Pedestrian Road Crossing Behavior at Signalized Intersections and Mid-Block Sections in Dhaka City.

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of BACHELOR OF SCIENCE IN CIVIL ENGINEERING

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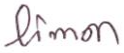
Md Shamiur Rahman Limon	BCE-1703012174	
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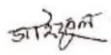
Saiful Islam	BCE-1702011063	
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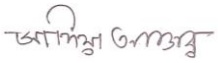
Sadia Akter	BCE-1802014079	

Dedicated

"This thesis work is dedicated to our supervisor, Asma Ul Hosna madam, Lecturer, who has been a constant source of support and encouragement during the challenges of graduate school and life. We are really grateful to have her as our supervisor. She has always helped us unselfishly. She has taught us much technical and nontechnical knowledge that we want to achieve. Special thanks to all the members of our group who worked together, to bring the successful outcome of this research work."

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ABSTRACT

Dhaka is one the most densely populated cities of the world. Here huge pedestrian gather in roads and intersections. At presents pedestrian crossing is one of the greatest challenges for the traffic and safety engineering communities. Present study deals with pedestrian crossing behavior at signalized intersections and mid-block sections in Dhaka city. To carry out the analysis at first number of intersections were collected from DCC and then survey were conducted to find out the existing pedestrian crossing facilities at near about 70 signalized intersections in Dhaka city. The study reveals that in Dhaka city area the generalized situation of pedestrian facilities are very poor. It signifies that about 70% intersections have no visible cross marking and about 76% intersections have no foot over bridges and underpasses. Six important intersections were selected to count the amount of pedestrian crossing at peak period namely Shahbag, Banglamotor, Sonargaon, Maghbazar, Elephant road and new market intersection. In this survey, direction wise amount of pedestrian crossing, number of pedestrian crossing with foot over bridge and number of legal and illegal crossing were collected. Pedestrian crossing behaviors were also observed at 6 selected intersections namely Shahbag Banglamotor, Sonargaon, Maghbazar, Elephant road, and New market. Pedestrian crossing rate at these intersections is about 5000 to 7000 per hour at peak period and average 15% to 25% illegal crossing occurs at those intersections. Categorized Pedestrian crossing behaviors are collected from video record survey for three intersections namely Shahbag, Sonargaon and New market which are different from different intersections. From the study it is observed that pedestrians are not willing to use grade separated crossing because it is time consuming and it consists physical labor. For doing this type of crossing they can take risky crossing. But in some intersections at grade crossing becomes very risky because of its high traffic volume and high vehicle speed. But pedestrians always prefer at grade crossing for this reason at grade pedestrian crossing facilities should be improved by different type of latest technologies.

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CHAPTER 1
INTRODUCTION

1.1 Background

A pedestrian is a person traveling on foot, whether walking or running. Pedestrian may be defined as those human traffic who are supposed to walk as a part of their movement and to use those facilities such as foot path, overpass, zebra crossing, subway etc. at any stage of their travel in order to accomplish their activities with which they are engaged in. Pedestrian activity is a major component in urban street capacity analysis and pedestrian characteristics are an important factor in the design and operation of transportation systems. An intersection is defined as an at-grade crossing of two or more roadways. Intersections are the most busy places in the road way. Pedestrian movement as well as pedestrian crossing at intersection is very important thing for the pedestrian safety and intersection capacity analysis. At busy intersections motorists, cyclists, and pedestrians often have to deal with complex situations and be aware of the position, movement and intent of other users. Mixed traffic of motor vehicles and pedestrians are common in urban intersections. Efficiency of intersections greatly affects the entire network performance. A pedestrian crossing or crosswalk is a designated point on a road at which some means are employed to assist pedestrians wishing to cross. They are designed to keep pedestrians together where they can be seen by motorists, and where they can cross most safely with the flow of vehicular traffic. Some times for improving pedestrian safety and intersection capacity, pedestrians are segregated from the way of motor vehicles by overpasses and underpasses. But Pedestrian chooses the shortest route for crossing the roadway and they want to minimize travel time. Pedestrian also have a basic resistance to change grades when crossing the roadways. They do not voluntarily make use of special pedestrian facilities such as overpasses and underpasses. In Dhaka city most of the pedestrian may take risk in crossing the road and they often cross at mid-block instead of using crosswalk.

In this circumstance, such a study regarding Pedestrian Road Crossing Behavior at Signalized Intersections and Mid-Block Sections in Dhaka City will reveal analysis on pedestrian road crossing behavior which will be helpful for future policy formulation regarding efficiency and safety improvement of the intersections.

1.2 Objectives of the Study

This study has been aimed at achieving the following objectives:

- To study pedestrian movement pattern at some selected intersections and foot over bridges in Dhaka City
- To identify the problems associated with pedestrian crossing at intersection.
- To evaluate the necessity of exclusive pedestrian phase at signalized intersection.
- To study the pedestrian crossing facilities at intersection in Dhaka City.

1.3 possible Outcome

This study is expected to have some findings about incorporation of pedestrian phasing in signal design process. This study will reveal problems and prospects of pedestrian movement pattern at intersections and foot over bridge of Dhaka City. It will make a clear clarification how to incorporate pedestrian issues in traffic engineering and transport management. In the long run this study will formulate policy guidelines how to incorporate pedestrian issues in future transportation planning and decision making.

1.4 Scope of the Study

Dhaka is the administrative, commercial and cultural capital of Bangladesh which serves as the nerve center of the country. It is one of the 10 mega cities in the world. Growing at a very fast rate, Dhaka's urban Population is predicted to increase from 11.3 million to about 21 million by 2015. With the growing importance of the city and mounting up pressure of population, traffic congestion is getting more and more precarious every year.

Pedestrian poses a significant position in traffic generation and increasing day by day in Dhaka. Most of the trips are started and ended as the means of a pedestrian. Dhaka is one of the fastest growing cities of the world. The city lacks proper transportation planning. Dhaka integrated transport study estimated 66% of all work trips are on foot. But unfortunately pedestrian facilities are poorly managed in Dhaka City. Walking is a commonly used mode of transport in Dhaka. The proportion of trips made by walking is increasing day by day. Existing pedestrian infrastructure and pedestrian facilities are not satisfactory. There is no pedestrian crossing phase at signalized intersection. There exist only 320.44 kilometers of footpaths in Dhaka City Corporation Area which belong to 155 acres of land. Average width

of the footpaths is 1.96 meter. But unfortunately most of them are not used properly. Hence, pedestrian movement at the intersection should be one of the major concerns to traffic engineers. Successful planning and design of pedestrian facility largely depends upon the better understanding the pedestrian crossing behavior and effective enforcement measures. A few studies have been so far conducted regarding pedestrian facilities. Md. Abdul Waresh (1991) pointed out in his thesis "Effect of Pedestrian Underpasses on Traffic Flow Characteristics: Metropolitan Dhaka" pedestrian crossing behavior in particular relation to the grade separated pedestrian facilities. He also assessed the effect of underpasses on traffic flow characteristics Hammed (2000) studied the factors that influence a pedestrian's waiting time and frequency of attempts to cross the street.

1.5 Limitations:

- The study does not cover deep analysis on signal designing and traffic management system for the studied area.
- Such a study requires financial and human resources to conduct extensive study. But due to resource and time constraint it limits to conduct more comprehensive study.
- It had not possible to conduct land use and traffic interaction for more analysis on the selectivity of the intersections to propose EPP.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Few studies have so far been conducted in Bangladesh regarding pedestrians. These studies are mainly focused on overview of the generalized problems related with pedestrians. But none of them has measured the state of pedestrians at intersections. To have better understanding on the conceptualization on the issue, information related to the research were collected from different available existing books/journals, unpublished thesis, seminar paper, magazine, newspapers etc. The study also used recommendations of different study reports related with the research. It was useful to collect opinions of different researchers in this matter. Some literatures on the issue are as follows:

The Highway Capacity Manual, TRB, National Research Council, Washington, D.C. focused on different Pedestrian capacity terminology, principles of pedestrian flow, pedestrian speed-density relationships, level of service which were studied for conceptual development on this issue.

2.2 Standard Terminology

The following terms are commonly used to pedestrian crossing.

1. **Types of Cross walk**

There are currently five types of formal pedestrian crossings used in the United Kingdom, these being Zebra, Pelican, Puffin, Toucan and Pegasus crossings. The most basic form of crossing is a pedestrian refuge; this is usually in the form of an island in the center of the road.

2. **Zebra Crossings**

This is characterized by wide longitudinal stripes on road, often with belisha beacons; pedestrians may cross at any time; drivers must give way to pedestrians who demonstrate intent to cross. It is also marked by black and white painted strips across the road and flashing amber beacons. The Highway Code says that motorists 'MUST give way when someone has moved onto a crossing'. However, pedestrians should remain on the kerbside for safety's sake until approaching vehicles have stopped. Zebra crossings are cheaper to build than traffic

signal crossings although their use on roads where traffic speeds are higher than 35mph is not recommended.

3. Refuge Island

It is also known as a pedestrian refuge or pedestrian island, is a small section of pavement or sidewalk, completely surrounded by asphalt or other road materials, where pedestrians can stop before finishing crossing a road. It is typically used when a street is very wide, as the pedestrian crossing can be too long for some individuals to cross in one traffic light cycle.

2.3 Pedestrian Crossing Facilities at Signalized Intersections

All traffic signals will be installed in accordance with the relevant Standards Australia and Austroads guidelines are given below.

Prioritizing of Intersection Upgrades

Designation of priority for installing symbolic pedestrian displays and audible tactile facilities at existing signalized intersections will include, so far as reasonably practical, consideration of Pedestrian demand the requirements of key stakeholders including blind and vision impaired stakeholders. Opportunities are needed to minimize installation costs by combining installations with other Upgrades/modifications at sites. Parallel Pedestrian Crossing Which Vehicles May Cross For the Full Pedestrian Crossing Period

Pedestrian signals will generally be configured to allow pedestrians to cross in parallel with traffic, with vehicles required to give way to pedestrians, when turning left or right across their path.

Parallel Pedestrian Crossing Which Vehicles May Cross After an Initial Period Pedestrian signals may be configured to prevent motor vehicles crossing the path of pedestrians for an initial period, less than the full crossing time. This will be provided at guidelines on pedestrian crossing facilities a signalis.doc main roads were all newly installed parallel pedestrian signal crossings for a period of 1 year, after which they will be considered by manager metropolitan traffic operations for reconfiguration to provide a parallel pedestrian crossing which vehicles may cross for the full pedestrian crossing period. Locations where driver behavior is considered by manager metropolitan traffic operations to be unsafe for a parallel pedestrian crossing which vehicles may cross for the full pedestrian crossing period.

Pedestrian signals may be configured to prevent motor vehicles crossing the path of pedestrians for the entire pedestrian crossing period when any one or more of the following criteria is met:

- The sight distance between motorists and pedestrians is less than the stopping distance for typical vehicle speeds near the intersection.
- Double left or right turns are permitted across pedestrian movements.
- There is significant use by children, the elderly or people with disabilities.
- The volume of heavy vehicles turning across the pedestrian crossing exceeds 50 vehicles per hour for each of the same 4 hours of a normal weekday.
- The speed limit exceeds 60 kmh.

Pedestrian signals may be configured to provide an exclusive pedestrian phase whereby all vehicle movements in all directions across the intersection are stopped and pedestrians are allowed to cross in all designated directions, when all of the following criteria are met:

- None of the roads is a declared highway or main road.
- The intersection is in a central business area or shopping area.
- An equivalent or better alternative route is available for through traffic to avoid the intersection if it so desires.
- The existing signal intersection is operating in a simple 2 traffic phase mode.

During any 4 periods (consecutive or non-consecutive) of 1 hour each, on anyone weekday, more than 200 pedestrians cross in all directions per hour and during the same hours, more than 400 vehicles turn within the intersection.

2.3.1 Signalized intersection

Cycle: One complete sequence of signal indications. Each phase has been serviced and the cycle is beginning again.

Cycle length (C): Total time for the signal to complete one cycle, generally express in second.

Phase: Part of cycle allocated to any combination of traffic movements receiving the right of way simultaneously during one or more interval.

Intersection: An intersection is defined as a grade crossing of two or more roadways.

Interval: Period of time during which all signal indications remain constant.

Change interval (Y): The "yellow" and /or "all-red" intervals, which occur at the end of a phase to provide for clearance of the intersection before conflicting movement are released also known as “Amber Period”.

Footbridge: A footbridge or pedestrian bridge is a bridge designed for pedestrians to provide safe and sustainable crossings. In many developed countries, footbridges are both functional and can be beautiful works of art and sculpture. Types of footbridge include Simple suspension bridge, clapper bridge, moon bridge, step-stone bridge, zigzag bridge. Types of residential-scale footbridges include plank, boardwalk, joisted, simple-truss. Different types of design footbridges include timber footbridges, steel footbridges, and concrete footbridges. Complicated engineering is not needed and the footbridges are built with readily available materials and basic tools.

Green time (G): Time within a given phase during which the "green" indication is shown, stated in seconds.

Lost time: Time during which the intersection is not effectively used by any movement, which occur during the change and clearance intervals (when the intersection is cleared) and at the beginning of each phase as the first few vehicles in a standing queue and experience start-up delays.

Effective green time (g): Time during which a given phase is effectively available for stable moving platoons of vehicles in the permitted movements, generally taken to be the green time plus the change and clearance interval minus the lost time for the designated movement, stated in seconds.

Green ratio (g/C): Ratio of effective green time to the cycle length.

Effective red (r): Time during which a given movement or set of movements is effectively not permitted to occur, the cycle length minus the effective green time, stated in seconds.

Mid-blocks: A Mid-block may be narrowly seen as the roadway section between two consecutive intersections, regardless of whether they are signalized or not. This view is in line with the traditional definition of a street block. Alternatively, a block may be broadly seen as the roadway section between two consecutive signalized intersections.

Actual Flow Rate: The design flow rate, or the maximum flow that is expected to use the intersection. See the theory and concepts modules on peak hour volume, design flow rate, and PHF.

All-red interval: Any portion of a signal cycle in which a red indication is observed by all approaches.

Approach: The portion of an intersection leg that is used by traffic approaching the intersection.

Capacity: The maximum number of vehicles that can reasonably be expected to pass over a given roadway or section of roadway, in one direction, during a given time period and under the prevailing roadway, traffic, and signalization conditions.

Change interval: Identical to the intergreen interval.

Clearance interval: Identical to the all-red interval.

Critical Flow Ratio: The flow ratio of the critical lane group within a phase. The actual or design flow rate for the critical movement divided by the saturation flow rate for that movement.

Critical Movement or Lane: The lane or movement for each phase, depending on how you choose to subdivide you intersection, that requires the greenest time.

Critical Volume: A volume, or combination of volumes, which produces the greatest utilization of capacity for the street or lane in question, given in terms of passenger car units per hour per lane or mixed vehicles per hour per lane.

Delay: The stopped time per vehicle (in seconds per vehicle), usually calculated separately for each lane group.

Design Flow Rate: Identical to the actual flow rate.

Effective Green Time: The green time that is actually used by traffic. Some lost time occurs initially while traffic responds to the green signal and begins to accelerate. Some time is also lost during the intergreen period as vehicles stop in anticipation of the next phase.

Flow Rate: The rate, in vehicles per hour or passenger car units per hour, at which traffic is entering an intersection.

Flow Ratio: The ratio of the actual flow rate to the saturation flow rate.

Green Interval: The portion of a signal phase in which the green signal is illuminated.

Green Ratio: The ratio of the effective green time to the cycle length.

Green Time: The length of the green interval and its change interval, given in seconds.

Hourly Volume: The number of mixed vehicles that traverse a given section of lane or roadway during an hour.

Wintergreen: The time interval between the end of a green indication for one phase and the beginning of green for the next phase.

Intersection Flow Ratio: The sum of all the critical flow ratios one from each phase.

Lane Group: Any group of lanes. Lanes can be combined during the signal timing design process in order to simplify the calculations.

Legs (intersection): The portions of the intersecting streets or roadways that are within close proximity to the actual intersection.

Level of Service (LOS): A measure of the operating conditions of an intersection.

Lost Time: The time during a given phase in which traffic could be discharging through the intersection, but it do not discharge. This is the period during the green interval and change intervals that is not used by discharging traffic.

Passenger Car Units: A unit of measure where by large trucks and turning movements are converted to passenger cars using multiplication factors. This allows you to deal with mixed traffic streams more accurately than if you had assumed all vehicles were created equal.

Peak-Hour: The hour of the day that observes the largest utilization of capacity, or the hour of the day in which the largest number of vehicles use the intersection approach or lane of interest.

Peak-Hour Factor: The ratio of the number of vehicles entering an approach during the peak hour to four times the number of vehicles entering during the peak 15 minute period. In the absence of field information, a value of 0.85 is normally used.

Pedestrian Crossing Time: The time that is required for a pedestrian to cross the intersection.

Phase: The portion of the cycle that is devoted to servicing a given traffic movement.

Phase Sequence: The predetermined order in which the phases of a cycle occur.

Queue: A closely spaced collection of vehicles.

Roadway Conditions: The physical aspects of the roadway, such as lane-width, number of lanes, easements, bike lanes, shoulder width, and any other aspect of the roadway.

Saturation Flow Rate: The maximum number of vehicles from a lane group that would pass through the intersection in one hour under the prevailing traffic and roadway conditions if the lane group was given a continuous green signal for that hour. This assumes that there is a continuous queue of vehicles with minimal headways.

Signalization Conditions: All the various aspects of the signal system, including timing, phasing, actuation, and so on.

Split: A percentage of a cycle length allocated to each of the various phases in a signal cycle.

Traffic Conditions: The qualities of traffic, such as traffic speed, density, vehicle types, and traffic flow rate.

CHAPTER 3

METHODOLOGY AND STUDY DATA

3. Outline of Methodology:

Methodology describes the procedures that have been followed to operationalize the research design for the collection and analysis of the information and data in confirmation with the research. Data from both primary and secondary sources has been used for this study. This study also maintains the following methodology for the achievement and successful accomplishment of the dissertation work.

Field survey has been conducted to identify the existing pedestrian crossing facilities are present at major intersection in Dhaka city. Existing pedestrian crossing facilities has been collected manually.

Pedestrian movement data has been collected by manual and video recording method of some selected intersections where traffic demand and pedestrian activities are very high. Direction wise pedestrian crossing data has been collected at evening peak period. Data analysis has been performed by MS Excel.

Pedestrian behavior studies have been done by manual observation and video recording survey. From this observation problems associated with pedestrian crossing at intersections has been identified.

Some signalized intersections have been selected to introduce exclusive pedestrian phase which are very busy and in which pedestrian activities are very high. Introducing EPP in this study is based on the hypothesis as an additional pedestrian phase has a positive correlation to increase efficiency of intersection. In other words, if a pedestrian phase is introduced it will lead to increase vehicle speed. To examine the hypothesis, traffic speed of different types of vehicles were determined through video recording in three selected intersections. Road width was calculated from GIS database prepared by RAJUK in Detailed Area Plan (DAP).

The video recording survey has also been performed to collect the traffic volume data which was necessary for signal design considering exclusive pedestrian phase and delay analysis has been performed by renowned Webster method.

Data Collection:

Both primary and secondary sources of data have been used by the study. But as the study of pedestrian situation in the study area is comparatively a new one, the study mostly depended on primary sources for data and information.

Primary Data Collection:

Manual and video recording methods of data collection have been applied in this study. Information has been collected about the basic parameters considered by the study. There are more than 70 signalized intersections in Dhaka city. But near about 70 signalized intersections were surveyed for lack of timing to identify the existing pedestrian crossing facilities. Some important unsignalized intersections were surveyed for the same cause which is controlled by traffic police. Pedestrian facilities in 70 intersections have been manually surveyed to know the generalized situation of the intersections of Dhaka city. The names of more than 70 intersections were collected from Dhaka City Corporation. As the population of Dhaka city is very high huge pedestrian gather in most of the intersections of Dhaka city. For the lack of timing it could not possible to count pedestrian crossing behavior at every signalized intersections of Dhaka city.

Six important intersections were selected to count the amount of crossing at peak period 5p.m to 6p.m. namely Shahbag, Banglamotor, Sonargaon, Mogbazar, elephant road and newmarket intersection. Although they are signalized intersections but most of them are not operated by traffic signal timing at peak period, they are only operated by traffic signal timing by off peak period and in peak period they are operated by one or more traffic police. In these survey direction wise amount of pedestrian crossing, number of pedestrian crossing with foot over bridge and number of legal and illegal crossing were surveyed. Here legal crossing means crossing with signal and grade separated crossing and illegal crossing means crossing without signal and risky crossing. Pedestrian crossing behavior were also observed at 6 selected intersections namely Shahbag, Banglamotor, Sonargaon, Mogbazar, elephant road and new market which consist of pedestrian traffic's age, education and destination.One hour Traffic Volume Survey were conducted by Video recording in 3 selected intersections at morning peak period from 8AM to 9PM and evening peak period from 5PM to 6PM for the necessity of achieving the objective of considering exclusive pedestrian phasing. At New market intersection morning peak hour were taken 9.30AM to 10.30AM because it is shopping areas which begin their activities after 9AM Applicability of introducing Exclusive pedestrian

Phase (EPP) was studied in three intersections as Shahbag, Sonargaon and Newmarket intersections.

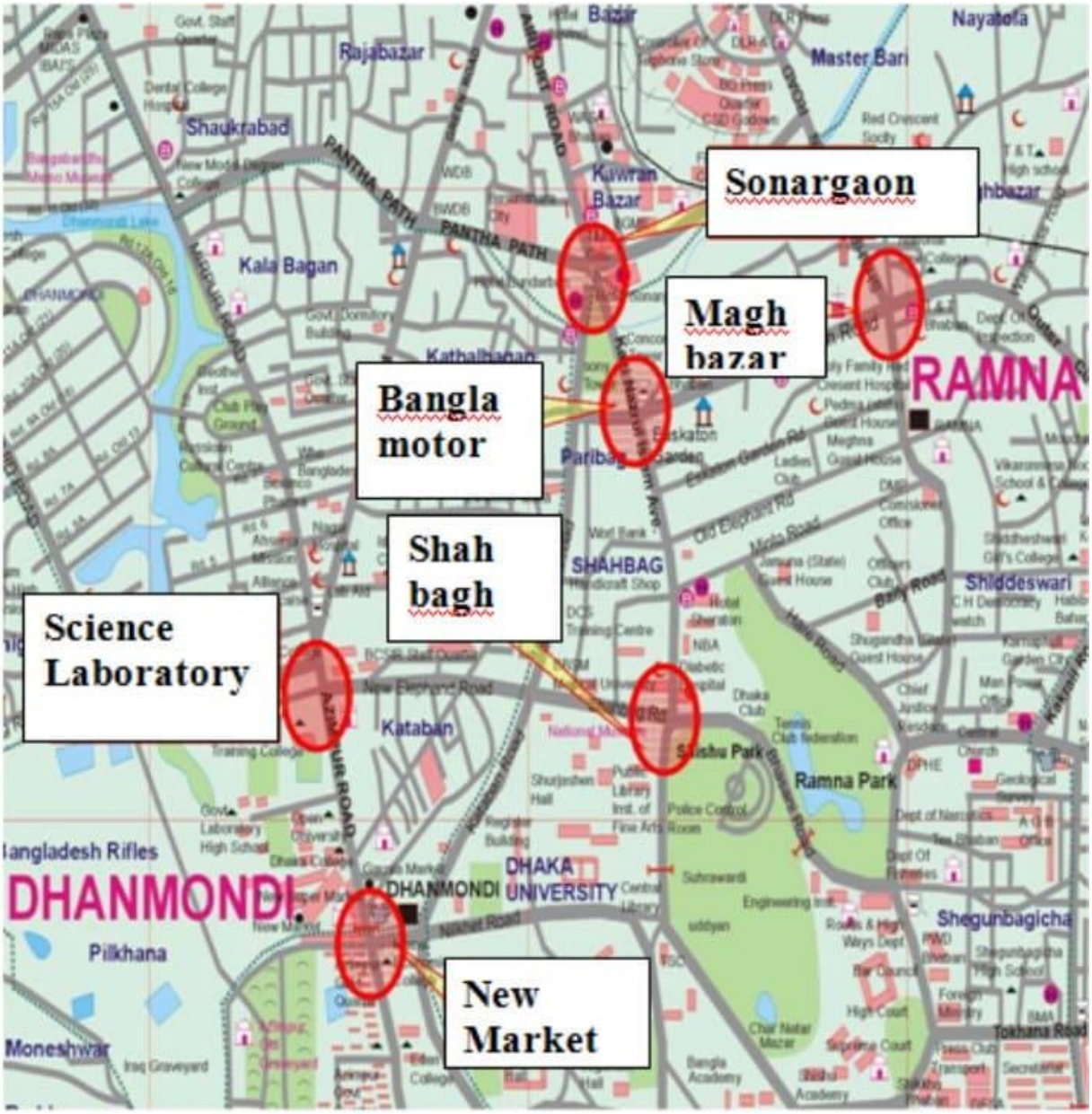


Fig: 3.1 Six Important Signalized Intersection of Dhaka City

Secondary data collection:

Secondary data has been collected from different sources as previous thesis, journals, books and internet. The maps of the study area, related plans, rules and regulations, etc were collected from secondary sources.

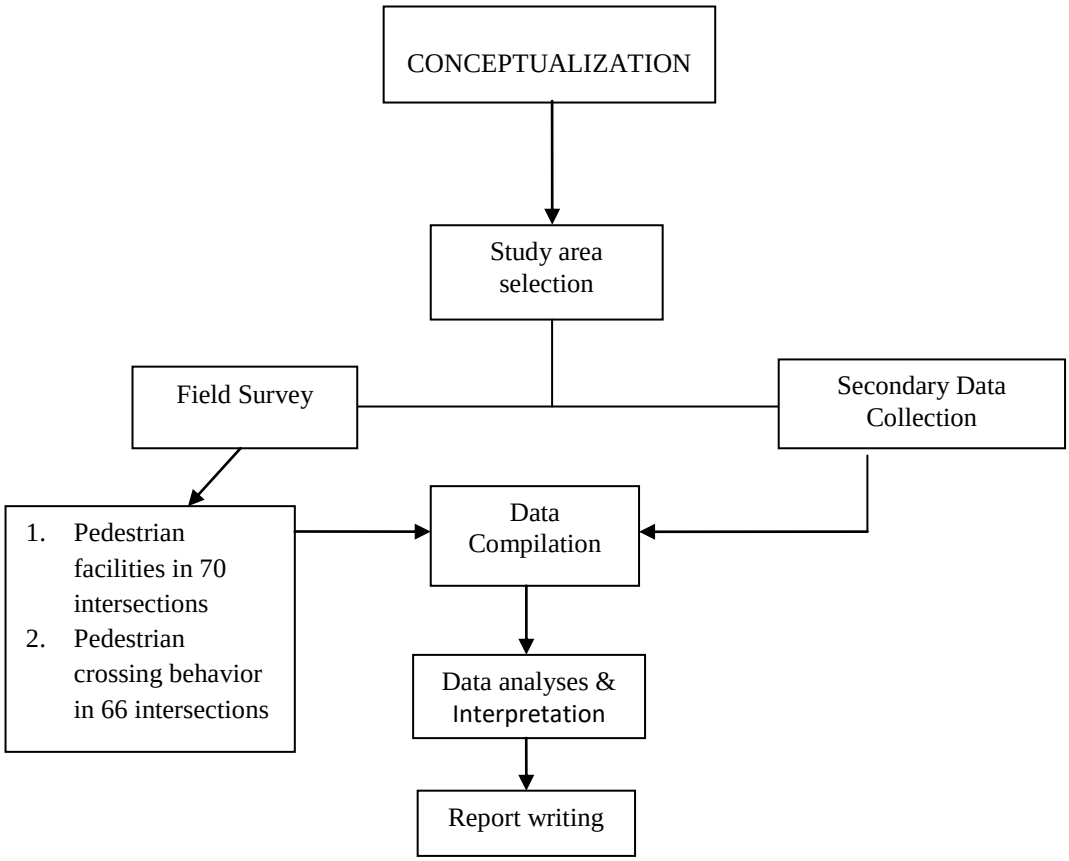


Fig: 3.2 Flow diagram of methodology

Data Processing

Raw data has been processed for data analysis. The data were processed according to their use for the fulfillment of objectives. Data are processed through statistical package software's spreadsheets and through map locations.

Data Analysis and Presentation

Processed data has been analyzed in the possible simple format. The analysis is statistical and calculative as far as possible for the purpose of the study. The computer software that are used in data processing and analysis are –Microsoft Office XP, Auto CAD 2007 which are used for graphical analysis and presentation in different format. The presentation of report is as possible as brief and in explanatory format. In this connection, the necessary software is the Microsoft Word (Version - Office XP) as well as the above.

CHAPTER 4
PEDESTRIAN CROSSING BEHAVIOR

4.1 Introduction

Pedestrian may be defined as those human traffic who are supposed to walk as a part of his movement and to use the facilities such as foot over bridge, zebra crossing, underpass, footpath etc. at any stage of their travel in order to accomplish their activities. All road users are pedestrians at some stage of each journey and some are pedestrians the whole time. Pedestrian crossing behavior depends on individual socio-demographic factors such as gender and age; environmental factors such as land use, street design, and facilities such as pedestrian overpasses and underpasses; traffic conditions such as heavy, high-speed traffic; enforcement factors; and factors related to education and policy. The movement of people and goods are linked with distribution and intensity of land use. People do not of course move on the roads for nothing. People move because of activities with which they are engaged in. As such pedestrian is, therefore function of activities. Pedestrians issue is important especially in urban areas where intense land use cause concentrated activities. They are the most difficult transport group to control and hard to enforce. The pedestrians are more often disobey the traffic control devices than are drivers. Their actions are less predictable than those of drivers, as many pedestrians consider themselves “outside the law” in traffic matters. Pedestrian is one of the dominant Mode of Transport. There is a wide variety of transport modes available in Dhaka city. Walking is a commonly used mode of transport in Dhaka. The proportion of trips made by walking is substantial and for some people, walking is a matter of choice and convenience. However, the reality is that for many people, walking is a matter of economic necessity .Beside the pedestrians, other means of travel are bicycle, rickshaw, motorcycle, baby-taxi, tempo, minibus, bus, car, taxi, jeep etc. Figure 4.1 shows about 60% mode of transport is walking.

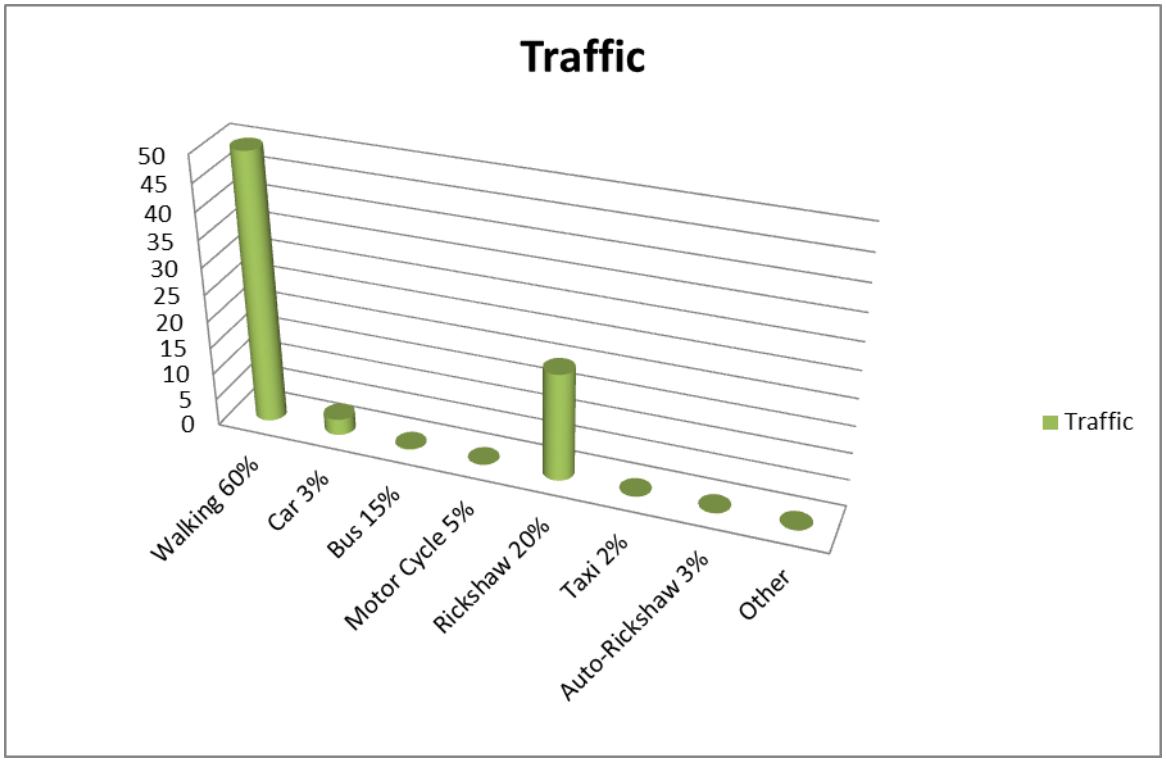


Fig: 4.1 Percentage of different Modal Vehicles of Dhaka City

Although walking mode is high, most of cases pedestrian do not get proper facilities to cross the road .The figure 4.2 shows the pedestrian crossing is difficult in a mixed mode zone.

Fig: 4.2 Crossing in a mixed mode

4.2 Pedestrian as one of the dominant Mode of Transport

Despite a high preponderance of walking, suitable pedestrian facilities have been neglected and have, in most cases, only been added as an afterthought to road improvements. It has been estimated that there are only about 400 kilometers of footpath within the DCC area. Where footpaths have been built, there are frequent obstructions that block or otherwise reduce their overall usefulness. Such obstructions include: -

- Temporary vender stations and hawkers who occupy portions of the footpaths;
- Parked cars;
- Solid Waste skips;
- Building materials and debris that are stored or abandoned on the footpath; and
- Holes, surface irregularities and water accumulation.

The following Fig: 4.3 shows waste dumping in the footpath which is force to pedestrian walking in the roads.

Fig: 4.3 Waste Dumping on the footpath

Fig: 4.4 Poor and Dilapidated footpaths and roads

Fig: 4.5 Water Logging is a threat for pedestrians

Pedestrian of Dhaka city confiscated with physical, infrastructural human made non compliances. As the urban infrastructures are not pre-planned pedestrian facilities are poorly devised in Dhaka. Water logging is a very common scenario which is a great obstacle for planning of pedestrian facilities. The Fig: 4.4 and Fig: 4.5 shows water logging is a great

threat for pedestrian Pedestrians face severe congestion as foot path are occupied by street venders locally named as ‘ferry wall as’. According to certain estimates, nearly 40% percent of the footpaths are being occupied illegally (STP, 2005). Fig: 4.6 and Fig: 4.7 shows that the footpaths are illegally occupied by vendors which is also threat for pedestrian.

Fig: 4.6 Footpaths are occupied by vendors

In spite of a High Court ruling on February 11, 2001, ordering that the responsible agencies make all footpaths free from illegal occupation, no significant change or improvement is evident. As a consequence, pedestrians are often forced to walk in the street instead of on the footpaths, even in areas where footpaths are provided. Pedestrians walking on the road increase the risk of traffic-related pedestrian injuries and also have the adverse effect of the reducing the capacity of the road and thereby increasing congestion. Available information indicates that pedestrians are involved in half of all road collisions in the city. Two-thirds of all traffic related fatalities are pedestrians. According to STP survey, pedestrian volumes of 10,000 to 20,000 per day are common and reach as high as 30,000 to 50,000 per day in the Old City area. During the peak hour pedestrian counts of 1,000 to 3,000 per hour are common and reach as high as 5,000 in the Old City area.

4.3 Category of Intersections in Dhaka City

In order to identify junctions where priority should be shifted to pedestrians it is necessary to understand the crossing behavior of pedestrians and their perceptions of different crossing types (Hao, Xu et all 2005). Manual and video recording methods of data collection have been applied in this study. Information has been collected about the basic parameters considered by the study. Pedestrian facilities in 70 intersections have been manually surveyed to know the generalized situation of the intersections of Dhaka city. The name of the 70 intersections was collected from Dhaka City Corporation. In the field of road transport, an intersection is a road junction where two or more roads either meet or cross at grade (they are at the same level). Such a road junction may also be called a crossroads. Some may classify intersections as 3-way, 4-way, 5-way, 6-way, 7-way etc. depending on the number of road segments (arms) that come together at the intersection. A junction between three road segments (arms) is a T junction (two arms form one road) or a Y-junction. 4-way intersections are the most common, because they usually involve a crossing over of two streets or roads. 5-way, 6-way and multiple intersections are less common but still exist, especially in urban areas with non- rectangular blocks. In Dhaka city area the study reveals that about a half of the intersections nearly 49% are T-type and Y-type, followed by 47% as 4-way intersection and the rest 4% are 5-way and more road junctions which is shown in Figure 4.8.

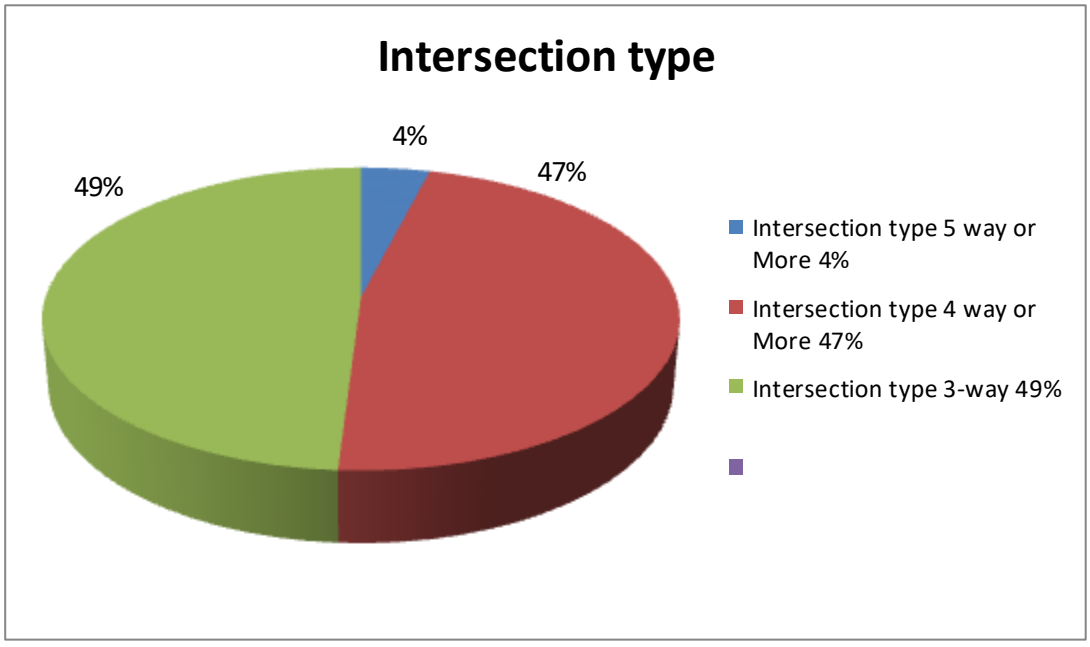


Fig: 4.7 Different types of Intersections in Dhaka City

4.4 Existing Pedestrian Facilities

4.4.1 Presence of Cross Marking

A pedestrian crossing or crosswalk is a designated point on a road at which some means are employed to assist pedestrians wishing to cross. They are designed to keep pedestrians together where they can be seen by motorists, and where they can cross most safely across the flow of vehicular traffic. Pedestrian crossings are found at intersections, and also be at other points on busy roads .They are generally also installed common where large numbers of pedestrians are attempting to cross (such as in shopping areas) or where vulnerable road users (such as school children) regularly cross etc. In Dhaka city area the study reveals that about 70% intersections have no cross marking and cross marking are present about 30% intersections which is shown in Figure 4.9.

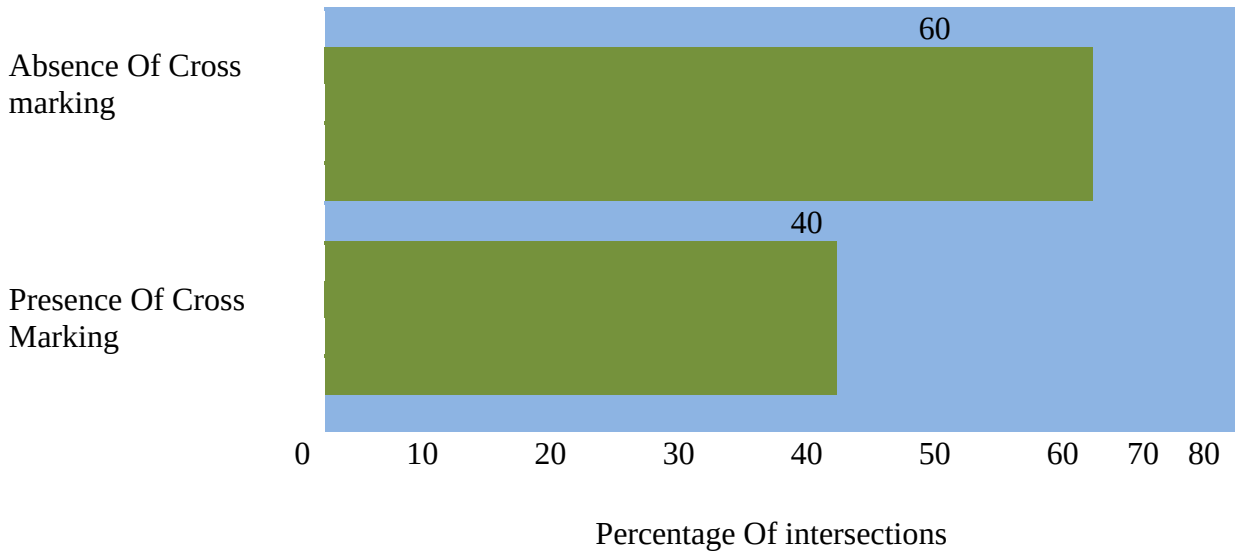


Fig: 4.8 Percentage of intersections having Cross mark

In Dhaka city most of the signalized intersections has no cross marking. The following Figure 4.10 shows a signalized intersection which has no cross marking

Fig: 4.9 Lack of cross marking

4.4.2 Foot Over Bridge/ Underpasses

These are grade separated crossing. A pedestrian overpass and underpass allows pedestrians safe crossing over busy roads without impacting traffic. In most cases pedestrian choose at grade crossing. But in most busy intersections these are very essential for safe pedestrian crossing. In Dhaka city area the study reveals that about 24% intersections which have foot over bridges and underpasses and about 76% intersections which have no foot over bridges and underpasses which is shown in Fig:4.10.

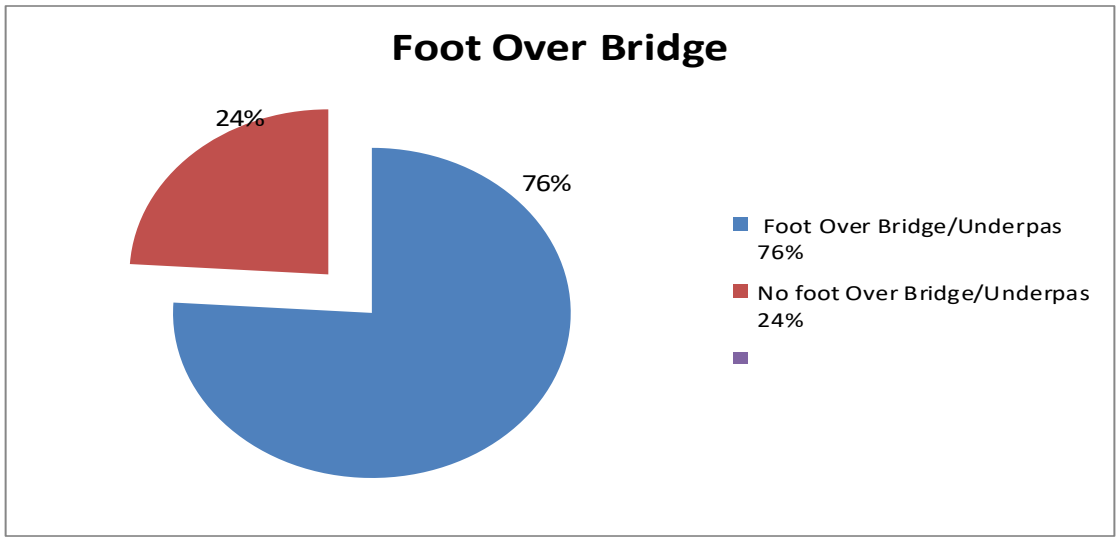


Fig: 4.10 Percentage of intersections having foot over bridge and underpasses

4.4.3 Refuge Island:

A refuge island, also known as a pedestrian refuge or pedestrian island, is a small section of pavement or sidewalk, where pedestrians can stop before finishing crossing a road. It is typically used when a street is very wide, as the pedestrian crossing can be too long for some individuals to cross in one traffic light cycle. It is one of the most important facilities for pedestrian road crossing. In Dhaka city the study reveals that about 75% intersections have refuge islands, about 5% are broken and about 20% intersections have no refuge island which is shown in the following Figure 4.12.

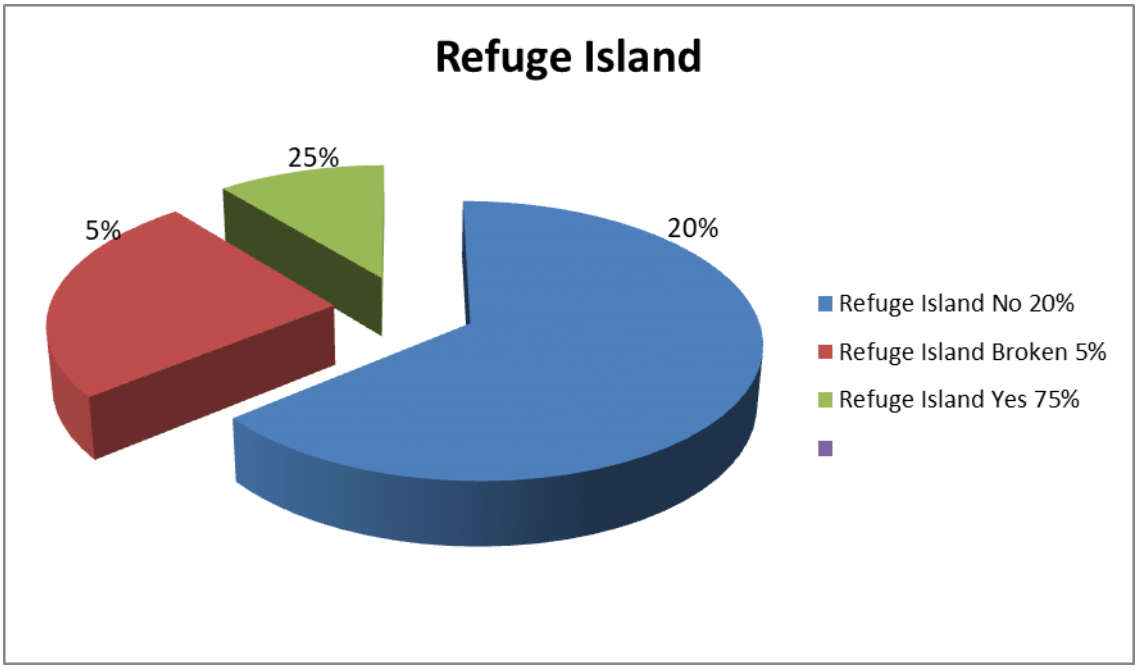


Fig: 4.11 Percentage of intersections having Refuge Island

4.4.5 Traffic Signals and Traffic Police

Traffic signals are electrically operated traffic control devices which alternately direct traffic to stop and to proceed. This discussion tells what factors enter into traffic engineers' decisions to install traffic signals. Because there is a common belief that signals are the answer to all traffic problems at intersections, this is offered in the interest of developing broader public understanding about what signals will do - and what they won't do.

Traffic guards are stationed at a crossing without signal or placed for extra safety at a junction. They stop pedestrians and vehicles from crossing a junction where another thing has

the right of way to cross. In addition they have to moderate the traffic density to not cause traffic jams. They guide motorists and pedestrian to follow the traffic laws.

4.5 Pedestrian crossing behavior

Urban traffic movement pattern has a relationship with the existing urban land use pattern. Existing theories relating patterns of pedestrian and vehicular movement to urban form characterize the problem in terms of flows to and from 'attractor' land uses (UCL, 2). Land use is a critical component affecting pedestrian behavior; creating an environment where pedestrians are comfortable will maintain a higher pedestrian mode share. So, surrounding land used in the selected intersections has been analyzed. Pedestrian crossing behavior in 6 intersections namely Shahbag, Banglamotor, Sonargaon, Mogbazar, Elephant road and New market were surveyed which consist of pedestrian traffic volume and direction wise pedestrian crossing. It is suggested that the configuration of the urban grid itself is the main generator of patterns of movement. In the study it has been found that intensity and movement pattern of traffic especially pedestrian flows varies due to category of surrounding land uses of the selected intersections described.

4.5.1 Shahbag Intersection

It is one of the most important intersections under the urban arterial system. A lot of institutions such as Dhaka University, BSMMU, BIRDEM Hospital, Ramna park, Shishu park, Public library and National Museum are situated surrounding this intersection. Huge pedestrian traffic is generated and destinated this area. But unfortunately pedestrian traffic route network has not been well developed. This study reveals that a total number of 7140 pedestrian traffic generated in an around the shahbag intersection per hour at peak period. The distribution of one hour pedestrian traffic along with the eight directions has been presented in the figure below. Pedestrian traffic volume per hour of eight direction of this intersection is presented in the following Fig 4.13. The figure is drawn considering the intensity of traffic volume. The figure is drawn based on the condition, Y/4=X where

X = Line width in inch

Y= No. of pedestrian crossing the road in one direction**.**

Total pedestrian crossing at Shahbag intersection which is occurred at evening peak period 5.00pm to 6.00pm is shown in Fig: 4.12. The figure shows total amount of pedestrian crossing including legal and illegal crossing. Here thick arrow represent pedestrian crossing intensity is high and vice-versa. The following Table 4.1 represent amount of pedestrian

crossing in signal (Vehicle red in that direction), foot over bridge and risky crossing in each direction and percentage of those crossing at evening peak period. In this table legal cross consist pedestrian crossing with signal and foot over bridge and illegal cross consist risky crossing.

Table 4.1: Status of Pedestrian traffic for Shahbag Intersection

Name (Direction)	Legal cross				Illegal Cross	Percentage (%)	Total Traffic
	signal	Percentage (%)	FOB used	Percentage (%)			
National .Museum To BSMMU	1036	85.05			182	14.95	1300
BSMMU To N.Museum	822	82.03			180	17.97	1500
BSMMU To BIRDEM	305	62.76	144	29.63	37	7.61	495
BIRDEM To BSMMU	402	37.57	580	54.20	88	8.23	1080
BIRDEM To DU.PS	1211	83.40	138	9.50	103	7.10	1075
DU.PS To BIRDEM	691	65.06	258	24.29	113	10.65	1467
DU.PS To N.Museum	350	87.06			52	12.94	408
N.Museum To DU.PS	339	75.67			109	24.33	480
						Total	7805

Legal vs. Illegal Crossing

In this study, legal crossing means crossing through using crosswalks and foot over bridge. Illegal crossing is counted pedestrian crossing without crosswalks and during vehicle running using mid blocks. In analyzing the direction wise pedestrian traffic data it has been found that a lot of factors influence the intensity of illegal crossing. The factors which influence the rate of illegal crossing are mainly traffic management pattern, existence of signal, foot over bridges, physical impediment or barriers, lack of imposition or existence of sidewalk barrier and median barrier. Data presented in Table 4.1 shows the highest no. of illegal crossing takes place namely 24.33 % in the direction of 'National Museum to Dhaka University Police Station' where foot over bridge is not existed and lack of mechanized signaling system. Movement of pedestrian traffic in an around Shahbag intersection is hindered insufficient foot path, lack of proper traffic management system, invisible traffic sign and signals. Streets and footpath are occupied by hawkers and vendors. The data shows that the most vulnerable direction where the rate of illegal crossing is higher in National Museum to Dhaka University

Police Station namely about a quarter (24.33%) of the total pedestrian of this direction. Table 4.2 shows direction wise total no of legal and illegal pedestrian crossing at Shahbag intersection.

Table 4.2: Status of Crossing at Shahbag Intersection

Name of Directions	Legal Cross		Illegal Cross	
	Frequency	%	Frequency	%
N.Museum To BSMMU	1036	85.06	182	14.94
BSMMU To N.Museum	822	82.04	180	17.96
BSMMU To BIRDEM	449	92.39	37	7.61
BIRDEM To BSMMU	982	91.78	88	8.22
BIRDEM To DU.PS	1349	92.91	103	7.09
DU.PS To BIRDEM	949	89.36	113	10.64
DU.PS To N.Museum	350	87.06	52	12.94
N.Museum To DU.PS	339	75.67	109	24.33
Total	6276	87.90	864	12.10

Source: Field Survey, 2020

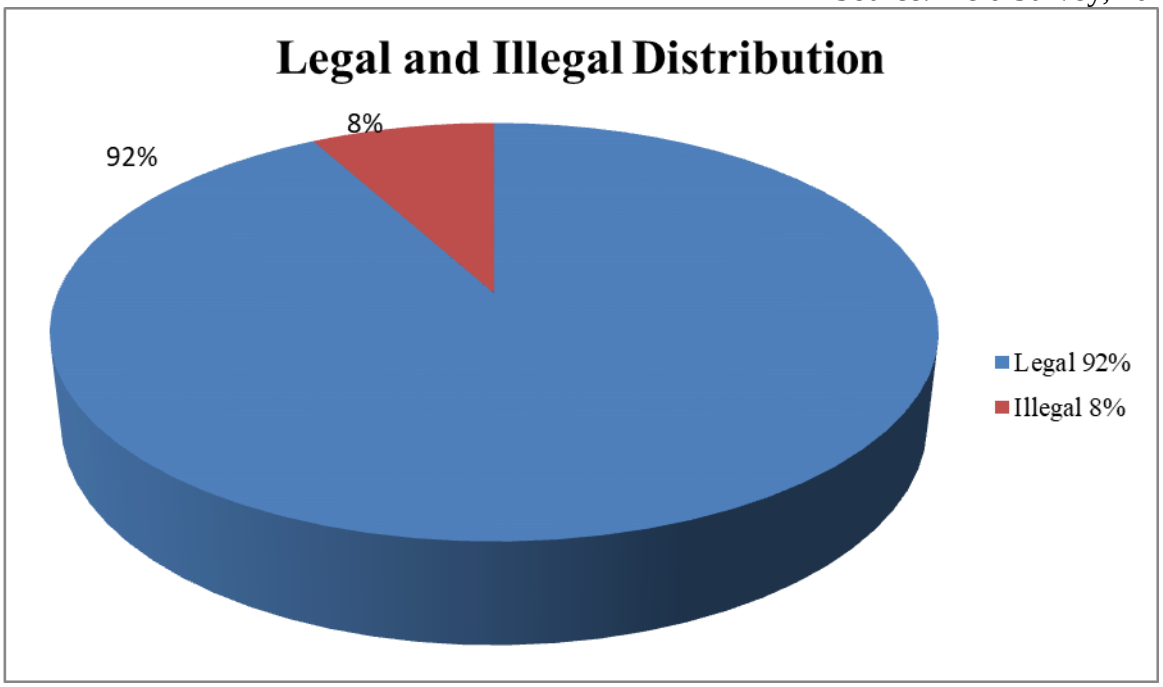


Fig: 4.12 Legal and Illegal Distribution of Pedestrian crossing for Shahbag Intersection

Pedestrian Crossing Behavior of Shahbag Intersection for One Hour

Crossing Behavior: Type1

Crossing behavior of the pedestrians depend on psychological characteristics as age, gender, awareness level of the pedestrians as well as modal characteristics, vehicular speed, presence foot over bridge and overall traffic management pattern prevailing in respective intersection. In Shahbag, it is mostly found that the pedestrians are intended to form a group as cordon to cross the road where vehicle speed is comparatively higher. Such types of crossing behavior were identified in Shahbag intersection which is much popularized intersections. Table 4.3 shows in Shahbagh intersection, the form of cordon is noticed to be higher namely 64.86% where the form of single crossing and double (two person together) crossing were 27.57% and 7.57% respectively. The reason of higher rate of cordon is considered as high vehicular speed.

Table 4.3: Percentage of Crossing by Single, Double and Group at Shahbag Intersection per Hour

Type of Crossing	No. of Pedestrian	Percentage (%)
Single	1924	27.57
Double	496	7.57
Cordon or group	4840	64.86
Total	7,260	100.00

Crossing Behavior: Type2

The pedestrians are noticed to walk normally represented by 88.80% where they are noticed to run quickly by 15.2% which is shown in the following Table 4.4. Such type of crossing by running is highly risky and any fatal injuries or deceased may be happened any time.

Table 4.4: Percentage of Crossing by Walking and Running at Shahbag Intersection per Hour

Type of Crossing	No. of Pedestrian	Percentage(%)
Walking	6255	84.80
Running	960	15.2
Total	7215	100.00

Crossing Behavior: Type3

This type of crossing behavior is classified in three categories for analysis. Some of them are found to use zebra crossing timely which is also legal crossing. Some pedestrians run quickly in mid-block section. A group of them are noticed to cross diagonally which type of crossing

poses higher probability of fatal accidents at any time. In Shahbagh intersection it was found to use zebra crossing by 82.5% of them where they were noticed to use midblock by 7.57% of them. About 9.93% of them are noticed to follow very risky diagonal crossing which is shown in the following Table 4.5.

Table 4.5: Percentage of Crossing by Zebra, Midblock and Diagonal crossing at Shahbag Intersection per Hour

Type of Crossing	No. of Pedestrian	Percentage (%)
Use zebra Crossing	6120	82.5
Use Mid-Block	496	7.57
Diagonal	608	9.93
Total	7224	100.00

4.5.3 Magbazar Intersection

Magbazar intersection is one of the important nodes in transportation network of Dhaka metropolitan area. Huge no. of pedestrian traffic is generated in and around it. As it is located at the important location connected residential areas like Eskaton, Malibagh, Siddheswari, shopping areas as Mouchak market and recreational zones of Ramna park and so on. Among the studied intersections this is provided with a well-designed foot over bridge covering four directions and seems to have sound pedestrian infrastructure. But unfortunately there is found huge illegally crossing pedestrian traffic in this intersection. This study reveals that a total number of 4393 pedestrian traffic generated in and around the Magbazar intersection. The survey was conducted at peak period of 5.00 to 6.00 pm along all the direction of Maghbazar Intersection. The four corners of the intersection are shown 1,2,3,4 for directional flow analysis of the pedestrians. Pedestrian traffic volume per hour of eight direction of this intersection is presented in the following Fig: 4.13. The figure is drawn considering the intensity of traffic volume. The traffic volume showing in the figure include both legal and illegal pedestrian crossing.

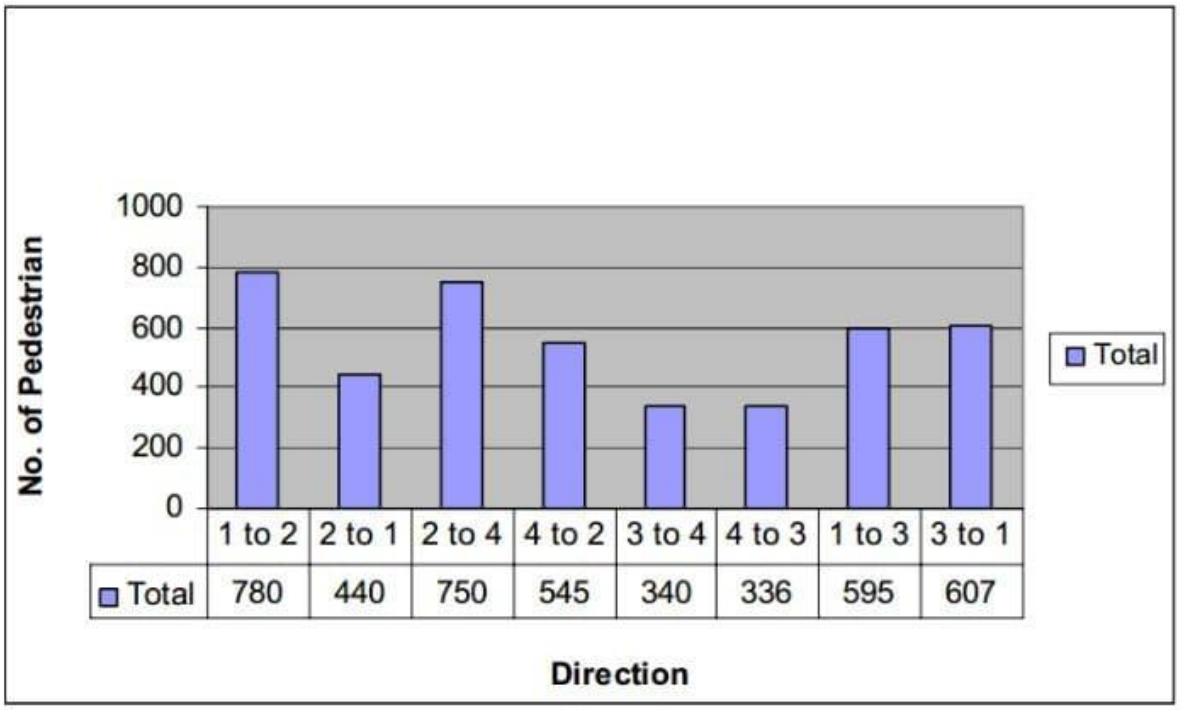


Fig: 4.13 No. of Pedestrian Traffic in all Directions for Maghbazar Intersection

Table 4.6: Status of Pedestrian traffic for Maghbazar Intersection

Name (Direction)	Legal cross				Illegal Cross	Percentage (%)	Total
	signal	Percentage (%)	FOB Used	Percentage (%)			
1 to 2	400	51.28	102	13.08	278	35.64	780
2 to 1	210	47.73	43	9.77	187	42.5	440
2 to 4	305	40.67	22	2.93	423	56.4	750
4 to 2	240	44.04	42	7.71	263	51.75	545
3 to 4	64	18.82	24	7.06	252	74.12	340
4 to 3	121	36.01	20	5.95	195	58.04	336
1 to 3	241	40.50	72	12.10	282	52.60	595
3 to 1	306	50.41	55	9.06	246	40.53	607
						Total	4393

Source: Field Survey, 2020

The following Table 4.7 shows direction wise legal and illegal pedestrian crossing for Maghbazar intersection. Illegal crossing is high at 2 to 4 direction.

Table 4.7 : Legal vs Illegal crossing for Maghbazar Intersection

Name (Direction)	Legal cross	Illegal cross
1 to 2	502	278
2 to 1	253	187
2 to 4	327	423
4 to 2	282	263
3 to 4	88	252
4 to 3	141	195
1 to 3	313	282
3 to 1	361	246
Total	2267	2126

Source: Field Survey, 2020

Among the total pedestrians it reveals that about 65% crosses legally by crosswalks and foot over bridge and about 35% crosses illegally which is shown in Fig: 4.17.

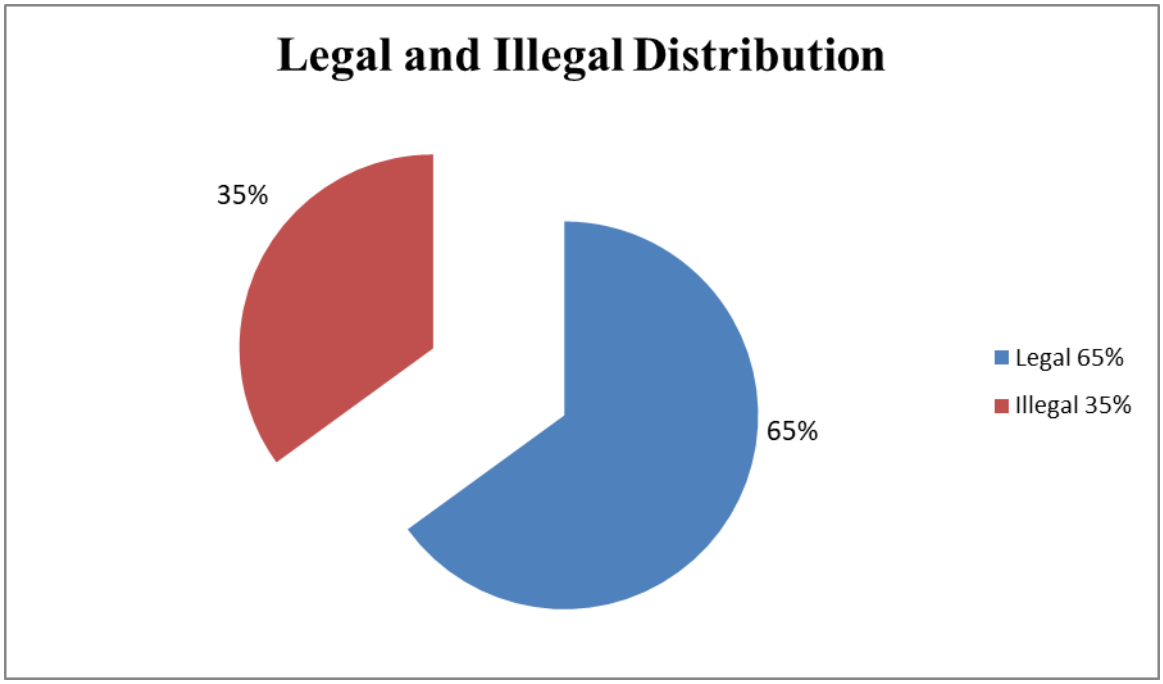


Fig: 4.14 Legal and Illegal Distribution of Pedestrian crossing for Maghbazar Intersection

During vehicle green time they make cordon and crosses in a platoon which is a great threat for pedestrian safety. Any time severe accident may happen. Although guardrail exists there

due to lack of compulsory imposition and options for crosswalk the rate of illegal crossing is higher in this intersection.

4.5.3 New Market Intersection

It is another important intersection under the urban arterial system. A lot of pedestrian traffic generated in and around New market area. It is located in an important location surrounded with Dhaka University, Eden College, Azimpur, Lalbag residential area, Govt staff quarters, Bangladesh University of Engineering and Technology (BUET) and so on. Huge pedestrian traffic is generated and destinated this area. But unfortunately pedestrian traffic route network has not been well developed. Pedestrian traffic volume per hour of eight direction of this intersection is presented in the following Fig 4.18. The figure is drawn considering the intensity of traffic volume.

Table 4.8 Status of Pedestrian traffic for New market Intersection

Name (Direction)	Legal cross				Illegal Cross	Percentage (%)	Total
	Signal	Percentage (%)	FOB used	Percentage (%)			
Quarter To Newmarket	558	91.77			50	8.23	625
Newmarket To Quarter	587	90.03			65	9.97	670
Nilkhet book stall To Newmarket	780	64.35	175	14.45	257	21.20	1300
Newmarket To Nilkhet book stall	827	65.95	187	14.91	240	19.14	1220
Nilkhet bedding stall To Quarter	586	92.57			47	7.43	640
Quarter To Nilkhet bedding stall	168	90.81			17	9.19	215
Nilkhet bedding stall To Nilkhet book stall	615	80.92			145	19.08	785
Nilkhet book stall to Nilkhet bedding stall	743	81.29			171	18.71	925
						Total	6380

The study reveals that the overall illegal crossing of Newmarket intersection is about 15% which is shown in Figure 4.19.

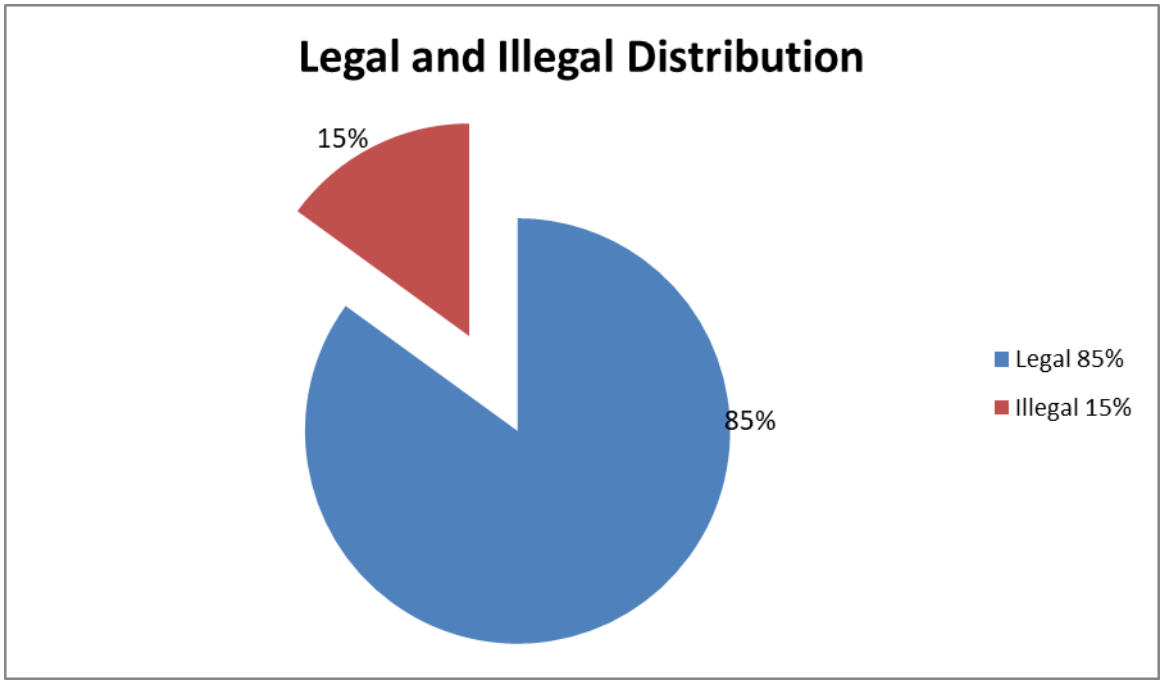


Fig: 4.15 Legal and Illegal Distribution of Pedestrian crossing for Newmarket Intersection

Pedestrian Crossing Behavior of Newmarket Intersection for One Hour

Crossing Behavior: Type1

Crossing behavior of the pedestrians depend on psychological characteristics as age, gender, awareness level of the pedestrians as well as surrounding land use, modal distribution, types of generating traffic, vehicle speed and traffic management pattern of the intersection. In New market intersection, there is found multimodal vehicle operations in combination with motorized and non-motorized traffic. As a result vehicle speed is comparatively slow. There is found crossing by single person namely 57.14% followed by dual crossing and cordon namely 28.56% and 14.30% respectively which is shown in Table 4.9. It is found that surrounding land use is another factor influencing crossing behavior. As it is dominated by shopping area the rate of single person crossing is higher in this intersection.

Table 4.9: Percentage of Crossing by Single, Double and Group at Newmarket Intersection per Hour

Type of Crossing	No. of Pedestrian	Percentage (%)
Single	3553	57.14
Double	1776	28.56
Cordon or group	889	14.30
Total	6218	100.00

Crossing Behavior: Type2

This type of crossing depends on vehicular speed, modal split of slow and fast moving vehicles. As New market intersection is characterized by mix modal agglomeration, vehicular speed is comparatively slow. The pedestrians are noticed to walk normally represented by 76.28% where they are noticed to run quickly by 23.71% which is mentioned in the following Table 4.10. Such type of crossing by running is highly risky and any fatal injuries or decease may be happened any time.

Table 4.10: Percentage of Crossing by Walking and Running at Newmarket Intersection per Hour

Type of Crossing	No. of Pedestrian	Percentage(%)
Walking	4743	76.28
Running	1474	23.71
Total	6218	100.00

Crossing Behavior: Type3

This type of crossing behavior is classified in three categories for analysis. Some of them are found to use zebra crossing timely which is also legal crossing. Some pedestrians run quickly in mid-block section. A group of them are noticed to cross diagonally which type of crossing poses higher probability of fatal accidents at any time. In Newmarket intersection it was found to use zebra crossing by 55.71% of them where they were noticed to use midblock by 37.15% of them. About 7.14% of them are noticed to follow very risky diagonal crossing which is shown in the following Table 4.11.

Table 4.11: Percentage of Crossing by Zebra, Midblock and Diagonal crossing at New market Intersection per Hour

Type of Crossing	No. of Pedestrian	Percentage(%)
Use zebra Crossing	3464	55.71
Use Mid-Block	2310	37.15
Diagonal	444	7.14
Total	6218	100.00

4.5.4 Elephant Road Intersection

It is one of the most important intersections under the urban arterial system. It is 3-way intersection. The Elephant road intersection has a foot over bridge. A lot of pedestrian traffic generated. As it is located at the important location connecting Dhanmondi, Mirpur road, elephant road shopping area, science laboratory, Hatirpul, Kataban and Shahbag, huge pedestrian traffic is generated and destinated this area. Pedestrian traffic volume per hour of eight direction of this intersection is presented in the following Figure 4.16.

Table 4.12: Status of Pedestrian traffic for Elephant Road Intersection

Name (Direction)	**Legal cross**				**Illegal Cross**	**Percentage (%)**	**Total**
	signal	**Percentage (%)**	**FOB used**	**Percentage (%)**			
Malancha restaurant to Science Laboratory School			96	32.00	204	68.00	330
S.L School To Malancha restaurant			210	41.18	300	58.82	525
City College To Malancha restaurant			216	100.00			235
Malancha restaurant To City College			258	100.00			288
Science .Laboratory School To Science .Laboratory			150	100.0			175
Science .Laboratory To Science Laboratory School			72				85
Science .Laboratory To City College			336	88.19	45	11.81	394
City College To Science Laboratory			246	89.13	30	10.87	282
Science Laboratory To Malancha	215	79.63			55	20.37	288
0Malancha To Science Laboratory	180	75.00			60	25.00	257
						Total	2529

Source: Field Survey, 2020

The study reveals that the overall illegal crossing at Elephant road intersection is 20% which is shown in Figure 4.21.

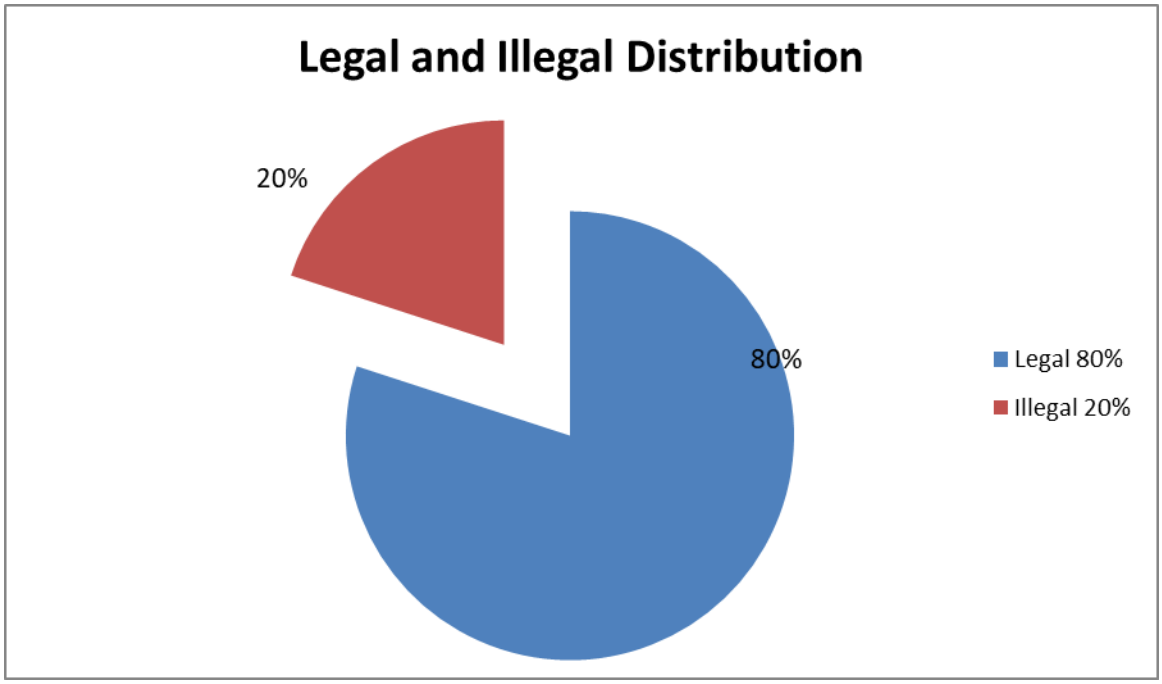


Fig: 4.16 Legal and Illegal Distribution of Pedestrian crossing for Elephant Road Intersection

4.5.5 Sonargaon Intersection

It is one of the most important intersections under the urban arterial system. It is a 5-way intersection. It has an underpass in the farmgate direction. A lot of pedestrian traffic generated in this intersection. As it is located at the important location connection Pan Pacific Sonargaon hotel, Bashundhara shopping mall, Panthapath commercial area, Kawran bazaar whole sale market and Kathalbagan mixed use zone, huge pedestrian traffic is generated and destinated this area. Although here exist an underpass near about 20 meter from this intersection it contributes to divert some pedestrian in one direction only. This study reveals that a total number of 6948 pedestrian traffic generated in an around the Sonargaon Intersection in the survey period 5 p.m. to 6 p.m. intersection

Table 4.13: Status of Pedestrian traffic for Sonargaon Intersection

Name (Direction)	Legal cross		Illegal Cross	Percentage (%)	Total
	signal	Percentage (%)			
1 to 2	695	83.09	105	16.91	800
2 to 1	823	87.00	112	13.00	935
2 to 4	663	81.10	126	18.90	789
4 to 2	641	77.89	165	22.11	806
3 to 4	1139	76.02	368	23.98	1507
4 to 3	655	73.17	241	26.83	896
1 to 3	808	79.21	158	20.79	966
3 to 1	294	74.93	84	25.07	387
				Total	7086

Source: Field Survey, 2020

Overall pedestrian crossing is in eight directions including legal and illegal crossing. More pedestrian crossings occur at 3 to 4 direction which is shown in the following figure.

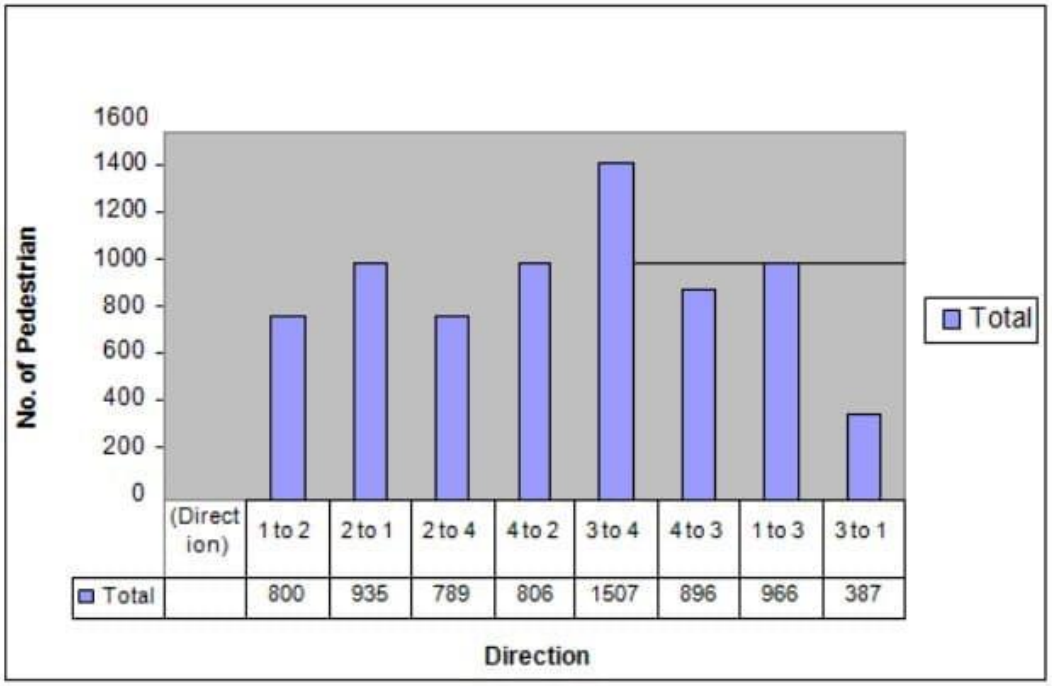


Fig: 4.17 Direction wise One Hour Pedestrian Crossing Data for Sonargaon Intersection

The following figure shows the overall illegal crossing of Sonargaon intersection is 18%.

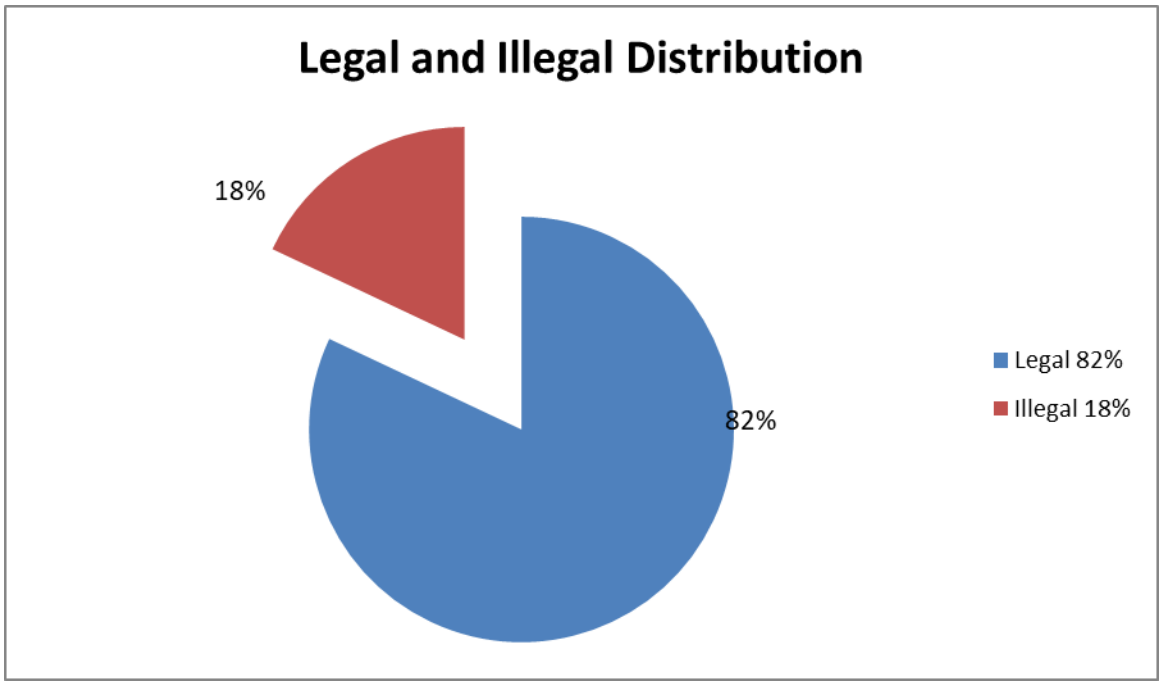


Fig: 4.18 Legal and Illegal Distribution of Pedestrian crossing for Sonargaon Intersection

Pedestrian Crossing Behavior of Sonargaon Intersection for One Hour

Crossing Behavior: Type1

Crossing behavior of the pedestrians depends on traffic speed, modal distribution and characteristics of traffic management. In Sonargaon Intersection, it is mostly found that the pedestrians are intended to form a group as cordon to cross the road where vehicle speed is comparatively higher. In Sonargaon intersection, the form of cordon is noticed to be higher namely 78.17% where the form of single crossing and double (two person together) crossing were 12.77% and 9.06% respectively which is shown in the following Table 4.14.

Table 4.14: Percentage of Crossing by Single, Double and Group at Sonargaon Intersection per Hour

Type of Crossing	No. of Pedestrian	Percentage(%)
Single	887	12.77
Double	630	9.06
Cordon or group	5431	78.17
Total	6948	100.00

Crossing Behavior: Type2

The pedestrians are noticed to walk normally represented by 94.44% where they are noticed to run quickly by 5.56% which is shown in the following Table 4.15. Such type of crossing by running is highly risky and any fatal injuries or deceased may be happened any time.

Table 4.15: Percentage of Crossing by Walking and Running at Sonargaon Intersection per Hour

Type of Crossing	No. of Pedestrian	Percentage(%)
Walking	6562	94.44
Running	386	5.56
Total	6948	100.00

Crossing Behavior: Type3

This type of crossing behavior is classified in three categories for analysis. Some of them are found to use zebra crossing timely which is also legal crossing. Some pedestrians run quickly in mid-block section. A group of them are noticed to cross diagonally which type of crossing poses higher probability of fatal accidents at any time. In Sonargaon intersection it was found to use zebra crossing by 92.58% of them where they were noticed to use midblock by 5.56% of them. About 1.86% of them are noticed to follow very risky diagonal crossing which is shown in the following Table 4.16.

Table 4.16: Percentage of Crossing by Zebra, Midblock and Diagonal crossing at Sonargaon Intersection per Hour

Type of Crossing	No. of Pedestrian	Percentage (%)
Use zebra Crossing	6433	92.58
Use Mid-Block	386	5.56
Diagonal	129	1.86
Total	6948	100.00

4.5.6 Bangla motor Intersection

It is one of the most important intersections under the urban arterial system. It is 4-way intersection. It has a foot over bridge in Sonargaon direction. A lot of pedestrian traffic generated in this intersection. As it is located at the important location connection of Kazi Nazrul Islam avenue, Bangla motor, New Eskaton, Dhaka Sheraton hotel, BSMMU, BIRDEM Hospital and so on, huge pedestrian traffic is generated and destined in this area. But unfortunately pedestrian traffic route network has not been well developed. The intersection generates huge pedestrian traffic in all directions is presented in the following Fig 4.26. The figure is drawn considering the intensity of traffic volume. The traffic volume

showing in the diagram include both legal and illegal pedestrian crossing. The figure is drawn based on the principles and conditions mentioned previously.

Table 4.17: Status of Pedestrian traffic for Bangla motor Intersection

Name (Direction)	Legal cross				Illegal Cross	Percentage (%)	Total
	signal	Percentage (%)	FOB used	Percentage (%)			
1 to 2	770	37.99	417	42.25	225	19.76	995
2 to 1	1118	47.55	518	41.67	175	10.78	1263
2 to 4	460	85.25			95	14.75	555
4 to 2	329	78.93			75	21.07	404
3 to 4	1092	88.92			158	11.08	1250
4 to 3	1210	91.78			125	8.22	1335
1 to 3	380	86.82			75	13.18	455
3 to 1	436	91.27			62	8.73	498
							6755

More pedestrian crossings occur at 4 to 3 direction is 1335 per hour at peak period which is shown in the Figure 4.19.

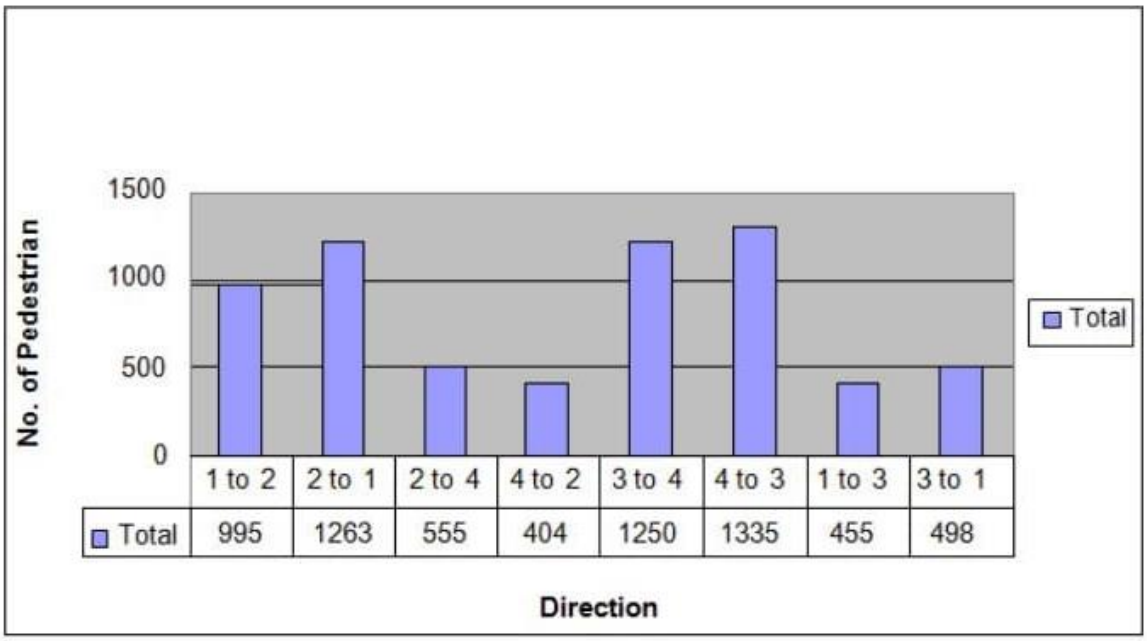


Fig: 4.19 Direction wise Pedestrian Crossing One Hour Pedestrian Crossing Data Bangla motor Intersection

The following figure shows the overall illegal crossing of Bangla motor intersection is about 20%

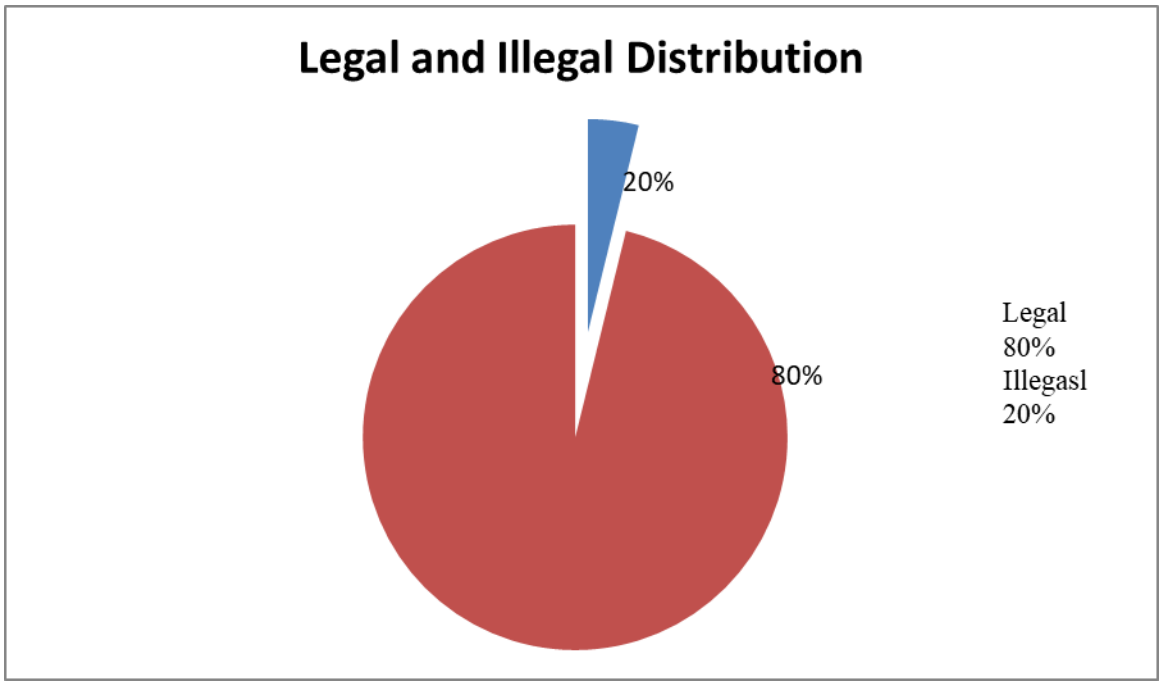


Fig: 4.20 Legal and Illegal Distribution of Pedestrian crossing for Banglamotor Intersection

4.6 Problems associates with pedestrian crossing at Intersections in Dhaka city:

One of the major problems associated with pedestrian crossing is lack of visible cross marking among the existing intersections of Dhaka city. The study reveals that only 30% of the signalized intersections are provided with visible cross marking. This is a great threat to the safety of pedestrian crossing in Dhaka city.

There does not exist enough footpaths, crossing facilities in most of the intersections. In many cases footpath exist but in dilapidated poor physical condition and poorly provided with the crossing facilities. There is possibility with multiple threat collision because there is not enough stop bar/ speed breaker to stop back far enough from the crossing points.

The study reveals that a quarter of the surveyed intersections are not provided with any median and refuge island where people cross the road in unsafe way. Median Island is necessary to split the traffic in two groups to cross the road.

In many cases illegal parking is found near the visible cross marks which obstacles pedestrian crossing and is a threat for safety. Street lighting around the crossing is found to be inadequate. As a result the visible cross marks are not easily captured by the vehicledrivers t0 have stopping sight distance to avoid collision.

CHAPTER 5
RESULTS AND DISCUSSIONS

5.1 Introduction

An Exclusive Pedestrian Phase which is known as a pedestrian scramble is a pedestrian crossing system that stops all vehicular traffic and allows pedestrians to cross an intersection in every direction, including diagonally, at the same time. It is also known as a 'X' Crossing in UK, diagonal crossing in USA, scramble intersection in Canada, and more poetically it is also called as Barnes Dance.

5.2 Global Perspectives

Pedestrian scramble phasing is also commonly referred to as “exclusive pedestrian phase”, “pedestrian criss-cross”, “scramble lights”, “scatter lights”, “scramble corners” and “Barnes Dance”. The last mentioned terminology is named after Henry Barnes, the prominent traffic engineer, who is credited to be the first to use the system in Kansas City (Kansas) and Vancouver (Washington) and then later in Denver (Colorado), Baltimore (Maryland) and New York City (New York). The terminology came from an article written by a reporter who stated “Barnes had made the people so happy they’re dancing in the streets” (Bissessar, R. et all, 2010). It was first used in Canada and the United States in the late 1940's and has since then been adopted in many other cities and countries. Though it fell out of favour with traffic engineers in some countries for a while as it prioritizes pedestrians higher (and thus more than cars, in some situations), the understanding of the benefits in terms of pedestrian amenity and safety have led to new examples being installed in many countries in recent years. The most famous implementation of this kind of intersection is present in Shibuya, Tokyo.

5.3 Successful best practices of EPP

The residential population of Beverly Hills was about 35,000 (Vaziri, 1996). However, the daytime population was estimated at about 150,000, mostly concentrated in the Business District, which is informally called the “Business Triangle.” Daytime pedestrian activity is very heavy in the Business District due to the concentration of businesses and services and the high volume of tourists visiting the area around famous Rodeo Drive. The primary concern for the City was the high number of conflicts between pedestrians and vehicles at

many of the intersections, especially during holidays and peak tourist seasons. Large pedestrian flows were blocking crosswalks to turning traffic during the entire green signal phase (Vaziri, 1996). A review of the accident history revealed several reported vehicle-pedestrian accidents. Numerous field observations also concluded many "close calls" occurred.

5.4 Design Principles of EPP

Introducing EPP in this study is based on the hypothesis as an additional pedestrian phase has a positive correlation to increase efficiency of intersection. In other words, if a pedestrian phase is introduced it will lead to increase vehicle speed. To examine the hypothesis, traffic speed of different types of vehicles were determined through video recording in three selected intersections. Road width of different dimension of roads was calculated from GIS database prepared by RAJUK in Detailed Area Plan (DAP). If the average vehicle speed is 15 km per hour, it is intended to be increased after introduction of EPP

5.4.1 Design Consideration of EPP

Traffic Volume Survey was conducted by Video recording in 3 intersections for the necessity of achieving the objectives of the study. Applicability of introducing Exclusive pedestrian Phase (EPP) was analyzed in three intersections as Shahbag, Sonargaon, and Newmarket. In order to improve pedestrian movements and provide pedestrian-friendly environment in the intersections of Dhaka, scramble pedestrian phase may be introduced in some selected intersections. Synchro traffic signal analysis is one of the software based method of designing scramble pedestrian phasing. The result from the Synchro traffic signal analysis suggest that the proposed pedestrian scramble signal has no significant impact to the current vehicular traffic operation at the intersection (Pitaksringkarn, 2005).

Pedestrian crossing requirements can be taken care by two ways; by suitable phase design or by providing an exclusive pedestrian phase. It is possible in some cases to allocate time for the pedestrians without providing an exclusive phase for them. For example, consider an intersection in which the traffic moves from north to south and also from east to west. If we are providing a phase which allows the traffic to flow only in north-south direction, then the pedestrians can cross in east-west direction and vice-versa. However in some cases, it may be necessary to provide an exclusive pedestrian phase. In such cases, the procedure involves computation of time duration of allocation of pedestrian phase.

5.4.2 Conditions of Exclusive pedestrian Phase

In a recent study, on exclusive pedestrian phase conducted by Australian Government suggests that Pedestrian signals may be configured to provide an exclusive pedestrian phase whereby all vehicle movements in all directions across the intersection are stopped and pedestrians are allowed to cross in all designated directions, when all of the following criteria are met:

- None of the roads is a declared highway or main road
- The intersection is in a central business area or shopping area
- An equivalent or better alternative route is available for through traffic to avoid the intersection if it so desires
- The existing signal intersection is operating in a simple 2 traffic phase mode
- During any 4 periods (consecutive or non-consecutive) of 1 hour each, on any one weekday, more than 200 pedestrians cross in all directions per hour and during the same hours, more than 400 vehicles turn within the intersection.

Toronto established the following criteria in introducing EPP

- High pedestrian volumes average > 3,000 pedestrians per hour for an eight hour period.
- Moderate pedestrian volumes average >2000 pedestrians per hour for an eight hour period.
- High turning vehicle volumes > 35 % of total vehicular approach volume.
- High concentration of pedestrian-vehicle collisions > three left-turn and right-turn collisions where pedestrians had the right-of way over a three year period
- There is a desire by at least 15% of pedestrians to cross diagonally.
- Unusual intersection geometry (five or more legs) that precludes normal pedestrian crossing operation.

5.5 Reasons of Selecting 'New market Intersection' for Exclusive pedestrian Phase

On the basis of before mentioned criterions it was examined if it is possible to introduce exclusive pedestrian phase in the selected intersections. One of the studied intersections namely "New market intersection' was prioritized to introduce because it fulfills all the requirements mentioned above because:

- It is situated on Mirpur road which is not a declared highway or main road

- The intersection is situated near one of the most important shopping area namely new market because people from different parts of the city visit this area for shopping every day.
- An equivalent or better alternative route like elephant road is available for diverting through traffic.
- This study reveals that about 6218 pedestrian traffic per hour generated in an around the new market intersection per hour in a peak period which fulfills the traffic volume requirement.

Green time for pedestrian crossing G_p can be found out by,

$G_p = t_s + d_x/u_p$

where Gp is the minimum safe time required for the pedestrians to cross, often referred to as the ``pedestrian green time", ts is the start-up lost time, dx is the crossing distance in metres, and up is the walking speed of pedestrians which is about 15th percentile speed. The start-up lost time ts can be assumed as 4.7 seconds and the walking speed can be assumed to be 1.2 m/s.

Performance measures:

Performance measures are parameters used to evaluate the effectiveness of the design. There are many parameters involved to evaluate the effectiveness of the design and most common of these include delay, queuing, and stops. Delay is a measure that most directly relates the driver's experience. It describes the amount of time that is consumed while traversing the intersection. The Figure 5.5 shows a plot of distance versus time for the progress of one vehicle.

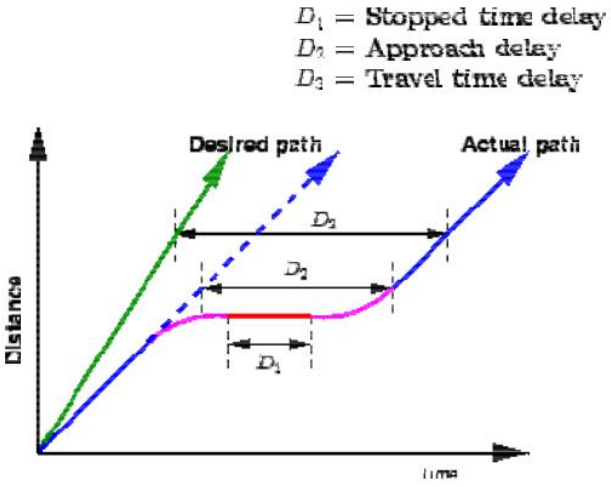


Fig: 5.1 Illustration of delay measures

The desired path of the vehicle as well as the actual progress of the vehicle is shown. There are three types of delay as shown in the figure. They are stopped delay, approach delay and control delay. Stopped time delay includes only the time at which the vehicle is actually stopped waiting at the red signal. It starts when the vehicle reaches a full stop, and ends when the vehicle begins to accelerate. Approach delay includes the stopped time as well as the time lost due to acceleration and deceleration. It is measured as the time differential between the actual path of the vehicle, and path had there been green signal. Control delay is measured as the difference between the time taken for crossing the intersection and time taken to traverse the same section, had been no intersection. For a signalized intersection, it is measured at the stop-line as the vehicle enters the intersection. Among various types of delays, stopped delay is easy to derive and often used as a performance indicator and will be discussed.

Vehicles are not uniformly coming to an intersection. i.e., they are not approaching the intersection at constant time intervals. They come in a random manner. This makes the modeling of signalized intersection delay complex. Most simple of the delay models is Webster's delay model. It assumes that the vehicles are arriving at a uniform rate. Plotting a graph with time along the x-axis and cumulative vehicles along the y-axis we get a graph as shown in figure. The delay per cycle is shown as the area of the hatched portion in the Figure 5.2.

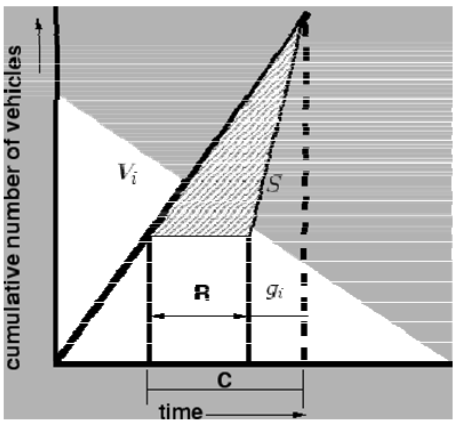


Fig: 5.2 Graph between time and cumulative number of vehicles at an intersection

$d_i = c/2\ (1-g_i/c)^2/\ (1-\ V_i/S)$

Webster derived an expression for delay per cycle based on this, which is as follows: Where gi is the effective green time, c is the cycle length, Vi is the critical flow for that phase, and S is the saturation flow. Delay is the most frequently used parameter of effectiveness for intersections. Other measures like length of queue at any given time (QT) and number of

stops are also useful. Length of queue is used to determine when a given intersection will impede the discharge from an adjacent upstream intersection. The number of stops made is an important input parameter in air quality models.

PCU Values:

For the design PCU value taken from Justo and Tuladhar chart. The chart is given to the following Table 5.3.

Table 5.1: PCU Values at Signalized Intersection

SL. No.	Organization/Author	TRRL	Justo and Reddy	Bhattacharya And Mandal	Justo and Tuladhar
	Class of Vehicle	PCU values			
1.	Car, Jeep	1.0	1.0	1.0	1.0
2.	Bus	2.25	2.8	2.25 (Single) 2.1 (Double) 1.5 (Min)	2.8
3.	Truck	1.75 (Medium) 2.25 (Heavy)	2.8	2.35	2.8
4.	Auto Rickshaw	0.33	0.4	0.35	0.4
5.	Scooter, Motor Cycle		0.3		0.3
6.	Pedal Cycle		0.35		0.4

Source: Justo and Tuladhar, 1984

Volume Capacity ratio:

For the design purpose volume capacity ratio is taken 0.9 and 0.95 which is near capacity condition. Volume capacity ratio table is given to the following table

Table 5.2: Intersection status criteria for planning

Critical v/c ratio (x cm)	Capacity condition
X cm ≤ 0.85	Under Capacity
0.85 <x cm ≤ 0.95	Near Capacity
0.95 <x cm ≤ 1.00	At Capacity
x cm < 1.00	Over Capacity

Source: Table 9-14, HCM 1994

5.5.1 Introducing EPP at New Market Intersection

Saturation Flow rate, s = 3575

Lost time Per Phase =2.4 sec

Amber time is = 3 sec

Assume v/c ratio = 0.9

Saturation Headway, h =3600/s =3600/3575 =1.01

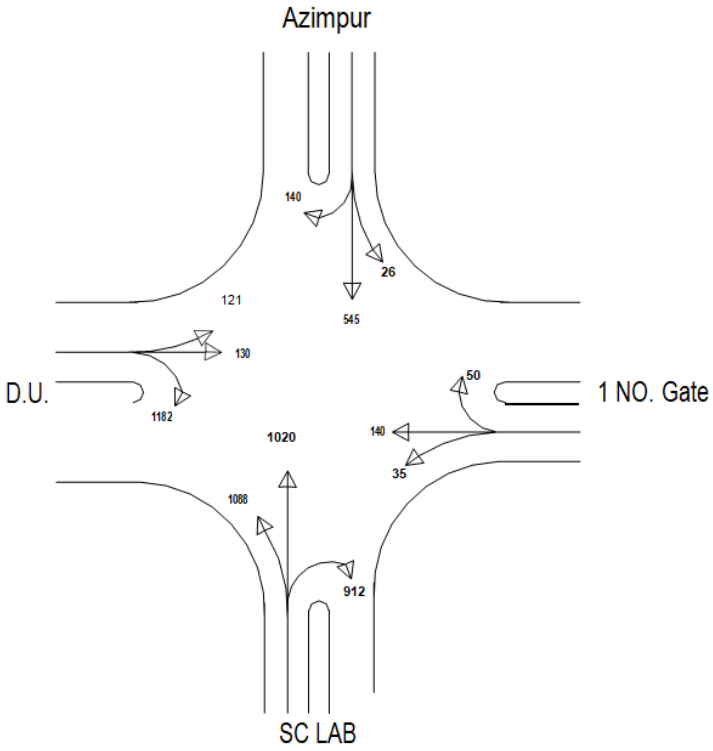


Fig: 5.3 One Hour Traffic Volume Data of New market Intersection

Figure 5.3 shows the traffic volume data of New market intersection from this figure the critical lane volume (highest lane volume) is taken for summation to get sum of critical lane volume Vci. Sum of critical lane volume is the sum of maximum lane volumes in each phase

Vci =545+1182+1088+140

= 2955

Cycle length can be found out from the equation $C = \frac{N*L*(v/c)}{(v/c - vc/si)}$

Where N = no. of phase

L = Lost time per Phase

v/c = Critical volume capacity ratio

C = 4*2.4*0.9/ (0.9- 2955/3575)

C = 117.668 sec

The effective green time can be found out as Gi =Vci/Vc (C-L) T

he effective green time = (117.668-2.4*4) =108.068 sec

Green splitting for different phase can be found out as

G1= 108.668* 1182/2955

= 43.467 sec

G2= 108.668* 1088/2955

= 40.01 sec

G3= 108.668* 140/2955

= 5 .148 sec

G4= 108.668* 545/2955

Similarly actual green time for phase 1,

G1=43.467-3+2.4

= 42.867 sec ≈ 43sec

Actual green time for phase 2,

G2= 40.01 -3+2.4

= 39.41 sec ≈ 40sec

Actual green time for phase 3,

G3=5 .148 -3+2.4=4.548 sec ≈ 5 sec

Actual green time for phase 4,

G4= 20.042 -3+2.4

=19.442 sec ≈ 20 sec

Pedestrian time can be found out from

G5 = 4+33.03/1.2 =30.25 =31.525 sec

The cycle length =43+40+5+20 +31+12 =151 sec

Geometric feature of Newmarket intersection from which road widths are taken to get pedestrian crossing time of the intersection diagonally. Because in the concept of exclusive pedestrian phase pedestrian can move all direction including diagonally. As crossing time of diagonal distance is high so this time is taken for the experiment Fig: 5.9 shows the phase

plan of New market intersection, phase is started in anti-clock wise direction. Phase-1 shows vehicle move from Dhaka University to all direction and get 43 second vehicle green which is shown in the Fig: 5.10. Phase-2 shows vehicle move from science laboratory to all direction and get 40 second to move. Phase-3 shows New market 1no.Gate direction to all direction and get only 5 second vehicle green time. Phase-4 shows vehicle move from Azimpur direction to all direction and get 20 second vehicle green time. At last Phase-5 which is pedestrian green time to cross the intersection. Here pedestrian green time is 27 second and total cycle is 151 second. In Fig: 5.4 red colour represent waiting time and yellow colour represent amber time.

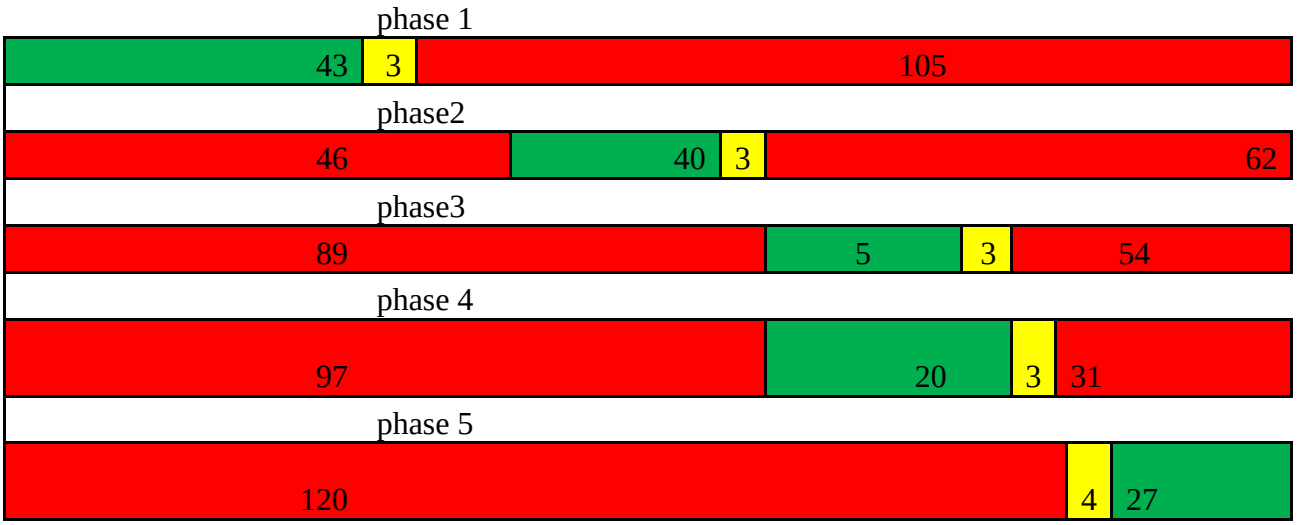


Fig: 5.4 Signal Timing Diagram for New market Intersection

5.5.2 Delay Measurement at the Newmarket Intersection by Webstar Method

$d_i = c/2\ (1-g_i/c)^2/\ (1-\ V_i/S)$

Delay at intersection in D.U to SC Lab direction can be found from the equation

$$D = \frac{151/2\{1-(43-2.4+3)/151\}^{\wedge}2}{(1-1182/3575)} \quad \frac{151/2\{1-(43-2.4+3)/151\}^{\wedge}2}{\{1-1182/3575\}}$$

=57.06 sec/cycle

Delay at intersection in SC Lab to Azim pur direction can be found from the equation

$$D = \frac{151/2\{1-(40-2.4+3)/151\}^{\wedge}2}{(1-1020/3575)}$$

=56.469 sec/cycle

Delay charts before and after use EPP are given in Appendix-5.

5.6 Reasons of Selecting ‘Shahbag Intersection’ for Exclusive pedestrian Phase On the basis of before mentioned criterions it was examined if it is possible to introduce exclusive pedestrian phase in the selected intersections. One of the studied intersections namely ‘Shahbag’ was prioritized to introduce because it fulfils all the requirements mentioned above because:

- It is situated on Kazi Nazrul Islam Avenue which is a major road but intersects Road of Dhaka University
- The intersection is situated near one of the most important Institutional area consisting Hospitals, Universities, Parks etc.
- An equivalent or better alternative route is not available for diverting through traffic
- This study reveals that about 7140 pedestrian traffic per hour generated in an around the Shahbagh intersection per hour in a peak period which fulfils the traffic volume requirement

5.6.1 Introducing EPP at Shabagh Intersection

A high number of conflicts between pedestrian and vehicles were occurring at busy intersections like Shahbagh .Many people gather here because it is a place of two reknowed hospital named BSMMU (Bangobandhu Sheikh Mujib Medical University) and Ibrahi Cardiac Medical College, Dhaka University, National Museumand and etc. However, the daytime population is huge, mostly concentrated in the Business District. Daytime pedestrian activity is very heavy in this area Business District due to the concentration of businesses and services and the high volume of tourists visiting the area around famous Ramna Park, Shishu Park, Sahrawardi Uddan. The primary concern for this area is the high number of conflicts between pedestrians and vehicles at the intersection, especially during holidays and peak tourist tine. Large pedestrian flows were blocking crosswalks to turning traffic during the entire green signal phase. A review of the accident history revealed several reported vehicle-pedestrian accidents.

Saturation Flow rate, s=5890

Lost time Per Phase =2.4 sec

Amber time is =3 sec

Assume, v/c ratio=0.95(Near Capacity)

Saturation Headway, h =3600/s

=3600/5890 =0.62

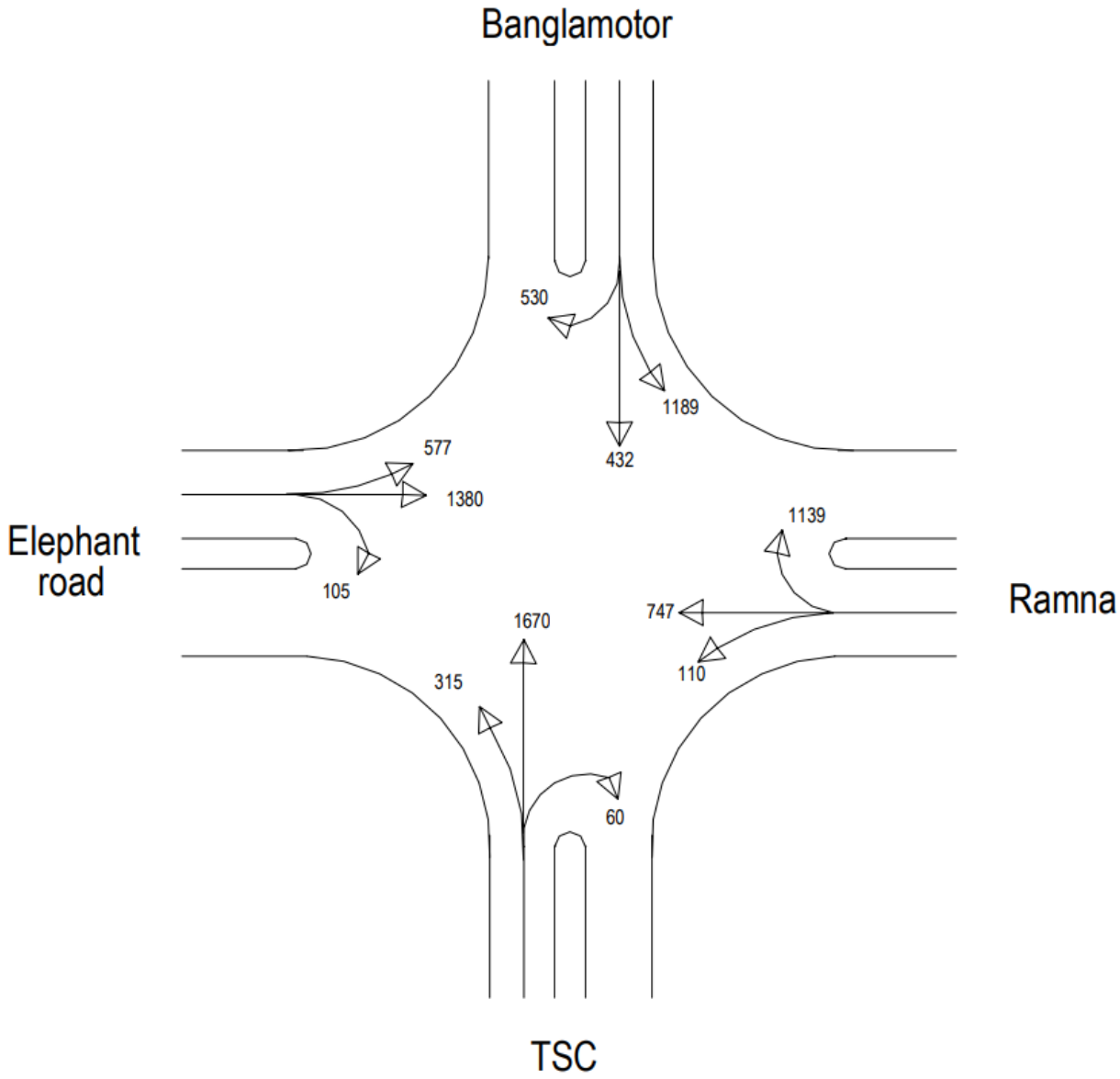


Fig: 5.5 One hour Traffic Volume Data of Shahbag Intersection

Fig: 5.5 shows the traffic volume data of Shahbag intersection from this figure the critical lane volume (highest lane volume) is taken for summation to get sum of critical lane volume Vci. Sum of critical lane volume is the sum of maximum lane volumes in each phase

Vci =1398+1196+1159+1693

= 5446

Cycle length can be found out from the equation

$$C = \frac{N*L*(v/c)}{(\frac{v}{c}-\frac{vc}{si})}$$

Where ,

N = no. of phase

L = Lost time per Phase

v/c = Critical volume capacity ratio

C = 4*2.4*0.95/(0.95- 5446/5890)

C = 304 sec

The effective green time can be found out as Gi =Vci/Vc (C-L) T

he effective green time = (304 - 2.4*4) =294.4 sec

Green splitting for different phase can be found out as G1= 294.4 * 1398/5446

75.57 sec

G2= 294.4 * 1196/5446

= 64.65 sec

G3= 294.4 * 1159/5446

= 62.65 sec

G4= 294.4 * 1693/5446

= 91.52 sec

Similarly actual green time for phase 1,

G1= 75.57 -3+2.4

= 68.37 sec ≈ 69 sec

Actual green time for phase 2,

G2= 64.65 -3+2.4

= 57.45 sec ≈ 58 sec

Actual green time for phase 3,

G3= 62.65 - 3+2.4

=55.45 sec ≈ 56 sec

Actual green time for phase 4,

G4= 91.52 - 3+2.4

= 90.92 sec ≈ 91 sec

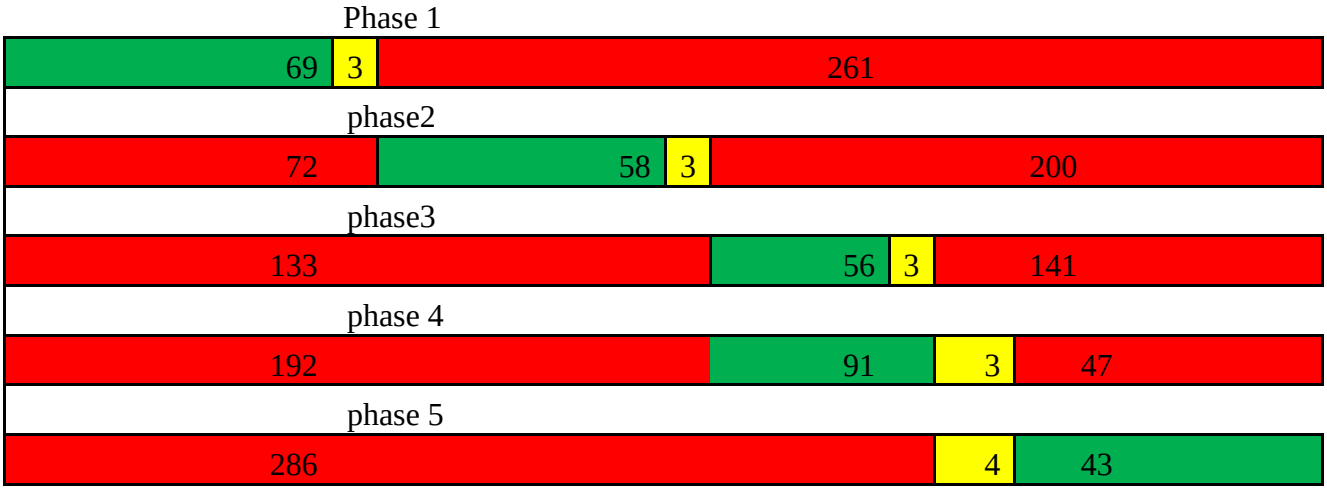
Pedestrian time can be found out from

G5 =4+65.67/1.2 = 58.73 =59 sec

The cycle length = 69+58+56+91+59 = 333 sec

Fig: 5.6 shows the phase plan of Shahbag intersection, phase is started in anti-clock wise direction. Phase-1 shows vehicle move from TSC to all direction and get 69 second vehicle green which is shown in the Fig: 5.6. Phase-2 shows vehicle move from Ramna to all

direction and get 58 second to move. Phase-3 shows Banglamotor direction to all direction and get 56 second vehicle green time. Phase-4 shows vehicle move from Elephant road direction to all direction and get 91 second vehicle green time. At last Phase-5 which is pedestrian green time to cross the intersection. Here pedestrian green time is 43second and total cycle is 333second. In Fig: 5.6 red colour represent waiting time and yellow colour represent amber time



Total 333 sec cycle time

Fig: 5.6 Signal Timing Diagram for Shahbagh Intersection

$d_i = c/2\ (1-g_i/c)^2/\ (1-\ V_i/S)$

5.6.2 Delay Measurement at Shahbag intersection by Webstar Method

Delay at intersection in Elephant road to Ramna direction can be found from the equation

$$D = \frac{333/2\{1-(69-2.4+3)/333\}^{\wedge}2}{(1-1693/5890)}$$

=149.544 sec/cycle

Delay at intersection in TSC to Banglamotor direction can be found from the equation

$$D = \frac{333/2\{1-(58-2.4+3)/333\}^{\wedge}2}{(1-1693/5890)}$$

= 159.13 sec/cycle

Delay charts before and after use EPP are given in Appendix-5.

5.7 Reasons of Selecting 'Sonargaon Intersection for Exclusive pedestrian Phase

A high number of conflicts between pedestrian and vehicles were occurring at busy intersections like Sonargaon. Many people gather here because it is one of the most busy

commercial area. The primary concern for this area is the high number of conflicts between pedestrians and vehicles at this intersection. A review of the accident history revealed several reported vehicle-pedestrian accidents.

5.7.1 Introducing EPP at Sonargaon Intersection

Saturation Flow rate, S = 9160

Lost time Per Phase = 2.4 sec

Amber time is =3 sec

Assume v/c ratio = 0.99

Saturation Headway, h =3600/s

=3600/9160=0.39

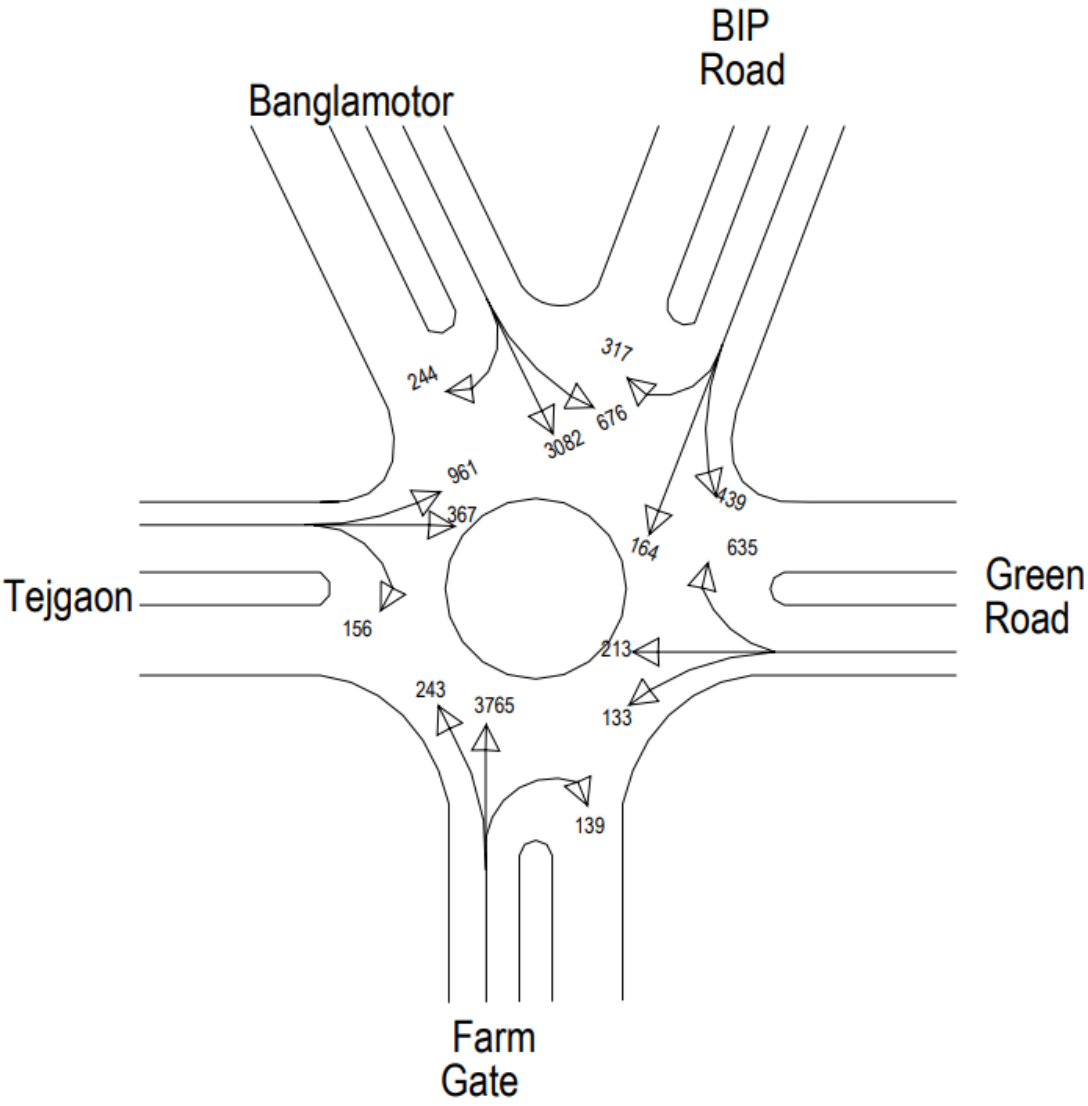


Fig: 5.7 One hour Traffic Volume Data of Sonargaon Intersection

Figure 5.7 shows the traffic volume data of Sonargaon intersection from this figure the critical lane volume (highest lane volume) is taken for summation to get sum of critical lane volume Vci.

Vci = 3890+3082+961=676

= 8609

Ve/ Si = 8609/9160 = 0.93

Cycle length can be found out from the equation

$$C = \frac{N*L*(v/c)}{(\frac{v}{c}-\frac{vc}{si})}$$

Where,

N = no. of phase

L = Lost time per Phase

v/c = Critical volume capacity ratio

C = 4*2.4*0.95 /(0.95 –8609/9160)

C = 456 sec

The effective green time can be found out as Gi =Vci/Vc (C-L)

The effective green time = (456 - 2.4*4) = 446.4sec

Green splitting for different phase can be found out as G1= 446.4 *3890/8609

= 201.7 sec

G2= 446.4* 676/8609

= 35.05 sec

G3= 446.4* 961/8609

= 49.83 sec

G4= 446.4* 3082/8609

= 153.2sec

Similarly actual green time for phase 1,

G1 = 201.7-3+2.4

= 201.1 sec ≈ 202 sec

Actual green time for phase 2,

G2= 35.05-3+2.4

=34.45 sec ≈35 sec

Actual green time for phase 3,

G3= 49.83+2.4

=49.23 sec ≈ 50 sec

Actual green time for phase 4,

G4= 153.2 -3+2.4

= 152.6 sec ≈ 153 sec

Pedestrian time can be found out from

G5 =4+64.5/1.2 =57.75 =58 sec

The cycle length =202+35+50+153+60 = 500 sec

5.8. Phase-2 shows vehicle move from Tejgaon to all direction and Green road to all direction and get 35 second green time to move. Phase-3 shows BIP road direction to all

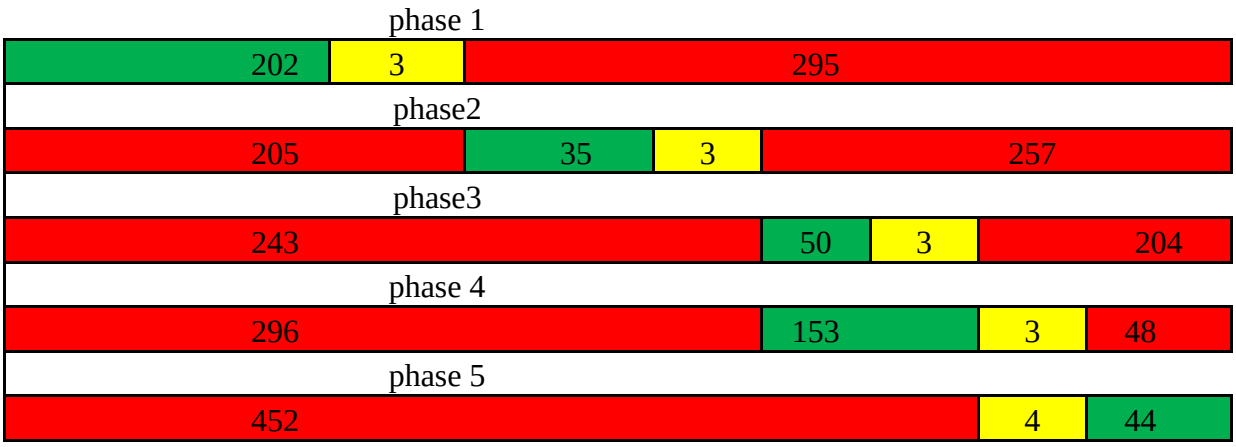


Fig: 5.8 Signal Timing Diagram for Sonargoan Intersection.

direction and get 50 second vehicle green time. At last Phase-5 which is pedestrian green time to cross the intersection. Here pedestrian green time is 44 second and total cycle is 500 second. In Fig: 5.8 red colour represent waiting time and yellow colour represent amber time.

5.7.2 Delay Measurement at Sonargaon intersection by Webstar Method

$d_i = c/2\ (1-g_i/c)^2/\ (1-\ V_i/S)$

Delay at intersection in Farm gate to Banglamotor direction can be found from the equation

$$D = \frac{500/2\{1-(202-2.4+3)/500\}^2}{(1-3890/9160)}$$

= 153.72 sec/cycle

Delay at intersection in Tejgaon to Green Road direction can be found from the equation

$$D = \frac{500/2\{1-(153-2.4+3)/500\}^2}{(1-3082/9160)}$$

=190.35sec/cycle

5.8 Increase Intersection Efficiency by EPP

A recent study on "Pedestrian Scramble Crossings" in Toronto reveals that approximately two thirds of the pedestrians believe that EPP would not have a negative impact on traffic flow and streetcar operations (Bissessar, R. et all, 2010).In this study, from GIS map and video record survey it is known that the vehicle speed of the three selected intersection is near about 16 kmph for Newmarket and Shahbag intersection and 17 kmph for Sonargaon intersection. If the intersections are provided with EPP, indiscriminate movement of pedestrian will be reduced and safety will be ensured. Thus it is possible to increase vehicle speed and introducing of EPP will impose no negative impact on vehicular flow in those intersections. For an instance, one intersection has one phase of 45 sec where vehicle speed is 16 kmph. If the vehicle speed is increased by 18 to 20 kmph then the required time for the cycle will be less by 5 to 9 sec for the phase duration of 45 sec. By this way it may be possible to decrease cycle time.

CHAPTER 6
CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Generalized situations of pedestrian facilities are very poor in Dhaka city. The study reveals that there is absence of visible cross marking in 70%, foot over bridge in 73%, Refuge Island in 30%. The situation may be overcome by providing more pedestrian facilities in the intersections of Dhaka city.

After studied some generalized intersections illegal and unsafe crossing is found in most of the intersections which is induced to face any fatal accident any time. Illegal crossings are found by the pedestrian of 12% in Shahbag intersection, 48% in Maghbazar intersection, 16% in Newmarket intersection, 26% in Elephant road intersection, 21% in Sonargaon intersection and 13% in Banglamotor intersction. This situation symbolized very chaotic situation. The situation must be overcome by introducing strong imposition to use foot over bridge and cross marking. Awareness generation is needed among pedestrian vehicle users citizens and all the concerned stake holders about safe road crossing and pedestrian safety. Scramble pedestrian phase is a tool of safe pedestrian crossing which is successfully being used in different cities of the world. In Dhaka city it can be introduced in pilot basis in some selective intersections where pedestrian traffic volume is high. This Study proposed exclusive pedestrian phase at some intersections in Dhaka city and signal designed has been hypothetically modeled incorporating EPP in two intersections of Dhaka city.

Pedestrian crossing behavior depends on the destination, age, education, physical condition and overall awareness of the pedestrian. The issues associated with pedestrian crossing activities generally create considerable emotional concern within the community, especially when the community is reacting to an incident involving pedestrian injury. Pedestrian crossing safety relies on the judgment exercised by pedestrians and drivers. To interact safely requires an exchange of information between 89 the pedestrian and the motorist. Although traffic control devices can help to promote an exchange of information, educating pedestrians and drivers is paramount to providing for a safe operation. Provision of visible cross marking must be installed in all the intersections. Considering the high density of pedestrian traffic all over the city, it should be provided to ensure safe pedestrian crossing. Median island with median barrier must be provided in all the intersections to ensure safe pedestrian crossing.

Street lighting around the crossing should be adequate so that cross marks are easily captured by the vehicle drivers to have stopping sight distance to avoid collision. Management of existing physical infrastructure must be enhanced to enable more effective use of crosswalks. It is provided with better road markings, signs, traffic signals, canalization at intersections, turn restrictions and separation barriers, space for bus stops, and parking or waiting areas for public transport vehicles (buses, rickshaws, auto-rickshaws, taxis, etc.). Pedestrian crossing should be considered carefully in traffic engineering and planning of the intersections and mid blocks.

Walking should be recognized as one of the dominant means of travel all over Dhaka city and facilities should be provided for the pedestrians on priority basis. Pedestrian crossing safety should be ensured based on traffic management, intersections and midblock design considerations, intersection geometry, signal designing, pedestrian facilities as signs, visible cross marking, existence of grade separated crossing facilities like over pass, underpass and many other factors.

Pedestrian walkways that are either non-existent or in poor physical condition should be improved so that it is not blocked by various obstacles and pedestrians are not forced to walk on the road. It is necessary to remove inappropriate and illegal non-transport related activities from the public right-of-way to reclaim the full potential capacity of the existing road. In some cases this may involve the need to help relocate or establish alternative sites for such activities. Initiatives should be taken to improve the ability of road users (motorists and pedestrians alike) to adopt behavioral patterns which lead to more efficient and safer transport services. Programs should be taken to alter community attitudes and invoke a greater willingness to accept better discipline by all users and 90 providers of the transport services. Enforcement of traffic rules is needed to ensure a greater compliance with community desired road user behavior. Enforcement actions can involve formal policing as well as informal pressure on individuals to adopt community norms of behavior and should include the involvement of community leaders. During pedestrian crossing vehicles are found to run with full speed which is a dangerous threat to pedestrian safety must be stopped. All the vehicles should be enforced properly to reduce speed at the zebra crossing in the entire semi automated signalized intersections.

The issue of safety must receive a high priority in analyzing pedestrian crossing behavior and future planning and designing of the intersections. Policies should be formulated to Implement EPP through PPP as it is challenging to implement and bear all the cost of

implementation of EPP by the Government alone. It can be an implementation strategy through Public-Private Partnership (PPP) for introducing EPP in intersections of Dhaka city where it will be feasible. Traffic control devices can help to promote an exchange of information, educating pedestrians and drivers is paramount to providing for a safe operation.

The pedestrian scramble signal will allow a pedestrian phase to be serviced exclusively. No vehicular traffic phases will be allowed to receive service during the pedestrian scramble phase. Improved pedestrian safety at intersections should be ensured through coordination among public authorities, professional engineers, media, education experts and vehicle designers to reduce both the number and severity of pedestrian collisions.

6.2 Recommendations

The following are some recommendations provided considering holistic thinking to facilitate safe pedestrian and future transportation policy making:

- Exclusive pedestrian Phase may be introduced in some selected intersections on pilot basis to improve pedestrian movements and provide pedestrian-friendly 91 environment. It can be introduced where pedestrian traffic volume is high and often followed pedestrian crossing haphazardly which reduces vehicle speed.
- Exclusive pedestrian Phase (EPP) may be introduced which will reduce vehicular delay in the intersections. Intersections such as in and around shopping areas, institutional zones are rushed with higher volume of pedestrian traffic and vehicle green time is affected due to haphazard crossing making cordon may be provided with EPP.
- Pedestrian movements may be incorporated in the various phasing schemes. At locations with heavy pedestrian volumes and heavy turning movements, it may be desirable to provide an exclusive phase for pedestrians.
- Illegal parking near the cross marks which obstacles pedestrian crossing and should be stopped.
- Pedestrians intended to avoid grade separated means of crossing for saving time and physical labor should be prohibited through legal actions against them.

- At grade crossing among the pedestrians should not be allowed randomly due to heavy traffic rush in most of the intersections because of high population density and increased volume of traffic in Dhaka city.
- A recommended sample of signal has been added in the annex A2 for pilot project of EPP in Dhaka city.
- It can be stated that introduction of exclusive pedestrian signal phasing in the major business and shopping areas of Dhaka city will be low cost and effective tool to improve safety and reduce the potential for automobile and pedestrian conflicts and may also increase efficiency of the intersections.

6.3 Limitations:

- The study does not cover deep analysis on signal designing and traffic management system for the studied area.
- Such a study requires financial and human resources to conduct extensive study. But due to resource and time constraint it limits to conduct more comprehensive study.
- It had not possible to conduct land use and traffic interaction for more analysis on the selectivity of the intersections to propose EPP.

6.4 Future Scope:

It poses enormous potentials to be further studied and recommend best options for selection of the intersection to introduce EPP and recommendation for signal designing in context of Dhaka City. Such research may enrich the quality of traffic management system for the worthy traffic congested city like Dhaka.

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