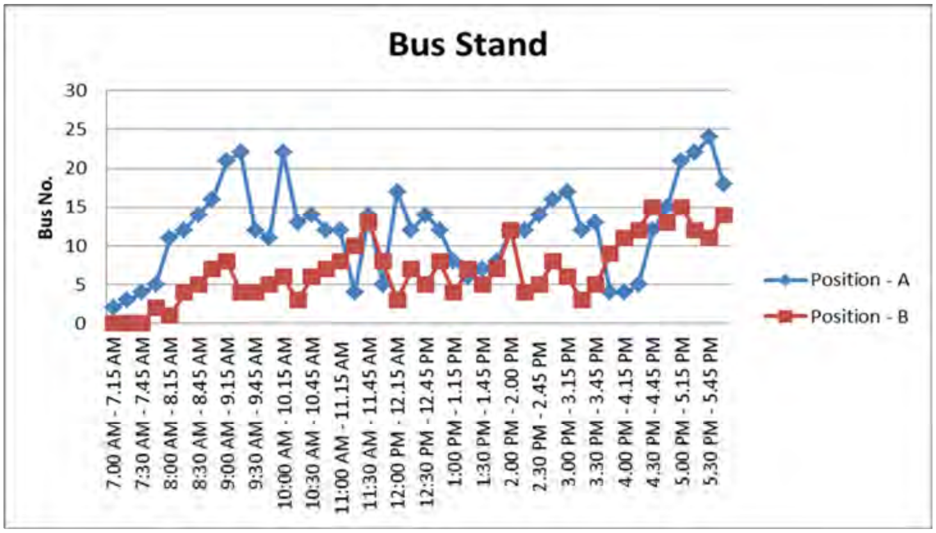
Figure 4.12.8: a) Position of Illegal Human Hauler Stand of Science Laboratory Intersection; b) Counting Survey of Human Hauler Stood Inside the Intersection.

From the above Figure 4.12.8 a) and b) analyzing the 11 hours survey result, a huge amount of human hauler were stood this point on the main approach of this intersection, on the mouth of Dhanmondi Road 2 to Science Lab approach. It disturbed the smooth flow of the vehicle through this intersection.

From the preliminary survey of this intersection, it was observed that, there were two (2) distinct points inside the intersection; bus illegally stood there, which created a lot of jam on the approaches. For understanding the real scenario of this illegal bus stand, a counting survey was organized in the final survey of this intersection. The result of this survey is presented here in Figure 4.12.9 a), b) and c).

Location: Scince Lab. Intersection





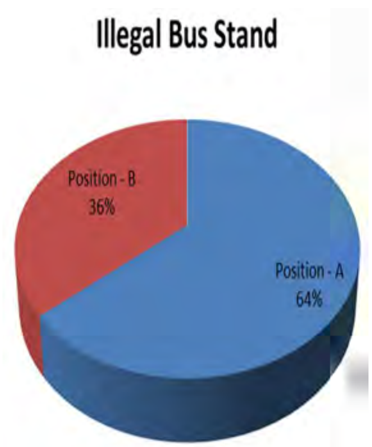


Figure 4.12.9: a) Position of Illegal Bus Stand of Science Laboratory Intersection; b) Counting Survey of Bus Stood inside the Intersection; c) Contribution of Illegal Bus Stands.

From the above Figure 4.12.9 a), b) and c) analyzing the 11 hours survey result, a huge amount of bus were stood these points on the main approach of this intersection, on the mouth of Dhanmondi Road 2 to Science Lab and Science Lab to Elephant Road to Science Lab approach. Among them, most illegally standee bus was found on the Elephant road beside the wall of Science lab. It disturbed the smooth flow of the vehicle through this intersection.

Generally the combined effect of side friction was observed in the traffic flow of this intersection. 50% of total road width at the mouth of approach of this intersection was blocked by this side friction in the peak hour. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing day by day.

iv. Traffic Control Devices

From the preliminary survey of this intersection, a condition survey of traffic control devices was organized. The outputs of this condition survey are given below in a tabular format, in Table 4.12.4.

Table 4.12.4: Signal Accessories of Science Laboratory Intersection.

Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Operate	Pedestrian Signal Operate
SP-1	OK	Rotated	Yes	No
SP-2	OK	OK	-	No
SP-3	OK	OK	-	No
SP-4	Hidden	All missing	-	-
SP-5	OK	OK	No	No
SP-6	OK	Rotated	-	No
SP-7	OK	Rotated	Yes	No
SP-8	OK	Missing	-	No
SP-9	Signal lights hidden	Missing	Yes	No
SP-10	OK	Missing	-	No
MAP-1	Signal lights hidden	Missing	Yes	No
MAP-2	OK	OK	-	-
MAP-3	OK	OK	-	No
MAP-4	Signal lights hidden	OK	No	-
MAP-5	One side signal light hidden	OK	Yes	No
TSC	OK	OK		

Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

In this intersection, for traffic control there was no use of traffic signal; instead of this, police controlled the traffic movement of this intersection manually based on traffic flow demands among six (6) approaches which is considered to be as

responsive signal system

this intersection in main two parts.

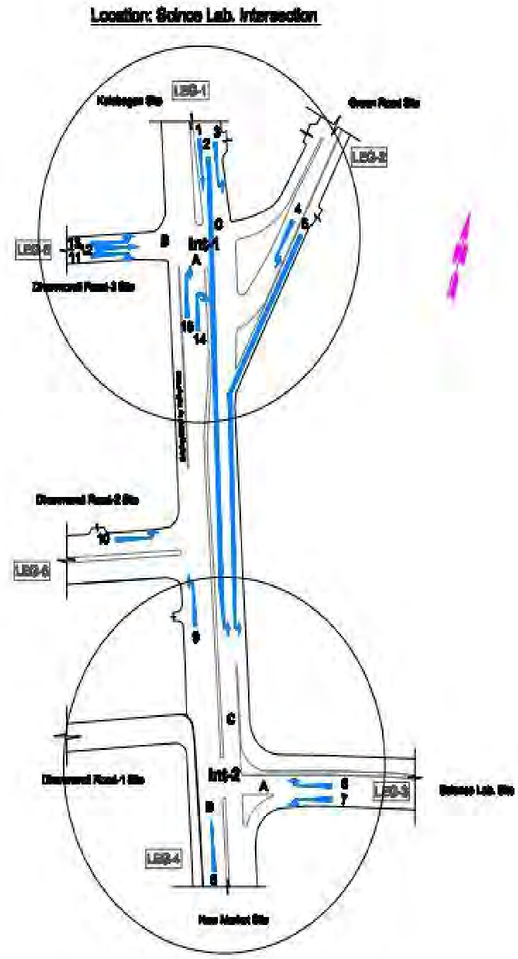


Figure 4.12.10: Two Main Parts of this Intersection inside the Science Laboratory Intersection.

For this police tried to follow here three (3) phase traffic controlling system for both intersectional points (one road two road stopped), which was the most inefficient method of traffic control. The traffic signal cycle time in this method is not consistent. The variation of signal cycle time in Science Lab intersection at peak periods are given in the followingFigure 4.12.11.

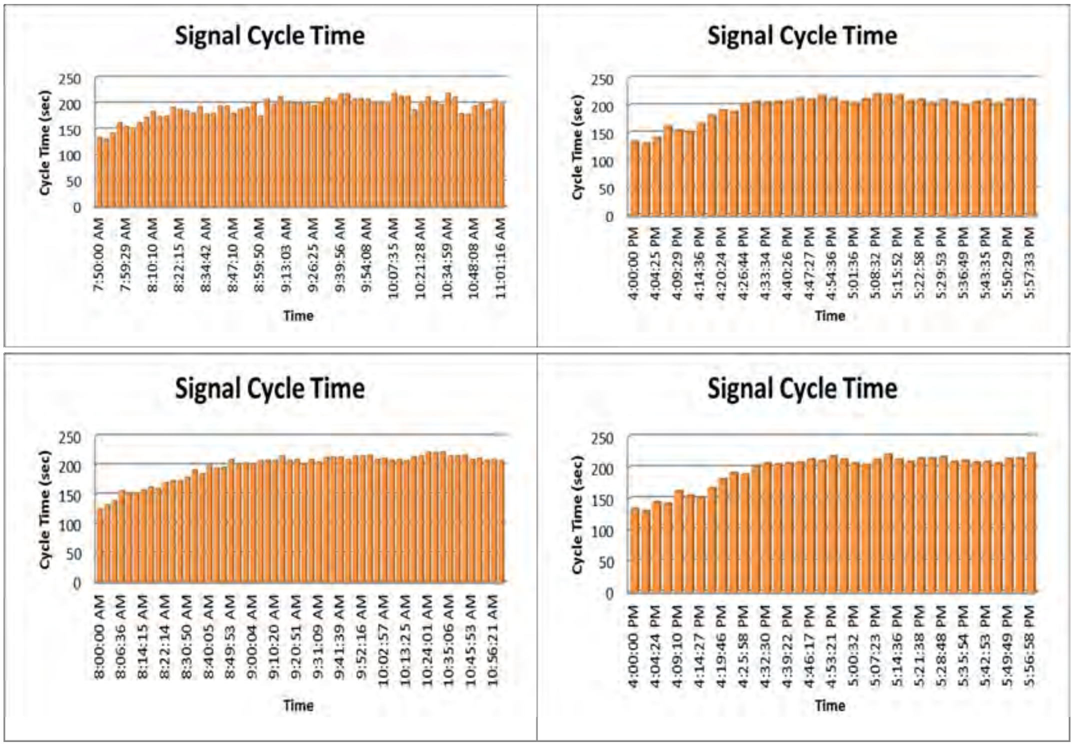


Figure 4.12.11: Signal Cycle Time at (Morning and Evening) Peak Periods a) Intersection 1, In Front of LABAID and b) Intersection 2, under the Over Bridge.

From the signal cycle time counting, it was observed that, 100% of total observation time was more than 120 sec, which is increasing the delay of the intersection as per research of *J. Li et al. (2004)*.

From the preliminary survey of this Science Laboratory intersection, the information about mode of operation of this intersection was observed. In the detail analysis of this information, it is tabulated in Table 4.12.5 below

Table 4.12.5: Existing Traffic Control System and Time of Operation of Science Laboratory intersection.

Sl. No.	Description	Duration of operation
1	Automatic signal lighting system	(09.00 P.M. 09.00 A.M.)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(09.00 AM 11.00 AM) (04.30 PM 07.30 PM)
4	Mixed	(11.00 AM 04.30 PM) (07.30P.M 09.00 PM)

Analyzing the Table 4.12.5 , it is found that Science Laboratory intersection is operated in three (3) methods and different hours; automatic signal lighting system 12 hours of the total time of the day, automatic signal system (control by traffic police demand responsive) 5 hours and mixed (both automatic and controlled by police) 7 hours. In peak period this intersection is controlled by police manually.

The flow ratio of the six (6) approaches of this intersection at peak period is calculated, it is tabulated in Table 4.12.6. This is given below

Table 4.12.6: Flow Ratio of Different Approaches of Science Laboratory Intersection.

Time	Kalabagan to Science Lab Intersection, y_1	Green Road to Science Lab Intersection, y_2	Elephant Road to Science Lab Intersection, y_3	New Market to Science Lab Intersection, y_4	Dhanmondi Road - 2 to Science Lab Intersection, y_5	Dhanmondi Road - 3 to Science Lab Intersection, y_6	Summation, Y
08.30 A.M. - 08.45 A.M.	0.62	0.44	0.31	0.56	0.59	0.61	3.14
08.45 A.M. - 09.00 A.M.	0.71	0.55	0.38	0.58	0.59	0.70	3.50
09.00 A.M. - 09.15 A.M.	0.83	0.77	0.62	0.71	0.66	0.80	4.39
09.15 A.M. - 09.30 A.M.	0.98	0.86	0.59	0.70	1.00	0.73	4.86
09.30 A.M. - 09.45 A.M.	0.96	1.00	0.59	0.77	0.98	0.72	5.01
09.45 A.M. - 10.00 A.M.	0.87	0.94	0.49	0.85	0.65	0.74	4.53
10.00 A.M. - 10.15 A.M.	0.99	0.83	0.52	0.87	0.67	0.67	4.55
10.15 A.M. - 10.30 A.M.	0.97	0.83	0.44	0.84	0.54	0.72	4.33
10.30 A.M. - 10.45 A.M.	0.99	0.72	0.38	0.70	0.65	0.78	4.21
10.45 A.M. - 11.00 A.M.	1.00	0.68	0.29	0.67	0.60	0.80	4.04
11.00 A.M. - 11.15 A.M.	0.95	0.56	0.32	0.72	0.51	0.78	3.83
11.15 A.M. - 11.30 A.M.	0.83	0.49	0.28	0.57	0.65	0.75	3.56
11.30 A.M. - 11.45 A.M.	0.75	0.47	0.30	0.57	0.59	0.92	3.60
11.45 A.M. - 12.00 P.M.	0.69	0.49	0.21	0.54	0.66	1.00	3.59
03.30 P.M. - 03.45 P.M.	0.52	0.47	0.31	0.48	0.43	0.65	2.86
03.45 P.M. - 04.00 P.M.	0.54	0.48	0.38	0.48	0.47	0.56	2.91
04.00 P.M. - 04.15 P.M.	0.63	0.47	0.44	0.47	0.53	0.68	3.22
04.15 P.M. - 04.30 P.M.	0.72	0.48	0.46	0.50	0.68	0.64	3.48
04.30 P.M. - 04.45 P.M.	0.68	0.59	0.53	0.58	0.66	0.59	3.63
04.45 P.M. - 05.00 P.M.	0.75	0.62	0.56	0.67	0.63	0.61	3.85
05.00 P.M. - 05.15 P.M.	0.84	0.80	0.68	0.90	0.72	0.57	4.50
05.15 P.M. - 05.30 P.M.	0.69	0.91	0.79	0.95	0.74	0.72	4.81
05.30 P.M. - 05.45 P.M.	0.64	0.93	0.84	0.88	0.85	0.81	4.95
05.45 P.M. - 06.00 P.M.	0.60	0.67	1.00	1.00	0.94	0.83	5.04

By analyzing the Table 4.12.6, it is found that the traffic operation system by automatic signal of this intersection will not work in peak period, because the summation of the flow ratio is greater than 1.00 all throughout the peak period of this intersection as per signal design theory.

D. Establishing Performance Evaluation Parameters for Signalized Road Intersections and Assesses Level of Service (LOS)

As per setout objectives of this research for finding out the LOS of the individual approach, queue length, delay was found out in detail survey of this intersection.

For finding out the effect of inefficiency in traffic control, queue length determination survey at peak period was organized in this intersection. The result of this survey is tabulated through the Table 4.12.7 and Table 4.12.8 below.

Table 4.12.7: Queue Length of Different Approach of Science Lab Intersection (Morning Peak).

Observation No.	**Time**	**Queue Length (in meter)**		
		Kalabagan to Science Lab Approach	**Elephant Road to Science Lab Approach**	**New Market to Science Lab Approach**
1.	07.45 A.M. 08.00 A.M.	0	0	151.90
2.	08.00 A.M. 08.15 A.M.	116.26	123.57	165.21
3.	08.15 A.M. 08.30 A.M.	187.34	134.56	188.34
4.	08.30 A.M. - 08.45 A.M.	221.34	176.63	190.93
5.	08.45 A.M. - 09.00 A.M.	278.34	217.34	227.91
6.	09.00 A.M. - 09.15 A.M.	328.92	265.77	211.32
7.	09.15 A.M. - 09.30 A.M.	309.69	298.23	221.46
8.	09.30 A.M. - 09.45 A.M.	345.67	312.23	209.90
9.	09.45 A.M. - 10.00 A.M.	355.45	332.43	208.96
10.	10.00 A.M. - 10.15 A.M.	378.97	342.22	228.32
11.	10.15 A.M. - 10.30 A.M.	393.43	328.92	218.33
12.	10.30 A.M. - 10.45 A.M.	412.21	309.69	226.44
13.	10.45 A.M. - 11.00 A.M.	354.44	345.67	224.59
14.	11.00 A.M. - 11.15 A.M.	385.33	355.45	226.77

Table 4.12.8: Queue Length of Different Approach of Science Lab Intersection (Evening Peak).

Observation No.	Time	Queue Length (in meter)		
		Kalabagan to Science Lab Approach	Elephant Road to Science Lab Approach	New Market to Science Lab Approach
1.	04.00 P.M. - 04.15 P.M.	355.45	355.45	311.33
2.	04.15 P.M. - 04.30 P.M.	378.97	378.97	323.33
3.	04.30 P.M. - 04.45 P.M.	393.43	393.43	352.33
4.	04.45 P.M. - 05.00 P.M.	412.21	445.67	287.22
5.	05.00 P.M. - 05.15 P.M.	354.44	354.44	322.32
6.	05.15 P.M. - 05.30 P.M.	385.33	385.33	311.22
7.	05.30 P.M. - 05.45 P.M.	392.23	392.23	309.76
8.	05.45 P.M. - 06.00 P.M.	404.44	404.44	312.56
9.	06.00 P.M. - 06.15 P.M.	408.22	408.22	365.44

Analyzing the result of the queue length survey, it was measured on three (3) approaches of this intersection. Maximum queue length was found in this intersection at different approach with the progress of the time. The queue length was observed in Kalabagan to Science Lab. approach at morning peak 412.21 m and at evening peak 412.21 m and Elephant Road to Science Lab approach at morning peak 355.45 m and at evening peak 445.67 m and New Market to Science Lab approach at morning peak 228.32 m and at evening peak 365.44 m. Among them, the queue length of this intersection was increasing with the progress of time, 84.06% of total observation time, the queue length was over 200 m, which was very worst as per research of *J. Li et al. (2004).*

After that, another parameter for determination of LOS, delay was found out through a delay determination survey. This survey had two parts; one was determination of travel time at free flow condition and other was determination of travel time in field condition. Firstly the free flow travel time in every approach of this intersection was counted. The free flow condition travel time of this Science Laboratory intersection is presented here in a tabular format in Table 4.12.9.

Table 4.12.9: Travel Time at Free Flow Condition of Science Laboratory Intersection (sec).

Observation No.	Time	Kalabagan to Science Lab. Intersection, sec	Bata Signal to Science Lab. Intersection, sec	New Market to Science Lab. Intersection, sec
1.	07.00 A.M. 07.30 A.M.	12	10	6

After this, for finding out the delay of this intersection, a travel time counting survey in field condition was organized; from here travel time was collected on every approaches of this intersection from 07.00 A.M to 06.00 P.M. After getting this travel time of every approach, deducting the free flow time from surveyed travel time, delay was found from every approaches all throughout the day. The delay of these approaches are shown below from 07.00 A.M. to 06.00 P.M. in Table 4.12.10

Table 4.12.10: Delay at Different Approach of Science Laboratory Intersection.

Observation No.	Time	Delay (KalaBagan to Science Lab. Intersection)	Delay (Bata Signal to science lab. Intersection)	Delay (New Market to Science Lab. Intersection)
1.	07.00 A.M. 07.30 A.M.	2	2	2
2.	07.30 A.M. 08.00 A.M.	10	4	6
3.	08.00 A.M. 08.30 A.M.	44	8	9
4.	08.30 A.M. 09.00 A.M.	175	17	27
5.	09.00 A.M. 09.30 A.M.	180	35	50
6.	09.30 A.M. 10.00 A.M.	218	314	62
7.	10.00 A.M. 10.30 A.M.	243	446	239
8.	10.30 A.M. 11.00 A.M.	588	468	339
9.	11.00 A.M. 11.30 A.M.	1008	425	427
10.	11.30 A.M. 12.00 P.M.	888	447	561
11.	12.00 P.M. 12.30 P.M.	828	524	664
12.	12.30 P.M. 01.00 P.M.	888	644	727
13.	01.00 P.M. 01.30 P.M.	708	772	672
14.	01.30 P.M. 02.00 P.M.	648	554	450
15.	02.00 P.M. 02.30 P.M.	708	776	1117
16.	02.30 P.M. 03.00 P.M.	1068	857	1225
17.	03.00 P.M. 03.30 P.M.	878	898	1083
18.	03.30 P.M. 04.00 P.M.	911	1079	1139
19.	04.00 P.M. 04.30 P.M.	1078	1113	1172
20.	04.30 P.M. 05.00 P.M.	860	1750	1651
21.	05.00 P.M. 05.30 P.M.	764	1644	1781
22.	05.30 P.M. 06.00 P.M.	509	1866	1250

Analyzing the Table 4.12.10 the delay at different approach of Science Laboratory intersection is increasing as the progress of the day time was found. Approach wise comparison of delay time is shown in Figure 4.12.12 below.

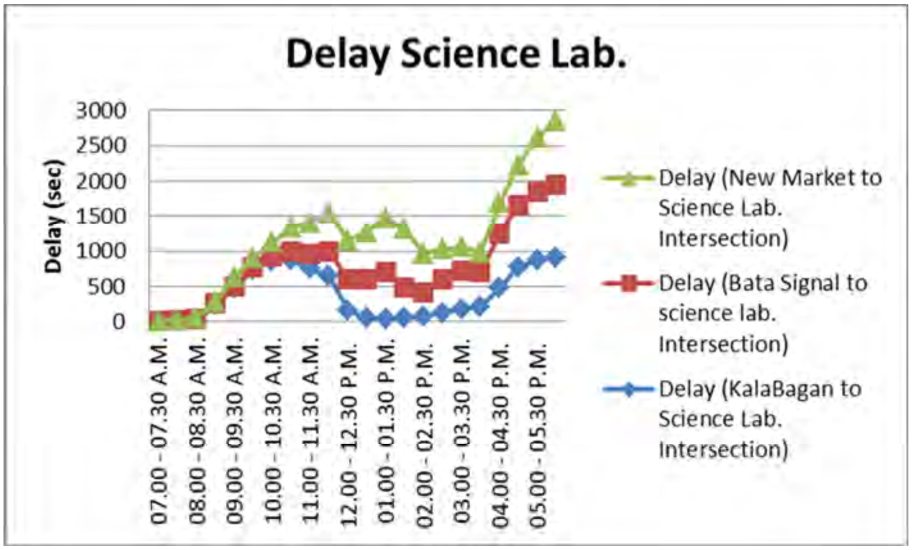


Figure 4.12.12: Comparison of Delay at Different Approach of Science Laboratory Intersection.

Analyzing the Figure 4.12.12 it was observed that, all the approaches of this intersection experienced maximum delay in traffic flow at the time of evening peak mostly.

E. Evaluation Performance of The Intersections Based on LOS Ranking

Finally, based on the delay on every approach of this intersection, LOS of three (3) approaches was calculated for Science Laboratory intersection. In the following Table 4.12.11 and Figure 4.12.13the LOS of this intersection is presented below, the detailed calculation of LOS given in Appendix A

Table 4.12.11: LOS of Different Approaches of Science Laboratory Intersection.

Observation No.	Time	LOS (Kala Bagan to Science Lab. Intersection)	LOS (Bata Signal to science lab. Intersection)	LOS (New Market to Science Lab. Intersection)
1.	07.00 A.M. 07.30 A.M.	A	A	A
2.	07.30 A.M. 08.00 A.M.	A	A	A
3.	08.00 A.M. 08.30 A.M.	E	A	A
4.	08.30 A.M. 09.00 A.M.	F	C	D
5.	09.00 A.M. 09.30 A.M.	F	D	E
6.	09.30 A.M. 10.00 A.M.	F	F	F
7.	10.00 A.M. 10.30 A.M.	F	F	F
8.	10.30 A.M. 11.00 A.M.	F	F	F
9.	11.00 A.M. 11.30 A.M.	F	F	F

10.	11.30 A.M. 12.00 P.M.	F	F	F
11.	12.00 P.M. 12.30 P.M.	F	F	F
12.	12.30 P.M. 01.00 P.M.	F	F	F
13.	01.00 P.M. 01.30 P.M.	F	F	F
14.	01.30 P.M. 02.00 P.M.	F	F	F
15.	02.00 P.M. 02.30 P.M.	F	F	F
16.	02.30 P.M. 03.00 P.M.	F	F	F
17.	03.00 P.M. 03.30 P.M.	F	F	F
18.	03.30 P.M. 04.00 P.M.	F	F	F
19.	04.00 P.M. 04.30 P.M.	F	F	F
20.	04.30 P.M. 05.00 P.M.	F	F	F
21.	05.00 P.M. 05.30 P.M.	F	F	F
22.	05.30 P.M. 06.00 P.M.	F	F	F

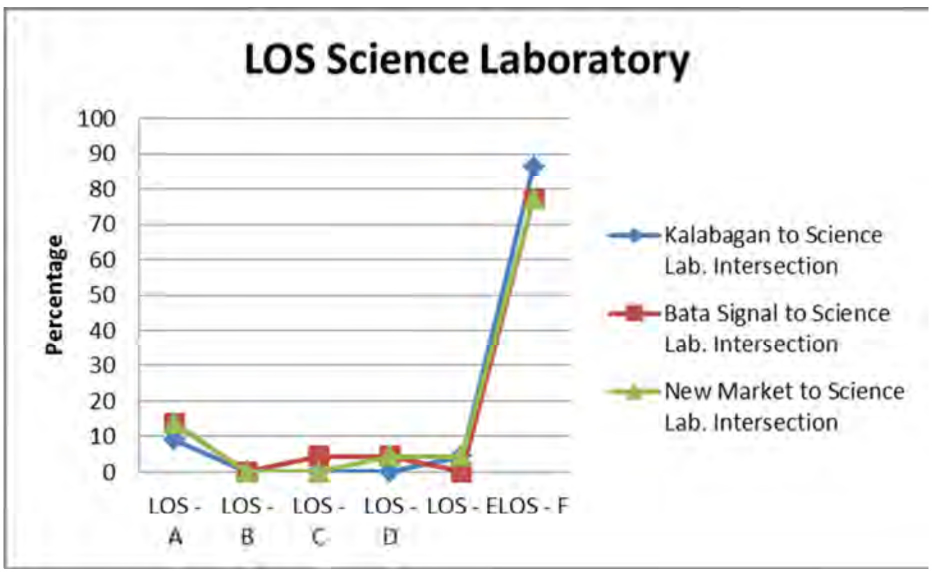


Figure 4.12.13: Percentage of Various LOS at Different Approaches of ScienceLaboratory Intersection.

By analyzing the Table 4.12.11 and Figure 4.12.13 the LOS of different approaches of this intersection, it was found that during 11 hours survey period for Kalabagan to Science Lab approach, the LOS level A, B, C, D, E and F were observed to be 9.0%, 0.0%, 0.0%, 0.0%, 4.5% and 86.36% of survey time respectively, similarly for Bata Signal to Science Lab approach the LOS level A, B, C, D, E and F were observed to be 13.63%, 0.0%, 4.5%, 4.5%, 0.0% and 77.27% of survey time respectively and similarly for New Market to Science Lab approach the LOS level A, B, C, D, E and F were observed to be 13.63%, 0.0%, 0.0%, 4.5%, 4.5% and 77.27% of survey time respectively. The LOS of every approach of this intersection was retaining at Level F consistently. For present Dhaka Metropolitan City, it is a curse.

4.13 Evaluation of Performance of the Intersection Based on Level of Service (LOS) Ranking and Accident Records

After finishing the calculation of LOS of different approach of selected seven (7) intersections of Dhaka city, the overall LOS of those intersections are found out through statistical analysis. The method of evaluation is named as Point Average

In this method, a scale of 1 to 6 has been used, where higher value indicates better condition and lower the value indicates worse condition of the intersection. This LOS based on grade value was suggested in the detail calculation of LOS based performance of intersections below

Serial No	LOS letter grade	LOS grade point value
1.	**A**	6
2.	**B**	5
3.	**C**	4
4.	**D**	3
5.	**E**	2
6.	**F**	1

Based on these grade point values, the approach wise LOS point value was calculated. Observing this point value, the overall LOS of these intersections was found out. The summary of this calculations are presented below, referring those intersections of Dhaka city

Table 4.13.1: Detail Calculation of LOS of Mirpur 1 Intersection.

Observation No.	From	To	LOS (Panir Tanki to Mirpur	LOS Point Value	LOS (Sony Cinema hall to Mirpur	LOS Point Value	LOS(Shah Ali Mazar to Mirpur 1)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6.00	A	6	A	6
2	7:30:00 AM	8:00:00 AM	A	6.00	A	6	A	6
3	8:00:00 AM	8:30:00 AM	A	6.00	B	5	A	6
4	8:30:00 AM	9:00:00 AM	A	6.00	A	6	A	6
5	9:00:00 AM	9:30:00 AM	F	1.00	C	4	A	6
6	9:30:00 AM	10:00:00 AM	F	1.00	D	3	B	5
7	10:00:00 AM	10:30:00 AM	F	1.00	E	2	D	3
8	10:30:00 AM	11:00:00 AM	F	1.00	F	1	D	3
9	11:00:00 AM	11:30:00 AM	F	1.00	F	1	E	2
10	11:30:00 AM	12:00:00 PM	F	1.00	F	1	E	2
11	12:00:00 PM	12:30:00 PM	E	2.00	F	1	F	1
12	12:30:00 PM	1:00:00 PM	E	2.00	F	1	F	1
13	1:00:00 PM	1:30:00 PM	E	2.00	F	1	F	1
14	1:30:00 PM	2:00:00 PM	E	2.00	F	1	F	1
15	2:00:00 PM	2:30:00 PM	E	2.00	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1.00	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1.00	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1.00	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1.00	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1.00	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1.00	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1.00	F	1	F	1
Avarage LOS Point Value Approach wise			D	2.14	D	2.14	D	2.59
Over all LOS of the Intersection			D	2.29				

Table 4.13.2: Detail Calculation of LOS of Shishu Mela Intersection.

Observation No.	From	To	LOS (Shyamoli to Shishu Mela)	LOS Point Value	LOS (Agargaon to Shishu Mela)	LOS Point Value	LOS (College Gate to Shishu Mela)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6	A	6
2	7:30:00 AM	8:00:00 AM	A	6	D	4	B	5
3	8:00:00 AM	8:30:00 AM	B	5	E	2	E	2
4	8:30:00 AM	9:00:00 AM	F	1	E	2	F	1
5	9:00:00 AM	9:30:00 AM	F	1	F	1	F	1
6	9:30:00 AM	10:00:00 AM	F	1	F	1	F	1
7	10:00:00 AM	10:30:00 AM	F	1	F	1	F	1
8	10:30:00 AM	11:00:00 AM	F	1	F	1	F	1
9	11:00:00 AM	11:30:00 AM	F	1	F	1	F	1
10	11:30:00 AM	12:00:00 PM	F	1	F	1	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1	F	1
13	1:00:00 PM	1:30:00 PM	F	1	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1	F	1
Avarage LOS Point Value Approach wise			E	1.64	E	1.45	E	1.45
Over all LOS of the Intersection			E	1.52				

Table 4.13.3: Detail Calculation of LOS of Agargaon Intersection.

Observation No.	From	To	LOS (Taltola to Agargaon Approach)	LOS Point Value	LOS (Sishu Mela to Agargaon Approach)	LOS Point Value	LOS (Planning Commission to Agargaon Appraoch)	LOS Point Value	LOS (Prime Minister Office to Agargaon Approach)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6	A	6	A	6
2	7:30:00 AM	8:00:00 AM	A	6	B	5	A	6	B	5
3	8:00:00 AM	8:30:00 AM	C	4	D	3	C	4	C	4
4	8:30:00 AM	9:00:00 AM	E	2	E	2	C	4	D	3
5	9:00:00 AM	9:30:00 AM	F	1	E	2	D	3	D	3
6	9:30:00 AM	10:00:00 AM	F	1	E	2	C	4	C	4
7	10:00:00 AM	10:30:00 AM	F	1	E	2	F	1	D	3
8	10:30:00 AM	11:00:00 AM	F	1	E	2	F	1	E	2
9	11:00:00 AM	11:30:00 AM	F	1	F	1	E	2	E	2
10	11:30:00 AM	12:00:00 PM	F	1	F	1	D	3	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1	F	1	F	1
13	1:00:00 PM	1:30:00 PM	F	1	F	1	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1	F	1	F	1
Avarage LOS Point Value Approach wise			E	1.64	E	1.73	D	2.09	D	2.05
Over all LOS of the Intersection			E	1.88						

Table 4.13.4: Detail Calculation of LOS of Bangla Motor Intersection.

Observation No.	From	To	LOS (SAARC Fowara to Bangla Motor)	LOS Point Value	LOS (Paribagh Over Bridge to Bangla Motor)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6
2	7:30:00 AM	8:00:00 AM	A	6	B	5
3	8:00:00 AM	8:30:00 AM	B	5	C	4
4	8:30:00 AM	9:00:00 AM	C	4	E	2
5	9:00:00 AM	9:30:00 AM	F	1	E	2
6	9:30:00 AM	10:00:00 AM	F	1	F	1
7	10:00:00 AM	10:30:00 AM	F	1	F	1
8	10:30:00 AM	11:00:00 AM	F	1	F	1
9	11:00:00 AM	11:30:00 AM	F	1	F	1
10	11:30:00 AM	12:00:00 PM	F	1	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1
13	1:00:00 PM	1:30:00 PM	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1
Avarage LOS Point Value Approach wise			E	1.77	E	1.64
Over all LOS of the Intersection			E	1.70		

Table 4.13.5: Detail Calculation of LOS of Mirpur 10 Intersection.

Observation No.	From	To	LOS (Benarasi 1 No. Gate to Mirpur - 10)	LOS Point Value	LOS (Al-Helal Hospital to Mirpur 10)	LOS Point Value	LOS (Mirpur 2 to Mirpur 10)	LOS Point Value	LOS (DWASA training Center to Mirpur 10)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6	A	6	A	6
2	7:30:00 AM	8:00:00 AM	B	5	A	6	A	6	A	6
3	8:00:00 AM	8:30:00 AM	C	4	D	3	A	6	C	4
4	8:30:00 AM	9:00:00 AM	F	1	D	3	A	6	E	2
5	9:00:00 AM	9:30:00 AM	F	1	C	4	F	1	F	1
6	9:30:00 AM	10:00:00 AM	F	1	D	3	F	1	F	1
7	10:00:00 AM	10:30:00 AM	F	1	E	2	F	1	F	1
8	10:30:00 AM	11:00:00 AM	F	1	F	1	F	1	F	1
9	11:00:00 AM	11:30:00 AM	F	1	F	1	F	1	F	1
10	11:30:00 AM	12:00:00 PM	F	1	F	1	F	1	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1	F	1	F	1
13	1:00:00 PM	1:30:00 PM	E	1	F	1	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1	F	1	F	1
Avarage LOS Point Value Approach wise			E	1.55	E	1.91	E	1.91	E	1.64
Over all LOS of the Intersection			E	1.75						

Table 4.13.6: Detail Calculation of LOS of Shapla Chattar Intersection.

Observation No.	From	To	LOS (R.K. Road to Shapla Chattar)	LOS Point Value	LOS (Arambagh Mor to Sgapla Chattar)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	C	4
2	7:30:00 AM	8:00:00 AM	C	4	D	3
3	8:00:00 AM	8:30:00 AM	E	2	E	2
4	8:30:00 AM	9:00:00 AM	F	1	E	2
5	9:00:00 AM	9:30:00 AM	F	1	F	1
6	9:30:00 AM	10:00:00 AM	F	1	F	1
7	10:00:00 AM	10:30:00 AM	F	1	F	1
8	10:30:00 AM	11:00:00 AM	F	1	F	1
9	11:00:00 AM	11:30:00 AM	F	1	F	1
10	11:30:00 AM	12:00:00 PM	F	1	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1
13	1:00:00 PM	1:30:00 PM	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1
Avarage LOS Point Value Approach wise			E	1.41	E	1.32
Over all LOS of the Intersection			E	1.36		

Table 4.13.7: Detail Calculation of LOS of Science Laboratory Intersection.

Observation No.	From	To	LOS (KalaBagan to Science Lab. Intersection)	LOS Point Value	LOS (Bata Signal to science lab. Intersection)	LOS Point Value	LOS (New Market to Science Lab. Intersection)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6	A	6
2	7:30:00 AM	8:00:00 AM	A	6	A	6	A	6
3	8:00:00 AM	8:30:00 AM	E	2	A	6	A	6
4	8:30:00 AM	9:00:00 AM	F	1	C	4	D	3
5	9:00:00 AM	9:30:00 AM	F	1	D	3	E	2
6	9:30:00 AM	10:00:00 AM	F	1	F	1	F	1
7	10:00:00 AM	10:30:00 AM	F	1	F	1	F	1
8	10:30:00 AM	11:00:00 AM	F	1	F	1	F	1
9	11:00:00 AM	11:30:00 AM	F	1	F	1	F	1
10	11:30:00 AM	12:00:00 PM	F	1	F	1	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1	F	1
13	1:00:00 PM	1:30:00 PM	F	1	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1	F	1
Avarage LOS Point Value Approach wise			E	1.50	E	1.91	E	1.82
Over all LOS of the Intersection			E	1.74				

After evaluating the overall Level of Service (LOS) of the intersections of Dhaka city through analyzing the result statistically, the following results was found, which is presented here through Table 4.13.8.

Table 4.13.8: Ranking of Dhaka City Intersections Based on LOS.

Serial No.	Intersection Name	LOS Point Value	Ranking
1	**Mirpur 1**	2.29	1
2	**Shishu Mela**	1.52	6
3	**Agargaon**	1.88	2
4	**Bangla Motor**	1.70	5
5	**Mirpur - 10**	1.75	3
6	**Shapla Chattar**	1.36	7
7	**Science Laboratory**	1.74	4

For the evaluation of the performance of the selected intersections of Dhaka city, based on accident records, the data was collected from Accident Research Institute (ARI) of BUET and analyzed later. From the analysis of accident data, it was found

Table 4.13.9: Accident Data Recorded from 1998 to 2014 in Dhaka Metropolitan City Area and its Ranking.

Serial No.	Intersection Name	Accident Number	Ranking
1	**Mirpur 1**	36	5
2	**Shishu Mela**	17	1
3	**Agargaon**	35	4
4	**Bangla Motor**	32	2
5	**Mirpur - 10**	34	3
6	**Shapla Chattar**	62	7
7	**Science Laboratory**	38	6

4.14 Overview

In this chapter data has been analyzed both qualitatively and quantitatively for establishing a procedure of ranking of intersection performance. This intersection ranking was done by analysis of data such as - delays, queue length, side friction, signal cycle, LOS and accident data. Intersection

findings are presented briefly at the end of this chapter in detail in a table format from this analysis. These data will help us to learn about the role of intersection in a city road network. Besides, it will also help in the ranking of signalized (though they are operated manually) intersections and further development of these intersections in near future.

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The main focus of this research is the performance evaluation of selected road intersections of Dhaka Metropolitan City, which will help the City Authority and Government for evaluating the present scenario of road network of Dhaka City, and also help them for finding out the appropriate elucidation of the present ill operated condition and giving a conceptual idea of economic loss due to present operation of intersections. Lastly, it will help for finding out ranking system of road intersection inside Dhaka Metropolitan City area. For this, manual methods of data collection were applied in this research study. Data was analyzed both qualitatively and quantitatively. Detailed studies results nd past accident record have been discussed so far. Based on these, the summary of findings of this study, conclusions and understandings of the factors of efficiency of those intersections, and future vision of development is going to be presented in following articles.

5.2 Findings of Qualitative Observations

General findings of these studies, which have been gathered during manual field survey of different sites of Dhaka Metropolitan City, findings are summarized below

i. At upstream of those intersections a clear segregation of motorized and non motorized vehicles is found. It is observed that that the motorized vehicles are occupied the right side of the approach of these intersections and non motorized vehicle is taken the left part of the approach.

ii. Queue is built up based on the optimum road space utilization criterion; when a vehicle join with the queue, main stimulus is the front gap irrespective of the lane in which it is available. As a result, it has been observed that straight ahead vehicles / through traffic, regardless of the type whether motorized or not, occupy any position across the road based on the available space.Another feature of the queue formation is that the smaller sized vehicles such as bi cycles and motor cycles use inter vehicular space to come in front of the queue. Sometimes the smaller vehicles do not try to follow the traffic signal.

iii. Another interesting observation is the performance of the non motorized vehicles at the end of green period. As the intersection of Dhaka city are quite wide in nature and the non motorized vehicles (NMV) take more time than the motorized vehicles (MV) to clear the junctions, the slow moving NMVs that violate the red signal become trapped at the end of green period. For making the junction clear, it demands a special all red period in signaling phase.

iv. For the smooth operation of a junction, it is not possible to make it delay free. Because the delay is associated in the operation of intersection, both manual and automatic signal system. This delay is increasing with the progress of time of the day. As a result, queue is increasing in every approach of these junctions, which affect the performance of those intersections of Dhaka City and reduces the level of service (LOS).

v. Another striking observation is the pedestrian crossing, though every intersections of Dhaka city have some crossing facilities, such as grade separated facility: over bridge, underpass, etc. at grade facility zebra crossing, pedestrian refuge, pedestrian signal, etc. But pedestrian cross through this intersection through road interrupting the traffic flow. Illegal encroachment of footpath and road side, illegal parking, bus stoppage, rickshaw stoppage, etc. increase the side friction, that delayed the traffic flow, decreases the performance of intersection and LOS.

vi. For the evaluation of the selected intersections of Dhaka City, based on accident records, the secondary data was collected from Accident Research Institute (ARI) of BUET. From the collection of accident data of ARI, an important characteristic of accident was found. In the intersections of Dhaka Metropolitan City, two types of accidents are found mostly: Right Angle collision and Rare End collision. Right Angle collision was occurred in the center of intersection and Rare End collision was occurred in the approach, which is adjacent to intersection.

5.3 Findings of Quantitative Analysis

5.3.1 Mirpur 1 Intersection

A. Geometric and Operating Condition:

1 intersection is ee intersection / Wye intersection as per geometric classification of intersection; it has three approaches. All the three (3) approaches of this intersection are made of flexile pavement and dual carriageway. This intersection has 100% footpath coverage. There is channelization on the mouth two (2) approaches; they are fully dedicated for left turner of this intersection. But heterogeneous traffic flows of this intersection don

have not got success. All approaches of this intersection are alienated by the non-engineering divider, which is not related with velocity profile of the vehicle. For pedestrian crossing, there is a three legged over bridge is located inside the intersection. Eight side roads are found in this intersection, coming from neighboring residential and commercial area.

B. Vehicular Flow:

Five individual movement were found in this intersection, among them Dar us Salam to Mirpur 2 movement contained maximum amount of vehicles, which was 29% of entire traffic flow. Two distinct peak hours were found in this intersection; one was in the morning period from 08.00 A.M. to 12.00 P.M. and another was in the evening from 04.30 P.M. to 06.00 P.M. & furthermore (beyond the observation time). In this intersection the dominancy of NMV was found; around 42% of total vehicle, the remaining part was MV. Among the entire vehicular flow, rickshaw was maximum, around 41% of total vehicle. By calculating the saturation flow of different approaches of this intersection, Mirpur 2 to Mirpur 1 approach contained the maximum, around 2601.76 PCU / Hour. Observing the flow ratio with respect to saturation flow, maximum flow ratio was found in the peak period of this intersection.

C. Pedestrian Flow:

In this intersection, maximum pedestrian flow was found at grade, around 76% of total pedestrian. 24% of total pedestrian used three legged over bridge as a grade separation facility. Maximum at grade pedestrian flow was found at the front of Mukto Bangla Shopping Complex.

D. Side Friction:

Three specified reasons for side friction were found in four (4) points inside the intersection. The reasons were rickshaw stand, Human Hauler / Laguna stand and Illegal Bus stand. 60% of total road width at the mouth of approach of this intersection was blocked by this side friction in the peak hour. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing throughout the day.

E. Traffic Control Devices:

Presently for this intersection, there was no use of traffic signal; instead of this, traffic police controlled the traffic movement of this intersection manually based on traffic flow demands among the three approaches. Traffic police followed here three (3) phase traffic controlling system; which is very inefficient method. The signal cycle time of this intersection was more than 120 sec, which was 98.11% of total observation time at peak period. It is increasing the delay of this intersection all throughout the day. From the analysis of total flow ratio of all the approaches were found greater than 1.00 in peak period, so automatic signal control cannot be successful in this intersection.

F. Queue Length:

After observing the hazardous condition of traffic control, consequently poor condition was observed in the queue length of every approach of this intersection. All throughout the day the queue length of this intersection was increased, 56.42% of total observation time, the queue length was over 200 m, which was very worst.

G. Delay:

The effect of queue length was directly observed in this intersection sequentially through delay. The delay at different approach of this intersection was found increased as the progress of the day time. Maximum delay was found in Sony Cinema Hall to Mirpur 1 approach of this intersection in evening time.

H. LOS:

The chronological effect of delay was found in the LOS of this intersection at different approaches. Averagely, 60.60 % of total observed time, the LOS of different approaches of this intersection was retaining at Level F; which is a curse for present Dhaka City.

Table 5.3.1: LOS of Different Approaches of Mirpur 1 Intersection.

Observation No.	From	To	LOS (Sony Cinema Hall to Mirpur 1)	LOS Point Value	LOS (Panir Tanki to Mirpur 1)	LOS Point Value	LOS (Shah Ali Mazar to Mirpur 1)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6	A	6
2	7:30:00 AM	8:00:00 AM	A	6	A	6	A	6
3	8:00:00 AM	8:30:00 AM	A	6	B	5	A	6
4	8:30:00 AM	9:00:00 AM	A	6	A	6	A	6
5	9:00:00 AM	9:30:00 AM	F	1	C	4	A	6
6	9:30:00 AM	10:00:00 AM	F	1	D	3	B	5
7	10:00:00 AM	10:30:00 AM	F	1	E	2	D	3
8	10:30:00 AM	11:00:00 AM	F	1	F	1	D	3
9	11:00:00 AM	11:30:00 AM	F	1	F	1	E	2
10	11:30:00 AM	12:00:00 PM	F	1	F	1	E	2
11	12:00:00 PM	12:30:00 PM	E	2	F	1	F	1
12	12:30:00 PM	1:00:00 PM	E	2	F	1	F	1
13	1:00:00 PM	1:30:00 PM	E	2	F	1	F	1
14	1:30:00 PM	2:00:00 PM	E	2	F	1	F	1
15	2:00:00 PM	2:30:00 PM	E	2	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1	F	1

Average LOS Point Value Approach wise	D	2.14	D	2.14	D	2.59
Over all LOS of the Intersection	**D**	**2.29**				

I. Accident Data:

From ARI, after collecting the secondary accident data of Dhaka Metropolitan City (from 1998 to 2014), the result was analyzed. The total reported accident in this intersection was found 36 in numbers.

5.3.2 Shishu Mela Intersection

A. Geometric and Operating Condition:

intersection is ee intersection as per geometric classification of intersection; it has three (3) approaches. All the three approaches of this intersection are made of flexile pavement and dual carriageway. This intersection has 100% footpath coverage. There is channelization on the mouth one approach; it is fully dedicated for left turner of this intersection. But heterogeneous traffic flows of this intersection don
follow lane properly, so the objective of this channelization has not got success. All approaches of this intersection are alienated by the non-engineering divider, which is not related with velocity profile of the vehicle. For pedestrian crossing, there is no grade separated facility. Pedestrian try to cross the intersection by finding suitable gap between vehicular flows. One (1) side road is found in this intersection, coming from neighboring residential / office area.

B. Vehicular Flow:

Six individual movement were found in this intersection, among them Shyamoli to College Gate movement contained maximum amount of vehicles, which was 29% of entire traffic flow. No distinct peak hour was found in this intersection, an increased constant vehicle flow all throughout the day was observed. This situation was continuing from 09.00 A.M. to 06.00 P.M. which was 81.81% of total observation time. In this intersection the dominancy of MV was found; around 86% of total vehicle, the remaining part was NMV. Among the entire vehicular flow, car / taxi was maximum, around 23% of total vehicle. By calculating the saturation flow of different approaches of this intersection, College Gate to Sishu Mela approach contained the maximum, around 3762.60 PCU / Hour. A constant increasing flow ratio was found all throughout the day.

C. Pedestrian Flow:

In this intersection, maximum pedestrian flow was found at grade, because there was no grade separated facility in this intersection; such as over bridge, underpass, etc. Maximum at grade pedestrian flow was found at the corner of Shishu Mela Park.

D. Side Friction:

Three specified reasons for side friction were found in four points inside the intersection. The reasons were rickshaw diversion, illegal vehicle stand and Illegal Bus stand. 70% of total road width at the mouth of approach of this intersection was blocked by this side friction in the peak hour. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing throughout the day.

E. Traffic Control Devices:

Presently for this intersection, there was no use of traffic signal; instead of this, traffic police controlled the traffic movement of this intersection manually based on traffic flow demands among the three approaches. Traffic police followed here 3 phase traffic controlling system; which is very inefficient method. The signal cycle time of this intersection was more than 120 sec, which was 95.09% of total observation time at peak period. It is increasing the delay of this intersection all throughout the day. From the analysis of total flow ratio of all the approaches were found greater than 1.00 in peak period, so automatic signal control cannot be successful in this intersection.

F. Queue Length:

After observing the hazardous condition of traffic control, consequently poor condition was observed in the queue length of every approach of this intersection. All throughout the day the queue length of this intersection was increased, 82.67% of total observation time, the queue length was over 200 m, which was very worst.

G. Delay:

The effect of queue length was directly observed in this intersection sequentially through delay. The delay at different approach of this intersection was found increased as the progress of the day time. Maximum delay was found in College Gate to Sishu Mela approach of this intersection in evening time.

H. LOS:

The chronological effect of delay was found in the LOS of this intersection at different approaches. Averagely, 85.06 % of total observed time, the LOS of different approaches of this intersection was retaining at Level F; which is a curse for present Dhaka City.

Table 5.3.2: LOS of Different Approaches of Shishu Mela Intersection.

Observation No.	From	To	LOS (Shyamoli to Shishu Mela)	LOS Point Value	LOS (Agargaon to Shishu Mela)	LOS Point Value	(College Gate to Shishu	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6	A	6
2	7:30:00 AM	8:00:00 AM	A	6	D	4	B	5

3	8:00:00 AM	8:30:00 AM	B	5	E	2	E	2
4	8:30:00 AM	9:00:00 AM	F	1	E	2	F	1
5	9:00:00 AM	9:30:00 AM	F	1	F	1	F	1
6	9:30:00 AM	10:00:00 AM	F	1	F	1	F	1
7	10:00:00 AM	10:30:00 AM	F	1	F	1	F	1
8	10:30:00 AM	11:00:00 AM	F	1	F	1	F	1
9	11:00:00 AM	11:30:00 AM	F	1	F	1	F	1
10	11:30:00 AM	12:00:00 PM	F	1	F	1	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1	F	1
13	1:00:00 PM	1:30:00 PM	F	1	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1	F	1
Average LOS Point Value Approach wise			E	1.64	E	1.45	E	1.45
Over all LOS of the Intersection			**E**	**1.52**				

I. Accident Data:

From ARI, after collecting the secondary accident data of Dhaka Metropolitan City (from 1998 to 2014), the result was analyzed. The total reported accident in this intersection was found 17 in numbers.

5.3.3 Agargaon Intersection

A. Geometric and Operating Condition:

intersection is as per geometric classification of intersection; it has four approaches. All the four approaches of this intersection are made of flexible pavement and dual carriageway. This intersection has 100% footpath coverage. There is channelization on the mouth two approaches; it is fully dedicated for left turner of this intersection. All approaches of this intersection are alienated by the non - engineering divider, except one approach contains engineering median (From Agargaon to Prime Minister Office). This non engineering divider is not related with velocity profile of vehicle of this intersection. For pedestrian crossing, there is no grade separated facility. Pedestrian try to cross the intersection by finding suitable gap between vehicular flows. Four side roads are found in this intersection, coming from neighboring residential / office area.

B. Vehicular Flow:

Eleven individual movement were found in this intersection, among them Mirpur 10 to Farmgate movement contained maximum amount of vehicles, which was 31% of entire traffic flow. Two distinct peak hours were found in traffic flow; one was in the morning period from 08.00 A.M. to 11.30 A.M. and another was in the evening from 04.30 P.M. to 06.00 P.M. & further (beyond the survey time), total peak period of the entire survey time was 5 hours, which was 45.45% of total survey time of that day. In this intersection the dominancy of MV was found; around 87% of total vehicle, the remaining part was NMV. Among the entire vehicular flow, car / taxi was maximum, around 38% of total vehicle. By calculating the saturation flow of different approaches of this intersection, Farmgate to Agargaon approach contained the maximum, around 4411.92 PCU / Hour. Two peak hours of flow ratio was found all throughout the day in this intersection.

C. Pedestrian Flow:

In this intersection, maximum pedestrian flow was found at grade, because there was no grade separated facility in this intersection; such as over bridge, underpass, etc. Maximum at grade pedestrian flow was found at the corner of Passport Office.

D. Side Friction:

Three specified reasons for side friction were found in three (3) points inside the intersection. The reasons were illegal rickshaw stand, illegal human hauler / Laguna stand and illegal bus stand. But this Agargaon intersection is the mostly planned intersection in among the Dhaka Metropolitan City. The effect of side friction is very negligible in the traffic flow of this intersection.

E. Traffic Control Devices:

Presently for this intersection, there was no use of traffic signal; instead of this, traffic police controlled the traffic movement of this intersection manually based on traffic flow demands among the three approaches. Traffic police followed here four (4) phase traffic controlling system; which is very inefficient method. The signal cycle time of this intersection was more than 120 sec, which was 100% of total observation time at peak period. It is increasing the delay of this intersection all throughout the day. From the analysis of total flow ratio of all the approaches were found greater than 1.00 in peak period, so automatic signal control cannot be successful in this intersection.

F. Queue Length:

After observing the hazardous condition of traffic control, consequently poor condition was observed in the queue length of every approach of this intersection. All throughout the day the queue length of this intersection was increased, 50.00% of total observation time, the queue length was over 200 m, which was very worst.

G. Delay:

The effect of queue length was directly observed in this intersection sequentially through delay. The delay at different approach of this intersection was found increased as the progress of the day time. Maximum delay was found in Planning Commission to Agargaon approach of this intersection in evening time.

H. LOS:

The chronological effect of delay was found in the LOS of this intersection at different approaches. Averagely, 67.04 % of total observed time, the LOS of different approaches of this intersection was retaining at Level F; which is a curse for present Dhaka City.

Table 5.3.3: LOS of Different Approaches of Agargaon Intersection.

Observation No.	From	To	LOS (Taltola to Agargaon Approach)	LOS Point Value	LOS (Sishu Mela to Agargaon Approach)	LOS Point Value	LOS (Planning Commission to Agargaon Appraoch)	LOS Point Value	LOS (Prime Minister Office to Agargaon Approach)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6	A	6	A	6
2	7:30:00 AM	8:00:00 AM	A	6	B	5	A	6	B	5
3	8:00:00 AM	8:30:00 AM	C	4	D	3	C	4	C	4
4	8:30:00 AM	9:00:00 AM	E	2	E	2	C	4	D	3
5	9:00:00 AM	9:30:00 AM	F	1	E	2	D	3	D	3
6	9:30:00 AM	10:00:00 AM	F	1	E	2	C	4	C	4
7	10:00:00 AM	10:30:00 AM	F	1	E	2	F	1	D	3
8	10:30:00 AM	11:00:00 AM	F	1	E	2	F	1	E	2
9	11:00:00 AM	11:30:00 AM	F	1	F	1	E	2	E	2
10	11:30:00 AM	12:00:00 PM	F	1	F	1	D	3	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1	F	1	F	1
13	1:00:00 PM	1:30:00 PM	F	1	F	1	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1	F	1	F	1
Average LOS Point Value Approach wise			E	1.64	E	1.73	D	2.09	D	2.05

Over all LOS of the Intersection	**E**	**1.88**

I. Accident Data:

From ARI, after collecting the secondary accident data of Dhaka Metropolitan City (from 1998 to 2014), the result was analyzed. The total reported accident in this intersection was found 35 in numbers.

5.3.4 Bangla Motor Intersection

A. Geometric and Operating Condition:

intersection is intersection as per geometric classification of intersection; it has four (4) approaches. All the four approaches of this intersection are made of flexible pavement and dual carriageway. This intersection has 100% footpath coverage. There is channelization on the mouth one approach; it is fully dedicated for left turner of this intersection. All approaches of this intersection are alienated by the non - engineering divider. This non engineering divider is not related with velocity profile of vehicle of this intersection. For pedestrian crossing, there is a two (2) legged over bridge as a grade separated facility. Though pedestrian try to cross the intersection by finding suitable gap between vehicular flows. Five side roads are found in this intersection, coming from neighboring residential / business area.

B. Vehicular Flow:

Ten individual movement were found in this intersection, among them Farmgate to Sheraton movement contained maximum amount of vehicles, which was 43% of entire traffic flow. Two (2) distinct peak hours were found in traffic flow; one was in the morning period from 08.00 A.M. to 01.00 P.M. and another was in the evening from 03.30 P.M. to 06.00 P.M. & further (beyond the survey time), total peak period of the entire survey time was 7.5 hours, which was 68.18% of total survey time of that day. In this intersection the dominancy of MV was found; around 90% of total vehicle, the remaining part was NMV. Among the entire vehicular flow, car / taxi was maximum, around 29% of total vehicle. By calculating the saturation flow of different approaches of this intersection, Farmgate to Bangla Motor approach contained the maximum, around 3291.16 PCU / Hour. Two peak hours of flow ratio was found all throughout the day in this intersection. But vehicular flow was interrupted in Bangla Motor to New Eskaton road approach due to construction of Mogbazar Mouchak flyover.

C. Pedestrian Flow:

In this intersection, maximum pedestrian flow was found at grade, around 74% of total pedestrian. 26% of total pedestrian used two legged over bridge as a grade separation facility. Maximum at grade pedestrian flow were at the corner of Sonargaon Road, MoghbazarRoad and Sheraton approaching Road.

D. Side Friction:

Two specified reasons for side friction were found in two points inside the intersection. The reasons were illegal bus stand and illegal rickshaw stand. 50% of total road width at the mouth of approach of this intersection was blocked by this side friction in the peak hour and the vehicular flow of primary road interrupted. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing.

E. Traffic Control Devices:

Presently for this intersection, there was no use of traffic signal; instead of this, traffic police controlled the traffic movement of this intersection manually based on traffic flow demands among the four approaches. Traffic police followed here four (4) phase traffic controlling system; which is very inefficient method. The signal cycle time of this intersection was more than 120 sec, which was 100% of total observation time at peak period. It is increasing the delay of this intersection all throughout the day. From the analysis of total flow ratio of all the approaches were found greater than 1.00 in peak period, so automatic signal control cannot be successful in this intersection.

F. Queue Length:

After observing the hazardous condition of traffic control, consequently poor condition was observed in the queue length of every approach of this intersection. All throughout the day the queue length of this intersection was increased, 81.03% of total observation time, the queue length was over 200 m, which was very worst.

G. Delay:

The effect of queue length was directly observed in this intersection sequentially through delay. The delay at different approach of this intersection was found increased as the progress of the day time. Maximum delay was found in Paribagh Over Bridge to Bangla Motor approach of this intersection in evening time.

H. LOS:

The chronological effect of delay was found in the LOS of this intersection at different approaches. Averagely, 79.54 % of total observed time, the LOS of different approaches of this intersection was retaining at Level F; which is a curse for present Dhaka City.

Table 5.3.4: LOS of Different Approaches of Bangla Motor Intersection.

Observation No.	From	To	LOS (SAARC Fowara to Bangla Motor)	LOS Point Value	LOS (Paribagh Over Bridge to Bangla Motor)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6

2	7:30:00 AM	8:00:00 AM	A	6	B	5
3	8:00:00 AM	8:30:00 AM	B	5	C	4
4	8:30:00 AM	9:00:00 AM	C	4	E	2
5	9:00:00 AM	9:30:00 AM	F	1	E	2
6	9:30:00 AM	10:00:00 AM	F	1	F	1
7	10:00:00 AM	10:30:00 AM	F	1	F	1
8	10:30:00 AM	11:00:00 AM	F	1	F	1
9	11:00:00 AM	11:30:00 AM	F	1	F	1
10	11:30:00 AM	12:00:00 PM	F	1	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1
13	1:00:00 PM	1:30:00 PM	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1
Average LOS Point Value Approach wise			E	1.77	E	1.64
Over all LOS of the Intersection			**E**	**1.70**		

I. Accident Data:

From ARI, after collecting the secondary accident data of Dhaka Metropolitan City (from 1998 to 2014), the result was analyzed. The total reported accident in this intersection was found 32 in numbers.

5.3.5 Mirpur 10 Intersection

A. Geometric and Operating Condition:

10 intersection is as per geometric classification of intersection; it has four approaches. All the four approaches of this intersection are made of flexible pavement and dual carriageway. This intersection has 100% footpath coverage. There is no channelization on the mouth approach of this intersection. All approaches of this intersection are alienated by the non - engineering divider. This non engineering divider is not related with velocity profile of vehicle of this intersection. For pedestrian crossing, there is a four legged over bridge as a grade separated facility. Though pedestrian try to cross the intersection by finding suitable gap between vehicular flows. Eight side roads are found in this intersection, coming from neighboring residential /

commercial area.

B. Vehicular Flow:

Twelve individual movement were found in this intersection, among them Mirpur 12 to Agargaon movement contained maximum amount of vehicles, which was 22% of entire traffic flow. Two distinct peak hours were found in traffic flow; one was in the morning period from 08.30 A.M. to 12.00 P.M. and another was in the evening from 03.30 P.M. to 06.00 P.M. & furthermore (beyond the survey time), total peak period of the entire survey time was 5.5 hours, which was 54.54% of total survey time of that day. In this intersection the dominancy of MV was found; around 85% of total vehicle, the remaining part was NMV. Among the entire vehicular flow, car / taxi and utility were maximum, around 17% of total vehicle. By calculating the saturation flow of different approaches of this intersection, Agargaon to Mirpur - 10 approach contained the maximum, around 2054.84 PCU / Hour. Two peak hours of flow ratio was found all throughout the day in this intersection.

C. Pedestrian Flow:

In this intersection, maximum pedestrian flow was found at grade. Maximum at grade pedestrian flow was at the corner of Fire Brigade and Civil Defense.

D. Side Friction:

Three specified reasons for side friction were found in four points inside the intersection. The reasons were rickshaw diversion, illegal human hauler / Laguna stand and illegal bus stand. 60% of total road width at the mouth of approach of this intersection was blocked by this side friction in the peak hour and the vehicular flow of primary road interrupted. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing.

E. Traffic Control Devices:

Presently for this intersection, there was no use of traffic signal; instead of this, traffic police controlled the traffic movement of this intersection manually based on traffic flow demands among the four approaches. Traffic police followed here four (4) phase traffic controlling system; which is very inefficient method. The signal cycle time of this intersection was more than 120 sec, which was 100% of total observation time at peak period. It is increasing the delay of this intersection all throughout the day. From the analysis of total flow ratio of all the approaches were found greater than 1.00 in peak period, so automatic signal control cannot be successful in this intersection.

F. Queue Length:

After observing the hazardous condition of traffic control, consequently poor condition was observed in the queue length of every approach of this intersection. All throughout the day the queue length of this intersection was increased, 70.19% of total observation time, the queue length was over 200 m, which was very worst.

G. Delay:

The effect of queue length was directly observed in this intersection sequentially through delay. The delay at different approach of this intersection was found increased as the progress of the day time. Maximum delay was found in every approach of this intersection in evening time.

H. LOS:

The chronological effect of delay was found in the LOS of this intersection at different approaches. Averagely, 79.54 % of total observed time, the LOS of different approaches of this intersection was retaining at Level F; which is a curse for present Dhaka City.

Table 5.3.5: LOS of Different Approaches of Mirpur 10Intersection.

ObservationNo.	From	To	LOS (Benarasi 1 No. Gate to Mirpur - 10)	LOS Point Value	LOS (Al-Helal Hospital to Mirpur 10)	LOS Point Value	LOS (Mirpur 2 to Mirpur 10)	LOS Point Value	LOS (DWASA training Center to Mirpur 10)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6	A	6	A	6
2	7:30:00 AM	8:00:00 AM	B	5	A	6	A	6	A	6
3	8:00:00 AM	8:30:00 AM	C	4	D	3	A	6	C	4
4	8:30:00 AM	9:00:00 AM	F	1	D	3	A	6	E	2
5	9:00:00 AM	9:30:00 AM	F	1	C	4	F	1	F	1
6	9:30:00 AM	10:00:00 AM	F	1	D	3	F	1	F	1
7	10:00:00 AM	10:30:00 AM	F	1	E	2	F	1	F	1
8	10:30:00 AM	11:00:00 AM	F	1	F	1	F	1	F	1
9	11:00:00 AM	11:30:00 AM	F	1	F	1	F	1	F	1
10	11:30:00 AM	12:00:00 PM	F	1	F	1	F	1	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1	F	1	F	1
13	1:00:00 PM	1:30:00 PM	E	1	F	1	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1	F	1	F	1

19	4:00:00 PM	4:30:00 PM	F	1	F	1	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1	F	1	F	1
Average LOS Point Value Approach wise			E	1.55	E	1.91	E	1.91	E	1.64
Over all LOS of the Intersection			**E**	**1.75**						

I. Accident Data:

From ARI, after collecting the secondary accident data of Dhaka Metropolitan City (from 1998 to 2014), the result was analyzed. The total reported accident in this intersection was found 34 in numbers.

5.3.6 Shapla Chattar Intersection

A. Geometric and Operating Condition:

intersection is as per geometric classification of intersection; it has four approaches. All the four (4) approaches of this intersection are made of flexible pavement and dual carriageway. This intersection has 100% footpath coverage. There is channelization on the mouth one approach of this intersection; it creates a dedicated left turning lane. All approaches of this intersection are alienated by the non - engineering divider. This non engineering divider is not related with velocity profile of vehicle of this intersection. For pedestrian crossing, there is a two (2) legged over bridge as a grade separated facility. Though pedestrian try to cross the intersection by finding suitable gap between vehicular flows. Ten (10) side roads are found in this intersection, coming from neighboring residential / commercial area.

B. Vehicular flow:

Six individual movement were found in this intersection, among them Fakirapul to Baitul Mukarram movement contained maximum amount of vehicles, which was 21% of entire traffic flow. Two distinct peak hours were found in traffic flow; one was in the morning period from 09.00 A.M. to 12.30 P.M. and another was in the evening from 04.30 P.M. to 06.00 P.M. & further (beyond the survey time), total peak period of the entire survey time was 5 hours, which was 45.45% of total survey time of that day. In this intersection the dominancy of MV was found; around 78% of total vehicle, the remaining part was NMV. Among the entire vehicular flow, car / taxi was maximum, around 23% of total vehicle. By calculating the saturation flow of different approaches of this intersection, Fakirapul to Shapla Chattar approach contained the maximum, around 2630.80 PCU / Hour. Two peak hours of flow ratio was found all throughout the day in this intersection.

C. Pedestrian Flow:

In this intersection, maximum pedestrian flow was found at grade. Maximum at grade pedestrian flow was at the corner of Bangladesh Bank.

D. Side Friction:

Two specified reasons for side friction were found in four points inside the intersection. The reasons were illegal rickshaw stand and illegal bus stand. 50% of total road width at the mouth of approach of this intersection was blocked by this side friction in the peak hour and the vehicular flow of primary road interrupted. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing.

E. Traffic Control Devices:

Presently for this intersection, there was no use of traffic signal; instead of this, traffic police controlled the traffic movement of this intersection manually based on traffic flow demands among the four approaches. Traffic police followed here two (2) phase traffic controlling system; which is very inefficient method. The signal cycle time of this intersection was more than 120 sec, which was 54.56% of total observation time at peak period. It is increasing the delay of this intersection all throughout the day. From the analysis of total flow ratio of all the approaches were found greater than 1.00 in peak period, so automatic signal control cannot be successful in this intersection.

F. Queue Length:

After observing the hazardous condition of traffic control, consequently poor condition was observed in the queue length of every approach of this intersection. All throughout the day the queue length of this intersection was increased, 79.54% of total observation time, the queue length was over 200 m, which was very worst.

G. Delay:

The effect of queue length was directly observed in this intersection sequentially through delay. The delay at different approach of this intersection was found increased as the progress of the day time. Maximum delay was found in every approach of this intersection in evening time.

H. LOS:

The chronological effect of delay was found in the LOS of this intersection at different approaches. Averagely, 84.09 % of total observed time, the LOS of different approaches of this intersection was retaining at Level F; which is a curse for present Dhaka City.

Table 5.3.6: LOS of Different Approaches of Shapla Chattar Intersection.

Observation No.	From	To	LOS (R.K. Road to Shapla Chattar)	LOS Point Value	LOS (Arambagh Mor to Sgapla Chattar)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	C	4
2	7:30:00 AM	8:00:00 AM	C	4	D	3
3	8:00:00 AM	8:30:00 AM	E	2	E	2
4	8:30:00 AM	9:00:00 AM	F	1	E	2
5	9:00:00 AM	9:30:00 AM	F	1	F	1
6	9:30:00 AM	10:00:00 AM	F	1	F	1
7	10:00:00 AM	10:30:00 AM	F	1	F	1
8	10:30:00 AM	11:00:00 AM	F	1	F	1
9	11:00:00 AM	11:30:00 AM	F	1	F	1
10	11:30:00 AM	12:00:00 PM	F	1	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1
13	1:00:00 PM	1:30:00 PM	F	1	F	1
14	1:30:00 PM	2:00:00 PM	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1
Average LOS Point Value Approach wise			E	1.41	E	1.32
Over all LOS of the Intersection			**E**	**1.36**		

I. Accident Data:

From ARI, after collecting the secondary accident data of Dhaka Metropolitan City (from 1998 to 2014), the result was analyzed. The total reported accident in this intersection was found 62 in numbers.

5.3.7 Science Laboratory Intersection

A. Geometric and Operating Condition:

intersection is - Legged Compound intersection as per geometric classification of intersection; it has six (6) approaches. All the six approaches of this intersection are made of flexible pavement and dual carriageway. This intersection has 100% footpath coverage. There is channelization on the mouth of one approach of this intersection; it creates a dedicated left turning lane. All approaches of this intersection are alienated by the non - engineering divider. This non engineering divider is not related with velocity profile of vehicle of this intersection. For pedestrian crossing, there is a four legged over bridge as a grade separated facility. Though pedestrian try to cross the intersection by finding suitable gap between vehicular flows. Eight (8) side roads are found in this intersection, coming from neighboring residential / commercial area.

B. Vehicular Flow:

Fifteen individual movement were found in this intersection, among them Kalabagan to Science Laboratory movement contained maximum amount of vehicles, which was 16% of entire traffic flow. Two distinct peak hours were found in traffic flow; one was in the morning period from 08.30 A.M. to 12.00 P.M. and another was in the evening from 03.30 P.M. to 06.00 P.M. & further (beyond the survey time), total peak period of the entire survey time was 6 hours, which was 54.54% of total survey time of that day. In this intersection the dominancy of MV was found; around 94% of total vehicle, the remaining part was NMV. Among the entire vehicular flow, car / taxi was maximum, around 34% of total vehicle. By calculating the saturation flow of different approaches of this intersection, Kalabagan to Science Laboratory approach contained the maximum, around 2852.56 PCU / Hour. Two peak hours of flow ratio was found all throughout the day in this intersection.

C. Pedestrian Flow:

In this intersection, maximum pedestrian flow was found at grade. Maximum at grade pedestrian flow was at the corner of Dhanmondi road 3 and in front of Alliance Francaise.

D. Side Friction:

Four specified reasons for side friction were found in four points inside the intersection. The reasons were rickshaw diversion, illegal human hauler / Laguna stand and illegal bus stand. 50% of total road width at the mouth of approach of this intersection was blocked by this side friction in the peak hour and the vehicular flow of primary road interrupted. Basically those vehicles were searching passengers on the mouth of the approach instead of legal stoppage area. In this consequences, the delay and queue length of this intersection are increasing.

E. Traffic Control Devices:

Presently for this intersection, there was no use of traffic signal; instead of this, traffic police controlled the traffic movement of this intersection manually based on traffic flow demands among the six approaches. Traffic police followed here 3 phase both intersection points traffic controlling system; which is very inefficient method. The signal cycle time of this intersection was more than 120 sec, which was 100.00% of total observation time at peak period. It is increasing the delay of this intersection all throughout the day. From the analysis of total flow ratio of all the approaches were found greater than 1.00 in peak period, so automatic signal control cannot be successful in this intersection.

F. Queue Length:

After observing the hazardous condition of traffic control, consequently poor condition was observed in the queue length of every approach of this intersection. All throughout the day the queue length of this intersection was increased, 84.06% of total observation time, the queue length was over 200 m, which was very worst.

G. Delay:

The effect of queue length was directly observed in this intersection sequentially through delay. The delay at different approach of this intersection was found increased as the progress of the day time. Maximum delay was found in every approach of this intersection in evening time.

H. LOS:

The chronological effect of delay was found in the LOS of this intersection at different approaches. Averagely, 80.30 % of total observed time, the LOS of different approaches of this intersection was retaining at Level F; which is a curse for present Dhaka City.

Table 5.3.7: LOS of Different Approaches of Science Laboratory Intersection.

Observation No.	From	To	LOS (KalaBagan to Science Lab. Intersection)	LOS Point Value	LOS (Bata Signal to science lab. Intersection)	LOS Point Value	LOS (New Market to Science Lab. Intersection)	LOS Point Value
1	7:00:00 AM	7:30:00 AM	A	6	A	6	A	6
2	7:30:00 AM	8:00:00 AM	A	6	A	6	A	6
3	8:00:00 AM	8:30:00 AM	E	2	A	6	A	6
4	8:30:00 AM	9:00:00 AM	F	1	C	4	D	3
5	9:00:00 AM	9:30:00 AM	F	1	D	3	E	2
6	9:30:00 AM	10:00:00 AM	F	1	F	1	F	1
7	10:00:00 AM	10:30:00 AM	F	1	F	1	F	1
8	10:30:00 AM	11:00:00 AM	F	1	F	1	F	1
9	11:00:00 AM	11:30:00 AM	F	1	F	1	F	1
10	11:30:00 AM	12:00:00 PM	F	1	F	1	F	1
11	12:00:00 PM	12:30:00 PM	F	1	F	1	F	1
12	12:30:00 PM	1:00:00 PM	F	1	F	1	F	1
13	1:00:00 PM	1:30:00 PM	F	1	F	1	F	1

14	1:30:00 PM	2:00:00 PM	F	1	F	1	F	1
15	2:00:00 PM	2:30:00 PM	F	1	F	1	F	1
16	2:30:00 PM	3:00:00 PM	F	1	F	1	F	1
17	3:00:00 PM	3:30:00 PM	F	1	F	1	F	1
18	3:30:00 PM	4:00:00 PM	F	1	F	1	F	1
19	4:00:00 PM	4:30:00 PM	F	1	F	1	F	1
20	4:30:00 PM	5:00:00 PM	F	1	F	1	F	1
21	5:00:00 PM	5:30:00 PM	F	1	F	1	F	1
22	5:30:00 PM	6:00:00 PM	F	1	F	1	F	1
Average LOS Point Value Approach wise			E	1.50	E	1.91	E	1.82
Over all LOS of the Intersection			**E**	**1.74**				

I. Accident Data:

From ARI, after collecting the secondary accident data of Dhaka Metropolitan City (from 1998 to 2014), the result was analyzed. The total reported accident in this intersection was found 38 in numbers.

5.4 Summary of Findings of Selected Intersections of Dhaka Metropolitan City

After evaluating the overall Level of Service (LOS) of the intersections of Dhaka city through analyzing the result statistically, the following results was found, which is presented here through Table 4.13.8.

Table 5.4.1: Ranking of Dhaka City Intersections Based on LOS.

Serial No.	Intersection Name	LOS Point Value	Ranking
1	**Mirpur - 1**	2.29	1
2	**Shishu Mela**	1.52	6
3	**Agargaon**	1.88	2
4	**Bangla Motor**	1.70	5
5	**Mirpur - 10**	1.75	3
6	**Shapla Chattar**	1.36	7
7	**Science Laboratory**	1.74	4

From above table, it can be found that among the seven intersections the worst performing intersection is Shapla Chattar at Motijheel with the LOS value 1.36 and the best performing intersection is Mirpur-1 with LOS value 2.29. The reason behind the worst performance of Shapla Chattar might be huge side friction and road side parking of buses as most of the bus routes terminus at this area. In addition to that Motijhhel area is the Bank headquarters area, therefore bank

near to the intersection, all these issues causes maximum delay at Shapla Chattar. On the other hand, Mirpur-1 intersection performing better, it was observed during survey period that overall volume of traffic is relatively low, the greater portion of motorized vehicle movement found from Mirpur-2 to Dar-us-Salam road, and side friction is relatively low.

For the evaluation of the performance of the selected intersections of Dhaka city, based on accident records, the data was collected from Accident Research Institute (ARI) of BUET and analyzed later. From the analysis of accident data, it was found

Table 5.4.2: Accident Data Recorded from 1998 to 2014 in Dhaka Metropolitan City Area and its Ranking.

Serial No.	Intersection Name	Accident Number	Ranking
1	**Mirpur 1**	36	5
2	**Shishu Mela**	17	1
3	**Agargaon**	35	4
4	**Bangla Motor**	32	2
5	**Mirpur - 10**	34	3
6	**Shapla Chattar**	62	7
7	**Science Laboratory**	38	6

From above table, it can be found that among the seven intersections the highest number of accident occurred during the sixteen years period at Shapla Chattar intersection and lowest number of accident occurred at Shishu Mela intersection. The reason behind the highest accident prone intersection of Shapla Chattar might be huge number pedestrians haphazard movement, serious disorder and unhealthy competition among the bus operators as a terminus point of bus routes mentioned earlier. On the other hand, accident number at Sishu Mela intersection is the lowest, reason behind may be the lower volume of pedestrian crossing movement and pedestrian find the opportunity to cross the road in between the signal (manual) of opposite direction vehicles. In addition to that NMV is not allowed to ply in Mirpur road.

5.5 Recommending Intersection Performance Improvement Measures

The findings from the study based on analysis of data have been discussed in detail in the above articles. Based on these findings, some general conclusions are made, which can be used as the scope of intersection improvement as well as in prioritizing capacity augmenting measures in Dhaka city. The general conclusions obtained from the study are summarized as follows.

A. Engineering / Planning Measures

- The present conditions of intersections of Dhaka Metropolitan city give emphasis on reviewing the plan of the city, presently Dhaka city is a well-developed city, but is very hard to review all the plans. Sequentially building a modernized / civilized city, it is number one priority to correct all previous planning of Dhaka city.
- Essentially, when a city is developed, at first the road network is designed, but for Dhaka city, the residential part had been developed first then the road network was thought later on. So it became hard to accommodate all basic needs for the citizen of Dhaka City Metropolitan Area. So it would be better to make a planned road network for satellite area of Dhaka city, such as Purbachal, Ashulia, etc.
- Depending on the present condition of Dhaka Metropolitan City and future development of this city, reviewing the plan / rethink the whole road network is the most prior work. There is no well identified zone now, specifically residential area, commercial area, school area, business area, university area, hospital area, office area, etc. All areas are now mixed together, for this, planning of road network often fail. It is the first priority to re-structure the whole city with the help of RAJUK again. It will simplify the plan of road and intersection facility and will optimize this facility with the economy.
- Presently the intersections of Dhaka City have no legally marked area for these developments were done indiscriminately. In the road network, intersections are characterized as a magnet; all developments are done by about this. The unplanned development of Dhaka city road intersections turns the situation in a hectic condition. Moreover, the corner plot of the intersections is developed in unplanned concept. So there is no scope of further engineered development in Dhaka city road intersections because of the development of corner plot by the land owners as market, shopping mall, huge building, hospital, school, etc. permanently. Consequently there is no possibility to rehabilitee again; if it is required to recover, great anomalies can be occurred.
- All intersections of Dhaka Metropolitan City area have to be restructured in automatic signaling system. The signals should be synchronized with neighboring intersections and coordinated, which lessens the delay in travel time and traffic police have to help in this positive movement.
- Lane discipline should be well planned in intersection for reducing the delay in traffic movement. Instantly, the heterogeneous traffic flow has to be converted into motorized traffic flow. Because, the homogeneous traffic flow makes the traffic operation very smooth.

- For dividing the whole Dhaka Metropolitan City area in specific traffic analysis zone, RAJUK have to take initiative for making a detailed area plan of this city and follow this plan strictly in land development.

B. Educational Measures

- Pedestrian crossing in intersection should be organized by providing footpath, over bridge, underpass, zebra crossing, conveyor belt, etc. Following the crossing rules should be practiced by all.
- Sign, VMS (Variable Message Sign), marking should be put again in intersection and the culture of following those should be built up from mind and behavior.
- Proper road behavior instructions, with focused message should be broadcast through mass media.
- Basic things of road planning should be introduced in basic science in course curriculum. It ensures the basic knowledge of all about the road infrastructure.

C. Enforcement Measures

- Always self-enforcing restrictive measures should be given preference over any regulatory measures.
- Traffic rules and laws should be enforced upon the all users.
- Protect the legal intersection area, RAJUK should apply lawful step in it.
- Maintaining signal, sign, marking should be properly highlighted in to the people.
- Driving license should be maintained lawfully.
- Fitness of vehicle should be maintained scientifically.
- Traffic control should be done automatically, sufficient traffic police must be deployed in proper place in the road network of Dhaka Metropolitan City area.

5.6 Recommendations for Further Research

Some potential areas for research are suggested below

- **Safety study** this study is done by using secondary data. It would be better, if this study can be done by analyzing primary police accident data.
- **Economic study -** comprehensive economic study of those intersections can be done by considering VOT (Value of Travel Time), VOC (Vehicle Operating Cost), Accident Costing, etc.
- **User** **-** find out the proper position of pedestrian crossing facilities, bus stoppage, rickshaw stand, commercial places, etc.

The above issues could be the potential topics for further research in this area.

REFFERENCES

Accident Research Institute (ARI), BUET *1998*
2009 [*http://www.buet.ac.bd/ari/Downloads.php*](http://www.buet.ac.bd/ari/Downloads.php)

Alam, M.S. [1997], *Performance Evaluation of Selected Signalized Intersection in Dhaka city.* **M.Sc. Thesis,** Department of Civil Engineering, **Bangladesh University of Engineering & Technology (BUET), Dhaka, Bangladesh**

American Association of State Highway and Transport Officials (AASHTO), **Fifth Edition, [2004]**

Bangladesh Road Transport Authority (BRTA) [March, 2000], Ministry of Communication, *Traffic Signs Manual, Volume 1 & 2*

Baumgaertner, W.E. [1996], *Level of Service Getting Ready for 21st Century* **ITE Journal**, January, **pp. 36 39**

Cameron, R. [1996], G3F7 *An Expanded LOS Gradation System* **ITE Journal,** January, **pp. 40 41**

Department of Transport, [January, 2012], *Guidance on Road Classification and the Primary Route Network*

Habib M.A., Armed M. and Siddique M.Z.H, [2005], *Transportation Problems and System Deficiencies of Dhaka City an Integrated Approach for Solutions* **BURP Thesis**, Department of Urban and Regional Planning (URP), **Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh**

Highway Research Board [2010], *Highway Capacity Manual* **HRB**, special **Report No. 209**, USA

Highway Capacity Manual (HCM), 2010

Hoque, M.S. [2012] Lecture Notes *Geometric Design of Highways*

Hoque, M.M. [2012] Lecture Notes *Accident in Road Intersection*

Hoque, M.S. [1994],*Modeling of signalized Intersection in developing Countries,***Ph.D. Thesis,** Department of Civil Engineering, **University of Southampton, UK**

Hoque, M.S., S.M. Sohel Mahmud, Abdus Shakur Kazi *Weakness of Transportation System of Dhaka Metropolitan City and Challenges for Sustainable Development*

Institute of Traffic Engineers [1994], *Transportation and Traffic Engineering Handbook* , Second Edition, Prentice Hall Inc. **New Jersey, USA**

J. Li; Z.Q. Yue; and S.C. Wong, M.ASCE [2004], *Signalized Urban Intersection under Mixed Traffic Conditions by Gray System Theory* **ASCE Journal,** January / February**, 2004, pp. 113 121**

Kadiyali, L.R. [1983], Second Edition, Khanna Publishers, **Delhi, India**

Khisty, C. Jotin & Kent Lal, B. [2003], *Transportation Engineering an Introduction* Third Edition, Prentice Hall of India Private Limited, **New Delhi, 110 001, 2006**

Mahmud, S.M. Sohel, [2009] *Identifying the Deficiencies of Land use Transport Development in Dhaka City* **M.Sc. Thesis,** Department of Civil Engineering, **Bangladesh University of Engineering & Technology (BUET), Dhaka, Bangladesh**

Miller, A.J. [1968] *The Capacity of Signalized Intersection in Australia* Bulletin No. 3, Australian Road Research Board, **Vermont, Australia**

MRT Line 6 Project, Historical Importance / Archaeological Survey Works, JICA Funded, [2015], *Historical Importance / Archaeological Study of Dhaka Mass Rapid Transit Development Project.* **Final Report**

Papacostas, C.S. & Prevedorous, P.D. [2001], *ortation Engineering & Planning* , **Third Edition,** Prentice Hall of India Private Limited, **New Delhi, 110 001, 2006**

Roads and Highway Department, [October, 2001] *Manual Traffic Counts Instruction Guide*

Road Safety Manual on Low Cost Engineering Countermeasures [1990], United Nation Economic Commission for Africa, Ethiopia

R.H. Purcell [January, 1981], *Calcutta Traffic Engineering Project: 3* Studies, Traffic Engineering & Control, **Vol. 22 No. 1**

Roads & Highway Division [1984], *Annual Traffic Survey Report, 2008 - 2010* Division 1, **Govt. of Bangladesh**

S. Rajasekar, P. Philominathan and V. Chinnathambi [2013], *Methodology* **Cornell University,** arXiv: **physics/0601009v3**

Singh, G., [1978] *Highway Engineering* **Delhi,**

India

Signal Synchronization Study, World Bank Funded, CASE Project [2013], *Traffic Signal Synchronization Study in Dhaka Metropolitan City Area* **IDA Credit No: 4581 BD Report**

Transport Road Research Laboratory (TRRL) *Guide Book*

Tamilnadu Police Traffic Wardens Organization, *Road Markings* http://www.trafficwardens.in/road_markings.html

Wright, P.H., Paquette, R.J. [1987], *Highway Engineering* **New York, USA**

Wiki books, *https://en.wikibooks.org/wiki/Fundamentals_of_Transportation/Traffic_Flow*

Wikipedia, *https://en.wikipedia.org/wiki/Traffic_flow*

Wikipedia, *Urban Planning* https://en.wikipedia.org/wiki/Urban_planning

Wikipedia, *Capital City* https://en.wikipedia.org/wiki/Capital_City#Capital_city

Wikipedia, *History of Urban Planning* https://en.m.wikipedia.org/wiki/History_of_urban_planning#Classical_and_Medieval_Europe

Wikipedia, *Urban Planner* https://en.wikipedia.org/wiki/Urban_planner

Wikipedia, , https://en.wikipedia.org/wiki/History_of_road_transport

Wikipedia, *Road Network* https://en.wikipedia.org/wiki/Road_network

Wikipedia, *Capital City* https://en.wikipedia.org/wiki/Capital_City

Wikipedia, *Hierarchy of Roads* , https://en.wikipedia.org/wiki/Hierarchy_of_roads

World Urbanization Prospects, Revision **[2003]** UN

Appendix A

1.1 Mirpur 1 Intersection

1.1.1 General Description

1 intersection site is situated on the segment of primary approach between 10 roundabout and Mazar road . This is one of the busy roads in Dhaka Metropolitan City. From south side the Dar-Us-Salam road meets at this intersection. These three roads form a Tee- intersection / Wye intersection . The presence of various markets, health clinic, wholesale market, restaurants, shopping malls, banks, ATM, private university, government / non-government offices, bus stoppage, human hauler and rickshaw stands, etc. make this intersection very busy with vehicular and pedestrian flow activities throughout the day. A major portion of motorized and non-motorized vehicles are choosing their routes from east to west and south to east through this intersection. The divergent roads from this intersection are linked with Mirpur residential area, Dhaka Cantonment area to the east side; Mirpur zoo, botanical garden to the north-east side; Shah Ali Mazar, Lal Kuthi, Gabtoli to the west side and Tolarbagh, Ansar Camp, Panir Tanki, GovernmentResidential area to the south side.

Figure 1.1.1: Google Map of Mirpur 1 Intersection.

At the intersection the road is divided by a narrow median and island with steel pedestrian barrier. A pedestrian over bridge is provided for safe crossing. Characteristics of this intersection are included with very high number of disorganized rickshaw movement and parking and it causes serious disruption for traffic movement. Besides, illegal bus and Laguna stoppage also cause congestion. Moreover there are no pedestrian signal lights in signaling system. The effective width of the road is reduced and traffic flow is hampered.

In Dhaka city, Mirpur is a place of Northwestern area. Once upon a time it was an isolated and backdated place with swampy land. It was filled with bushes and trees. Now it is a developed part of Dhaka. It is under the Dhaka Metropolitan City area, it remains in the Dhaka North City Corporation (DNCC) area. Mirpur 1 intersection is under the Mirpur 1 no. section in Government Map. It is situated in between of Shah Ali Mazar road and Mirpur Zoo area.At first it was a residential area. But now with the progress of of Dhaka City it is turned in to a commercial cum residential place.

Figure 1.1.2: Mirpur 1 Intersection Map.

Now Mirpur 1 intersection is a center place of Market, Shopping Mall, Private University, Government office, Clinic, etc. But development of this Mirpur 1 intersection is not a regular one. Discreet development causes a huge trouble. Unplanned development of Mirpur 1 intersection, reduces the chance of future sustainable development. Mirpur 1 intersection is three (3) legged / Tee intersection / Wye intersection. It contains three leg or link. Those links are Mazar Road, Dar-us-Salam Road and Mirpur 10 Road.

Figure 1.1.3: Approach Road: (a) Mazar Road, (b) Dar-us-Salam Road and(c) Mirpur 10 Road.

1.1.2 Approaches from Intersection

1 intersection contains flexible pavement in road structure. There is no marking on road in this intersection. Frequent maintenance work, such as overlay of bitumen led the sign and marking swipe out from road. The overall lane provisions of the different links are

a) Mazar Road 2 Lane both directions.
b) Dar-us-Salam Road 2 lane both directions.
c) Mirpur 10 Road 2 lane both directions.

There is exclusive left turn in Mirpur Road and Dar-us-Salam Road. Some roads contain the provision of channelization. The pictures are given below

Figure 1.1.4: Inside Intersection: Channelization on Dar-us-Salam Road.

Some of the links contain Median with or without picket barrier, Marking, Sign, etc. In this intersection, there are some facilities of pedestrian crossing, such as over bridge, pedestrian movement facilities, such as footpath. Pedestrian cross the road illegally also. They usually cross the median barrier for crossing movement.

Figure 1.1.5: Inside the Intersection: (a) Over Bridge, (b) Median Barrier and (c) Footpath Occupied by Vendor.

For movement of Non Motorized Vehicle, there is separate lane for this; it is located in front Mukto Bangla Shopping Complex. But it is not properly used by NMV.

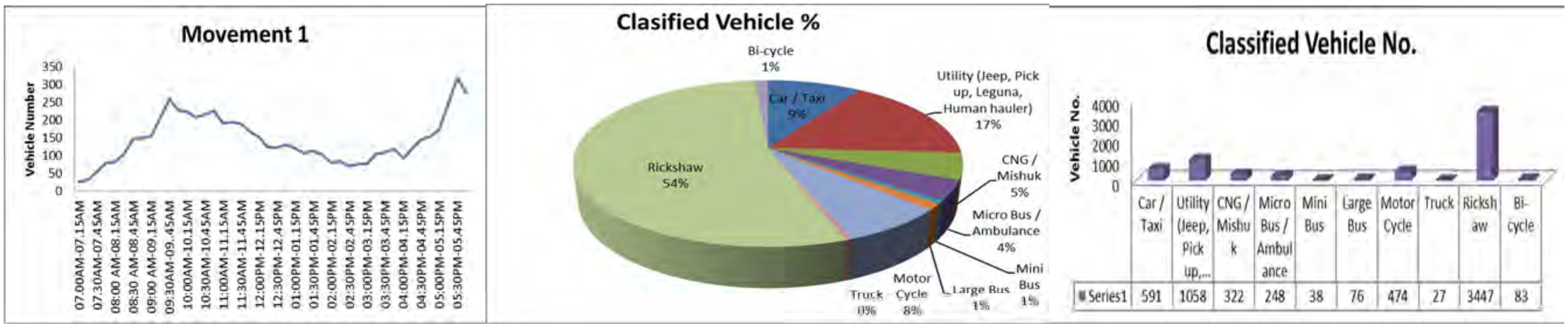
Figure 1.1.6: Separated NMV Lane.

1.1.3 Vehicular Flow of this Intersection

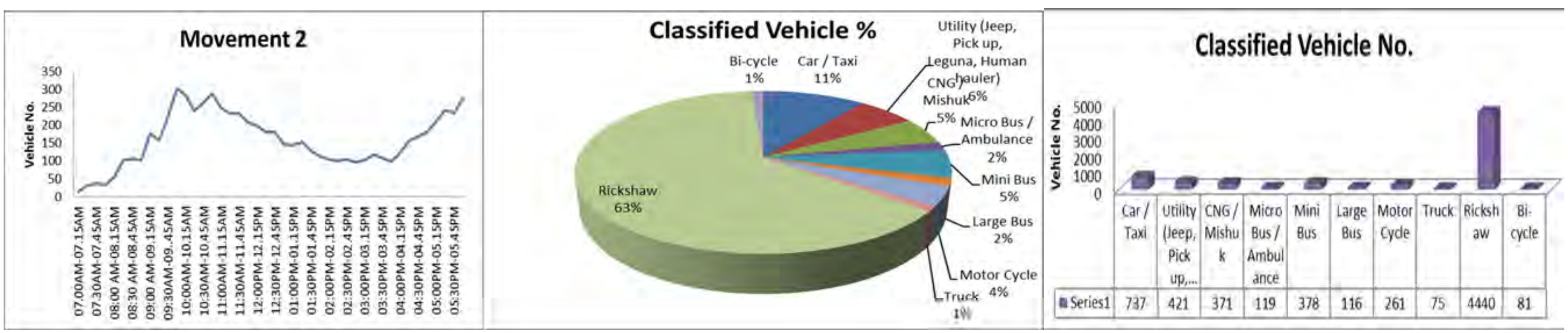
For finding out the level of service (LOS) of this intersection, the decision of classified vehicle counting in this intersection was taken. From preliminary survey of this intersection they found two peak hours, one in the morning from 08.00 AM to 12.00 P.M. and other is in the evening from 04.00 P.M. to 06.00 P.M. and furthermore. So the time of survey was fixed from 07.00 AM to 06.00 PM, total 11 hours. The result of the vehicular survey is going to be described below

From the preliminary survey of this intersection the researcher team found 5 movements in this intersection. They are (1) Mazar Road to Mirpur 2, (2) Mirpur 2 to Mazar Road, (3) Mirpur 2 to Dar us Salam, (4) Dar us Salam to Mirpur 2 and (5) Dar us Salam to Mazar Road. The vehicular counting data is given below.

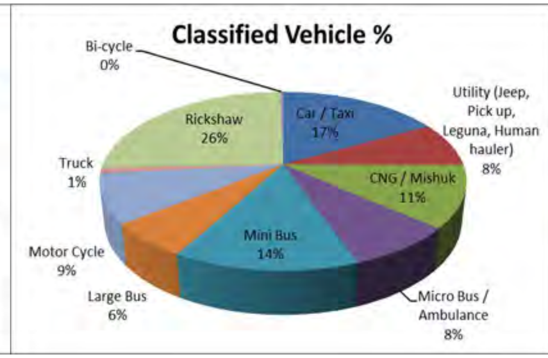
Movement: 1 Mazar Road to Mirpur 2.

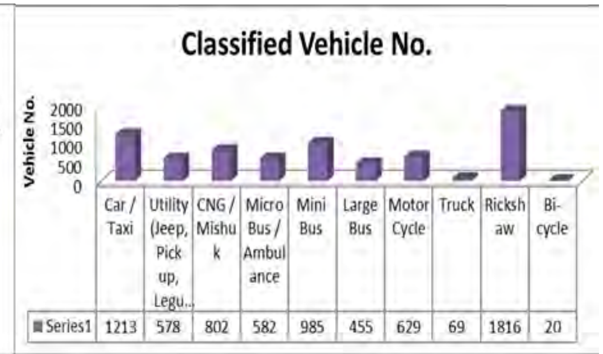


Movement: 2 Mirpur 2 to Mazar Road.

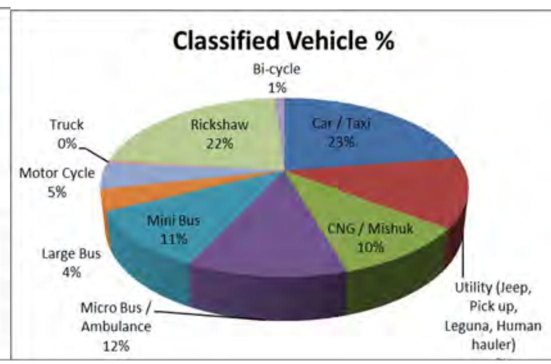


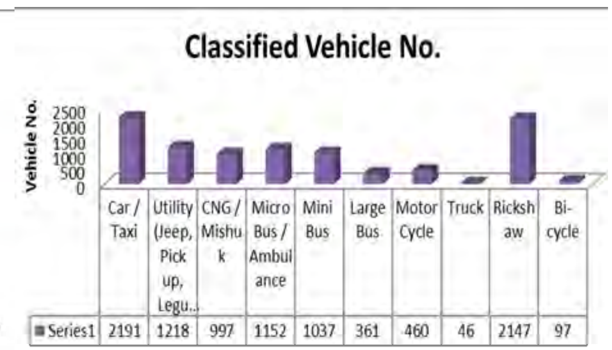
Movement: 3 Mirpur 2 to Dar us Salam.



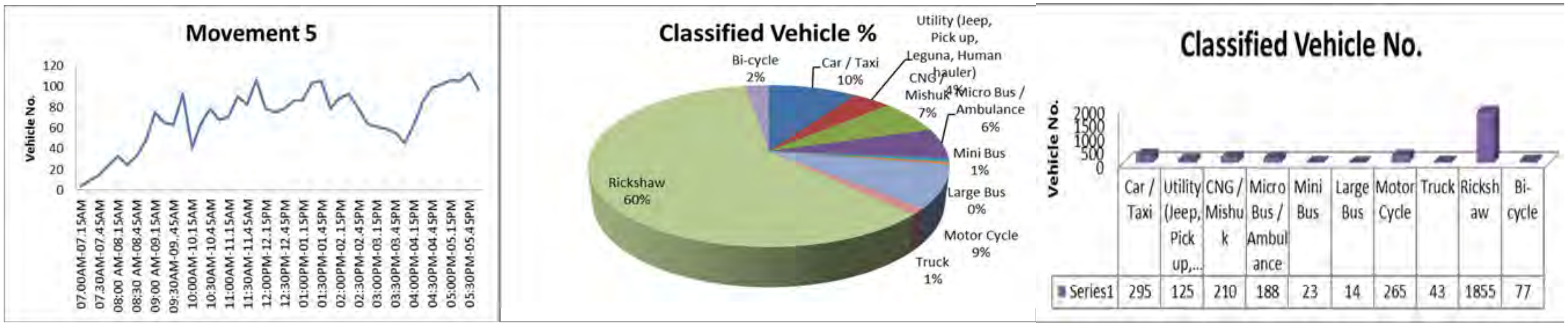


Movement: 4 Dar us Salam to Mirpur 2.





Movement: 5 Dar us Salam to Mazar Road.



After finishing the vehicular survey, the analyzing of vehicular flow data was done. The result of this analysis are given below From the analysis it was found that Movement 4 (Dar us Salam to Mirpur 2) contains maximum traffic flow of this intersection. Non-Motorized Vehicle rickshaw is dominant in this intersection.

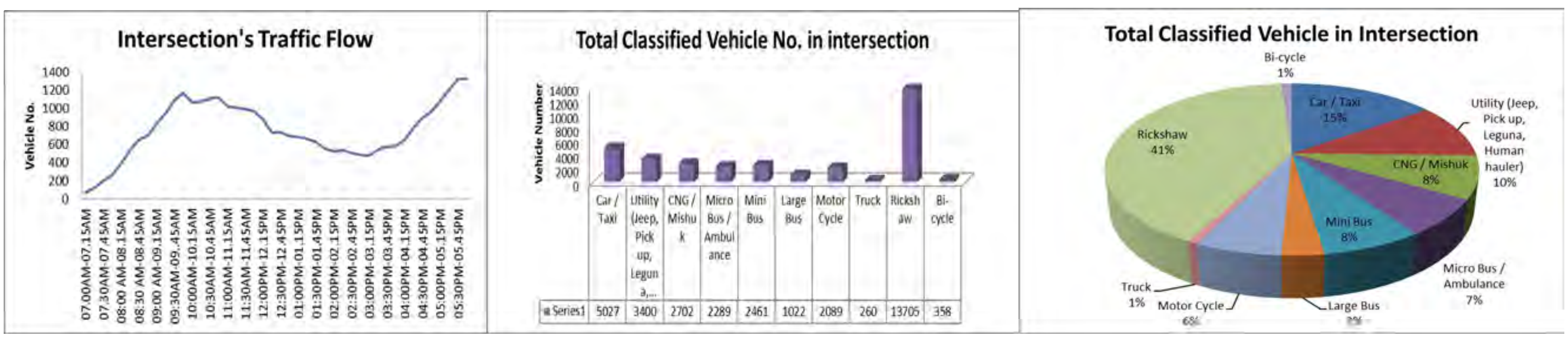


Figure 1.1.7: Traffic Flow through Mirpur 1 Intersection.

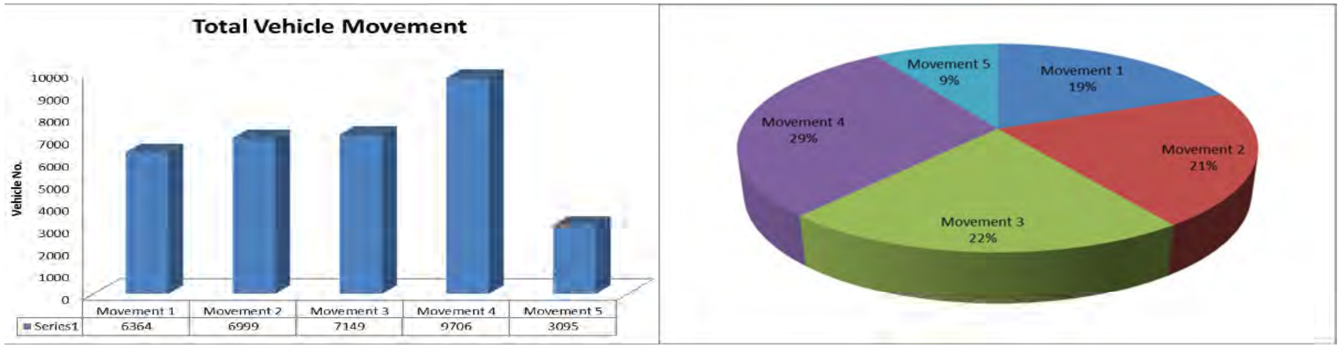


Figure 1.1.8: Vehicle Movement in Various Directions.

The researcher team also counts the flow ratio of the three (3) approaches for finding out the condition of traffic flow situation of individual approach which is related with signal system, phasing, queue length, delay, etc. of this intersection. The data of flow ratio around the survey period is shown below

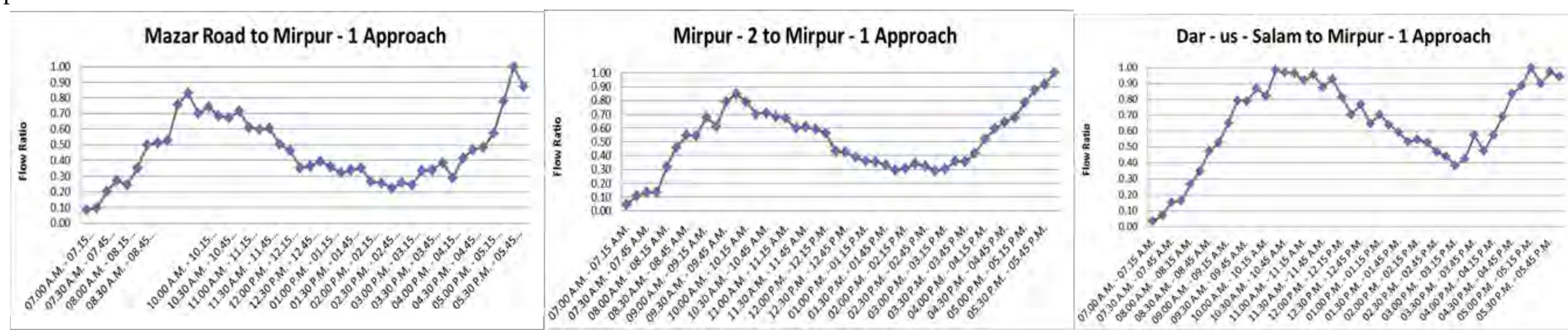


Figure 1.1.9: a) Flow Ratio of Mazar Road to Mirpur 1 Approach; b) Flow Ratio of Mirpur 2 to Mirpur 1 Approach; c) Flow Ratio of Dar us Salam to Mirpur 1 Approach.

1.1.4 Pedestrian Flow of this Intersection

In the time of field survey, the pedestrian flow of this intersection was surveyed with the vehicular flow of this intersection. The result of pedestrian survey is given below.

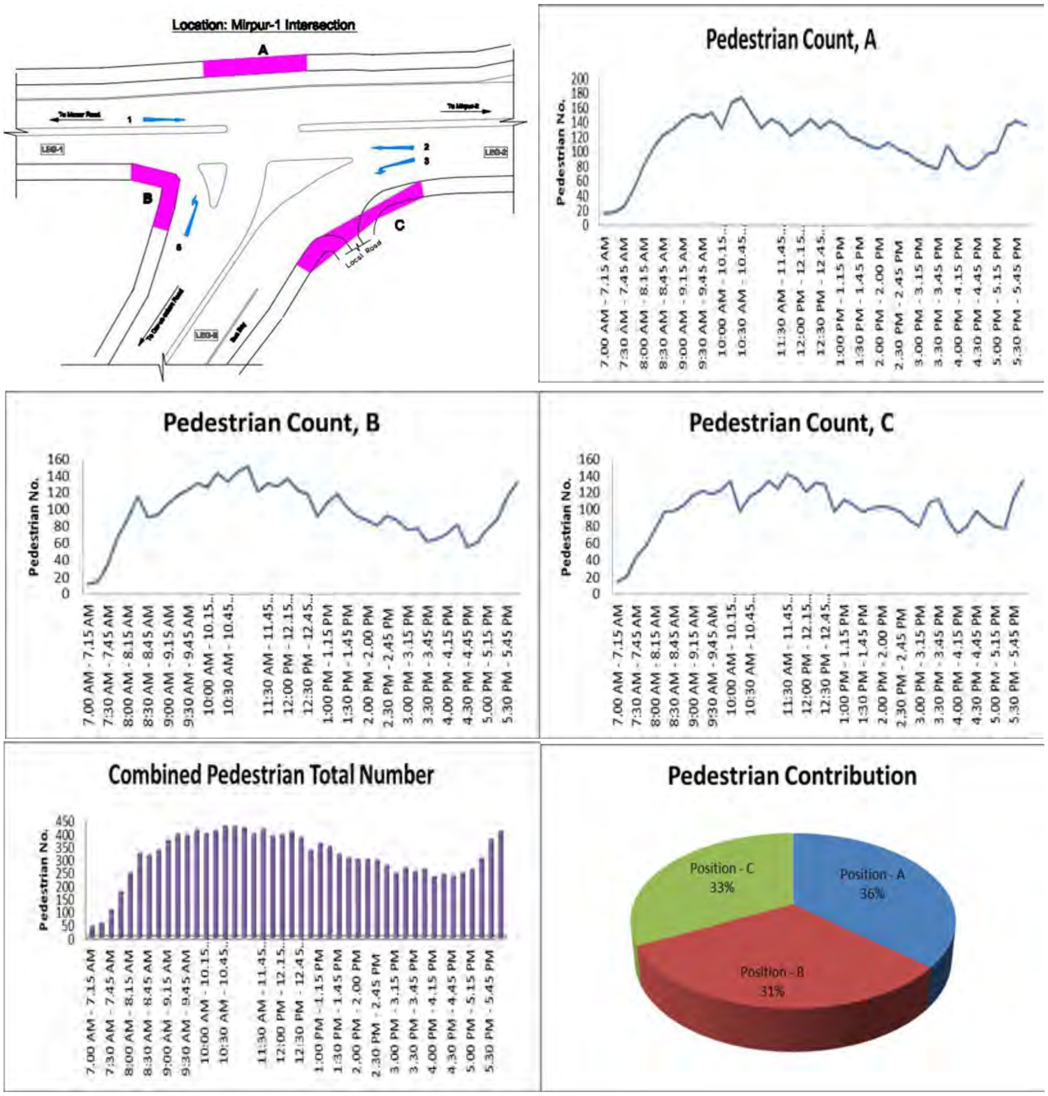


Figure 1.1.10: a) Pedestrian Survey Position inside Mirpur-1 Intersection; b) Pedestrian Flow; c) Pedestrian Flow Contribution among three (3) Positions.

In this intersection, for pedestrian crossing there is an over bridge, having three (3) leg. The researcher team tried to find out the percentage of pedestrian using this crossing facility. The result of this survey is given below.

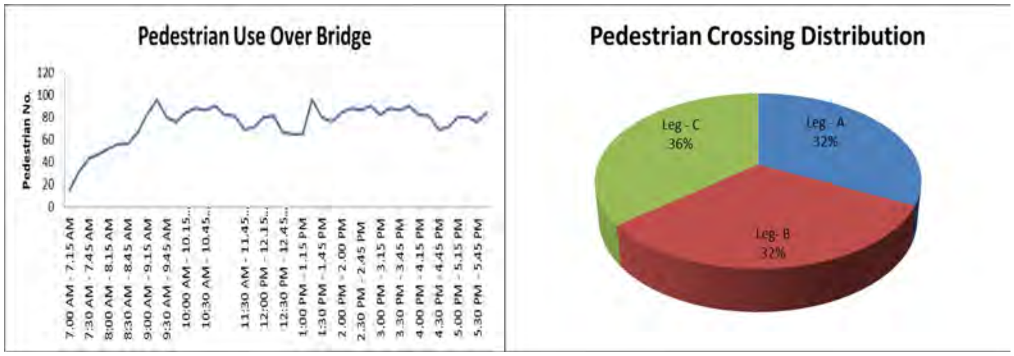


Figure 1.1.11: a) Grade Separated Pedestrian Flow; b) Pedestrian Flow Contribution among three (3) Legs.

In this intersection, there is no forceful rule of using of over bridge for crossing the intersection, so pedestrian cross the intersection illegally at various places at grade. Only 24% of total pedestrian of this intersection use the over bridge as a crossing facilities. This is very much poor.

1.1.5 Side Friction of this intersection

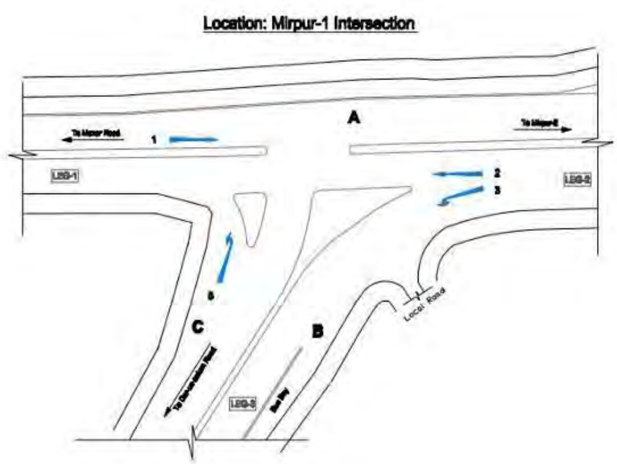


Figure 1.1.12: Rickshaw Stopping Points inside the Mirpur 1 Intersection.

Mirpur 1 intersection is a NMV dominant intersection consequently there should be the presence of side friction in this intersection. In the preliminary survey time, it was found out three points as usual rickshaw stopping area of this intersection. A CAD drawing denoting the points is shown below.

A rickshaw counting survey was done by the team. After 15 minutes interval, survey team counted the numbers of rickshaw in these points. The results are shown below.

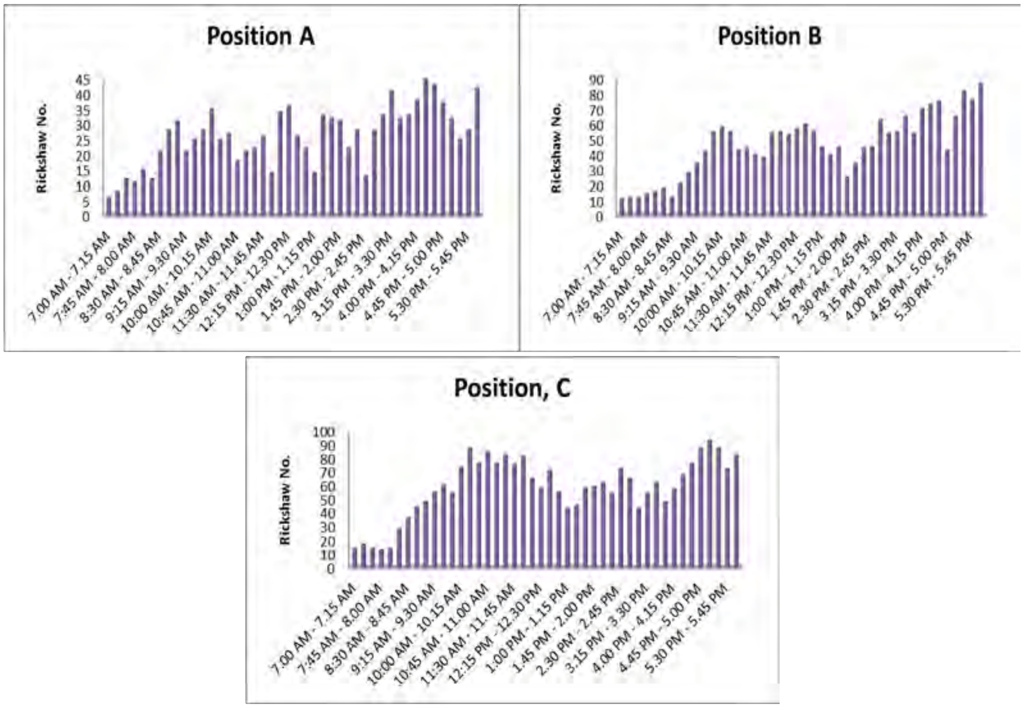
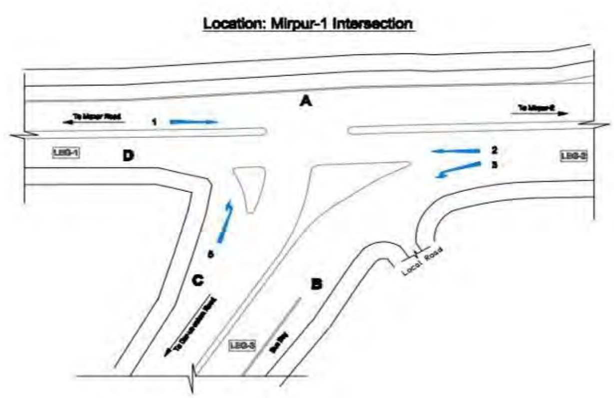
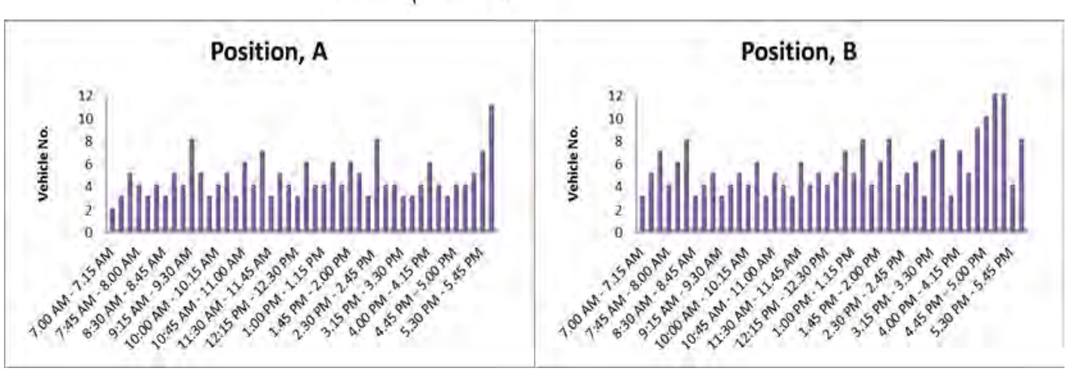


Figure 1.1.13: Rickshaw Survey in three (3) Positions.

Besides the rickshaw, in this intersection four human haulers / Laguna stand were found out. A counting survey was arranged for finding out the real condition. The results are shown below.





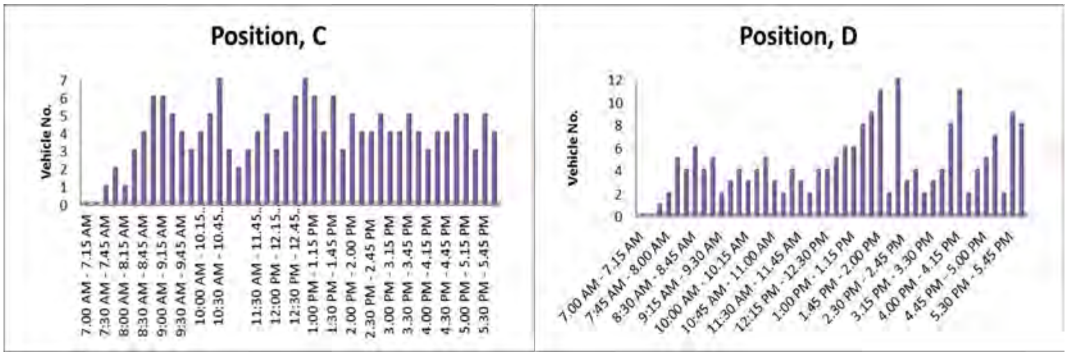
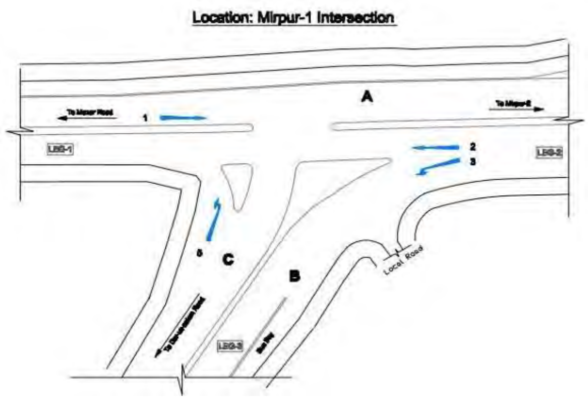
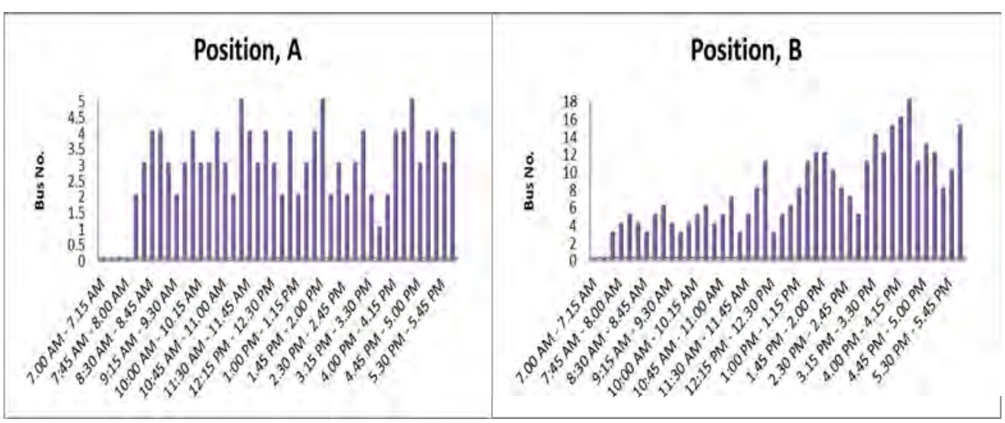


Figure 1.1.14: a) Human Hauler / Laguna Stopping Points inside the Mirpur 1 Intersection; b) Human Hauler Number in four (4) Positions.

In preliminary survey, a lot of buses were found standing at various places inside Mirpur 1 intersection. After a close observation of this issue the three (3) distinct places was found, where the buses illegally stopped. A manual counting survey was organized in theseplaces for finding out the real situation. The result is shown below.





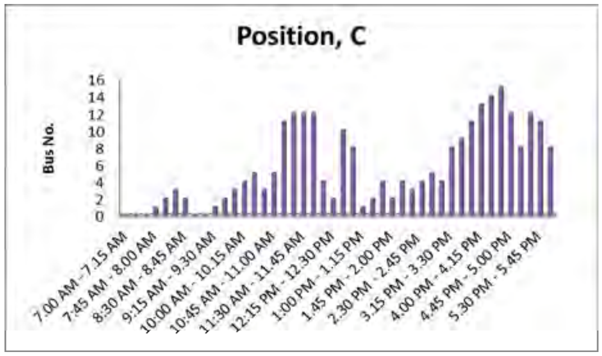


Figure 1.1.15: a) Bus Stopping Points inside the Mirpur 1 Intersection; b) Bus Number in three (3) Positions.

1.1.6 Traffic Control Device

In this intersection, the traffic management is done by the police. Their method of management is
also. But these facilities are not used by the police. The signal is fixed time signal. As usually, in management of traffic in an intersection causes some delay. This delay gives chance to traffic for building up the queue in the approaches. In Mirpur 1 intersection, queue was also found in different approaches.

A preliminary survey of traffic control devices were done in Mirpur 1 intersection. The result of this survey is described below.

Table 1.1.1: Features of Intersection and Traffic Control System.

Sl No.	Description	Nos.
1	Number of legs	3
2	Direction of traffic	5
3	Signal post for vehicular and pedestrian movement	6
4	Traffic signal controller box	1
5	Traffic police box	1

Table 1.1.2: Duty of Traffic police.

Post	Morning Shift	Evening Shift
Traffic inspector	1	
Traffic sergeant	1	1
Traffic police	3	3
Ansar	-	-

Table 1.1.3: Existing Traffic Control System and Time of Operation.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(08.00 PM 08.00 AM)
2	Automatic signal lighting system (Control by traffic police)	

3	Signal system control by traffic police	(08.00 AM 11.00 AM) (05.00 PM 08.00 PM)
4	Mixed	(12.00 PM 05.00 PM)

Table 1.1.4: Signal Accessories.

Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Light Operation	Pedestrian Signal Light Operation
SP-1	OK	OK	Yes	-
SP-2	OK	OK	Yes	-
SP-3	OK	OK	No	-
SP-4	OK	OK	Yes	-
SP-5	OK	OK	Yes	-
MAP 1	OK	OK	Yes	-
TSC	OK	Shutter Missing	-	-

Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

During this preliminary survey, we found signal post on every approach of this intersection. In this preliminary survey the researcher team tried to find out the cycle time of these signals. The cycle time measuring data is given below.

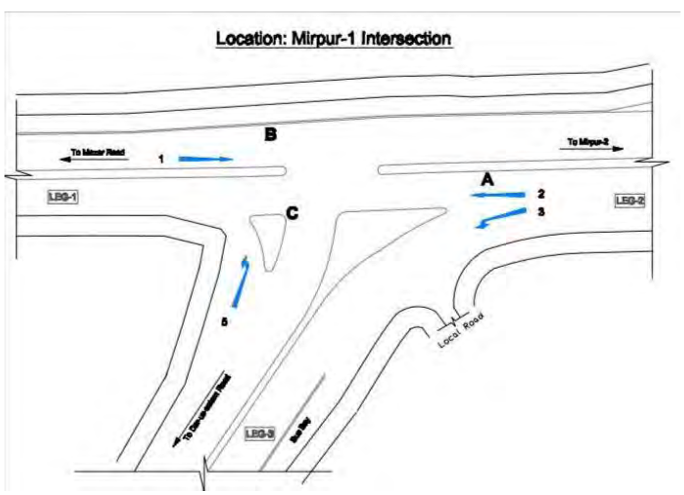


Figure 1.1.16: Position of Signal Post inside the Intersection.

This signal cycle time survey was done in two (2) peak hour from 07.45 AM to 11.04 AM and from 04.00 PM to 06.00 PM.

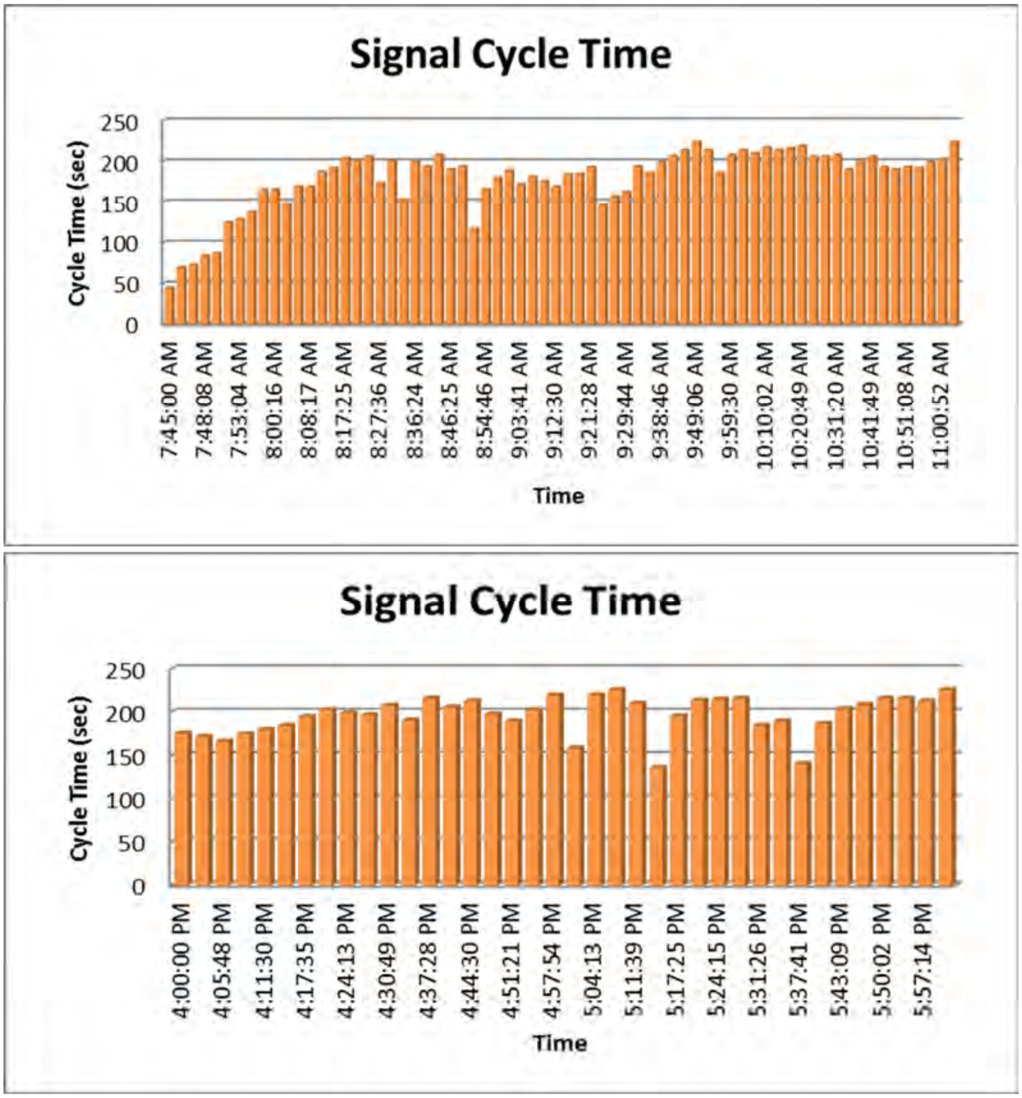


Figure 1.1.17: Signal Cycle time (i) from 07.45 AM to 11.04 AM and (ii) from 04.00 PM to 06.00 PM.

1.1.7 Queue Length

Due to long signal cycle time, signal phasing, side friction, traffic demand responsive signal system, queue length was found in three approaches of this intersection. The decision for collecting primary data of this intersection from the field survey and later compared with the secondary data (*CASE study of World Bank Funded nal Synchronization Study, 2013* The primary data of the survey team is given here under.

Table 1.1.5: Queue Length at Different Approach of Mirpur 1 Intersection in meter (at Morning Peak).

Observation No.	From	To	Mazar road to Mirpur - 1 Approach	Dar - us - Salam to Mirpur - 1 Approach	Mirpur - 2 to Mirpur - 1 Approach
1	7:45:00 AM	8:00:00 AM	0	0	86.3
2	8:00:00 AM	8:15:00 AM	0	0	122.31
3	8:15:00 AM	8:30:00 AM	0	0	165.59
4	8:30:00 AM	8:45:00 AM	0	0	151.90
5	8:45:00 AM	9:00:00 AM	0	78.91	165.21
6	9:00:00 AM	9:15:00 AM	0	124.56	188.34
7	9:15:00 AM	9:30:00 AM	156.55	154.33	190.93
8	9:30:00 AM	9:45:00 AM	187.33	188.77	227.91
9	9:45:00 AM	10:00:00 AM	213.33	211.32	211.32
10	10:00:00 AM	10:15:00 AM	219.88	224.35	221.46
11	10:15:00 AM	10:30:00 AM	218.32	238.26	209.90
12	10:30:00 AM	10:45:00 AM	222.32	289.77	208.96
13	10:45:00 AM	11:00:00 AM	234.25	311.44	228.32
14	11:00:00 AM	11:15:00 AM	238.23	324.55	218.33
15	11:15:00 AM	11:30:00 AM	300.54	331.22	226.44
16	11:30:00 AM	11:45:00 AM	267.54	327.44	224.59
17	11:45:00 AM	12:00:00 PM	249.33	302.22	226.77

Table 1.1.6: Queue Length at Different Approach of Mirpur 1 Intersection in meter (at Evening Peak).

Observation No.	From	To	Mazar road to Mirpur - 1 Approach	Dar - us - Salam to Mirpur - 1 Approach	Mirpur - 2 to Mirpur - 1 Approach
1	4:00:00 PM	4:15:00 PM	0	145.67	0
2	4:15:00 PM	4:30:00 PM	0	165.77	0
3	4:30:00 PM	4:45:00 PM	143.66	197.54	145.44
4	4:45:00 PM	5:00:00 PM	167.87	226.78	187.77
5	5:00:00 PM	5:15:00 PM	227.55	309.88	221.00
6	5:15:00 PM	5:30:00 PM	275.66	332.76	235.66
7	5:30:00 PM	5:45:00 PM	288.94	345.67	221.33
8	5:45:00 PM	6:00:00 PM	328.43	331.22	227.89
9	6:00:00 PM	6:15:00 PM	342.56	342.00	228.21

1.1.8 Delay of Intersection

After observing the queue length of Mirpur 1 intersection on three (3) approaches, the decision of finding delay on every approach was taken. The travel time at free flow condition from 07.00 AM to 07.30 AM was collected. In this condition, the Mirpur 1 intersection and surrounding intersection areas were found calm and soft. So the collectionof travel time of vehicle in free flow condition was taken very easily in every approach. The travel time in free flow condition is given below.

Table 1.1.7: Travel Time at Free Flow Condition of Mirpur 1 Intersection (sec) at from 07.00 A.M to 07.30 A.M.

Observation No.	From	To	Sony Cinema hall to Mirpur 1(sec)	Panir tanki to Mirpur 1	Shah Ali Mazar to Mirpur 1
1	7:00:00 AM	7:30:00 AM	4	11	8

By considering the free flow condition time of vehicle, the delay in every approach of this intersection was counted. The data of delay is given below.

Table 1.1.8: Delay at Different Approach of Mirpur 1 Intersection.

	Intersection Name:					Mirpur 1		
	Intersection Type:					Three Legged Intersection / T inte		
Observation No.	From	To	Sony Cinema hall to Mirpur 1	Delay (Sony Cinema Hall to	Panir tanki to Mirpur 1	Delay (Panir Tanki to Mirpur 1)	Shah Ali Mazar to Mirpur 1	Delay (Shah Ali Mazar to Mirpur 1)
1	7:00:00 AM	7:30:00 AM	5	1	12	1	14	6
2	7:30:00 AM	8:00:00 AM	5	1	16	5	15	7
3	8:00:00 AM	8:30:00 AM	7	3	22	11	18	10
4	8:30:00 AM	9:00:00 AM	8	4	18	7	15	7
5	9:00:00 AM	9:30:00 AM	65	61	34	23	17	9
6	9:30:00 AM	10:00:00 AM	56	52	41	30	21	13
7	10:00:00 AM	10:30:00 AM	77	73	56	45	34	26
8	10:30:00 AM	11:00:00 AM	65	61	67	56	37	29
9	11:00:00 AM	11:30:00 AM	55	51	78	67	44	36
10	11:30:00 AM	12:00:00 PM	67	63	81	70	53	45
11	12:00:00 PM	12:30:00 PM	43	39	91	80	66	58
12	12:30:00 PM	1:00:00 PM	45	41	106	95	77	69
13	1:00:00 PM	1:30:00 PM	45	41	89	78	86	78
14	1:30:00 PM	2:00:00 PM	44	40	112	101	72	64
15	2:00:00 PM	2:30:00 PM	43	39	132	121	67	59
16	2:30:00 PM	3:00:00 PM	61	57	145	134	68	60
17	3:00:00 PM	3:30:00 PM	76	72	132	121	67	59
18	3:30:00 PM	4:00:00 PM	72	68	122	111	112	104
19	4:00:00 PM	4:30:00 PM	56	52	87	76	110	102
20	4:30:00 PM	5:00:00 PM	112	108	134	123	123	115
21	5:00:00 PM	5:30:00 PM	156	152	143	132	135	127
22	5:30:00 PM	6:00:00 PM	187	183	156	145	132	124

1.1.9 Level of Service (LOS)

After calculating the delay of every approach of Mirpur 1 intersection, the delay data was compared with the standard un signalized intersection delay data *(HCM, 2010)*. This intersection was controlled by police manually, so definitely Mirpur 1 intersection is an un signalized intersection. By comparing with the standardized delay time with the intersection delay data, the level of services of different approaches of Mirpur 1 intersection was calculated on the basis of delay. The result of this calculation is tabulated below.

Table 1.1.9: LOS of Different Approaches of Mirpur 1 Intersection.

Observation No.	**Time**	**LOS(Sony Cinema Hall to Mirpur 1)**	**LOS (Panir Tanki to Mirpur 1)**	**LOS (Shah Ali Mazar to Mirpur 1)**
1.	07.00 A.M. 07.30 A.M.	A	A	A
2.	07.30 A.M. 08.00 A.M.	A	A	A
3.	08.00 A.M. 08.30 A.M.	A	B	A
4.	08.30 A.M. 09.00 A.M.	A	A	A
5.	09.00 A.M. 09.30 A.M.	F	C	A
6.	09.30 A.M. 10.00 A.M.	F	D	B
7.	10.00 A.M. 10.30 A.M.	F	E	D
8.	10.30 A.M. 11.00 A.M.	F	F	D
9.	11.00 A.M. 11.30 A.M.	F	F	E
10.	11.30 A.M. 12.00 P.M.	F	F	E
11.	12.00 P.M. 12.30 P.M.	E	F	F
12.	12.30 P.M. 01.00 P.M.	E	F	F
13.	01.00 P.M. 01.30 P.M.	E	F	F
14.	01.30 P.M. 02.00 P.M.	E	F	F
15.	02.00 P.M. 02.30 P.M.	E	F	F
16.	02.30 P.M. 03.00 P.M.	F	F	F
17.	03.00 P.M. 03.30 P.M.	F	F	F
18.	03.30 P.M. 04.00 P.M.	F	F	F
19.	04.00 P.M. 04.30 P.M.	F	F	F
20.	04.30 P.M. 05.00 P.M.	F	F	F
21.	05.00 P.M. 05.30 P.M.	F	F	F
22.	05.30 P.M. 06.00 P.M.	F	F	F

By observing the result of LOS of different approaches of Mirpur 1 intersection, failure condition throughout the day was found. Most of the time of the day, the level of service (LOS) of this intersection was persisted on Level F or failure condition. This is disastrous for today Modern Dhaka City.

1.2 Shishu Mela Intersection

1.2.1 General Description

intersection site is situated on Mirpur road between Shyamoli intersection to the north and Gonovaban intersection to the south. At this intersection a link road from Agargaon intersection to the east, namely Syed Mahbub Morshed Avenue is joined. Syed Mahbub Morshed Avenue was built as a cross link road between the two (2) major roads; one is Mirpur road and other is Begum Rokeya Avenue, by the side of the roads Asian

Development Bank (ADB), World Bank (WB), Government hospital, Passport office, LGED office, Radio Center, Sher-e-Bangla Agricultural University, Schools, etc. and many otherimportant offices and staff quarters are built up. It is used as a short cut road. But linking road from Agargaon Intersection to Prime Minister Office invited a lot of traffic in Shishu Mela intersection.

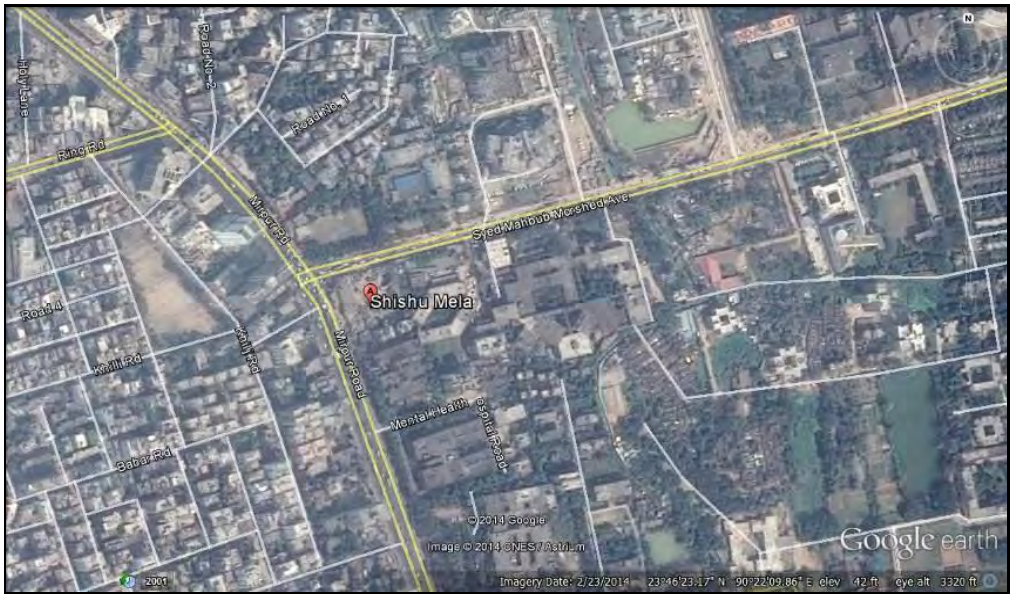


Figure 1.2.1: Google Map of Shishu Mela Intersection.

On other hand the major traffic load from Gabtoli moves towards the south passes through this intersection. So this intersection is very important and very busy all throughout the day. The three approaches of this junction are divided by narrow medians without barrier. The presence of non-motorized vehicle in all approaches encourages purveyors to occupy pavement illegally and thereby makes the junction operation very difficult and complicated. Though it is a signalized junction, it is operated by traffic police intervention. Presence of large number of vehicles near the junction corner and low speed of moving traffic encourages pedestrian to cross the junction in any direction. It is observed that many people cross this junction matching with their desire paths.

Figure 1.2.2: Shishu Mela Intersection Map.

It was first built as a cross link road between two major roads. It was first used as a short cut road. But linking road from Agargaon Intersection to Prime Minister Office (PMO) invited a lot of traffic in this intersection. So it became a busier intersection than previous. Land beside the road side of Syed Mahbub Morshed Avenue developed very quickly. There were slums at that area in past. But now it is well developed by various Government Offices, institutions, Schools and Colleges, etc. At past the link road between two intersections Syed Mahbub Morshed Avenue was constructed as a two lane both directions road. But now a day, with the increasing demand of traffic, the two lane capacity was failed. So improvement is now a major requirement of this intersection and its link road.

Figure 1.2.3: Approach Road: (a) Agargaon Road, (b) Shyamoli Road, (c) College Road and (d) Khilji Road.

1.2.2 Approaches from Intersection

This Shishu Mela contains the flexible pavement as road structure. The road is marked with lane sign, marking, etc. The lane condition of different approaches of this intersection is given below

a) Shyamoli Road 3 lanes both directions,
b) Agargaon Road 2 lanes both directions,
c) College Gate 3 lanes both directions, and
d) Khilji Road (Minor Local road) No lane division.

There is exclusive left turn lane on the mouth of Agargaon road. There is right turning lane on Mirpur road.

Figure 1.2.4: Inside the Intersection: (a) Left Turning Lane and (b) Right Turning Lane.

Some of the links contain Median with or without barrier, Marking, Sign, etc. On the mouth of Agargaon road contains the provision of channelization. Unfortunately there is no facility for pedestrian crossing in this intersection. So pedestrians have to cross the road with risk through the road. Footpath area is illegally occupied by the hawkers.

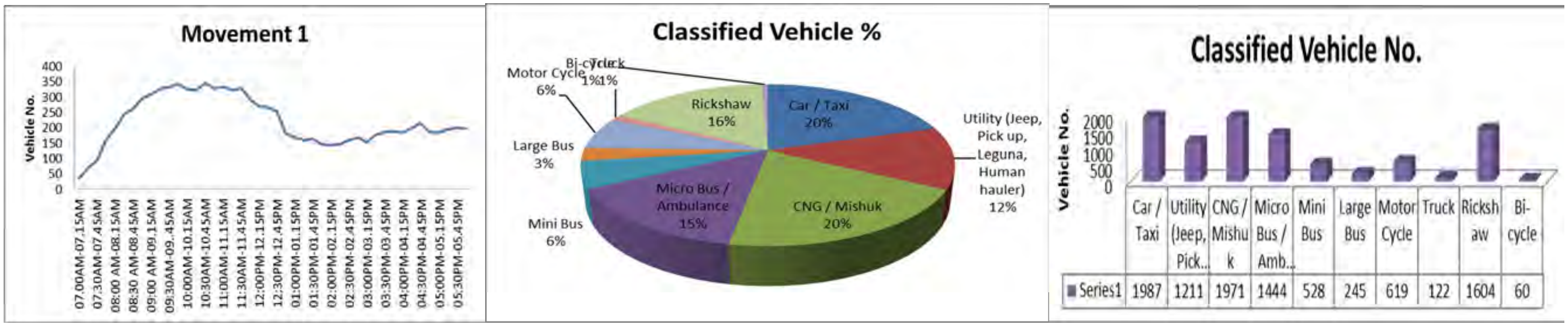
Figure 1.2.5: Illegal Footpath Occupy of Shishu Mela Intersection.

1.2.3 Vehicular Flow of this Intersection

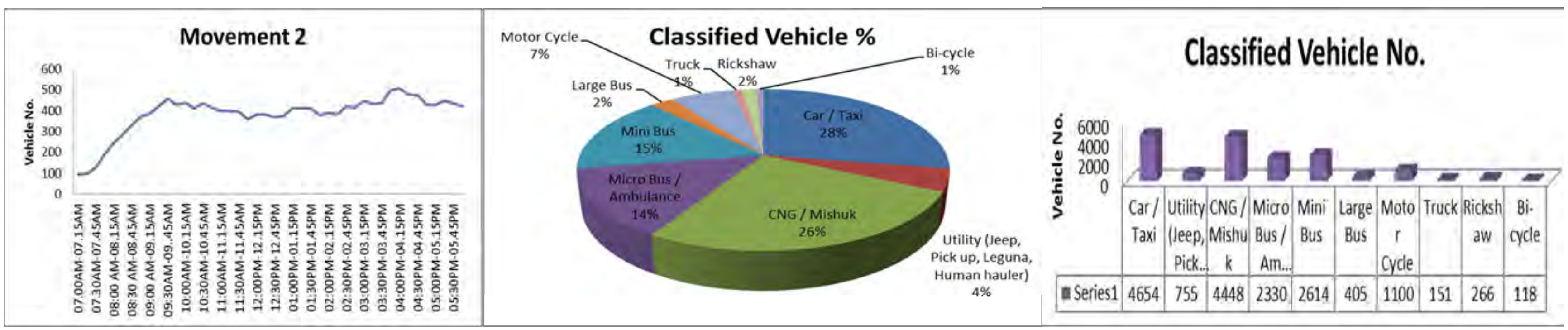
For finding out the Level of Service (LOS) of this intersection, the counting survey of classified vehicle in this intersection was organized. From preliminary survey of this intersection no peak hour was found, a constant flow of traffic was present there all through the day. For finding out the vehicular scenario of this intersection, the time was set for survey from 07.00 AM to 06.00 PM, total 11 hours. The result of the vehicular survey is going to be described below.

From the preliminary survey of Shishu Mela intersection, six (6) movements were found in this intersection. They were (1) Shyamoli to Agargaon, (2) Shyamoli to College Gate, (3) Agargaon to Shyamoli, (4) Agargaon to College Gate, (5) College Gate to Shyamoli and (6) College Gate to Agargaon. The vehicular counting data is given below.

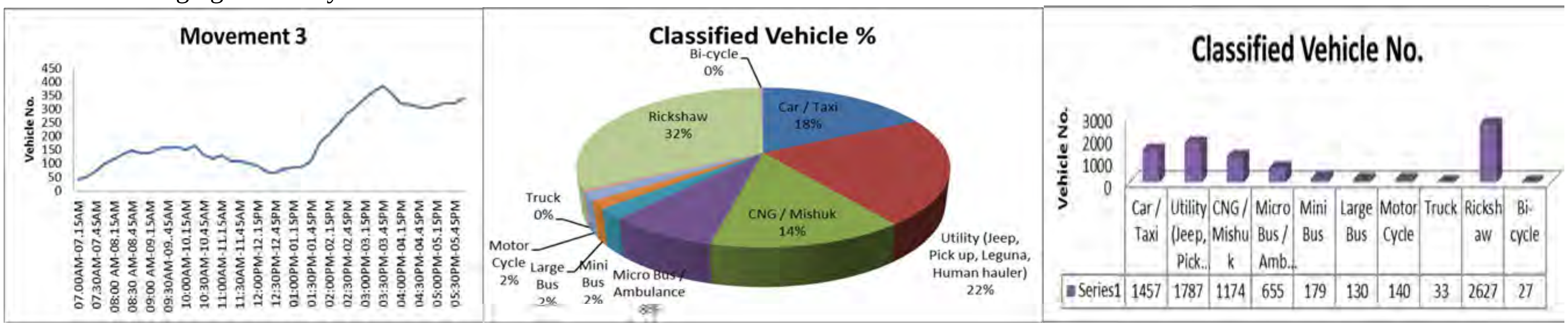
Movement: 1 Shyamoli to Agargaon.



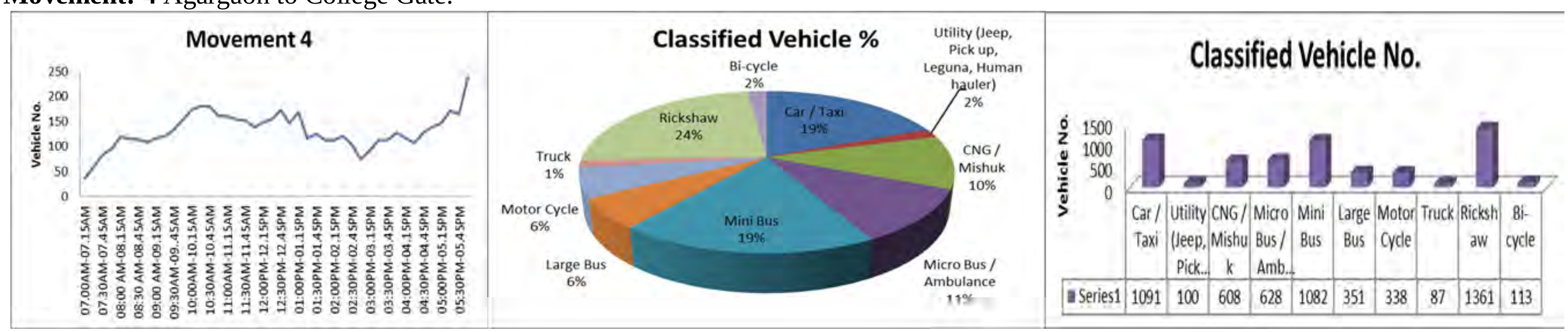
Movement: 2 Shyamoli to College Gate.



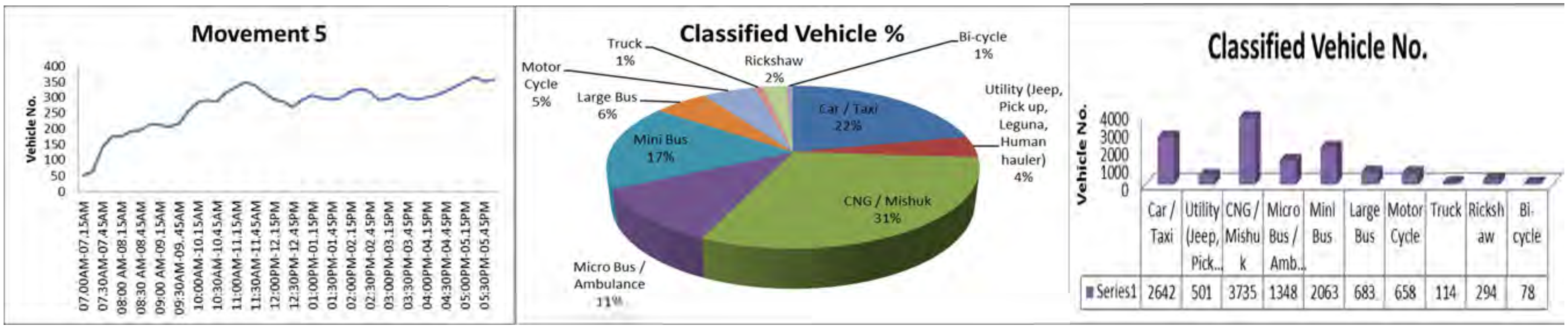
Movement: 3 Agargaon to Shyamoli.



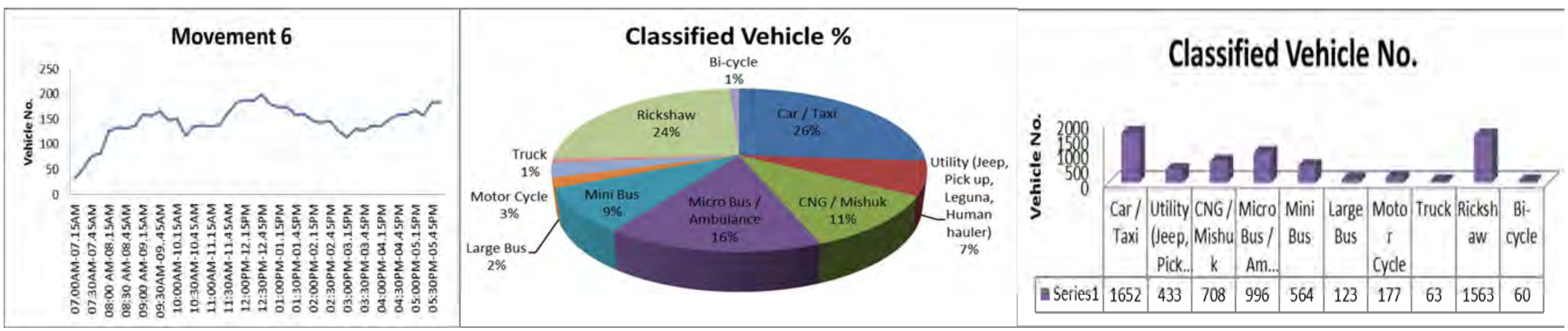
Movement: 4 Agargaon to College Gate.



Movement: 5 College Gate to Shyamoli.



Movement: 6 College Gate to Agargaon.



After finishing the vehicular survey, the analyzing of vehicular flow data was done. The result of this analysis are given below From the analysis it was found that Movement 2 (Shyamoli to College Gate) contains maximum traffic flow of this intersection. Motorized vehicle is dominant in this intersection.

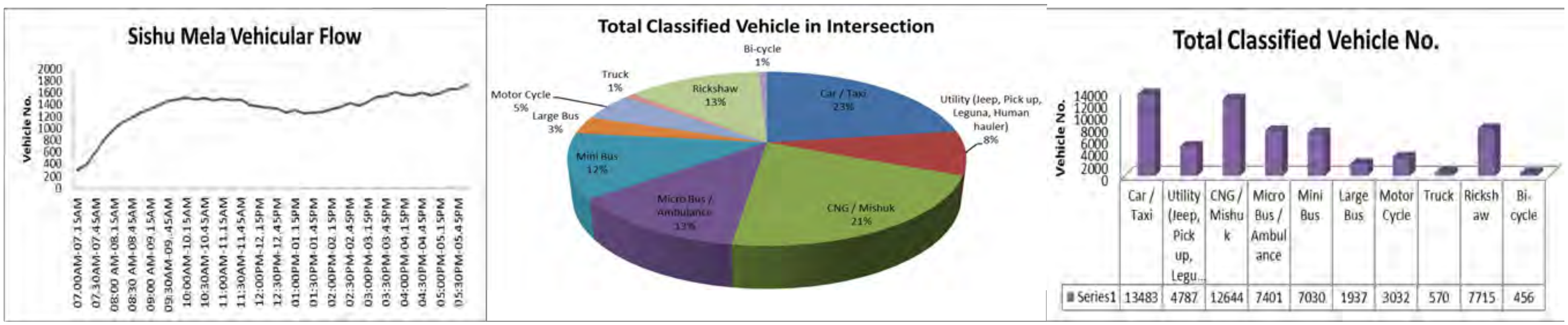


Figure 1.2.6: Traffic Flow through Shishu Mela Intersection.

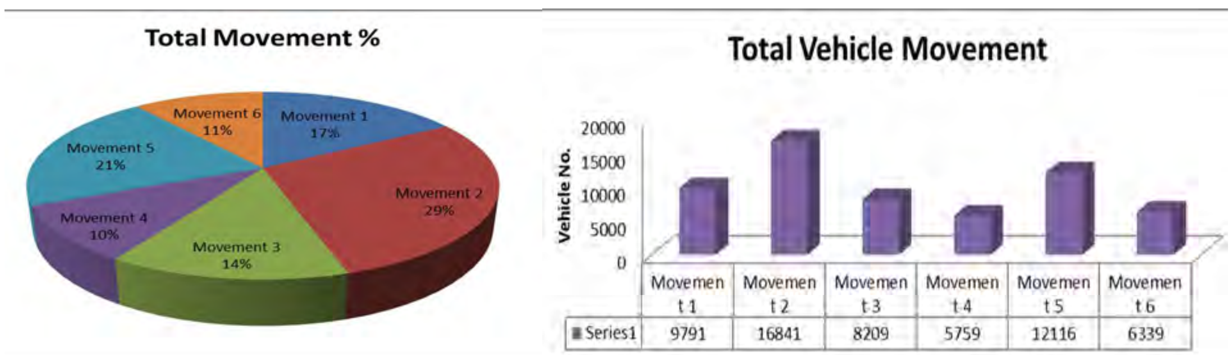


Figure 1.2.7: Vehicle Movement in various Directions.

The flow ratio of the three (3) approaches of this intersection was also counted for finding out the condition of traffic flow situation of individual approach which is related with signal system, signal phasing, queue length, delay, etc. of this intersection. The data of flow ratio of every approach is presented below.

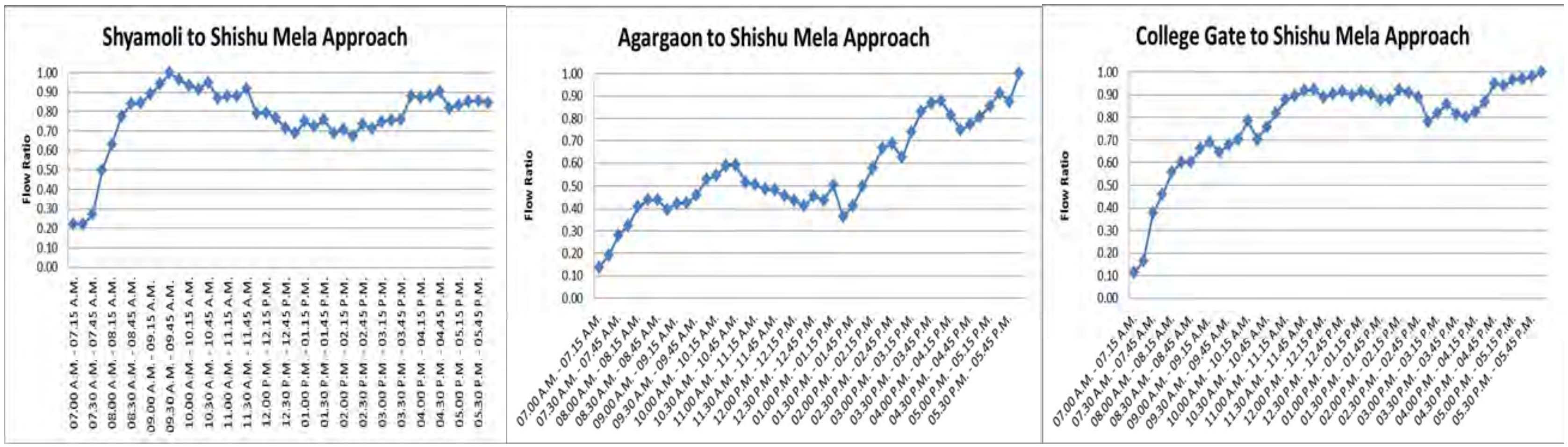


Figure 1.2.8: a) Flow Ratio of Shyamoli to Shishu Mela Approach; b) Flow Ratio of Agargaon to Shishu Mela Approach; c) Flow Ratio of College Gate to Shishu Mela Approach.

1.2.4 Pedestrian Flow of this Intersection

In the time of field survey, the survey of the pedestrian flow was done in this intersection accompany with the vehicular flow of this intersection. The result of pedestrian survey is given below.

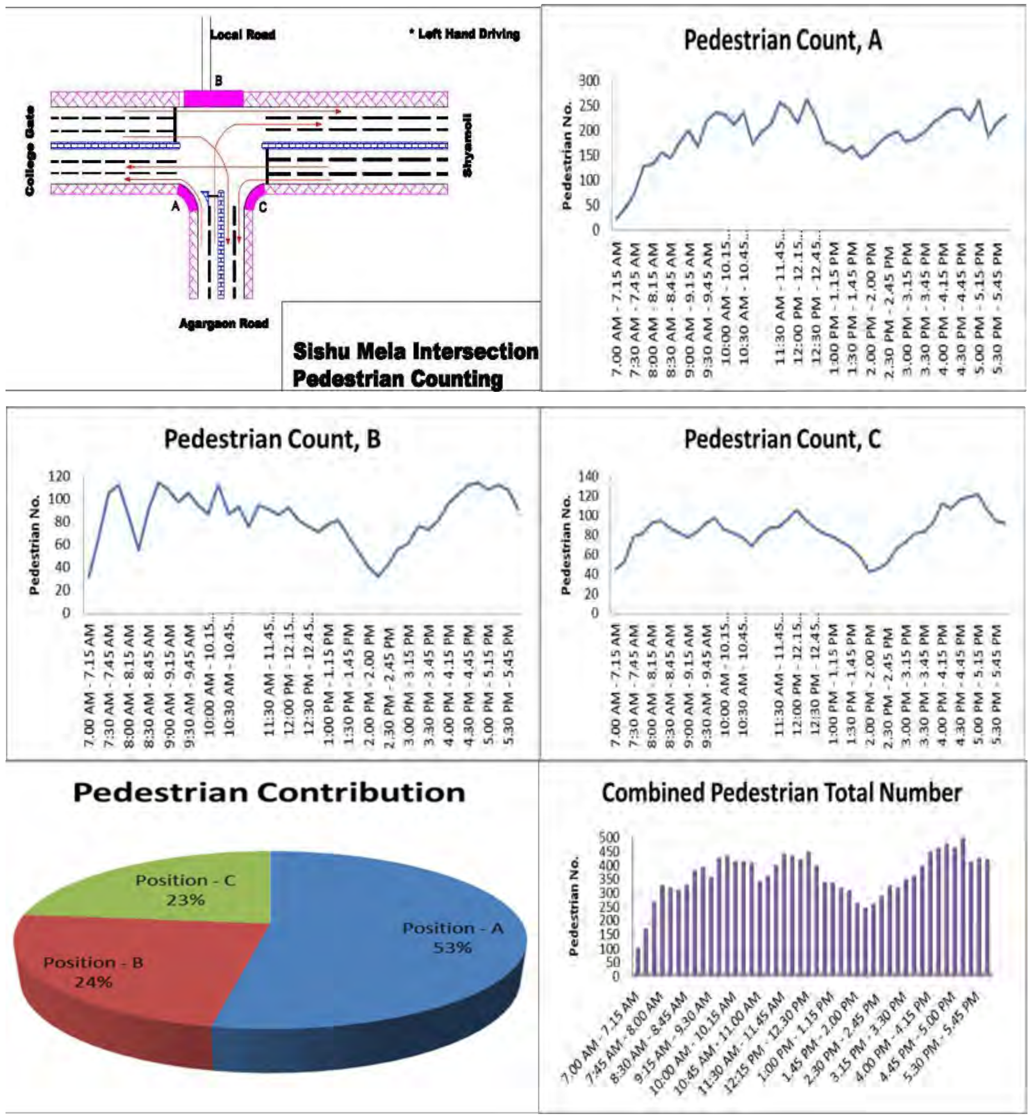


Figure 1.2.9: a) Pedestrian Survey Position inside Shishu Mela Intersection; b) Pedestrian Flow; c) Pedestrian Flow Contribution among three (3) Positions.

In this intersection, there is no facility of road crossing, such as over bridge, under pass, etc. The pedestrian as usually crossed this road by taking chance in between flow of traffic on the road.

1.2.5 Side Friction

Shishu Mela intersection is a motorized vehicle dominant intersection. By analyzing this intersection of this intersection was found out. In the preliminary survey of this intersection, the researcher team found out the as usual rickshaw stopping area inside the intersection area. Illegal rickshaw stand found inside the intersection, in a CAD drawing the position of rickshaw stand are shown below.

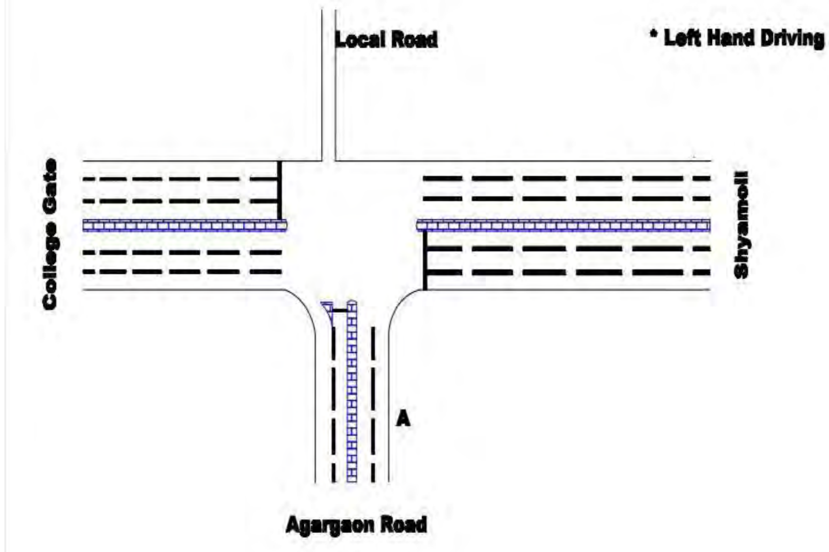


Figure 1.2.10: Position of Illegal Rickshaw Stand.

A rickshaw counting survey was done by the team. After 15 minutes interval, survey team counted the numbers of rickshaw in these points. The results are shown below

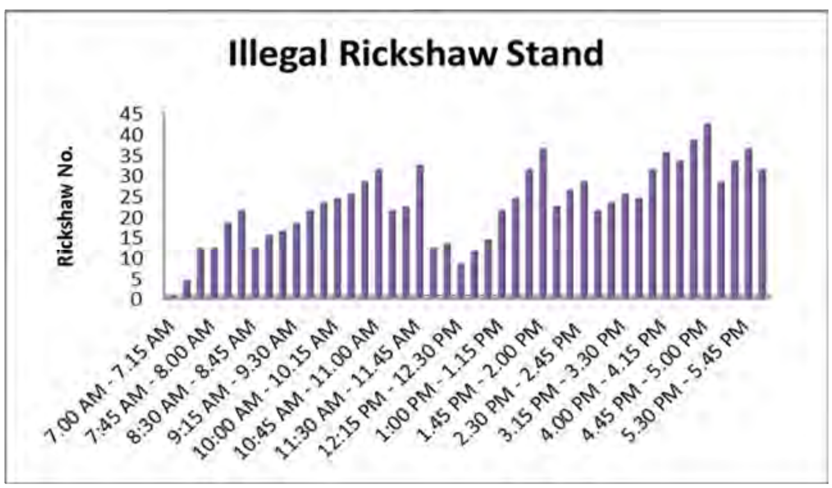


Figure 1.2.11: Illegal Rickshaw Stand Condition.

Besides this, in the preliminary survey of this intersection, diversion of Non Motorized vehicle was found from this intersection in two points, Agargaon Road and Khilji Road. The survey team also arranged a diverted NMV counting from these two (2) points. The data of this counting survey is given below

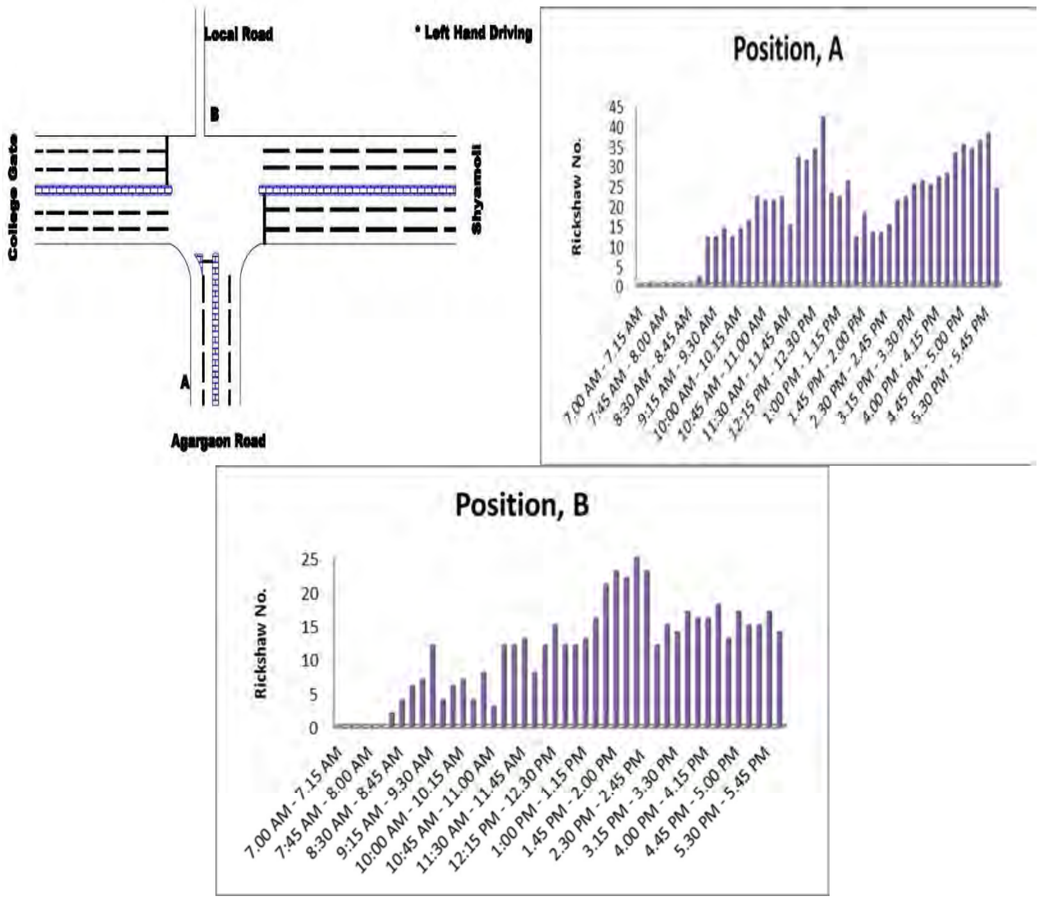


Figure 1.2.12: Position of Rickshaw Diversion and its Contribution.

On the Agargaon road, at the corner area of this intersection, an illegal stand of Human hauler was found. It was slowing the flow of vehicle in this approach. The survey team arranged a counting survey for finding out the side friction of this illegal human hauler stand. The data of this survey is given below

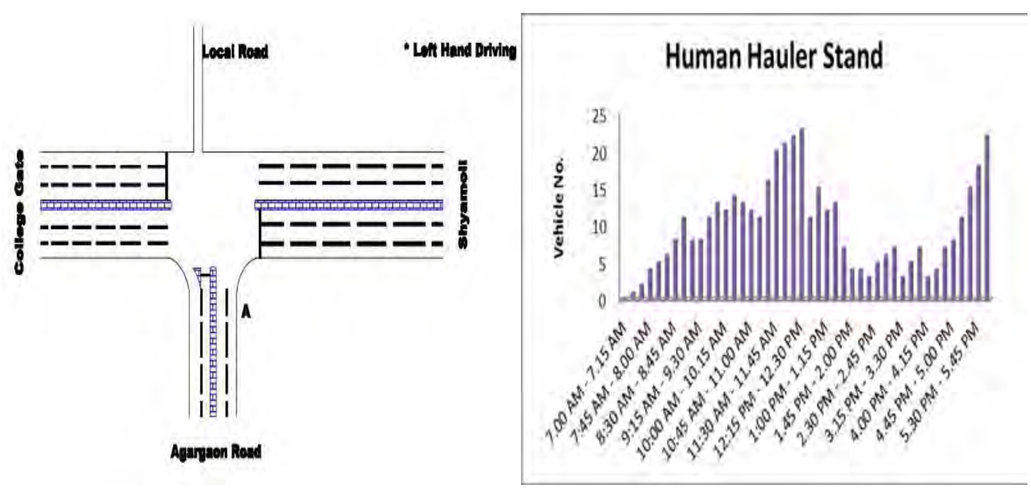


Figure 1.2.13: Position of Human Hauler Stand inside the Intersection and its Contribution.

1.2.6 Traffic Control Devices

In this intersection, the traffic management is done by the police. Their method of management is
also. But these facilities are not used by the police. The signal is fixed time signal. As usually, the management of traffic in an intersection causes some delay. This delay gives chance to traffic for building up the queue in the approaches. In Shishu Mela intersection, the researcher team found queue also.

A survey of traffic control devices were done in the time of preliminary survey of Shishu Mela intersection. The result of this survey is described below.

Table 1.2.1: Features of Intersection and Traffic Control System.

Sl No.	Description	Nos.
1	Number of legs	3
2	Direction of traffic	9
3	Signal post for vehicular and pedestrian movement	6
4	Traffic signal controller box	1
5	Traffic police box	1

Table 1.2.2: Duty of Traffic Police.

Post	Morning Shift	Evening Shift
Traffic inspector	1	
Traffic sergeant	1	1
Traffic police	3	3
Ansar	-	-

Table 1.2.3: Existing Traffic Control System and Time of Operation.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(08.00 PM 08.00 AM)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(08.00 AM 11.00 AM) (05.00 PM 08.00 PM)
4	Mixed	(11.00 AM 05.00 PM)

Table 1.2.4: Signal Accessories.
Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/ MAP	Visibility	Physical Condition	Vehicle Signal Light Operate	Pedestrian Signal Light Operate
SP-1	OK	OK	Yes	-
SP-2	OK	OK	Yes	-
SP-3	OK	OK	No	-

SP-4	OK	OK	Yes	-
SP-5	OK	OK	Yes	No
MAP-1	OK	One shed missing	Yes	-
MAP-2	OK	OK	Yes	-
MAP-3	OK	OK	Yes	-
TSC	OK	OK	-	-

Notes: - No: Currently damage / not working
Yes: In working condition
(-): Not installed

From the preliminary survey, we found signal post on every approach of this intersection. In this preliminary survey the cycle time of these signals were found. The cycle time measuring data is given below.

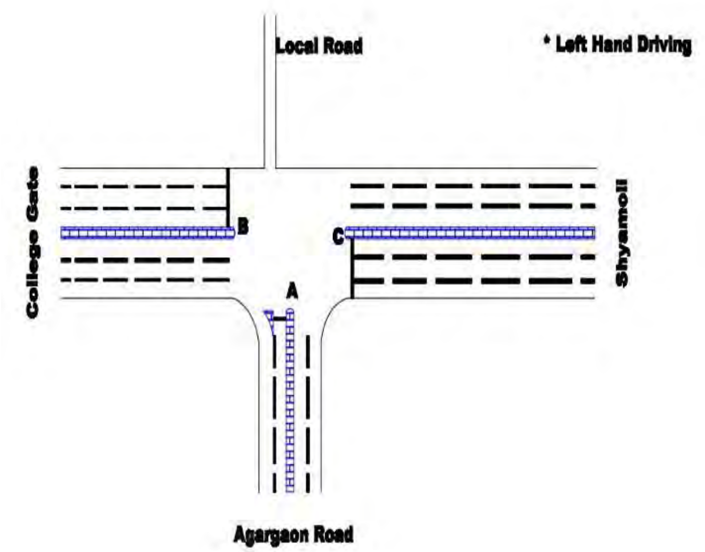


Figure 1.2.14: Position of Signal Post inside Intersection.

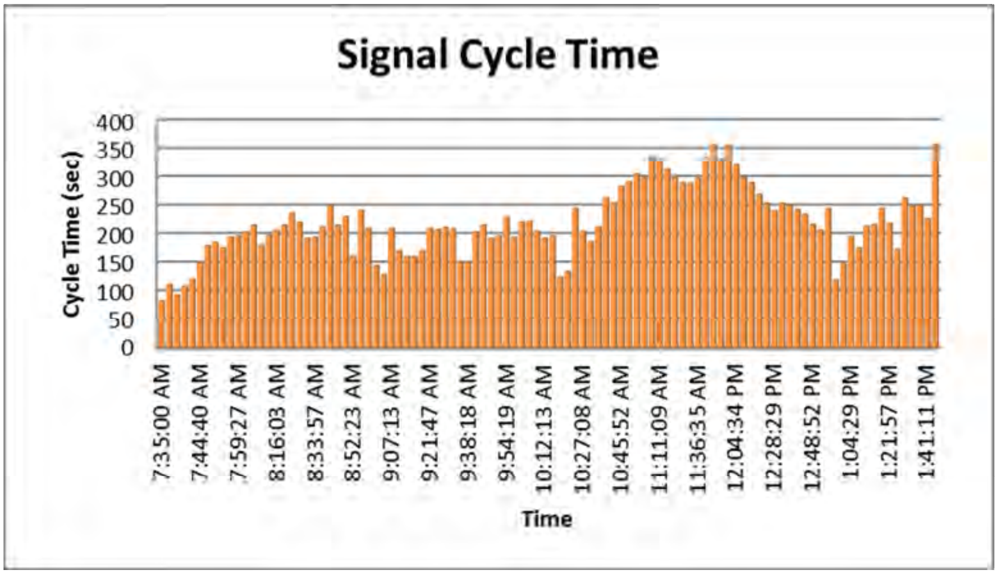


Figure 1.2.15: Signal Cycle time from 07.35 AM to 01.41 PM.

1.2.7 Queue Length

Due to long signal cycle time, signal phasing, side friction, demand responsive traffic operation, the surveyor team found queue length in three (3) approaches of this intersection. The collection of primary data of this intersection from the field survey was taken and later compared with the secondary data *(CASE study of World Bank Funded* The primary data of the survey team is given here under

Table 1.2.5: Queue Length at Different Approach of Shishu Mela Intersection in meter.

Observation No.	From	To	Agargaon to Shishu Mela approach	College Gate to Shishu Mela approach	Shyamoli to Shishu Mela approach
1	7:45:00 AM	8:00:00 AM	145.54	155.22	125.32
2	8:00:00 AM	8:15:00 AM	178.65	176.22	145.54
3	8:15:00 AM	8:30:00 AM	202.34	145.54	178.65
4	8:30:00 AM	8:45:00 AM	225.54	178.65	202.34
5	8:45:00 AM	9:00:00 AM	278.66	202.34	225.54
6	9:00:00 AM	9:15:00 AM	224.55	225.54	145.54
7	9:15:00 AM	9:30:00 AM	312.33	276.22	178.65
8	9:30:00 AM	9:45:00 AM	354.88	245.34	202.34
9	9:45:00 AM	10:00:00 AM	378.88	296.33	225.54
10	10:00:00 AM	10:15:00 AM	425.65	306.67	201.34
11	10:15:00 AM	10:30:00 AM	478.77	312.32	198.77
12	10:30:00 AM	10:45:00 AM	422.56	332,32	186.78
13	10:45:00 AM	11:00:00 AM	432.77	345.63	296.33
14	11:00:00 AM	11:15:00 AM	397.77	376.00	306.67
15	11:15:00 AM	11:30:00 AM	354.66	402.34	312.32
16	11:30:00 AM	11:45:00 AM	405.77	389.77	332,32
17	11:45:00 AM	12:00:00 PM	378.66	416.77	345.63
18	12:00:00 PM	12:15:00 PM	322.66	422.83	354.88
19	12:15:00 PM	12:30:00 PM	389.65	395.45	378.88
20	12:30:00 PM	12:45:00 PM	405.23	412.34	425.65
21	12:45:00 PM	1:00:00 PM	411.23	435.22	312.32
22	1:00:00 PM	1:15:00 PM	411.66	389.67	332,32
23	1:15:00 PM	1:30:00 PM	367.23	438.00	345.63
24	1:30:00 PM	1:45:00 PM	392.23	451.12	376.00
25	1:45:00 PM	2:00:00 PM	402.55	419.21	389.77

1.2.8 Delay of Intersection

After observing the queue length of Shishu Mela intersection on three (3) approaches, the decision of finding delay on every approach of this intersection was taken. The decision for taking data of free flow travel time from 07.00 AM to 07.30 AM was taken. In this condition, the Shishu Mela intersection and surrounding areas were calm and soft. So the collection the time of vehicle data in free flow condition was very easy in every approach. The travel time in free flow condition is given below.

Table 1.2.6: Travel Time at Free Flow Condition of Shishu Mela Intersection (sec) from 07.00 A.M to 07.30 A.M.

Observation No.	From	To	Shyamoli to Shishu Mela	Agargaon to Shishu Mela	College Gate to Sishu Mela
1	7:00:00 AM	7:30:00 AM	4	28	6

By considering the free flow condition time of vehicle, the delay in every approach of this intersection was counted. The data of delay is given below.

Table 1.2.7: Delay at Different Approach of Shishu Mela Intersection.

Observation No.	From	To	Shyamoli to Shishu Mela	Delay (Shyamoli to Shishu Mela)	Agargaon to Shishu Mela	Delay (Agargaon to Shishu Mela)	College Gate to Sishu Mela	Delay (College Gate to Shishu Mela)
1	7:00:00 AM	7:30:00 AM	6	2	35	7	9	3
2	7:30:00 AM	8:00:00 AM	8	4	54	26	17	11
3	8:00:00 AM	8:30:00 AM	16	12	69	41	56	50
4	8:30:00 AM	9:00:00 AM	87	83	76	48	187	181
5	9:00:00 AM	9:30:00 AM	312	308	92	64	149	143
6	9:30:00 AM	10:00:00 AM	228	224	117	89	228	222
7	10:00:00 AM	10:30:00 AM	347	343	145	117	276	270
8	10:30:00 AM	11:00:00 AM	459	455	189	161	327	321
9	11:00:00 AM	11:30:00 AM	554	550	237	209	452	446
10	11:30:00 AM	12:00:00 PM	654	650	287	259	439	433
11	12:00:00 PM	12:30:00 PM	767	763	298	270	587	581
12	12:30:00 PM	1:00:00 PM	576	572	312	284	643	637
13	1:00:00 PM	1:30:00 PM	645	641	339	311	768	762
14	1:30:00 PM	2:00:00 PM	334	330	337	309	887	881
15	2:00:00 PM	2:30:00 PM	323	319	478	450	967	961
16	2:30:00 PM	3:00:00 PM	432	428	568	540	956	950
17	3:00:00 PM	3:30:00 PM	516	512	678	650	984	978
18	3:30:00 PM	4:00:00 PM	432	428	689	661	1067	1061
19	4:00:00 PM	4:30:00 PM	332	328	745	717	1044	1038
20	4:30:00 PM	5:00:00 PM	223	219	867	839	1143	1137
21	5:00:00 PM	5:30:00 PM	254	250	886	858	1223	1217
22	5:30:00 PM	6:00:00 PM	187	183	921	893	1338	1332

1.2.9 Level of Services (LOS)

After calculating the delay of every approach of Shishu Mela intersection, the delay data was compared with the standard un signalized intersection delay data *(HCM, 2010)*. This intersection was controlled by police manually, so definitely Shishu Mela intersection is an un signalized intersection. By comparing with the standardized delay time with the intersection delay data, the level of services of different approaches of Shishu Mela intersection was calculated on the basis of delay. The result of this calculation is tabulated below.

Table 1.2.8: LOS of Different Approaches of Shishu Mela Intersection.

Observation No.	**Time**	**LOS (Shyamoli to Shishu Mela)**	**LOS (Agargaon to Shishu Mela)**	**LOS (College Gate to Shishu Mela) sec**
1.	07.00 A.M. 07.30 A.M.	A	A	A
2.	07.30 A.M. 08.00 A.M.	A	D	B
3.	08.00 A.M. 08.30 A.M.	B	E	E
4.	08.30 A.M. 09.00 A.M.	F	E	F
5.	09.00 A.M. 09.30 A.M.	F	F	F
6.	09.30 A.M. 10.00 A.M.	F	F	F
7.	10.00 A.M. 10.30 A.M.	F	F	F
8.	10.30 A.M. 11.00 A.M.	F	F	F
9.	11.00 A.M. 11.30 A.M.	F	F	F
10.	11.30 A.M. 12.00 P.M.	F	F	F
11.	12.00 P.M. 12.30 P.M.	F	F	F
12.	12.30 P.M. 01.00 P.M.	F	F	F
13.	01.00 P.M. 01.30 P.M.	F	F	F
14.	01.30 P.M. 02.00 P.M.	F	F	F
15.	02.00 P.M. 02.30 P.M.	F	F	F
16.	02.30 P.M. 03.00 P.M.	F	F	F
17.	03.00 P.M. 03.30 P.M.	F	F	F
18.	03.30 P.M. 04.00 P.M.	F	F	F
19.	04.00 P.M. 04.30 P.M.	F	F	F
20.	04.30 P.M. 05.00 P.M.	F	F	F
21.	05.00 P.M. 05.30 P.M.	F	F	F
22.	05.30 P.M. 06.00 P.M.	F	F	F

By observing the result of LOS of different approaches of Shishu Mela intersection, failure condition throughout the day was found. Most of the time of the day, the level of service of this intersection was persisted on Level F or failure condition. This is disastrous for today Modern Dhaka city.

1.3 Agargaon Intersection

1.3.1 General Description

to south connecting with Syed Mahbub Morshed Avenue to west coming from Shishu Mela intersection and Bir Uttom Major General Azizur Rahman Road to the east meeting with the Tejgaon Airport road. This is very busy as well as wide cross-junction. The four (4) approaches of the junction are divided by narrow medians without barrier. Among the four approaches, the east approach road (towards Tejgaon Airport road) the flows of non-motorized vehicles are restricted.

Figure 1.3.1: Google Map of Agargaon Intersection.

The other three approaches contain heterogeneous traffic. Though it is a signalized junction, it is operated by traffic police. At this junction the facilities for pedestrian crossing is absent. So, pedestrian cross the junction matching with their desire paths under risk. Pedestrian would hardly find the suitable gaps within the moving traffic stream to perform the crossing maneuver. To the north approach (towards Mirpur) near the vicinity at the junction there are two bus stoppages both the sides. For this, the width of the approach near the junction reduces the effective width of the road for vehicle movement.

Agargaon intersection is now an important intersection. It is the entry and exit gateway of Mirpur area. In past it was three (3) legged intersection, but now it is a four legged intersection. It is converted into the four (4) legged intersection due to making a new link road to Prime Minister Office. It is a well-planned intersection inside the Dhaka metropolitan city area. It is a less crowded office area. IDB bhaban, LGED office, World Bank, ADB bank is situated around this intersection. Importantly, this intersection has a higher level of service among all intersections of Dhaka Metropolitan City.

Figure 1.3.2: Agargaon Intersection Map.

In early stage, when the Rokeya Sarani was created, it was an entry position of Mirpur zone. But now this intersection, which keeps a good connect with Uttora zone. So a lot of vehicles use this intersection for getting the utility of this service. It reduces the travel time of going Uttora form Mirpur. So this intersection becomes so much popular now a day. It is a four legged or crossed intersection.

1.3.2 Approaches from Intersection

There are four links in this intersection. They are Mirpur Road, Shyamoli Road, Farm gate Road and New link road (to Prime Minister Office).

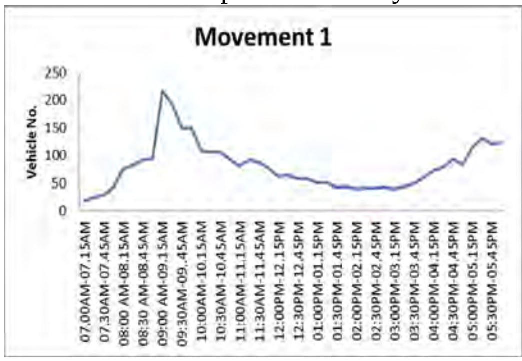
Figure 1.3.3: Approach Road (a) Mirpur Road, (b) Agargaon Shyamoli Road, (c) Farmgate Road and (d) New Link Road (to Prime Minister Office).

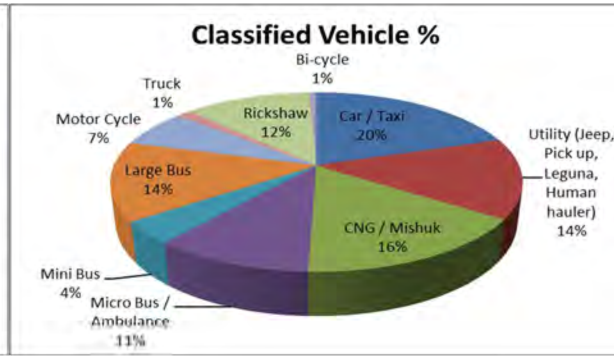
1.3.3 Vehicular Flow of this Intersection

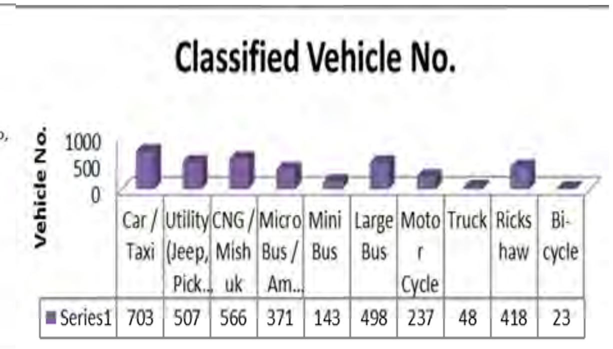
For finding out the level of service (LOS) of this intersection, the decision of counting survey of classified vehicle was taken. From preliminary survey of this intersection two peak hours were found, one in the morning from 08.00 AM to 11.30 AM and other is in the evening from 04.30 PM to 06.00 P.M. and furthermore more. So the time of survey was set from 07.00 AM to 06.00 PM, total 11 hours. The result of the vehicular survey is going to be described below.

From the preliminary survey of this intersection the researcher team found eleven (11) movements in this intersection. They are (1) Mirpur 10 to Shyamoli, (2) Mirpur 10 to Farmgate, (3) Mirpur 10 to Prime Minister Office (PMO), (4) Prime Minister Office (PMO) to Mirpur 10, (5) Prime Minister Office (PMO) to Shyamoli; (6) Prime Minister Office (PMO) to Farmgate, (7) Farmgate to Mirpur 10, (8) Farmgate to Shyamoli, (9) Shyamoli to Farmgate, (10) Shyamoli to Prime Minister Office (PMO) and (11) Shyamoli to Mirpur 10. The vehicular counting data is given below.

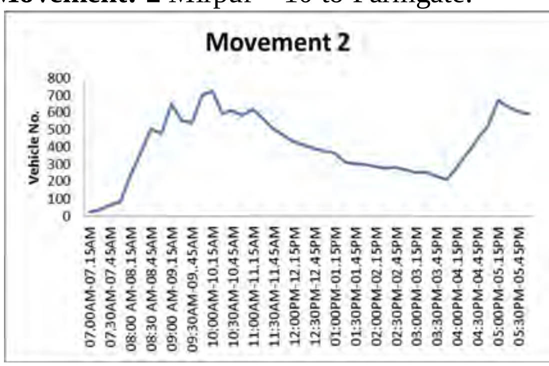
Movement: 1 Mirpur 10 to Shyamoli.

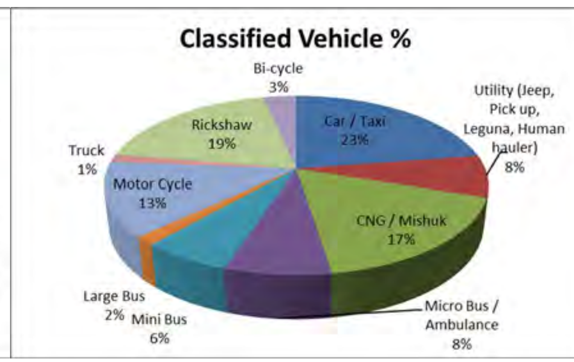


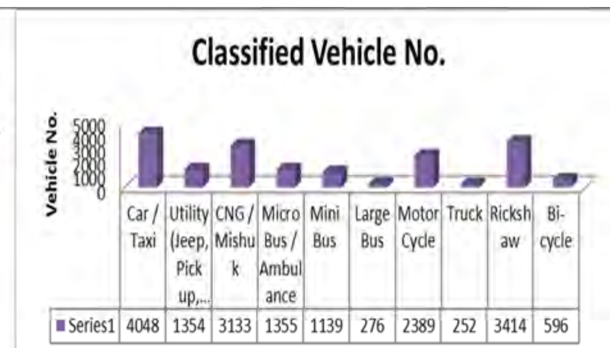




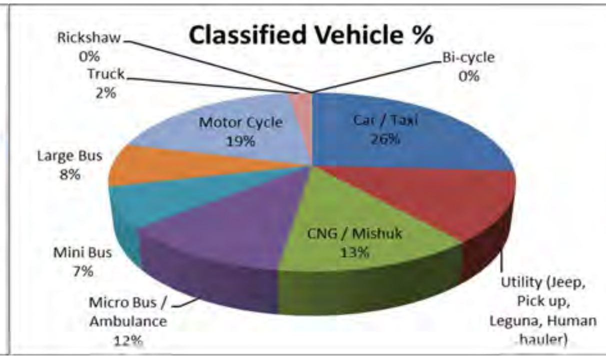
Movement: 2 Mirpur 10 to Farmgate.

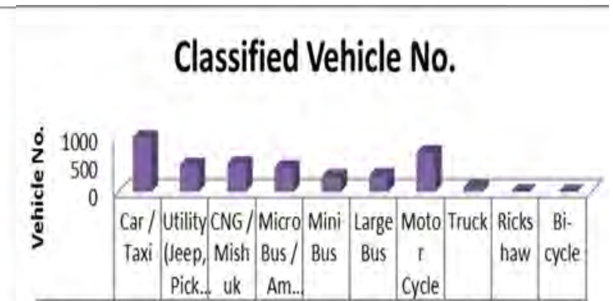






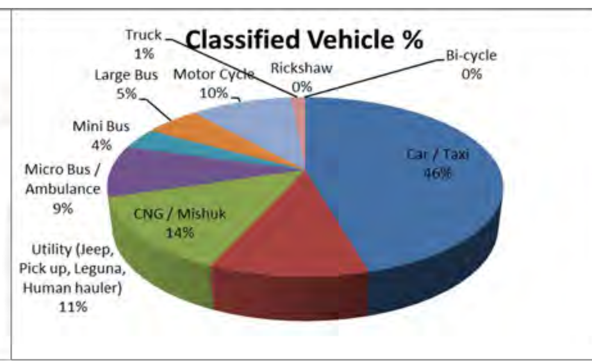
Movement: 3 Mirpur 10 to Prime Minister Office.





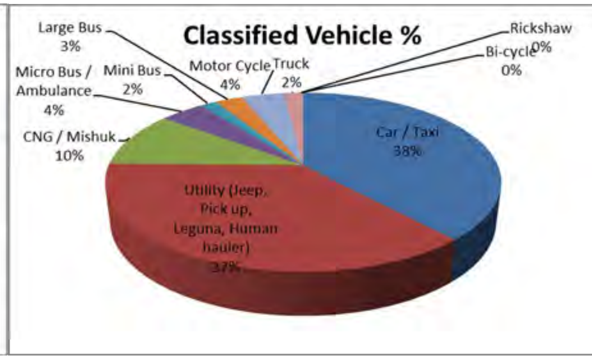
	Car / Taxi	Utility (Jeep, Pick...	CNG / Mishuk	Micro Bus / Am...	Mini Bus	Large Bus	Motor Cycle	Truck	Rickshaw	Bi-cycle
Series1	963	478	499	434	271	289	696	79	4	0

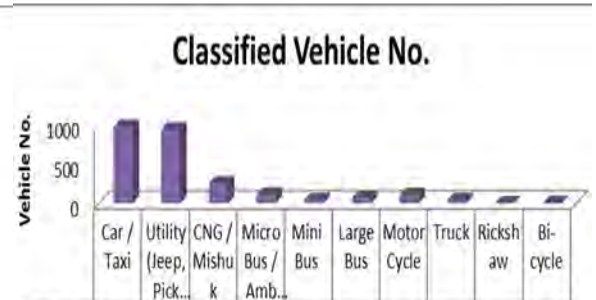
Movement: 4 Prime Minister Office to Mirpur 10.



	Car / Taxi	Utility (Jeep, Pick...	CNG / Mishuk	Micro Bus / Amb...	Mini Bus	Large Bus	Motor Cycle	Truck	Rickshaw	Bi-cycle
Series1	1325	319	397	267	109	156	290	40	0	0

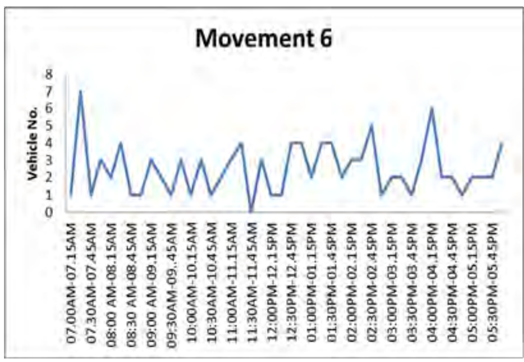
Movement: 5 Prime Minister Office to Shyamoli.

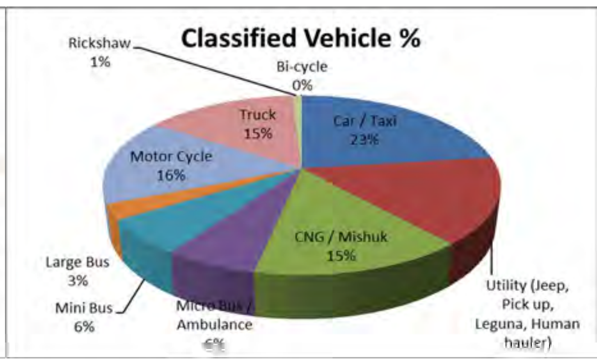




	Car / Taxi	Utility (Jeep, Pick...	CNG / Mishuk	Micro Bus / Amb...	Mini Bus	Large Bus	Motor Cycle	Truck	Rickshaw	Bi-cycle
Series1	963	934	251	109	40	67	106	42	1	4

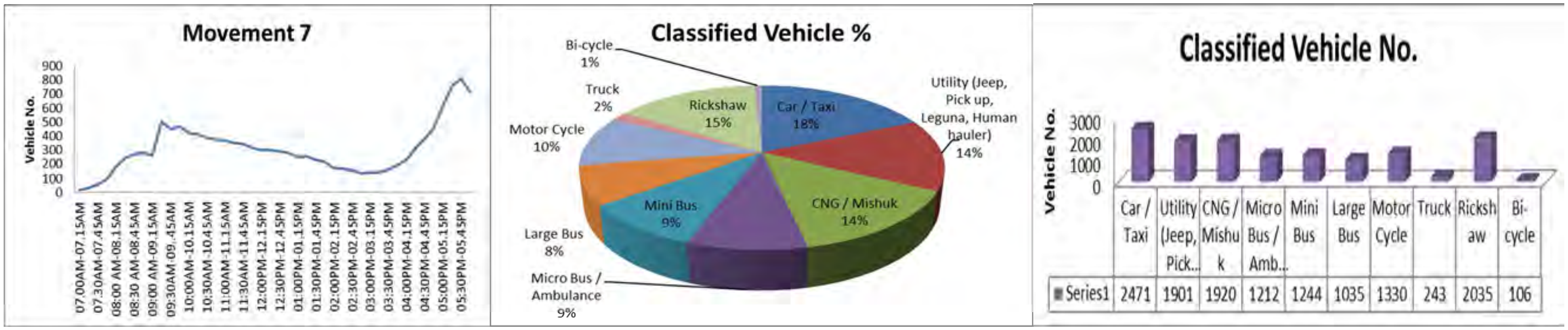
Movement: 6 Prime Minister Office to Farmgate.



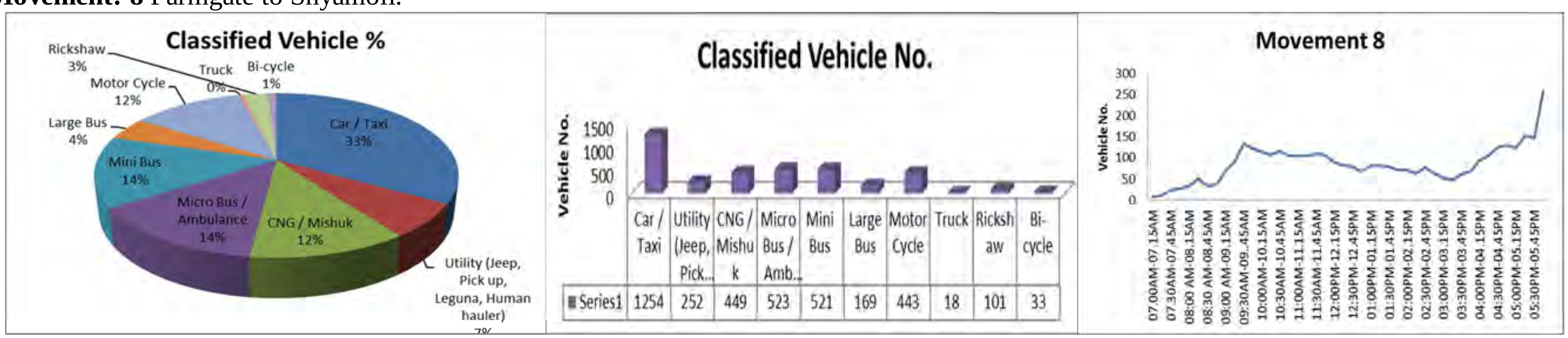


	Car / Taxi	Utility (Jeep, Pick...	CNG / Mishuk	Micro Bus / Am...	Mini Bus	Large Bus	Motor Cycle	Truck	Rickshaw	Bi-cycle
Series1	25	17	16	7	7	3	17	16	1	0

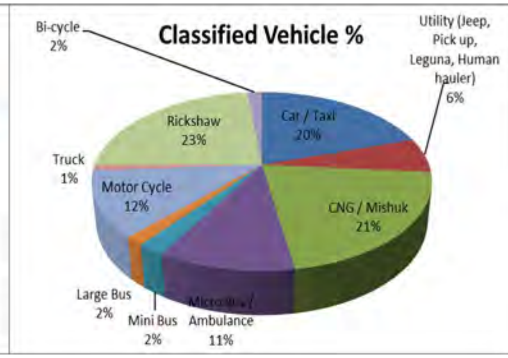
Movement: 7 Farmgate to Mirpur 10.

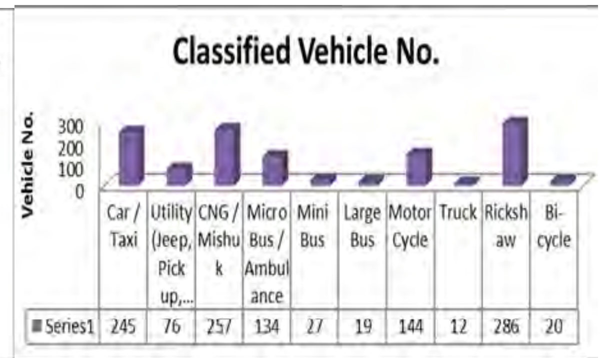


Movement: 8 Farmgate to Shyamoli.

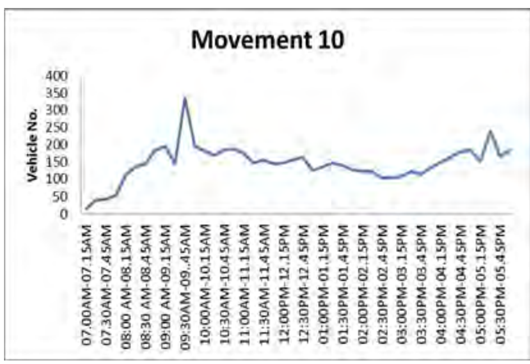


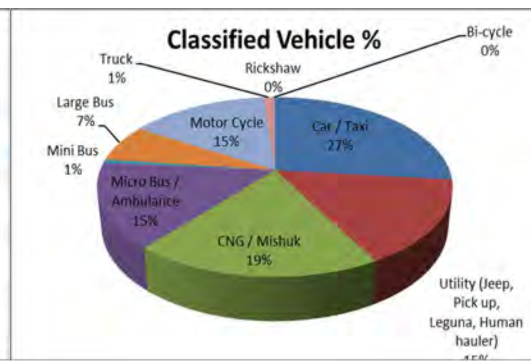
Movement: 9 Shyamoli to Farmgate.

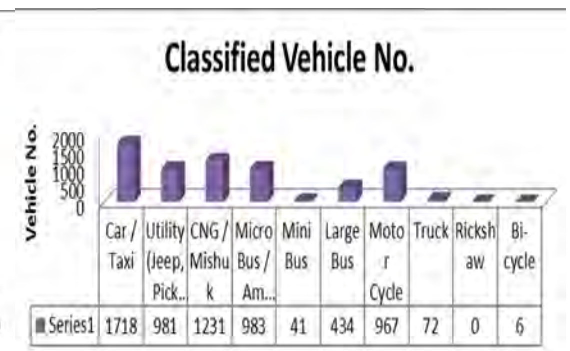




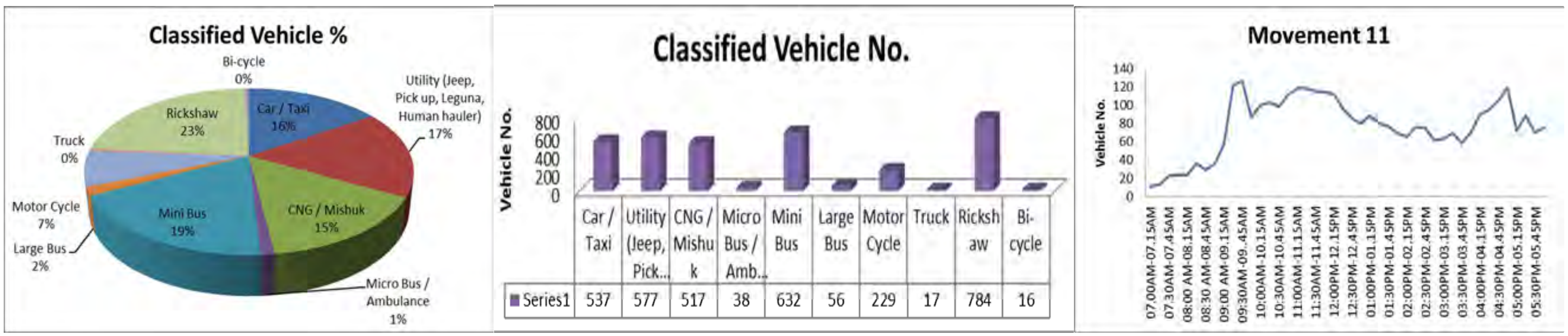
Movement: 10 Shyamoli to Prime Minister Office.







Movement: 11 Shyamoli to Mirpur 10.



After finishing the vehicular survey, the analyzing of vehicular flow data was done. The results of this analysis are given below. From the analysis it was found that Movement 2 (Mirpur 10 to Farmgate) contain maximum traffic flow of this intersection. Motorized vehicle was dominant in this intersection.

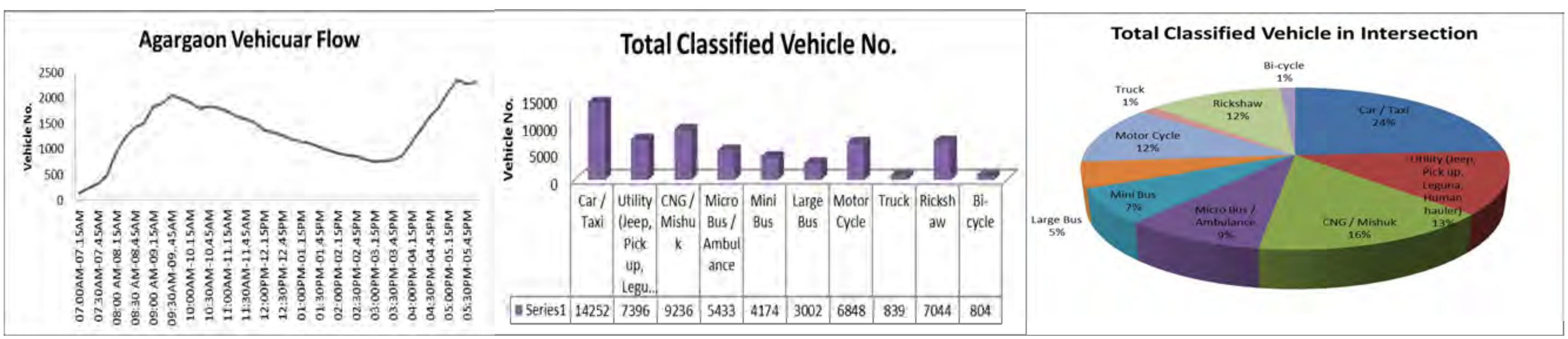


Figure 1.3.4: Vehicle Movement through Agargaon Intersection.

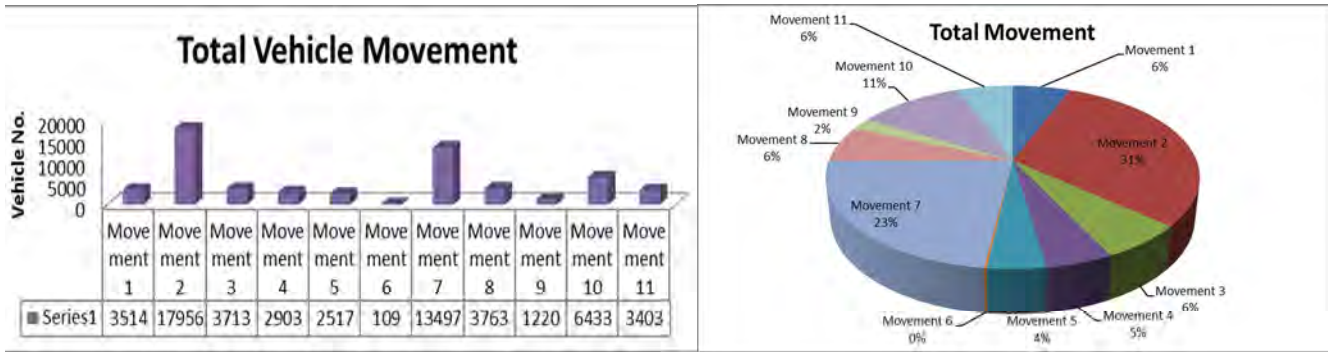
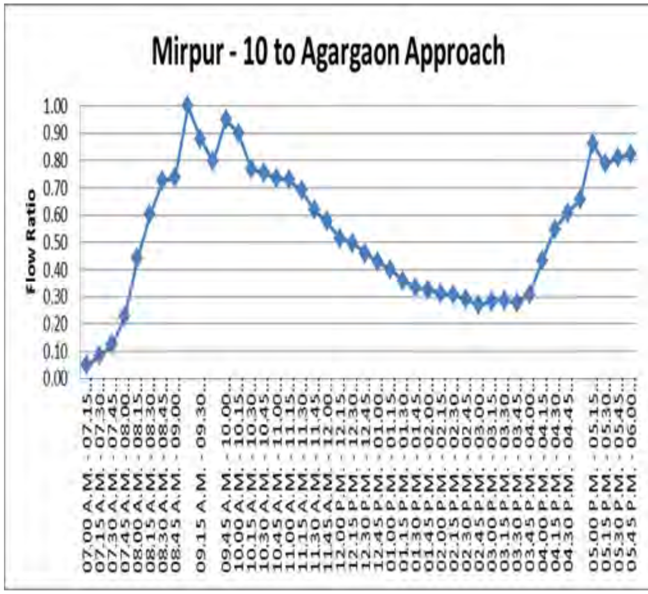
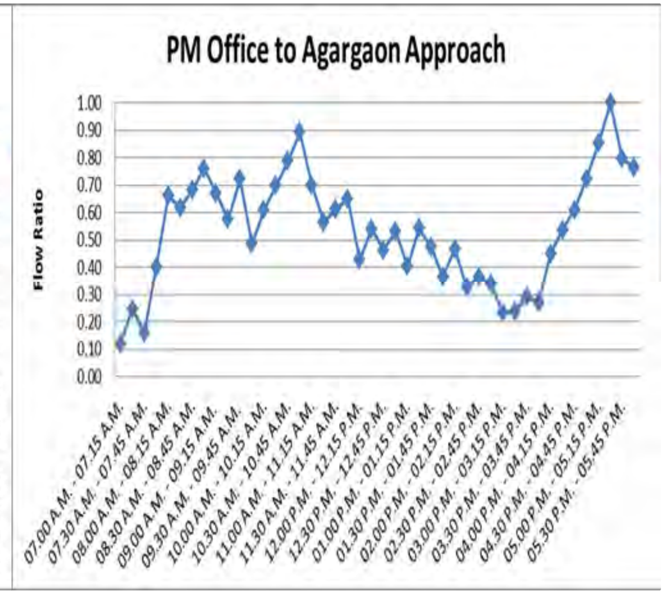


Figure 1.3.5: Vehicle Movement in Various Directions.

The flow ratio of the four (4) approaches was counted for finding out the field condition of traffic flow situation of every individual approach which is related with signal system, signal phasing, queue length, delay, etc. of this intersection. The data of flow ratio around the survey period is shown below.


Mirpur - 10 to Agargaon Approach
Flow Ratio
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


PM Office to Agargaon Approach
Flow Ratio
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

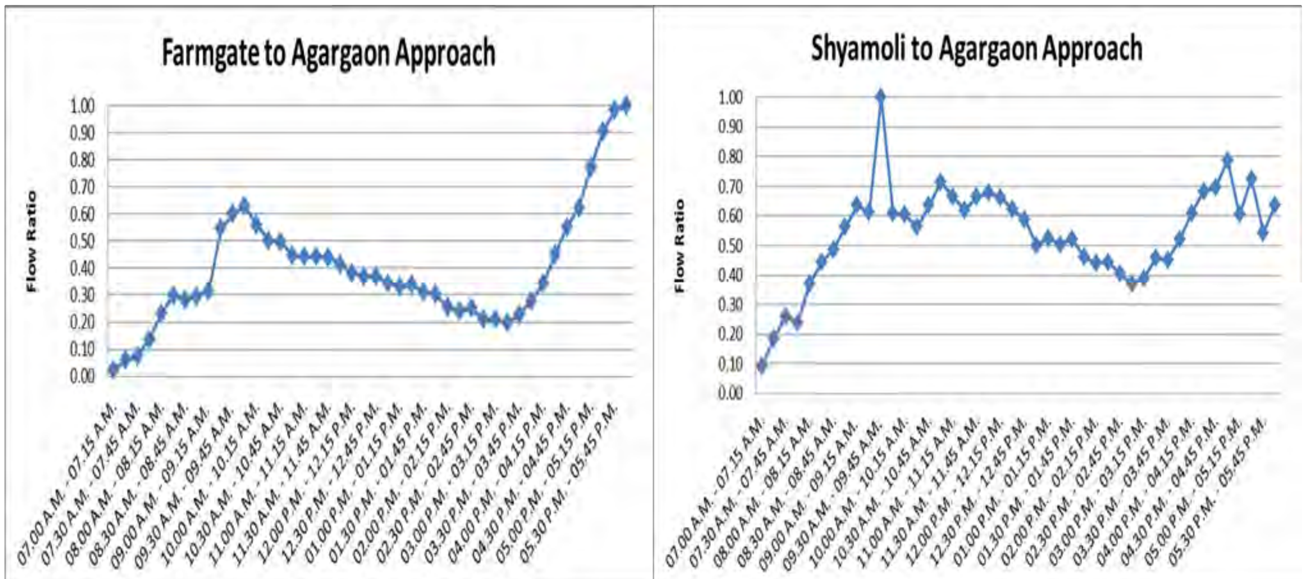
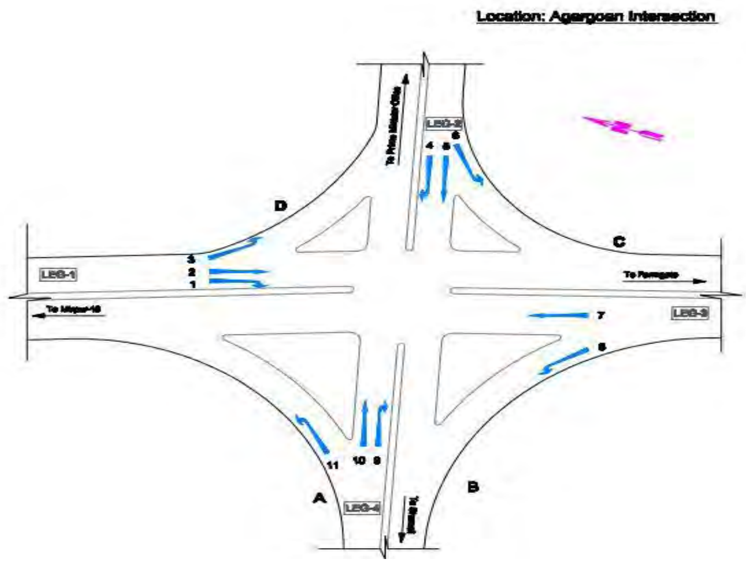
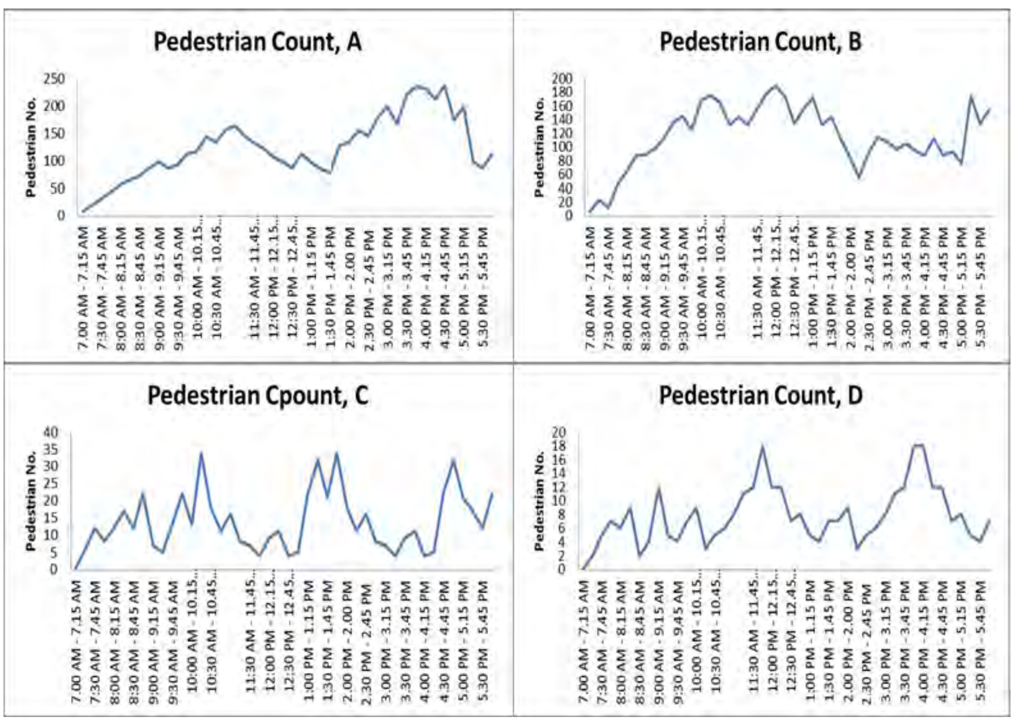


Figure 1.3.6: a) Flow Ratio of Mirpur 10 to Agargaon Approach; b) Flow Ratio of PM Office to Agargaon Approach; c) Flow Ratio of Farmgate to Agargaon Approach; d) Shyamoli to Agargaon Approach.

1.3.4 Pedestrian Flow of this Intersection

In the time of field survey, the pedestrian flow was also surveyed with the vehicular flow. The result of pedestrian survey is given below





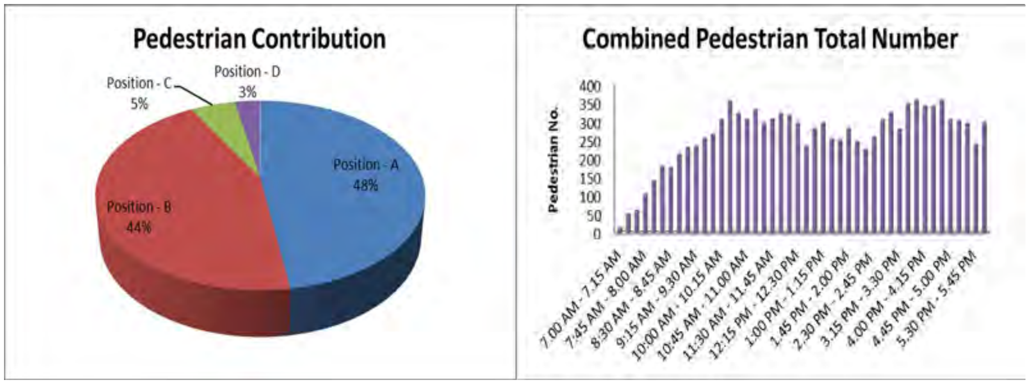
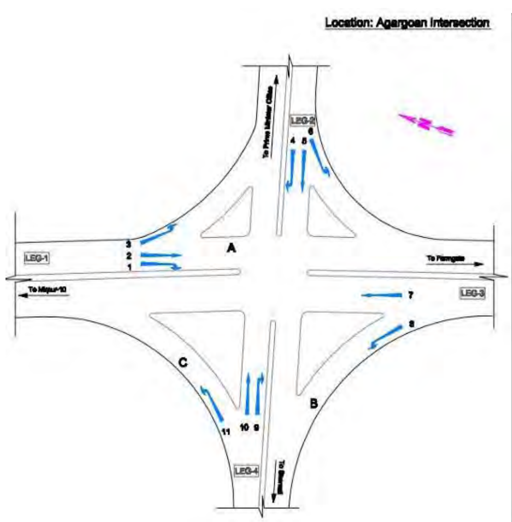


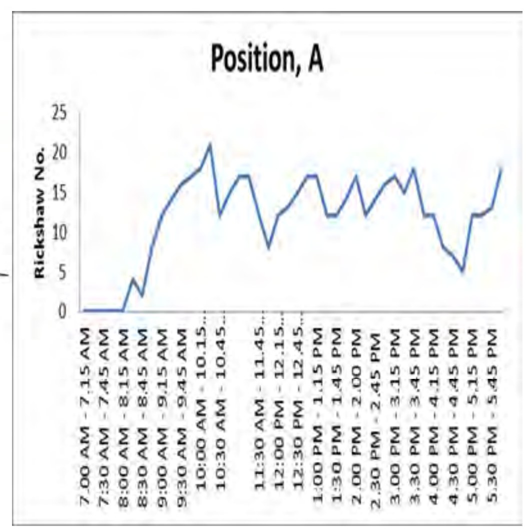
Figure 1.3.7: Pedestrian Survey in four (4) Positions inside the Intersection.

In this intersection, there is no facility of road crossing, such as over bridge, under pass, etc. Pedestrian as usually cross this road by taking chance in between flow of traffic on the road.

1.3.5 Side Friction

Comparing to other intersection of Dhaka city, this Agargaon intersection is quite different. Because, the intersection is inside the office area and Motorized vehicle is dominant here. The amount of Non Motorized vehicle using this intersection is comparatively less than other intersection. Inside the intersection, there are three points, which were used as illegal rickshaw stand in the time of preliminary survey. A counting survey for finding out the field condition of this intersection was arranged. The data of this survey is given below.





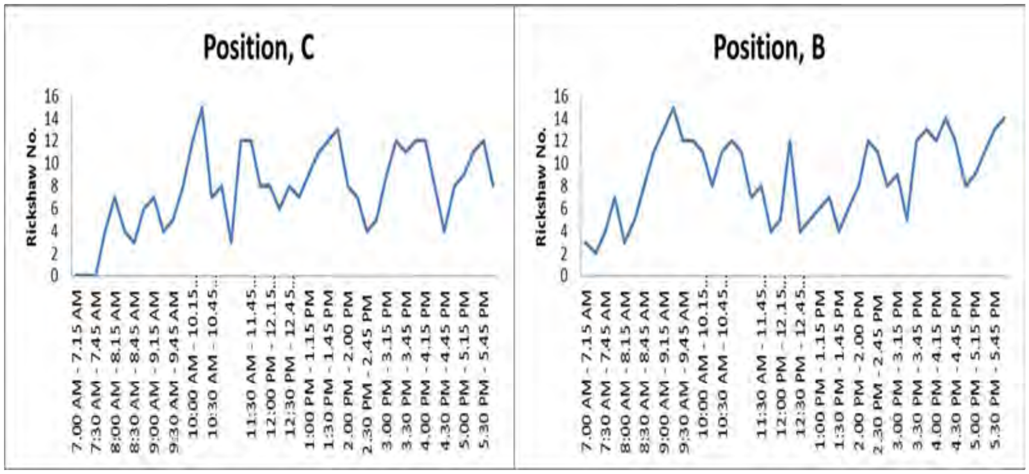


Figure 1.3.8: Illegal Rickshaw Stand.

In the preliminary survey of this intersection, three (3) points were found as illegal Laguna stoppage. For finding the condition of this illegal Laguna stoppage, a counting survey was organized. The data of this counting survey is given below.

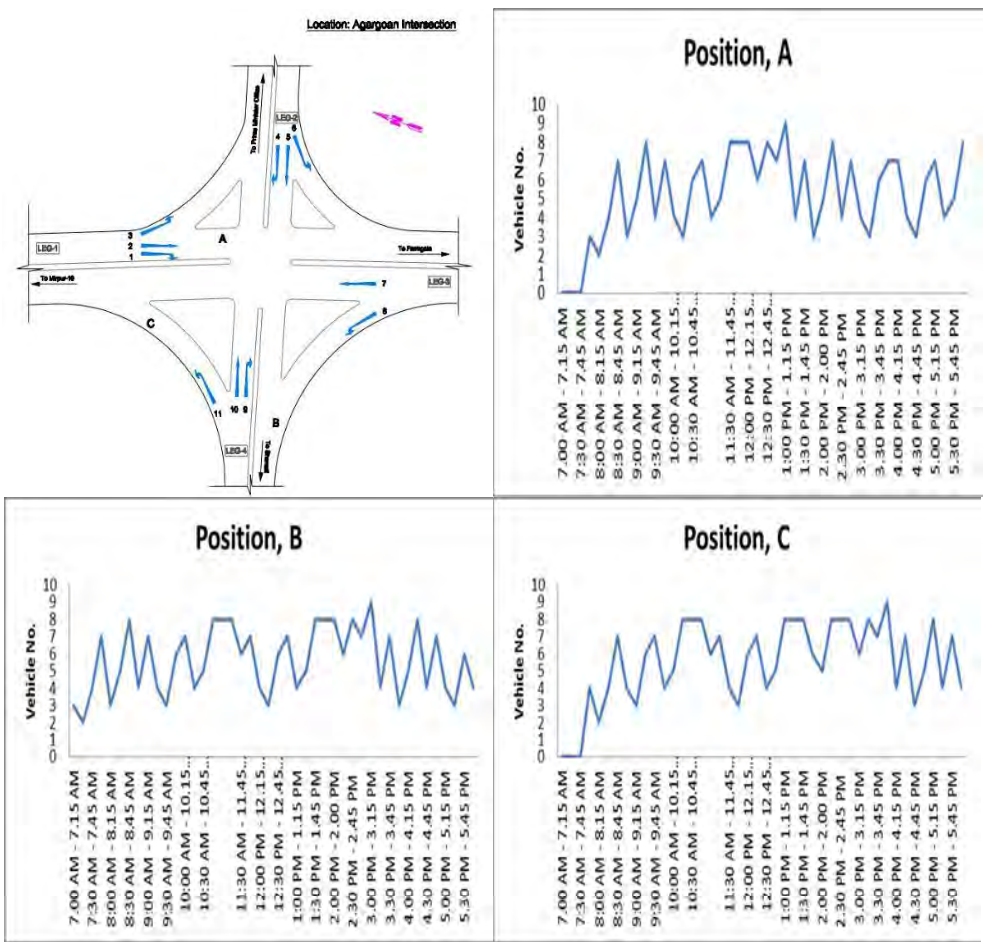


Figure 1.3.9: Illegal Laguna Stand.

As usually, there is no illegal bus stoppage. Buses usually stop at the time of traffic signal.

1.3.6 Traffic Control Devices

In this intersection, the traffic management is done by the police. Their method of management is . But there is signal light also. But these facilities are not used by the police. The signal is fixed time signal. As usually, the management of traffic in an intersection causes delay. This delay gives chance to traffic for building up the queue in the approaches. In Agargaon intersection, queue was found also.

A survey of traffic control devices were done in the time of preliminary survey of Agargaon intersection. The result of this survey is described below.

Table 1.3.1: Features of Intersection and Traffic Control System.

Sl No.	Description	Nos.
1	Number of legs	4
2	Direction of traffic	11
3	Signal post for vehicular and pedestrian movement	12
4	Traffic signal controller box	1
5	Traffic police box	1

Table 1.3.2: Duty of Traffic Police.

Post	Morning Shift	Evening Shift
Traffic inspector	1	
Traffic sergeant	1	1
Traffic police	4	4
Ansar	1	1

Table 1.3.3: Existing Traffic Control System and Time of Operation.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(08.00 PM 08.00 AM)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(08.00 AM 11.00 AM) (05.00 PM 08.00 PM)
4	Mixed	(12 PM 05.00 PM)

Table 1.3.4: Signal Accessories.

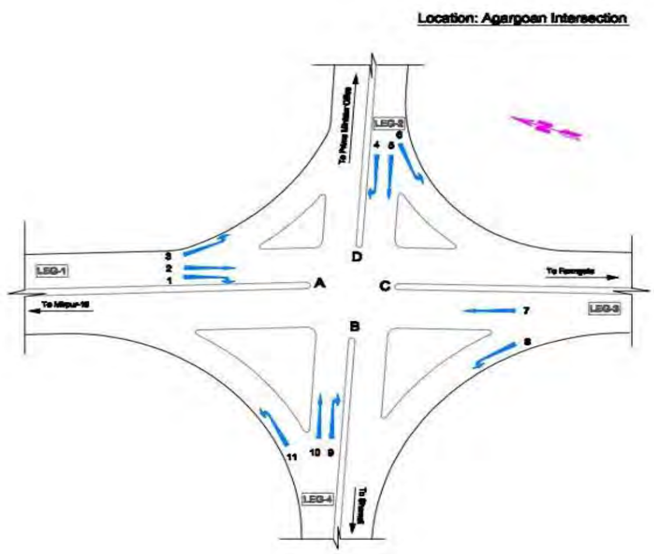
Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

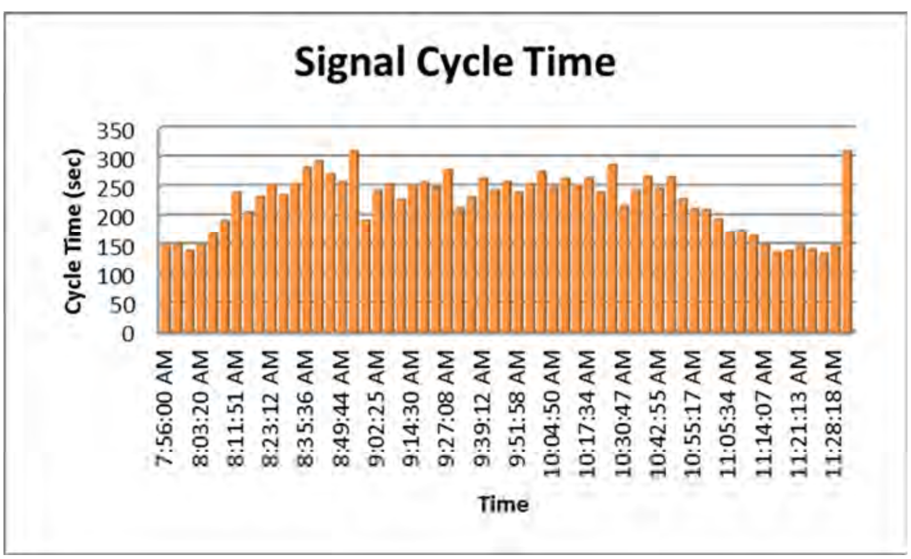
SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Light Operate	Pedestrian Signal Light Operate
SP-1	OK	OK	Yes	No
SP-2	OK	OK	Yes	-
SP-3	OK	OK	Yes	No

SP-4	OK	Two lamp missing	Yes	No
SP-5	OK	One lamp missing	Yes	No
SP-6	OK	OK	Yes	-
SP-7	OK	OK	Yes	No
SP-8	OK	OK	Yes	-
SP-9	OK	Two lamp missing	Yes	No
SP-10	OK	One lamp missing	-	No
MAP-1	OK	Two lamp missing	Yes	No
MAP-2	OK	OK	Yes	-
TSC	OK	OK	-	-

Notes: - No: Currently damage / not working
Yes: In working condition
(-): Not installed

In this preliminary survey, signal posts were found on every approach of this intersection. In this preliminary survey the cycle time of these manually operation of traffic signals were collected. The cycle time measuring data is given below.





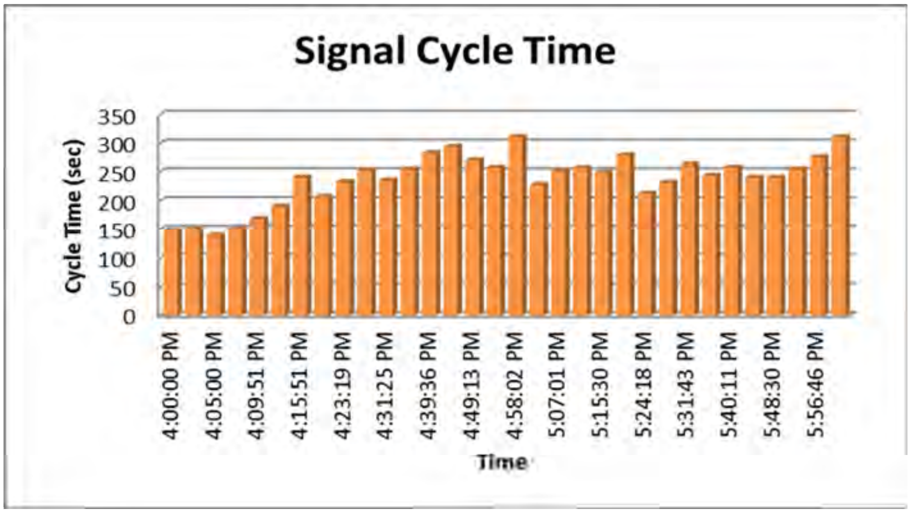


Figure 1.3.10: Signal Cycle time (i) from 07.56 AM to 11.28 AM and (ii) from 04.00 PM to 05.56 PM.

1.3.7 Queue Length

Due to long signal cycle time, signal phasing, side friction, demand responsive traffic operation, queue length in four approaches of this intersection was found. For collecting primary data of this intersection from the field survey was taken and later compared with the secondary data (CASE study of World Bank Funded *Synchronization Study, 2013* The primary data of the survey team is given here under.

Table 1.3.5: Queue Length at Different Approach of Agargaon Intersection in meter (at Morning Peak).

Observation No.	From	To	Mirpur - 10 to Agargaon approach (m)	Shyamoli to Agargaon approach (m)	Farmgate to Agargaon approach (m)	PM Office to Agargaon approach (m)
1	8:00:00 AM	8:15:00 AM	0	0	0	0
2	8:15:00 AM	8:30:00 AM	0	155.22	0	0
3	8:30:00 AM	8:45:00 AM	135.34	176.22	0	0
4	8:45:00 AM	9:00:00 AM	165.77	145.54	0	0
5	9:00:00 AM	9:15:00 AM	187.33	178.65	0	0
6	9:15:00 AM	9:30:00 AM	245.32	202.34	125.99	145.22
7	9:30:00 AM	9:45:00 AM	255.34	225.54	155.66	176.67
8	9:45:00 AM	10:00:00 AM	278.34	276.22	145.54	212.33
9	10:00:00 AM	10:15:00 AM	323.44	245.34	178.65	202.34
10	10:15:00 AM	10:30:00 AM	297.66	296.33	202.34	225.54
11	10:30:00 AM	10:45:00 AM	305.33	306.67	225.54	276.22
12	10:45:00 AM	11:00:00 AM	275.77	312.32	276.22	245.34
13	11:00:00 AM	11:15:00 AM	315.44	342.46	255.66	235.00
14	11:15:00 AM	11:30:00 AM	344.21	305.73	221.37	295.66

Table 1.3.6: Queue Length at Different Approach of Agargaon Intersection in meter (at Evening Peak).

Observation No.	From	To	Mirpur - 10 to Agargaon approach (m)	Shyamoli to Agargaon approach (m)	Farmgate to Agargaon approach (m)	PM Office to Agargaon approach (m)
1	4:00:00 PM	4:15:00 PM	185.88	112.45	143.55	112.67
2	4:15:00 PM	4:30:00 PM	276.00	122.56	136.58	98.76
3	4:30:00 PM	4:45:00 PM	321.00	245.78	155.75	115.78
4	4:45:00 PM	5:00:00 PM	334.67	332.67	187.76	187.78
5	5:00:00 PM	5:15:00 PM	342.22	312.67	145.67	177.86
6	5:15:00 PM	5:30:00 PM	375.22	302.66	152.34	185.56
7	5:30:00 PM	5:45:00 PM	411.76	287.78	187.98	209.87
8	5:45:00 PM	6:00:00 PM	427.44	297.66	376.88	334.57

1.3.8 Delay of Intersection

After observing the queue length of Agargaon intersection on three approaches, the decision of finding delay on every approach was taken. The decision for taking data of free flow from 07.00 AM to 07.30 AM was taken. In this condition, the Agargaon intersection and surrounding areas were calm and soft. So the vehicular data was collected in free flow condition very easily in every approach. The travel time in free flow condition is given below.

Table 1.3.7: Travel Time at Free Flow Condition of Agargaon Intersection (sec) at from 07.00 A.M to 07.30 A.M.

Observation No.	From	To	Taltola to Agargaon Inter section	Shishu Mela to Agargaon Intersection	Planning Comission Intersection to Agargaon Intersection	Prime Minister Office to Agargaon Intersection
1	7:00:00 AM	7:30:00 AM	5	28	6	31

By considering the free flow condition travel time of vehicle, the delay in every approach of this intersection was counted. The data of delay is given below.

Table 1.3.8: Delay at Different Approach of Agargaon Intersection.

Observation No.	From	To	Taltola to Agargaon Inter section	Delay (Taltola to Agargaon Intersection)	Shishu Mela to Agargaon Intersection	Delay (Shishu Mela to Agargaon Intersection)	Planning Comission Intersection to Agargaon Intersection	Delay (Planning Comission Intersection to Agargaon Intersection)	Prime Minister Office to Agargaon Intersection	Delay (Prime Minister Office to Agargaon Intersection)
1	7:00:00 AM	7:30:00 AM	6	1	28	0	8	2	36	5
2	7:30:00 AM	8:00:00 AM	12	7	39	11	12	6	44	13
3	8:00:00 AM	8:30:00 AM	22	17	54	26	22	16	53	22
4	8:30:00 AM	9:00:00 AM	45	40	67	39	24	18	66	35
5	9:00:00 AM	9:30:00 AM	58	53	74	46	34	28	58	27
6	9:30:00 AM	10:00:00 AM	69	64	77	49	25	19	56	25
7	10:00:00 AM	10:30:00 AM	92	87	78	50	65	59	62	31
8	10:30:00 AM	11:00:00 AM	128	123	77	49	67	61	67	36
9	11:00:00 AM	11:30:00 AM	253	248	112	84	44	38	73	42
10	11:30:00 AM	12:00:00 PM	327	322	121	93	34	28	74	43
11	12:00:00 PM	12:30:00 PM	287	282	223	195	112	106	87	56
12	12:30:00 PM	1:00:00 PM	223	218	228	200	124	118	96	65
13	1:00:00 PM	1:30:00 PM	187	182	331	303	132	126	112	81
14	1:30:00 PM	2:00:00 PM	154	149	236	208	221	215	124	93
15	2:00:00 PM	2:30:00 PM	87	82	224	196	224	218	128	97
16	2:30:00 PM	3:00:00 PM	114	109	188	160	223	217	99	68
17	3:00:00 PM	3:30:00 PM	128	123	172	144	225	219	87	56
18	3:30:00 PM	4:00:00 PM	116	111	118	90	278	272	89	58
19	4:00:00 PM	4:30:00 PM	78	73	114	86	225	219	87	56
20	4:30:00 PM	5:00:00 PM	124	119	226	198	256	250	85	54
21	5:00:00 PM	5:30:00 PM	122	117	221	193	227	221	116	85
22	5:30:00 PM	6:00:00 PM	132	127	297	269	254	248	128	97

1.3.9 Level of Service (LOS)

After calculating the delay of every approach of Agargaon intersection, the delay data was compared with the standard un signalized intersection delay data *(HCM, 2010)*. This intersection was controlled by police manually, so definitely Agargaon intersection is an un signalized intersection. By comparing with the standardized delay time with the intersection delay data, the level of services of different approaches of Agargaon intersection was calculated on the basis of delay. The result of this calculation is tabulated below.

Table 1.3.9: LOS of Different Approaches of Agargaon Intersection.

Observation No.	**Time**	**LOS (Taltola to Agargaon)**	**LOS (Shishu Mela to Agargaon)**	**LOS (Planning Commission to Agargaon)**	**LOS (Prime Minister Office to Agargaon)**
1.	07.00 A.M. 07.30 A.M.	A	A	A	A
2.	07.30 A.M. 08.00 A.M.	A	B	A	B
3.	08.00 A.M. 08.30 A.M.	C	D	C	C
4.	08.30 A.M. 09.00 A.M.	E	E	C	D
5.	09.00 A.M. 09.30 A.M.	F	E	D	D
6.	09.30 A.M. 10.00 A.M.	F	E	C	C
7.	10.00 A.M. 10.30 A.M.	F	E	F	D
8.	10.30 A.M. 11.00 A.M.	F	E	F	E
9.	11.00 A.M. 11.30 A.M.	F	F	E	E
10.	11.30 A.M. 12.00 P.M.	F	F	D	F
11.	12.00 P.M. 12.30 P.M.	F	F	F	F
12.	12.30 P.M. 01.00 P.M.	F	F	F	F
13.	01.00 P.M. 01.30 P.M.	F	F	F	F
14.	01.30 P.M. 02.00 P.M.	F	F	F	F
15.	02.00 P.M. 02.30 P.M.	F	F	F	F
16.	02.30 P.M. 03.00 P.M.	F	F	F	F
17.	03.00 P.M. 03.30 P.M.	F	F	F	F
18.	03.30 P.M. 04.00 P.M.	F	F	F	F
19.	04.00 P.M. 04.30 P.M.	F	F	F	F
20.	04.30 P.M. 05.00 P.M.	F	F	F	F
21.	05.00 P.M. 05.30 P.M.	F	F	F	F
22.	05.30 P.M. 06.00 P.M.	F	F	F	F

By observing the result of LOS of different approaches of Agargaon intersection, failure condition throughout the day was found. Most of the time of the day, the level of service of this intersection was persisted on Level F or failure condition. This is disastrous for today Modern Dhaka city.

1.4 Bangla Motor Intersection

1.4.1 General Description

Bangla Motor intersection is situated on primary road, Kazi Nazrul Islam Avenue in north to south connecting with New Eskaton Road to east coming from Mouchak intersection and short road connecting Bir Uttam CR Dutta Road to the west. This is a very busy intersection.The four approaches of the junction are divided by narrowmedians with barrier.

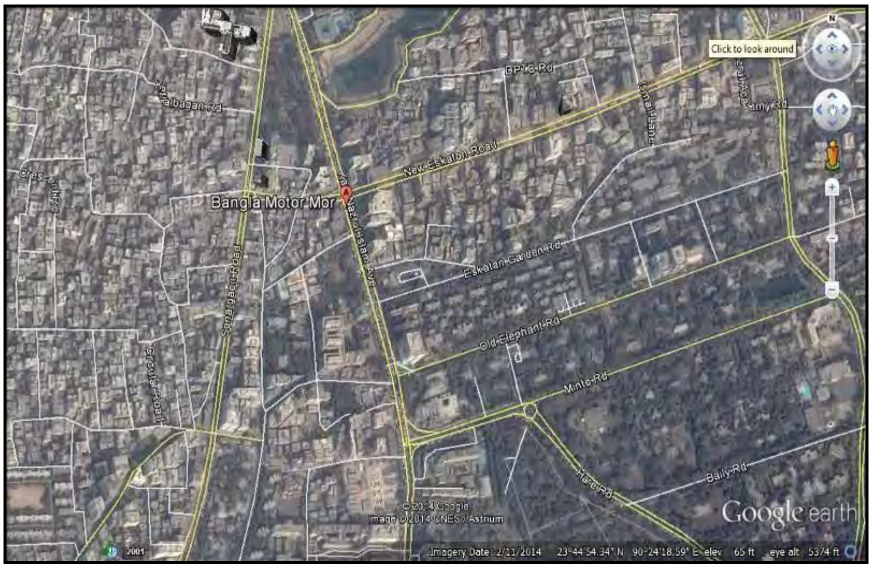


Figure 1.4.1: Google Map of Bangla Motor Intersection.

Among the four approaches, the north south approaches contained motorized vehicle and the remaining east and west approaches contain heterogeneous traffic. Especially the west approach towards eastern plaza the traffic flow is relatively low. On other hand, the east approach towards Mogbazar always governs a large number of traffic with mixed flow. Though it is a signalized junction, it is operated by traffic police. At this junction the facility for pedestrian crossing is provided through over bridge but the pedestrian always try to ignore this facility. As a result, the junction is always over crowded by pedestrian. Pedestrians cross the junction matching with their desire paths under risk. Pedestrian would hardly find the suitable gaps within the moving traffic stream to perform the crossing maneuver. Some of the passengers moving towards the Shahabag from Kawran Bazar are getting down at this intersection providing illegal bus stoppage. At the same time some of the passengers get ride to the bus from this intersection under the over bridge, there are illegal bus stoppages too. Sometime artificial jams are found.

Bangla Motor intersection is situated in the middle part of Dhaka city. It is in the VIP road. This is a crossed intersection. It consists of two (2) major links and two (2) minor links. From the starting of this intersection, the place was commercial area. Till now it is a busy commercial area. It is a link of keeping contact with the Western part of Dhaka with Middle part of Dhaka. It is a gateway of connecting the two part of Dhaka Metropolitan City area. This area is developed by keeping pace with the development of Dhaka Metropolitan city. Around this intersection, there are some tall buildings.

Figure 1.4.2: Bangla Motor Intersection

Figure 1.4.3: Approach Road (a) Road from Farmgate, (b) Road from Moghbazar, (c) Road fromShahbag, (d) Sonargaon Link Road.

1.4.2 Approaches from Intersection

Bangla Motor contains the flexible pavement as road structure. The road is marked with lane sign, marking, etc. The condition of lane at different approaches of this intersection is

a) Road from Farmgate 3 lanes both direction,
b) Road from Moghbazar 2 lanes both direction,
c) Road from Shahbag 3 lanes both direction and
d) Sonargaon Link Road 2 lanes both direction.

There is exclusive left turn in Moghbazar Road. There is right turning lane in Road from Shahbag. Some of the links contain Median with or without barrier, Marking, Sign, etc.

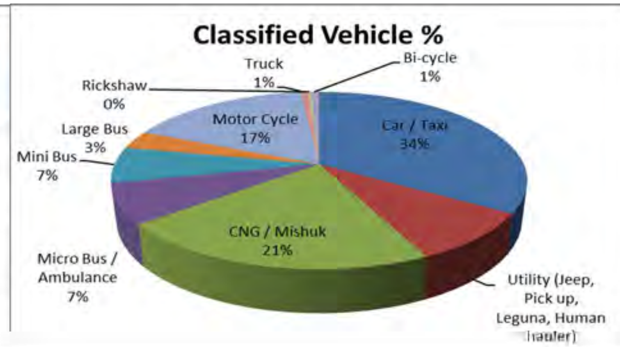
Figure 1.4.4: Inside the Intersection: (a) Left Turn Lane on Moghbazar (b) Right Turn Lane on Shahbag Approach.

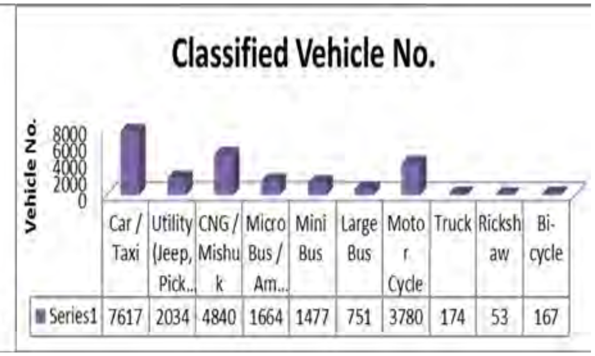
1.4.3 Vehicular Flow of this Intersection

For finding out the level of service (LOS) of this intersection, the decision of classified vehicle counting in this intersection was taken. From preliminary survey of this intersection, 2 (two) distinct peak hours were found in traffic flow; one was in the morning period from 08.00 A.M. to 01.00 P.M. and another was in the evening from 03.30 P.M. to 06.00 P.M. and furthermore. So the time of survey was set from 07.00 AM to 06.00 PM, total 11 hours. The result of the vehicular survey is going to be described below.

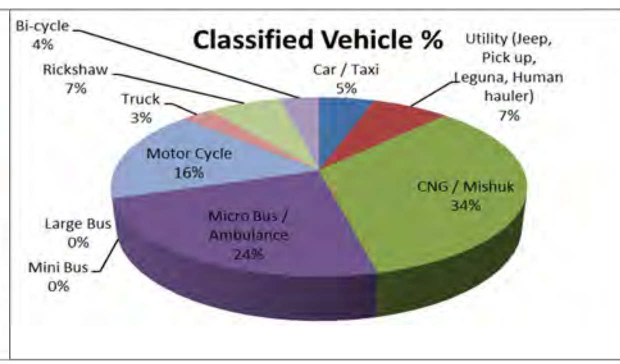
From the preliminary survey of this intersection the researcher team found ten (10) movements in this intersection. They are (1) Farmgate to Sheraton, (2) Farmgate to Moghbazar, (3) Moghbazar to Farmgate, (4) Moghbazar to Sonargaon Road, (5) Moghbazar to Sheraton, (6) Sheraton to Farmgate, (7) Sheraton to Sonargaon Road, (8) Sonargaon road to Sheraton, (9) Sonargaon Road to Moghbazar and (10) Sonargaon Road to Farmgate. The vehicular counting data is given below.

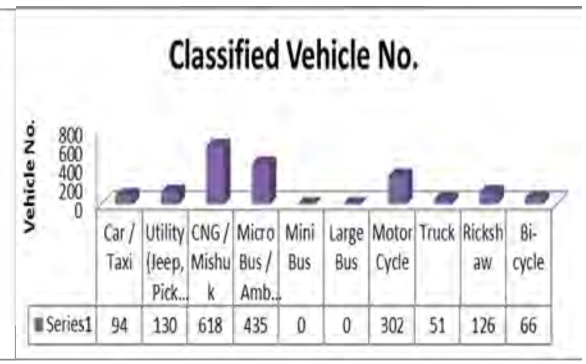
Movement: 1 Farmgate to Sheraton.



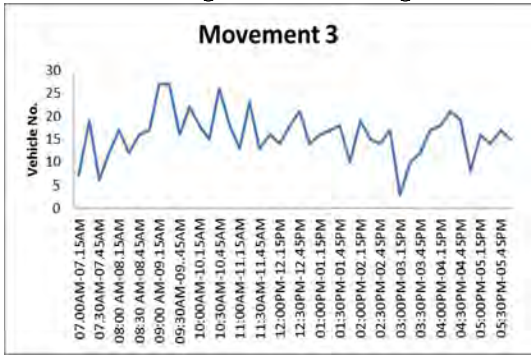


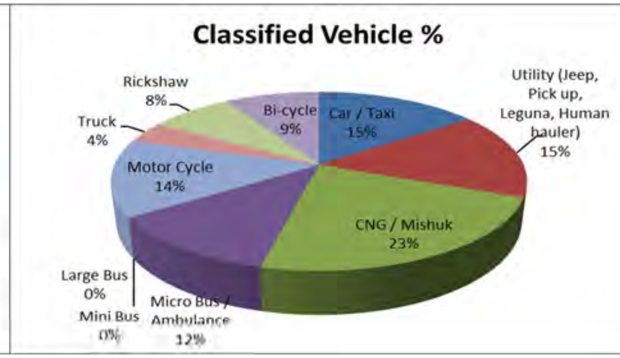
Movement: 2 Farmgate to Moghbazar.

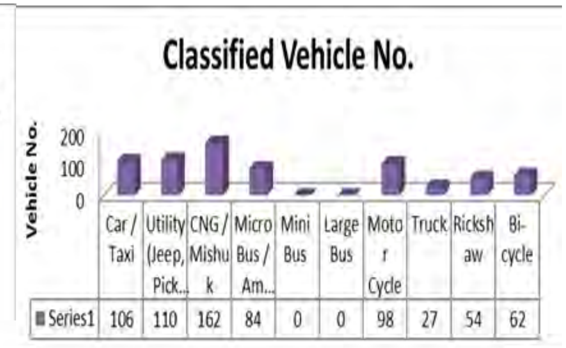




Movement: 3 Moghbazar to Farmgate.

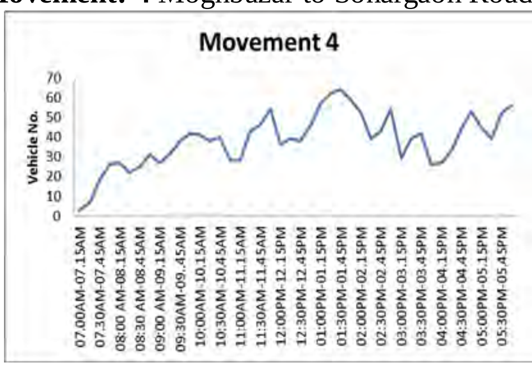


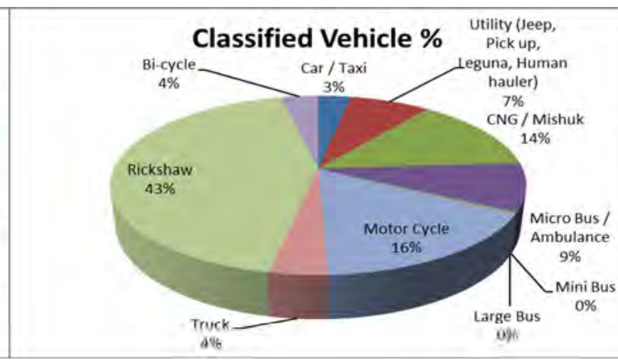


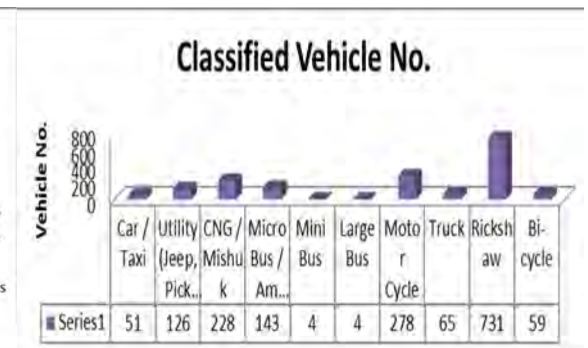


	Car / Taxi	Utility (Jeep, Pick...	CNG / Mishuk	Micro Bus / Am...	Mini Bus	Large Bus	Motor Cycle	Truck	Rickshaw	Bi-cycle
Series1	106	110	162	84	0	0	98	27	54	62

Movement: 4 Moghbazar to Sonargaon Road.

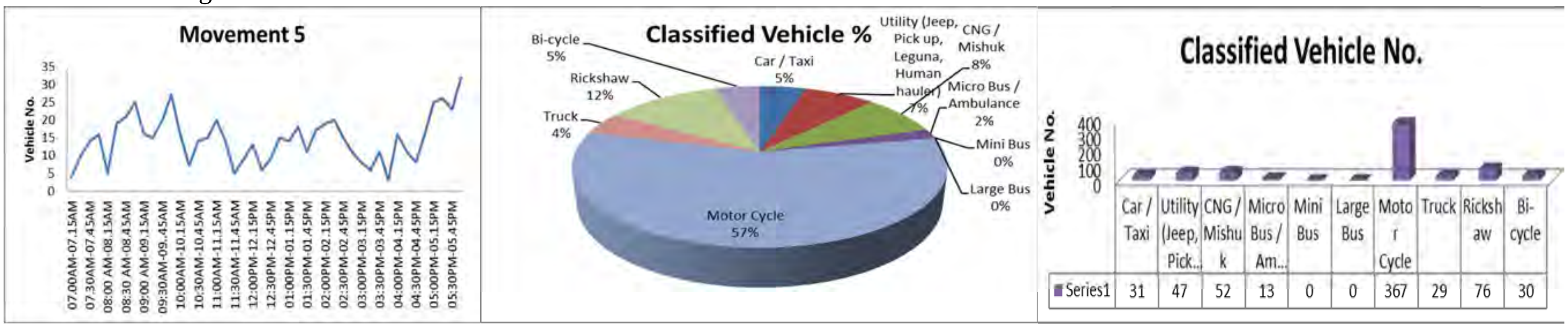




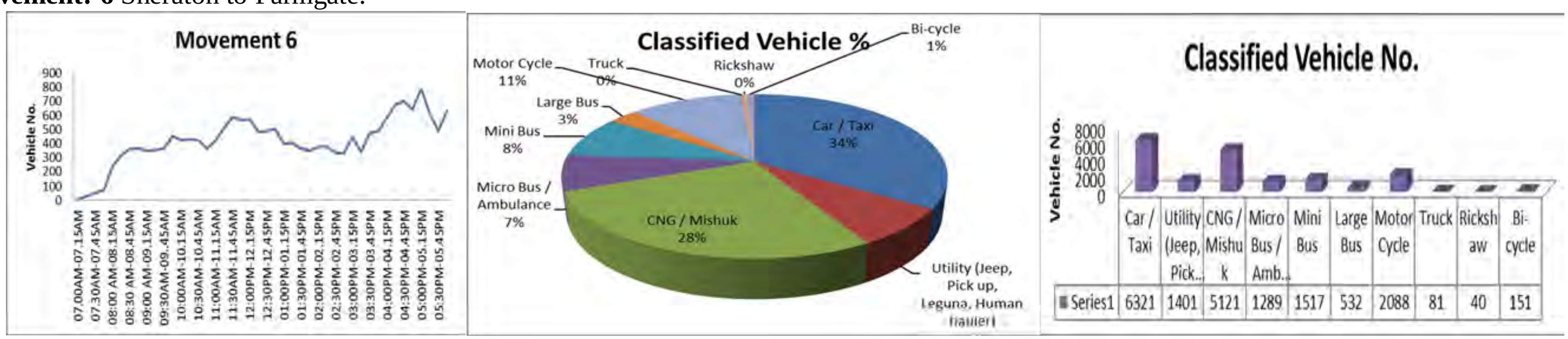


	Car / Taxi	Utility (Jeep, Pick...	CNG / Mishuk	Micro Bus / Am...	Mini Bus	Large Bus	Motor Cycle	Truck	Rickshaw	Bi-cycle
Series1	51	126	228	143	4	4	278	65	731	59

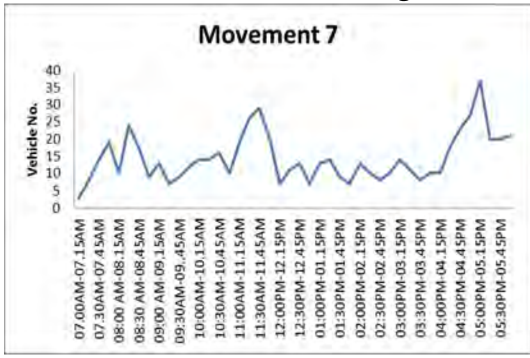
Movement: 5 Moghbazar to Sheraton.

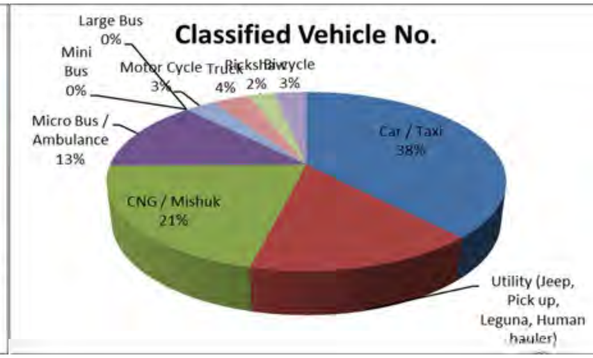


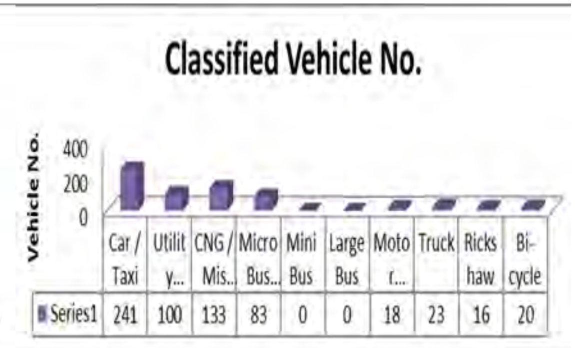
Movement: 6 Sheraton to Farmgate.



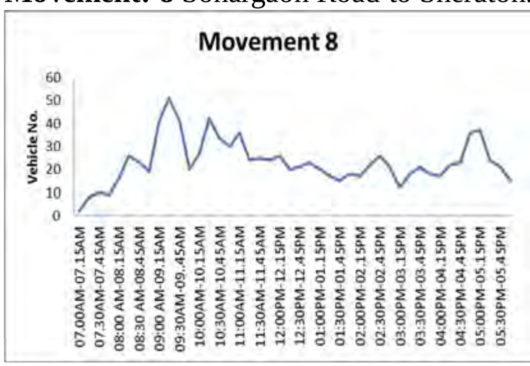
Movement: 7 Sheraton to Sonargaon Road.

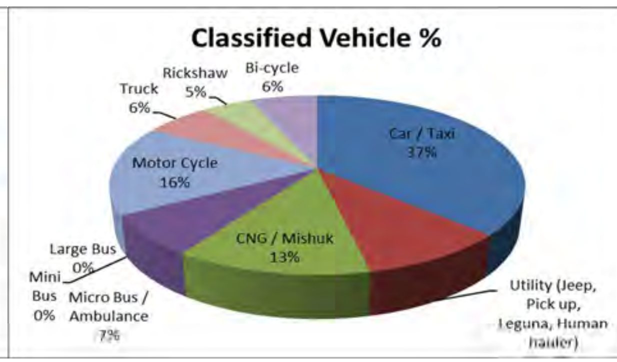


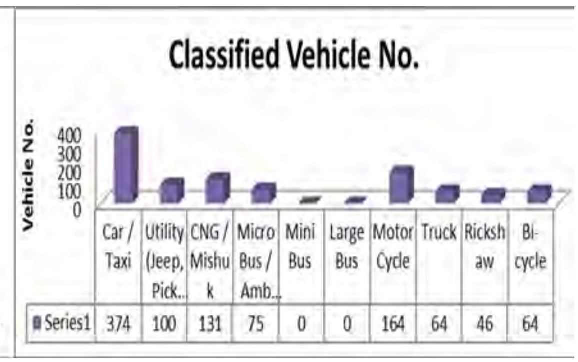




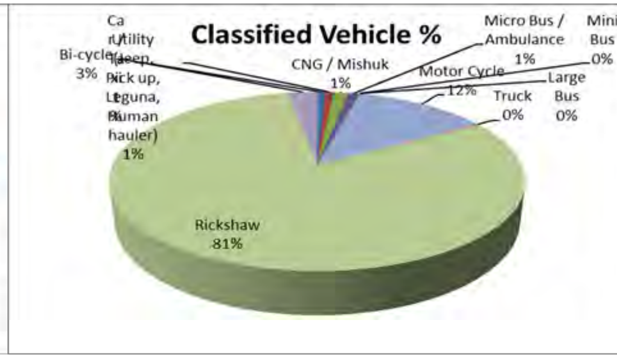
Movement: 8 Sonargaon Road to Sheraton.

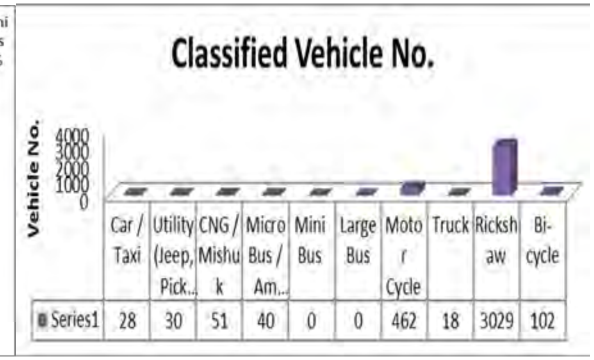




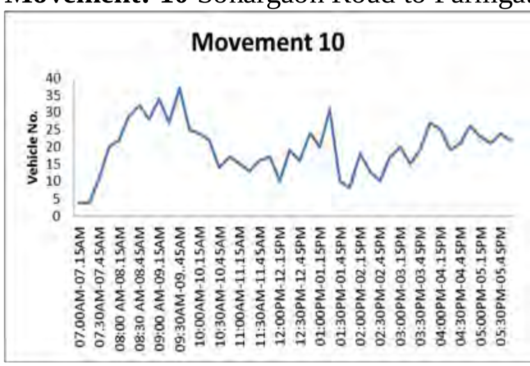


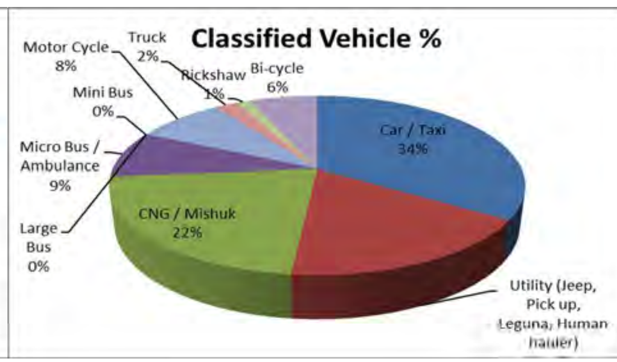
Movement: 9 Sonargaon Road to Moghbazar.

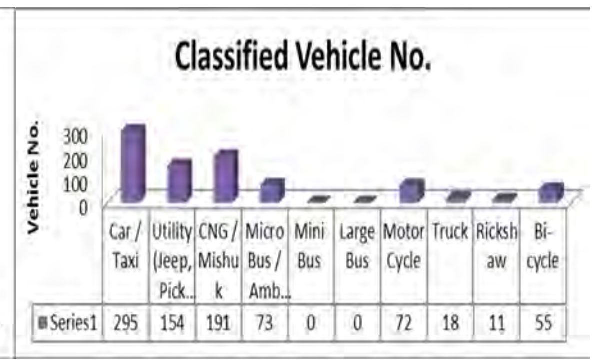




Movement: 10 Sonargaon Road to Farmgate.







After finishing the vehicular survey, the analyzing of vehicular flow data was done. The result of this analysis is given below.

From the analysis it was found that Movement 1 (Farmgate to Sheraton) contains maximum traffic flow of this intersection. Motorized vehicle is dominant in this intersection.

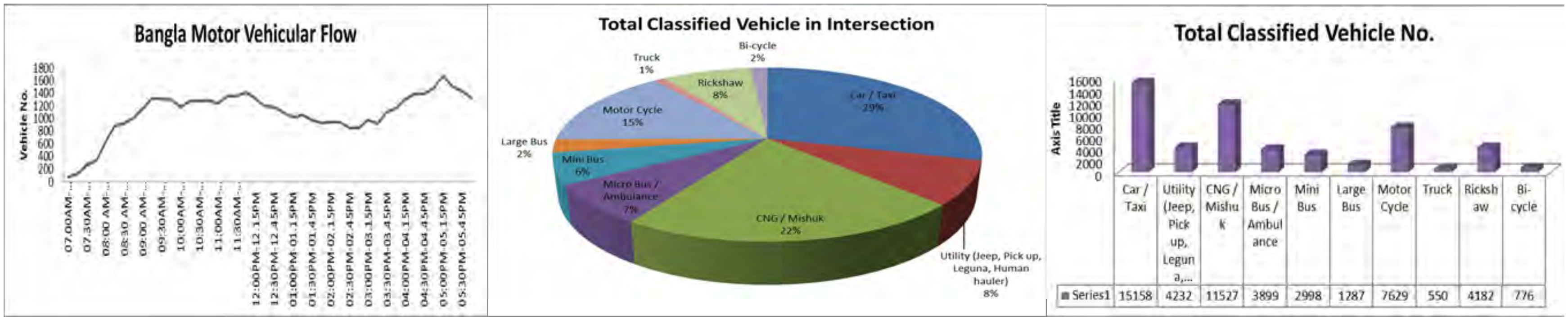


Figure 1.4.5: Vehicle Movement through Bangla Motor Intersection.

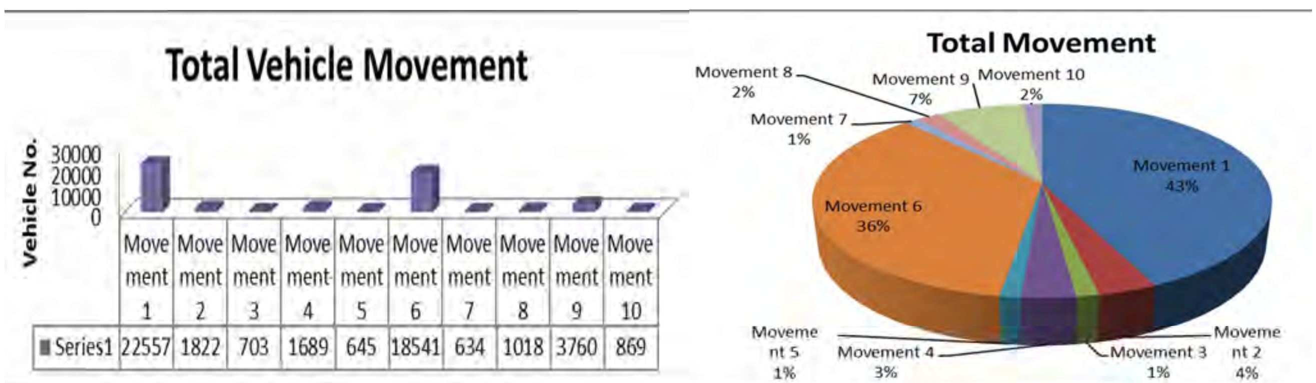


Figure 1.4.6**:** Vehicle Movement in Various Directions.

The flow ratio of the four approaches was calculated for finding out the condition of traffic flow situation of individual approach which is related with signal system, signal phasing, queue length, delay, etc. of this intersection. The data of flow ratio of every approachin the survey period is shown below.

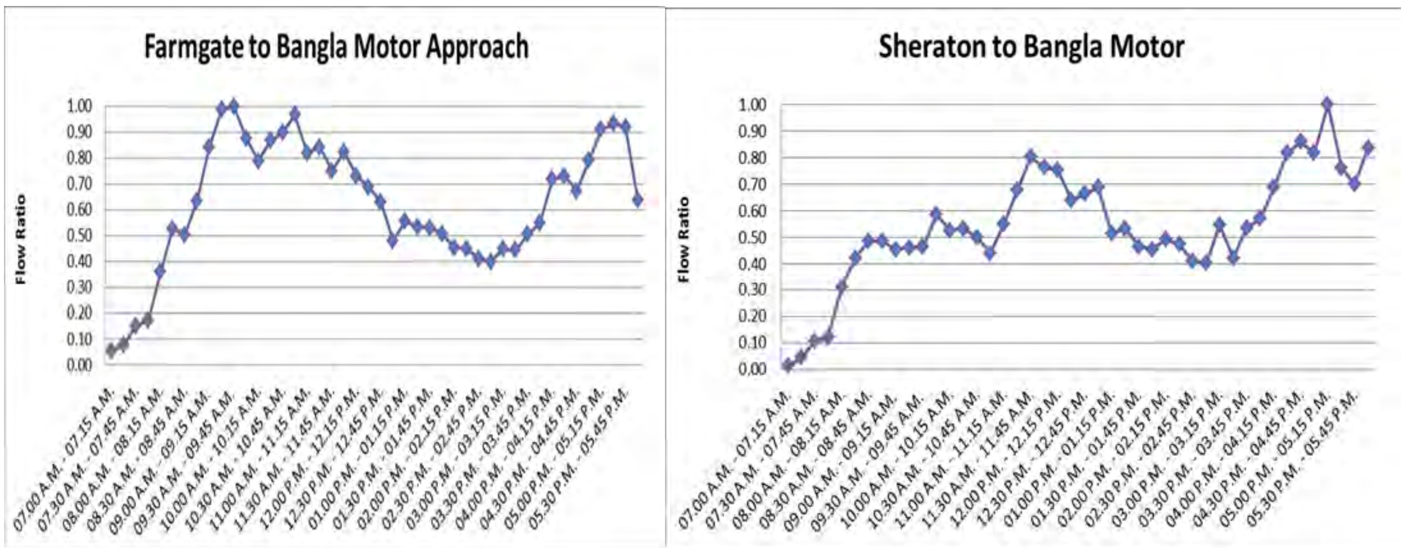
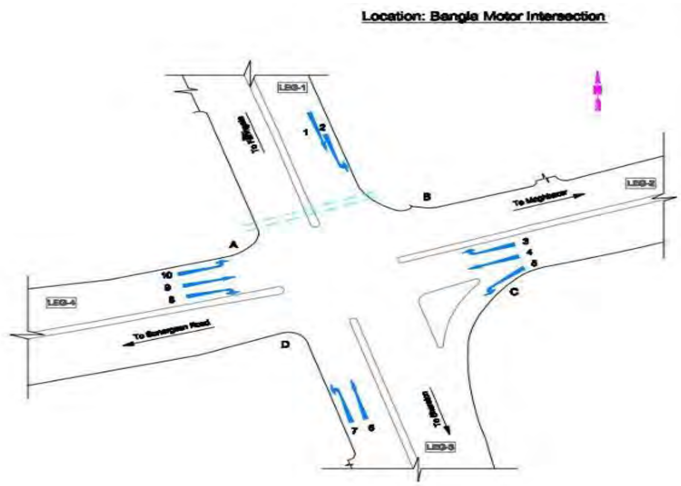
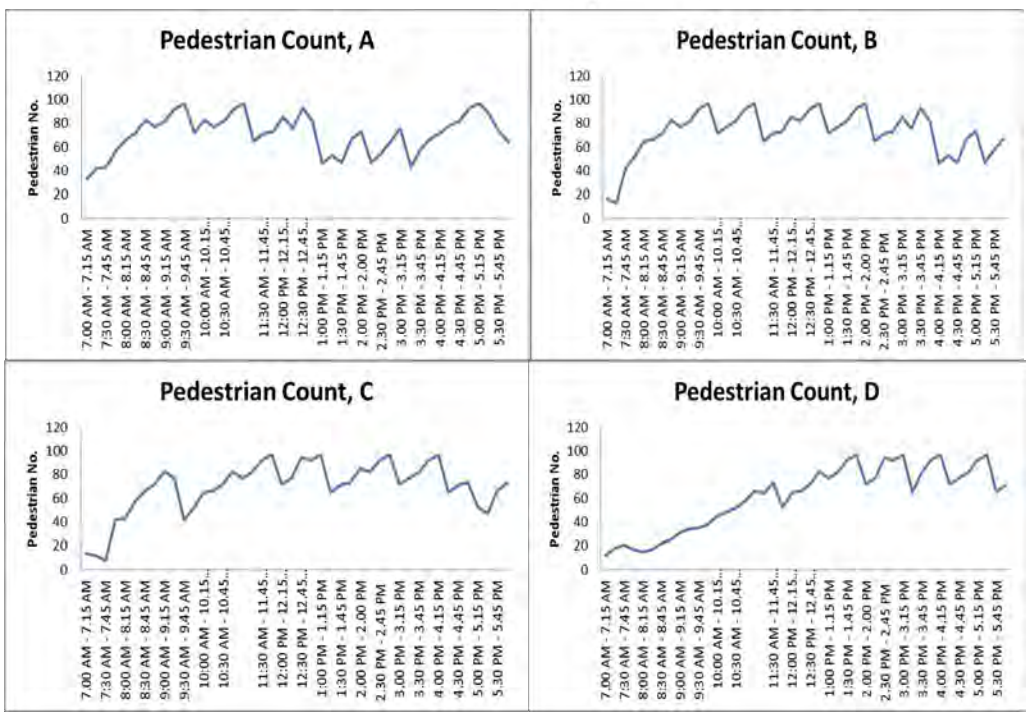


Figure 1.4.7: a) Flow Ratio of Farmgate to Bangla Motor Approach; b) Flow Ratio of Sheraton to Bangla Motor Approach.

1.4.4 Pedestrian Flow of this Intersection

In the time of field survey, the survey of the pedestrian flow was arranged with the vehicular flow of this intersection. The result of pedestrian survey is given below.





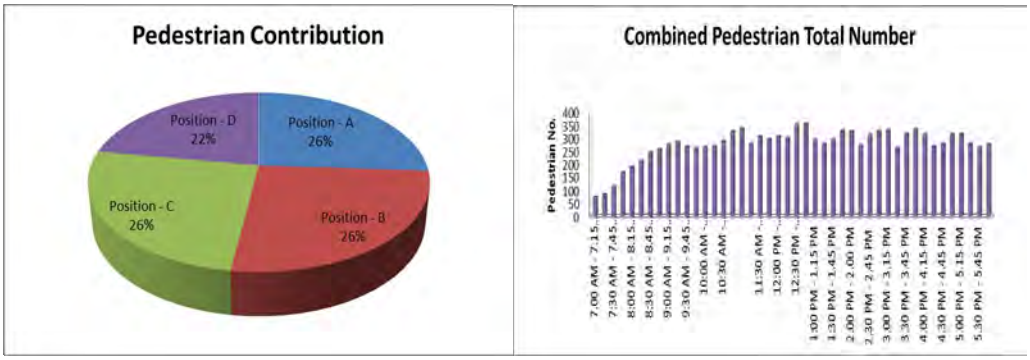


Figure 1.4.8: Pedestrian Counting Survey inside the Intersection.

In this intersection, for pedestrian crossing there is an over bridge which has two legs. The percentage of pedestrian using this crossing facility was found out. The result of this survey is given below.

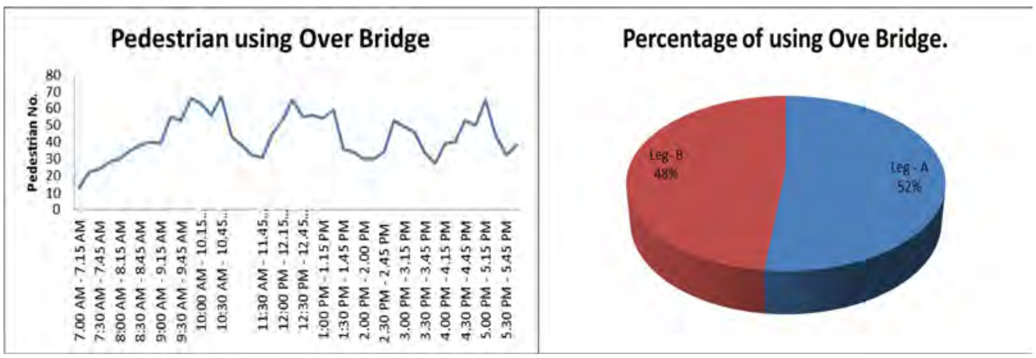


Figure 1.4.9: Pedestrian Using Foot Over Bridge.

From the pedestrian counting survey, only 16% pedestrian with respect to total pedestrian flow were using this crossing facility in this intersection.

1.4.5 Side Friction

From the field survey of Bangla Motor intersection, the dominance of motorized vehicle was found. In vehicular flow stream, around 91% of total vehicular flow is motorized vehicle. Besides this some instance of side friction in this intersection was found. So some counting survey for finding out the real situation at field was arranged. The survey data is presented below.

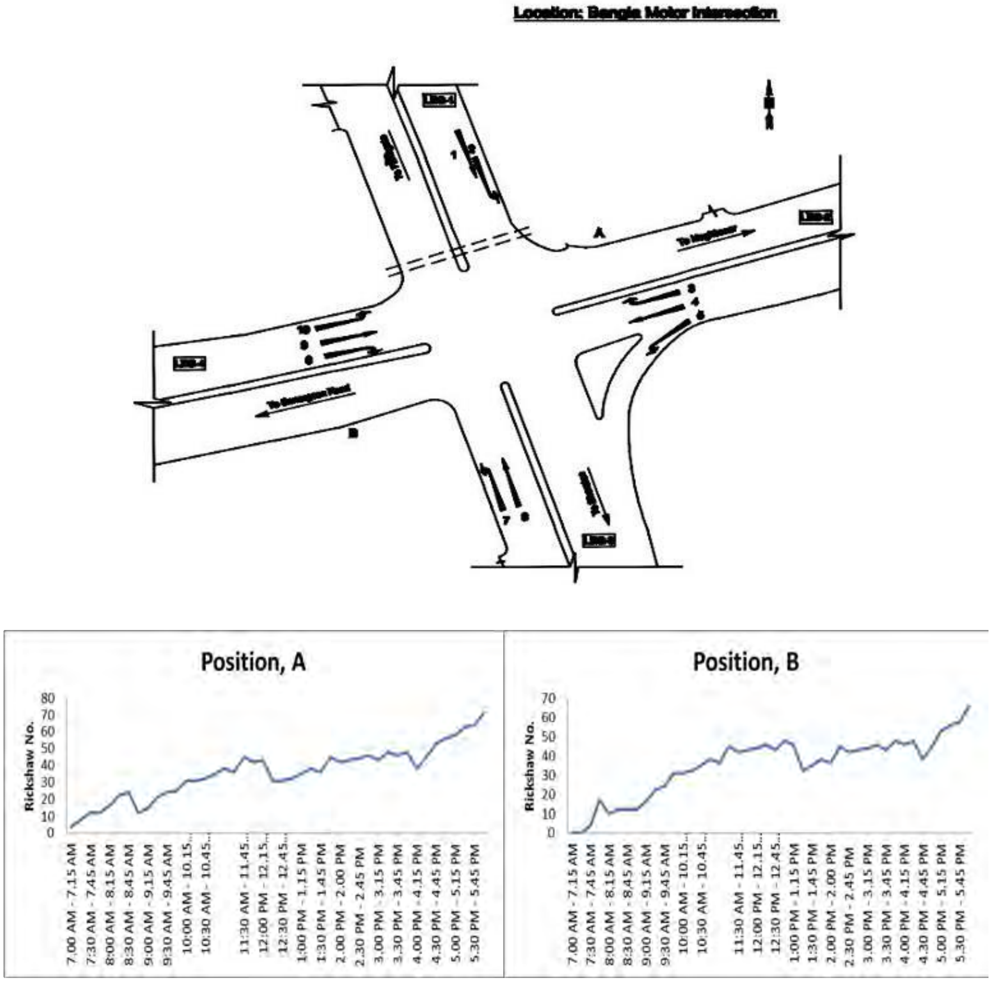


Figure 1.4.10: Illegal Rickshaw Stand.

In this intersection we found illegal rickshaw stand on the mouth of two (2) minor roads, Sonargaon road and Moghbazar road. These places are denoted on the map of Bangla Motor intersection below.

Under the over bridge of this intersection both side of the road, two illegal bus stoppages was found inside the intersection. As usually the public buses stop in these area and collect passengers. So the stopped buses interrupt the free traffic flow on the primary road. A counting survey was arranged for this. The survey data of this is given below.

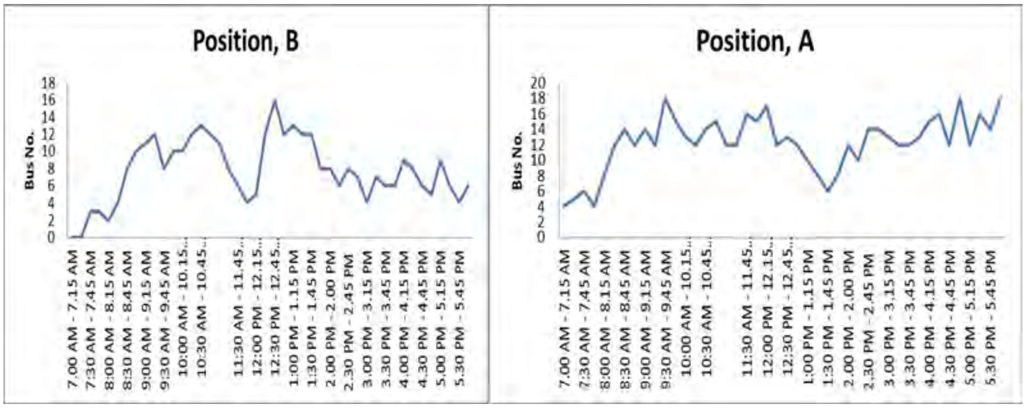


Figure 1.4.11: Illegal Bus Stoppage.

1.4.6 Traffic Control Devices

In this intersection, the traffic management is done by the police. There method of management is . But there is signal light also. But these facilities are not used by the police. The signal is fixed time signal. As usually, in management of traffic in an intersection cause some delay. This delay gives chance to traffic for building up the queue in the approaches.

A survey of traffic control devices were done in the time of preliminary survey of Bangla Motor intersection. The result of this survey is described below.

Table 1.4.1: Features of Intersection and Traffic Control System.

Sl No.	Description	Nos.
1	Number of legs	4
2	Direction of traffic	10
3	Signal post for vehicular and pedestrian movement	7
4	Traffic signal controller box	1
5	Traffic police box	1

Table 1.4.2: Duty of Traffic Police.

Post	Morning Shift	Evening Shift
Traffic inspector	1	
Traffic sergeant	1	1
Traffic police	3	3
Ansar	-	-

Table 1.4.3: Existing Traffic Control System and Time of Operation.

Sl. No.	Description	Duration of operation
1	Automatic signal lighting system	(08.00 PM 08.00 AM)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(08.00 AM 11.00 AM) (05.00 PM 08.00 PM)

4	Mixed	(11.00AM 05.00 PM)

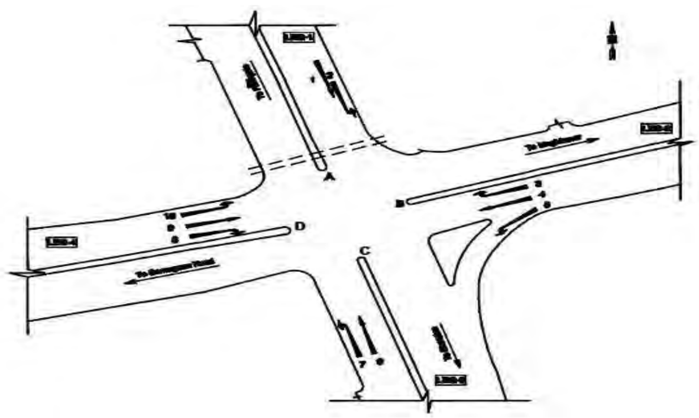
Table 1.4.4: Signal Accessories.

Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/MAP	**Visibility**	**Physical Condition**	**Vehicle Signal Light Operate**	**Pedestrian Signal Light Operate**
SP-1	OK	Two lamp missing	Yes	No
SP-2	OK	Broken	Yes	No
SP-3	OK	Two lamp missing	Yes	No
SP-4	OK	One lamp missing	-	No
MAP-1	OK	OK	Yes	-
MAP-2	OK	One lamp missing	Yes	No
MAP-3	OK	One lamp missing	Yes	-
TSC	OK	OK	-	-

Notes: - No: Currently damage / not working
Yes: In working condition
(-): Not installed

In this preliminary survey, signal postswere found on every approach of this intersection. In this preliminary survey the cycle time of these manually operated traffic signals was calculated. The cycle time measuring data is given below.



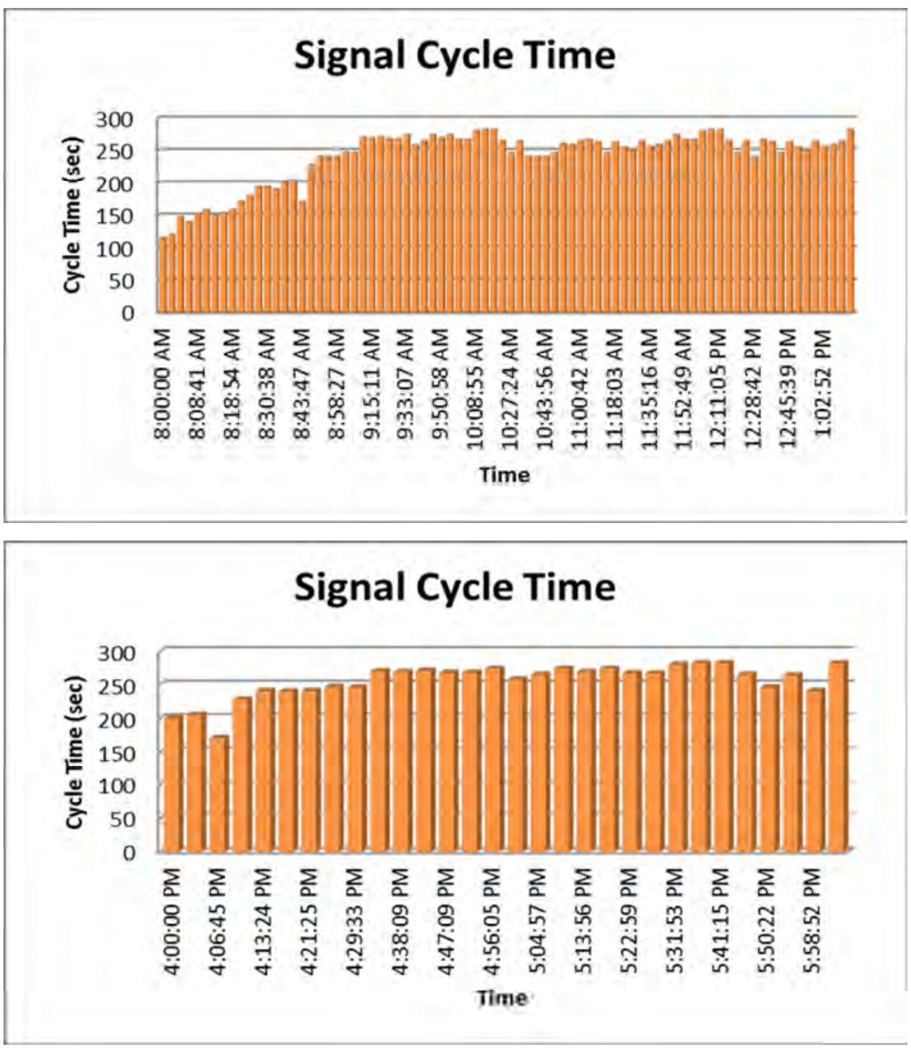


Figure 1.4.12: Signal Cycle Time at Peak Period (a) from 08.00 A.M. to 01.11 P.M. (b) from04.00 P.M. to 05.58 P.M.

1.4.7 Queue Length

Due to long signal cycle time, signal phasing, side friction, demand responsive traffic operation, the queue length was found in two(2) approaches of this intersection, due to construction work of Moghbazar Mouchak flyover. The decision of collection of primary data of this intersection was taken from the field survey and later compared with the secondary data *(CASE study of World Bank Funded Synchronization Study, 2013* The queue length survey result is given here under

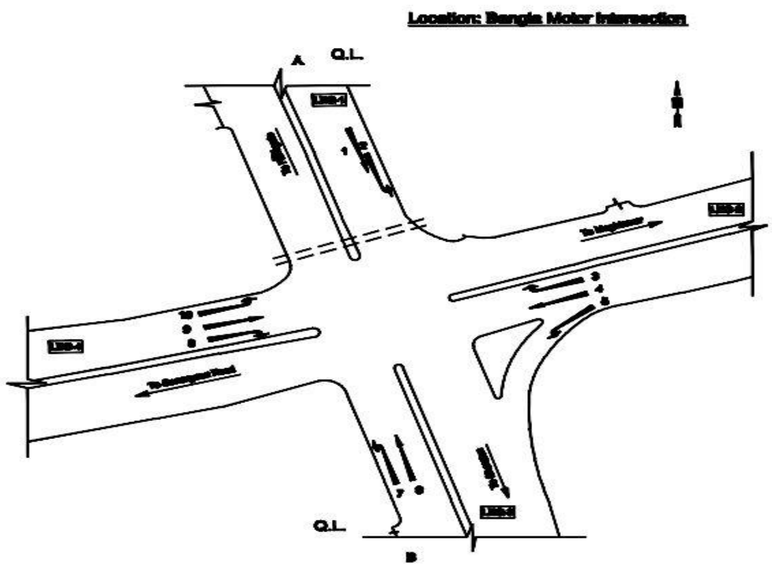


Table 1.4.5: Queue Length at Different Approach of Bangla Motor Intersection in meter (at Morning Peak).

Observation No.	From	To	Farmgate to Bangla Motor approach	Sheraton to Bangla Motor approach
1	8:00:00 AM	8:15:00 AM	0	0
2	8:15:00 AM	8:30:00 AM	116.26	0
3	8:30:00 AM	8:45:00 AM	187.34	0
4	8:45:00 AM	9:00:00 AM	221.34	0
5	9:00:00 AM	9:15:00 AM	278.34	123.57
6	9:15:00 AM	9:30:00 AM	328.92	134.56
7	9:30:00 AM	9:45:00 AM	309.69	176.63
8	9:45:00 AM	10:00:00 AM	345.67	217.34
9	10:00:00 AM	10:15:00 AM	355.45	265.77
10	10:15:00 AM	10:30:00 AM	378.97	298.23
11	10:30:00 AM	10:45:00 AM	393.43	312.23
12	10:45:00 AM	11:00:00 AM	412.21	332.43
13	11:00:00 AM	11:15:00 AM	354.44	342.22
14	11:15:00 AM	11:30:00 AM	385.33	328.92
15	11:30:00 AM	11:45:00 AM	392.23	309.69
16	11:45:00 AM	12:00:00 PM	404.44	345.67
17	12:00:00 PM	12:15:00 PM	408.22	355.45
18	12:15:00 PM	12:30:00 PM	394.56	378.97
19	12:30:00 PM	12:45:00 PM	407.21	393.43
20	12:45:00 PM	1:00:00 PM	401.59	432.22

Table 1.4.6: Queue Length at Different Approach of Bangla Motor Intersection in meter (at Evening Peak).

Observation No.	From	To	Farmgate to Bangla Motor Approach	Sheraton to Bangla Motor Approach
1	4:00:00 PM	4:15:00 PM	355.45	278.44
2	4:15:00 PM	4:30:00 PM	378.97	312.43
3	4:30:00 PM	4:45:00 PM	393.43	356.78
4	4:45:00 PM	5:00:00 PM	412.21	378.53
5	5:00:00 PM	5:15:00 PM	354.44	412.33
6	5:15:00 PM	5:30:00 PM	385.33	443.66
7	5:30:00 PM	5:45:00 PM	392.23	392.23
8	5:45:00 PM	6:00:00 PM	404.44	412.23
9	6:00:00 PM	6:15:00 PM	408.22	422.32

1.4.8 Delay of Intersection

After observing the queue length of Bangla Motor intersection on two (2) approaches, the decision of finding delay on every approach was taken. Due to flyover construction, the data was taken from two approaches only. The free flow travel time was taken from 07.00 AM to 07.30 AM. In this time, the Bangla Motor intersection and its surrounding area areas were calm and soft. So the travel time at free flow condition was collected from two approaches very easily. The travel time in free flow condition is given below.

Table 1.4.7: Travel Time at Free Flow Condition of Bangla Motor Intersection (sec) at from 07.00 A.M to 07.30 A.M.

Observation No.	From	To	SAARC Fowara to Bangla Motor	Paribagh Over Bridge to Bangla Motor
1	7:00:00 AM	7:30:00 AM	4	7

By considering the free flow condition time of vehicle, the delay in two (2) approaches of this intersection was counted. The data of delay is given below.

Table 1.4.8: Delay at Different Approach of Bangla Motor Intersection.

Observation No.	Time		Delay (SAARC Fowara to Bangla Motor) sec	Delay (Paribagh to Bangla Motor) sec
1.	07.00 A.M.	07.30 A.M.	4	4
2.	07.30 A.M.	08.00 A.M.	10	11
3.	08.00 A.M.	08.30 A.M.	14	22
4.	08.30 A.M.	09.00 A.M.	24	42
5.	09.00 A.M.	09.30 A.M.	52	38
6.	09.30 A.M.	10.00 A.M.	72	60

7.	10.00 A.M. 10.30 A.M.	121	106
8.	10.30 A.M. 11.00 A.M.	266	121
9.	11.00 A.M. 11.30 A.M.	321	160
10.	11.30 A.M. 12.00 P.M.	781	288
11.	12.00 P.M. 12.30 P.M.	830	360
12.	12.30 P.M. 01.00 P.M.	928	441
13.	01.00 P.M. 01.30 P.M.	994	537
14.	01.30 P.M. 02.00 P.M.	980	771
15.	02.00 P.M. 02.30 P.M.	963	860
16.	02.30 P.M. 03.00 P.M.	872	758
17.	03.00 P.M. 03.30 P.M.	659	661
18.	03.30 P.M. 04.00 P.M.	883	732
19.	04.00 P.M. 04.30 P.M.	967	819
20.	04.30 P.M. 05.00 P.M.	1039	987
21.	05.00 P.M. 05.30 P.M.	980	980
22.	05.30 P.M. 06.00 P.M.	241	966

1.4.9 Level of Service (LOS)

After calculating the delay of every approach of Bangla Motor intersection, the delay data was compared with the standard un signalized intersection delay data *(HCM, 2010)*. This intersection was controlled by police manually, so definitely Bangla Motor intersection is an un signalized intersection. By comparing with the standardized delay time with the intersection delay data, the level of services of different approaches of Bangla Motor intersection was calculated on the basis of delay. The result of this calculation is tabulated below.

Table 1.4.9: LOS of Different Approaches of Bangla Motor Intersection.

Observation No.	**Time**	**LOS (SAARC Fowara to Bangla Motor)**	**LOS (Paribagh to Bangla Motor)**
1.	07.00 A.M. 07.30 A.M.	A	A
2.	07.30 A.M. 08.00 A.M.	A	B
3.	08.00 A.M. 08.30 A.M.	B	C
4.	08.30 A.M. 09.00 A.M.	C	E
5.	09.00 A.M. 09.30 A.M.	F	E
6.	09.30 A.M. 10.00 A.M.	F	F
7.	10.00 A.M. 10.30 A.M.	F	F
8.	10.30 A.M. 11.00 A.M.	F	F
9.	11.00 A.M. 11.30 A.M.	F	F
10.	11.30 A.M. 12.00 P.M.	F	F
11.	12.00 P.M. 12.30 P.M.	F	F
12.	12.30 P.M. 01.00 P.M.	F	F
13.	01.00 P.M. 01.30 P.M.	F	F

14.	01.30 P.M. 02.00 P.M.	F	F
15.	02.00 P.M. 02.30 P.M.	F	F
16.	02.30 P.M. 03.00 P.M.	F	F
17.	03.00 P.M. 03.30 P.M.	F	F
18.	03.30 P.M. 04.00 P.M.	F	F
19.	04.00 P.M. 04.30 P.M.	F	F
20.	04.30 P.M. 05.00 P.M.	F	F
21.	05.00 P.M. 05.30 P.M.	F	F
22.	05.30 P.M. 06.00 P.M.	F	F

By observing the result of LOS of different approaches of Bangla Motor intersection, failure condition throughout the day was found. Most of the time of the day, the level of service of this intersection was persisted on Level F or failure condition. This is disastrous for today Modern Dhaka city.

In very near future, Bangla Motor intersection will be used as an entrance of Moghbazar Mouchak flyover. The Mogbazar road was blocked for the construction of this flyover around three (3) years.

1.5 Mirpur 10 Intersection

1.5.1 General Description

10 (Golchakkar) roundabout situated on the primary road, Begum Rokeya Avenue at Shah Ali Market. There are four (4) approaches in this round about. The four approaches are divided by narrow medians with barrier. Among the four approaches, the north approaches towards Mirpur 12, there are so many land use activity such asshopping malls, markets, banks, schools, indoor stadium, health clinic, Garments factory, Cantonment area, residential area by both of the sides. To the south approach (towards Agargaon intersection) there are residential areas, shopping mall, government / non-government office, super markets, banks, private schools and colleges, clinics, commercial areas built up both of the sides.

Figure 1.5.1: Google Map of Mirpur 10 intersection.

To the east approach towards Mirpur 14, there are police barrack, NAM Vaban, BRTA office, renowned schools and colleges, Cantonment area, health clinic, residential area are both of the sides. To the west approach, towards Mirpur 1 intersection, Sher-e-Bangla National Cricket Stadium, Swimming pool, BTCL office, National Heart foundation, Kidney foundation, Bank training Institute, Grameen Bank office, university, college, schools, technical institutes, City Corporation office, Markets, Shopping malls, residential area, etc. are built up both of the sides. These land use activities generate huge pedestrian and vehicular flow which creates a tremendous thrust on this round about. All the approaches of the roundabout contain mixed traffic flow. The footpath facilities for pedestrian movements are completely blocked by the street hawkers, forcing pedestrian on to the roadway. Though there is an over bridge for pedestrian crossing the road safely, a very few pedestrian use it. Pedestrians cross the junction matching with their desire paths under risk. Pedestrian would hardly find the suitable gaps within the moving traffic stream to perform the crossing maneuver. At the vicinity of the roundabout approaches, almost all the approaches are provided with illegal stoppage, where the vehicles stands haphazardly create jam. There by reduces the effective width of the road. It is a signalized junction, but it is operated by traffic police manually. Roundabout often quickly become block if circulating traffic is not given right of way. Although the safety record of roundabout is generally good, but it creates problem with slow moving vehicle.

Figure 1.5.2: Mirpur 10 Intersection.

Figure 1.5.3: Approach Road: (a) Towards Mirpur 12, (b) Towards Mirpur 14, (c) Towards Mirpur 2 and (d) Towards Agargaon.

1.5.2 Approaches from Intersection

This Mirpur - 10 contains the flexible pavement as road structure. The road is marked with lane sign, marking, etc. The condition of lane at different of approaches of this intersection is given below.

a) Towards Mirpur 12 - 2 lanes both direction,
b) Towards Mirpur 14 - 2 lanes both direction,
c) Towards Agargaon - 2 lanes both direction, and
d) Towards Mirpur 2 - 2 lanes both direction.

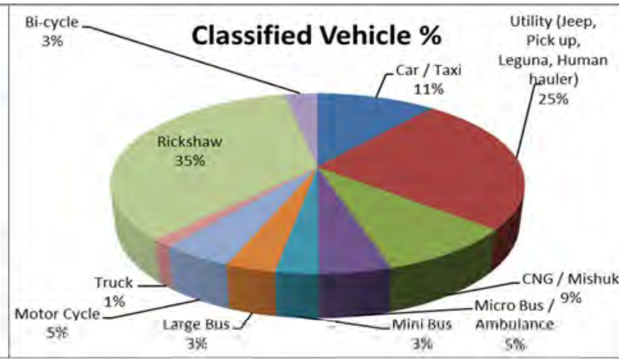
There is no exclusive channelization foe left turn and right turn lane in this intersection.

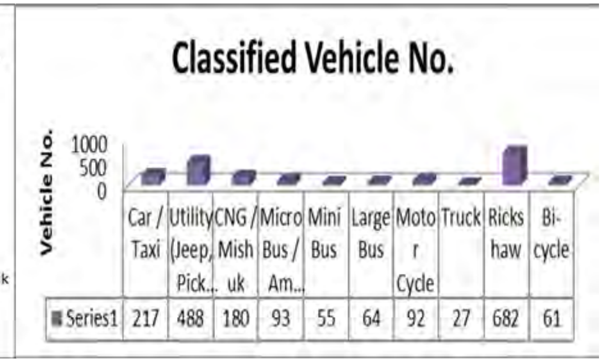
1.5.3 Vehicular Flow of this Intersection

For finding out the level of service (LOS) of this intersection, the decision of classified vehicle counting was taken for this intersection. From preliminary survey of this intersection they found two distinct peak hours 08.30 AM to 12.00 P.M. and 03.30 PM to 06.00 PM and furthermore. So the time was set for survey from 07.00 AM to 06.00 PM, total 11 hours. The result of the vehicular survey is going to be described below.

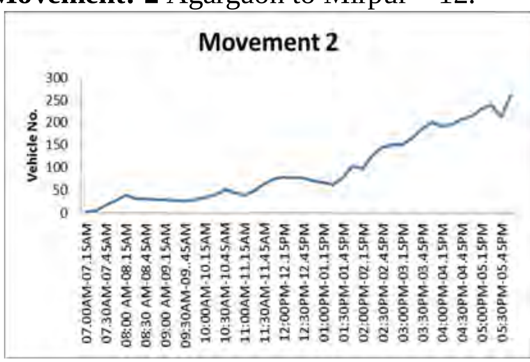
From the preliminary survey of this twelve (12) movements were found in this intersection. They are (1) Agargaon to Mirpur 14, (2) Agargaon to Mirpur 12, (3) Agargaon to Mirpur Thana, (4) Mirpur Thana to Agargaon, (5) Mirpur Thana to Mirpur 14, (6) Mirpur Thana to Mirpur 12, (7) Mirpur 12 to Mirpur Thana, (8) Mirpur 12 to Agargaon, (9) Mirpur 12 to Mirpur 14, (10) Mirpur 14 to Mirpur 12, (11) Mirpur 14 to Mirpur Thana and (12) Mirpur 14 to Agargaon. The vehicular counting data is given below.

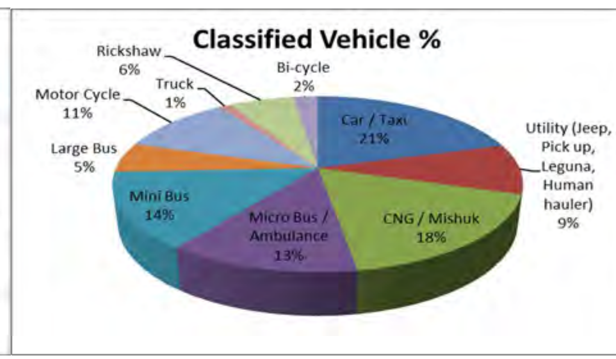
Movement: 1 Agargaon to Mirpur 14.

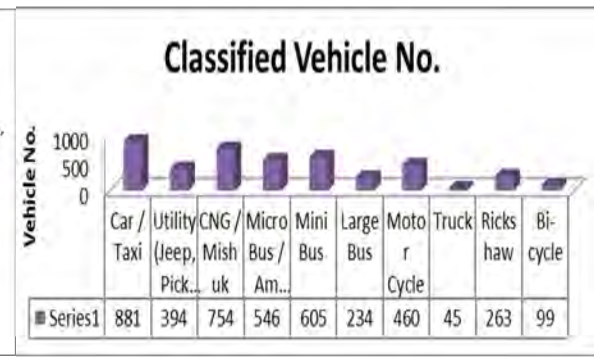




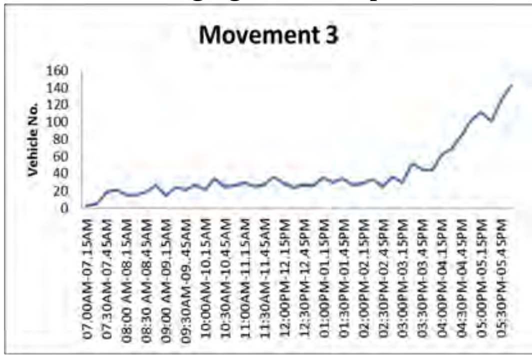
Movement: 2 Agargaon to Mirpur 12.

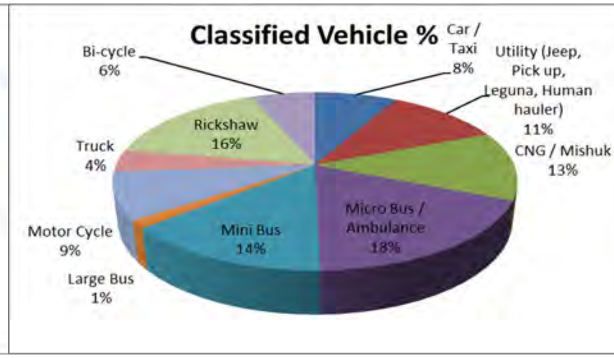


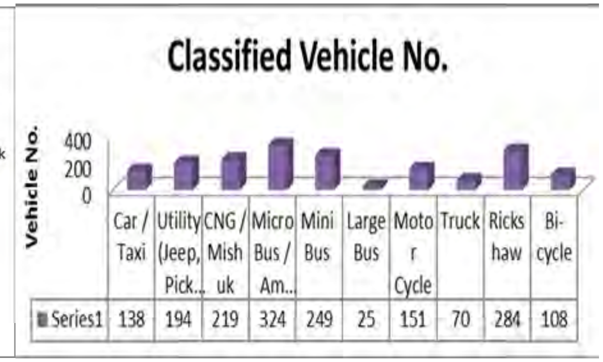




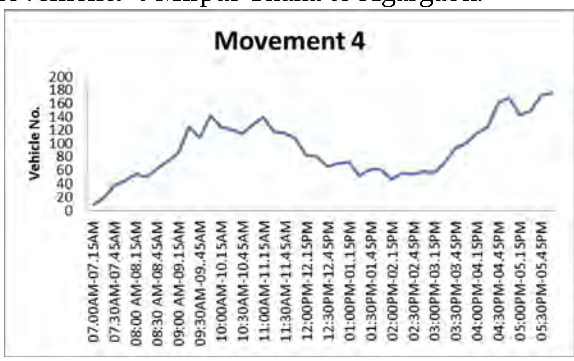
Movement: 3 Agargaon to Mirpur Thana.

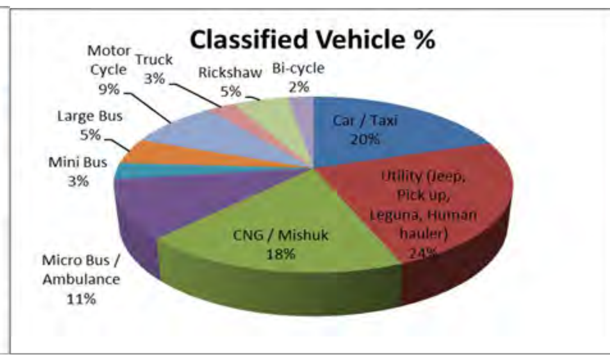


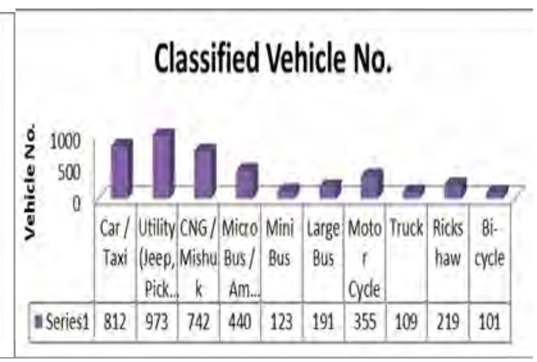




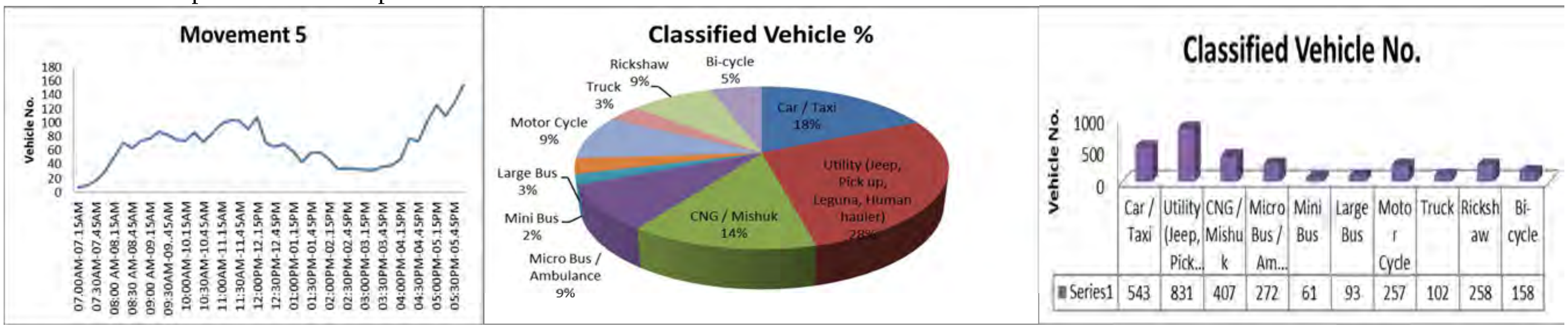
Movement: 4 Mirpur Thana to Agargaon.



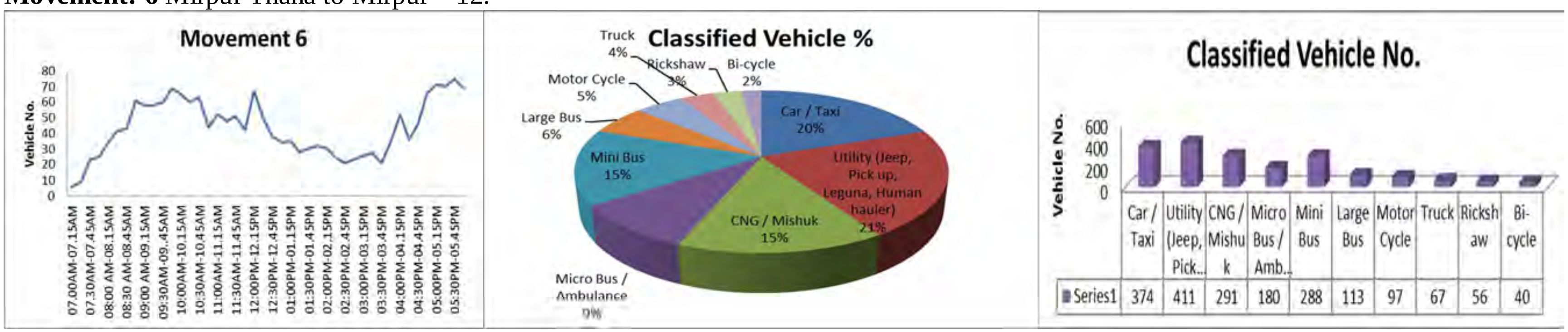




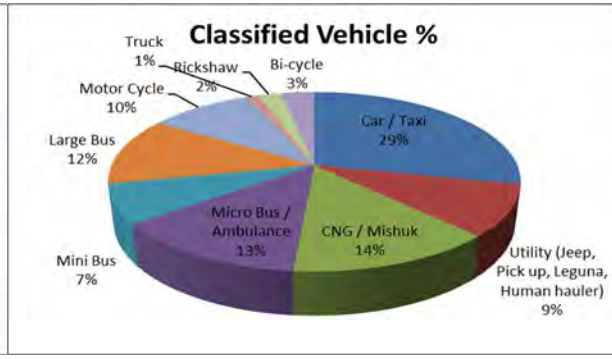
Movement: 5 Mirpur Thana to Mirpur 14.

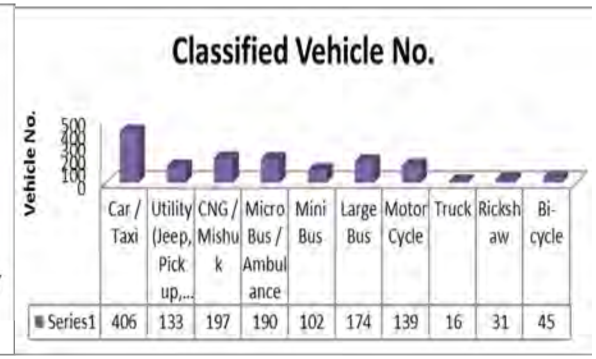


Movement: 6 Mirpur Thana to Mirpur 12.

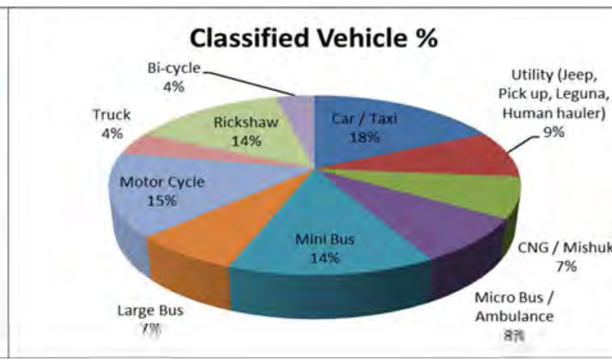


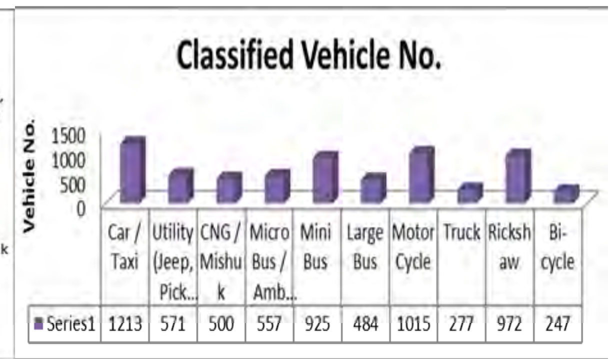
Movement: 7 Mirpur 12 to Mirpur Thana.



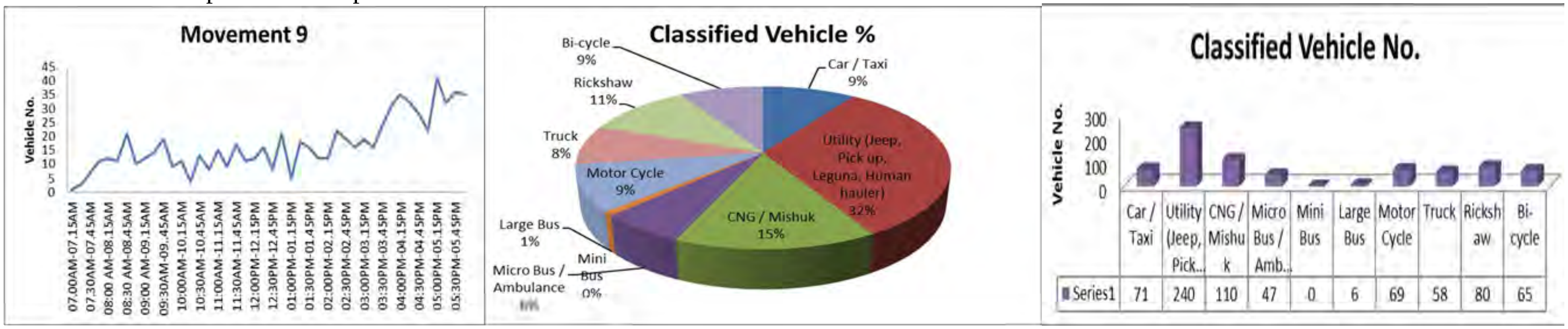


Movement: 8 Mirpur 12 to Agargaon.

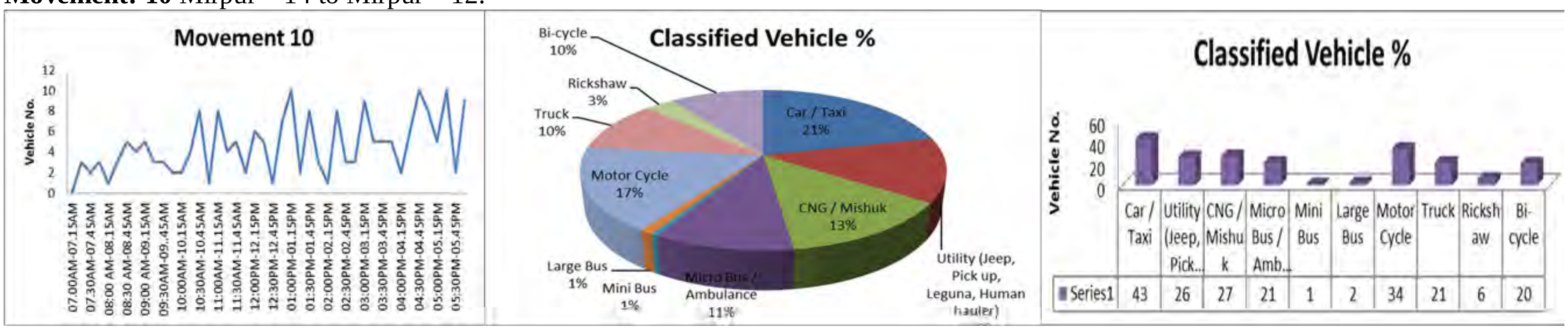




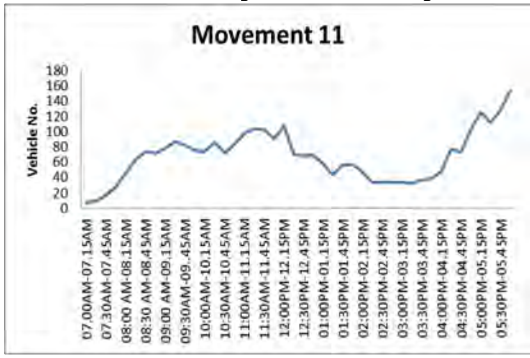
Movement: 9 Mirpur 12 to Mirpur 14.

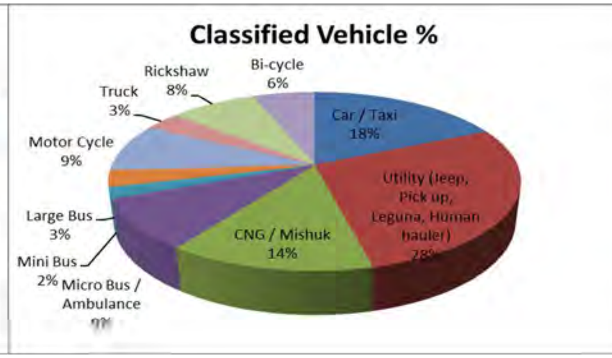


Movement: 10 Mirpur 14 to Mirpur 12.



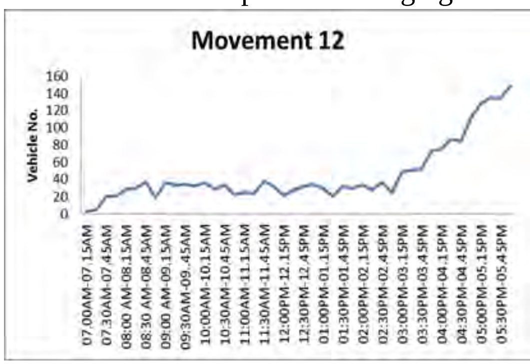
Movement: 11 Mirpur 14 to Mirpur Thana.

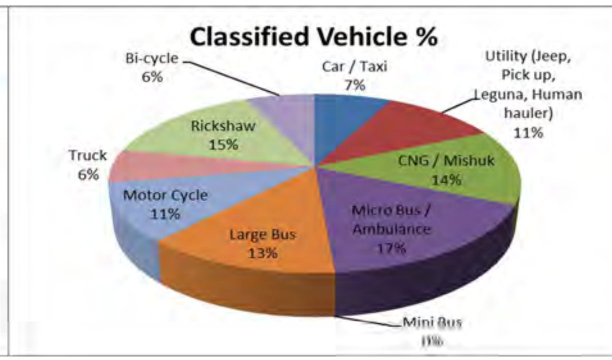




	Car / Taxi	Utility (Jeep, Pick..	CNG / Mishuk	Micro Bus / Amb..	Mini Bus	Large Bus	Motor Cycle	Truck	Rickshaw	Bi-cycle
Series1	544	835	406	276	61	90	256	100	244	173

Movement: 12 Mirpur 14 to Agargaon.





	Car / Taxi	Utility (Jeep, Pick..	CNG / Mishuk	Micro Bus / Am..	Mini Bus	Large Bus	Motor Cycle	Truck	Rickshaw	Bi-cycle
Series1	145	219	275	342	0	261	213	120	308	131

The flow ratio of the four (4) approaches were calculated for finding out the condition of traffic flow situation of individual approach which is related with signal system, signal phasing, queue length, delay, etc. of this intersection. The data of flow ratio is shown below.

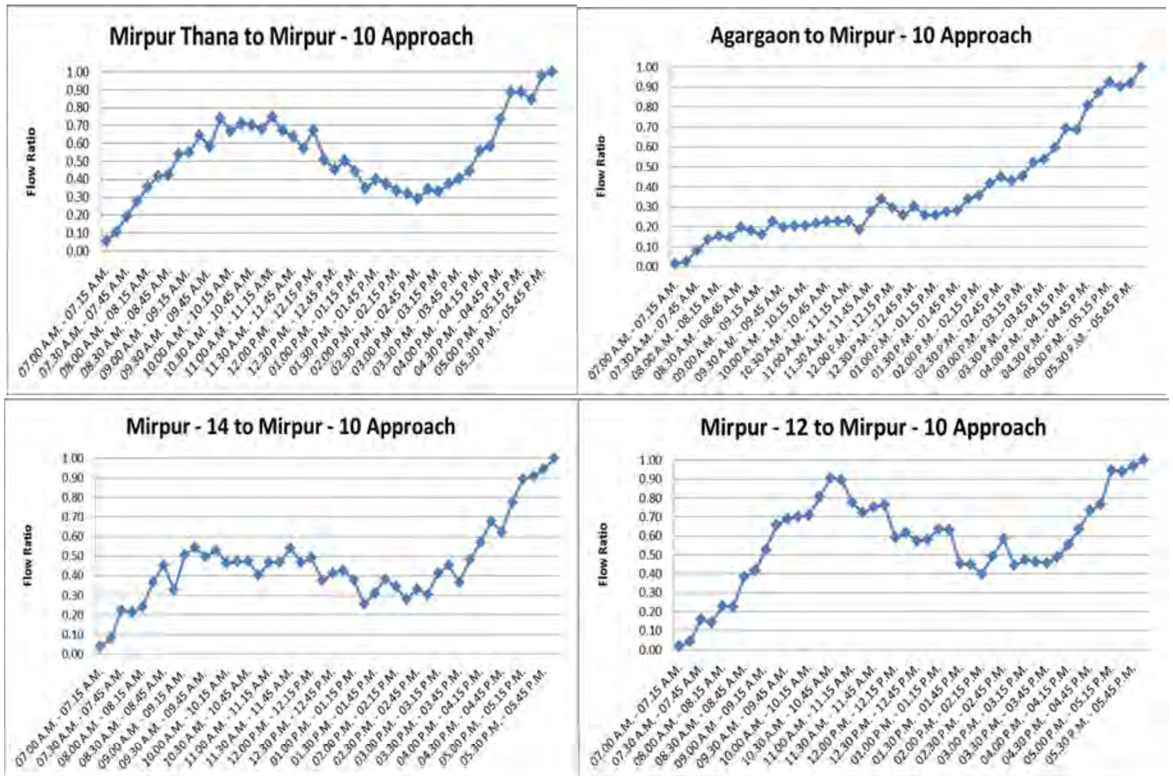


Figure 1.5.4: a) Flow Ratio of Mirpur Thana to Mirpur - 10 Approach; b) Flow Ratio of Agargaon to Mirpur 10 Approach; c) Flow Ratio of Mirpur 14 to Mirpur 10 Approach; d) Flow Ratio of Mirpur 12 to Mirpur 10 Approach.

1.5.4 Pedestrian Flow of this Intersection

In the time of field survey, the pedestrian flow was measured in this intersection with the vehicular flow. The result of pedestrian survey is given below.

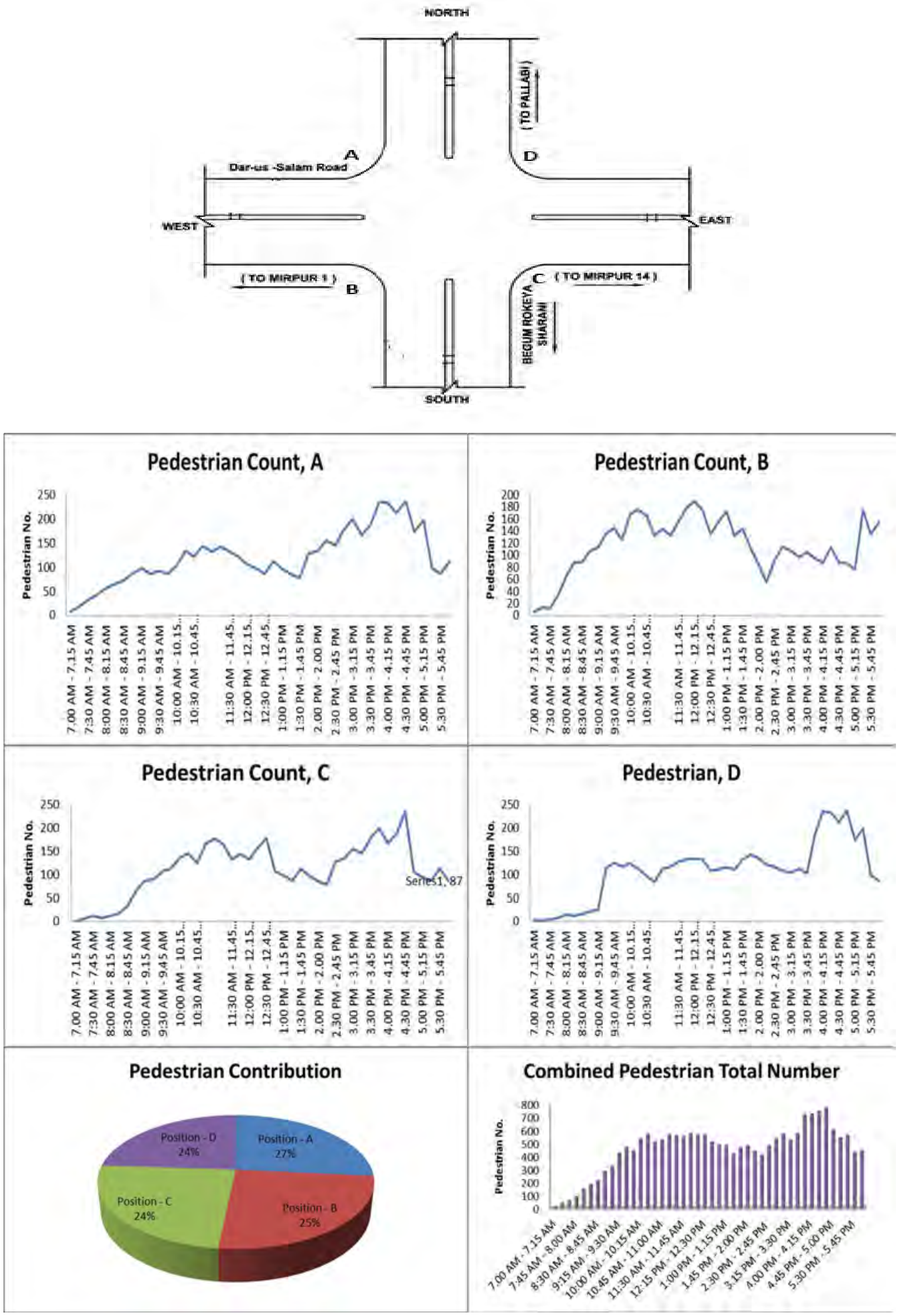


Figure 1.5.5: Pedestrian Count of Mirpur 10 Intersection**.**

In this intersection, there is an over bridge having four (4) leg. A very few amount of pedestrian use it for road crossing. A counting survey was arranged for finding out the pedestrian amount from this survey. The survey data is given here under.

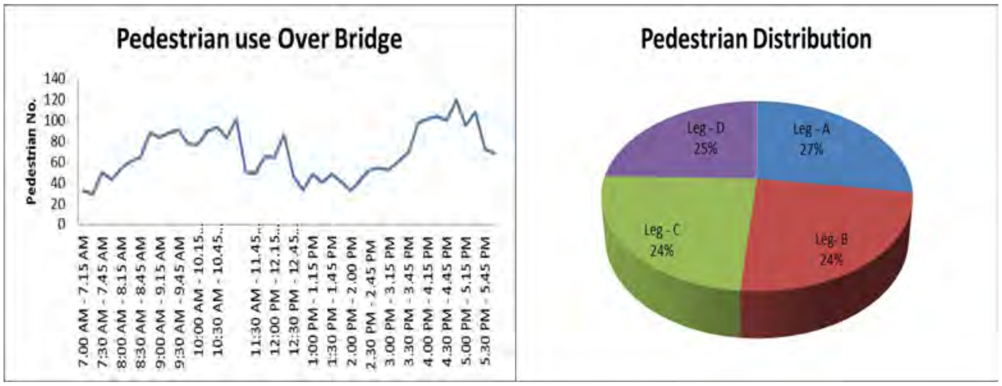


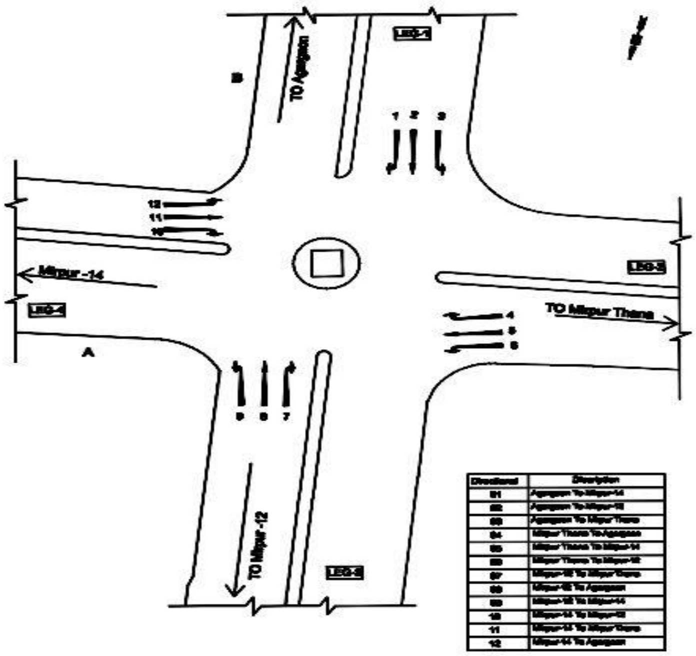
Figure 1.5.6: Pedestrian Using Foot Over Bridge.

Around 15% of total pedestrian of this intersection are using this over bridge.

1.5.5 Side Friction

By analyzing the detail survey of Mirpur 10 intersection, a lot of source for side friction were found. In side this intersection rickshaw stand, Laguna stand, buss stand, etc. was found, and for finding out the real situation county survey was arranged.

In this intersection, two Laguna / Human Hauler / CNG stand was found. The positions of the two places are shown in a CAD drawing of Mirpur 10 intersection.



Mirpur-10 Intersection

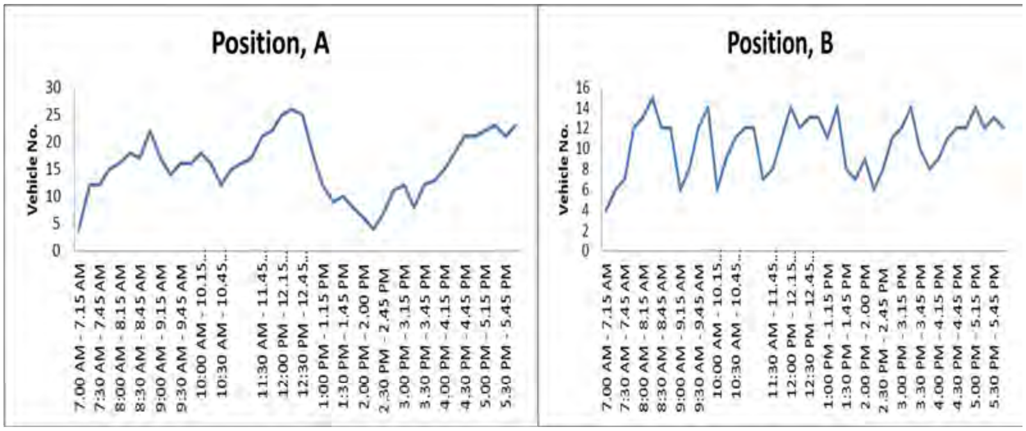


Figure 1.5.7: Illegal Human Hauler / Laguna Stand.

In the field survey, the three positions were found, where illegal bus stand situated. This type of bus stoppage reduced the effective width of the road. A counting survey was organized in these positions for finding out the real situation. The data of this survey is given below.

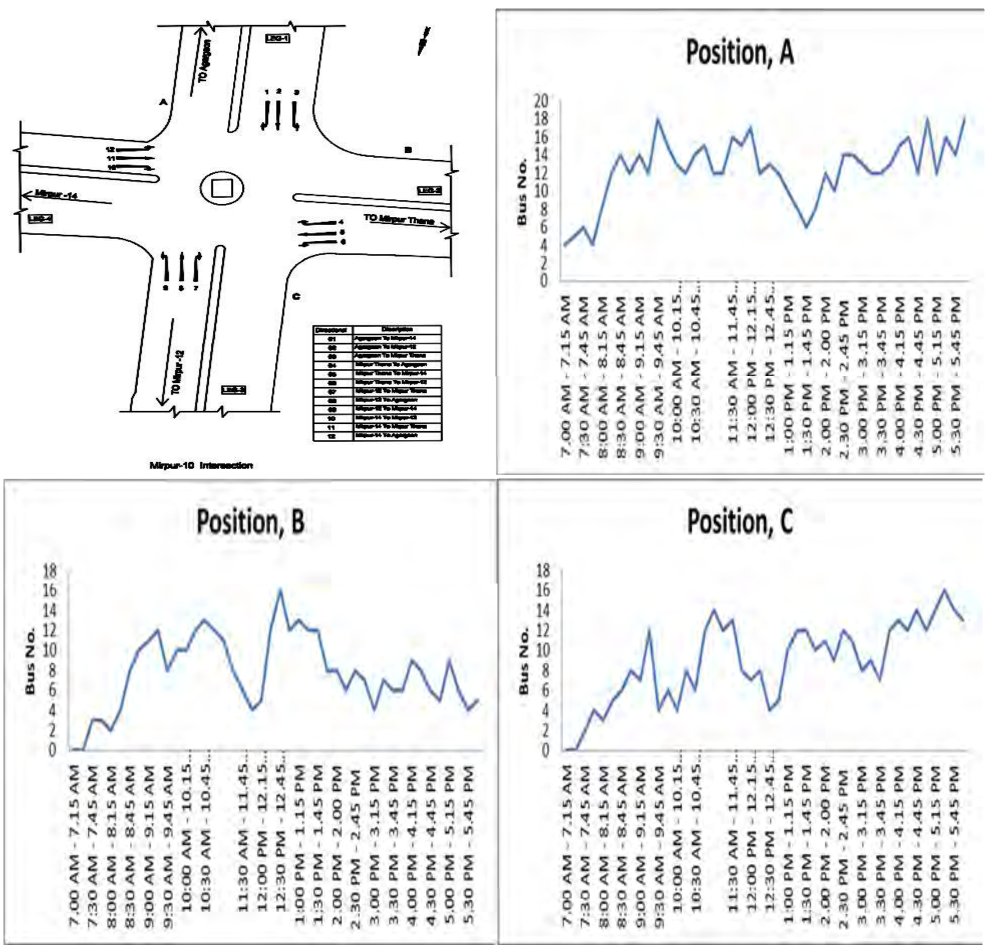


Figure 1.5.8: Illegal Bus Stand.

In this intersection, the illegal rickshaw stand was found. Though community polices try to divert all rickshaws from this intersection. But four (4) distinct places were found using as a rickshaw stand inside the intersection. A counting survey was organized for finding out the real situation. The data of this survey is given below.

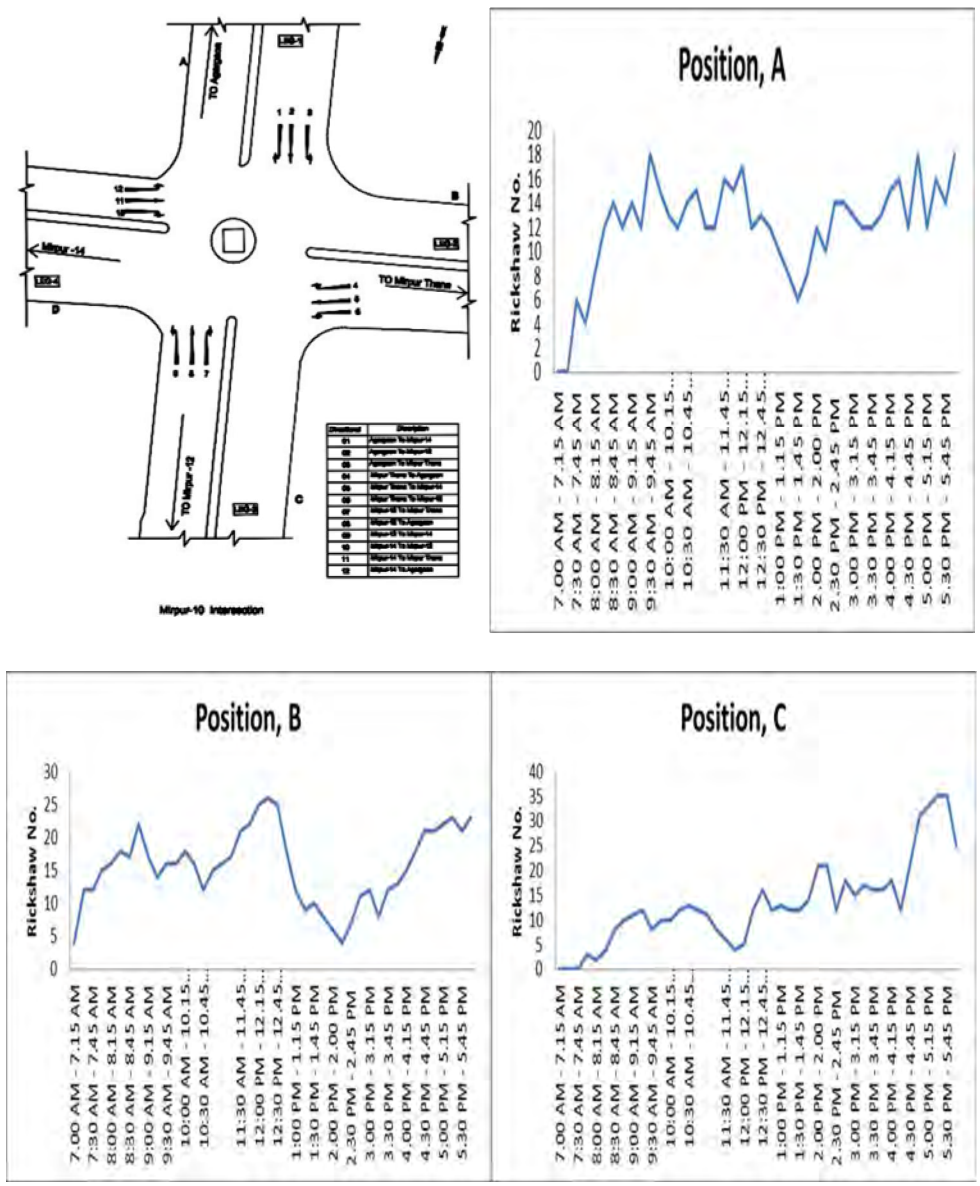


Figure 1.5.9: Illegal Rickshaw Stand.

A lot of side frictions were found on the mouth of the approach of this intersection, which interrupted the traffic flow in this intersection. It delayed the vehicular flow of this intersection. For this the Level of Service (LOS) dropped a lot in this intersection.

1.5.6 Traffic Control Devices

Though Mirpur 10 intersection is a roundabout intersection. But it is operated as a four leg intersection. Internationally, there is no provision to operate a roundabout with signal. But in this Mirpur 10 intersection, there are signals in every approaches.

A survey of traffic control device was done in the time of preliminary survey of Mirpur 10 intersection. The result of this survey is described below.

Table 1.5.1: Features of Intersection and Traffic Control System.

Sl No.	Description	Nos.
1	Number of legs	4
2	Direction of traffic	12
3	Signal post for vehicular and pedestrian movement	15
4	Traffic signal controller box	1
5	Traffic police box	1

Table 1.5.2: Duty of Traffic Police.

Post	Morning Shift	Evening Shift
Traffic inspector	1	
Traffic sergeant	1	1
Traffic police	4	4
Community police	3	3

Table 1.5.3: Existing Traffic Control System and Time of Operation.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(08.00 PM 08.00 AM)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(08.00 AM 11.00 AM) (05.00 PM 08.00 PM)
4	Mixed	(11.00AM 05.00 PM)

Table 1.5.4: Signal Accessories.

Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Operate	Pedestrian Signal Operate
SP-1	OK	Rotated	Yes	No
SP-2	OK	OK	-	No
SP-3	OK	OK	-	No
SP-4	OK	All missing	-	-
SP-5	OK	OK	No	No
SP-6	OK	Rotated	-	No
SP-7	OK	Rotated	Yes	No
SP-8	OK	Missing	-	No

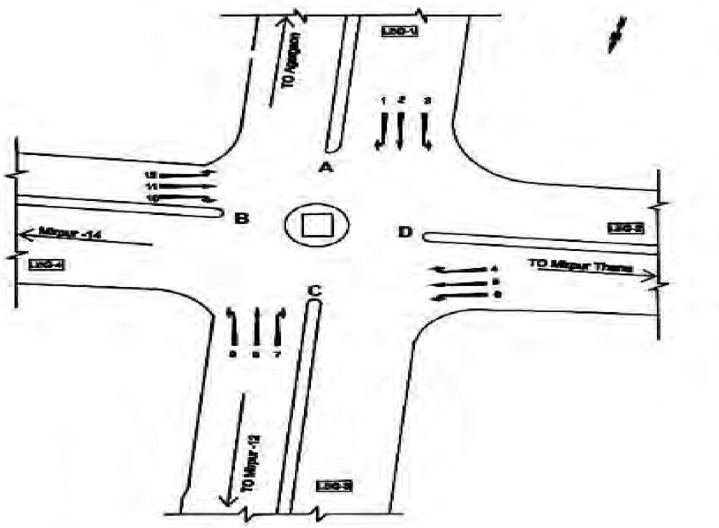
SP-9	Signal lights hidden	Missing	Yes	No
SP-10	OK	Missing	-	No
MAP-1	Signal lights hidden	Missing	Yes	No
MAP-2	OK	OK	-	-
MAP-3	OK	Rotated	-	No
MAP-4	OK	Missing	No	-
MAP-5	One side signal light hidden	OK	Yes	No
TSC	OK	OK	-	-

Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

This preliminary survey, signal posts were found on every approach of this intersection. In this preliminary survey, the cycle time of these signals was found. The cycle time measuring data is given below.



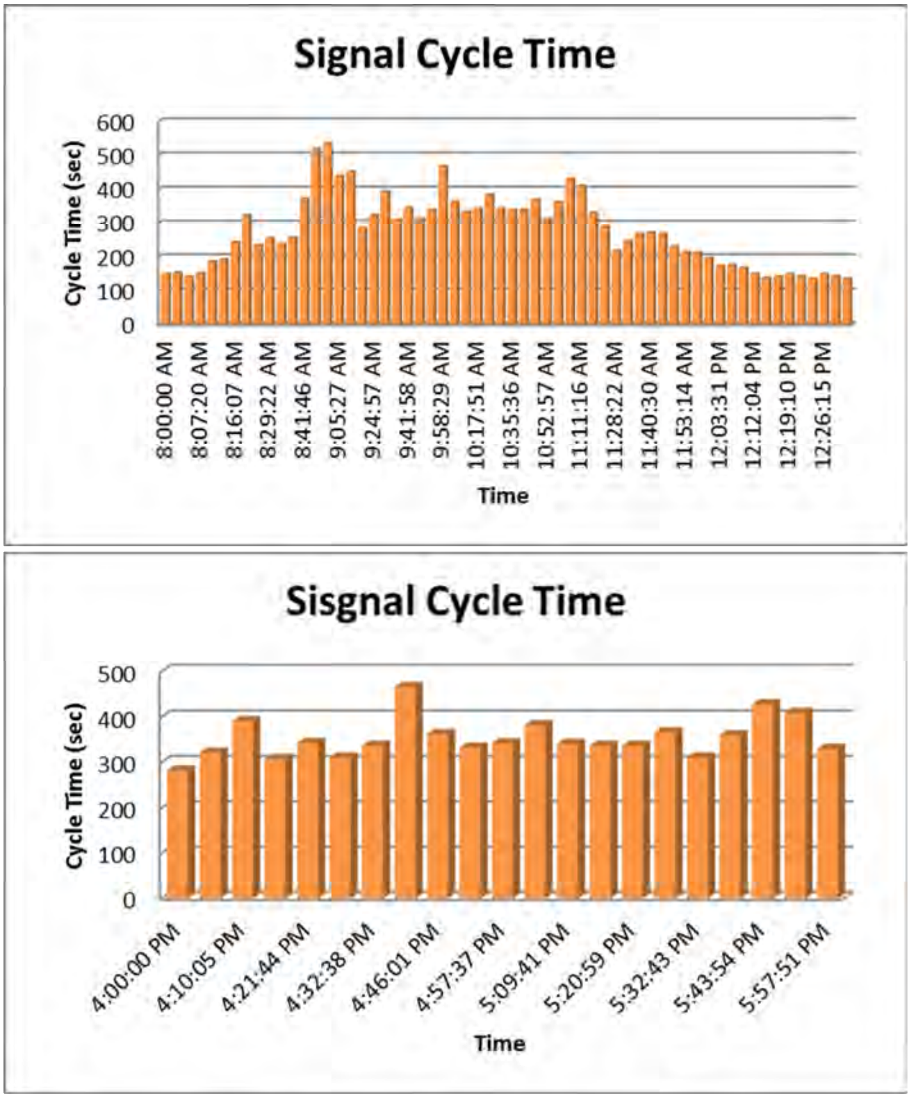


Figure 1.5.10: Position of Signal Post and Signal Cycle Time at Peak periods a) from 08.00 A.M. to 12.31 P.M. and b) from 04.00 P.M. to 05.57 P.M.

1.5.7 Queue Length

Due to long signal cycle time, signal phasing, side friction, demand responsive traffic operation, queue length was found in three approaches of this intersection. For collecting primary data decision was taken of this intersection from the field survey and later compared with the secondary data (CASE study of World Bank Funded *Signal Synchronization Study, 2013* The primary data of the survey team is given here under.

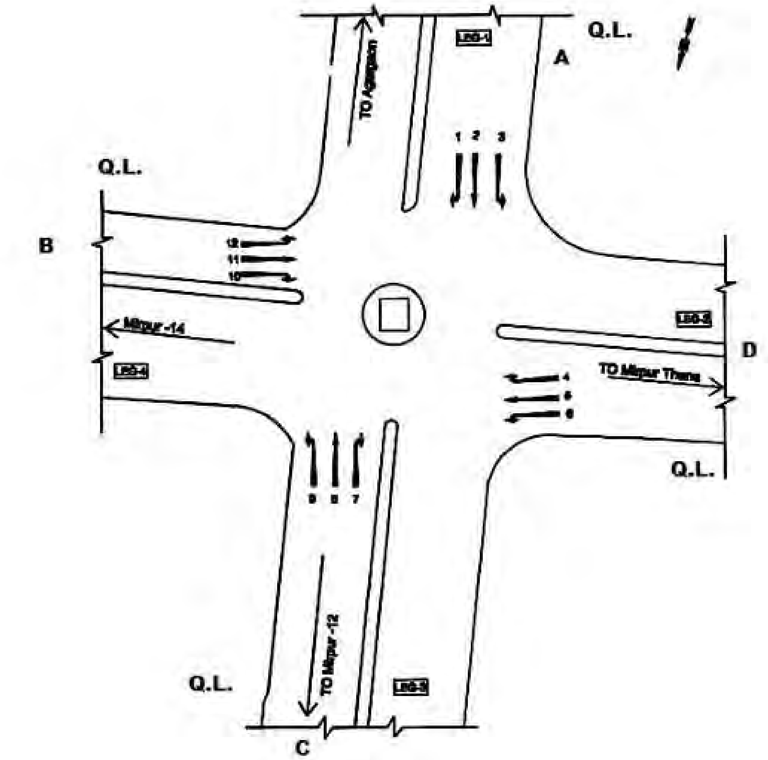


Table 1.5.5: Queue Length at Different Approach of Mirpur 10 Intersection in meter (at Morning Peak).

Observation No.	From	To	Agargaon to Mirpur - 10 approach	Mirpur 14 to Mirpur - 10 approach	Mirpur 12 to Mirpur - 10 approach	Mirpur Thana to Mirpur - 10 approach
1	8:00:00 AM	8:15:00 AM	0	0	125.67	0
2	8:15:00 AM	8:30:00 AM	95.7	0	145.44	0
3	8:30:00 AM	8:45:00 AM	142.05	67.83	212.33	112.32
4	8:45:00 AM	9:00:00 AM	162.05	87.23	245.21	142.33
5	9:00:00 AM	9:15:00 AM	185.49	74.56	279.32	162.05
6	9:15:00 AM	9:30:00 AM	211.06	91.23	282.31	185.49
7	9:30:00 AM	9:45:00 AM	214.77	88.34	311.33	211.06
8	9:45:00 AM	10:00:00 AM	239.81	101.45	323.33	214.77
9	10:00:00 AM	10:15:00 AM	176.76	103.56	344.32	239.81
10	10:15:00 AM	10:30:00 AM	188.98	112.34	287.22	176.76
11	10:30:00 AM	10:45:00 AM	221.77	98.33	322.32	188.98
12	10:45:00 AM	11:00:00 AM	204.46	87.97	311.22	212.33
13	11:00:00 AM	11:15:00 AM	243.78	106.45	309.76	245.21
14	11:15:00 AM	11:30:00 AM	245.76	105.78	312.56	279.32
15	11:30:00 AM	11:45:00 AM	252.77	144.78	332.22	282.31
16	11:45:00 AM	12:00:00 PM	231.23	132.56	307.92	311.33
17	12:00:00 PM	12:15:00 PM	228.98	167.76	282.33	323.33
18	12:15:00 PM	12:30:00 PM	232.67	202.33	266.55	312.33

Table 1.5.6: Queue Length at Different Approach of Mirpur 10 Intersection in meter (at Evening Peak).

Observation No.	From	To	Agargaon to Mirpur - 10 approach	Mirpur 14 to Mirpur - 10 approach	Mirpur 12 to Mirpur - 10 approach	Mirpur Thana to Mirpur - 10 approach
1	4:00:00 PM	4:15:00 PM	311.33	124.45	279.32	322.32
2	4:15:00 PM	4:30:00 PM	323.33	127.41	282.31	311.22
3	4:30:00 PM	4:45:00 PM	352.33	118.00	311.33	309.76
4	4:45:00 PM	5:00:00 PM	287.22	134.67	323.33	312.56
5	5:00:00 PM	5:15:00 PM	322.32	154.78	348.32	332.22
6	5:15:00 PM	5:30:00 PM	311.22	207.89	287.22	307.92
7	5:30:00 PM	5:45:00 PM	309.76	245.67	322.32	282.33
8	5:45:00 PM	6:00:00 PM	312.56	255.67	311.22	266.55

1.5.8 Delay of Intersection

After observing the queue length of Mirpur 10 intersection on four (4) approaches, the decision of finding delay on every approach was taken. For taking data of free flow travel time from 07.00 AM to 07.30 AM was taken. In this condition, the Mirpur 10 intersection and its surrounding intersection areas were calm and soft. So the researcher team collected vehicle travel time in free flow condition very easily all four approaches. The travel time in free flow condition is given below.

Table 1.5.7: Travel Time at Free Flow Condition of Mirpur 10Intersection (sec) at from 07.00 A.M to 07.30 A.M.

Observation No.	From	To	Benarosi 1 No. Gate to Mirpur 10	Al-Helal Hospital to Mirpur 10	Mirpur 2 to Mirpur 10	DWASA training Center to Mirpur 10
1	7:00:00 AM	7:30:00 AM	4	7	5	8

By considering the free flow condition time of vehicle, the delay in four (4) approaches of this intersection was counted. The data of delay is given below.

Table 1.5.8: Delay at Different Approach of Mirpur 10 Intersection.

Observation No.	From	To	Benarosi 1 No. Gate to Mirpur 10	Delay (Benarasi 1 No. Gate to Mirpur 10)	Al-Helal Hospital to Mirpur 10	Delay (Al-Helal Hospital to Mirpur 10)	Mirpur 2 to Mirpur 10	Delay (Mirpur 2 to Mirpur 10)	DWASA training Center to Mirpur 10	Delay (DWASA training Center to Mirpur 10)
1	7:00:00 AM	7:30:00 AM	8	4	11	4	7	2	8	0
2	7:30:00 AM	8:00:00 AM	18	14	14	7	12	7	16	8
3	8:00:00 AM	8:30:00 AM	25	21	34	27	14	9	32	24
4	8:30:00 AM	9:00:00 AM	245	241	33	26	13	8	44	36
5	9:00:00 AM	9:30:00 AM	485	481	28	21	132	127	89	81
6	9:30:00 AM	10:00:00 AM	746	742	34	27	144	139	121	113
7	10:00:00 AM	10:30:00 AM	865	861	65	58	213	208	221	213
8	10:30:00 AM	11:00:00 AM	884	880	127	120	332	327	287	279
9	11:00:00 AM	11:30:00 AM	755	751	223	216	446	441	128	120
10	11:30:00 AM	12:00:00 PM	656	652	356	349	548	543	89	81
11	12:00:00 PM	12:30:00 PM	168	164	443	436	557	552	229	221
12	12:30:00 PM	1:00:00 PM	56	52	558	551	674	669	367	359
13	1:00:00 PM	1:30:00 PM	43	39	669	662	778	773	478	470
14	1:30:00 PM	2:00:00 PM	55	51	442	435	831	826	598	590
15	2:00:00 PM	2:30:00 PM	87	83	335	328	556	551	659	651
16	2:30:00 PM	3:00:00 PM	132	128	487	480	433	428	879	871
17	3:00:00 PM	3:30:00 PM	187	183	552	545	339	334	998	990
18	3:30:00 PM	4:00:00 PM	221	217	487	480	287	282	1078	1070
19	4:00:00 PM	4:30:00 PM	487	483	776	769	445	440	945	937
20	4:30:00 PM	5:00:00 PM	785	781	887	880	558	553	996	988
21	5:00:00 PM	5:30:00 PM	877	873	978	971	776	771	987	979
22	5:30:00 PM	6:00:00 PM	916	912	1038	1031	914	909	887	879

1.5.9 Level of Service (LOS)

After calculating the delay of every approach of Mirpur - 10intersection, the delay data was compared with the standard un signalized intersection delay data *(HCM, 2010)*. This intersection was controlled by police manually, so definitely Mirpur - 10intersection is an un signalized intersection. By comparing with the standardized delay time with the intersection delay data, the level of services of different approaches of Mirpur - 10intersectionwas calculated on the basis of delay. The result of this calculation is tabulated below.

Table 1.5.9: LOS of Different Approaches of Mirpur 10 Intersection.

Observation No.	Time	LOS (Benarasi 1 No. Gate to Mirpur - 10)	LOS (Al-Helal Hospital to Mirpur 10)	LOS (Mirpur 2 to Mirpur 10)	LOS (DWASA training Center to Mirpur 10)
1.	07.00 A.M. 07.30 A.M.	A	A	A	A
2.	07.30 A.M. 08.00 A.M.	B	A	A	A
3.	08.00 A.M. 08.30 A.M.	C	D	A	C
4.	08.30 A.M. 09.00 A.M.	F	D	A	E

5.	09.00 A.M.	09.30 A.M.	F	C	F	F
6.	09.30 A.M.	10.00 A.M.	F	D	F	F
7.	10.00 A.M.	10.30 A.M.	F	E	F	F
8.	10.30 A.M.	11.00 A.M.	F	F	F	F
9.	11.00 A.M.	11.30 A.M.	F	F	F	F
10.	11.30 A.M.	12.00 P.M.	F	F	F	F
11.	12.00 P.M.	12.30 P.M.	F	F	F	F
12.	12.30 P.M.	01.00 P.M.	F	F	F	F
13.	01.00 P.M.	01.30 P.M.	E	F	F	F
14.	01.30 P.M.	02.00 P.M.	F	F	F	F
15.	02.00 P.M.	02.30 P.M.	F	F	F	F
16.	02.30 P.M.	03.00 P.M.	F	F	F	F
17.	03.00 P.M.	03.30 P.M.	F	F	F	F
18.	03.30 P.M.	04.00 P.M.	F	F	F	F
19.	04.00 P.M.	04.30 P.M.	F	F	F	F
20.	04.30 P.M.	05.00 P.M.	F	F	F	F
21.	05.00 P.M.	05.30 P.M.	F	F	F	F
22.	05.30 P.M.	06.00 P.M.	F	F	F	F

By observing the result of LOS of different approaches of Mirpur - 10intersection, failure condition throughout the day was found. Most of the time of the day, the level of service of this intersection was persisted on Level F or failure condition. This is disastrous for today Modern Dhaka City.

1.6 Shapla Chattar Intersection

1.6.1 General Description

The Shapla Chattar roundabout intersection is situated on the central part of the Dhaka Metropolitan city at Motijheel in front of Bangladesh Bank. This is a busy intersection as well as wide roundabout junction. This is a three legged round about junction. The three approaches of the intersection are divided by the narrow medians without barrier. Among the three approaches, the north approaches towards Toyenbee road, there are so many land using activity such as shopping malls, market, banks,schools, colleges, business complex, high rise office buildings, health clinics, government staff quarters, residential area by both of the sides.To the south approach (meeting with Ram Krishno Mission Road) there are residential areas, shopping malls, government / non-government office, Dhaka Stock Exchange, super markets, banks, private school and college, clinics, commercial areas are built up on both of the sides.

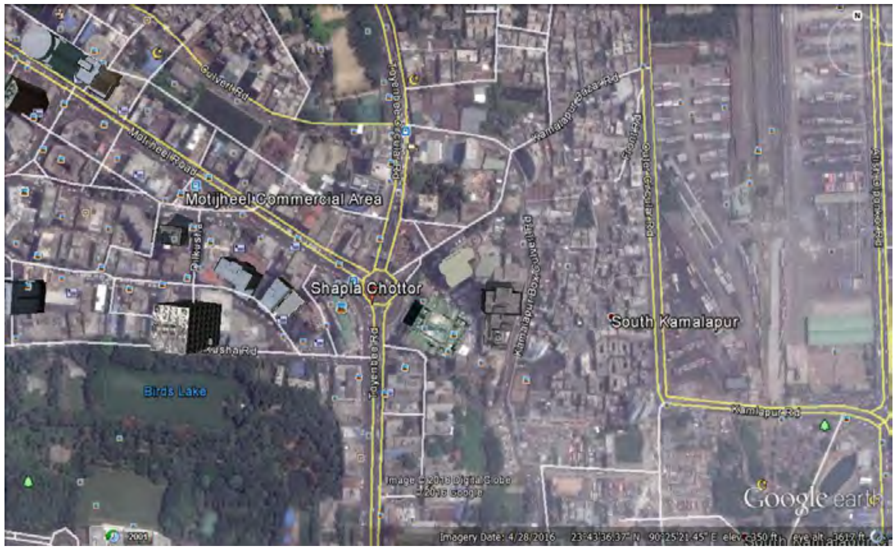


Figure 1.6.1: Google Map of Shapla Chattar intersection.

To the west approach towards High Court Intersection Bangabandhu Stadium, Baitul Mukarram Mosque, renowned hotels, Bank

Football Club, Baitul Mukarram market, secretariat, GPO, Press Club, etc. are built up on both of the sides. These land using activities generate huge pedestrian and vehicular flow which creates a tremendous thrust on this round about. All the approaches of the roundabout contain mixed traffic flow. The footpath facilities for pedestrian movements are completely blocked by the street hawkers, forcing pedestrian on to the roadway. Though there is an over bridge on Northern approach for pedestrian crossing the road safely, a very few pedestrian use it. Pedestrians cross the junction matching with their desire paths under risk. Pedestrian would hardly find the suitable gaps within the moving traffic stream to perform the crossing maneuver. Parts of the road space always remain block with parked vehicle. At the vicinity of the roundabout approaches, almost all the approaches are provided with illegal stoppage, where the vehicles stand haphazardly creating jam. There by reduces the effective width of the road. It is a signalized junction, but it is operated by traffic police manually. Roundabout often quickly become block if circulating traffic is not given right of way. Although the safety record of roundabout is generally good, but it creates problem with slow moving vehicle.

Figure 1.6.2: Shapla Chattar Map.

Shapla Chattar intersection is situated in the Central Business District (CBD) in Dhaka Metropolitan City area. It is situated in Motijheel area. A lot of offices are around in this intersection. Very important educational institute are near about from this intersection, such as Notre Dame College. This intersection keep link with Kamlapur Railway Station, Banga Vaban, Bangbandhu National Stadium, Baitul Mukarram and many other places. It ensures the traffic flow from CBD. This is a commercial place indeed. Three government bank is situated in this intersection is very closely, they are

a) Bangladesh Bank,
b) Sonali Bank and
c) Janata Bank.

Figure 1.6.3: Approach Road (a) Tikatuli Road; (b) Kamlapur Road, (c) Arambagh Road, and (d) Shapla Chattar Intersection.

1.6.2 Approaches from Intersection

This Shapla Chattar contains the flexible pavement as road structure. The road is marked with lane sign, marking, etc. The condition of lane at different approaches of this intersection is given below.

a) Road from Baitul Mukarram 3 lane both direction,
b) Road from Arambagh 3 lane both direction,
c) Road from Tikatuli 3 lane both direction,
d) Road from Kamlapur No lane division (Minor Road).

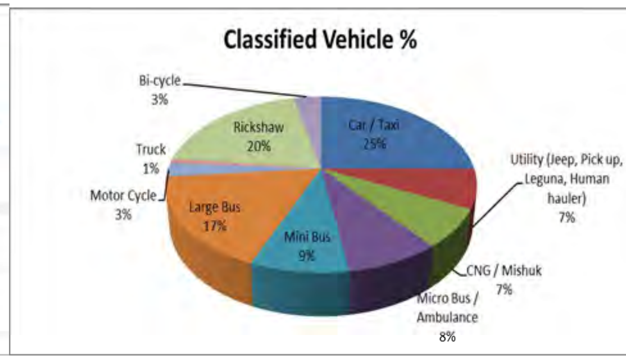
There is an exclusive left turn on the mouth of Baitul Mukarram Road and right turn lane in this intersection.

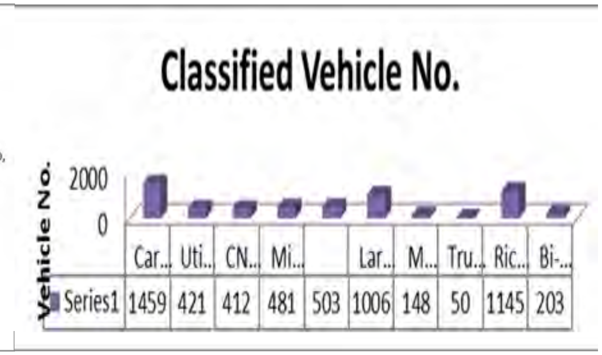
1.6.3 Vehicular Flow of this Intersection

For finding out the level of service (LOS) of this intersection, classified vehicle counting survey was organized in this intersection. From preliminary survey of this intersection they found two distinct peak hours 09.00 AM to 12.30 PM and 04.30 PM to 06.00 P.M and furthermore. So survey time was set from 07.00 AM to 06.00 PM, total 11 hours. The result of the vehicular survey is going to be described below.

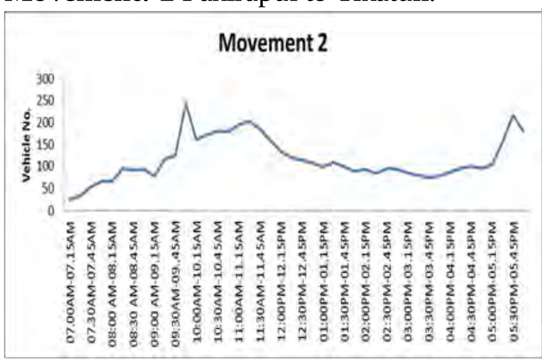
From the preliminary survey of this intersection, six (6) movements were found in this intersection. They are (1) Fakirapul to Baitul Mukarram, (2) Fakirapul to Tikatuli, (3) Kamplapur to Baitul Mukarram / Tikatuli, (4) Tikatuli to Fakirapul, (5) Tikatuli to Baitul Mukarram and (6) Baitul Mukarram to Fakirapul. The vehicular counting data is given below.

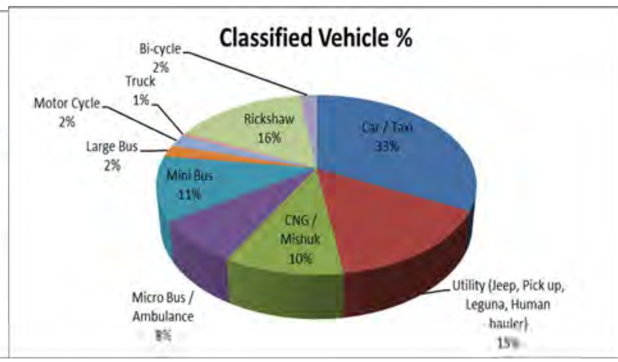
Movement: 1 Fakirapul to Baitul Mukarram.

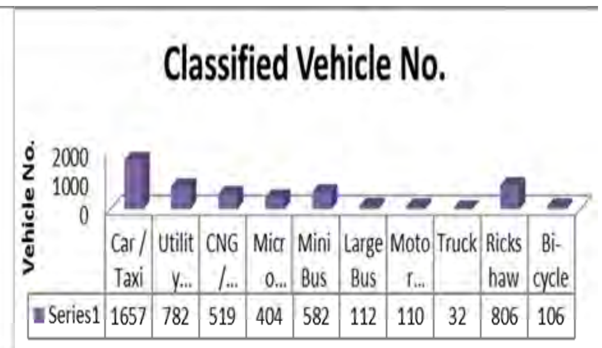




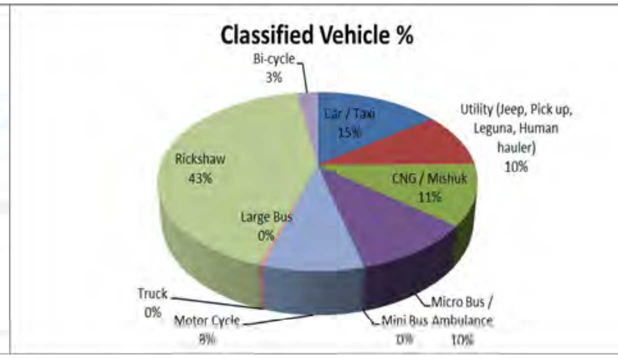
Movement: 2 Fakirapul to Tikatuli.

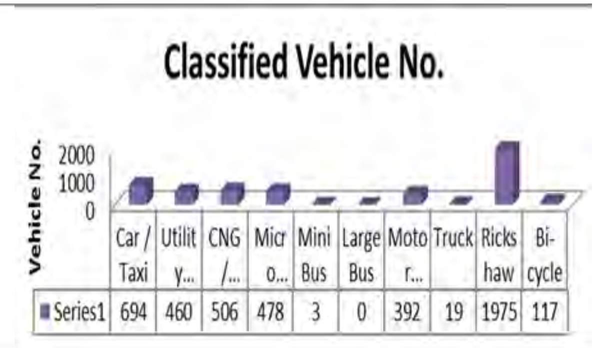




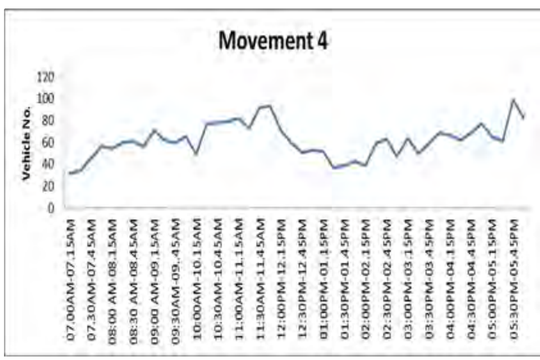


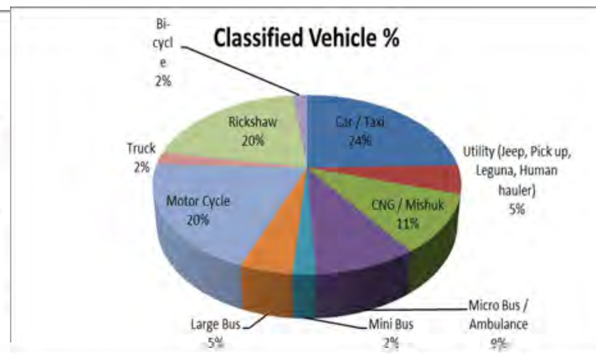
Movement: 3 Kamplapur to Baitul Mukarram / Tikatuli.

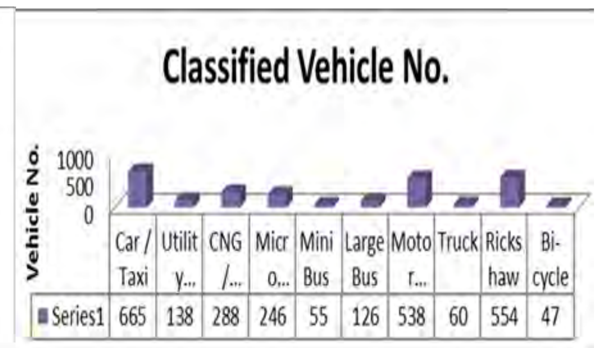




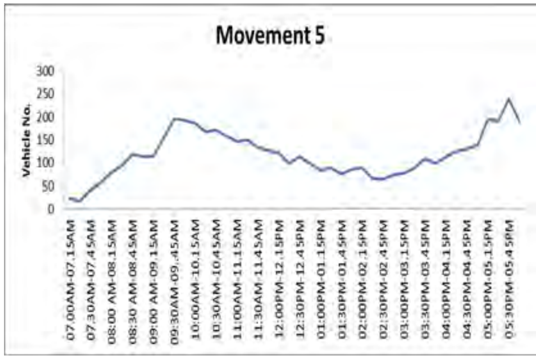
Movement: 4 Tikatuli to Fakirapul.

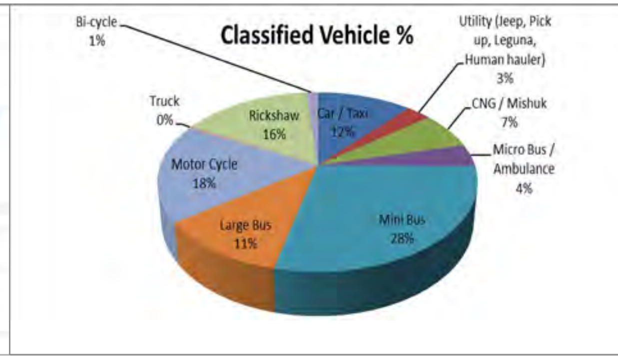


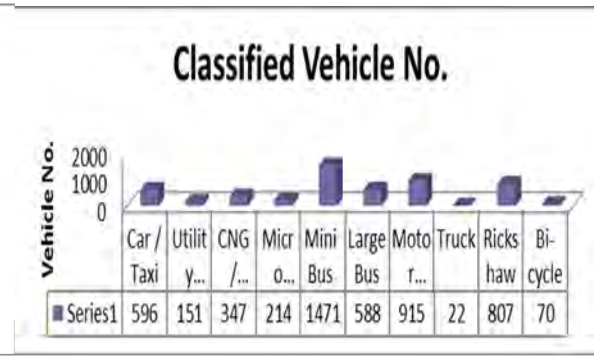




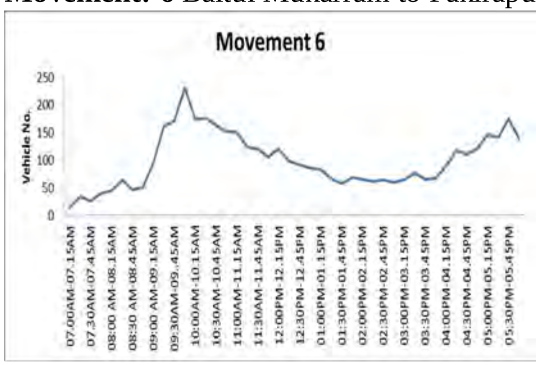
Movement: 5 Tikatuli to Baitul Mukarram.

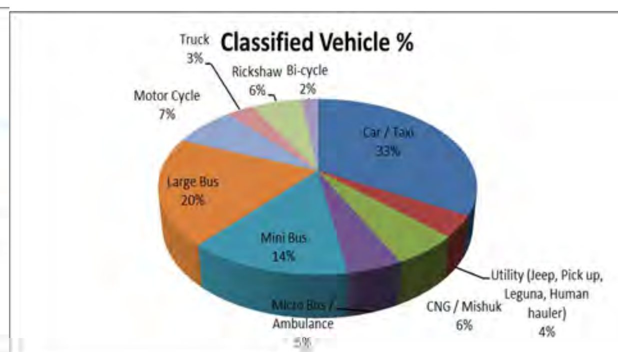


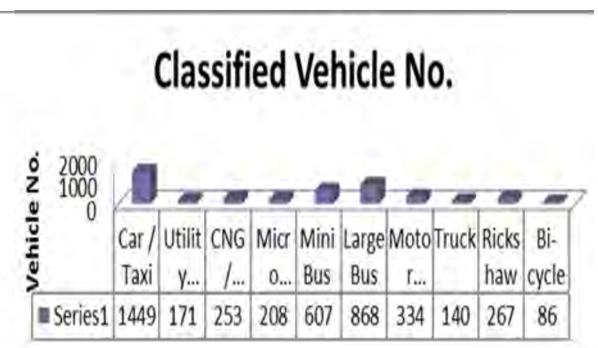




Movement: 6 Baitul Mukarram to Fakirapul.







The flow ratio of the four (4) approaches was calculated for finding out the condition of traffic flow situation of individual approach of this intersection, which is related with signal system, signal phasing, queue length, delay, etc. The data of flow ratio is presented below.

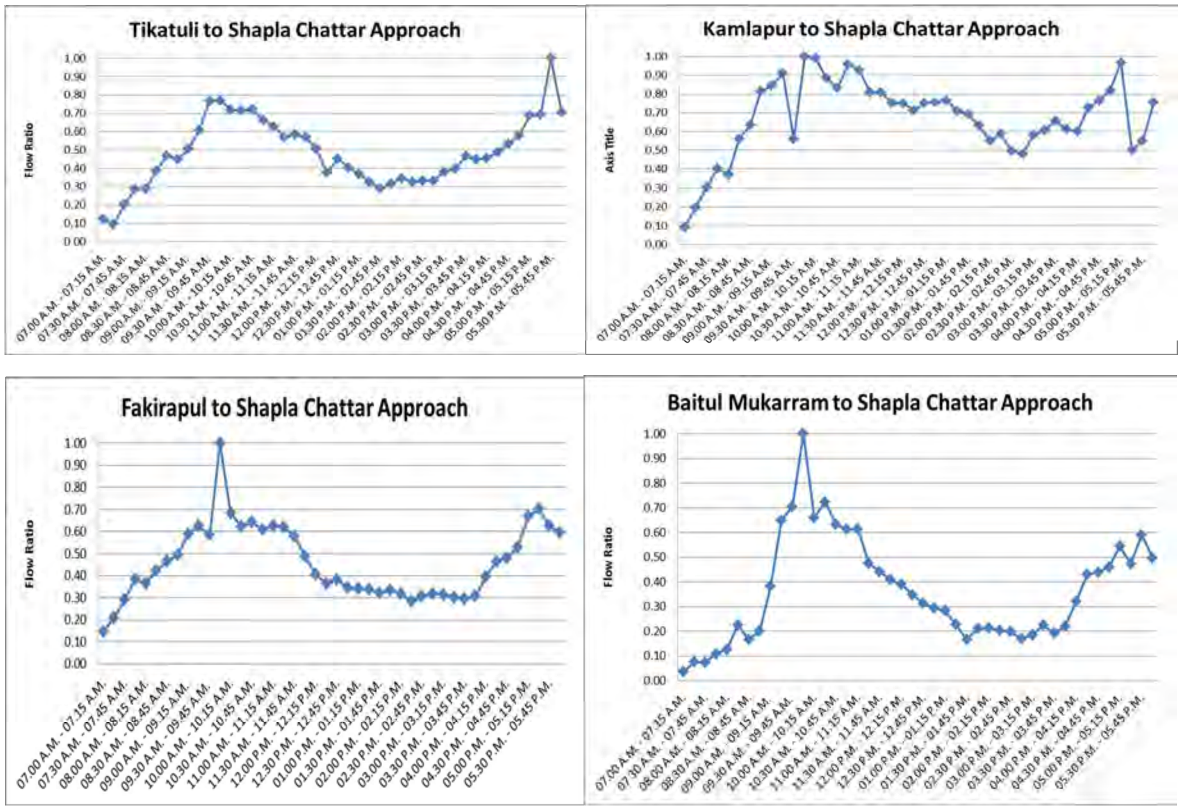


Figure 1.6.4: a) Flow Ratio of Tikatuli to Shapla Chattar Approach; b) Flow Ratio of Kamlapur to Shapla Chattar Approach; c) Flow Ratio of Fakirapul to Shapla Chattar Approach, d) Flow Ratio of Baitul Mukarram to Shapla Chattar Approach.

1.6.4 Pedestrian Flow of this Intersection

In the time of field survey, the survey of pedestrian flow was done with the vehicular flow of this intersection. The result of pedestrian survey is given below.

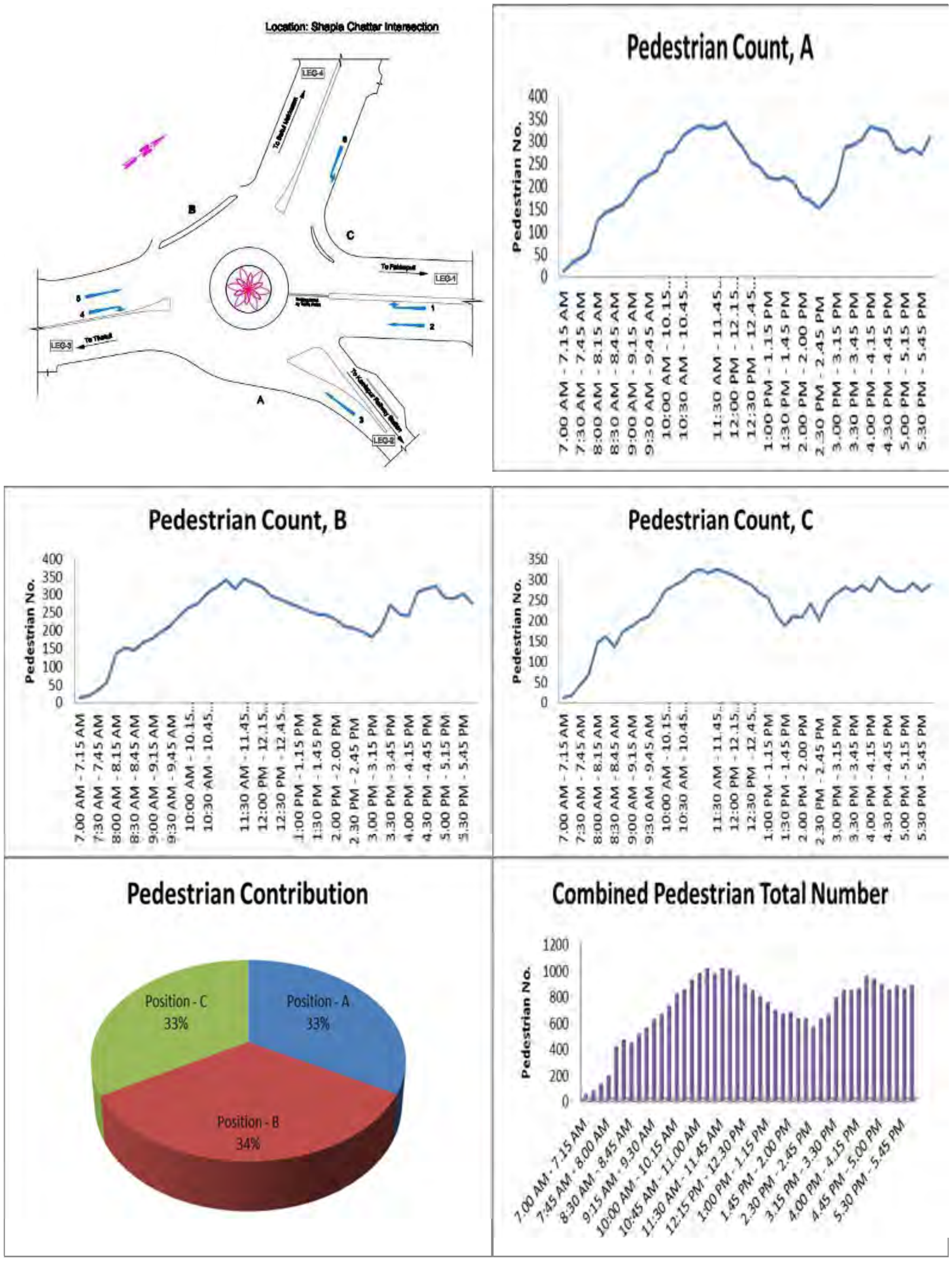


Figure 1.6.5: Pedestrian Count inside the Intersection.

In this intersection, there is an over bridge having two (2) legs. A very few amount of pedestrian use it for road crossing. A counting survey was arranged for finding out the pedestrian crossing amount from this survey. The survey data is given here under.

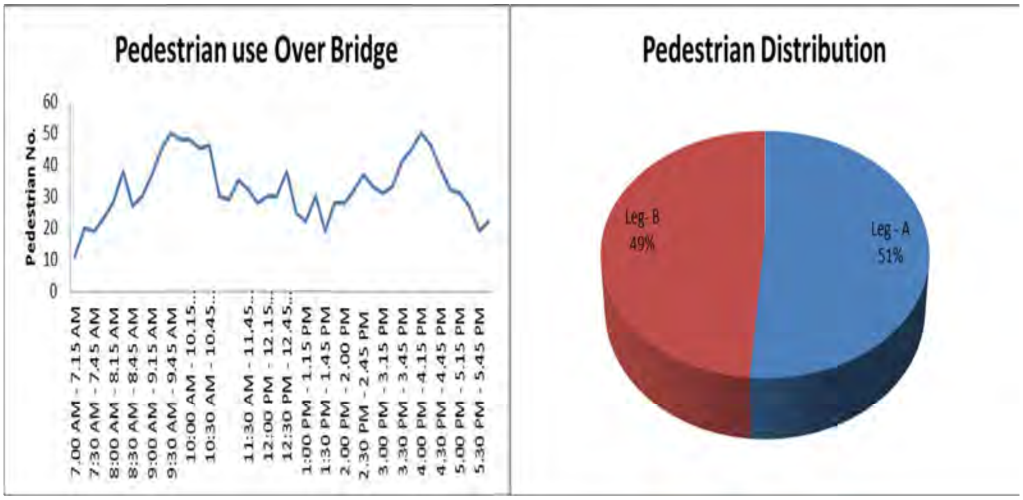


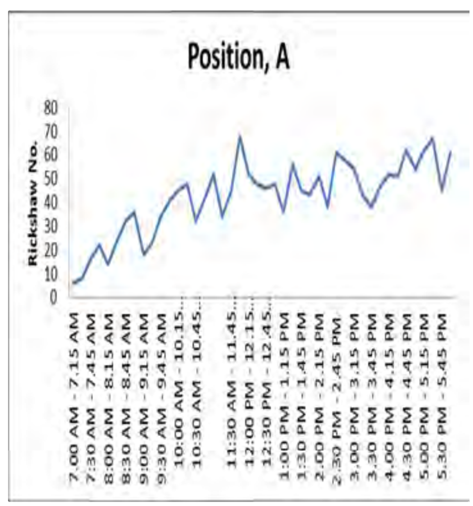
Figure 1.6.6: Pedestrian Using Over Bridge.

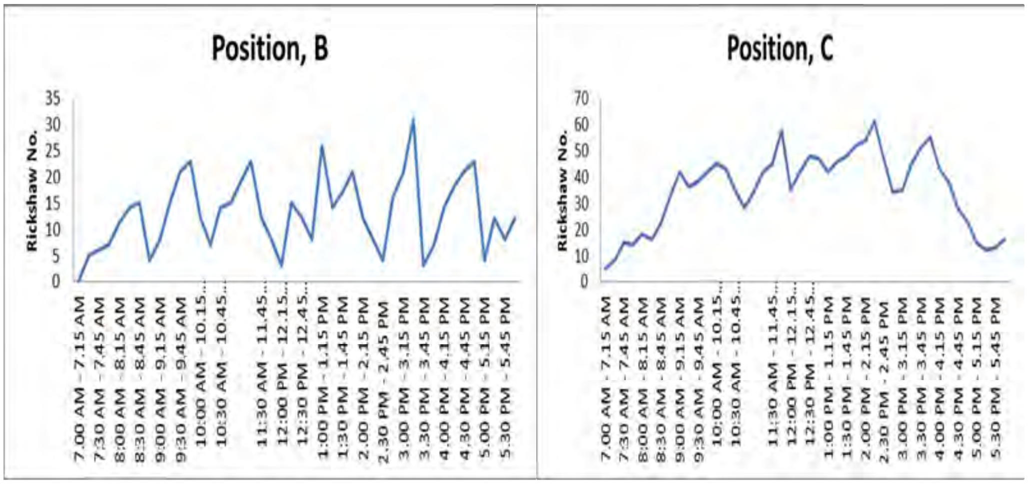
Around 9% of total pedestrian of this intersection are using the over bridge.

1.6.5 Side Friction

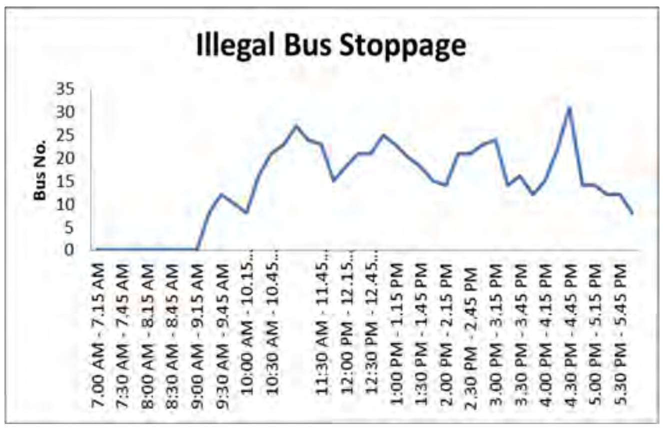
By analyzing the detail survey of Shapla Chattar intersection, a lot of source for side friction were found out. In this intersection the rickshaw stand, Laguna stand, bus stand, etc. were found. For finding out the real situation in this intersection, a counting survey was organized in these three (3) illegal rickshaw stands, one (1) bus stoppage and one (1) Laguna stand.

Illegal Rickshaw stands

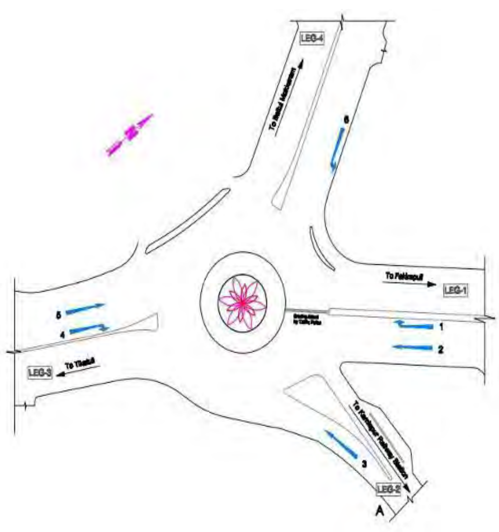


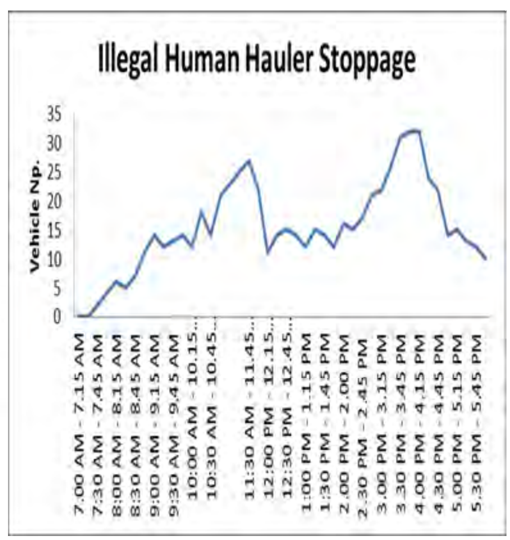


Illegal Bus stoppage inside the intersection



Laguna / Human Hauler stoppage inside the intersection





1.6.6 Traffic Control Devices

Though Shapla Chattar intersection is a roundabout intersection, but it is operated as a three (3) leg intersection. Internationally, there is no provision to operate a roundabout with signal. But in this Shapla Chattar intersection, there are signals in every approach.

A survey of traffic control devices were done in the time of preliminary survey of Shapla Chattar intersection. The result of this survey is described below.

Table 1.6.1: Features of Intersection and Traffic Control System.

Sl No.	Description	Nos.
1	Number of legs	Major-3 and non-major-1
2	Direction of traffic	7
3	Signal post for vehicular and pedestrian movement	15
4	Traffic signal controller box	1
5	Traffic police box	2

Table 1.6.2: Duty of Traffic Police.

Post	Morning Shift	Evening Shift
Traffic inspector	1	
Traffic sergeant	1	1
Traffic police	3	3
Ansar	-	-

Table 1.6.3: Existing Traffic Control System and Time of Operation.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(07.30 P.M 07.30 A.M.)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(09.00 AM 11.00 AM) (04.30 PM 07.30 PM)
4	Mixed	(11.00 AM 04.30 PM) (07.30 AM 09.00 AM)

Table 1.6.4: Signal Accessories.
Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Operate	Pedestrian Signal Operate
SP-1	OK	Rotated	Yes	No
SP-2	OK	OK	-	No
SP-3	OK	OK	-	No
SP-4	Hidden	All missing	-	-
SP-5	OK	OK	No	No

SP-6	OK	Rotated	-	No
SP-7	OK	Rotated	Yes	No
SP-8	OK	Missing	-	No
SP-9	Signal lights hidden	Missing	Yes	No
SP-10	OK	Missing	-	No
MAP-1	Signal lights hidden	Missing	Yes	No
MAP-2	OK	OK	-	-
MAP-3	OK	OK	-	No
MAP-4	Signal lights hidden	OK	No	-
MAP-5	One side signal light hidden	OK	Yes	No
TSC	OK	OK	-	-

Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

Cycle length of the signal -

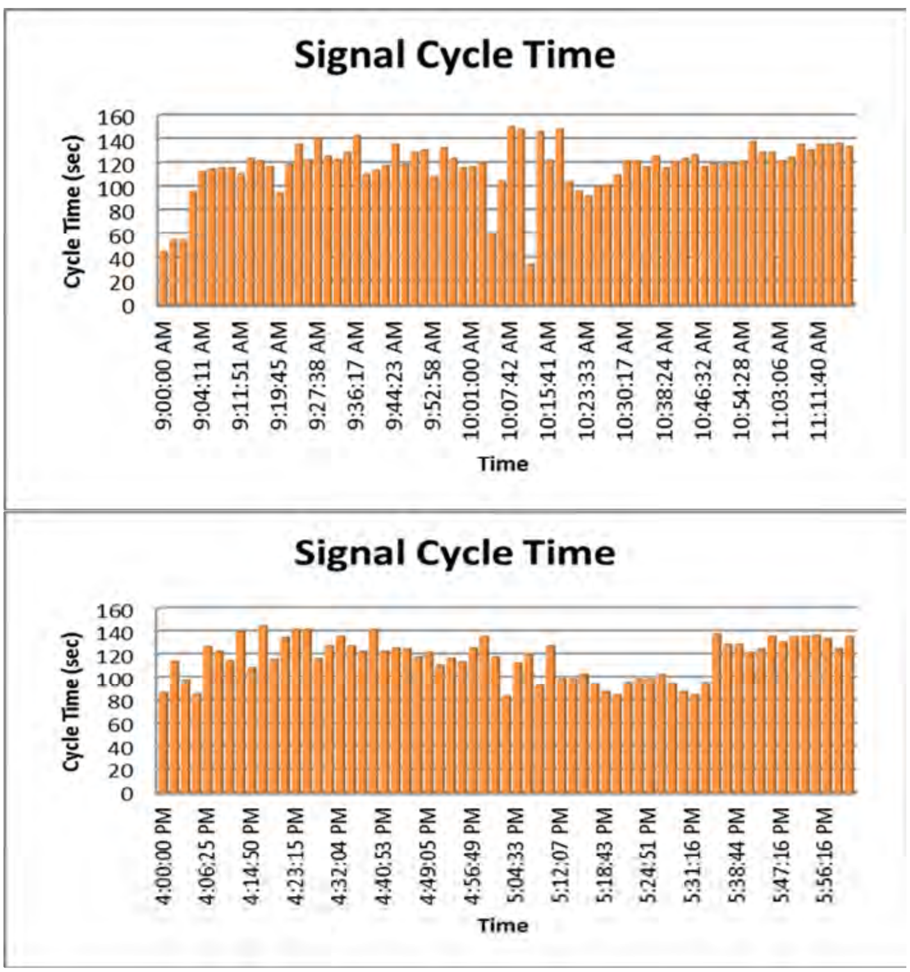


Figure 1.6.7: Signal cycle time at peak periods a) from 09.00 A.M. to 11.18 A.M. b) from 04.00 P.M. to 06.00 P.M.

1.6.7 Queue Length

Due to long signal cycle time, signal phasing, side friction, demand responsive traffic operation, the queue length in three approaches were found of this intersection. The decision for collecting primary data of this intersection from the field survey was taken and later compared with the secondary data (CASE study of World Bank Funded

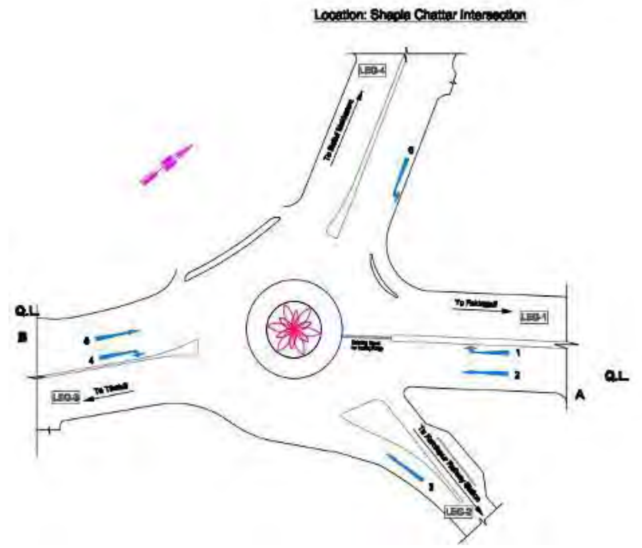


Table 1.6.5: Queue Length at Different Approach of Shapla Chattar Intersection in meter (at Morning Peak).

Observation No.	From	To	Shapla Chattar to Fakirapul approach	Shapla Chattar to Tikatuli
1	9:00:00 AM	9:15:00 AM	0	0
2	9:15:00 AM	9:30:00 AM	0	0
3	9:30:00 AM	9:45:00 AM	121.33	0
4	9:45:00 AM	10:00:00 AM	145.47	132.22
5	10:00:00 AM	10:15:00 AM	212.33	156.67
6	10:15:00 AM	10:30:00 AM	257.64	212.87
7	10:30:00 AM	10:45:00 AM	264.47	256.75
8	10:45:00 AM	11:00:00 AM	312.32	288.65
9	11:00:00 AM	11:15:00 AM	334.21	312.00
10	11:15:00 AM	11:30:00 AM	298.56	342.54
11	11:30:00 AM	11:45:00 AM	323.45	365.00
12	11:45:00 AM	12:00:00 PM	316.57	342.22
13	12:00:00 PM	12:15:00 PM	332.32	311.23

Table 1.6.6: Queue Length at Different Approach of Shapla Chattar Intersection in meter (at Evening Peak).

Observation No.	From	To	Shapla Chattar to Fakirapul approach	Shapla Chattar to Tikatuli
1	4:00:00 PM	4:15:00 PM	212.33	212.87
2	4:15:00 PM	4:30:00 PM	257.64	256.75
3	4:30:00 PM	4:45:00 PM	264.47	288.65
4	4:45:00 PM	5:00:00 PM	312.32	312.00
5	5:00:00 PM	5:15:00 PM	328.67	342.54
6	5:15:00 PM	5:30:00 PM	298.56	312.33
7	5:30:00 PM	5:45:00 PM	323.45	342.22
8	5:45:00 PM	6:00:00 PM	316.57	311.23
9	6:00:00 PM	6:15:00 PM	333.12	346.72

1.6.8 Delay of Intersection

After observing the queue length of Shapla Chattar intersection on three (3) approaches, the decision of finding delay on every approach was taken. The decision for taking data of free flow travel at from 07.00 AM to 07.30 AM was taken. In this condition, the Shapla Chattar intersection and its surrounding intersection areas were calm and soft. So the collection of the travel time of vehicle in free flow condition was collected very easily in three approaches. The travel time in free flow condition is given below.

Table 1.6.7: Travel Time at Free Flow Condition of Shapla Chattar Intersection (sec)

Observation No.	From	To	R.K. Road to Shapla Chattar	Arambagh Mor to Shapla Chattar
1	7:00:00 AM	7:30:00 AM	10	8

By considering the free flow condition time of vehicle, the delay in four approaches of this intersection was counted. The data of delay is given below.

Table 1.6.8: Delay at Different Approach of Shapla Chattar Intersection.

Observation No.	From	To	R.K. Road to Shapla Chattar	Delay (R.K. Road to Shapla Chattar)	Arambagh Mor to Shapla Chattar	Delay(Arambagh Mor to Sgapla Chattar)
1	7:00:00 AM	7:30:00 AM	22	12	34	26
2	7:30:00 AM	8:00:00 AM	32	22	44	36
3	8:00:00 AM	8:30:00 AM	56	46	48	40
4	8:30:00 AM	9:00:00 AM	67	57	55	47
5	9:00:00 AM	9:30:00 AM	78	68	77	69
6	9:30:00 AM	10:00:00 AM	123	113	89	81
7	10:00:00 AM	10:30:00 AM	134	124	121	113
8	10:30:00 AM	11:00:00 AM	126	116	135	127
9	11:00:00 AM	11:30:00 AM	138	128	163	155
10	11:30:00 AM	12:00:00 PM	245	235	167	159
11	12:00:00 PM	12:30:00 PM	300	290	278	270
12	12:30:00 PM	1:00:00 PM	378	368	345	337
13	1:00:00 PM	1:30:00 PM	426	416	460	452
14	1:30:00 PM	2:00:00 PM	546	536	678	670
15	2:00:00 PM	2:30:00 PM	536	526	734	726
16	2:30:00 PM	3:00:00 PM	723	713	876	868
17	3:00:00 PM	3:30:00 PM	742	732	978	970
18	3:30:00 PM	4:00:00 PM	879	869	987	979
19	4:00:00 PM	4:30:00 PM	978	968	988	980
20	4:30:00 PM	5:00:00 PM	1034	1024	1076	1068
21	5:00:00 PM	5:30:00 PM	778	768	874	866
22	5:30:00 PM	6:00:00 PM	567	557	568	560

1.6.9 Level of Service (LOS)

After calculating the delay of every approach of Shapla Chattar intersection, the delay data was compared with the standard un signalized intersection delay data *(HCM, 2010).* This intersection was controlled by police manually, so definitely Shapla Chattar intersection is an un signalized intersection. By comparing with the standardized delay time with the intersection delay data, the level of services of different approaches of Shapla Chattar intersection was calculated on the basis of delay. The result of this calculation is tabulated below.

Table 1.6.9: LOS of Different Approaches of Shapla Chattar Intersection.

Observation No.	Time	LOS (R.K. Road to Shapla Chattar)	LOS (Arambagh Mor to Shapla Chattar)
1.	07.00 A.M. 07.30 A.M.	A	C
2.	07.30 A.M. 08.00 A.M.	C	D
3.	08.00 A.M. 08.30 A.M.	E	E
4.	08.30 A.M. 09.00 A.M.	F	E
5.	09.00 A.M. 09.30 A.M.	F	F
6.	09.30 A.M. 10.00 A.M.	F	F
7.	10.00 A.M. 10.30 A.M.	F	F
8.	10.30 A.M. 11.00 A.M.	F	F
9.	11.00 A.M. 11.30 A.M.	F	F
10.	11.30 A.M. 12.00 P.M.	F	F
11.	12.00 P.M. 12.30 P.M.	F	F
12.	12.30 P.M. 01.00 P.M.	F	F
13.	01.00 P.M. 01.30 P.M.	F	F
14.	01.30 P.M. 02.00 P.M.	F	F
15.	02.00 P.M. 02.30 P.M.	F	F
16.	02.30 P.M. 03.00 P.M.	F	F
17.	03.00 P.M. 03.30 P.M.	F	F
18.	03.30 P.M. 04.00 P.M.	F	F
19.	04.00 P.M. 04.30 P.M.	F	F
20.	04.30 P.M. 05.00 P.M.	F	F
21.	05.00 P.M. 05.30 P.M.	F	F
22.	05.30 P.M. 06.00 P.M.	F	F

By observing the result of LOS of different approaches of Shapla Chattar intersection, failure condition throughout the day was found. Most of the time of the day, the level of service of this intersection was persisted on Level F or failure condition. This is disastrous for today Modern Dhaka city.

1.7 Science Laboratory Intersection

1.7.1 General Description

The Science Laboratory intersection is situated on a primary road (Mirpur road). This intersection has a huge area. It is a multi legged compound intersection of combining one four leg and two Tee intersections. Green roads, Elephant road, New Market road, Dhanmondi road 1, 2, 3, Mirpur road are joining in this intersection. This is a busyplace of Dhaka city.

Figure 1.7.1: Google Map of Science Laboratory Intersection

In every approach of this intersection contain markets, shopping mall, offices, schools, colleges, restaurants, private universities, etc. So this intersection has to carry huge load of vehicles and pedestrians. Non-motorized vehicle is not allowed in this intersection. A separate lane is provided in this intersection. This is a central business district of Dhaka city. This intersection has an over bridge for safe pedestrian crossing. But a negligible amount of pedestrian uses this crossing facility. Pedestrians cross the junction matching with their desire paths under risk. Pedestrian would hardly find the suitable gaps within the moving traffic stream to perform the crossing maneuver. All the approaches of this intersection contain motorized traffic flow. The footpath facilities for pedestrian movements are completely blocked by the street hawkers, forcing pedestrian on to the roadway. Parts of the road space always remain block with parked vehicle. At the vicinity of this intersection approaches, almost all the approaches are provided with illegal stoppage, where the vehicles stand haphazardly create jam by reducing the effective width of the road. It is a signalized junction, but it is operated by traffic police manually.

Figure 1.7.2 Various Position of Science Laboratory Intersection.

1.7.2 Approaches from Intersection

This intersection contains the flexible pavement as road structure. The road is marked with lane sign, marking, etc. The condition of lane at different links of this intersection is

a) Green Road (2 lanes both direction.),
b) Elephant Road (2 Lanes both direction.),
c) New Market Road (3 Lanes both direction.),
d) Dhanmondi Road 1 (Rickshaw Lane) there is no lane marking,
e) Dhanmondi Road 2 (In front of Dhaka City College) (2 lanes both direction),
f) Dhanmondi Road 3 (Beside Happy Arcade) - there is no lane marking,
g) Mirpur Road 3 Lanes both direction.

On the mouth of Elephant road, left turning lane and on the Mirpur road there are right turning lane, the researcher team found those in this intersection.

Figure 1.7.3: Inside the Intersection: Left Turning Lane.

Figure 1.7.4: Inside the Intersection: Exclusive Right Turn Lane

For NMV movement, in this intersection, there was a separate rickshaw lane from Dhanmondi Road 1 to New Market Road.

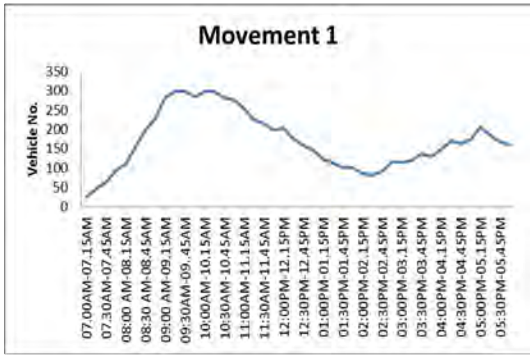
Figure 1.7.5: Separate Lane: Rickshaw Lane (Dhanmondi Road 1).

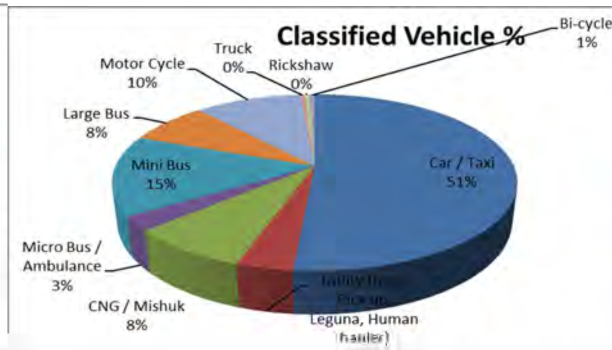
1.7.3 Vehicular Flow of Science Lab. Intersection

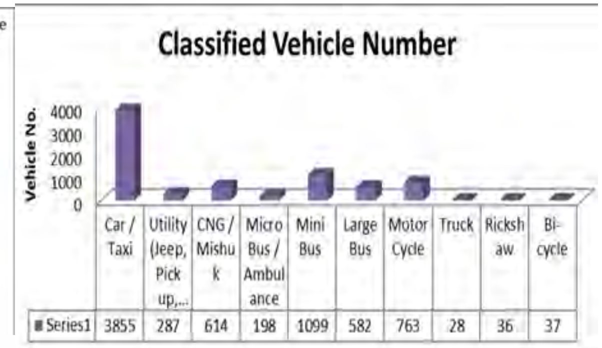
For finding out the level of service (LOS) of this intersection, the classified vehicle counting in this intersection was organized. From preliminary survey of this intersection they found two distinct peak hours 08.30 AM to 12.00 PM and 03.30PM to 06.00 PM and furthermore. So the survey time was set from 07.00 AM to 06.00 PM, total 11 hours. The result of the vehicular survey is going to be described below.

From the preliminary survey, fifteen (15) movements were found in this intersection. They are (1) Kalabagan to New Market, (2) Kalabagan to Science Laboratory, (3) Kalabagan to Green Road, (4) Green Road New Market, (5) Green Road to Science Laboratory, (6) Science Laboratory to Kalabagan, (7) Science Laboratory to New Market, (8) New Market to Kalabagan, (9) New Market to Dhanmondi Road 2, (10) Dhanmondi Road 2 to Kalabagan, (11) Dhanmondi Road 3 to New Market, (12) Dhanmondi Road 2 to Green Road, (13) Dhanmondi Road 3 to Kalabagan, (14) New Market Side U Turn and (15) New Market to Green Road. The vehicular counting data is given below.

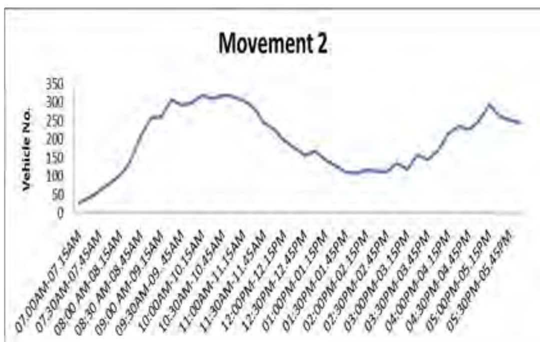
Movement: 1 Kalabagan to New Market.

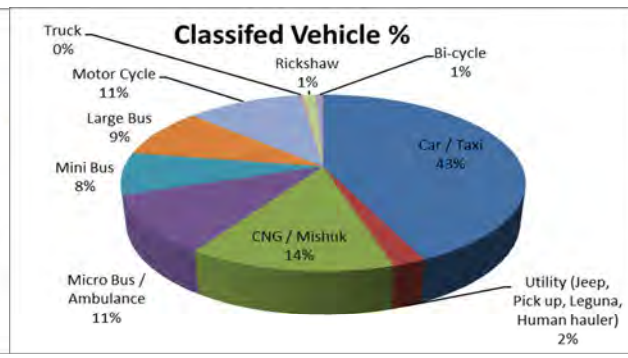


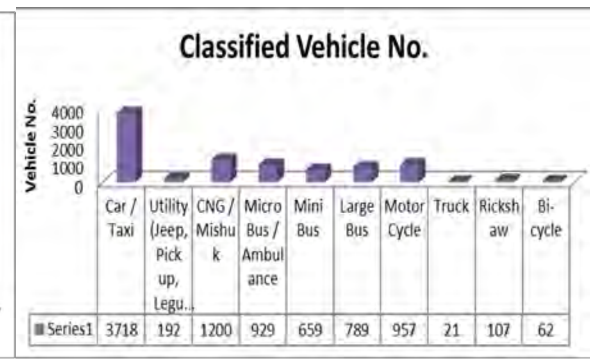




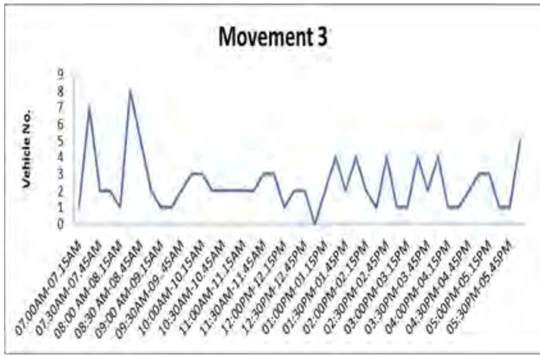
Movement: 2 Kalabagan to Science Laboratory.

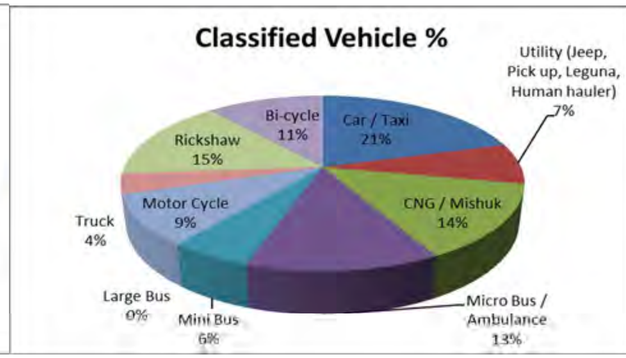


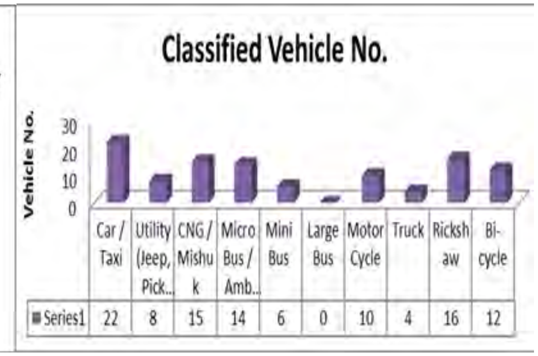




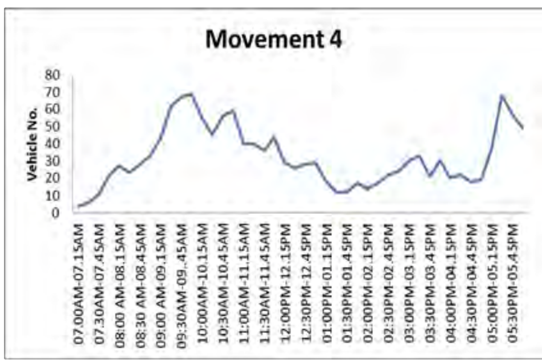
Movement: 3 Kalabagan to Green Road.

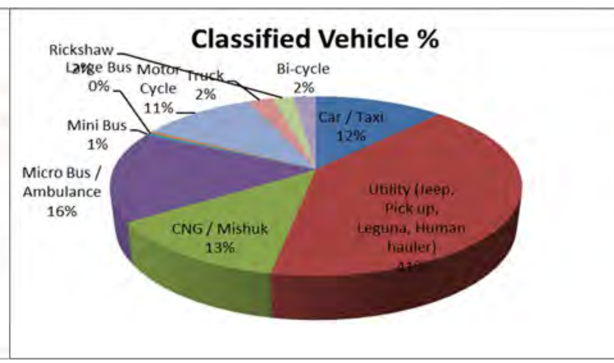


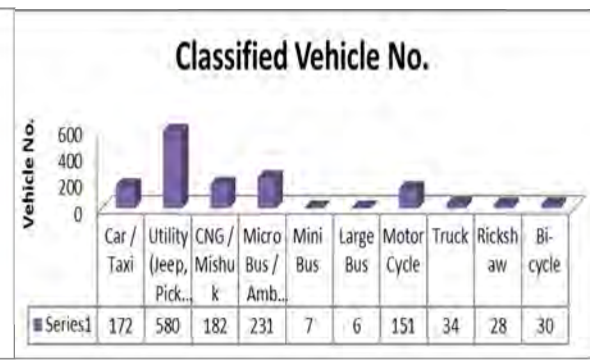




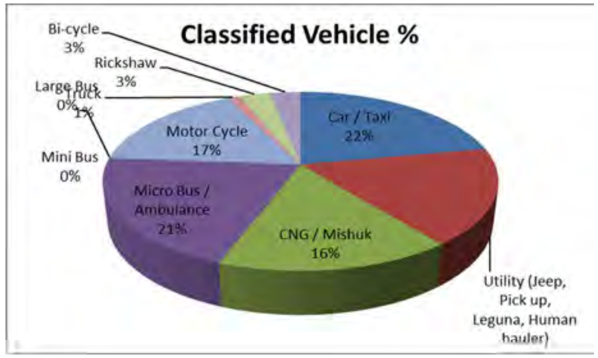
Movement: 4 Green Road to New Market.

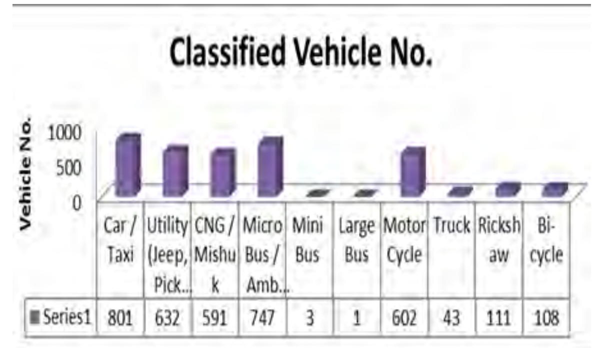




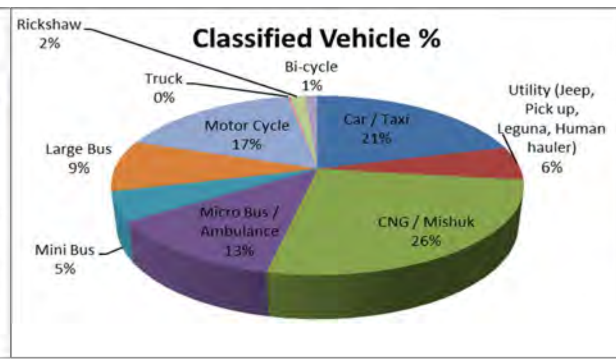


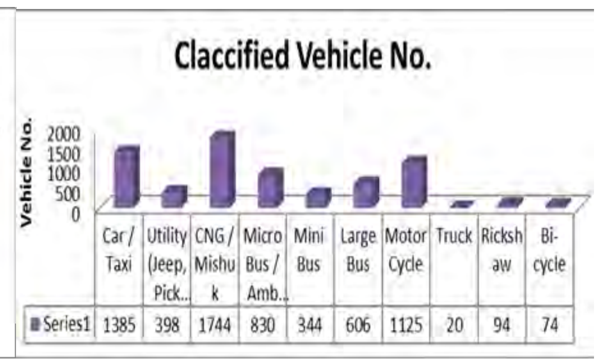
Movement: 5 Green Road to Science Laboratory.



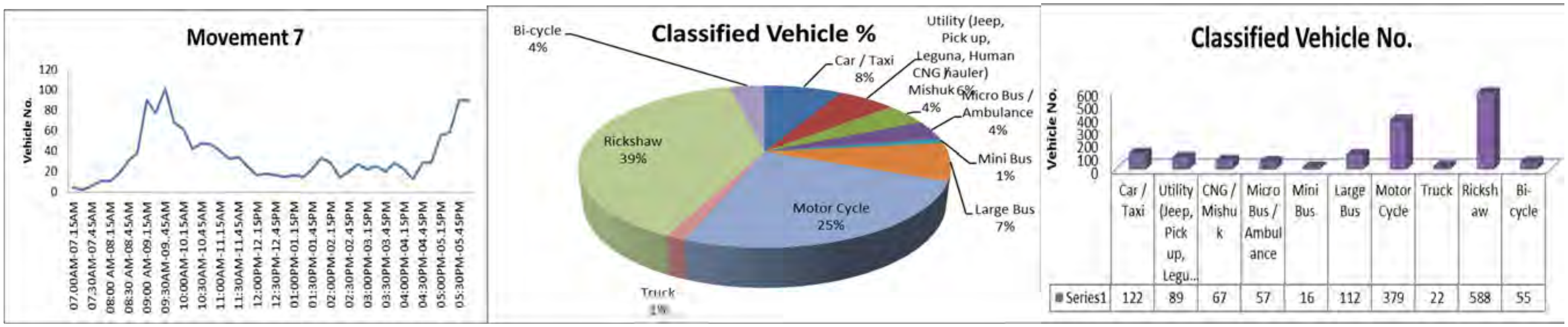


Movement: 6 Science Laboratory to Kalabagan.

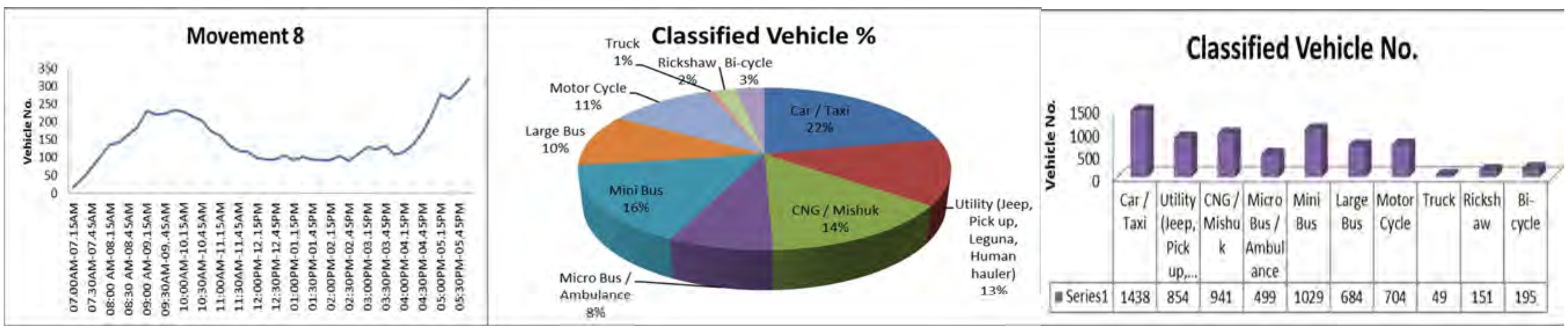




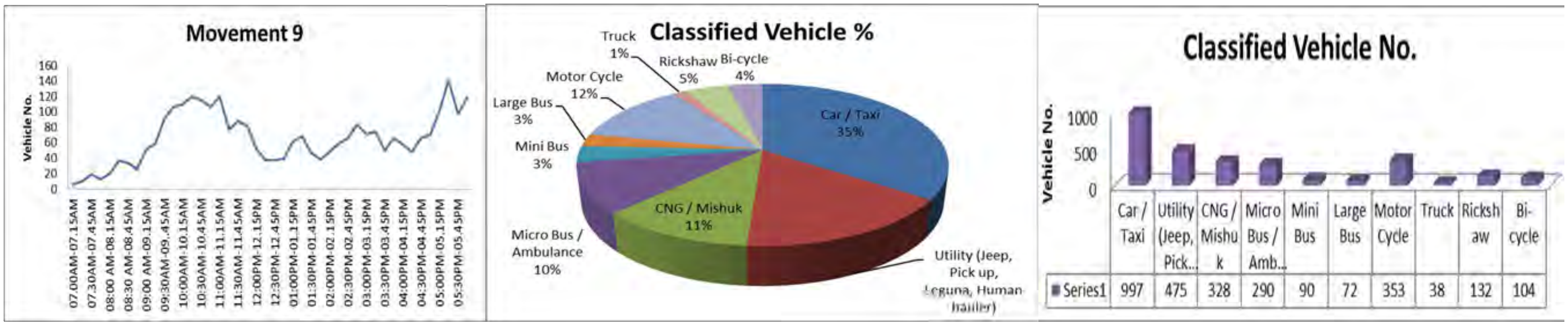
Movement: 7 Science Laboratory to New Market.



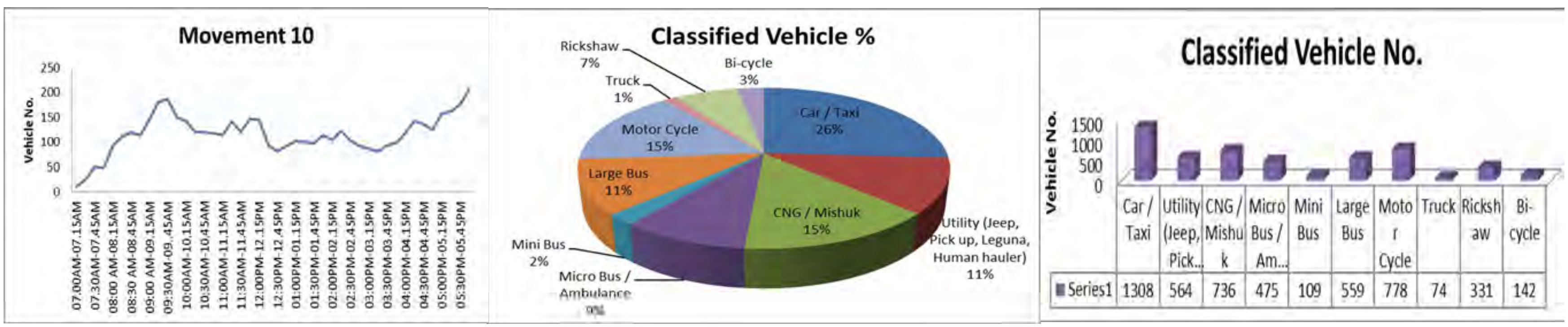
Movement: 8 New Market to Kalabagan.



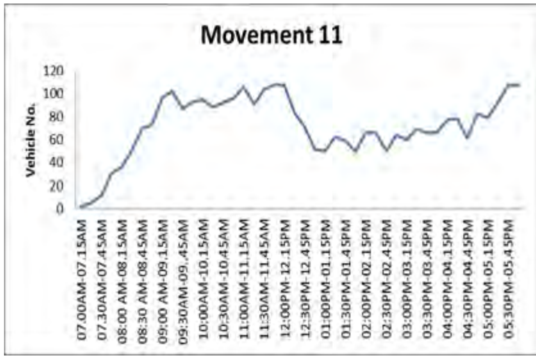
Movement: 9 New Market to Dhanmondi Road 2.

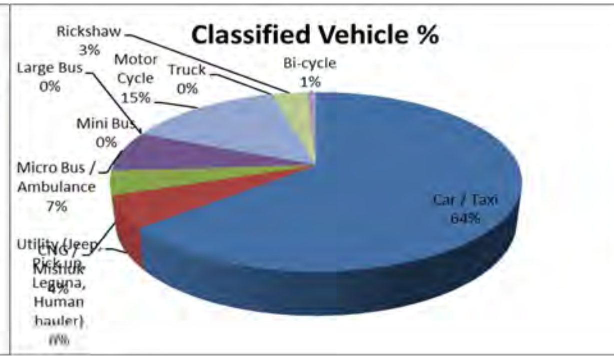


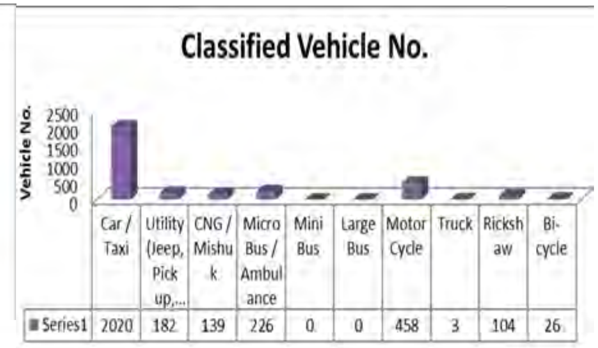
Movement: 10 Dhanmondi Road 2 to Kalabagan.



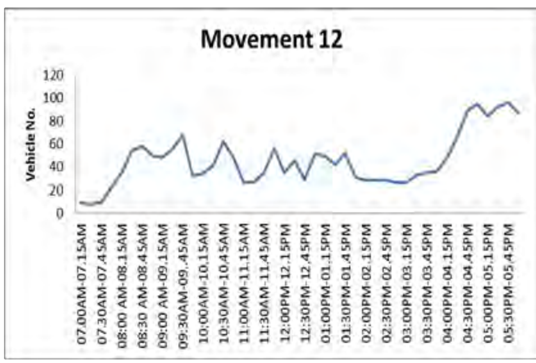
Movement: 11 Dhanmondi Road 3 to New Market.

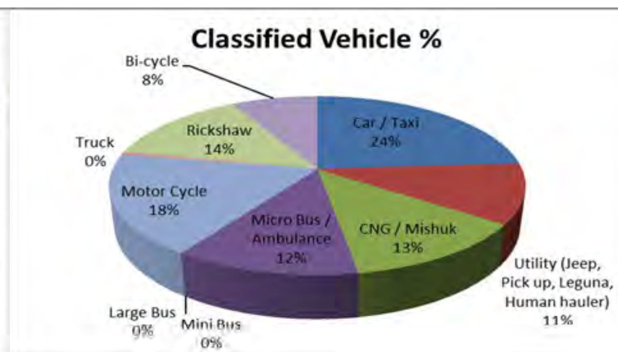


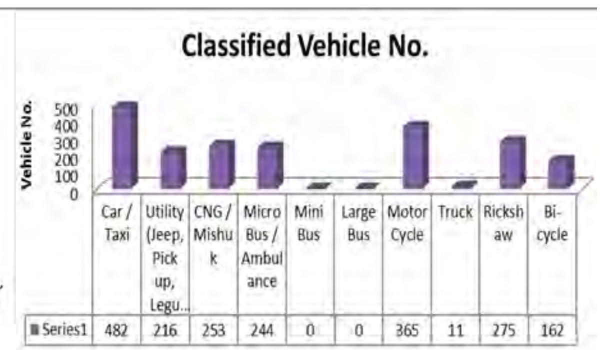




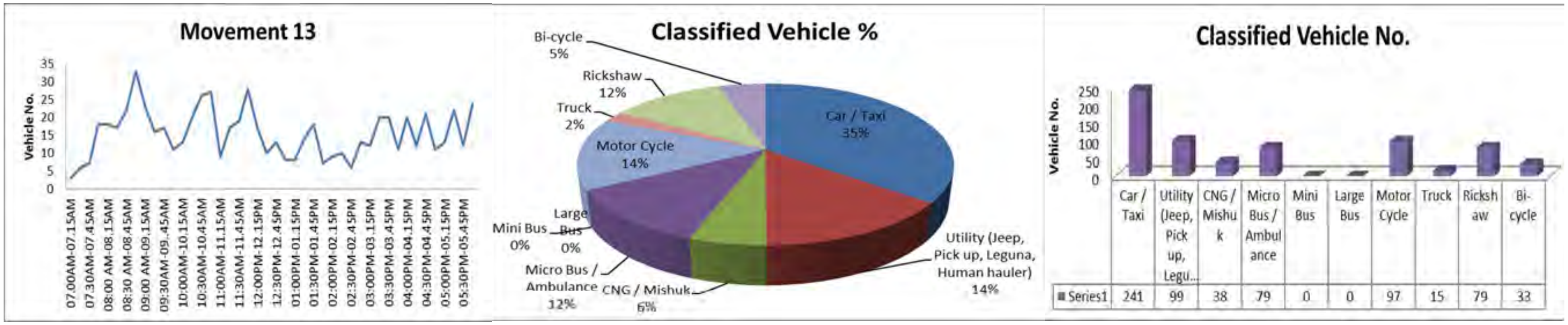
Movement: 12 Dhanmondi Road 2 to Green Road.



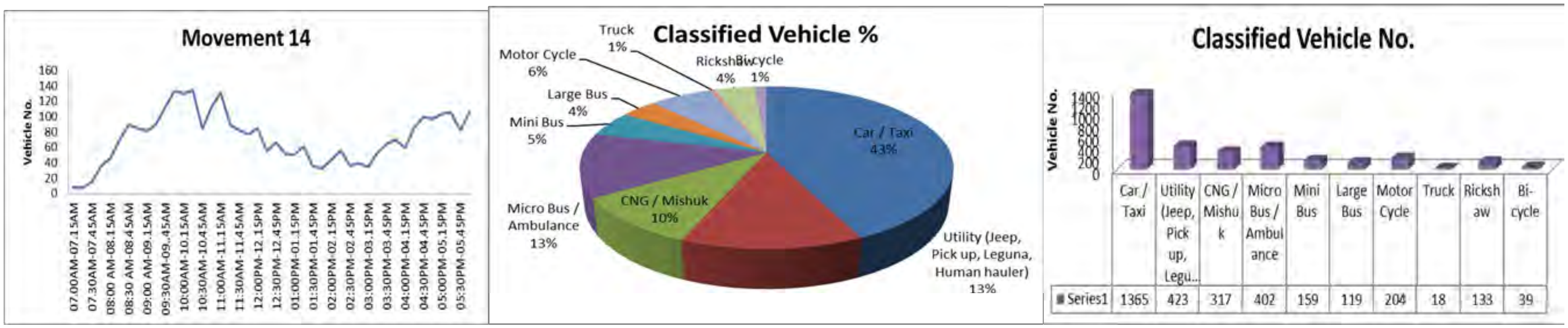




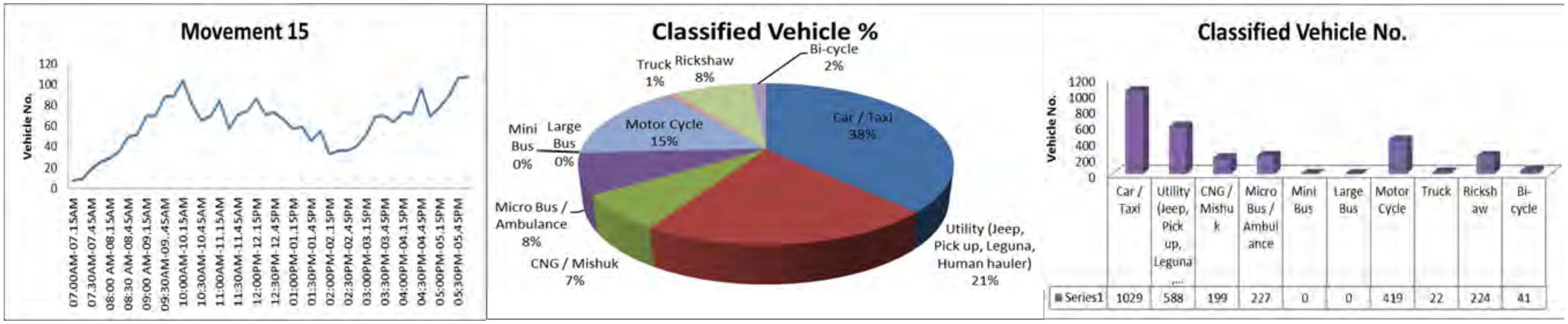
Movement: 13 Dhanmondi Road 3 to Kalabagan.



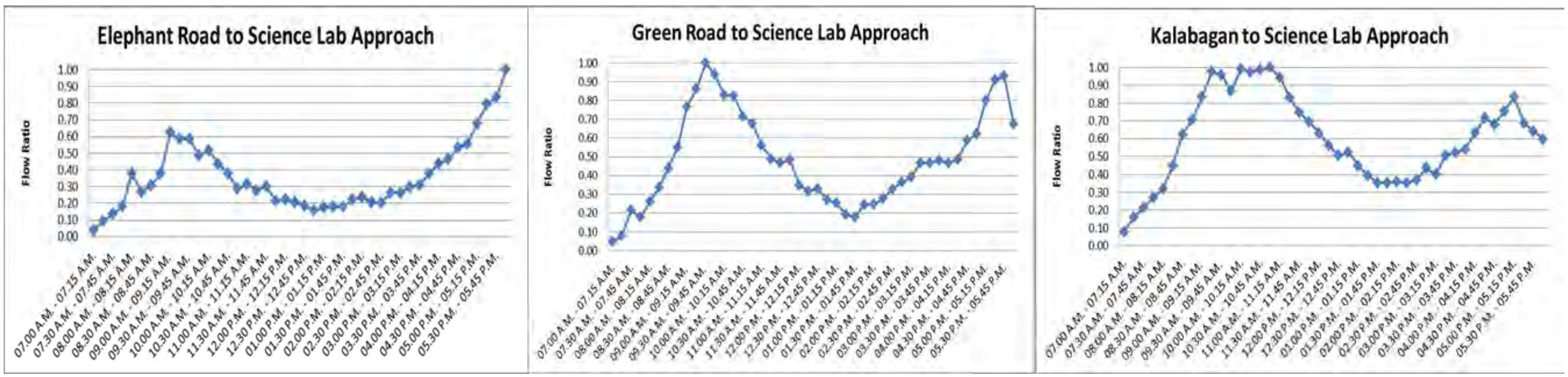
Movement: 14 New Market Side U Turn.



Movement: 15 New Market to Green Road.



The flow ratio of the six (6) approaches was calculated for finding out the condition of traffic flow situation of individual approach which is related with signal system, signal phasing, queue length, delay, etc. of this intersection. The data of flow ratio is shown below.



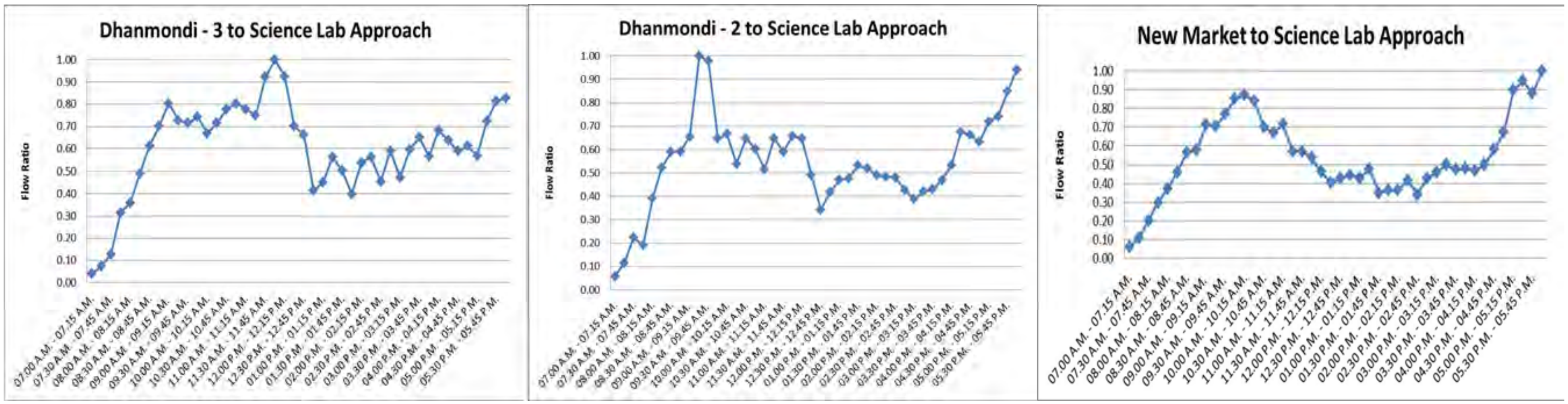
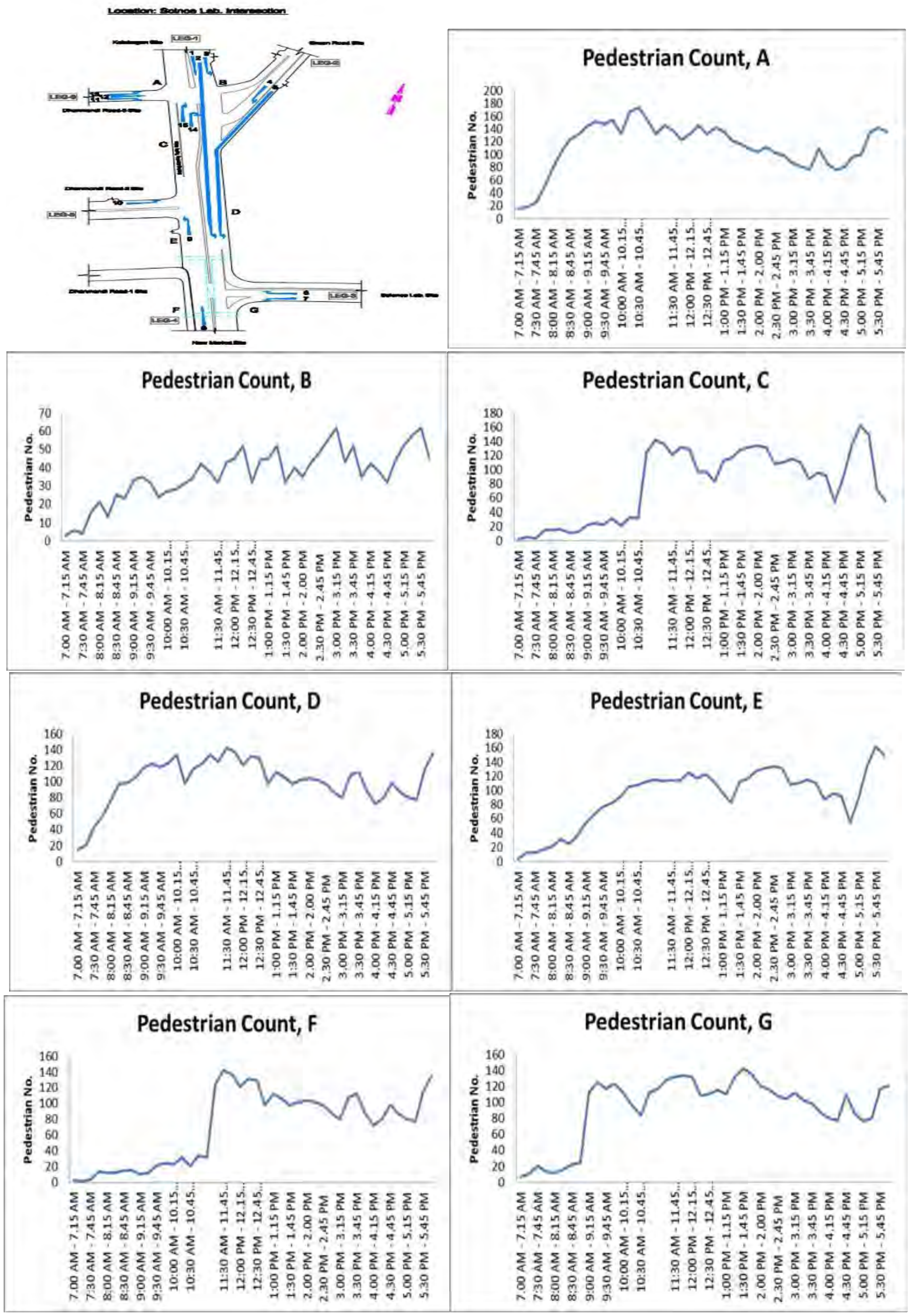


Figure 1.7.6: Flow Ratio of Different Approaches of Science Lab. Intersection.

1.7.4 Pedestrian Flow of Science Lab. Intersection

In the time of field survey, the pedestrian flow in this intersection was surveyed with the vehicular flow. The result of pedestrian survey is given below.



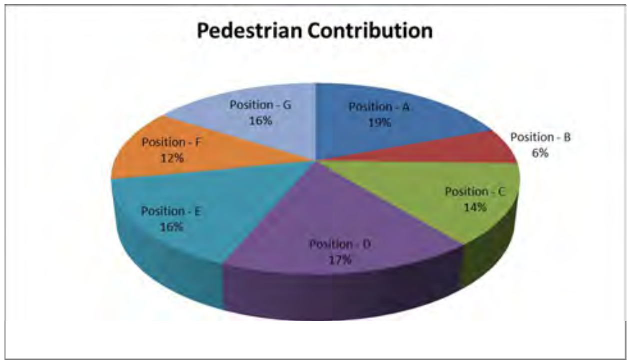


Figure 1.7.7: Pedestrian Survey of Science Laboratory Intersection.

In this intersection, there is an over bridge having four legs. A very few amount of pedestrian use it for road crossing. A counting survey was arranged for finding out the pedestrian amount from this survey. The survey data is given here under.

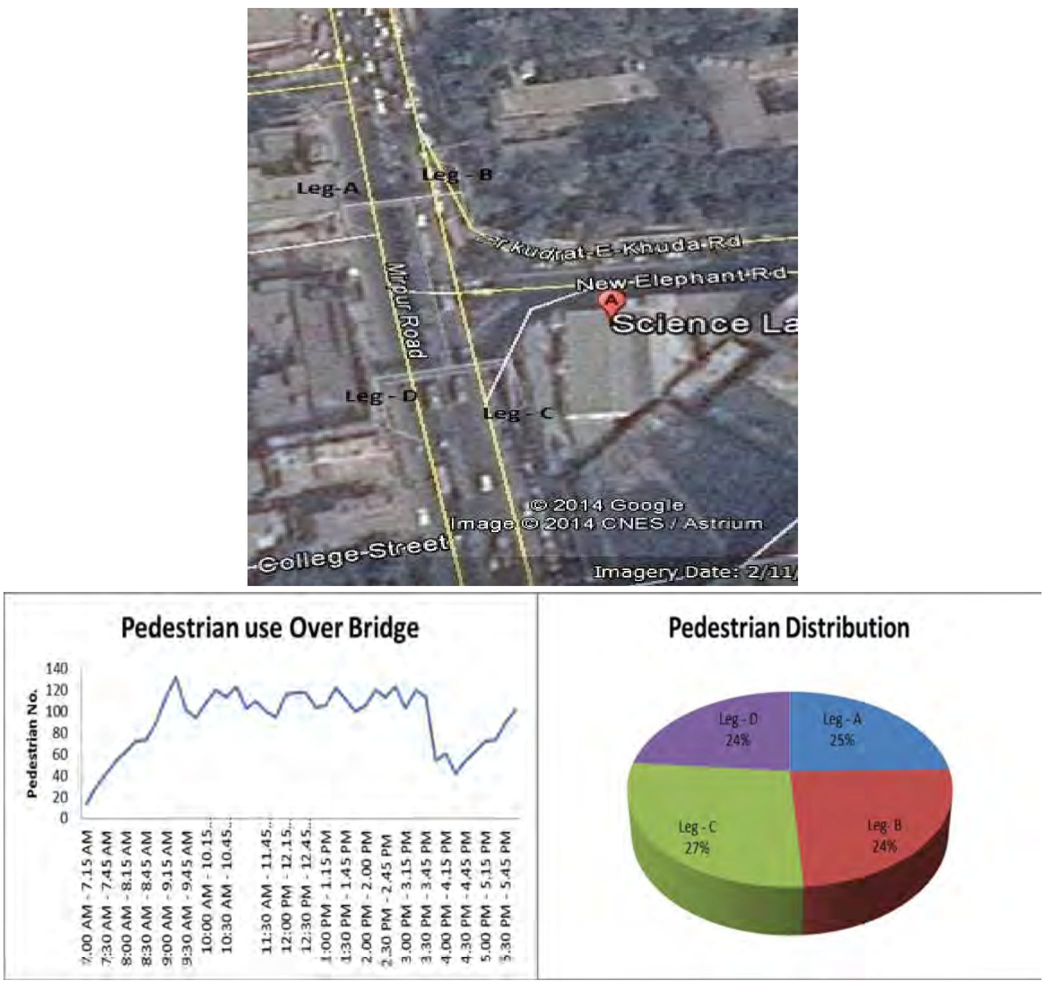


Figure 1.7.8: Foot Over Bridge User

1.7.5 Side Friction

By analyzing the detail survey of Science Laboratory intersection, a lot of source for side friction was observed. Inside this intersection the Laguna stand, bus stand, etc. were found. For finding out the real situation in this intersection, a vehicle counting survey was done in these places. The result of this survey is given below.

Rickshaw lane, in Dhanmondi Road no 1, this road is used as a dedicated lane towards New Market. The amount of rickshaw in this lane was counted and the result of this counting is given below.

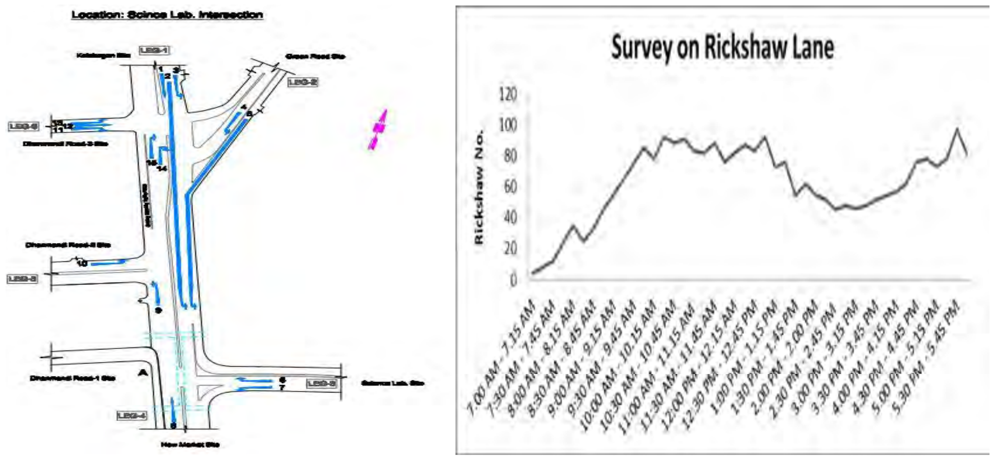


Figure 1.7.9: Dedicated Rickshaw Lane.

The surveyor also found rickshaw diversion on Green Road. A counting survey was arranged here too. The result is shown below.

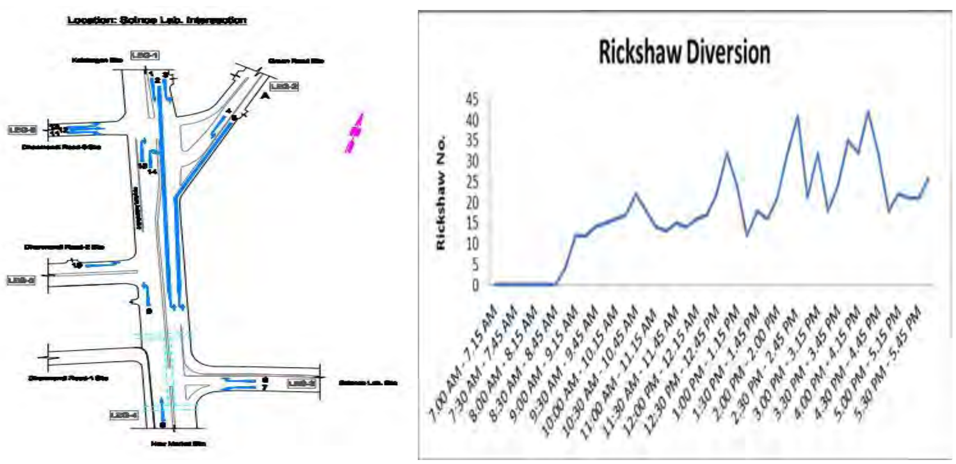


Figure 1.7.10: Rickshaw Diversion.

There is illegal human hauler stoppage in front of Dhaka City College. A counting survey was arranged for finding out the number of human hauler in this point. The survey result is given below.

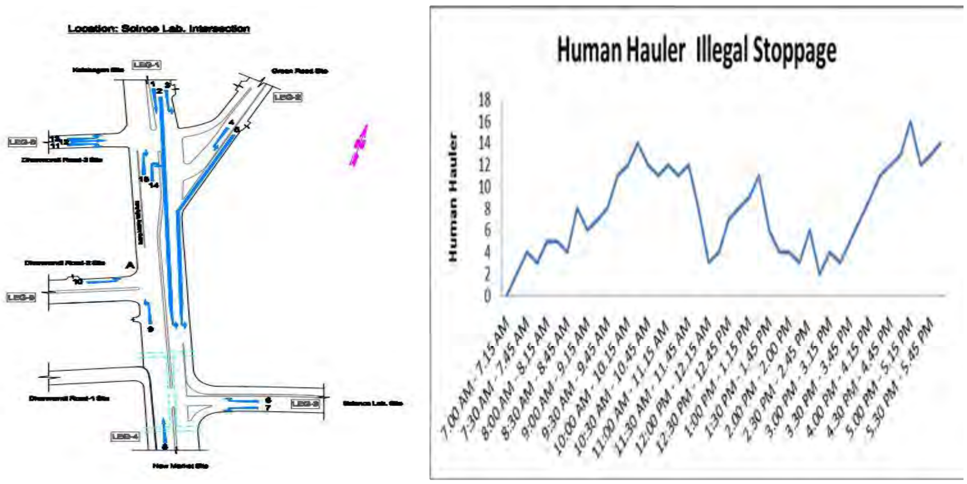
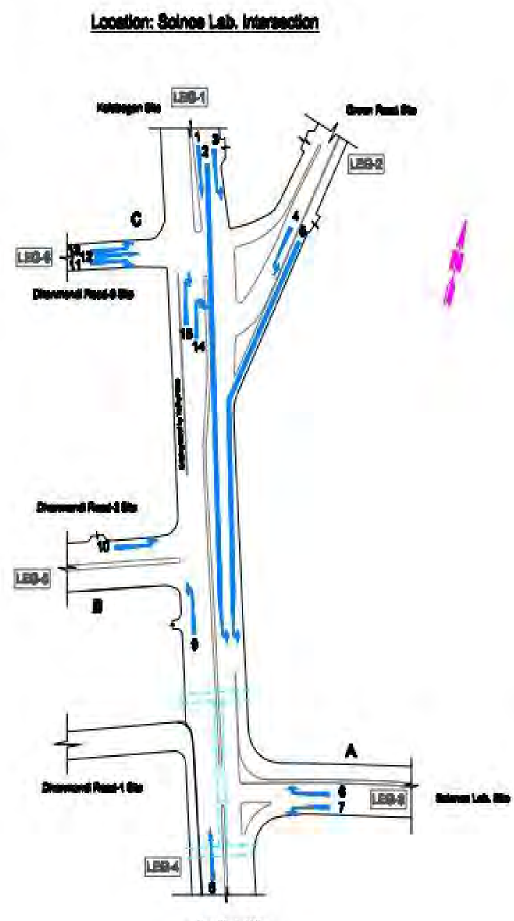


Figure 1.7.11: Illegal Human Hauler Stand.

From the preliminary survey, the survey / researcher team found two illegal bus stoppages. A counting survey was arranged in these three places. The survey result is shown below.



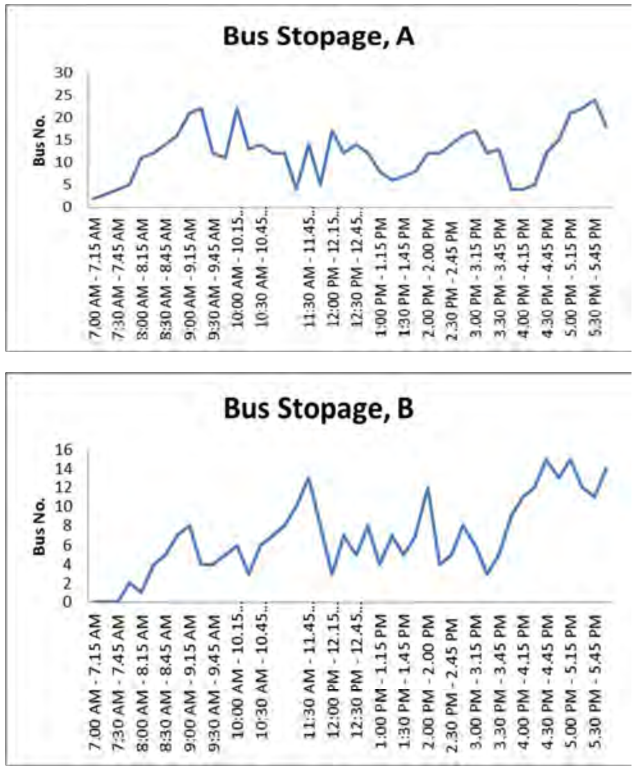
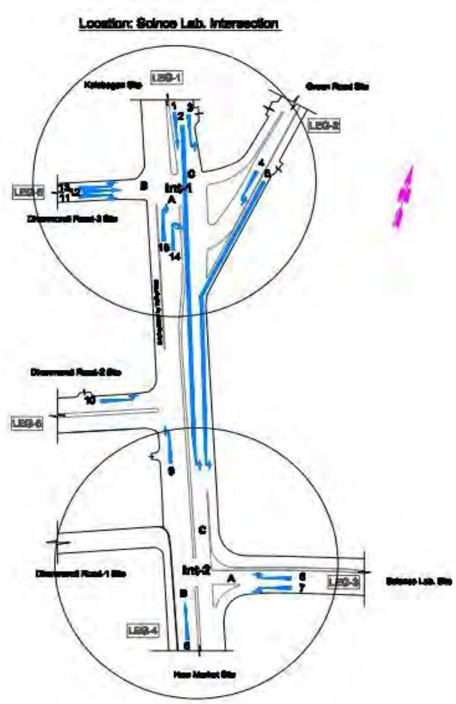


Figure 1.7.12: Illegal Bus Stoppage.

1.7.6 Traffic Control Devices

The Science Laboratory intersection is a compound intersection, two (2) intersections were found here. A picture with proper detail is given below.



These two intersections are operated independently by the traffic police manually. A survey of traffic control device was done in the time of preliminary survey of Science Laboratory intersection. The result of this survey is given below.

Table 1.7.1: Features of Intersection and Traffic Control System.

Sl No.	Description	Nos.
1	Number of legs	6
2	Direction of traffic	15
3	Signal post for vehicular and pedestrian movement	21
4	Traffic signal controller box	1
5	Traffic police box	1

Table 1.7.2: Duty of Traffic Police.

Post	Morning Shift	Evening Shift
Traffic inspector	1	
Traffic sergeant	1	1
Traffic police	6	6
Ansar	-	-

Table 1.7.3: Existing Traffic Control System and Time of Operation.

Sl. No.	Description	Duration of Operation
1	Automatic signal lighting system	(09.00 P.M. 09.00 A.M.)
2	Automatic signal lighting system (Control by traffic police)	
3	Signal system control by traffic police	(09.00 AM 11.00 AM) (04.30 PM 07.30 PM)
4	Mixed	(11.00 AM 04.30 PM) (07.30 PM 09.00 PM)

Table 1.7.4: Signal Accessories.

Signal Post (SP), Traffic Signal Controller (TSC) and Mast Arm Pole (MAP)

SP/TSC/MAP	Visibility	Physical Condition	Vehicle Signal Light Operation	Pedestrian Signal Light Operation
SP-1	OK	OK	-	No
SP-2	OK	OK	Yes	-
SP-3	OK	OK	-	No
SP-4	OK	OK	No	-
SP-5	OK	OK	No	-
SP-6	OK	One signal light broken	No	-

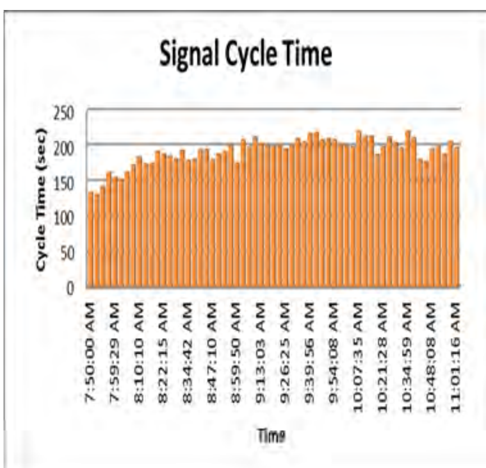
SP-7	OK	OK	Yes	-
SP-8	Signal lights hidden	OK	Yes	-
SP-9	OK	All lights broken	No	-
SP-10	OK	OK	Yes	-
SP-11	OK	Two pedestrian lamp shades missing	-	No
SP-12	OK	Two pedestrian lamp shades missing	No	No
SP-13	OK	OK	Yes	-
SP-14	OK	OK	-	No
SP-15	OK	Two pedestrian lamp shades missing	No	No
SP-16	OK	One pedestrian lamp shades missing	Yes	-
MAP-1	OK	OK	Yes	-
MAP-2	OK	OK	Yes	-
MAP-3	OK	OK	Yes	-
MAP-4	OK	OK	No	-
MAP-5	OK	OK	Yes	-
TSC	OK	OK	-	-

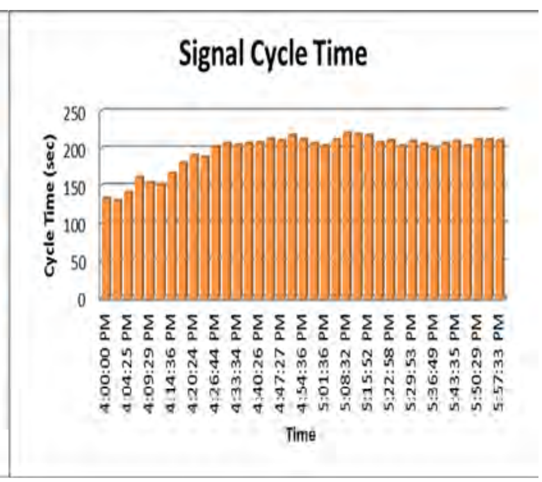
Notes: - No: Currently damage / not working

Yes: In working condition

(-): Not installed

Intersection: 1





Intersection: 2

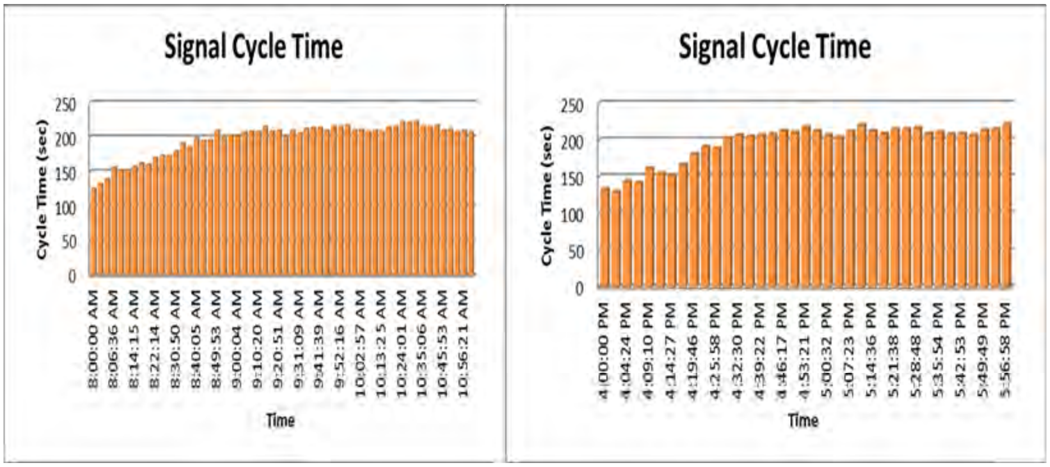


Figure 1.7.13: Signal Cycle Time a) at Morning Peak and b) Evening Peak.

1.7.7 Queue Length

Due to long signal cycle time, signal phasing, side friction, demand responsive traffic operation, the queue length in three approaches of this intersection was found. The decision was taken for collection of primary data of this intersection from the field survey and later compared with the secondary data (CASE study of World Bank Funded

Table 1.7.5: Queue Length at Different Approach of Science Laboratory Intersection in meter (at Morning Peak).

Observation No.	From	To	Kalabagan to Science Lab approach	Elephant Road to Science Lab	New Market to Science Lab approach
1	7:45:00 AM	8:00:00 AM	0	0	151.90
2	8:00:00 AM	8:15:00 AM	116.26	123.57	165.21
3	8:15:00 AM	8:30:00 AM	187.34	134.56	188.34
4	8:30:00 AM	8:45:00 AM	221.34	176.63	190.93
5	8:45:00 AM	9:00:00 AM	278.34	217.34	227.91
6	9:00:00 AM	9:15:00 AM	328.92	265.77	211.32
7	9:15:00 AM	9:30:00 AM	309.69	298.23	221.46
8	9:30:00 AM	9:45:00 AM	345.67	312.23	209.90
9	9:45:00 AM	10:00:00 AM	355.45	332.43	208.96
10	10:00:00 AM	10:15:00 AM	378.97	342.22	228.32
11	10:15:00 AM	10:30:00 AM	393.43	328.92	218.33
12	10:30:00 AM	10:45:00 AM	412.21	309.69	226.44
13	10:45:00 AM	11:00:00 AM	354.44	345.67	224.59
14	11:00:00 AM	11:15:00 AM	385.33	355.45	226.77

Table 1.7.6: Queue Length at Different Approach of Science Laboratory Intersection in meter (at Evening Peak).

Observation No.	From	To	Kalabagan to Science Lab approach	Elephant Road to Science Lab approach	New Market to Science Lab approach
1	4:00:00 PM	4:15:00 PM	355.45	355.45	311.33
2	4:15:00 PM	4:30:00 PM	378.97	378.97	323.33
3	4:30:00 PM	4:45:00 PM	393.43	393.43	352.33
4	4:45:00 PM	5:00:00 PM	412.21	445.67	287.22
5	5:00:00 PM	5:15:00 PM	354.44	354.44	322.32
6	5:15:00 PM	5:30:00 PM	385.33	385.33	311.22
7	5:30:00 PM	5:45:00 PM	392.23	392.23	309.76
8	5:45:00 PM	6:00:00 PM	404.44	404.44	312.56
9	6:00:00 PM	6:15:00 PM	408.22	408.22	365.44

1.7.8 Delay of Intersection

After observing the queue length of Science Laboratory intersection on three (3) approaches, finding delay on every approach was done. The decision for taking data of free flow was taken from 07.00 AM to 07.30 AM. In this condition, the Science Laboratory intersection and its surrounding intersection areas were calm and soft. So the collection of the travel time of vehicle in free flow condition was collected very easily from three approaches. The travel time in free flow condition is given below.

Table 1.7.7: Travel Time at Free Flow Condition of Science Laboratory Intersection (sec)

Observation No.	From	To	Kalabagan to Science Lab. Intersection	Bata Signal to Science Lab. Intersection	New Market to Science Lab. Intersection
1	7:00:00 AM	7:30:00 AM	12	10	6

By considering the free flow condition time of vehicle, the delay in three approaches of this intersection was counted by the researcher team. The data of delay is given below.

Table 1.7.8**:** Delay at Different Approach of Science Laboratory Intersection.

Observation No.	From	To	Kalabagan to Science Lab. Intersection	Delay (KalaBagan to Science Lab. Intersection)	Bata Signal to Science Lab. Intersection	Delay (Bata Signal to science lab. Intersection)	New Market to Science Lab. Intersection	Delay (New Market to Science Lab. Intersection)
1	7:00:00 AM	7:30:00 AM	14	2	12	2	8	2
2	7:30:00 AM	8:00:00 AM	22	10	14	4	12	6
3	8:00:00 AM	8:30:00 AM	56	44	18	8	15	9
4	8:30:00 AM	9:00:00 AM	187	175	27	17	33	27
5	9:00:00 AM	9:30:00 AM	192	180	45	35	56	50
6	9:30:00 AM	10:00:00 AM	230	218	324	314	68	62
7	10:00:00 AM	10:30:00 AM	255	243	456	446	245	239
8	10:30:00 AM	11:00:00 AM	600	588	478	468	345	339
9	11:00:00 AM	11:30:00 AM	1020	1008	435	425	433	427
10	11:30:00 AM	12:00:00 PM	900	888	457	447	567	561
11	12:00:00 PM	12:30:00 PM	840	828	534	524	670	664
12	12:30:00 PM	1:00:00 PM	900	888	654	644	733	727
13	1:00:00 PM	1:30:00 PM	720	708	782	772	678	672
14	1:30:00 PM	2:00:00 PM	660	648	564	554	456	450
15	2:00:00 PM	2:30:00 PM	720	708	786	776	1123	1117
16	2:30:00 PM	3:00:00 PM	1080	1068	867	857	1231	1225
17	3:00:00 PM	3:30:00 PM	890	878	908	898	1089	1083
18	3:30:00 PM	4:00:00 PM	923	911	1089	1079	1145	1139
19	4:00:00 PM	4:30:00 PM	1090	1078	1123	1113	1178	1172
20	4:30:00 PM	5:00:00 PM	872	860	1760	1750	1657	1651
21	5:00:00 PM	5:30:00 PM	776	764	1654	1644	1787	1781
22	5:30:00 PM	6:00:00 PM	521	509	1876	1866	1256	1250

1.7.9 Level of Service (LOS)

After calculating the delay of every approach of Science Laboratory intersection, the delay data was compared with the standard un signalized intersection delay data *(HCM, 2010)*. This intersection was controlled by police manually, so definitely Science Laboratory intersection is a un signalized intersection. By comparing with the standardized delay time with the intersection delay data, the level of services of different approaches of Science Laboratory intersection was calculated on the basis of delay. The result of this calculation is tabulated below.

Table 1.7.9: LOS of Different Approaches of Science Laboratory Intersection.

Observation No.	**Time**	**LOS (Kala Bagan to Science Lab. Intersection)**	**LOS (Bata Signal To Science Lab. Intersection)**	**LOS (New Market to Science Lab. Intersection)**
1.	07.00 A.M. 07.30 A.M.	A	A	A
2.	07.30 A.M. 08.00 A.M.	A	A	A
3.	08.00 A.M. 08.30 A.M.	E	A	A
4.	08.30 A.M. 09.00 A.M.	F	C	D
5.	09.00 A.M. 09.30 A.M.	F	D	E

6.	09.30 A.M. 10.00 A.M.	F	F	F
7.	10.00 A.M. 10.30 A.M.	F	F	F
8.	10.30 A.M. 11.00 A.M.	F	F	F
9.	11.00 A.M. 11.30 A.M.	F	F	F
10.	11.30 A.M. 12.00 P.M.	F	F	F
11.	12.00 P.M. 12.30 P.M.	F	F	F
12.	12.30 P.M. 01.00 P.M.	F	F	F
13.	01.00 P.M. 01.30 P.M.	F	F	F
14.	01.30 P.M. 02.00 P.M.	F	F	F
15.	02.00 P.M. 02.30 P.M.	F	F	F
16.	02.30 P.M. 03.00 P.M.	F	F	F
17.	03.00 P.M. 03.30 P.M.	F	F	F
18.	03.30 P.M. 04.00 P.M.	F	F	F
19.	04.00 P.M. 04.30 P.M.	F	F	F
20.	04.30 P.M. 05.00 P.M.	F	F	F
21.	05.00 P.M. 05.30 P.M.	F	F	F
22.	05.30 P.M. 06.00 P.M.	F	F	F

By observing the result of LOS of different approaches of Science Laboratory intersection, failure condition throughout the day was found. Most of the time of the day, the level of service of this intersection was persisted on Level F or failure condition. This is disastrous for today Modern Dhaka City.

1.8 Intersection Accident Data

The Accident Research Institute (ARI), formerly known as Accident Research Centre (ARC), is a Center of Excellence for the advancement of safety research in Bangladesh. After nearly six years of launching in January 2002, the Accident Research Institute (ARI) has started formally as an institute with its organogram and rules-regulations approved by the Syndicate of BUET in its 418th meeting held on 12 January 2008 following the recommendation of the Finance Committee on 08/01/2008.

The main objectives of the Institute are to carry out scientific research and investigation to ascertain the causes of accidents on roads, railways and waterways in Bangladesh. The institute has also given the mandated function to create awareness for safety issues at different stages of community across the country and share acquired knowledge with the professionals at different levels to ensure safer transportation system. In order to achieve the above, there are two (2) divisions in the institute: (i) Research and Investigation, and (ii) Education and Training.

ARI is conducting road safety research and investigation, which are useful in documenting the accident problem characteristics and provide the means to develop and evaluate effective countermeasures. Some major areas of research and investigation include:

- Accident Database Development.
- Identification and Treatment of Hazardous Road Locations.
- Investigation of Major Fatal Road Accidents and Accidents during Festival Periods.
- Metropolitan street accident characteristics and safety improvements.
- Involvement of Pedestrians and Children in Road Accidents.
- Heavy Vehicle Involvement in Road Accidents.
- Analysis of Inland Water Transport Accidents and Identification of Remedial Measures.
- Railway accident data collection.
- Level of under reporting of road traffic accidents in Bangladesh.
- Study on problems of vehicle modification in road traffic accident (Accident Research Institute (ARI), BUET, *website).*

As a secondary data of accident, in this research, the accident data was collected from this organization. By observing the accident reporting sheet, which was filled up by police, rare end collision occurred outside of the center of intersection and right collision occurred in the center of the intersection. A table containing accident data from 1998 to 2014 (Accident Research Institute (ARI), BUET *Hazardous Intersection of DMP 1998 2014* ow.

Table 1.8.1: Hazardous Intersection of DMP 1998 2014 (16 years).

Serial No.	Name of Intersections	Type of Intersections	Total Accident (Nos.)
1.	Jatrabari	Roundabout	174
2.	Farmgate	Multiple	130
3.	Shonargaon Panthapath ETV	Roundabout	108
4.	Bijoy Sarani	Cross	97
5.	Topkhana Purana Paltan	Cross	87
6.	Saidabad	Tee	93
7.	Shonir Akhra Crossing	Cross	76
8.	Jashim Uddin Road Crossing	Tee	85
9.	Kakoli (Mymen. Rd. + Kamal At. Av.)	Cross	85
10.	Shahbag	Roundabout	74
11.	Staff Rd. Crossing (Dhk Mymen Rd.)	Tee	58
12.	GPO (Abdul Gani Road)	Multiple	63
13.	Hotel Sheraton (Kazi Naz + Mintoo Rd)	Multiple	59
14.	Shapla Chattar	Roundabout	62
15.	New Eskaton (NE Rd. + Kazi Naz. Rd)	Tee	57

Serial No.	Name of Intersections	Type of Intersections	Total Accident (Nos.)
16.	Kakrail, Bhasani R. 10m N Star Gate	Multiple (2 Tee)	55
17.	New Airport Rd. + Bijoy Sarani	Tee	53
18.	Tongi Diversion Rd.	Multiple (1 Cross + 1 Tee)	52
19.	Moghbazar	Cross	55
20.	Mirpur Rd. + Cresent Lake Rd Crossing	Multiple	52
21.	Shanshad, Manik Mia Av.	Tee	52
22.	Progoti Sarani (Badda)	Tee	52
23.	Manik Mia Av. Indira Road (Rajabazar)	Multiple	43
24.	Malibag Crossing	Tee	45
25.	Joar Shahara	Tee	50
26.	Kakrail Traffic Signal	Stagg. Cross	45
27.	Hatkhola Crossing (At Hatkhola Rd.)	Tee	38
28.	Mahakhali Crossing	Tee	36
29.	Asad Gate	Stagg. Cross	39
30.	New Market, Mirpur Road	Stagg. Cross	35
31.	Kuril Bishwa Road at Level Crossing	Railway	35
32.	Mirpur 1 (Shah Ali) (Collected from DMP)	Tee	36

Serial No.	Name of Intersections	Type of Intersections	Total Accident (Nos.)
33.	Mohakhali	Tee	37
34.	Rokeya Shoroni(Mirpur 10 round circle)	Multiple (1 Round + 1 Cross)	34
35.	Green Rd. Junction (In front of Science Lab. Mirpur Road)	Tee	38
36.	Gulistan	Multiple	36
37.	Shyamoli, Mirpur Rd.	Multiple (2 Tee + 1 Cross)	42
38.	Mowchak	Tee	33
39.	Bangla Motor (Collected from DMP)	Cross	32
40.	Ramna, Bhasani Gate, at star gate	Roundabout	33
41.	Rokeya Shoroni (At Agargaon Junction)	Tee	35
42.	Motijheel	Cross	33
43.	Satrasta Round Circle	Roundabout	32
44.	Osmani Uddyan	Tee	28
45.	Flying Club Crossing	Tee	30
46.	Cantt. Zia Colony Gate, Mymen. Rd.	Tee	26
47.	Tikatuli, Toynobee Circ. Rd. At noor Community Center		24
48.	DIT Extn. Rd. Police Hospital (Near Motijheel Thana)	Cross	23
49.	Russel Square	Tee	2

Serial No.	Name of Intersections	Type of Intersections	Total Accident (Nos.)
50.	Katabon Crossing (Near Elephant Rd.)	Cross	21
51.	Rainbow Crossing (Tongi Diversion Rd.)	Tee	27
52.	Postogola (Railway Crossing + Madrasha Rd. Crossing)	Cross	25
53.	Baily Rd. Crossing (Near Monsur Ali Shoroni)	Cross	20
54.	Sugandha Crossing (Hare Road)	Tee	23
55.	Shishu Mela (Shyamoli) (Collected from DMP)	Tee	17
56.	Bangshal Crossing (At North-South Road)	Railway + Tee	19

1.9 Accident Prone Intersections of Dhaka City

Source: (Accident Research Institute (ARI), BUET, website)

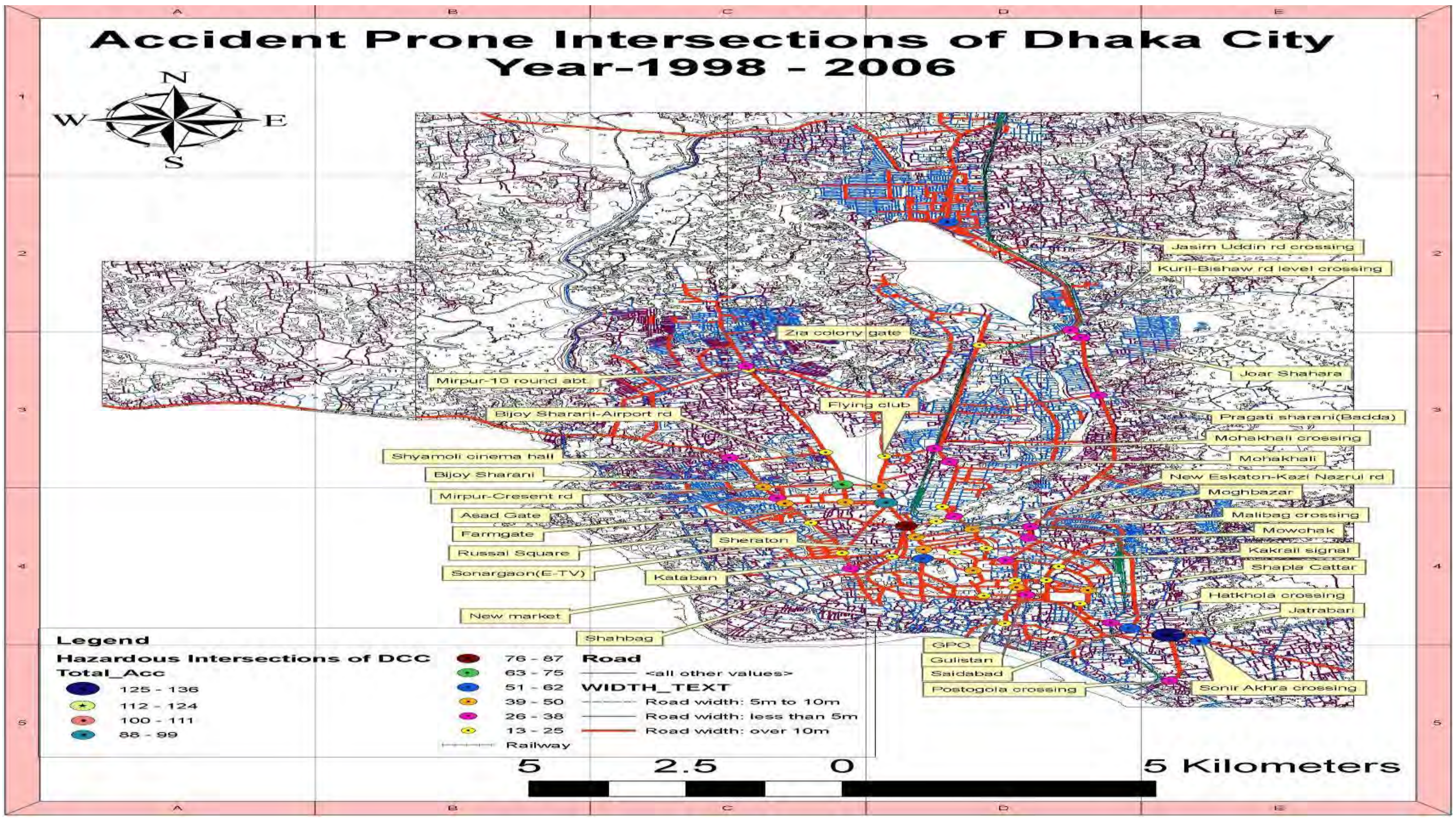


Figure 1.9.1: Intersection of Accident Prone inside Dhaka City