TRAFFIC FLOW CHARACTERISTICS AND MODELING FOR ESTIMATION OF AADT IN SELECTED RURAL HIGHWAYS

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Traffic Flow Characteristics and Modeling for Estimation of AADT in Selected Rural Highways

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(Hamid-uz-Zaman)

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The Author

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ABSTRACT

This study is performed to analyze traffic flow characteristics and estimation of AADT from short counts on selected rural highway. The North Bengal Corridor has been selected for this purpose based on availability of 7 years of daily flow data and 13 weeks of hourly data on Jamuna Multipurpose Bridge and 1 year of daily flow data on Nalka-Hatikamrul-Bonpara road.

From the analyses of traffic flow data, it has been found that the basic flow patterns on the selected route are repetitive in nature. Analyses such as hourly, daily, weekly, seasonal variations, directional distribution, traffic composition, traffic growth pattern have been performed. It was observed that the normal flow pattern is sometimes affected by certain external factors such as Eid festivals, national strikes, transport strikes, flood etc. Considering the critical flow value caused by Eid festivals, emphasis has been given in analyzing the impact of Eid festivals on traffic flow.

The AADT of 1999 and 2005 has been found to be 2416 and 5288 respectively. Taking the average from 1999 to 2005, the AADT is 3749. Growth rate of total traffic is 14% per annum. From flow pattern analyses, it has been found that maximum and minimum hourly flow occurs at 1:00–2:00 and 5:00-6:00 carrying 5.68% and 2.25% of total daily traffic respectively. Maximum daily flow occurs on Friday (East to West 15.16% and West to East 15.25%) and December carries maximum monthly volume (9.45% of yearly volume). Dry season (Nov. to Apr.) carries slightly higher percentage of traffic (51.48%) than rainy season (May to Oct.) Average directional distribution is almost equal, but it varies significantly in hourly pattern. In all the cases, individual vehicle class shows different pattern from total traffic. Therefore, class-wise separate analyses have been performed and factors have been established. From traffic composition analysis, it has been observed that, trucks and buses together comprise of 84.06% of traffic stream.

For estimation of AADT from short counts, expansion factors as well as regression models have been established. Their accuracy has been found to be around 80%, by checking with external data. Calibration curves from regression analysis have also been established.

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CHAPTER 1

INTRODUCTION

1.1 Background

Traffic flow varies over time. Traffic flow in a particular road may vary over hours, days, months, year etc. It also exhibits numerous characteristics depending on the several factors. In Transportation Engineering, the study of vehicular flow characteristics carries great importance because the same imply useful information for developing highways, transportation planning, performing economic analyses, performance evaluation of a transport facility, establishment of geometric criteria etc. Traffic flow parameters such as Average Daily Traffic (ADT), Average Annual Daily Traffic (AADT), Directional Distribution (DD), Peak Hour Factor (PHF), Design Hourly Volume (DHV), Truck Percentage etc. have important aspects in terms of both geometric and structural design of highways.

DHV is the economic hourly flow of future year, which is chosen in such a way that during the design period it should not be exceeded too often or too much. According to AASHTO [1990] geometric design guidelines, it is usually taken as the 30^{th} highest hourly volume of the design year in case of long duration count or availability of annual average daily traffic (AADT) data. Whereas in case of short duration count or ADT (average daily traffic), it may be determined by multiplying the ADT by a percent representative of the amount of traffic occurring during the peak hour in an average weekday. The percentage, K is known as the peak hour factor and is typically 8 to 12% for urban facilities and 12 to 18% for rural facilities. Directional Distribution (DD) is the

one-way volume in the predominant direction of travel, expressed as a percentage of the two-way design hourly volume. DD ranges from 55 to 80% for rural road and typically is about 67% [AASHTO 1990]. In the developed countries, in general, traffic tends to more equally divided by the direction near the city center, where a value of 55% is common. On the other hand, in the outer fringe of the city, a value of 67% or even 70% occur with considerable frequency. In Bangladesh, usually these above parameters are assumed on the basis of standard values established for the developed country situation. So far no attempt has been made yet to establish these values for the local traffic conditions, though there is a crying need to establish these parameters as it leads to economic design of roadways.

In the developed countries, the transport authorities monitor, collect and preserve traffic flow data in a continuous basis and in a systematic form to be able to utilize those for analyzing traffic flow characteristics as well as determination of future traffic on the basis of traffic growth pattern. Two types of traffic counts namely short and continuous counts are carried out at several locations within the jurisdiction of an authority to collect flow data. By analyzing these data, the authorities are able to explore important facts by which they can maintain existing roads as well as design future roads in an efficient manner. A major task involved in the whole process is expansion of short counts to best match the data collected in the permanent counters. This is accomplished by either determining some expansion factors representing different time scale or by developing equations from regression analysis. By using these factors or equations one can easily calculate AADT of a particular highway by taking traffic counts for even less than an hour. Again these factors or equations are regularly updated in order to encounter the continuously changing parameters of the very dynamic system. This concept is used worldwide for any transportation planning purpose.

1.2 Statement of the Problem

As stated earlier that in Bangladesh the required parameters for evaluation of a road facility, planning or designing are not available. Instead those of developed or neighboring countries are often used for the purpose. One can easily understand that,

traffic flow depends on numerous parameters and thus traffic characteristics of one locality do not fully match with others. One of the main reasons why attempts were not made earlier in Bangladesh to establish these basic parameters is the lack of long term reliable data. Long duration data collection and preservation is very expensive, as it requires extra logistics like permanent counting stations and manpower. Necessary allocation for this purpose is very difficult to provide in country like Bangladesh where there is acute shortage of money for maintaining existing roadway infrastructures and as well as for expansion of road network. Besides, there is a lack of consciousness and inability to understand the importance of these parameters for engineering use. As such, there is a great need to study and research in this area.

As Jamuna Multipurpose Bridge (JMB) is a tolled bridge, the toll collecting agencies and Jamuna Multipurpose Bridge Authority (JMBA) are systematically preserving flow data since its opening in June 1998. Gaining access to the database will give the opportunity to establish the basic flow parameters for at least one of the major corridors of Bangladesh. If these parameters can be established, they can also give a basic idea about these parameters in other regions of the country as well.

Prediction of flow for design year is also important for the geometric and structural design of highway. For reliable assessment of average annual traffic as well as future demand, it is desirable that traffic counts are undertaken throughout the year to take account of seasonal variations in traffic flows. In the absence of long duration count, there are two approaches for the estimation of AADT from short counts, either by using regression model or by applying previously established expansion factors for the similar facilities (Garber 1990).

Several studies (Ertunmwunsee 1991, Sharma 1989 and Kaub 1988) carried out in developed countries have shown that if continuous flow data is available for a particular road segment of a highway, model could be built considering recursive pattern of traffic flow in order to predict AADT from short count (i.e. less 24 hours) data. In India (Highway Research Record 1982) attempt is also made to establish trend in traffic volumes pertaining to daily, weekly, monthly and yearly flow patterns and to use these particulars for forecasting of traffic volumes. Though, these studies were carried out in

developed and developing country like India many years ago, so far no such effort in this subject is made in Bangladesh. One of the main reasons is stated earlier that is lack of long duration round the clock flow data. Moreover, to make a time series model in the context of Bangladesh is somewhat complex and intricate in nature as compared to that of developed countries for the following reasons:

- The shifting nature of the month of Ramadan and Eid festivals greatly affect the traffic flow pattern and makes it difficult to predict monthly expansion factors. But in the western world, main festivals like Christmas, New year or even summer vacations does not shift compared to the calendar year.
- During the monsoon season, substantial portion of bulk freight is transported through waterways. Since the duration of monsoon is not constant, it is difficult to develop a similar yearly flow pattern.
- Unusual events such as hartals (political strikes), transport strikes etc., which greatly affect normal traffic flow, are more frequent in Bangladesh than in developed countries.
- Natural calamities like heavy rainfall, long duration flood is also external parameter which needs to be considered while analyzing flow pattern in Bangladesh.

Design considerations and performance evaluation of highways is not possible using either incorrect or assumed traffic data. This may the road networks to be inadequately facilitated or over designed. This problem arises due to unavailability of long duration continuous traffic data upon which a reliable pattern analysis can be done and expansion factors or equations can be determined. But the so far collected and preserved traffic flow data on Jamuna bridge by the toll operators is providing a good opportunity for the transportation planners to effectively utilize these data for traffic flow analyses. Moreover, some other sources of short and long counts data have also been discovered during the study. Therefore, this study avails fair amount of quality traffic data for traffic flow characteristics analyses and expansion of short counts in the North Bengal corridor.

1.3 Objective of the Study

The primary objective of the study is to determine cyclic patterns and characteristics of vehicular flows on the Jamuna bridge corridor so that it is possible to develop predictive models. This would be highly beneficial to estimate annual revenues from the toll facilities cost effectively and reliably. In addition, the geometric design for new highways and linking roads along this corridor could be performs more meaningfully and economically.

The specific objectives of this study are as follows:

- To study on the general characteristics of vehicular flow
- To determine vehicular flow patterns and their related parameters
- To develop expansion factors and regression models for reliable estimation of AADT from short count data
- To analyze traffic growth pattern for reliable estimation of future traffic demand

1.4 Scope of the Study

This study is to be performed using the traffic flow data on the North Bengal corridor. The expansion factors and regression models for the estimation of AADT from short counts to be established during this study are applicable for the North Bengal corridor, more specifically Jamuna bridge only. But similar analyses can be performed to established factors or models for other corridors of Bangladesh using flow data of particular corridors.

It is expected that the following outcome can be made possible through this study.

- If the flow parameters and expansion factors/equations for estimation of AADT from short counts can be established for the Jamuna bridge access road, it is expected that, it would be possible to understand the flow patterns of the North Bengal corridor.
- By using the expansion factors or equations in the selected corridor, independent audit of toll collection would be possible.
- Traffic parameters determined in this study can be used to design new road facility.

- Comparison of traffic flow between two roads within one corridor can be done.
- The framework developed during the study can be used as a model for developing traffic monitoring software.

1.5 Outline of Methodology

The first task is to review the relevant literatures to broaden the understanding of various vehicular flow characteristics in particular relation to geometric and structural design of pavements. It will also be helpful for better understanding of expansion methods of short counts. Moreover, the necessity of reviewing previously performed studies in the related topic will also be covered.

Then, a corridor will be selected among various corridors in consideration of availability of data. For the selected corridor the necessary data for this study is then to be collected. During this study 2 years of daily flow data on Jamuna bridge from present toll operator Marga Net One Ltd., 1 year daily flow data from the toll operator of Hatikamrul road Pubali-Alloy JV Ltd. and some short counts data will be collected. The rest of flow data required for this study will be collected from BUET.

After the data collection task is completed, the collected data is to be sorted and summarized in a systematic manner. The summarized datasheet will then be searched for data errors that cause irregularities to normal traffic flow. The identified erroneous data will either be eliminated or corresponding factors will be determined.

The next task would be to plot traffic flow data against different time scale to observe the flow pattern. The patterns are expected to be repetitive in nature. Repetitive nature would conform that the corridor is stabilized and expansion methods can be effectively applied to this corridor for the expansion of short counts to obtain AADT. Various important flow parameters will also be determined during the analyses of traffic flow. In this aspect, an attempt will also be made for comparison the flow data between two roads in the same corridor, since the opportunity can be made possible by collecting flow data from Hatikamrul road.

Finally, using the summarized flow data expansion factors and equations from regression analyses will be determined for estimation of AADT from short counts. The factors and equations will be checked for accuracy and after necessary calibration works the factors and equations will be finalized.

It is to be mentioned here, the whole calculation and analyzing process will be performed in MS Excel worksheet by interlinking formulae and thus a framework will be developed, which can be populated further with updated traffic data. The study plan can be represented graphically as the following flow chart.

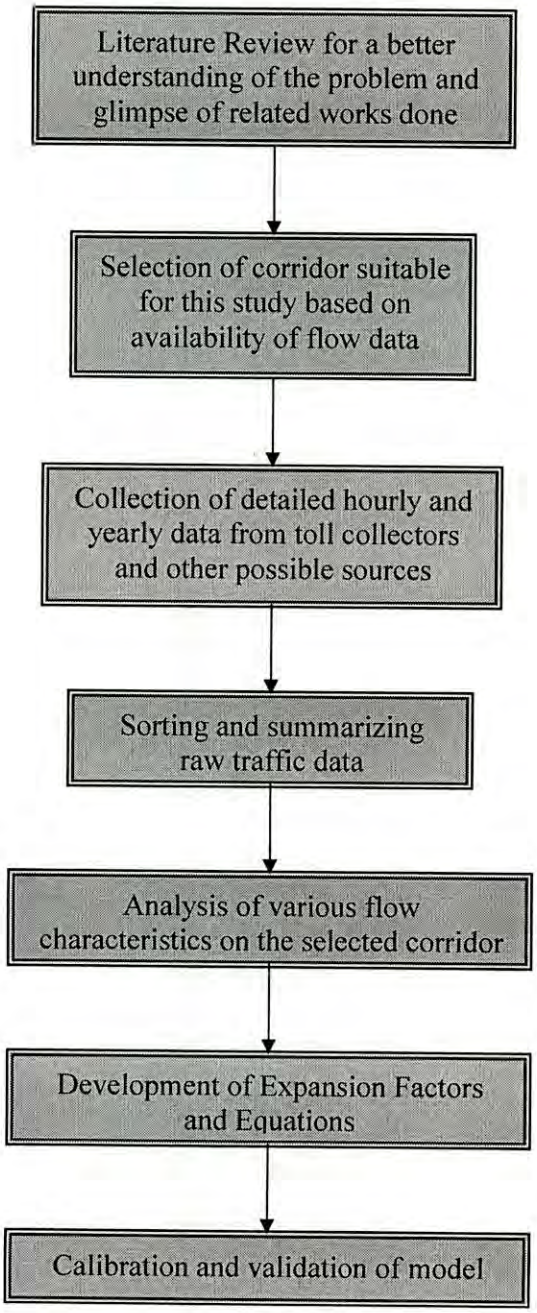


Figure 1.1: Flow chart of the study methodology

1.6 Organization of the Thesis

The research works performed in this study are divided into different topics and presented in six chapters.

A brief introduction to the background and statement of the problem is presented in the first chapter. The chapter also contains the objective and scope of the study along with brief description of the study plan.

Chapter 2 presents the literature review of related topics. In this chapter the definition of the related terms, guidelines for traffic monitoring and previously performed similar works have been described.

In chapter 3, the methodology of this study is described. This covers the corridor selection, data collection, data processing, and framework development processes used in this study.

Chapter 4 contains the main flow characteristics analyses. In this chapter the hourly, daily, weekly, monthly flow variations as well as directional distribution, traffic composition, truck percentage, eid factor, traffic growth pattern on the selected corridor are described.

Chapter 5 presents the evaluation of expansion factors, regression analyses, determination of regression equations and calibration models for estimation of AADT from short counts. An example of estimating AADT from short counts using the established factors is also given in the chapter.

The conclusion of the entire study along with summary of study results is presented in chapter 6. The chapter also contains suggestions and recommendations for future study and limitations of this study.

An appendix is attached at the end of this report containing necessary traffic flow data and graphs.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Study on traffic flow pattern and its variability over time carries a great importance to understand the characteristics of a traffic stream. Analysis of traffic flow pattern from existing data is performed to determine important characteristics of traffic flow that are used in geometric & structural design of highways, traffic monitoring programs, roadway maintenance and operation, feasibility studies, economic evaluation, traffic flow prediction, highway financing, evaluation of safety programs and many other related decision making.

Although transport authorities and agencies in many developed countries extensively record traffic flow data through short counting as well as continuous counting stations in order to monitor their trend of traffic growth, changes in traffic characteristics and evaluation of expansion factors and/or equations, not many studies have been performed in Bangladesh on traffic characteristics and determination of expansion factors from which AADT can be reliably estimated from short counts. During the literature review on previously performed studies in Bangladesh on related topic, it was revealed that a similar study was carried out by Roads and Highways Department, as a part of Development of Geometric Design Standards, in 1994, on some important highways. Capt. Sheikh Muhibur Rahman performed a study on Vehicular Flow Pattern on Jamuna Multipurpose Bridge Access Road in 2002 during his B.Sc. Engg. project work. Both of the reports have been studied and they have been analyzed in this chapter.

This chapter also contains brief discussion on Traffic Monitoring Guidelines 2001, published by Federal Highway Administration of U.S. Department of Transport, where thorough guidelines are provided for analysis of traffic characteristics and evaluation of expansion factors, and an Assessment of Data Collection Techniques for Highway Agencies, which have been helpful as guidelines for this study.

2.2 Definition of the Related Terms

Before going into the detail of this study, it is important to get familiarized with the terms related to traffic flow characteristics and computation of expansion factors or equations. Therefore, in this section, the important parameters of traffic flow, which are frequently used in this study, are stated in brief.

Traffic Volume

Traffic Volume is defined as the number of vehicles that pass a particular point along a roadway or traffic lane per unit of time. Volume is a measure to quantify the traffic flow and is commonly measured in units of vehicles per hour, vehicles per day and so on.

ADT

ADT stands for Annual Daily Traffic and is defined by the average number of vehicles that pass a particular point during a period greater than one day and less than one year. It is determined by dividing the total number of vehicles within a period by the number of days.

ADT is a fundamental measurement of traffic that is used for the determination of the vehicle-kilometer of travel on the various categories of highway system. Vehicle-kilometers are important for the development of highway financing or taxation schedules, the evaluation of safety programs, and as a measure of service provided by a highway transportation system.

AADT

Average Annual Daily Traffic is represented by the total number of vehicles passing a particular point, averaged over one year data. AADT is a very important factor for geometric design of highways.

Design Hourly Volume

The Design Hourly Volume (abbreviated as DHV) is a future hourly volume that is used for design. It is usually the 30^{th} highest hourly volume of the design year. The DHV is the most significant measure of highly volume since traffic volumes are much heavier during certain hours of the day or year, and it is for these hours that the highway is designed.

Peak Hour Factor

The Peak Hour Factor is defined as the ratio of total hourly volume to the maximum rate of flow within the hour.

Truck Percentage

The percentage of truck among a traffic stream is an important factor used for geometric and structural design of highways. The percentage of truck traveling along a roadway may vary differently from total vehicle traveling over time and AASHTO recommends to classification-wise data collection and represent by which this important factor can be determined.

Directional Distribution

Directional distribution refers to the percentage of traffic flow in one direction during a particular time of day. This factor is particularly important in the case of commuter roads, where maximum flow occurs in one direction in the morning and the other in the evening. This also needs to be considered for efficient geometric design.

2.3 Variability in Traffic Stream

Traffic Monitoring Guide 2001 by Federal Highway Administration of U.S. Department of Transport has given comprehensive guidelines on variability in traffic stream, computation and application of factors to short counts to obtain AADT. This article briefly discusses the variations in traffic stream and important issues related to expansion factors in light of Traffic Monitoring Guide 2001.

It is an obvious statement that traffic flow varies over time. These variations are observed over a number of time scales such as – time of day, day of week, season (month) of the year. Traffic also varies from place to place, facility to facility depending on numerous parameters viz. economic, agricultural cycles, cultural, religious, recreational activities, function of the facility, surrounding locality, purpose of trip and many other factors.

2.3.1 Hourly Variation of Traffic

The Traffic Monitoring Guide 2001 provides useful recommendations for traffic flow analysis and creating factors. According to the guide, in case of hourly traffic variations, the flow of both light and heavy vehicles fall into either of two basic time-of-day patterns. This may a one-humped or two-humped pattern. The variation exhibited by light vehicles may not be those of heavy vehicles. The time-of-day variations usually depends on function of the road facility showing peak at a particular time of day. Some of the trends usually seen in the USA are discussed in the guide, such as – "Cars tend to follow either the traditional two-humped urban commute pattern or the single-hump pattern commonly seen in rural areas, where traffic volumes continue to grow throughout the day until they begin to taper off in the evening. Trucks also have a single-hump pattern. However, the truck pattern differs from the rural car pattern in that it peaks in the early morning (many trucks are used to make deliveries early in the morning to help prepare businesses for the coming work day) and tapers off gradually, until early afternoon, when it declines quickly. In addition, some types of trucks follow a very different time-of-day pattern. These trucks, usually involved in hauling freight long distances, travel constantly throughout the day.

The traffic at any given site comprises some combination of these types of movements. In addition, at any specific location, time-of-day patterns differ significantly as a result of local trip generation patterns that differ from the "norm." For example, Las Vegas, Nevada, generates an "abnormal" amount of traffic during the night, because that city is very active late at night. Local patterns also have a significant effect on the directional time-of-day pattern for any given road.

Because the volumes of cars and trucks often are very different, the effect of these different time-of-day patterns on summary statistics such as "percent trucks" and "total volume" can be unexpected. Often, in daylight hours car volumes are so high in comparison to truck volumes that the car travel pattern dominates, and the percentage of trucks is very low. However, at night on that same roadway, car volumes may decrease significantly while through-truck movements continue, so that the truck percentage increases considerably, and total volume declines less that the car pattern would predict. Again these variations may not be similar on weekdays and on weekend.

Because these changes can be so significant, it is important to account for them in the design and execution of the traffic monitoring program, as well as in the computation and reporting of summary statistics.

2.3.2 Daily Variation of Traffic

Like hourly fluctuation of traffic flow, there are variations in flow within days of week. Day-of-week patterns also fall into either of two basic patterns. In the traditional urban pattern, volumes are fairly constant during weekdays and then decline slightly on the weekend. This pattern also exists on man rural roads. The other pattern, usually found on rural areas that contain recreational travel, shows constant weekday volumes followed by an increased volume on weekend. Trucks also have two patterns, both driven by the need of businesses. The pattern may be different where percentage of through-traffic is high. Considering these, the Traffic Monitoring Guide suggests that – "These significant changes in traffic volumes during the course of the week have several effects on the traffic monitoring program. Most importantly, the monitoring program needs to collect

data that allow a State to describe these variations. Second, the monitoring program must allow this knowledge to be shared with the users of the traffic data and applied to individual locations.

Without these two steps, many of the analyses performed with traffic monitoring data will be inaccurate. Pavement designers need to account for reductions in truck traffic on the weekends if they are to accurately predict annual loading rates. Likewise, accident rate comparisons for different vehicle classifications are not realistic unless these differences are accounted for in estimates of vehicle-miles-travel by class.

2.3.3 Seasonal Variations

Traffic flow also varies over seasons in a year. According to the Traffic Monitoring Guide 2001, mot states in the United States track four or more seasonal pattern and they base the patterns being followed on some combination of functional classification of roadway and geographic location. Geography and functional classification are used as readily available substitute measures for describing roads that follow that basic pattern. Geographic stratification is particularly important when different parts of a state experience very different travel pattern. For example, travel in areas that experience heavy recreational movements follow different travel patterns than those in areas without such movements. The guide has observed that truck traffic has different seasonal patterns than other vehicles. Some truck movements are stable throughout the year while other truck movements are highly seasonal. For example, in agricultural areas weight carried by truck varies with season. Recent research has shown that seasonal monitoring and adjustment must be done separately for trucks and cars. (Hallenbeck et al 1997). Truck volume patterns can vary considerably from car volume patterns. Roads that carry significant volumes of through-trucks tend to have very different seasonal patterns than roads that carry predominately local freight traffic. Roads that carry large volumes of recreational traffic often do not experience similarly large increases in truck traffic, but do often experience major increases in the number of recreational vehicles which share many characteristics with trucks. Thus, it is highly recommended that States monitor and

account for seasonal variation in truck traffic directly, and that these procedures be independent of the procedures used to account for variations in car volume.

In Bangladesh, seasonal variation of traffic is mainly governed by agricultural cycle, monsoon climate and religious festival Eid. In the case of Eid, the seasonal variation is more complex because of the rotation nature of Arabic calendar in comparison to the English calendar.

2.3.4 Directional Variation

Some roads such as urban commuter roads involve a heavy inbound traffic in the morning and an outbound movement in the afternoon. On many sub-urban roads this directional behaviour is replaced by heavy peak movements in both directions in both peak periods. The time-of-day pattern for traffic on a particular road on bothway can differ to those for inbound and outbound traffic, when directional variation is large.

In areas with high recreational traffic flows, directional movements change the day-of-week traffic patterns as much as the time-of-day patterns. Travelers often arrive in the area starting late Thursday night and depart on Sunday.

Truck volumes and characteristics can also change by direction. One "classic" example of directional differences in trucks is the movement of loaded trucks in one direction along a road, with a return movement of empty trucks. This is often the case in regions where mineral resources are extracted. Volumes by vehicle classification can also change from one direction to another, for example when loaded logging trucks (classified as 5-axle tractor semi-trailers) move in one direction, and unloaded logging trucks (which carry the trailer dollies on the tractor and are classified as 3-axle single units) move in the other. Tracking these directional movements as part of the statewide monitoring program is important not only for planning, design, and operation of existing roadways, but as an important supplement to the knowledge base needed to estimate the impacts that new development will generate in previously undeveloped, rural lands.

2.4 Short Count Expansion Methods

Robichaud K., and Gordon, M. performed a study for British Columbia Ministry of Transportation (BCMoT) to assess the accuracy of their existing traffic monitoring system and to compare it to the alternatives for estimating traffic volumes on their highway network. The study report was published in March 2002 and includes a review of findings from similar projects by the Brunswick Department of Transportation and the Prince Edward Island Department of Transportation and Public Works.

The following discussion is based on this study report and reveals the types of counts used in traffic monitoring programs as well as the expansions methods used to attain AADT from short counts.

Traffic Counts:

Agencies in Canada and the United States use similar approaches for collecting traffic volume data on their highway networks. Basically, two types of counts are completed - continuous counts at a limited number of permanent counting sites and short-term counts at a greater number of temporary counting sites.

The permanent counting sites provide a measure of the variation in traffic volumes over the entire year. Volumes are typically recorded in 15 minute or hourly intervals, 7 days a week, 365 days a year. These counters are located in areas to capture the different traffic patterns such as urban, rural and recreational flows on the various classes of highways in a province or state.

Short-term counters collect data over a period typically ranging from 1 to 7 days in length. Volumes are recorded in 15 minute or hourly intervals over the sampling period. These counters provide samples of traffic volumes over a greater extent of the highway network and are often referred to as coverage counts.

Summary measures such as annual average daily traffic (AADT) volumes and summer average daily traffic (SADT) volumes are estimated from the short-term counts using the

seasonal patterns from the permanent counters. This process is often referred to as expanding the short-term count. Many transportation agencies in Canada use variations of a method developed by the Ontario Ministry of Transportation for expanding short-term counts, which is based on regression analysis. State agencies use an approach commonly called the factoring method for expanding their short-term counts to AADT volumes.

Mainly two approaches are used to expand traffic data from shot counts to attain AADT. These are:

1. Factoring Approach
2. Regression Based Approach

The methods are discussed below.

2.4.1 Factoring Approach

The Factoring Approach is widely used in the United States primarily because it is recommended in the Federal Highway Administrator's (FHWA) Traffic Monitoring Guide (Office of Highway Policy, 2001), (Office of Highway Information Management, 1995), the American Association of State Highway and Transportation Official's Guidelines for Traffic Data Programs (AASHTO, 1992), and the ASTM Standard Practice for Highway Traffic Monitoring (ASTM, 1994). This approach uses data from permanent counters to develop group factors, which are applied to the short counts to estimate summary measures. Daily and monthly factors to expand short-term counts in an agency's jurisdiction are developed following the approach described in these guidelines. A day-of-the-week factor compensates for differences between the monthly average daily traffic volume and the average volume on a Monday, Tuesday, Wednesday, etc. In effect, it is used to estimate an MADT volume from a 24-hour count. There are, therefore, seven day-of-the-week factors for each month for a total of 84 factors for the year. If a short count is taken on a Monday in July, then the day-of-the-week factor for a Monday in July is used to expand the short count to an average daily traffic volume for the month. Similarly, there is one seasonal factor for each month for a total of 12 factors. Using the previous example, an AADT volume can be estimated from the short count by

multiplying the MADT estimate by the seasonal factor for July. It is recommended in the most recent Traffic Monitoring Guide (Office of Highway Policy Information, 2001) that factors be calculated using the current year of data.

Developing seasonal factors for a jurisdiction involves two tasks:

1. Grouping of permanent counters with similar variability; and
2. Identifying unique characteristics for each group.

It is important for an agency to have a firm understanding of all the traffic characteristics within its jurisdiction to ensure an adequate number of groups are developed describing each seasonal pattern. Ideally, the variability within each group should be minimized while the variability between groups is maximized. In most jurisdictions, three to five groups tend to adequately reflect the variation exhibited by all counters (Office of Highway Information Management, 1995).

The factors applied to individual short counts are averages calculated for each group of permanent counters. Permanent counters are grouped based on a clustering analysis, which segments the permanent counter population based on seasonal or regional variability. The determination of seasonal and daily factors requires a minimum dataset to ensure statistical validity. It has been found by the FHWA that five to eight individual counters should be included in each group to determine average factors that are statistically significant. This results in a minimum of 25 permanent counters to determine expansion factors for a jurisdiction (Office of Highway Information Management, 1995). Short-term counts are assigned to a group by reviewing characteristics such as functional classification, seasonal patterns, geography and levels of surrounding development. The assignment process requires a good knowledge of the agency's transportation system and professional judgment.

2.4.2 Regression Based Approach

The premise behind all short count expansion is the assumption that the seasonal variation of a short count can be estimated from a dataset of permanent counters with similar

variation patterns. In the regression-based system, a short-term count is matched to a permanent counter using regression analysis. Once collected, the short count data is compared to data from the permanent counters during the same time period. The intent is to find a permanent counter whose volume variation pattern compares well with the short count's variation. (The comparison can be made on hourly or, more commonly, daily traffic volumes)

Least squares linear regression is the most common regression method of comparison. The coefficient of determination (R^2) is calculated for each permanent-short count regression. The permanent counter having the highest R^2 value is selected as the one with a variation in traffic volumes best matching the short count. Summary measures such as annual, monthly, summer and winter average daily traffic volumes (AADT, MADT, SADT and WADT) are then estimated using the equation developed from the regression analysis.

2.5 Previously Performed Studies in Bangladesh

Not many studies on similar topic were performed in Bangladesh. This is probably due to lack of continuous reliable traffic data. The literature review has revealed that the following studies were made on similar topic. A brief discussion on those studies has been rendered in this article.

2.5.1 Development of Geometric Design Standards, RHD 1994

This study was performed by Joint venture of Howard Humphreys & Partners Ltd. (UK) and CEBTP (France) in collaboration with local consultant Development Design Consultants Ltd. The study was report was published in 1994. This was a project of Roads and Highways Department of Ministry of Communication of Government of Bangladesh, financed by European Economic Community, named "Road Materials and Standards Study Bangladesh". As a part of this study, Volume VIIA covered Development of Geometric Design Standards.

During this study, traffic survey was performed on four major corridors in Bangladesh namely Dhaka-Aricha Road, Dhka-Sylhet Road, Dhaka-Mymensingh Road and Dhaka-Chittagong Road. Using these data and data collected from RHD, flow variation analyses were performed. In this study, hourly flow variations, 12-24 and 16-24 hourly factors, peak hour factor were determined. Daily and Seasonal variation of traffic flow were also analyzed and respective factors were determined.

The analyses could not be made and hence the factors could not be determined with high accuracy because of lack of long duration count data availability. The consultants performed year-long surveys at each location with varying time period, but no consistent data base was available at that time. In some cases, ferry record data was used, where deficiencies were noticed like not all the road traffic cross river by ferry. Moreover, during the survey period large number of non-motorized vehicle used to use highways as well. Due to these reasons, the factors evaluated in the project do not best represent the actual present scenario of traffic flow.

2.5.2 Study of Vehicular Flow Pattern on Jamuna Bridge, 2001

Rahman, S.K. (2002) performed a study on Vehicular Flow Pattern on Jamuna Multipurpose Bridge Access Road in 2002 during his B.Sc. Engg. project work. That study report has been extensively conferred with during this study. The project used 5 years of daily traffic data as well as 13 weeks of hourly data in the analyses.

The expansion factors determined in that study more or less match with those determined here. But, the study lacked some important analyses such as Eid factor, Truck Percentage, etc.

2.6 Overview

From the discussions made in this chapter, a brief idea on traffic monitoring methodologies has been found. The chapter has discussed the basic related terms and definitions that have been important in this study. The Traffic Monitoring Guidelines has provided useful recommendations on types of counts and expansion methodologies. It was found that, Factoring approach is widely used in the United States.

The chapter also discussed about the previously performed studies in Bangladesh on the related topic. It was revealed that, there is scope to make further comprehensive analyses on the traffic characteristics on Jamuna bridge access road, since the previous studies had less available data to work with.

CHAPTER 3

METHODOLOGY

3.1 Introduction

To develop a model for the analyses of traffic flow characteristics and estimation of AADT from short counts, it is of great importance to adopt a sound, systematic approach for data collection, analysis and development of the framework. Traffic flow in Bangladesh not only varies with time (i.e. time of day, day of week, seasonal etc.) because of regular economic activities, but also certain external parameters such as excessive rainfall, flood, Eid festivals, political strikes etc. often affect the natural flow pattern. Therefore, to establish a consistent flow pattern showing repetitive nature, through which it can be possible to determine the expansion factors reliably, requires an organized methodology.

This chapter discusses about the methods adopted during corridor selection, data collection, sorting of raw data, identification and minimization or elimination of data errors, development of flow patterns, determination of expansion factors, regression anaysis and study of other factors related to traffic flow. In order to achieve one of the objectives of this study, all the above tasks are to be compiled in one comprehensive framework, which can be used for analysis of traffic flow characteristics in a particular corridor.

3.2 Corridor Selection

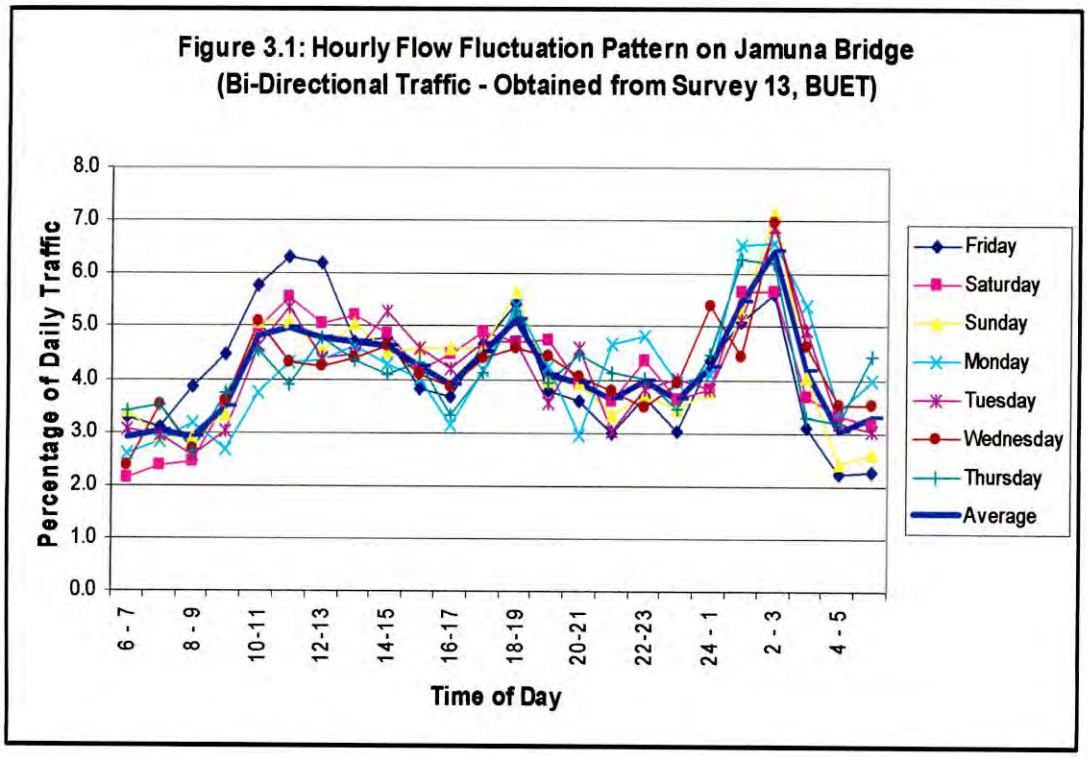
Some of the major highway corridors in Bangladesh are –

1. Dhaka-Chittagong Highway (National Highway No. N1)
2. Dhaka-Sylhet Highway (N2)
3. Dhaka-North Bengal Corridor (N5, N6)
4. Dhaka-Aricha Road to South Bengal (N5, N7. N8)

Different corridors exhibit different characteristics because of the variation in their economic activities. For example, as discussed in Chapter 2, if a corridor is full of mineral resources, the flow pattern, directional distribution, traffic composition would be different from those of an agriculturally resourceful corridor. All these considerations are to play their roles in flow pattern analysis and the development of the framework model. However, in either case, for an efficient analysis of traffic flow characteristics on rural highways, large quantity of reliable data is required.

Before the commencement of Jamuna Multipurpose Bridge operation, long duration reliable traffic data were not available. Jamuna Multipurpose Bridge was opened for public in June 1998. Since then, its operators have collected and preserved daily traffic data in an orderly fashion. Considering that it has taken around six months for the corridor to be stabilized, seven years of daily traffic data is available on Jamuna Bridge. Moreover, Bangladesh University of Engineering and Technology had conducted thirteen weekly surveys on Jamuna Bridge, where hourly traffic was also counted. And also, the first tolled road in the country 'Nalka-Hatikamrul-Bonpara New Road' is also situated in the North Bengal corridor. Taking all these into account, this is rather an easy task to select the corridor for this study.

Now, the selected corridor should not only possess long duration traffic data, but also the quality of those data has to be high. Although, traffic generation and flow is a random event, but research has shown that, traffic flow in a particular corridor maintains definite flow pattern and also the same is repetitive in nature. Figure 3.1 shows a typical hourly traffic flow pattern on Jamuna Multipurpose Bridge obtained from 13th Survey conducted by BUET.



From the above figure, it can be seen that, all days of the week maintain similar flow variation pattern. This undoubtedly proves the stability of the corridor from traffic flow point of view and also the quality of the data and only this type of quality data is worth to be used for flow characteristics analyses and determination of expansion factors.

3.3 Data Collection

Long-term traffic data is very important for any type of analysis in particular modeling of traffic flow characteristics. Scarcity of long term traffic flow data in Bangladesh has made this difficult to perform any such studies. At present there is no permanent counting station to measure traffic data which is one of the sole responsibilities of the government. Without long duration traffic flow data reliable prediction of future traffic demand would not be possible. Besides, there is no special program to collect corridor wise annual traffic data. Therefore, during this study it was a challenge to collect fair amount of traffic flow data with which a reliable model could be developed. But, most of

the toll operators collect toll manually and do not maintain or record traffic flow record in usable format. Since the commencement of Jamuna bridge operation, the toll operators have been recording flow data in computer database. Some of the recently opened bridge and even highway are tolled, where the operators are using computer database system. For the collection of data pre-requisite for this study, the following sources have been used:

- 5 years (June 1998 to March 2004) of both direction daily flow data recorded in three 8 hourly shifts on Jamuna Bridge toll plaza by JOMAC, the then bridge operator and maintenance company.
- 2 years (April 2004 to December 2005) of daily flow data on Jamuna Bridge collected by MargaNet, present bridge operator and maintenance company.
- 13 weeks of hourly flow data spreaded over almost 4 years (October 1998 to May 2002) collected by BUET.
- 1 year (May 2004 to April 2005) of daily flow data on Nalka-Hatikamrul-Bonpara road collected by Pubali-Alloy JV Ltd., the present toll operator.

Among these JOMAC, MargaNet, and Pubali-Alloy JV use similar data collection and recording method. Data is entered into the computer at the toll collection booth at the time of toll collection and they are directly stored into the main database in the toll plaza. The vehicle classification is identified manually by the toll collector as per the registration of respective vehicle. From the main database, the toll operator prepares a monthly summary of daily traffic flow record along with toll amount and submit the same to the concerned authority.

Bureau of Research Testing & Consultation, BUET conducted their survey as a part of the consultation project financed by Jamuna Multipurpose Bridge Authority (JMBA), Ministry of Communication, Government of Bangladesh, for auditing purpose. They collected the flow data independently by teams of enumerators round the clock for continuous seven days on each survey. Thus BUET had performed 13 surveys in different seasons within a span of three and half years. After the collection of raw data, the same was summarized and the final report of each survey was presented to the concerned authority. The survey dates are given in the following table.

Table 3.1: Duration of Traffic Count Surveys Carried out by BUET

Survey No.	Duration
1	Oct 24, 1998 to Oct 30, 1998
2	Dec 16, 1998 to Dec 22, 1998
3	Feb 12, 1999 to Feb 18, 1999
4	Apr 23, 1999 to Apr 29, 1999
5	Jun 04, 1999 to Jun 10, 1999
6	Aug 27, 1999 to Sep 02, 1999
7	Dec 03, 1999 to Dec 09, 1999
8	Mar 03, 2000 to Mar 09, 2000
9	Jul 07, 2000 to Jul 13, 2000
10	Nov 03, 2000 to Nov 09, 2000
11	May 11, 2001 to May 17, 2001
12	Oct 19, 2001 to Oct 25, 2001
13	May 24, 2002 to May 30, 2002

Collecting necessary data for this study from the operators was not an easy task. Comprehensive effort has been given for this purpose. At the commencement of this study, four and half years of daily data on Jamuna Bridge recorded in 3 shifts by JOMAC (June 1998 to March 2004) and 13 weeks of hourly flow data collected by BUET was available. These data were used in a project work by Captain Sheikh Muhibur Rahman as mentioned in Chapter 2. But, these data was not sufficient for developing a comprehensive model on flow pattern analysis and flow prediction. Therefore, attempts were made to collect more data on the same route for the next available years. Hence, Jamuna Multipurpose Bridge Authority (JMBA) was officially requested for the permission for obtaining electronic version of traffic flow data on Jamuna Bridge from the present operator MargaNet, who started their operation on March 31, 2004. After the official permission had been obtained from the JMBA, the Jamuna Bridge was visited and Traffic flow data was collected from MargaNet office at the East Toll Plaza.

The main reason behind feeling the necessity of collecting traffic flow data on 'Nalka-Hatikamrul-Bonpara New Road' was that this is the first tolled road in the country. Since, the road is situated in North Bengal, it was anticipated that, analyzing this data could reveal some exclusive findings on traffic flow characteristics on the selected

corridor. This analysis has never been attempted in Bangladesh due to lack of availability of such data and this golden opportunity was not to be neglected. For collecting this data The Roads & Highways department was first contacted. With their permission, the toll plaza situated at Hatikamrul was visited and daily data recorded by the toll collection & maintenance company Pubali-Alloy JV Ltd. In this case, only one year (May 2004 to April 2005) of traffic data was provided by the operator.

Attempt has also been made to collect data from different toll stations situated at other National Highways, but because of manual method of toll collection system, no traffic flow data could be found in usable format. Although Pakshi bridge toll collection system is computerized, as it has been inaugurated very recently, sufficient amount of traffic data is not available for reliable analysis.

3.3.1 Problems Encountered During Data Collection

Here follows some of the problems encountered while collection of the above traffic data.

- The concerned government authorities do not keep any systematic record of traffic data in electronic version, which is extremely needed for research purpose.
- The operators do not use one specified software to maintain a unified data collection and recording system. As a result, the data were collected as hard copy and they had to be put into the input file of the framework manually.
- There does not exist any unified vehicle classification system. It was found that the classification used by Hatikamrul road operator does not match with that of Jamuna Bridge.
- Only tolled vehicles are counted and recorded by the operator. It is to be mentioned here that the army vehicles, maintenance vehicles are exempted from toll and thus considerable amount of army vehicles are not counted and hence leading to data errors.

3.4 Data Processing

Processing raw data is an important part of this study. The data processing task involves exclusion of data during unstabilized period, identification of external factors causing variations in regular patterns and elimination of those external factors. After the data processing has been completed, the summarized data is sorted in such a manner that the analyses works are best facilitated.

3.4.1 Exclusion of Data During Unstabilized Period

Any newly introduced transportation route takes a certain time during its initial period to become stabilized. This happens because of the following reasons.

- The route users initially take some time to realize the benefits of the new facility and then shift to the same.
- Some recreational trips occur during the initial period after opening.
- During the early period of a new route, the traffic data may not be collected and recorded properly.
- Construction activities are not completely finished, resulting some consultants', contractors', authorities' vehicle flow. But these are not regular users of the road facility.

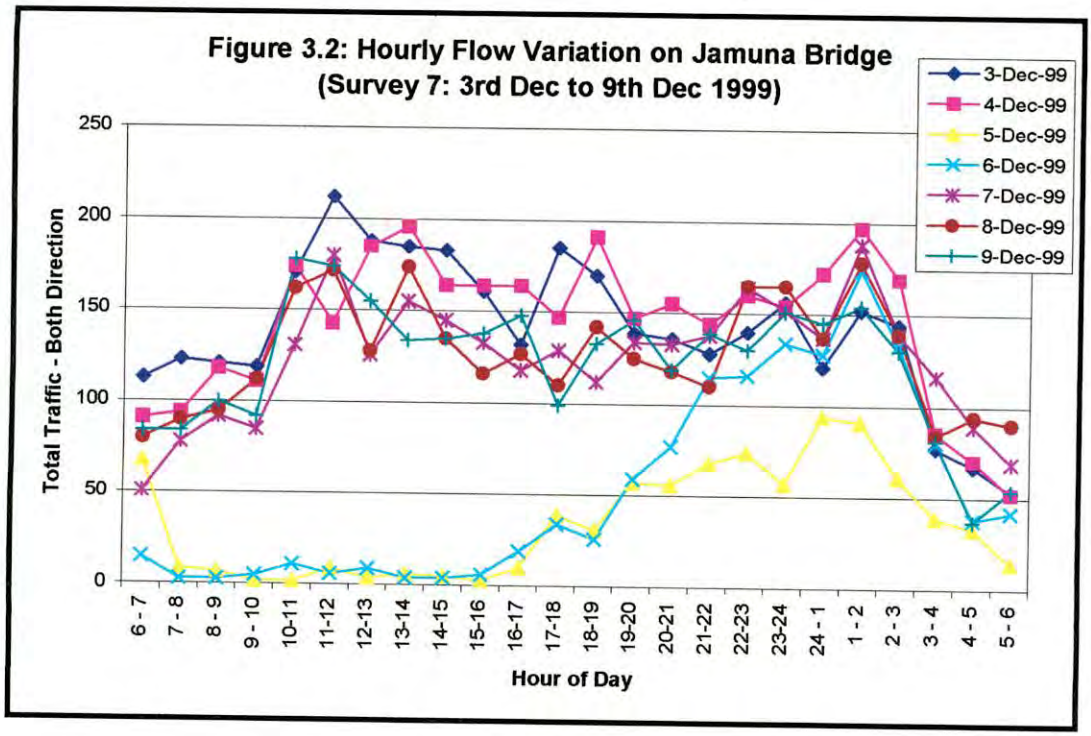
Considering the above reasons the initial six months of traffic data on Jamuna Bridge and initial four months of data on Hatikamrul road have been excluded from the analyses in this study.

3.4.2 Identification of Data Errors

In Bangladesh, several external factors such as political strike, transport strikes, excessive rainfall, flood, Eids, Ramjan etc., affect the normal traffic flow. Due to these factors, the repetitive nature of traffic flow is often hampered. The shifting nature of Ramjan as well as Eid-ul-Fitr and Eid-ul-Ajha makes the pattern even more complex, as all these are

based on Arabic calendar, which is 10/11 days shorter than the English calendar. Since it is important to define or establish a flow trend before going into further analysis of data and determination of the expansion factors, the raw traffic flow data was first put into rigorous scrutiny in order to identify the possible data errors by observing any unusual patterns shown in the flow pattern curves.

In Figure 3.2, hourly traffic flow data in both direction collected by BUET during its 7th weekly survey on 3rd Dec '99 to 9th Dec '99, has been put into the hourly variation of flow pattern framework. It is clearly seen that, five days traffic flow maintain similar flow pattern but 5th and 6th Dec traffic flow are unusually lower than the other days of the week. The record of JOMAC also showed similar discrepancies. To find out the fact, the Daily Prothom Alo library was visited and from the newspapers of those specific days, it has been found that, there was a national strike on 5th and 6th Dec 1999. The traffic flow was very low due to the Hartal. Naturally, one can understand that, this type of data noises will create errors in the expansion factors and the same must be excluded from the analysis.



Likewise, by checking expected total daily traffic flow for a particular day with that of normal flow value, the other abnormal days occurred within the study period were also traced.

Another example is shown in Figure 3.3, where it is seen that, the peak monthly flow of light vehicles is not on one particular month but it is gradually shifted every year. This happens due to shifting nature of the two Eids.

Figure 3.3: Impact of Eid on Flow of Light Vehicles on Jamuna Bridge

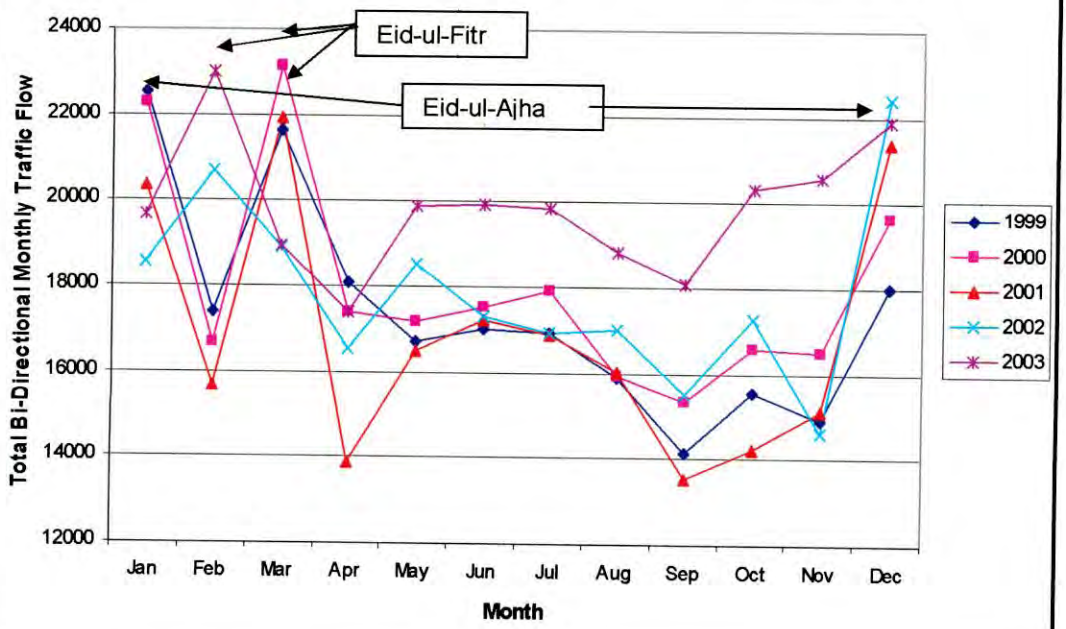


Table 3.2: Eid Festival dates during the last seven years

Eid ul Fitr	Eid ul Ajha
21-Jan-99	29-Mar-99
09-Jan-00	17-Mar-00
28-Dec-00	07-Mar-01
17-Dec-01	24-Feb-02
07-Dec-02	12-Feb-03
26-Nov-03	02-Feb-04
15-Nov-04	22-Jan-05
05-Nov-05	

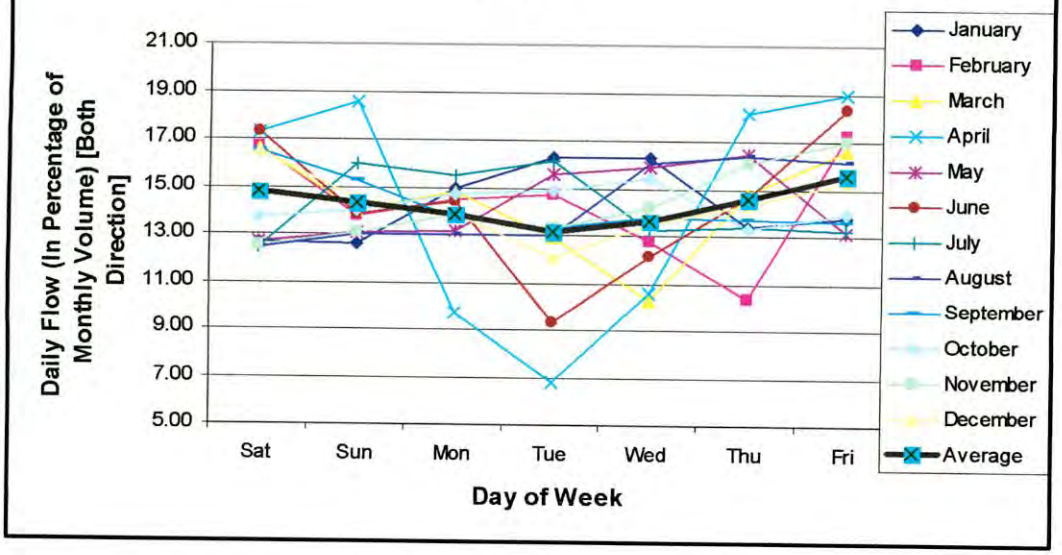
The Eid timings on the concerned years is shown on Table 3.2 and from this, the impact of Eid festival months on the flow of light vehicles on Jamuna Bridge is distinctly observed. It is also observed from further analysis shown in Article 4.2.10 that, flow patterns of all class of vehicles do not exhibit similar changes due to Eid month. In other words, Eid months cause different impacts on different type of vehicles. Therefore, the variation may not be observed as clearly as in this figure for all classes of vehicles or the flow pattern of total traffic.

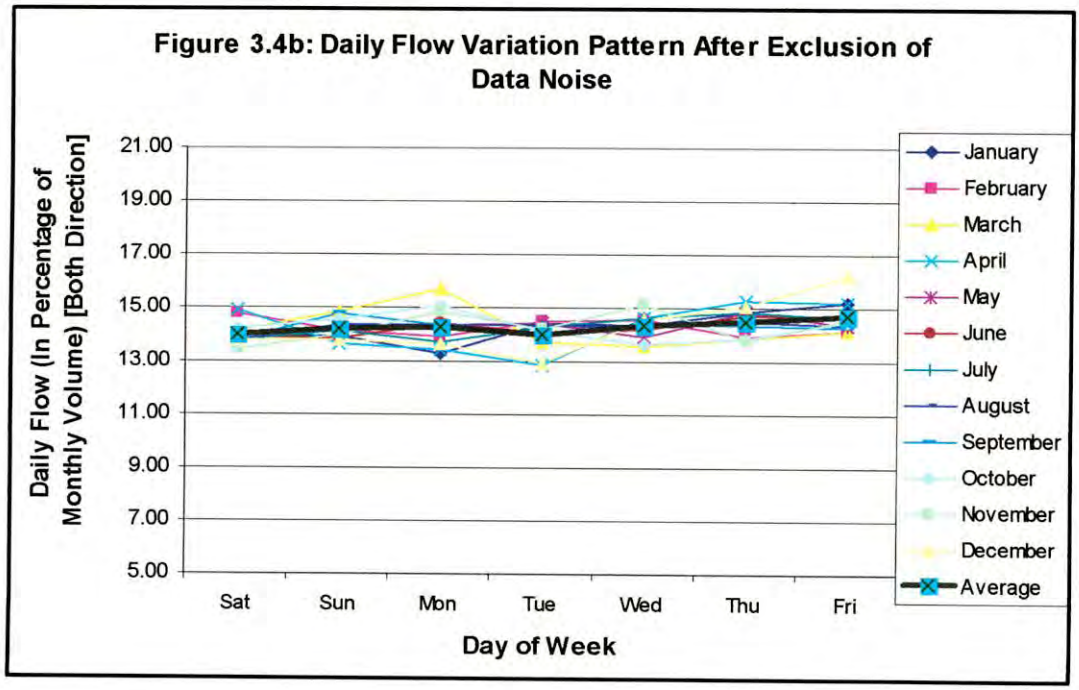
Therefore, from the above figures, it is understood that, the external factors create considerable variation in flow pattern and thus the natural traffic flow pattern is affected.

3.4.3 Elimination of Data Errors

In order to establish a reliable database for accurate analysis of traffic flow, particularly for developing pattern based expansion factors, the raw database should be cleaned to get rid of any possible error. If the traffic data resulting from variations due to external factors are excluded from the analyses, the flow patterns are expected to be similar and accordingly repetitive nature can be achieved.

Figure 3.4a: Daily Flow Variation Pattern Before Exclusion of Data Noise

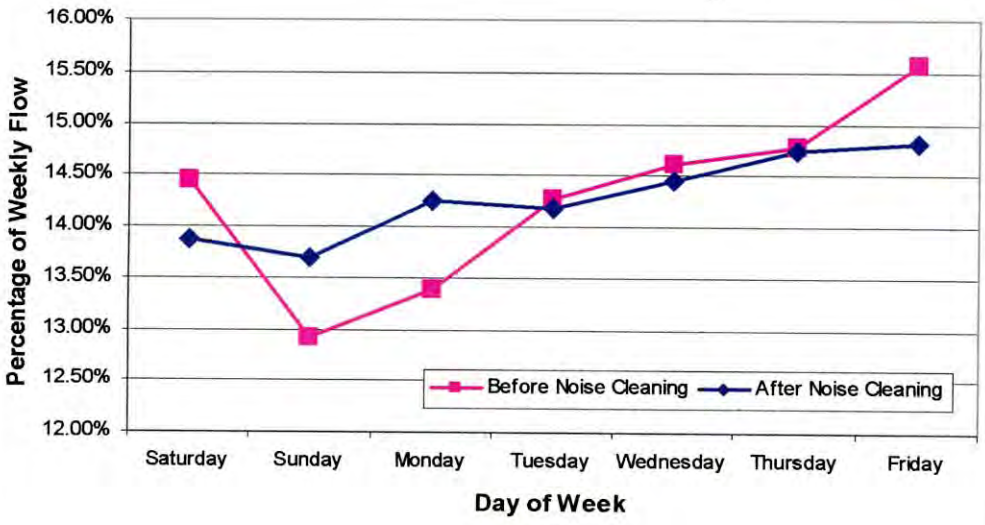




In Figure 3.4a, the flow data on Jamuna bridge in 2001 including the possible data errors has been put into the Daily Flow Variation model. It is observed that, there does not exist any definite flow variation pattern and pattern is erratic. But, after exclusion of possible data noises, the pattern, as shown in Figure 3.4b, is much similar for every month.

The changes caused by the exclusion of data noises can be quite dramatic, which even changes the whole flow pattern. Such observation is shown in Figure 3.5. It is seen that the daily flow pattern is much different in the case of data after data noise cleaning than those before noise cleaning.

Figure 3.5: Daily Flow Variation on Jamuna Bridge - Before and After Noise Cleaning



This leads to a fact that, to determine the expansion factors accurately, all the data noises must be excluded from the database. Then the clean data are to be put into the flow pattern framework and only then the flow patterns can show repetitive nature.

But, for practical consideration, it would be more rational approach to analyze the impact of events such as Eid, Hartal etc., rather than omit the flow data caused by these events. Because, for efficient planning of a transport facility, it is important to understand the impact of these events. For example, one day of national strike may hamper the natural traffic flow of that particular day, but at the same time, may have some impact on the flow on adjacent days. Or, how long does the impact of Eid festivals sustain? It is clearly understood that, political strikes or transport strikes reduces the traffic flow significantly, but traffic flow around Eid days are considerably higher than those normal days causing critical value for design.

Therefore, an attempt has been made in this study to analyze flow data around Eid festivals and to develop a factor representing that so that the critical flow value can be determined. The analysis of Eid festival on traffic flow on the selected corridor is given in the next chapter.

3.5 Development of Framework

One of the objectives of this study is to develop a framework through which the following analyses of traffic flow for a particular corridor can be made.

- Summarizing hourly, daily, weekly, monthly & yearly traffic data
- Traffic composition
- Directional Distribution
- Render hourly, daily, monthly, yearly flow pattern charts
- Identifying data noises
- Flow pattern of predominant vehicle classes
- Calculation of Hourly Expansion Factors
- Calculation of Daily Expansion Factors
- Calculation of Monthly Expansion Factors
- Yearly Growth Pattern and determination of Growth Factors
- Regression analysis of hourly, daily and monthly data and preparation of correlation charts
- Corridor vehicle flow pattern analysis
- Checking consistency of flow pattern for auditing purpose

The framework should be such that, raw data from field surveys can be entered into the input spreadsheet and the formulae & equations are interlinked with the output charts and tables. In this study, Microsoft Excel compatible with MS Windows has been used for the purpose, although more comprehensive and user friendly model could have been established with a framework developed with MS Access Data Base hyper linked with Visual Basic. However, the latter method is recommended for future works.

3.5.1 Framework Flow Chart

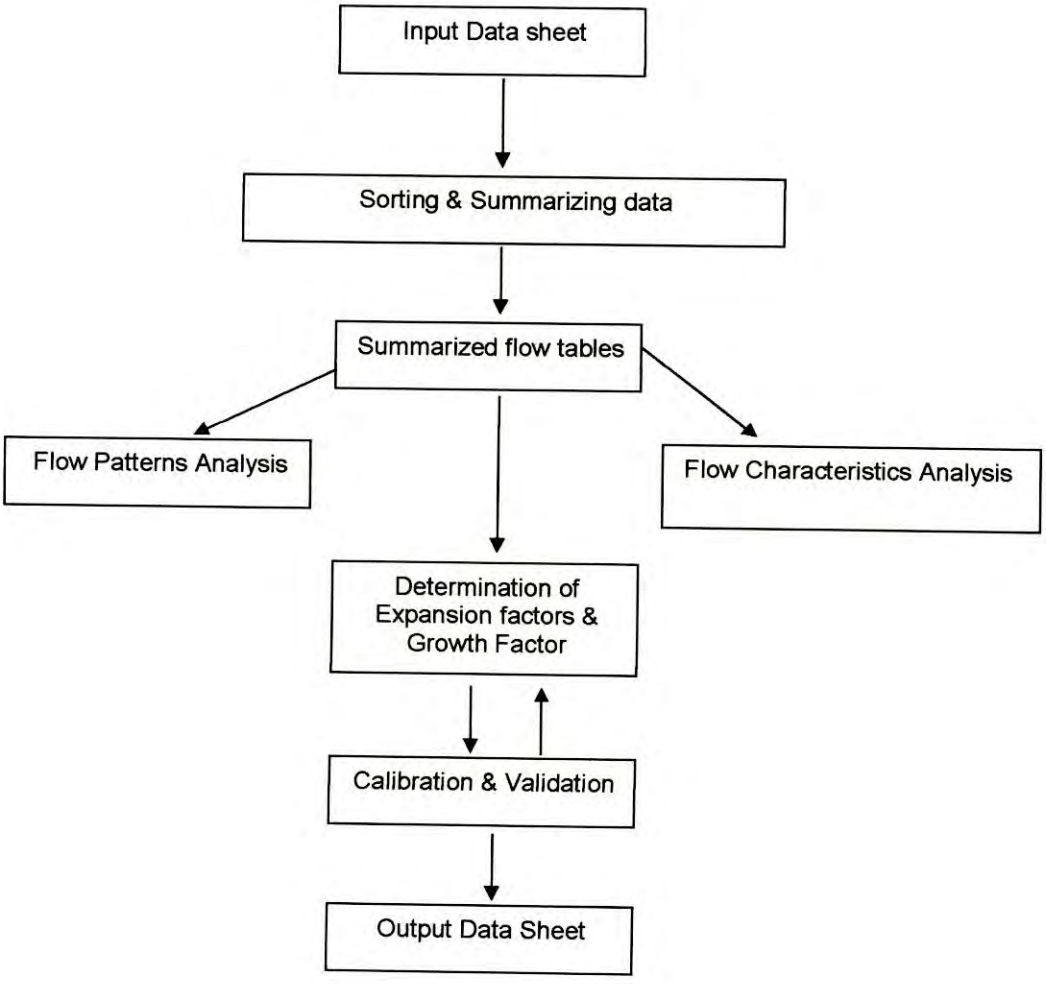


Figure 3.6: Flowchart of the analysis framework

3.5.2 Framework Types

Four types of analysis model have been developed during this study depending on the type of input data and analysis scope. For plotting hourly, daily, monthly, yearly flow variation patterns and determination of expansion factors, the following three models have been developed.

1. This model uses the hourly flow data in its input file. The raw traffic database has been summarized by BUET. From the summarized traffic flow sheet, the model plots hourly, daily variation of flow, traffic composition, directional distribution charts and determines hourly, daily expansion factors.

2. The second model uses the traffic flow data collected from JOMAC. Volume data was recorded by JOMAC in three shifts.
   - Shift 1: 06:00 to 14:00
   - Shift 2: 14:00 to 22:00
   - Shift 3: 22:00 to 06:00

   Therefore, this model can analyze daily, weekly, monthly and yearly variation of flow as well as day-night flow fluctuation, directional distribution traffic composition etc and thus determination of daily, monthly expansion factors and yearly growth pattern.

3. The third model uses flow data collected from MargaNet. The volume data provided by MargaNet is bi-directional daily data. This model is used to develop daily, weekly, monthly, yearly flow pattern but analyses such as directional distribution, day-night flow fluctuation is not included in the model because only bi-directional total daily traffic flow data was available from the operator.

4. The fourth model uses both Hatikamrul road and Jamuna bridge daily data for corridor analysis. The model can be useful for auditing purpose since it plots the traffic daily flow on the two mentioned locations in the same charts which compares the traffic movement and also determines the percentage of traffic volume on Hatikamrul road to that on Jamuna bridge. If the two flow patterns are similar, it is easily understood that the toll collections have been accurate.

CHAPTER 4

ANALYSIS OF FLOW CHARACTERISTICS

4.1 Introduction

The major objectives of this study are to analyze traffic flow data on the selected corridor, study of the traffic flow characteristics and to develop a model for estimation of AADT from short counts. To attain this, long duration round the clock flow data is essential and accordingly those have been collected in different forms from the toll operators of Jamuna Bridge and Nalka-Hatikamrul-Bonpara New Road. Data collected by BUET for audit purpose on Jamuna Bridge in 13 weekly surveys has also been used in this study. All these data have been sorted and summarized into a format to make them usable for the analysis and modeling purpose. This chapter discusses the traffic data analysis and various flow characteristics on Jamuna Bridge.

4.2 Analysis of Flow Characteristics

Using the summarized database of traffic flow on Jamuna bridge, a range of analyses on traffic flow have been rendered during this study. This section contains the analysis of flow characteristics on Jamuna bridge. Primarily the flow patterns have been developed to see the nature of traffic flow fluctuation and then various flow characteristics have been established.

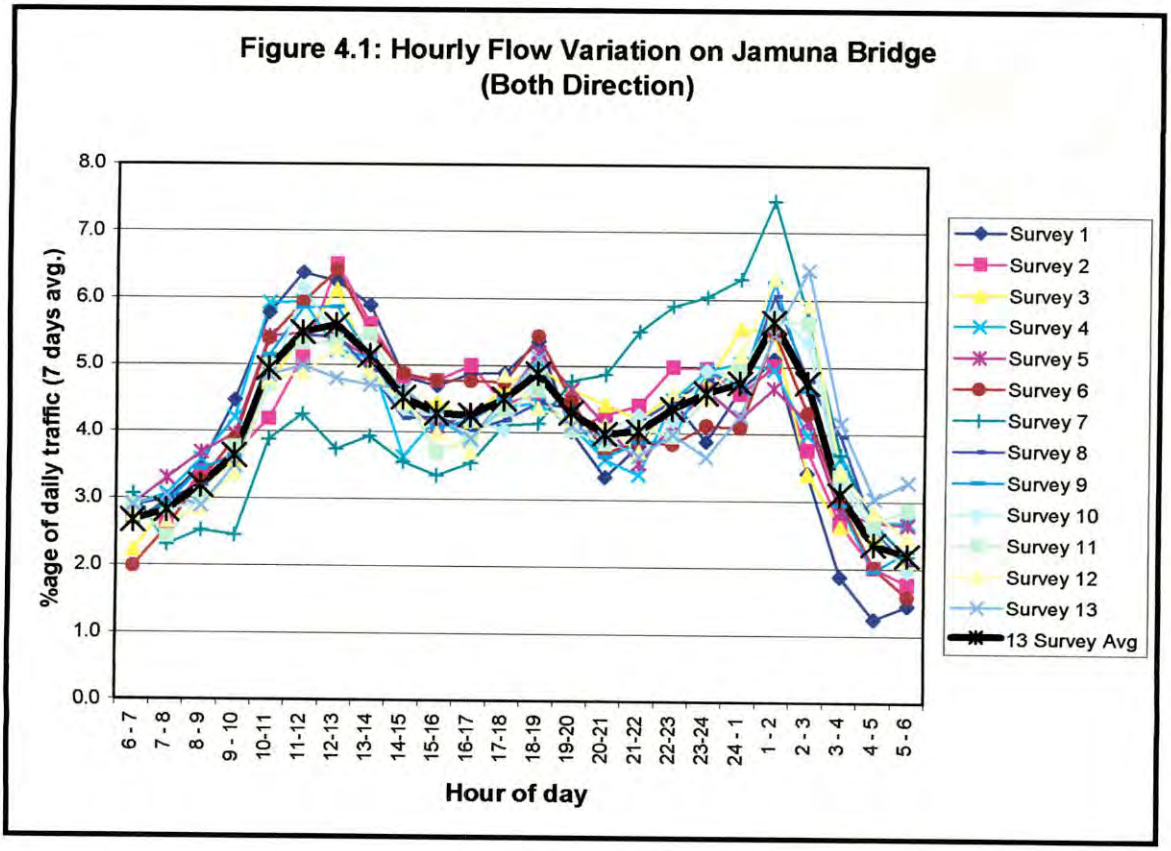
4.2.1 Flow Pattern

Traffic flow varies over time. The variation is observed in hours of day, days of week, months of year showing definite repetitive nature. These variations are important aspects of flow characteristics, which have been discussed in the following sections.

4.2.2 Hourly Flow Variation

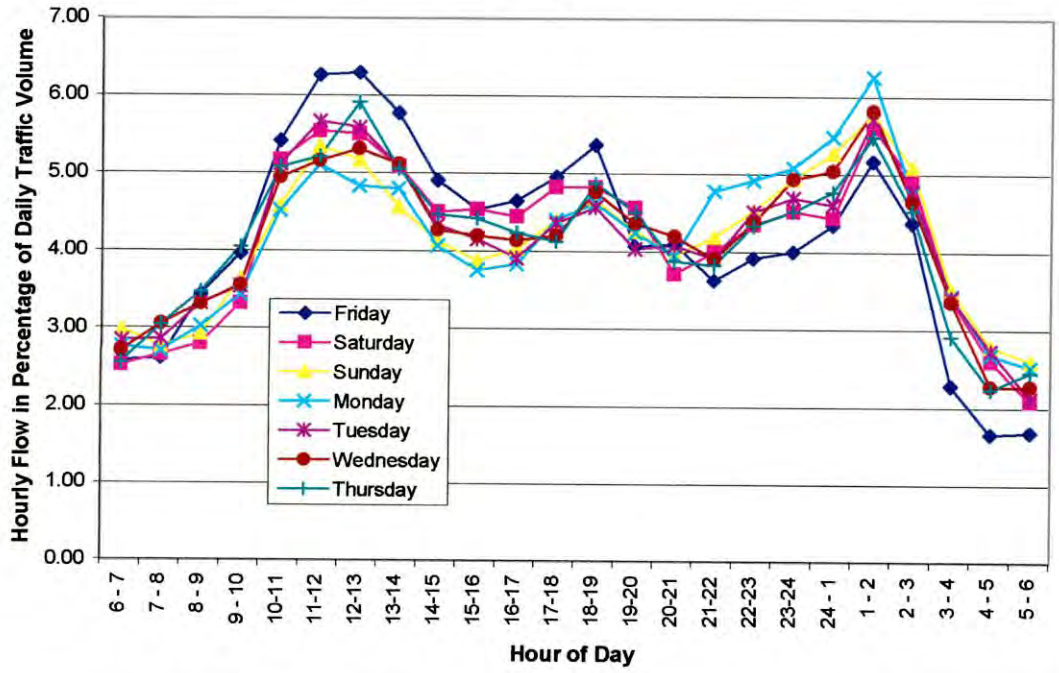
Hourly flow variation pattern has been developed using the data collected by BUET, where 13 weeks of hourly traffic flow have been recorded. By potting the hourly traffic flow in all the surveys, it is found that, the traffic follows similar hourly variation pattern throughout day and night. Figure 4.1 shows typical hourly fluctuation of traffic on Jamuna Bridge.

Figure 4.1: Hourly Flow Variation on Jamuna Bridge (Both Direction)



It is seen in Figure 4.1 that, total bi-directional traffic maintains prominent pattern in terms of hour of day variation, which is very similar in all 13 surveys. There exists three distinct peak hours (12:00-13:00, 18:00-19:00 and 1:00 – 2:00) of traffic flow for the case of percentage of total daily vehicles averaged over all weekdays. In the case of hourly flow percentages of total daily vehicles for particular days of week, averaged over 13 surveys, (Figure 4.2) also exhibit similar hourly flow pattern with a slight differences in the peak hour percentages.

Figure 4.2: Hourly Flow Variation on Each Day of Week (Both Direction)



In Figure 4.2, it is observed that the peak hours occur between 11:00 to 13:00, 17:00 to 18:00 and 1:00 to 2:00. It is also observed that, the variation is more pronounced on Fridays, where maximum traffic flow occurs between 11:00 to 12:00 (6.29% of total daily traffic) and the minimum flow occurs between 4:00 to 5:00, when 1.66% of total daily flow takes place. The following table (Table 4.1) shows the hourly percentage of traffic on each weekday, averaged over 13 weeks traffic data. Using the table, analyzing average hourly percentage of daily traffic flow, taking all weekdays in consideration, the

peak hour is found to be 01:00 to 02:00 and the corresponding traffic flow is 5.68% of total daily traffic.

Table 4.1: Day wise hourly traffic fluctuation – in percentage of total daily volume – averaged over 13 weeks (both direction)

Hour	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Avg. %
6 - 7	2.58	2.53	2.99	2.76	2.85	2.72	2.56	**2.71**
7 - 8	2.61	2.66	2.77	2.71	2.86	3.06	3.05	**2.82**
8 - 9	3.44	2.80	2.93	3.03	3.32	3.32	3.48	**3.19**
9 - 10	3.97	3.32	3.64	3.44	3.54	3.56	4.05	**3.65**
10-11	5.42	5.17	4.58	4.52	5.12	4.95	5.08	**4.98**
11-12	6.26	5.54	5.35	5.11	5.67	5.16	5.21	**5.47**
12-13	6.29	5.50	5.17	4.83	5.59	5.31	5.91	**5.51**
13-14	5.77	5.09	4.57	4.80	5.09	5.12	5.06	**5.07**
14-15	4.91	4.51	4.13	4.07	4.34	4.28	4.47	**4.39**
15-16	4.54	4.54	3.88	3.75	4.16	4.20	4.42	**4.21**
16-17	4.65	4.45	4.04	3.84	3.91	4.14	4.24	**4.18**
17-18	4.96	4.83	4.40	4.41	4.37	4.20	4.13	**4.47**
18-19	5.37	4.83	4.66	4.63	4.57	4.77	4.87	**4.81**
19-20	4.07	4.56	4.27	4.24	4.04	4.37	4.51	**4.29**
20-21	4.10	3.72	3.95	3.95	4.08	4.20	3.88	**3.98**
21-22	3.63	4.00	4.19	4.78	3.91	3.91	3.83	**4.04**
22-23	3.92	4.35	4.53	4.92	4.52	4.38	4.34	**4.42**
23-24	4.01	4.53	4.94	5.08	4.70	4.94	4.53	**4.67**
24 - 1	4.35	4.44	5.27	5.48	4.61	5.05	4.77	**4.85**
1 - 2	5.17	5.60	5.76	6.26	5.71	5.82	5.48	**5.68**
2 - 3	4.38	4.94	5.09	4.76	4.78	4.65	4.53	**4.73**
3 - 4	2.28	3.40	3.52	3.44	3.42	3.36	2.91	**3.19**
4 - 5	1.66	2.60	2.79	2.68	2.74	2.27	2.24	**2.42**
5 - 6	1.68	2.09	2.60	2.52	2.12	2.27	2.45	**2.25**
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source Data: BUET

Figure 4.1 and 4.2 show the hourly fluctuation of total traffic flow over Jamuna bridge, but it is observed from the following charts that, all classes of vehicles do not follow similar hourly fluctuation during the day. This is an important issue considering that, the vehicle composition on Jamuna bridge is gradually changing with time, where percentage

of heavy vehicles is increasing every year (The vehicle composition trend is discussed in section 4.2.6). Vehicle composition has especial implication in particular relation to geometric and structural design of highways.

Figure 4.3: Hourly Flow Fluctuation of Large Buses (Both Direction)

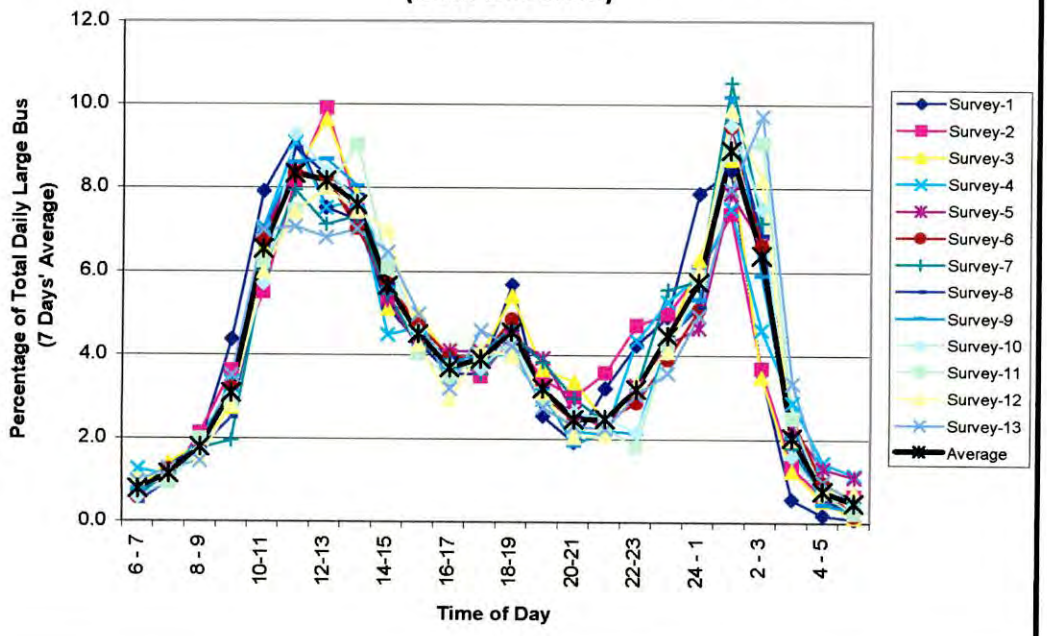


Figure 4.4: Hourly Flow Fluctuation of Medium Trucks (Both Direction)

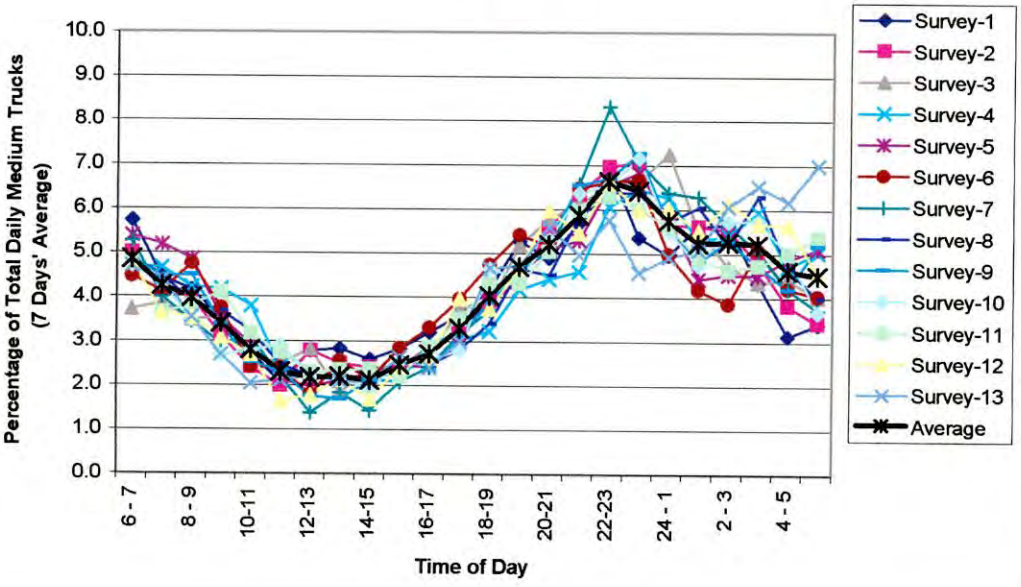


Figure 4.5: Hourly Flow Fluctuation of Light Vehicles (Both Direction)

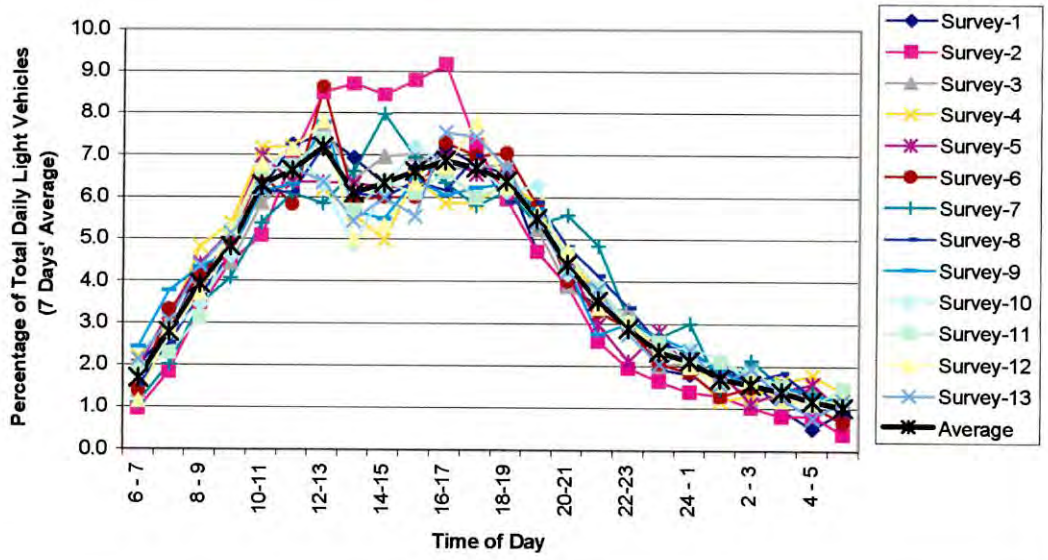


Figure 4.3, 4.4 and 4.5 show the hourly flow fluctuation of the three predominant vehicle classes on Jamuna bridge, i.e. Large Buses, Medium Trucks and Light Vehicles respectively on an average weekday. From figure 4.3, it is observed that, the flow fluctuation of Large Buses are similar to that for total traffic. Three distinct peaks are found among which the most prominent occurs between 1:00 to 2:00. On the other hand, the flow of Medium Truck rises twice a day (Figure 4.4) with maximum flow between 22:00 to 1:00. In this case, the minimum flow occurs between 12:00 to 14:00. In case of Light Vehicles, night time traffic is very low and the peak rises between 11:00 to 17:00.

Therefore, from the above analyses, it is evident that, for accurate flow prediction modeling from short counts, the hourly expansion factors should be determined individually for all vehicle classes; the total flow fluctuation is not representative of all vehicle class.

Summary of Findings:

The following table (Table 4.2) summarizes the important aspects of hourly fluctuation of traffic flow on Jamuna bridge, in light of the above analyses.

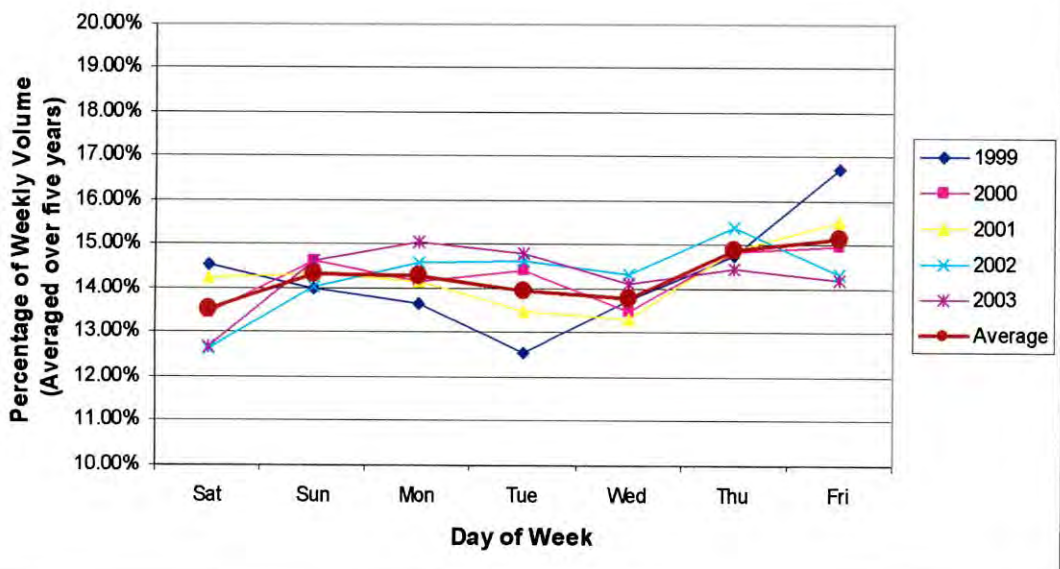
Table 4.2: Maximum and Minimum Hourly Flow Percentages on Jamuna Bridge (Both Direction)

Vehicle Class	Peak Hour	Peak Hour Percentage	Minimum Flow Hour	Minimum Flow Percentage
Total Traffic	1:00-2:00	5.68%	5:00-6:00	2.25%
Large Buses	1:00-2:00	8.91%	5:00-6:00	0.48%
Medium Trucks	22:00-23:00	6.64%	14:00-15:00	2.12%
Light Vehicles	12:00-13:00	7.20%	5:00-6:00	1.03%

4.2.3 Daily Flow Variation

Daily flow fluctuation on highways is an important parameter of flow characteristics where the variation of flow in days-of-week is observed. From the analysis of 5 years data collected from JOMAC (1999 to 2003), distinct daily flow fluctuation pattern can be achieved. In Figures 4.6a & b, the average daily flow, in either direction, in percentage of total weekly volume have been plotted against respective days of week. It is clearly observed that daily flow variation for inbound (West to East) and outbound (East to West) traffic does not exhibit similar pattern.

Figure 4.6a: Daily Flow Fluctuation on Jamuna Bridge (East to West Direction)



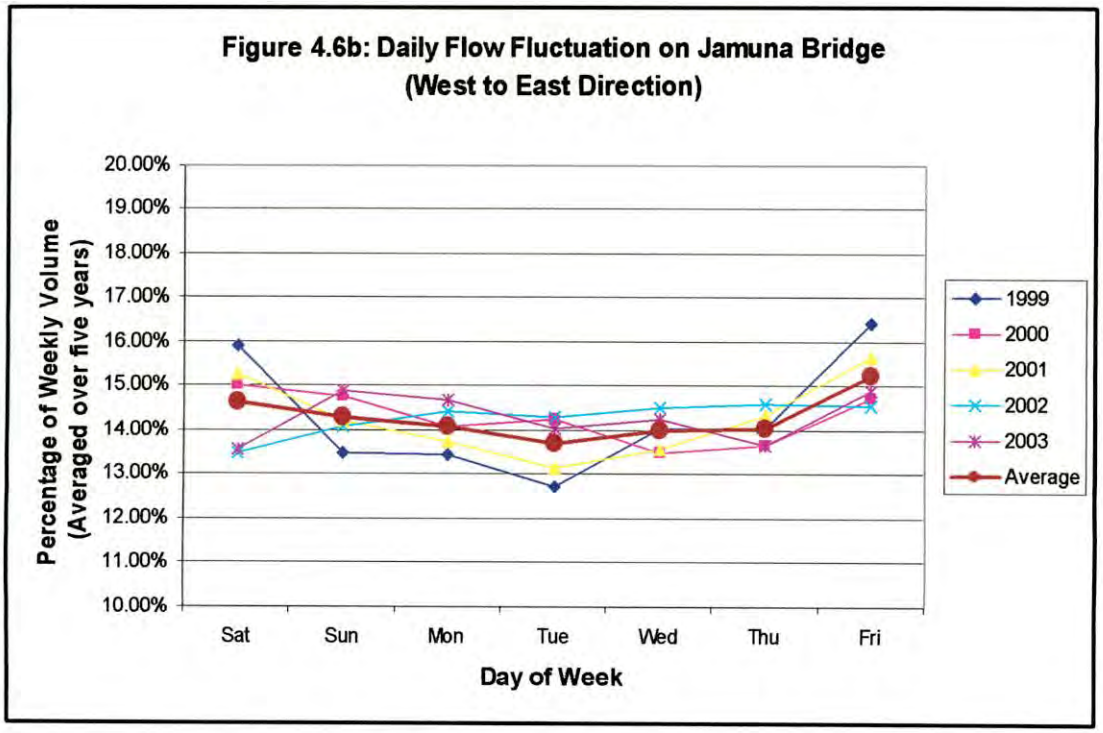


Figure 4.6a shows the flow variation for traffic from East to West. On this direction, it is found that the average maximum flow occurs on Friday (15.16%) and Thursday (14.87%). This may happen because of weekend factor, i.e. people from North Bengal tend to visit their native town/village during the weekend from their workplaces in Dhaka. On the other hand, for West to East flow direction (Figure 4.6b) average maximum flow takes place on Friday (15.25%) and Saturday (14.65%), because people return to workplaces in Dhaka at the beginning of week. In both the cases, the curves tend to sag on midweek (Tuesday & Wednesday) where traffic flow is minimum.

It is evident from the above patterns, that freight vehicle movement has little impact on these variations, as weekend factor is more prominent on passenger movement. Therefore, the need for analyzing daily flow variation separately for vehicle classes is realized. Accordingly, curves have been plotted for three predominant vehicle classes on Jamuna bridge, which are given hereunder.

Figure 4.7a: Daily Flow Fluctuation of Medium Truck on Jamuna Bridge (East to West)

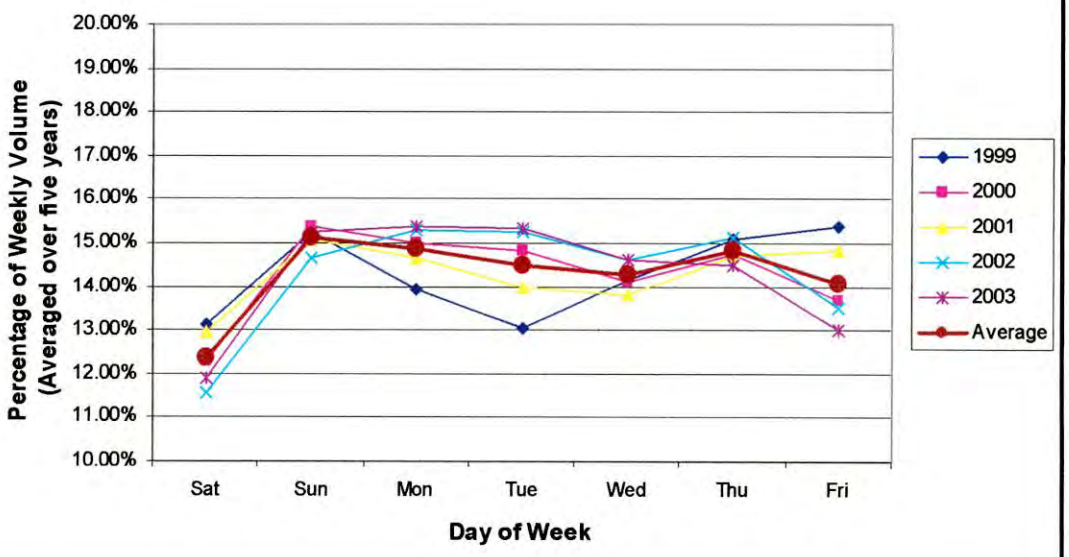
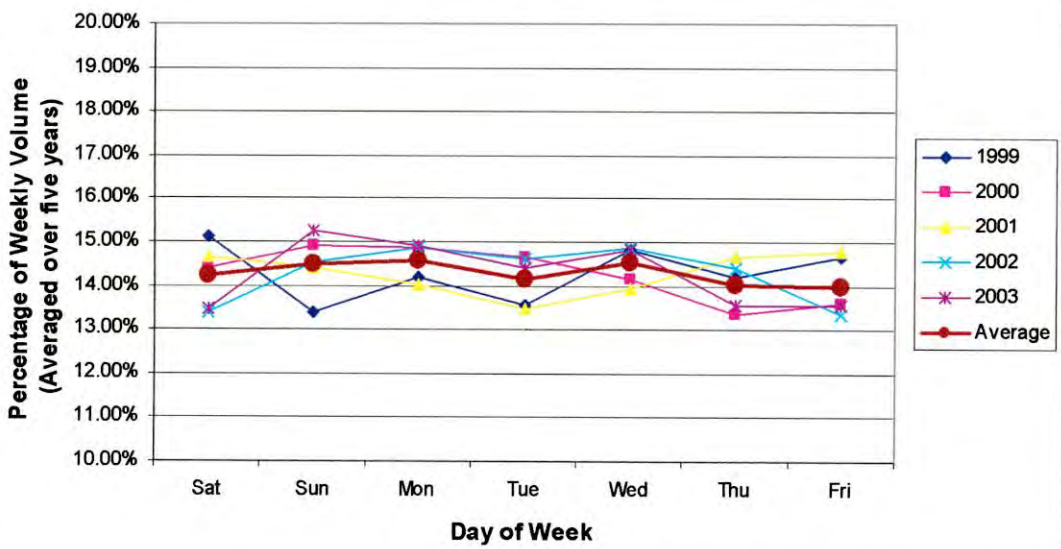


Figure 4.7b: Daily Flow Fluctuation of Medium Truck on Jamuna Bridge (West to East)



In Figure 4.7a and Figure 4.7b, daily flow variation of medium trucks are shown for outbound and inbound traffic respectively. It is observed from figure 4.7b that, the daily flow percentage for inbound medium trucks are relatively equal on all weekdays than those for outbound medium trucks. Apart from a distinct drop of outbound medium trucks on Saturday, the percentage of flow remains around 14% on all weekdays for both directions.

Figure 4.8a: Daily Flow Fluctuation of Large Bus on Jamuna Bridge (East to West)

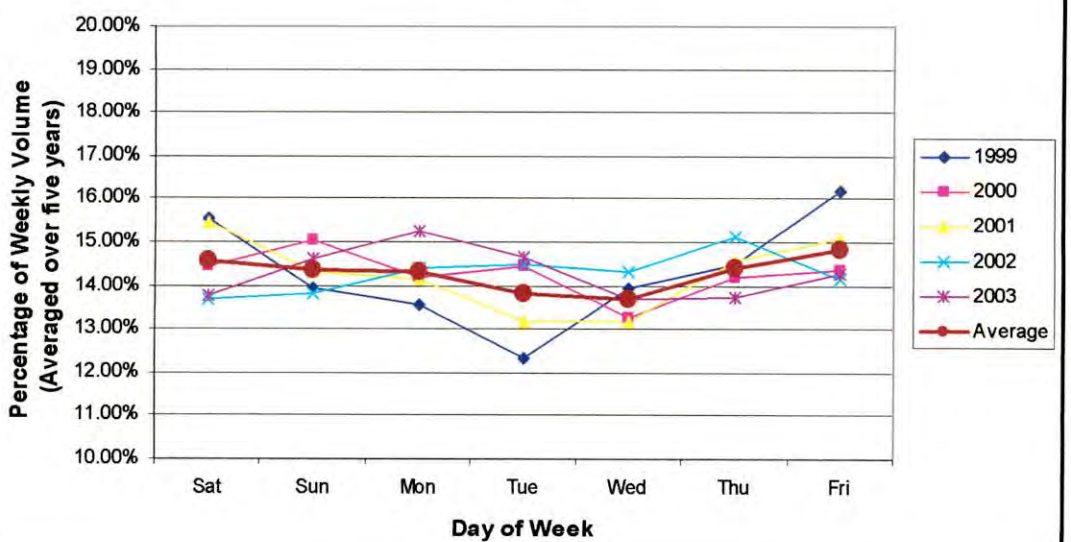
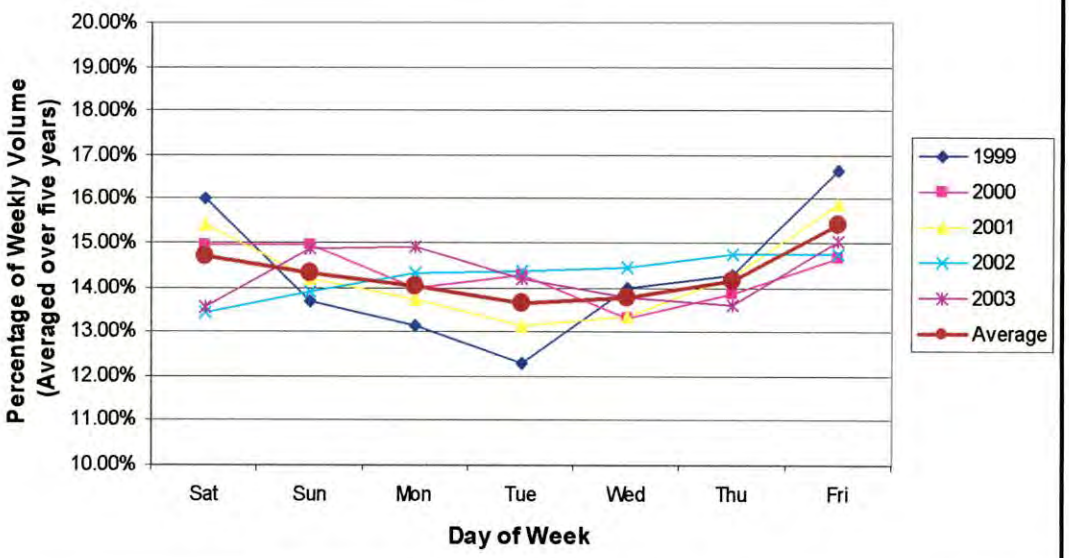


Figure 4.8b: Daily Flow Fluctuation of Large Bus on Jamuna Bridge (West to East)



In the case of Large Bus, as shown in Figures 4.8a and 4.8b, the daily flow variation is similar to that for total traffic, where daily percentage of flow rise on weekend with a moderate sag on midweek. For both direction of flow, the highest flow occurs on Friday, which is justified by the weekend factor.

But, from the patterns of daily flow fluctuation of Light Vehicles, as shown in Figures 4.9a and 4.9b, distinct rise of flow on weekend are observed. For outbound traffic, the maximum flow occurs on Friday, carrying 17.45% of total weekly volume, which is quite high in comparison to the other major vehicle classes. For inbound traffic pattern, prominent sag on midweek is observed with most traffic traveling on Friday (17.11%) and Saturday (15.52%).

Figure 4.9a: Daily Flow Fluctuation of Light Vehicle on Jamuna Bridge (East to West)

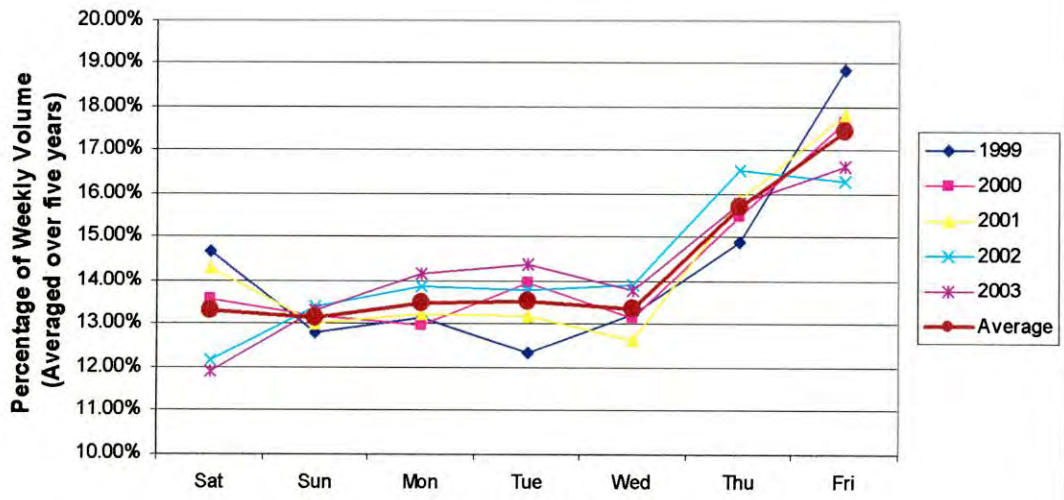
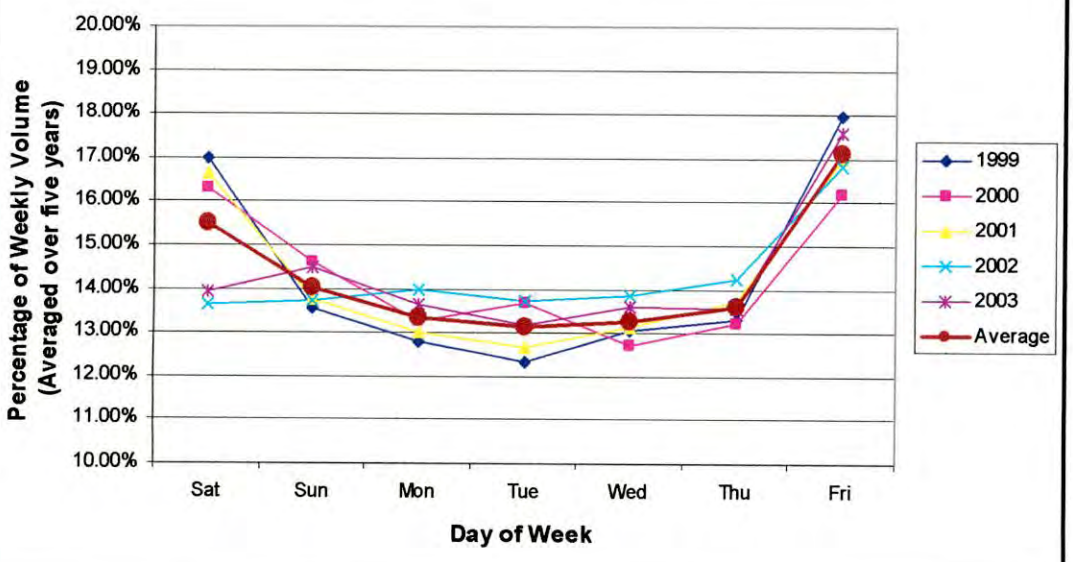
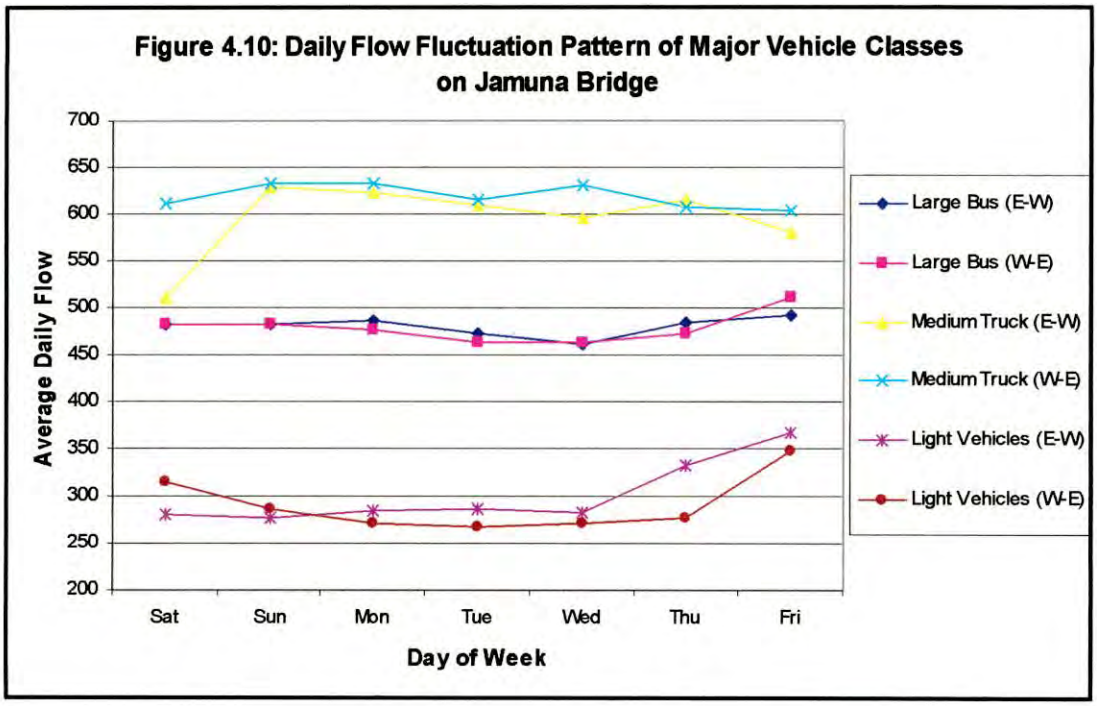


Figure 4.9b: Daily Flow Fluctuation of Light Vehicle on Jamuna Bridge (West to East)



The following Figure summarizes the pattern of these three major vehicles classes.



Now, it is a matter of interest to see, how each month of year affect this daily flow fluctuation. To make this observation, curves have been plotted showing daily flow variation for all months of a year during this study. Two of such charts are given in Figure 4.11 and Figure 4.12, where the average daily flow variation pattern are found to conform to those obtained from the previous analyses, but no definite relation can be established in terms of influence of individual month on these daily variations. This implies that, individual month has no significant effect on daily variation of traffic flow on the selected corridor.

Figure 4.11: Month-wise Daily Flow Variation on Jamuna Bridge, 1999 (Both Directional Traffic)

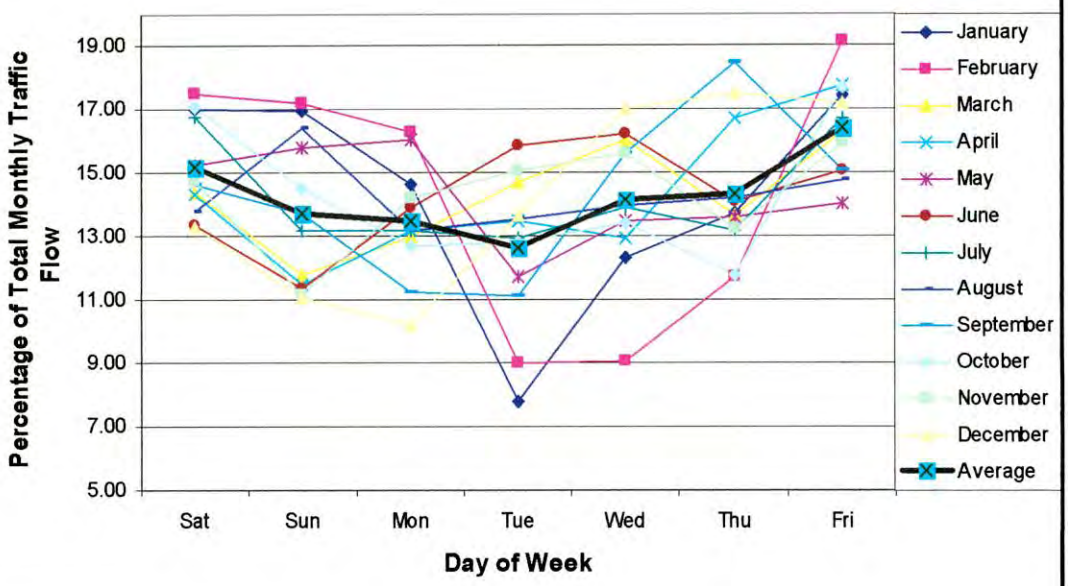
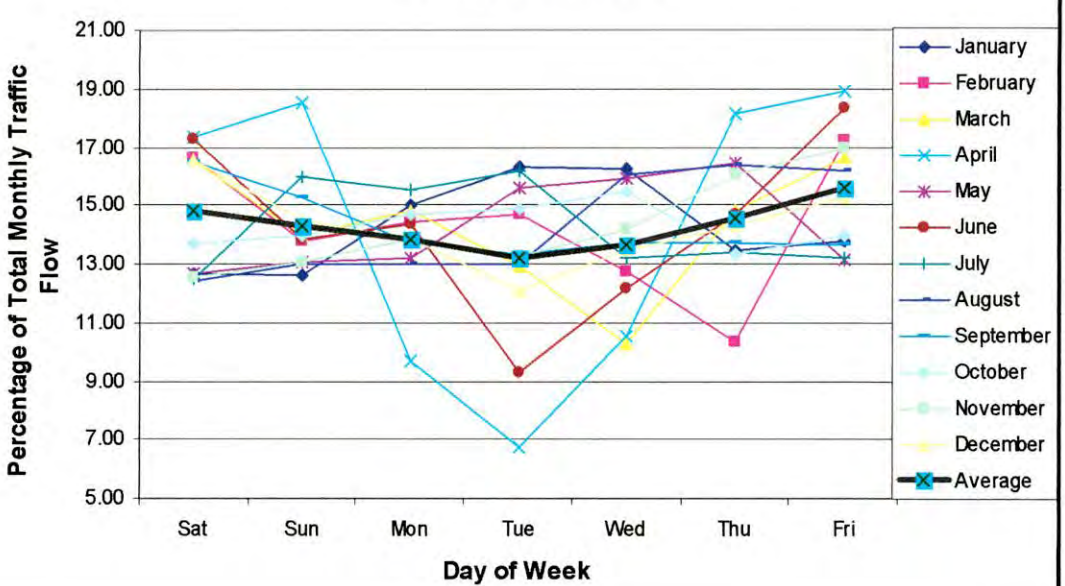


Figure 4.12: Month-wise Daily Flow Variation on Jamuna Bridge, 2001 (Both Direction)



It is to be noted here that, only two years (1999, 2001) of month-wise daily flow variation pattern have been shown above. Similar analysis curves for 2000, 2002 & 2003 are given in the Appendix B (Figure B7 to B9).

Summary of Findings:

From the above analyses, the following important flow characteristics parameters have been obtained.

Table 4.3: Summary Table - Daily Flow Variation

Vehicle Class	Flow Direction	Maximum Flow		Minimum Flow	
		Day of Week	Percentage of Weekly Volume	Day of Week	Percentage of Weekly Volume
Total Traffic	East to West	Friday	15.16%	Saturday	13.53%
	West to East	Friday	15.25%	Tuesday	13.69%
Medium Truck	East to West	Sunday	15.12%	Saturday	12.36%
	West to East	Monday	14.58%	Friday	13.99%
Large Bus	East to West	Friday	14.82%	Wednesday	13.68%
	West to East	Friday	15.41%	Tuesday	13.64%
Light Vehicles	East to West	Friday	17.45%	Sunday	13.15%
	West to East	Friday	17.11%	Tuesday	13.12%

4.2.4 Weekly Flow Variation

Depending on the economic activities of highway corridors, traffic flow may exhibit weekly flow variation, i.e. considering four weeks in a month; the flow may vary from week to week. To find out these characteristics on the selected corridor, weekly flow analysis has been done in this study.

Each month has been divided into four weeks. The first three weeks have seven days each and the fourth week, except February, has 9 to 10 days depending on the month. So, it is anticipated that the fourth week will naturally contain more traffic. To compensate

this possible error, the model uses weekly ADT instead of weekly volume and then compares between the four weekly ADTs of each month from January 1999 to December 2003. A typical table of weekly flow variation analysis is shown in Table 4.4.

Curves have been plotted in Figure 4.13a and 4.13b showing variation in weekly flow on Jamuna bridge in the year 2001. From the chart, it is seen that, the weekly flow percentages do not maintain any significant pattern in a month.

Figure 4.13a: Weekly Flow Variation on Jamuna Bridge, 2001 (East to West)

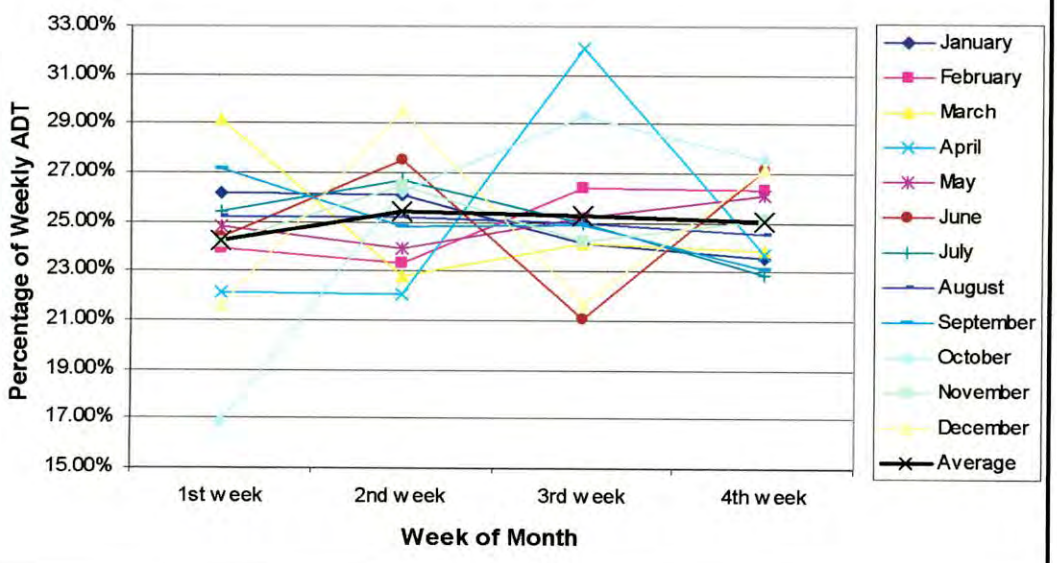
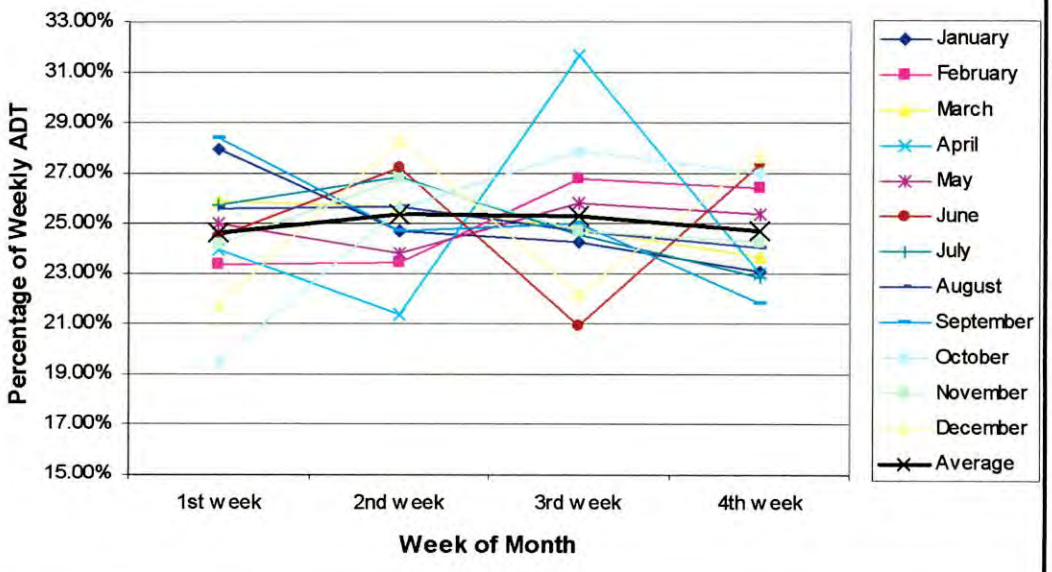


Figure 4.13b: Weekly Flow Variation on Jamuna Bridge, 2001 (West to East)

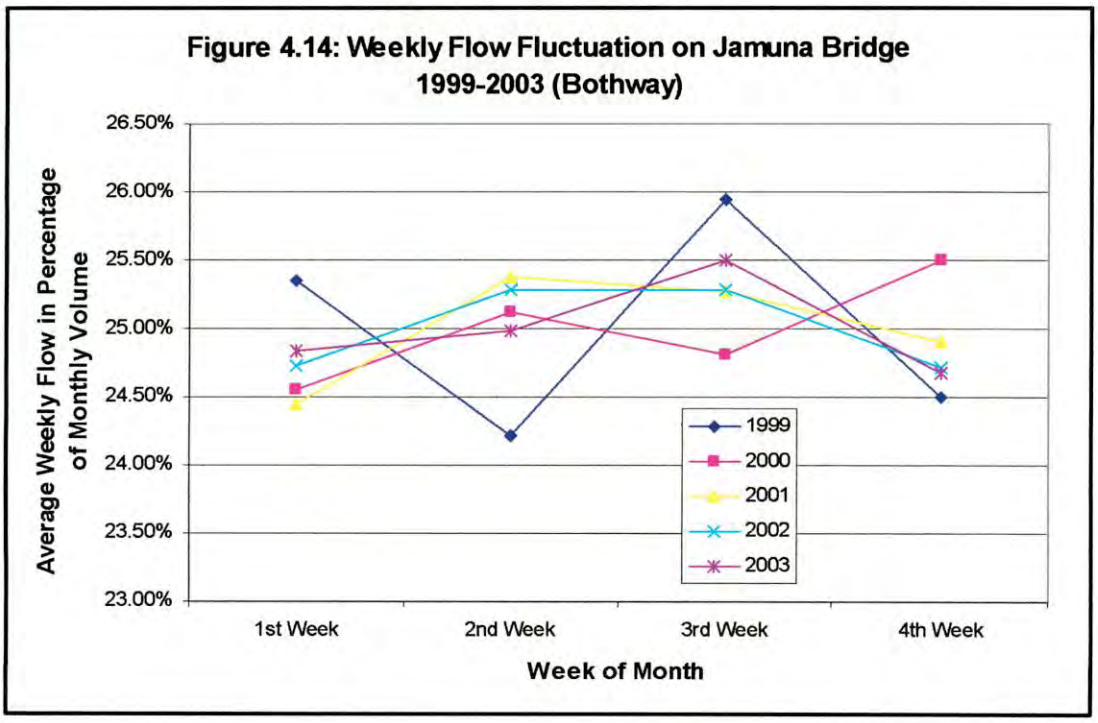


This implies that, in the North Bengal corridor, there are no such activities which affect the weekly flow variation.

However, Table 4.4 summarizes the weekly flow variation on Jamuna bridge for five years. The graphical representation is shown in Figure 4.14. Year wise weekly flow fluctuation charts for the other four years are given in Appendix B (Figure B10 to B13).

Table 4.4: Summary of Weekly Flow Variation

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
1999	25.35%	24.21%	25.94%	24.50%
2000	24.56%	25.12%	24.81%	25.51%
2001	24.45%	25.37%	25.27%	24.90%
2002	24.72%	25.28%	25.29%	24.71%
2003	24.83%	24.99%	25.50%	24.68%

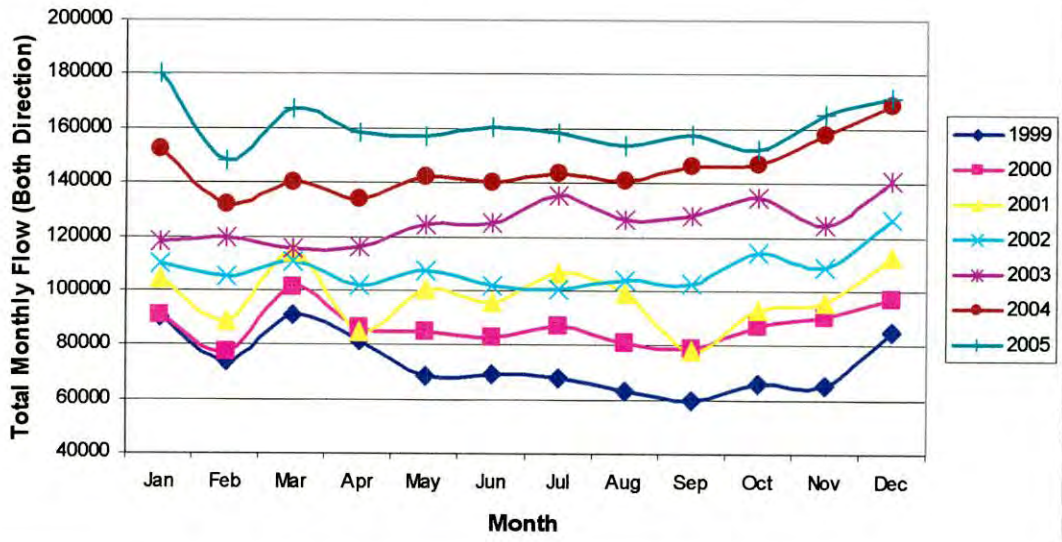


4.2.5 Monthly Flow Variation

Monthly flow variation is an important parameter in traffic flow characteristics. It is also named as Seasonal variation of flow. In this study, seven years of traffic flow data on Jamuna bridge collected from JOMAC and MargaNet has been used for monthly flow variation analysis, which has given a thorough understanding of nature of traffic flow variation in different months of a year.

Characteristics curves showing monthly flow variation is shown in Figure 4.15. It can be seen that, monthly flow variation in every year shows very similar repetitive nature of flow fluctuation. The magnitude of flow has risen every year but the flow pattern remains same, which implies that month has influences over traffic flow along this corridor.

Figure 4.15: Monthly Flow Variation on Jamuna Bridge Bothway, 1999-2005



The following table (Table 4.5) shows the monthly flow variation on Jamuna bridge, in percentage of total yearly volume, for the years 1999 to 2005. The graphical representation is shown on Figure 4.16.

Table 4.6 shows the maximum and minimum monthly flow percentage, by sorting the above table. Maximum and minimum flow is marked in red and blue respectively.

Table 4.5: Monthly Bi-directional Flow Variation on Jamuna Bridge, in percentage of total yearly volume, 1999 to 2005

Month\Year	1999	2000	2001	2002	2003	2004	2005	Average
Jan	10.25%	8.73%	8.89%	8.53%	7.86%	8.73%	9.35%	**8.90%**
Feb	8.41%	7.42%	7.47%	8.15%	7.92%	7.57%	7.67%	**7.80%**
Mar	10.36%	9.71%	9.72%	8.56%	7.68%	8.04%	8.67%	**8.96%**
Apr	9.25%	8.23%	7.25%	7.86%	7.69%	7.68%	8.20%	**8.02%**
May	7.75%	8.12%	8.58%	8.28%	8.23%	8.15%	8.15%	**8.18%**
Jun	7.83%	7.92%	8.19%	7.89%	8.30%	8.04%	8.33%	**8.07%**
Jul	7.73%	8.32%	9.09%	7.77%	8.95%	8.21%	8.22%	**8.33%**
Aug	7.14%	7.74%	8.44%	8.03%	8.37%	8.07%	7.96%	**7.96%**
Sep	6.81%	7.52%	6.68%	7.93%	8.50%	8.39%	8.16%	**7.71%**
Oct	7.48%	8.35%	7.92%	8.84%	8.94%	8.43%	7.88%	**8.26%**
Nov	7.39%	8.63%	8.15%	8.39%	8.24%	9.02%	8.56%	**8.34%**
Dec	9.60%	9.33%	9.61%	9.77%	9.31%	9.68%	8.87%	**9.45%**
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

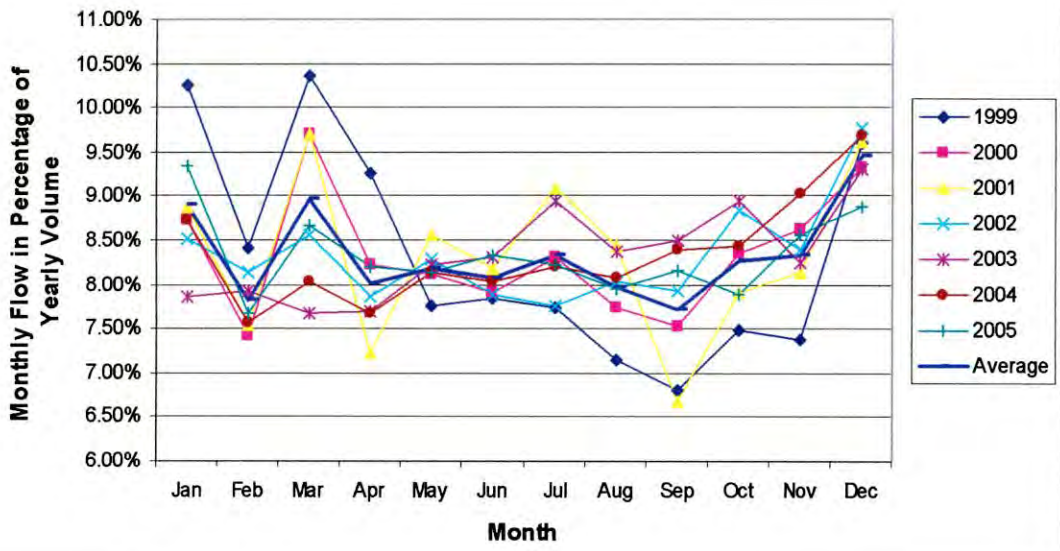
Source Data: JOMAC, MargaNet

Table 4.6: Maximum & Minimum Monthly Flow Table

Month\Year	1999	2000	2001	2002	2003	2004	2005	Average
Dec	9.60%	9.33%	9.61%	9.77%	9.31%	9.68%	8.87%	**9.45%**
Mar	10.36%	9.71%	9.72%	8.56%	7.68%	8.04%	8.67%	**8.96%**
Jan	10.25%	8.73%	8.89%	8.53%	7.86%	8.73%	9.35%	**8.90%**
Nov	7.39%	8.63%	8.15%	8.39%	8.24%	9.02%	8.56%	**8.34%**
Jul	7.73%	8.32%	9.09%	7.77%	8.95%	8.21%	8.22%	**8.33%**
Oct	7.48%	8.35%	7.92%	8.84%	8.94%	8.43%	7.88%	**8.26%**
May	7.75%	8.12%	8.58%	8.28%	8.23%	8.15%	8.15%	**8.18%**
Jun	7.83%	7.92%	8.19%	7.89%	8.30%	8.04%	8.33%	**8.07%**
Apr	9.25%	8.23%	7.25%	7.86%	7.69%	7.68%	8.20%	**8.02%**
Aug	7.14%	7.74%	8.44%	8.03%	8.37%	8.07%	7.96%	**7.96%**
Feb	8.41%	7.42%	7.47%	8.15%	7.92%	7.57%	7.67%	**7.80%**
Sep	6.81%	7.52%	6.68%	7.93%	8.50%	8.39%	8.16%	**7.71%**
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Max.	10.36%	9.71%	9.72%	9.77%	9.31%	9.68%	9.35%	9.45%
Min.	6.81%	7.42%	6.68%	7.77%	7.68%	7.57%	7.67%	7.71%

Source Data: JOMAC, MargaNet

Figure 4.16: Monthly Flow Variation (In percentage of Yearly Volume for Bi-Directional Traffic)



It is found from above tables that, the maximum monthly flow percentage occurs more frequently on March, January and December while the average maximum flow occurs on December. On the other hand, February carries minimum flow more frequently but the average minimum flow occurs on September. Broadly, it is observed, as shown in Table 4.7, (graphically represented in Figure 4.18) that more flow occurs on dry season (51.48%) than on the rainy season (48.52%). Following are the possible reasons behind such distribution of monthly flow.

- In Bangladesh dry season is considered from November to April, and rainy season stays from May to October. Because of more freight movement on waterways during the rainy season, the traffic flow percentage on roadway is less. The seasonal distribution chart is as follows:

Figure 4.17: Seasonal Flow Variation on Jamuna Bridge 1999-2005 (Bothway)

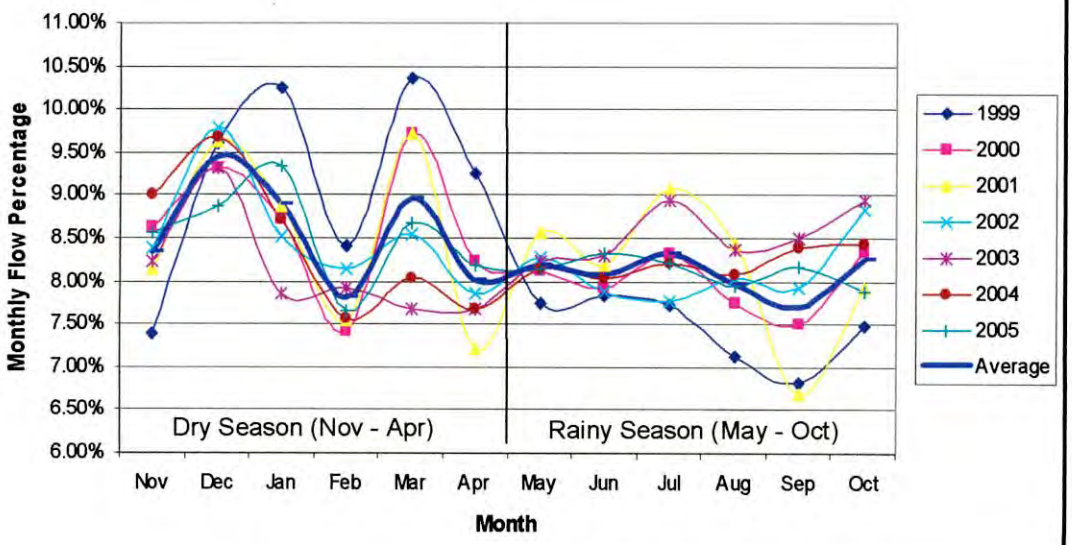


Table 4.7: Summarized Seasonal Flow Variation Table

Dry Season		Rainy Season	
Month	Flow % in Season	Month	Flow % in Season
Nov	8.34%	May	8.18%
Dec	9.46%	Jun	8.07%
Jan	8.90%	Jul	8.33%
Feb	7.81%	Aug	7.96%
Mar	8.96%	Sep	7.71%
Apr	8.02%	Oct	8.26%
Total	51.49%	Total	48.51%

Data Source: JOMAC

Figure 4.18: Seasonal Distribution of Traffic on Jamuna Bridge (Bothway), 1999-2005

- Recreational trips are more pronounced during the winter, which is a part of dry season.
- Presence of Eid festivals in Dry season during the years under consideration in this study has its significant effect on increased traffic flow, which is evident from the vehicle classwise seasonal flow variations on Figures 4.19, 4.20 and 4.21. The effect of Eid festivals is more pronounced on flow of light vehicles, which might be a contributing factor for higher traffic flow during the Eid seasons.

It is to be noted here that, although dry season carries higher percentage of yearly traffic, among the months in dry season, February carries significantly lower volume of traffic. This may be because of lesser number of days in the month. Besides, in some years February has fallen between two Eids and thus carrying lower volume of traffic in comparison to adjacent months.

Table 4.8, 4.9 and 4.10 show the monthly flow variation in years from 1999 to 2003 for Large Bus, Medium Truck and Light Vehicles at a glance, with maximum and minimum monthly flow marked as red and blue respectively. Year-wise separate tables showing seasonal flow variation are given in the Appendix B (Table B10 to B14).

Table 4.8: Monthly Flow Variation of Large Bus on Jamuna Bridge

Year / Month	Total Monthly Flow of Large Bus (Both Direction)					Monthly Flow Percentage					
	1999	2000	2001	2002	2003	1999	2000	2001	2002	2003	Average
Jan	20,313	23,587	28,128	29,447	38,434	9.36%	8.55%	9.31%	6.62%	7.51%	**8.27%**
Feb	15,359	18,308	20,373	35,746	45,483	7.08%	6.64%	6.74%	8.03%	8.88%	**7.47%**
Mar	18,037	24,615	30,053	39,320	40,536	8.32%	8.92%	9.94%	8.84%	7.92%	**8.79%**
Apr	20,558	20,180	19,235	34,033	38,732	9.48%	7.32%	6.36%	7.65%	7.57%	**7.67%**
May	18,151	19,577	24,989	36,496	40,882	8.37%	7.10%	8.27%	8.20%	7.99%	**7.98%**
Jun	16,891	22,767	24,763	35,909	41,107	7.79%	8.25%	8.19%	8.07%	8.03%	**8.07%**
Jul	16,855	24,485	27,392	35,893	44,247	7.77%	8.88%	9.06%	8.07%	8.64%	**8.48%**
Aug	16,850	23,213	26,792	37,789	42,567	7.77%	8.41%	8.87%	8.49%	8.31%	**8.37%**
Sep	17,617	24,172	21,841	36,763	41,836	8.12%	8.76%	7.23%	8.26%	8.17%	**8.11%**
Oct	19,908	25,192	24,407	38,682	43,862	9.18%	9.13%	8.08%	8.69%	8.57%	**8.73%**
Nov	17,370	24,304	23,781	34,800	44,548	8.01%	8.81%	7.87%	7.82%	8.70%	**8.24%**
Dec	19,004	25,465	30,466	50,132	49,738	8.76%	9.23%	10.08%	11.27%	9.71%	**9.81%**
Total	**216,913**	**275,865**	**302,220**	**445,010**	**511,972**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	20,558	25,465	30,466	50,132	49,738	9.48%	9.23%	10.08%	11.27%	9.71%	9.81%
Min. Flow	15,359	18,308	19,235	29,447	38,434	7.08%	6.64%	6.36%	6.62%	7.51%	7.47%

Source Data: JOMAC

Table 4.9: Monthly Flow Variation of Medium Truck on Jamuna Bridge

Year / Month	Total Monthly Flow of Medium Truck (Both Direction)					Monthly Flow Percentage					
	1999	2000	2001	2002	2003	1999	2000	2001	2002	2003	Average
Jan	31,636	28,940	38,855	42,317	49,338	10.42%	7.82%	8.61%	8.65%	8.20%	**8.74%**
Feb	28,903	30,056	39,029	38,017	40,053	9.52%	8.12%	8.64%	7.77%	6.66%	**8.14%**
Mar	36,943	36,439	42,211	41,384	45,629	12.17%	9.84%	9.35%	8.46%	7.59%	**9.48%**
Apr	28,985	35,188	37,116	40,319	47,645	9.55%	9.50%	8.22%	8.24%	7.92%	**8.69%**
May	22,032	34,080	40,475	40,248	49,948	7.26%	9.21%	8.96%	8.23%	8.31%	**8.39%**
Jun	23,238	27,410	35,429	37,508	50,887	7.66%	7.40%	7.85%	7.67%	8.46%	**7.81%**
Jul	21,516	28,402	41,890	36,258	56,947	7.09%	7.67%	9.28%	7.41%	9.47%	**8.18%**
Aug	17,772	26,246	37,282	37,067	51,375	5.86%	7.09%	8.26%	7.58%	8.54%	**7.46%**
Sep	16,788	24,476	27,275	39,153	53,579	5.53%	6.61%	6.04%	8.00%	8.91%	**7.02%**
Oct	18,276	29,909	35,958	45,968	55,310	6.02%	8.08%	7.96%	9.40%	9.20%	**8.13%**
Nov	21,869	33,390	37,516	48,646	45,260	7.21%	9.02%	8.31%	9.94%	7.53%	**8.40%**
Dec	35,530	35,697	38,497	42,389	55,396	11.71%	9.64%	8.53%	8.66%	9.21%	**9.55%**
Total	**303,488**	**370,233**	**451,533**	**489,274**	**601,367**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	36,943	36,439	42,211	48,646	56,947	12.17%	9.84%	9.35%	9.94%	9.47%	9.55%
Min. Flow	16,788	24,476	27,275	36,258	40,053	5.53%	6.61%	6.04%	7.41%	6.66%	7.02%

Source Data: JOMAC

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Table 4.10: Monthly Flow Variation of Light Vehicles on Jamuna Bridge

Year / Month	Total Monthly Flow of Light Vehicles (Both Direction)					Monthly Flow Percentage					
	1999	2000	2001	2002	2003	1999	2000	2001	2002	2003	Average
Jan	22,529	22,276	20,344	18,574	19,688	10.79%	10.27%	10.03%	8.67%	8.26%	**9.60%**
Feb	17,415	17,318	15,696	20,721	23,025	8.34%	7.99%	7.74%	9.67%	9.66%	**8.68%**
Mar	21,657	23,154	21,929	18,901	18,936	10.37%	10.68%	10.81%	8.82%	7.94%	**9.73%**
Apr	18,093	17,381	13,906	16,555	17,388	8.66%	8.02%	6.86%	7.72%	7.29%	**7.71%**
May	16,707	17,201	16,485	18,527	19,883	8.00%	7.93%	8.13%	8.64%	8.34%	**8.21%**
Jun	17,014	17,549	17,224	17,323	19,946	8.15%	8.09%	8.49%	8.08%	8.37%	**8.24%**
Jul	16,924	17,909	16,879	16,908	19,857	8.10%	8.26%	8.32%	7.89%	8.33%	**8.18%**
Aug	15,881	15,960	16,028	16,996	18,810	7.61%	7.36%	7.90%	7.93%	7.89%	**7.74%**
Sep	14,131	15,358	13,537	15,521	18,067	6.77%	7.08%	6.68%	7.24%	7.58%	**7.07%**
Oct	15,537	16,591	14,224	17,278	20,305	7.44%	7.65%	7.02%	8.06%	8.52%	**7.74%**
Nov	14,924	16,514	15,115	14,621	20,573	7.15%	7.62%	7.45%	6.82%	8.63%	**7.53%**
Dec	17,999	19,640	21,398	22,402	21,891	8.62%	9.06%	10.55%	10.45%	9.18%	**9.57%**
Total	**208,811**	**216,851**	**202,765**	**214,327**	**238,369**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	22,529	23,154	21,929	22,402	23,025	10.79%	10.68%	10.81%	10.45%	9.66%	9.73%
Min. Flow	14,131	15,358	13,537	14,621	17,388	6.77%	7.08%	6.68%	6.82%	7.29%	7.07%

Source Data: JOMAC

Figure 4.19: Seasonal Flow Variation of Large Bus (Both Direction), 1999-2003

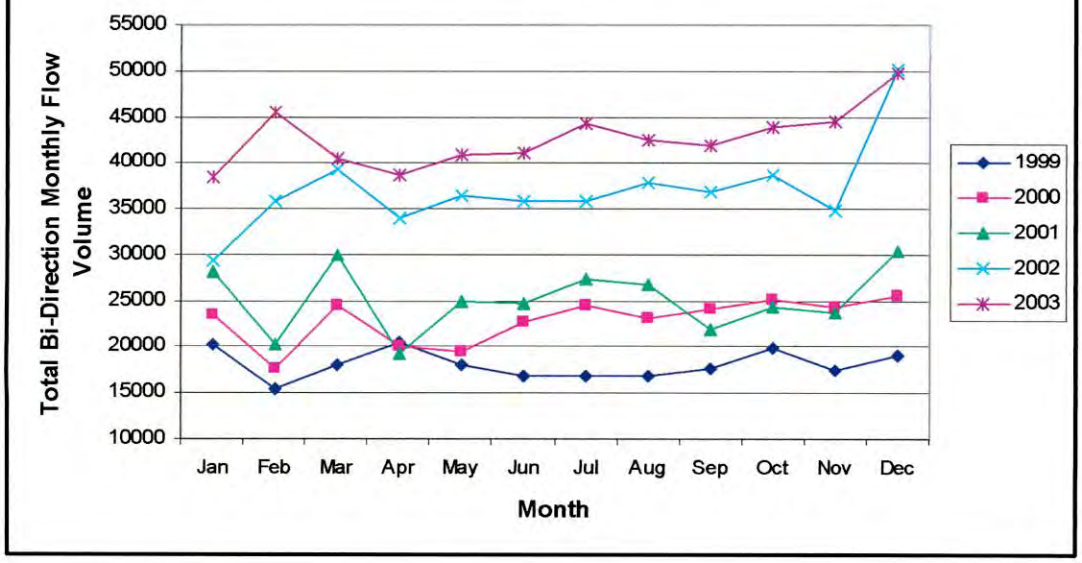
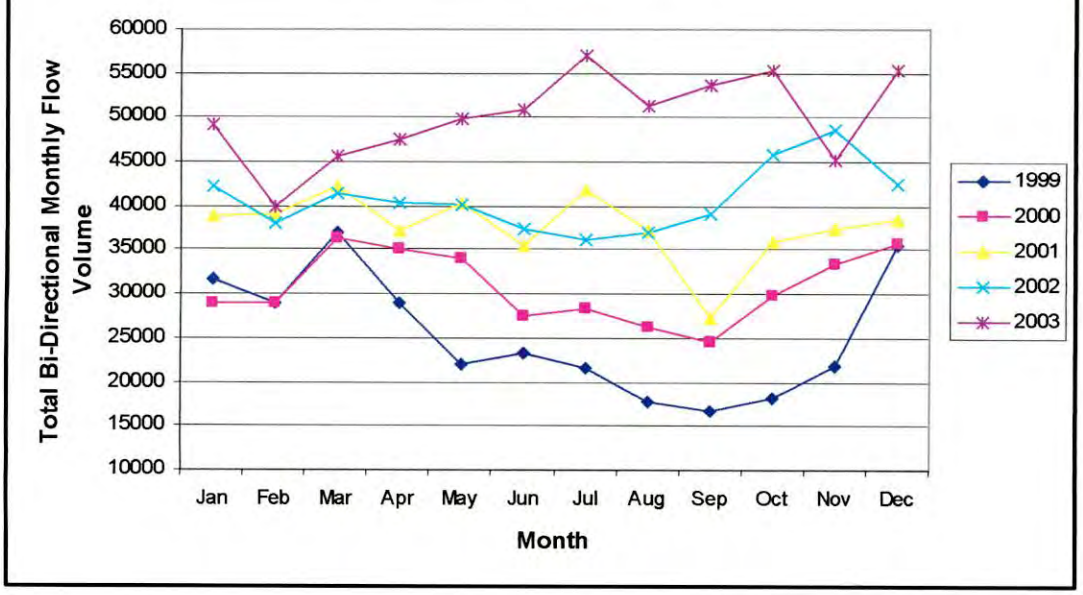
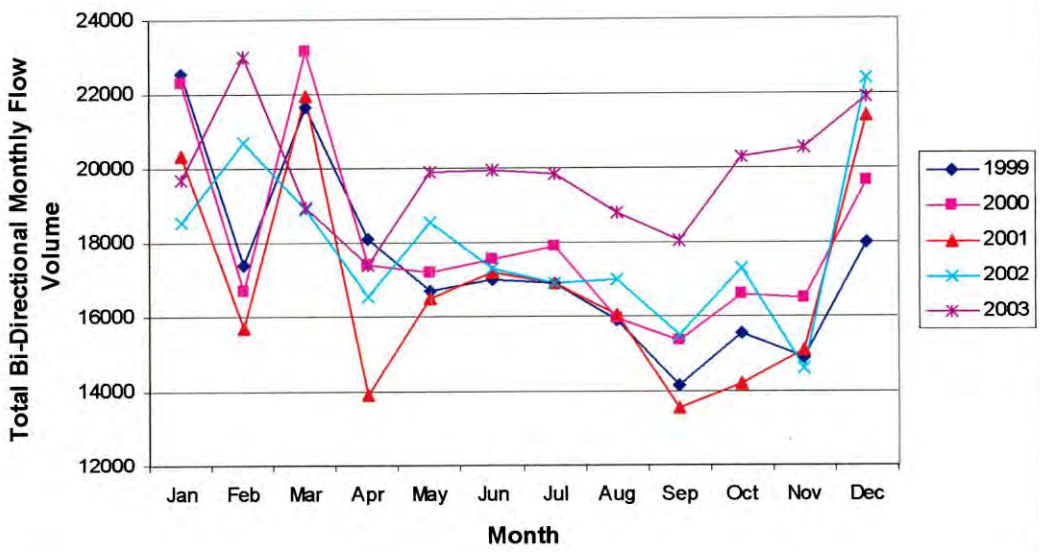


Figure 4.20: Seasonal Flow Variation of Medium Trucks (Both Direction), 1999-2003



Fugure 4.21: Seasonal Flow Variation of Light Vehicles on Jamuna Bridge (Both Direction), 1999-2003



Summary of Findings:

Following are the summarized findings from the seasonal flow analysis on Jamuna Bridge.

Table 4.11: Summary Table - Seasonal Flow Variation (average of five years)

Vehicle Class	Maximum Flow		Minimum Flow	
	Month	Percentage of Yearly Volume	Month	Percentage of Yearly Volume
Total Traffic	December	9.45%	September	7.71%
Medium Truck	December	9.55%	September	7.02%
Large Bus	December	9.81%	February	7.47%
Light Vehicles	March	9.73%	September	7.07%

4.2.6 Traffic Composition

Traffic composition , particularly the proportion of heavy vehicles in a traffic stream, is a very important parameter of traffic flow. Geometric and structural design of any road facility greatly depends on traffic composition. Therefore, it is essential to know about the traffic composition of a highway for comprehensive flow pattern analysis.

In Bangladesh there is no unified vehicle classification system until now. Hence, different road operators are using different vehicle classification system and thus making traffic composition analysis more complex, which has already been encountered during this study. In Jamuna bridge, since it is a tolled bridge, it was necessary to define a vehicle classification for setting toll amount for different classes of vehicles passing through the bridge. The classification system has some serious laggings which have been discussed in the latter part of this thesis. It has also been found during this study that the operator of Hatikamrul road along the same corridor uses different classification system.

In Jamuna bridge, total traffic is divided into seven classes considering vehicle size and capacity as follows.

1. Motor Cycle: Motor cycles, two wheelers
2. Light Vehicle: Car, Jeep, Pickup, Microbus
3. Small Bus: Buses containing upto 30 seats
4. Large Bus: Buses containing more than 30 seats
5. Small Truck: Truck having less than 5 ton carrying capacity
6. Medium Truck: Trucks having 5 to 8 ton carrying capacity
7. Large Truck: Multi-axle trucks, semi-trailers

On the other hand, six vehicle classes are used in the Hatikamrul road along the same corridor. They are:

1. Pickup: Pickup trucks, vans
2. Car: Passenger car, Jeep, Microbus
3. Minibus: Minibus, coaster
4. Bus/Truck: Inter-district buses, Medium trucks
5. Crane: Cranes
6. Large Bus/Truck: Luxury inter-district buses, Multi-axle Large trucks

This discrepancy has ceased the opportunity to render classification wise comparison between the two roads. However, from the analysis of traffic composition on the Jamuna bridge, some important findings have been obtained which have been discussed in this section.

Figure 4.22 shows the classification wise yearly volume of traffic on Jamuna bridge, while Figure 4.23 shows the traffic composition pattern from 1999 to 2005 on Jamuna Bridge. It can be seen from the figure that most predominant vehicle classes are medium truck, large bus and light vehicles. There plied a fair amount small buses till 2001 but in 2002 its proportion has considerably decreased. It is also found that, though the proportion of small truck is not much, it is gradually increasing. On the contrary, percentage of small bus has decreased considerably during the last seven years and presently is very low.

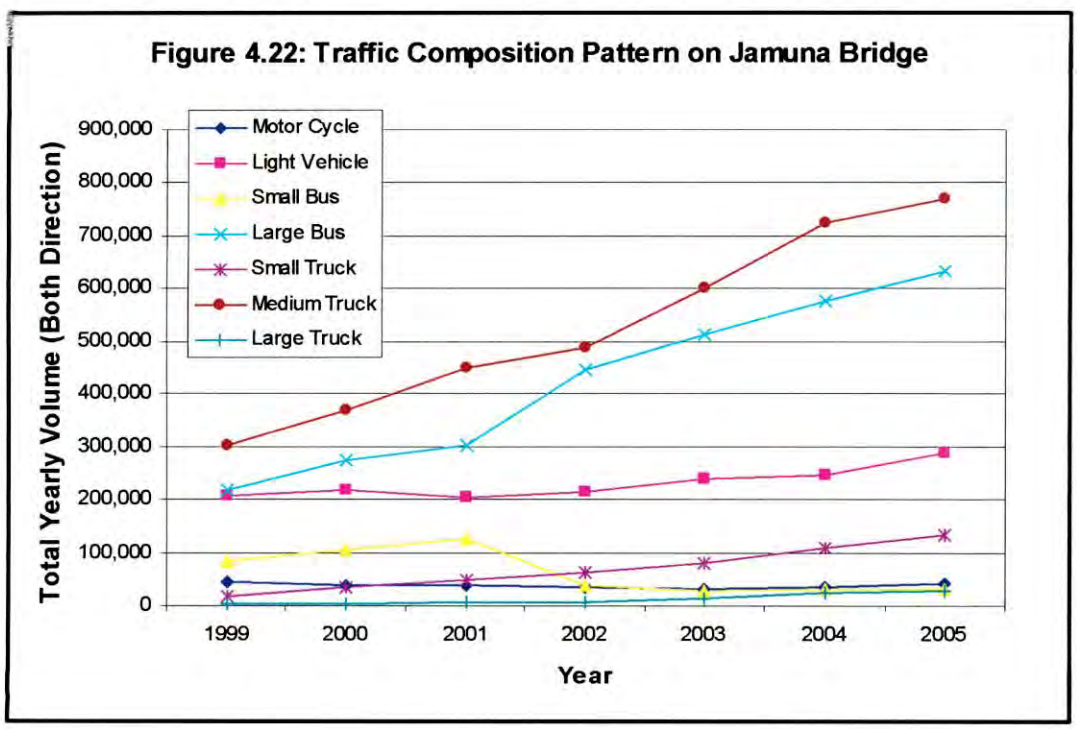
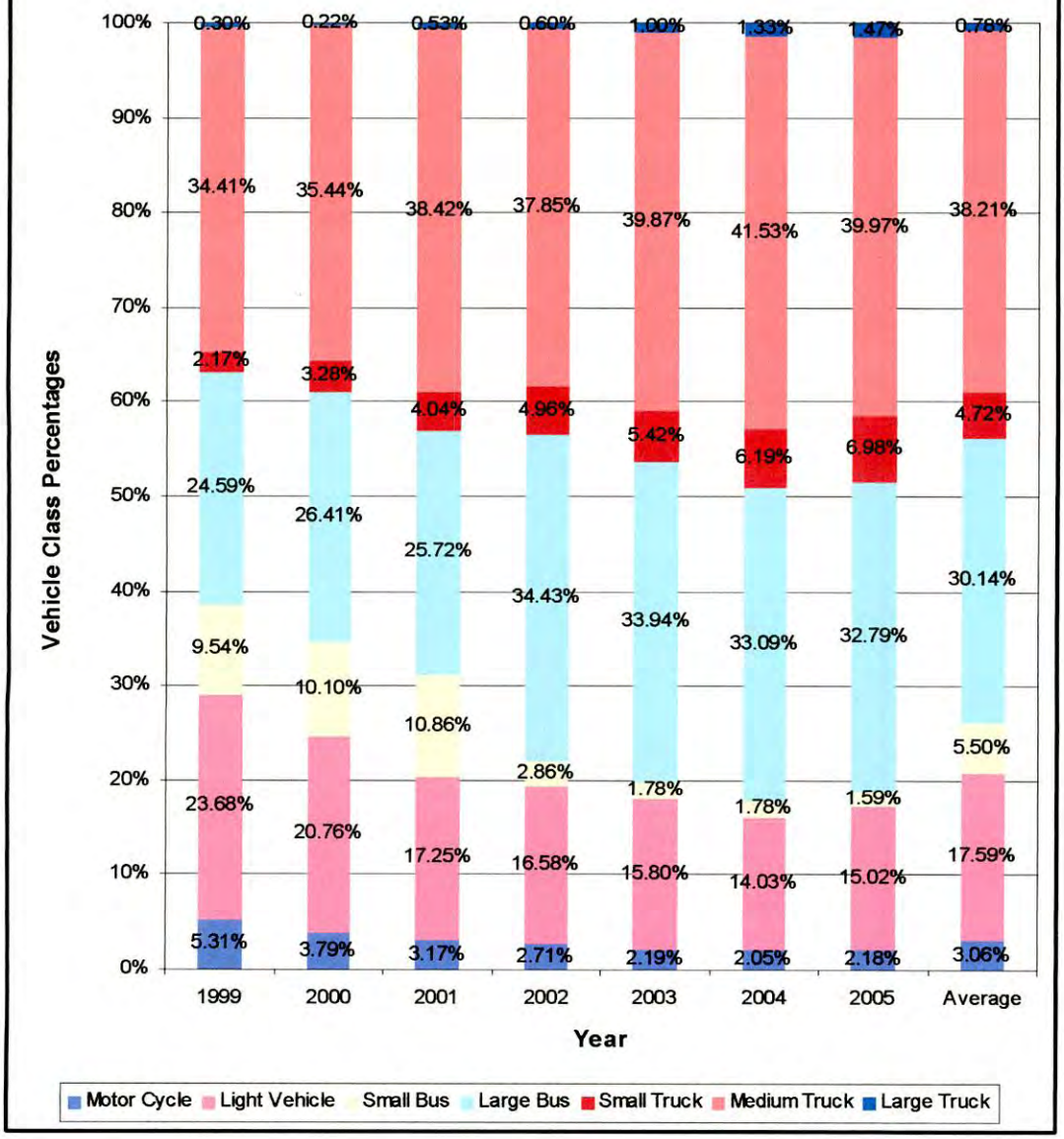


Figure 4.22: Traffic Composition Pattern on Jamuna Bridge

Figure 4.23: Traffic Composition Pattern on Jamuna Bridge (In Percentage of Total Vehicle)



In Figure 4.23, vehicle class percentages on Jamuna bridge are shown. It is found that, medium truck has the highest percentage in the traffic stream. In 1999, the percentage was 34.41% and during the next years the proportion raised higher and became almost 40% in 2005. The average percentage of medium truck from 1999 to 2005 is 38.21%. The second highest percentage of vehicle class is Large Bus, the proportion of which was

24.59% in 1999 and increased to 32.79% in 2005. Taking the average percentages of Large Bus from 1999 to 2005, the percentage of the same 30.14%. The third highest contributing class to the total traffic flow is Light Vehicles, which includes cars, pickups, Jeeps, microbuses etc. In 1999, its percentage was 23.68% and after gradual reduction in proportion, it became 15.02% in the year of 2005, the average is found to be 17.59%. Taking the traffic flow data on Jamuna Bridge from 1999 to 2005, it is found that these three pre-dominant vehicle classes comprise of total 85.94% of total traffic flow. Rest 14.06% is shared between motorcycle (3.06%), small bus (5.05%), small truck (4.72%) and large truck (0.78%). From the highway's structural and geometric point of view, it is a matter of concern that, the percentage of heavier vehicles is increasing every year and lighter vehicles are decreasing. Such as, from 1999 to 2005, the percentage of motorcycle has reduced from 5.31% to 2.18%, light vehicles from 23.68% to 15.02% but the percentage of small trucks has risen from 2.17% to 6.98%, medium trucks from 34.41% to 39.97%, large bus from 24.59% to 32.79% and Large truck from 0.30% to 1.47%. Introduction of luxury buses for passenger travels in all major routes of Bangladesh is a contributing factor behind small bus being replaced by large bus. But, the reason behind increase in percentage of small truck might be the tendency to save toll. Since the classification system used by JMBA is based on the capacity of the trucks, but toll is not collected in weight basis. Although, a weighing scale was installed at the toll plaza initially, but currently it is not under operation. So, truck owners show the carrying capacity of their vehicles much less than the actual to escape higher toll amount, although they are carrying as much as three times of their permitted capacity, as has been observed physically. This faulty classification system has been discussed more elaborately in Chapter 6.

It is also to be noted here that, only tolled vehicle have been taken into consideration in this analysis. The military vehicles, operator's vehicles and some other VVIP vehicles are not counted by the operator since they are toll exempted, although fair quantity (about 2% of tolled vehicles) of such vehicles pass the bridge every day.

4.2.7 Heavy Vehicles Percentage

Percentage of heavy vehicles refer to the percentage of truck and bus in a traffic stream. Heavier vehicles cause more damage to the roadway. For this reason, this is an important parameter for structural design of highway. Moreover, higher proportion of larger sized vehicles is important in the aspect of geometric design of highways as large vehicles are critical for the design of grade, turnings, road width, warrant for curve widening and auxiliary lane at vertical curve etc. The following section discusses the proportion of heavier vehicles on Jamuna bridge flow and their travel pattern.

4.2.7.1 Truck Percentage

In Jamuna bridge, according to the vehicle classification system used by the operators, truck as a class is sub-divided into three groups namely small trucks, medium trucks and large trucks. Small trucks are of capacity less than 5 tons. In Bangladesh commonly used 3-ton capacity trucks, mainly small utility covered trucks are contained within this class. Trucks having capacity of 5 ton to 8 ton are classed as Medium trucks. This class is most common in Bangladesh and hence contributor of the highest percentage of traffic. Large trucks' capacity is more than 8 ton and usually possesses more than two rear axles. It is observed from field survey that the toll collectors are often confused about the classification between the trucks falling near to boundary conditions.

However, from the analysis of traffic flow data from 1999 to 2005 on Jamuna bridge, taking the average of these years, it is found that the percentage of all classes of trucks 43.71% of total vehicle. Among this, the percentages of small truck, medium truck and large trucks are 4.72%, 38.21% and 0.78% respectively (Figure 4.24). Table 4.12 shows the year-wise truck percentages. It is to be noted that, the total percentage of trucks are increasing every year at a rate of 1.92%, considering linear increment. Figure 4.25 shows the growth pattern of trucks on North Bengal Corridor.

Table 4.12: Truck Percentages on Jamuna Bridge (Both Direction)

Year	Small Truck	Medium Truck	Large Truck	Total Trucks
1999	2.17%	34.41%	0.30%	**36.88%**
2000	3.28%	35.44%	0.22%	**38.95%**
2001	4.04%	38.42%	0.53%	**43.00%**
2002	4.96%	37.85%	0.60%	**43.41%**
2003	5.42%	39.87%	1.00%	**46.29%**
2004	6.19%	41.53%	1.33%	**49.05%**
2005	6.98%	39.97%	1.47%	**48.42%**
Average	**4.72%**	**38.21%**	**0.78%**	**43.71%**

Date Source: JOMAC, MargaNet

Figure 4.24: Truck Percentages on Jamuna Bridge (Average from 1999 to 2005)

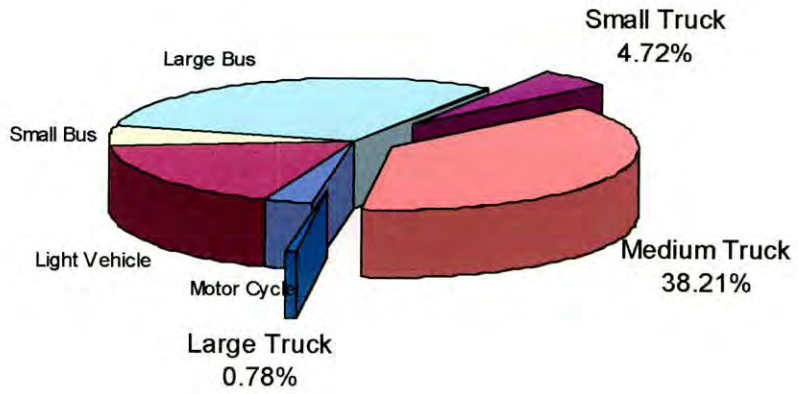
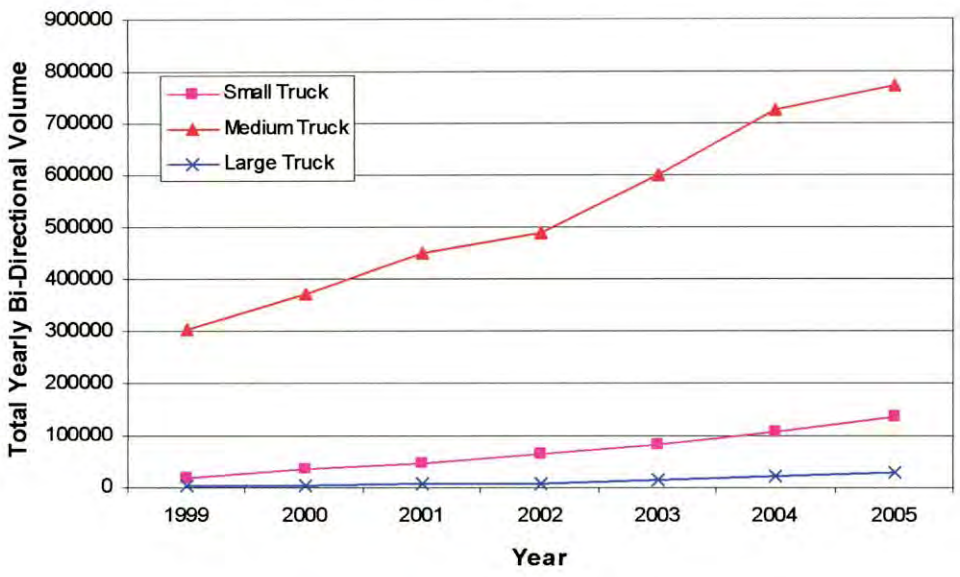


Figure 4.25: Growth Pattern of Trucks



4.2.7.2 Bus Percentage

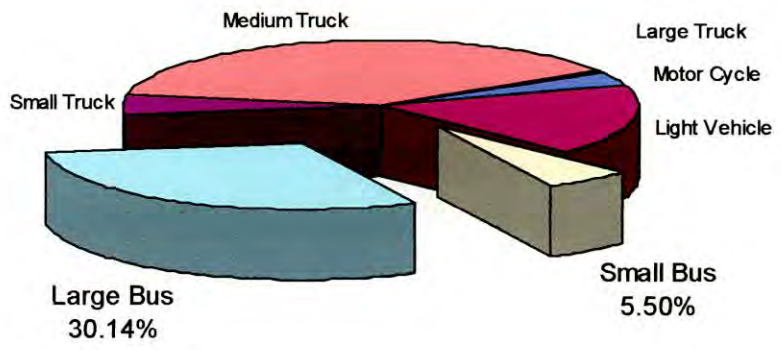
Buses passing through Jamuna bridge are classified into two groups namely Small Bus and Large Bus. Buses having capacity of 30 seats of less are classed as small bus and buses having more than 30 seats capacity are classed as Large Bus.

Table 4.13: Bus Percentages on Jamuna Bridge (Both Direction)

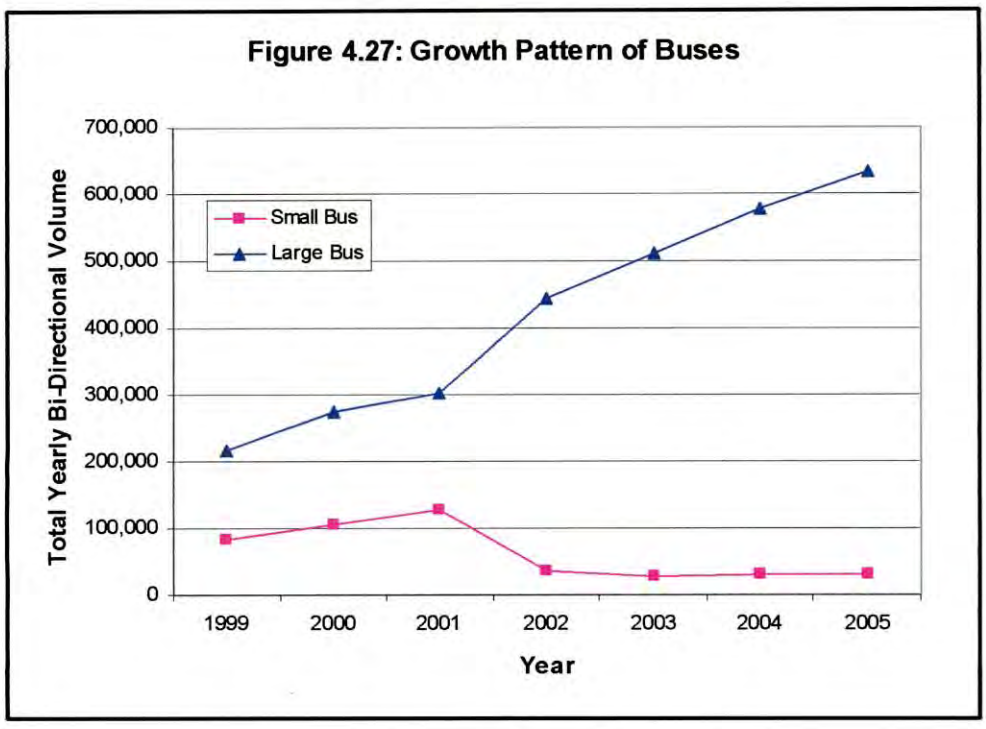
Year	Small Bus	Large Bus	Total Buses
1999	9.54%	24.59%	**34.13%**
2000	10.10%	26.41%	**36.51%**
2001	10.86%	25.72%	**36.58%**
2002	2.86%	34.43%	**37.29%**
2003	1.78%	33.94%	**35.72%**
2004	1.78%	33.09%	**34.87%**
2005	1.59%	32.79%	**34.38%**
Average	**5.50%**	**30.14%**	**35.64%**

Date Source: JOMAC, MargaNet

Figure 4.26: Bus Percentages on Jamuna Bridge (Average from 1999 to 2005)



From Figure 4.26, it is seen that total 35.64% of total annual flow (taking average from 1999 to 2005) comprises of buses. Among this, 30.41% is large bus and 5.50% is small bus. Annual increase pattern of total number buses is shown in Figure 4.27. Although the total number is increasing at a quite high rate, but from Table 4.13, it can be seen that the percentage of bus has remained almost same. (34.13% in 1999 and 34.38% in 2005). This has happened because the percentage of large bus has increased every year at an average rate of 1.37% per annum but at the same time, small bus percentage has fallen equally.



4.2.8 Directional Distribution

Directional distribution of a two-way road varies within a wide range depending on the type and utility of a road facility. In some cases, as in urban commuter road, the directional flow can reach even over 80% during the peak hours [Pignataro 1973]. Again, some rural highways may show unequal directional split of traffic based on its economic activities, availability of alternate route and many other reasons. Hence, the importance of directional distribution of a two-way road system for complete analysis of traffic flow characteristics can be understood.

In this study, 13 weeks of hourly data collected by BUET and 5 year of daily data collected by JOMAC has been used for three types of directional distribution analysis. They are as follows:

4.2.8.1 Hourly Directional Distribution

From the analysis of 13 weeks of hourly data, as shown in Figure 4.28, it can be seen that, in the direction of West to East the peak flow rises at 1:00 – 2:00, carrying 68.69% of total flow. The maximum flow in East to West direction occurs within 10:00 to 11:00 AM carrying 62.10% of total hourly flow. To find out reasons behind such distribution of flow, class-wise directional distribution analysis has been rendered.

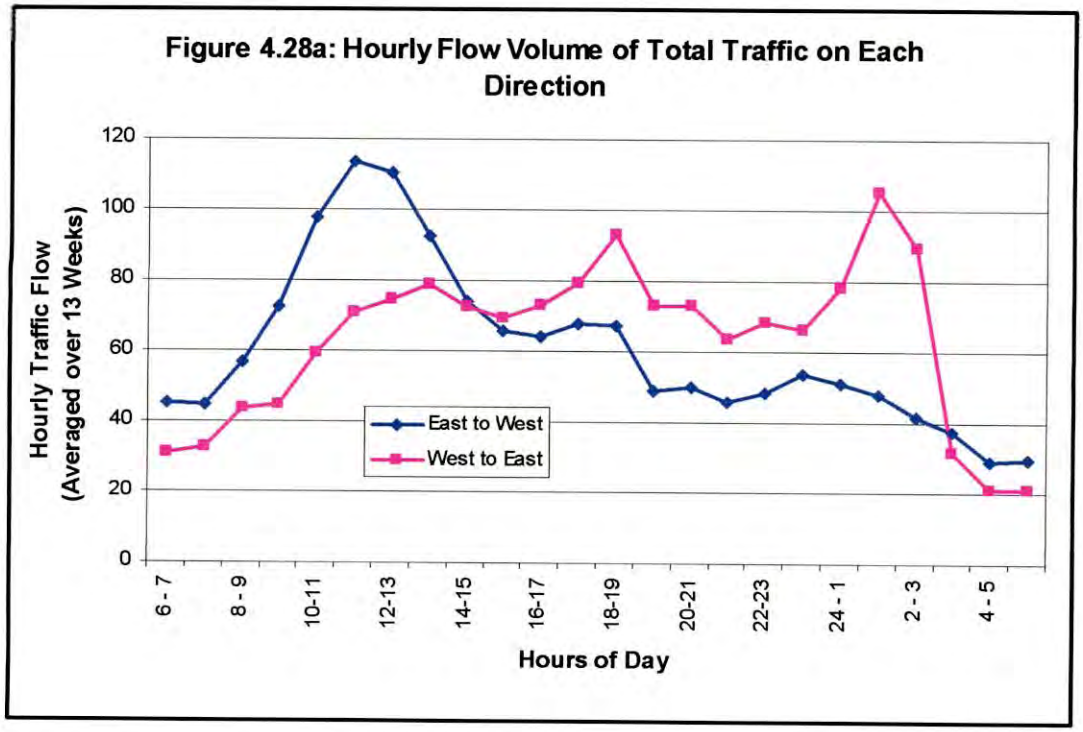


Figure 4.28b: Hourly Directional Distribution of Total Traffic

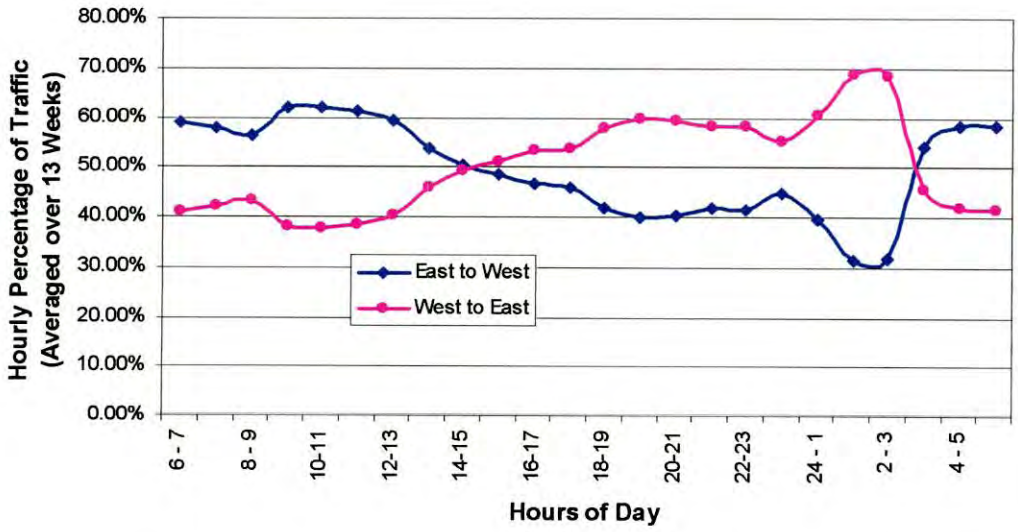


Figure 4.29a: Hourly Flow Volume of Large Bus on Each Direction

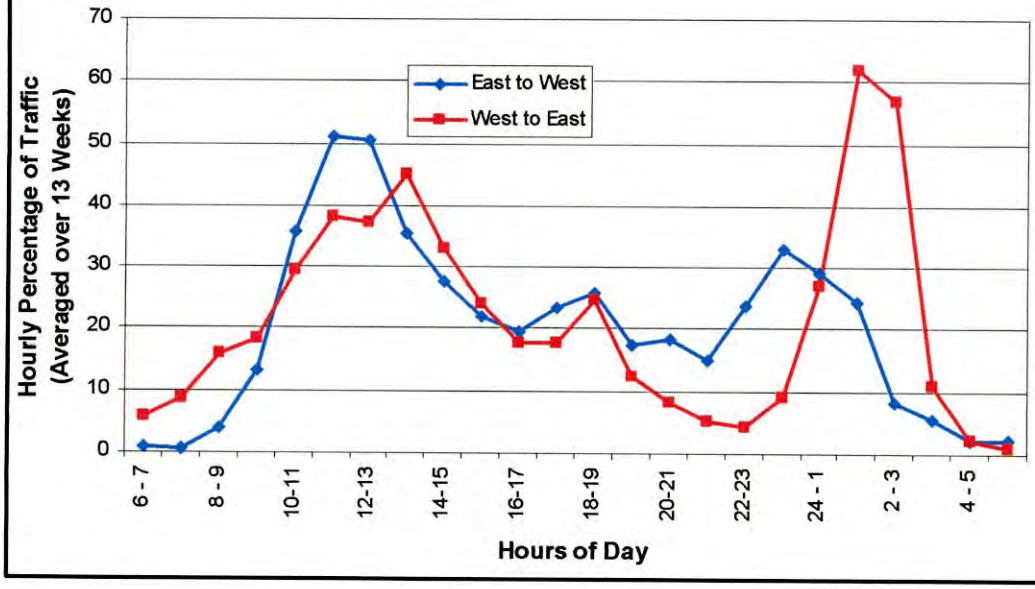
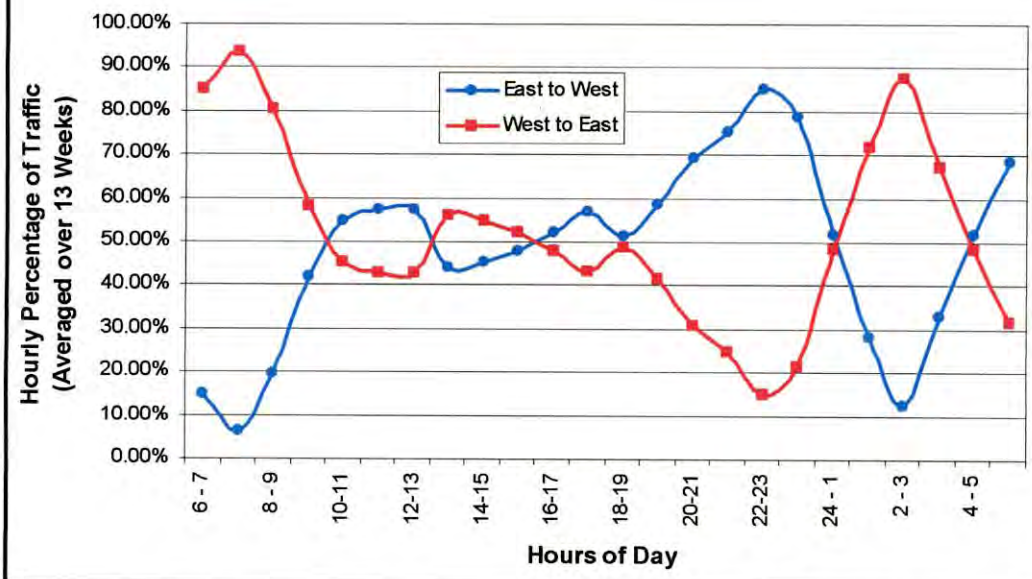


Figure 4.29b: Hourly Directional Distribution of Large Bus



In Figure 4.29, the hourly directional distribution of Large Bus on Jamuna Bridge is shown. It is observed from the chart that, maximum flow percentage in West to East direction occurs within 7:00 to 8:00 AM, carrying as many as 93.44% of total hourly volume. Another peak flow from West to East takes place within 2:00 to 3:00AM, where is the percentage in the said direction is 87.63%. This happens because the passenger buses starting from different parts of North Bengal reach their destination Dhaka in the early morning and thus cross the bridge in a group at that specific time of night. On the other hand, maximum flow in East to West direction occurs within 22:00 to 23:00 PM carrying 85.04% of traffic. In this case, passenger buses starting from Dhaka in the evening and traveling towards cities in the North Bengal are the major contributing factors.

It is to be noted here that, directional distribution graphs are not always truly representative of the actual scenario. For example, although the maximum West to East directional flow occurs within 7:00 to 8:00 AM in the morning, but from Table 4.14, it can be seen that, the volume of traffic is negligible during that hour. Therefore, it can be

understood that. higher percentage of directional flow in a particular direction may not be critical if that occurs during off-peak period.

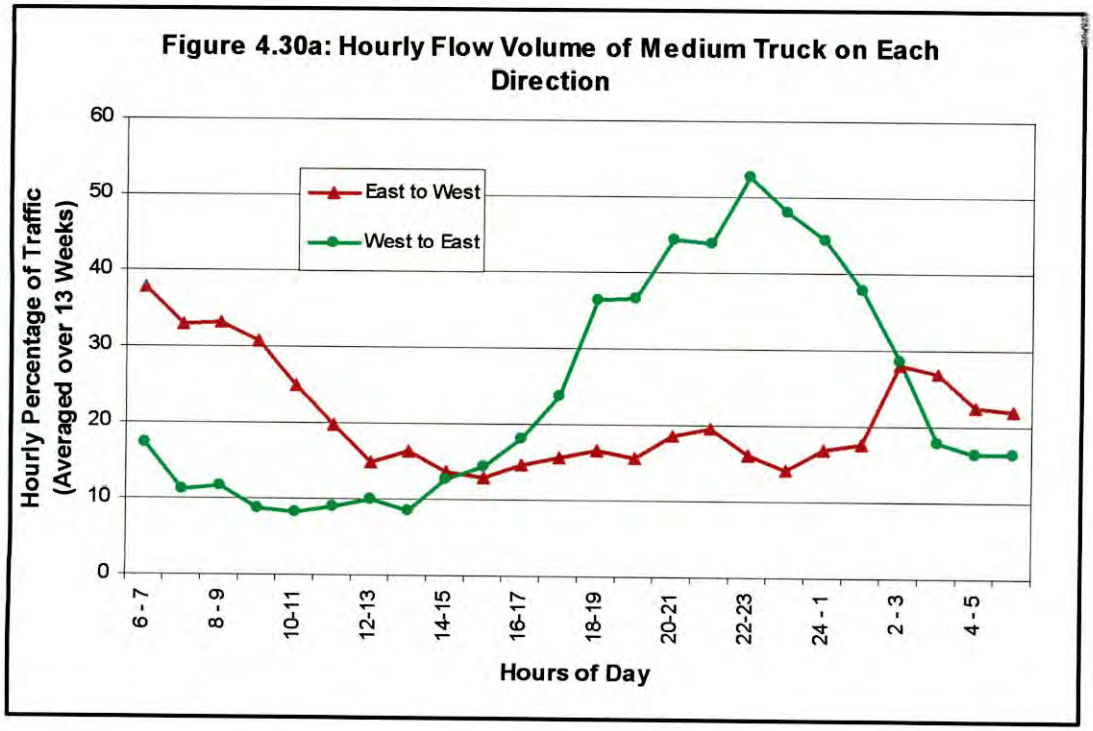
Table 4.14: Hourly Directional Distribution of Large Bus on Jamuna Bridge

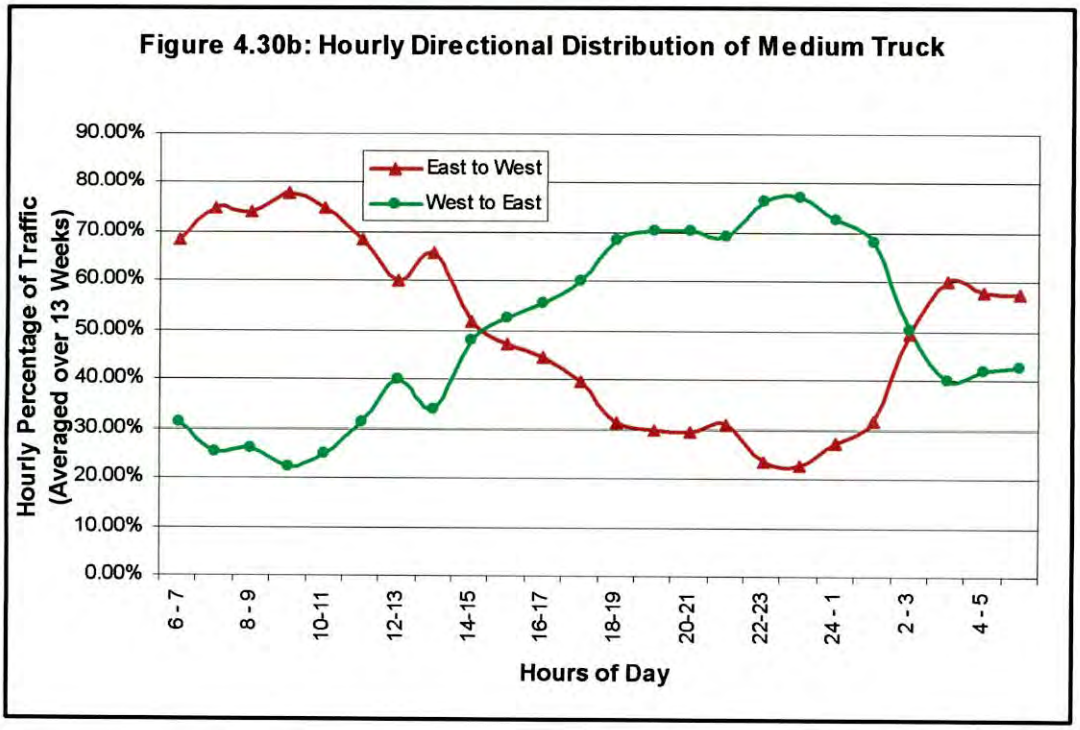
Hours	Avg. Hourly Volume			Directional Split	
	E-W	W-E	Total	E-W	W-E
6 – 7	1	6	7	15.12%	84.88%
7 – 8	1	9	9	6.56%	93.44%
8 – 9	4	16	20	19.84%	80.16%
9 – 10	13	18	32	41.95%	58.05%
10-11	36	30	65	54.66%	45.34%
11-12	51	38	89	57.25%	42.75%
12-13	50	37	88	57.41%	42.59%
13-14	35	45	81	43.99%	56.01%
14-15	28	33	61	45.44%	54.56%
15-16	22	24	46	47.82%	52.18%
16-17	20	18	37	52.26%	47.74%
17-18	23	18	41	56.64%	43.36%
18-19	26	25	50	51.15%	48.85%
19-20	17	12	30	58.51%	41.49%
20-21	18	8	27	69.16%	30.84%
21-22	15	5	20	75.10%	24.90%
22-23	24	4	28	85.04%	14.96%
23-24	33	9	42	78.47%	21.53%
24 – 1	29	27	56	51.78%	48.22%
1 – 2	24	62	86	28.25%	71.75%
2 – 3	8	57	65	12.37%	87.63%
3 – 4	5	11	16	33.01%	66.99%
4 – 5	2	2	4	51.79%	48.21%
5 – 6	2	1	3	68.42%	31.58%

Data Source: BUET

Hourly directional distribution of medium truck is shown in Table 4.15 and graphically in figure 4.30. It is found that, maximum East to West flow (77.82%) occurs within 9:00 to 10:00 and maximum West to East flow (77.16%) occurs within 23:00 to 24:00. This is because there is a restriction for the trucks to enter Dhaka City from 8:00 AM to 10:00

PM. Therefore, trucks carrying goods (mainly agricultural products) to Dhaka from North Bengal cross Jamuna Bridge at around midnight to reach Dhaka in the early morning. Again, trucks starting from Dhaka in the early morning cross the bridge at around 9:00 to 10:00 AM. However, the directional split of medium trucks does not fluctuate as much as that for Large Buses.





From the analysis of Light Vehicles' directional distribution pattern, it is found that, maximum light vehicles start from Dhaka towards North Bengal in the morning causing maximum East to West flow (68.78%) on the bridge at 11:00 to 12:00 and return to Dhaka at night causing maximum flow (65.13%) in the West to East direction at around midnight.

Table 4.15: Hourly Directional Distribution of Medium Truck

Hours	Avg. Hourly Volume			Directional Split	
	E-W	W-E	Total	E-W	W-E
6 - 7	38	17	55	68.48%	31.52%
7 - 8	33	11	44	74.69%	25.31%
8 - 9	33	12	45	74.05%	25.95%
9 - 10	31	9	40	77.82%	22.18%
10-11	25	8	33	75.06%	24.94%
11-12	20	9	29	68.45%	31.55%
12-13	15	10	25	60.06%	39.94%
13-14	16	8	25	65.94%	34.06%
14-15	14	13	26	51.91%	48.09%
15-16	13	14	27	47.31%	52.69%
16-17	15	18	33	44.47%	55.53%
17-18	16	24	39	39.80%	60.20%
18-19	17	36	53	31.40%	68.60%
19-20	16	37	52	29.85%	70.15%
20-21	19	44	63	29.51%	70.49%
21-22	20	44	64	30.83%	69.17%
22-23	16	53	69	23.46%	76.54%
23-24	14	48	62	22.84%	77.16%
24 - 1	17	44	61	27.39%	72.61%
1 - 2	18	38	55	31.76%	68.24%
2 - 3	28	29	57	49.59%	50.41%
3 - 4	27	18	45	60.03%	39.97%
4 - 5	22	16	39	57.97%	42.03%
5 - 6	22	16	38	57.34%	42.66%

Figure 4.31a: Hourly Flow Volume of Light Vehicles on Each Direction

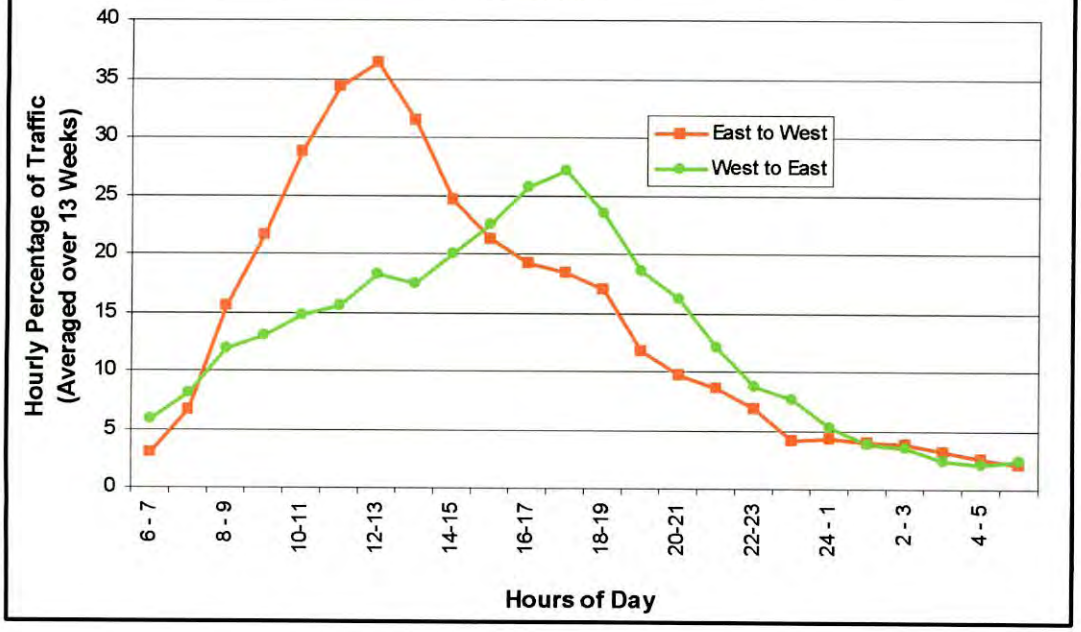


Figure 4.31b: Hourly Directional Distribution of Light Vehicles

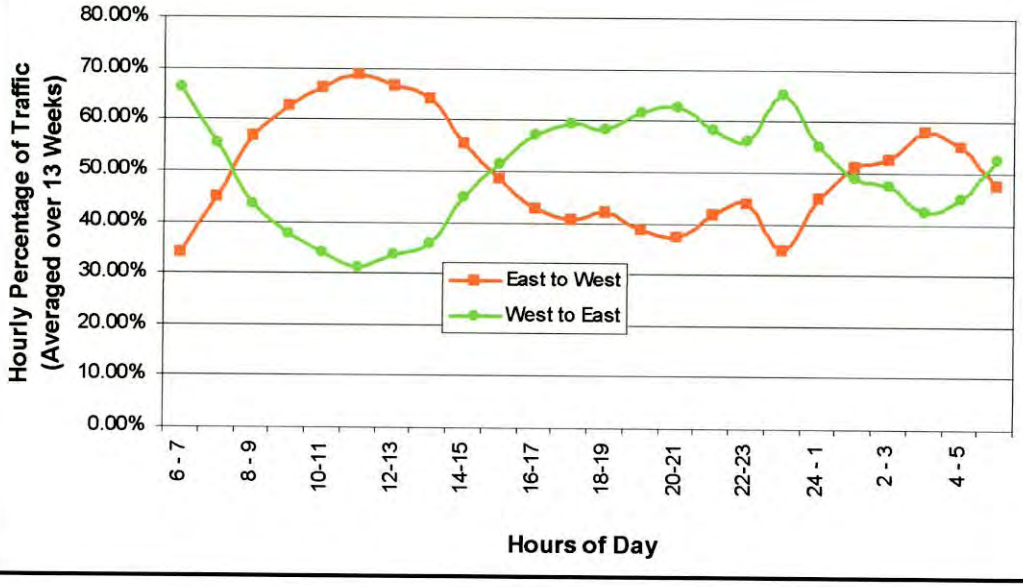


Table 4.16: Hourly Directional Distribution of Light Vehicles

Hours	Avg. Hourly Volume			Directional Split	
	E-W	W-E	Total	E-W	W-E
6 - 7	3	6	9	33.91%	66.09%
7 - 8	7	8	15	44.79%	55.21%
8 - 9	16	12	28	56.70%	43.30%
9 - 10	22	13	35	62.44%	37.56%
10-11	29	15	44	66.08%	33.92%
11-12	34	16	50	68.78%	31.22%
12-13	36	18	55	66.48%	33.52%
13-14	31	18	49	64.21%	35.79%
14-15	25	20	45	55.27%	44.73%
15-16	21	22	44	48.68%	51.32%
16-17	19	26	45	42.74%	57.26%
17-18	18	27	46	40.54%	59.46%
18-19	17	24	40	41.83%	58.17%
19-20	12	19	30	38.58%	61.42%
20-21	10	16	26	37.31%	62.69%
21-22	9	12	21	41.57%	58.43%
22-23	7	9	16	43.84%	56.16%
23-24	4	8	12	34.87%	65.13%
24 - 1	4	5	10	44.80%	55.20%
1 - 2	4	4	8	51.00%	49.00%
2 - 3	4	3	7	52.63%	47.37%
3 - 4	3	2	5	57.75%	42.25%
4 - 5	3	2	5	55.00%	45.00%
5 - 6	2	2	4	47.37%	52.63%

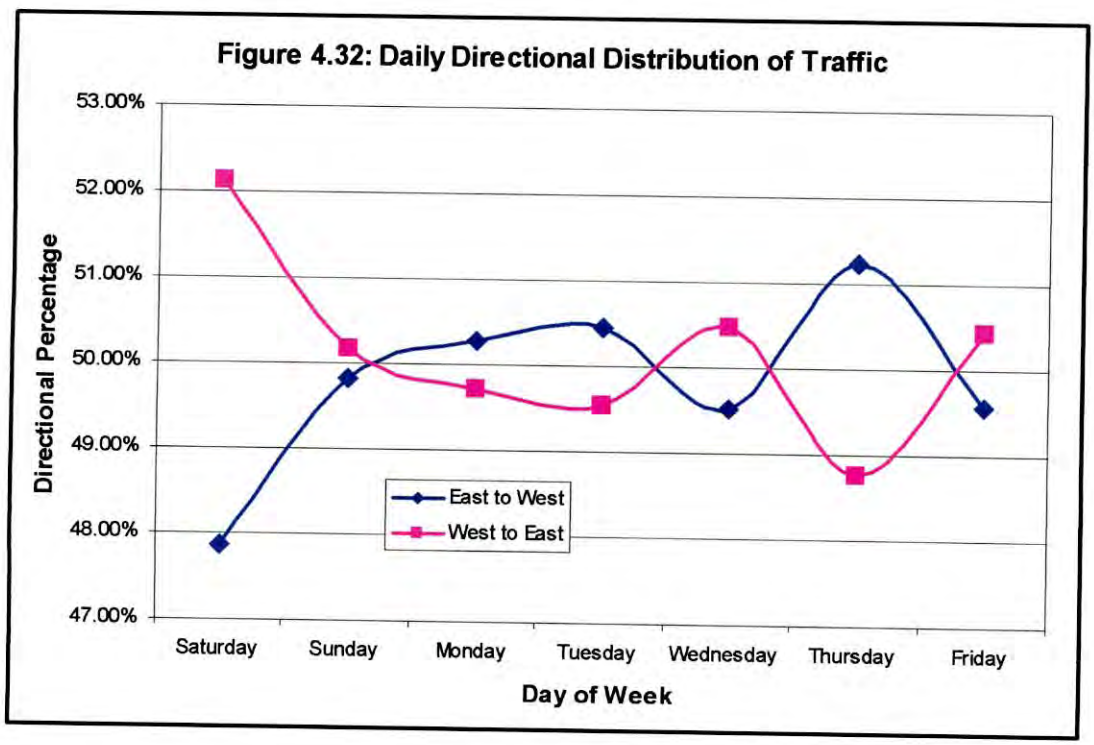
Table 4.16 and Figure 4.31 given above show the hourly directional distribution of Light Vehicles on Jamuna bridge, from the analysis of 13 weeks data collected by BUET.

4.2.8.2 Daily Directional Distribution

Analysis of daily directional distribution of traffic on Jamuna bridge has been done using 5 years (1999 to 2003) of traffic data collected by JOMAC. In Table 4.17, the summarized daily directional distribution data are shown. Here average daily ADT on each day of week have been determined from 5 years' data.

Table 4.17: Daily Directional Distribution of Traffic on Jamuna Bridge

Weekday	Avg. Daily ADT			Directional Split	
	East to West	West to East	Total	East to West	West to East
Saturday	1,514	1,648	3,161	47.88%	52.12%
Sunday	1,620	1,630	3,250	49.84%	50.16%
Monday	1,625	1,607	3,232	50.28%	49.72%
Tuesday	1,591	1,563	3,153	50.45%	49.55%
Wednesday	1,562	1,592	3,154	49.51%	50.49%
Thursday	1,678	1,596	3,274	51.25%	48.75%
Friday	1,694	1,724	3,418	49.57%	50.43%



It can seen in Figure 4.32 that, daily directional distribution varies from around 48% to 52%. People working in and around capital Dhaka tend to visit their native town/village on the weekend and thus causing maximum outbound (East to West) flow on Thursday, which is 51.25%. Again, they return to their workplaces in and around Dhaka on Saturday creating maximum inbound (West to East) traffic (52.12%) on Saturdays.

4.2.8.3 Monthly Directional Distribution

Month-wise directional distribution of traffic on Jamuna bridge is shown in Table 4.18. Figure 4.33 shows the graphical representation. From the table and figure, it can be seen that, the directional split is very close to 50%. This implies, that there is no alternate route available for the users of this bridge. The overall directional distribution, averaged over 5 years monthly traffic flow data, is found to 50.17% in the West to East direction and 49.83% in the East to West Direction. Figure 4.34 shows the overall directional distribution of traffic on Jamuna bridge.

Table 4.18: Monthly Directional Distribution of Traffic on Jamuna Bridge

Month	Average Monthly Volume (1999 to 2003)			Directional Split	
	East to West	West to East	Total	East to West	West to East
Jan	51,040	51,923	102,963	49.57%	50.43%
Feb	46,275	46,759	93,034	49.74%	50.26%
Mar	53,109	53,573	106,682	49.78%	50.22%
Apr	46,785	47,242	94,027	49.76%	50.24%
May	48,621	48,422	97,043	50.10%	49.90%
Jun	47,507	47,518	95,025	49.99%	50.01%
Jul	49,844	49,609	99,453	50.12%	49.88%
Aug	47,210	47,369	94,579	49.92%	50.08%
Sep	44,565	44,959	89,524	49.78%	50.22%
Oct	49,210	49,860	99,071	49.67%	50.33%
Nov	48,051	48,720	96,771	49.65%	50.35%
Dec	56,054	56,342	112,396	49.87%	50.13%
Average	49,023	49,358	98,381	**49.83%**	**50.17%**

Figure 4.33: Monthly Directional Distribution of Traffic

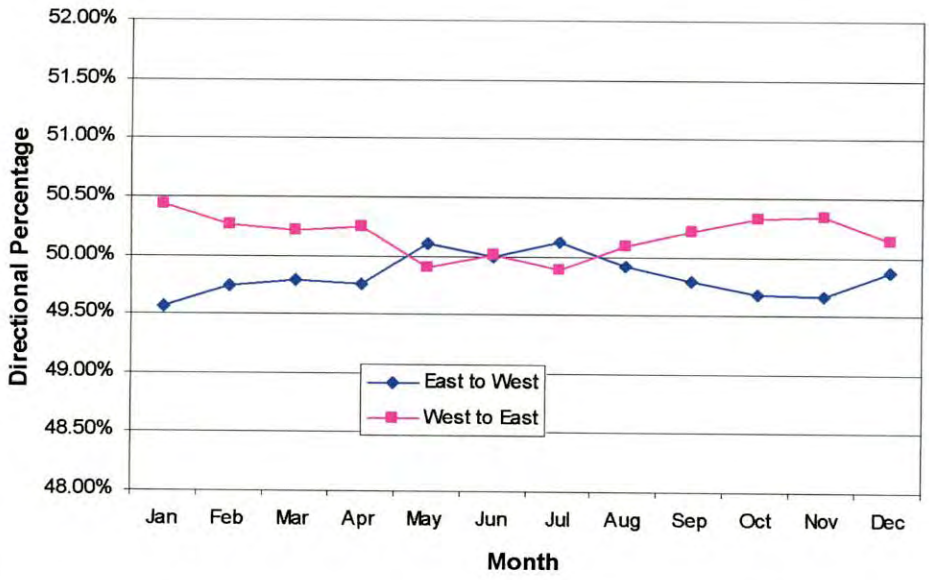
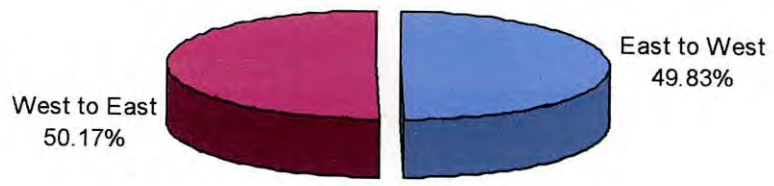


Figure 4.34: Avarage Directional Distribution of Traffic on Jamuna Bridge Corridor



4.2.9 Day-Night Fluctuation

From the analysis of day and night traffic fluctuation on Jamuna Bridge, it is found that, it varies within a range of approximately 44% to 56%. Daytime is considered from 6:00AM to 6:00 PM and nighttime refers to 6:00PM to 6:00AM. Table 4.19 shows the day-wise summarized day-night fluctuation data averaged over 13 weeks data collected by BUET.

Table 4.19: Summarized Day-Night Traffic Fluctuation Table

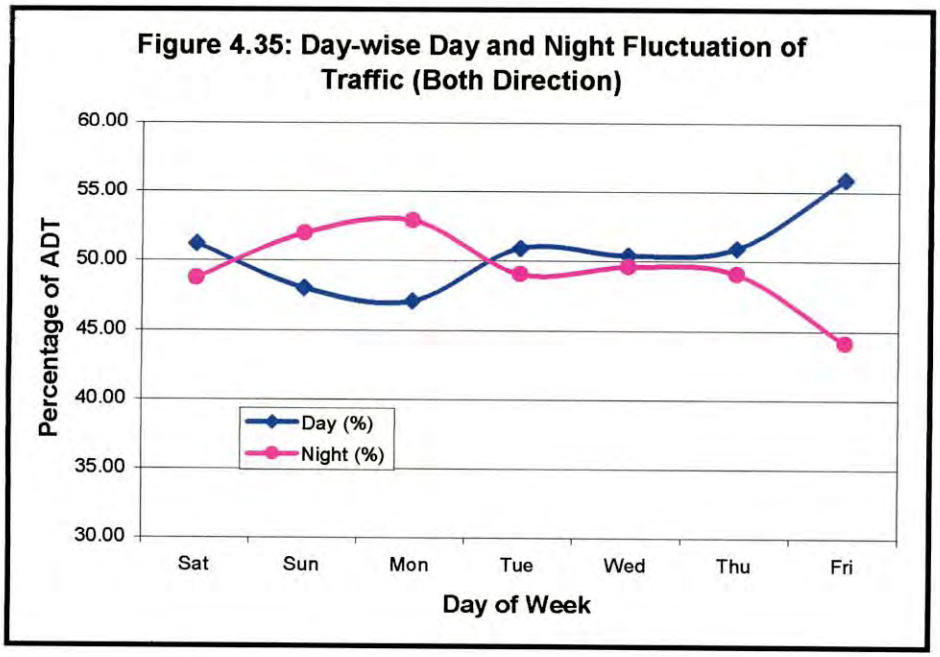
Day	Day (%)	Night (%)
Sat	51.22	48.78
Sun	48.02	51.98
Mon	47.09	52.91
Tue	50.94	49.06
Wed	50.41	49.59
Thu	50.93	49.07
Fri	55.90	44.10
Average	**50.64**	**49.36**

Data Source: BUET

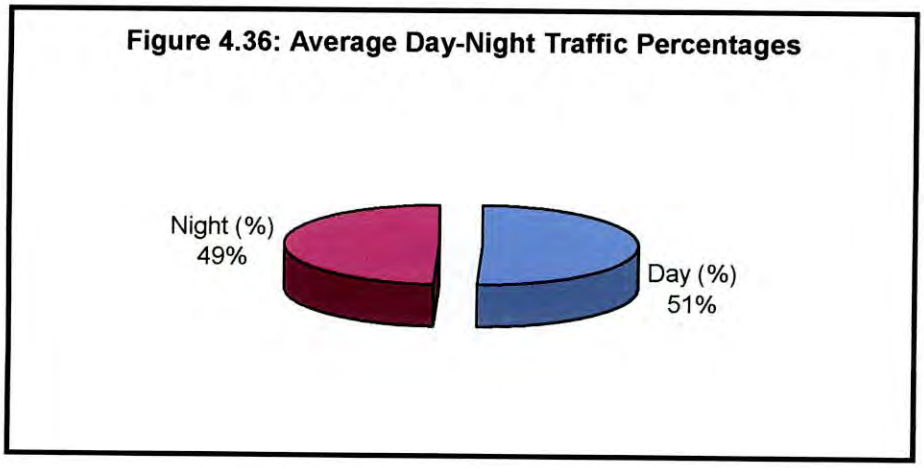
Note: Data summarized by BUET

It is observed from day-night traffic fluctuation chart (Figure 4.35) that, maximum daytime traffic occurs on Friday, the percentage being 55.90% and maximum nighttime flow takes place on Monday carrying 52.91% of total daily traffic.

From the analysis of class-wise hourly variation of traffic, as given in Article 4.2.2, it is found that, medium trucks are major contributors to nighttime traffic flow, whereas, light vehicles cross the bridge mostly within daytime.



Taking the average of all weekdays, average daytime flow percentage is 50.64% and that at nighttime is 49.36%, as shown in Figure 4.36.



4.2.10 Impact of Eid Festivals on Traffic Flow

It was observed earlier in Article 4.2 that, Eid festivals leave significant impact on traffic flow on Jamuna Bridge, which is anticipated in other corridors in Bangladesh as well. Due to this, different traffic flow parameters are greatly affected and thus the need for analyzing the extent of Eid Festivals' impact is deeply realized. Since, the traffic flow around an Eid is higher than usual traffic flow, it is easily understood that, a factor representing the impact of Eid festival should be determined by which the traffic flow around an Eid can be more precisely estimated, which is expected to be the critical flow value.

For this analysis, seven years of continuous daily traffic flow data obtained from JOMAC and MargaNet has been used. To identify the variation caused by Eid festivals, traffic flow in month containing Eid shall be compared with average yearly traffic flow or even traffic flow in other years for that particular month not containing Eid. By summarizing seven years' continuous daily flow data, it is found that, taking the average daily flow on all months in successive seven years, the average daily flow percentage is around 3.00% to 3.50% of corresponding monthly flow volume (Figure. 4.37).

Figure 4.37: Average Continuous Daily Flow Pecentage

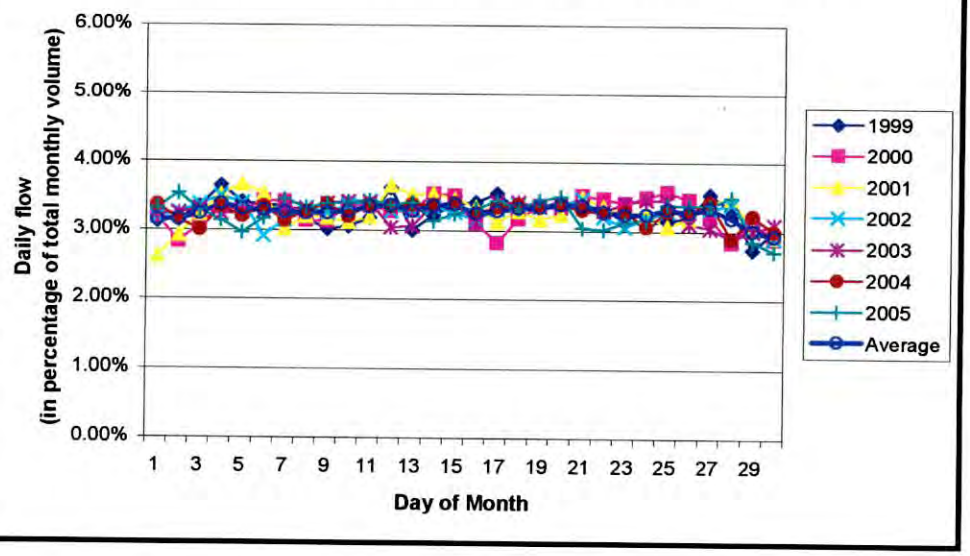


Table 4.20: Summarized Daily Flow Percentage Table (Both Direction)

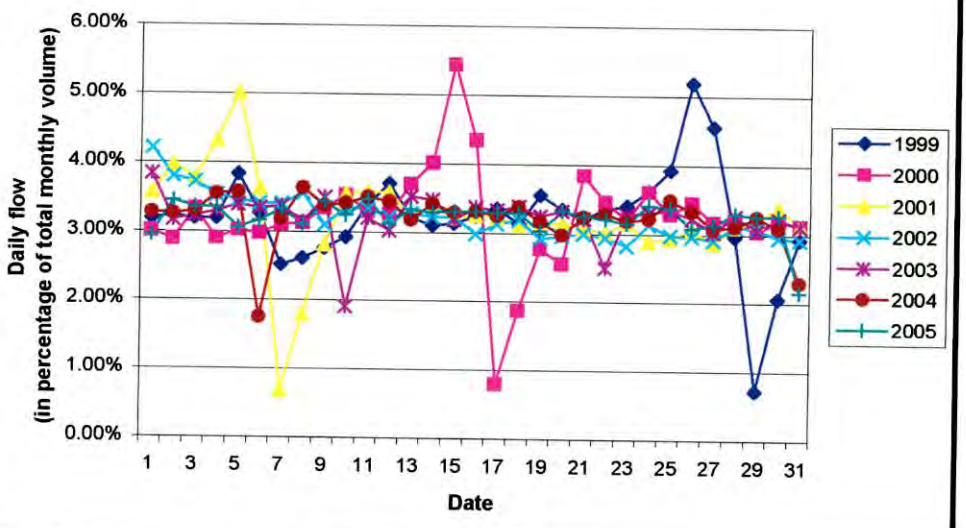
Date	Daily Flow Percentage (Averaged Over 12 Months)							
	1999	2000	2001	2002	2003	2004	2005	Average
1	3.08%	3.15%	2.59%	3.15%	3.19%	3.32%	3.28%	**3.11%**
2	3.10%	2.79%	2.89%	3.21%	3.20%	3.11%	3.49%	**3.11%**
3	3.30%	3.05%	3.18%	3.33%	3.27%	2.96%	3.25%	**3.19%**
4	3.60%	3.29%	3.47%	3.44%	3.19%	3.29%	3.10%	**3.34%**
5	3.36%	3.24%	3.62%	3.35%	3.21%	3.16%	2.93%	**3.27%**
6	3.32%	3.38%	3.49%	2.88%	3.22%	3.30%	3.13%	**3.25%**
7	3.31%	3.37%	2.98%	3.10%	3.28%	3.09%	3.41%	**3.22%**
8	3.12%	3.09%	3.16%	3.28%	3.26%	3.23%	3.29%	**3.20%**
9	2.98%	3.08%	3.14%	3.21%	3.35%	3.34%	3.34%	**3.21%**
10	3.02%	3.33%	3.07%	3.32%	3.37%	3.15%	3.37%	**3.23%**
11	3.14%	3.31%	3.15%	3.38%	3.37%	3.33%	3.39%	**3.30%**
12	3.56%	3.23%	3.60%	3.23%	3.00%	3.30%	3.33%	**3.32%**
13	2.96%	3.24%	3.47%	3.25%	3.02%	3.33%	3.37%	**3.24%**
14	3.18%	3.49%	3.49%	3.30%	3.34%	3.32%	3.10%	**3.32%**
15	3.34%	3.46%	3.41%	3.22%	3.36%	3.36%	3.20%	**3.34%**
16	3.37%	3.07%	3.30%	3.11%	3.08%	3.22%	3.28%	**3.20%**
17	3.49%	2.79%	3.09%	3.27%	3.37%	3.29%	3.39%	**3.24%**
18	3.27%	3.13%	3.24%	3.34%	3.37%	3.34%	3.28%	**3.28%**
19	3.31%	3.32%	3.12%	3.30%	3.32%	3.30%	3.41%	**3.30%**
20	3.38%	3.29%	3.20%	3.34%	3.35%	3.34%	3.45%	**3.33%**
21	3.34%	3.47%	3.44%	3.42%	3.33%	3.26%	3.00%	**3.32%**
22	3.28%	3.42%	3.31%	3.16%	3.25%	3.22%	2.98%	**3.23%**
23	3.10%	3.36%	3.19%	3.02%	3.36%	3.24%	3.08%	**3.19%**
24	3.07%	3.44%	3.18%	3.14%	3.41%	3.02%	3.12%	**3.20%**
25	3.10%	3.52%	3.03%	3.25%	3.40%	3.24%	3.34%	**3.27%**
26	3.16%	3.41%	3.13%	3.25%	3.07%	3.22%	3.33%	**3.22%**
27	3.49%	3.14%	3.38%	3.28%	3.01%	3.38%	3.33%	**3.29%**
28	3.27%	2.80%	3.43%	3.35%	2.85%	2.85%	3.45%	**3.14%**
29	2.70%	3.10%	3.01%	2.99%	2.97%	3.18%	2.82%	**2.97%**
30	2.96%	2.85%	2.87%	2.87%	3.06%	2.96%	2.67%	**2.89%**
31	3.33%	3.38%	3.33%	3.27%	3.15%	3.36%	3.06%	**3.27%**
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Average Daily Flow Percentage (Averaged Over 7 Years)								**3.23%**
Standard Deviation								**0.10%**

Data Source: JOMAC, MargaNet

In Table 4.20, daily both directional flow, in percentage of total monthly volume, averaged over 12 months, from 1999 to 2005, is shown. Here it is to be noted that, flow percentage in 31st day of month came to be low because of presence of 31st day in only seven months in a year. This has been compensated by taking proportionate 12 months' flow value for the 31st day. However, the average daily flow percentage comes to be 3.23% with an astonishing standard deviation of only 0.10%. This leads to a fact that, even with the effects of all external factors causing deviations in normal traffic flow, the average daily flow is quite predictable.

Now, for the years under consideration in this study, months from November to March have contained the two Eid festivals. If an Eid month, say March is taken into account, the flow variation exhibits some remarkable facts, as shown in Figure 4.38.

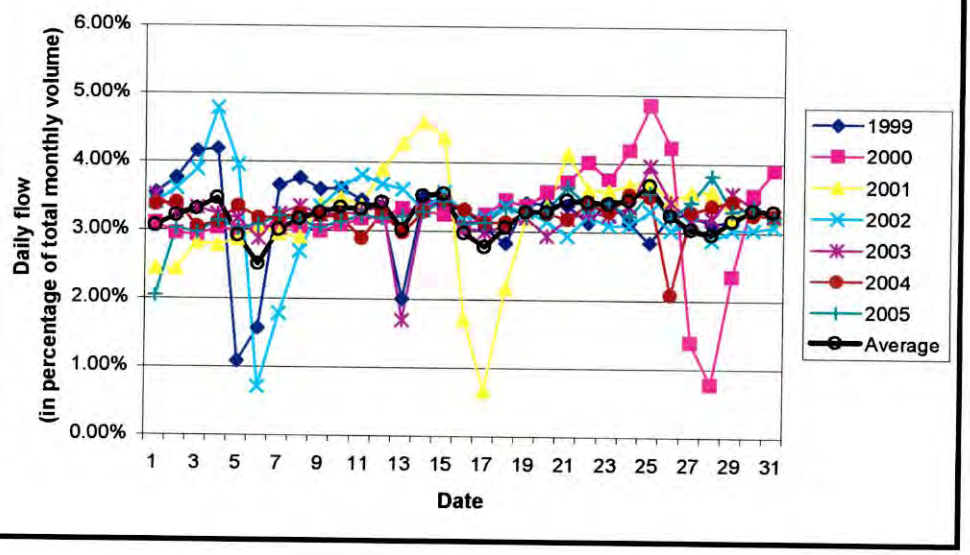
Figure 4.38: Daily Flow Pecentage on March



It can be clearly seen that, from 2002 to 2005 maintain near about 3.00% to 3.50% of daily flow percentage, since March did not contain any Eid during these years. On the contrary, for the years 1999, 2000 and 2001, three distinct peaks followed by abrupt fall in traffic flow is observed. In all three cases, the lowest traffic occurred on Eid day and the peak flow has taken place two days prior to Eid. Naturally one can understand that, this has happened because of increased passenger movement during Eid, as most city

people usually spend Eid at their native town or village and the Eid vacation starts from the previous day of Eid day. So, the peak flow occurs two days prior to Eid. Flow chart for December also exhibits similar characteristics, as shown in Figure 4.39.

Figure 4.39: Daily Flow Pecentage on December



In this case, the Eid festivals has taken place on December in the years 2000, 2001 and 2002. In every case, the flow rises to the peak before Eid and immediately falls on Eid day. Some other falls are also observed which might have occurred for strikes or Hartals. But, since these are potentially creating critical flow value, the issue is not important in this study.

From the above analysis for all individual Eid months, it has been found that, the peak flow percentage rises upto 6.49% in February 2002. But in most of the cases the peak value stays within a range of 5.00% to 6.00%, which is approximately 70% higher than normal traffic flow.

Another approach can be made to see the impact of Eid festivals on daily traffic flow. If all the daily bi-directional flow in a particular year is sorted in the descending order, it is found that, most of the peak daily volume occurs within one week of Eid. In Table 4.21,

the daily both directional traffic volumes in the year 1999 to 2003 has been sorted in descending order and highest 15 daily volumes are listed. It is observed that, most of the days carrying highest daily traffic in a year are within a week of an Eid.

It is also found that, the highest daily flow in a year caused by Eid event carries as much as 90% higher volume than AADT of that particular year. From this analysis, one can easily understand that, the highest daily flow in a particular year occurs at the time of Eid and the transportation planners should consider this fact while designing highways in Bangladesh.

Table 4.21: Highest Daily Traffic Flow within a Year

Sl. No. (In Descending Order of Daily Flow Volume)	1999 (AADT = 2416)			2000 (AADT = 2854)			2001 (AADT = 3220)			2002 (AADT = 3541)			2003 (AADT = 4133)		
	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT
1	03/26/99	4743	96.29%	03/15/00	5524	93.53%	03/05/01	5725	77.81%	02/21/02	6830	92.87%	02/10/03	7597	83.82%
2	03/27/99	4166	72.41%	12/25/00	4731	65.75%	12/14/01	5194	61.32%	12/04/02	6052	70.90%	02/11/03	6748	63.28%
3	01/29/99	3890	60.99%	03/16/00	4407	54.40%	03/04/01	4941	53.46%	02/20/02	5855	65.34%	11/24/03	6659	61.12%
4	04/02/99	3852	59.41%	01/06/00	4213	47.60%	12/15/01	4938	53.37%	12/05/02	4999	41.17%	02/09/03	5737	38.82%
5	01/23/99	3781	56.48%	12/26/00	4130	44.69%	12/13/01	4846	50.51%	12/03/02	4913	38.74%	11/25/03	5588	35.21%
6	02/19/99	3778	56.35%	12/24/00	4086	43.15%	12/21/01	4679	45.32%	12/11/02	4824	36.23%	12/25/03	5576	34.92%
7	02/12/99	3704	53.29%	03/14/00	4070	42.59%	03/02/01	4540	41.01%	02/19/02	4658	31.54%	11/30/03	5525	33.69%
8	01/25/99	3703	53.25%	12/22/00	3911	37.02%	12/12/01	4409	36.94%	03/01/02	4656	31.48%	11/23/03	5465	32.23%
9	01/22/99	3690	52.71%	03/21/00	3899	36.60%	03/03/01	4323	34.27%	12/12/02	4654	31.42%	02/16/03	5117	23.81%
10	04/03/99	3679	52.25%	12/31/00	3807	33.38%	04/13/01	4275	32.78%	12/10/02	4588	29.56%	12/29/03	5014	21.32%
11	02/05/99	3602	49.07%	03/13/00	3758	31.66%	12/25/01	4223	31.16%	12/02/02	4568	29.00%	12/01/03	4942	19.58%
12	03/25/99	3594	48.74%	01/07/00	3719	30.29%	12/24/01	4174	29.64%	12/13/02	4561	28.80%	10/22/03	4926	19.19%
13	01/18/99	3562	47.41%	12/23/00	3669	28.54%	03/06/01	4145	28.74%	02/18/02	4541	28.23%	02/17/03	4922	19.10%
14	12/04/99	3549	46.87%	03/24/00	3668	28.51%	04/08/01	4114	27.78%	12/15/02	4504	27.19%	02/08/03	4915	18.93%
15	12/03/99	3519	45.63%	12/21/00	3631	27.21%	01/04/01	4095	27.19%	02/28/02	4455	25.80%	11/21/03	4881	18.10%

Data Source: JOMAC

Now, this is of interest to see whether this causes any significant directional split. The both directional flow percentage itself has come to be 70% higher than average daily flow. If that is coupled with higher percentage of flow in a particular direction, that will certainly pertain the highest flow value, which is critical for geometric design.

In Article 4.2.8, the directional distribution analysis has been shown where it has been found that the maximum directional split come to be 52.12% and mostly it is a 50-50 directional distribution corridor. But from the directional distribution curve plotted in Figure 4.40, it is found that, in February, 2002 the East to West flow on the previous day of Eid day has reached upto 65.28%. On the day where highest flow percentage had taken place, i.e. on 22nd February, the outbound traffic flow was 58.10%, which is significantly higher than normal directional distribution. Moreover, it is observed that, before Eid festival, the outbound increases from around three days and reach the peak and then starts falling while the inbound traffic starts increasing after Eid. From similar analysis for other Eid months, it has been found that the impact of Eid start from 3 days prior to the Eid day and stays until 5/6 after Eid.

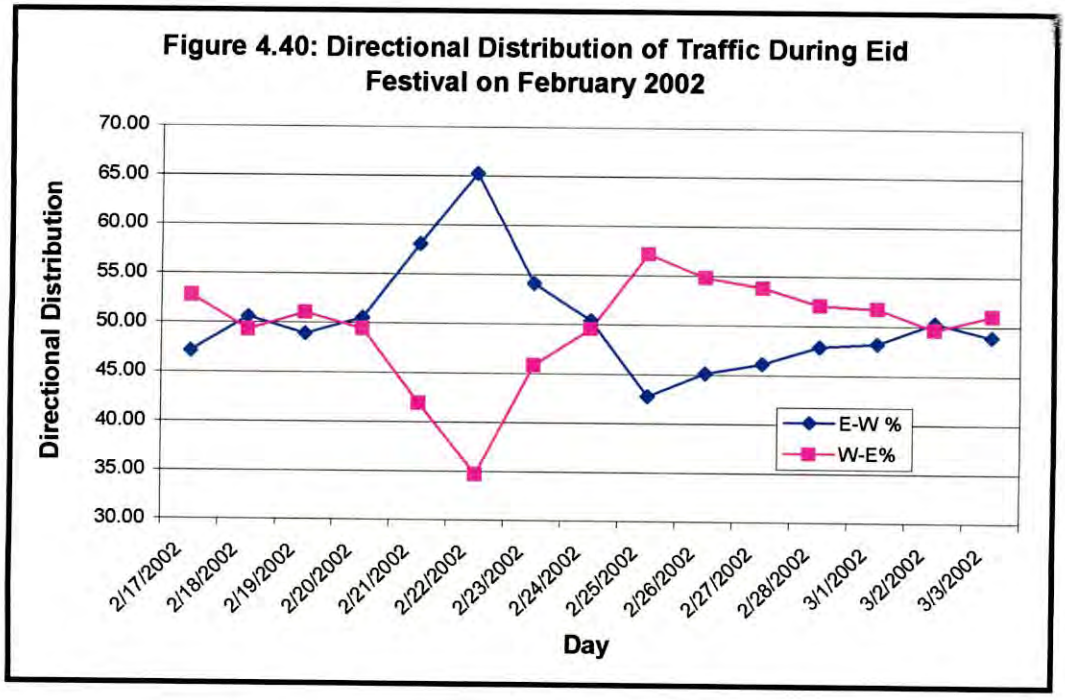
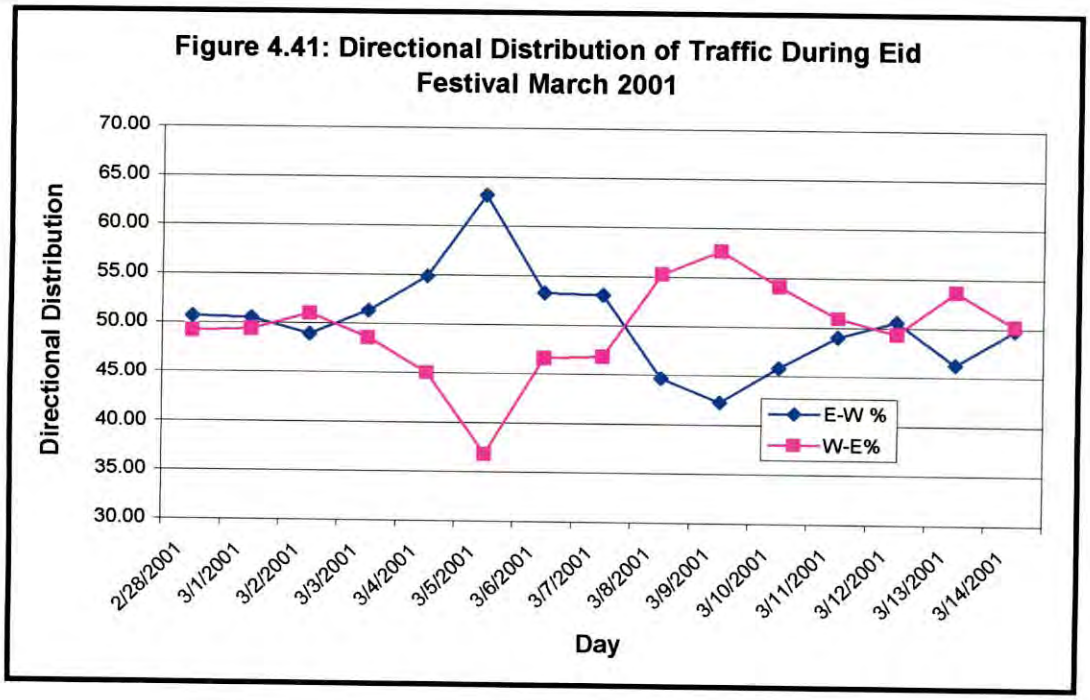


Figure 4.40: Directional Distribution of Traffic During Eid Festival on February 2002

Similar analysis of Eid impact on directional distribution of traffic flow is shown in Figure 4.41, where the maximum directional split from East to West is 63.16%.



Summary of Findings:

From the above analyses, it is clearly understood that, Eid festivals have crucial impact on traffic flow in Bangladesh. Therefore, for accurate estimation of AADT from short counts, not only expansion factors are sufficient for precise estimation, but also an Eid factor is to be determined and introduced, so that the peak hour flow can be correctly estimated.

- Duration of Eid Impact: 3 days before and 6 days after Eid day; total 10 days.
- Maximum Daily Flow Percentage: 6.49% (bothway) before Eid in February 2002.
- Average Daily Flow Percentage: 3.23%, Standard Deviation: 0.10%
- Average Daily Flow Percentage before Eid: 5.38% (Averaged over 12 Eid occasions from 1999 to 2003)

- All highest Daily Volume in a year are within Eid effect range, carrying upto 90% more traffic than AADT.
- Maximum Directional Distribution: 65.28%, East to West, February 2002
- Average Directional Distribution: 61.45% (Averaged over 4 Eid occasions)

4.2.11 Traffic Growth Pattern

Traffic growth is a natural phenomenon in any country. It can be found from previous flow pattern analyses that, although the daily, monthly flow variation exhibit similar fluctuation pattern, but the magnitude of flow increases every successive year (Figure 4.15). This indicates that since the stabilization of the corridor, total yearly traffic is gradually increasing. Analysis of traffic growth pattern is important for reliable prediction of future traffic flow by extrapolation method. Moreover, for estimating future traffic for geometric and structural design or prediction of future traffic flow in terms of PCU and total ESAL, the pattern of growth rate of traffic is necessary. This article analyzes the seven years of traffic flow data from 1999 to 2003 to understand the true pattern of traffic growth.

Figure 4.42: Yearly Traffic Growth Pattern on Jamuna Bridge

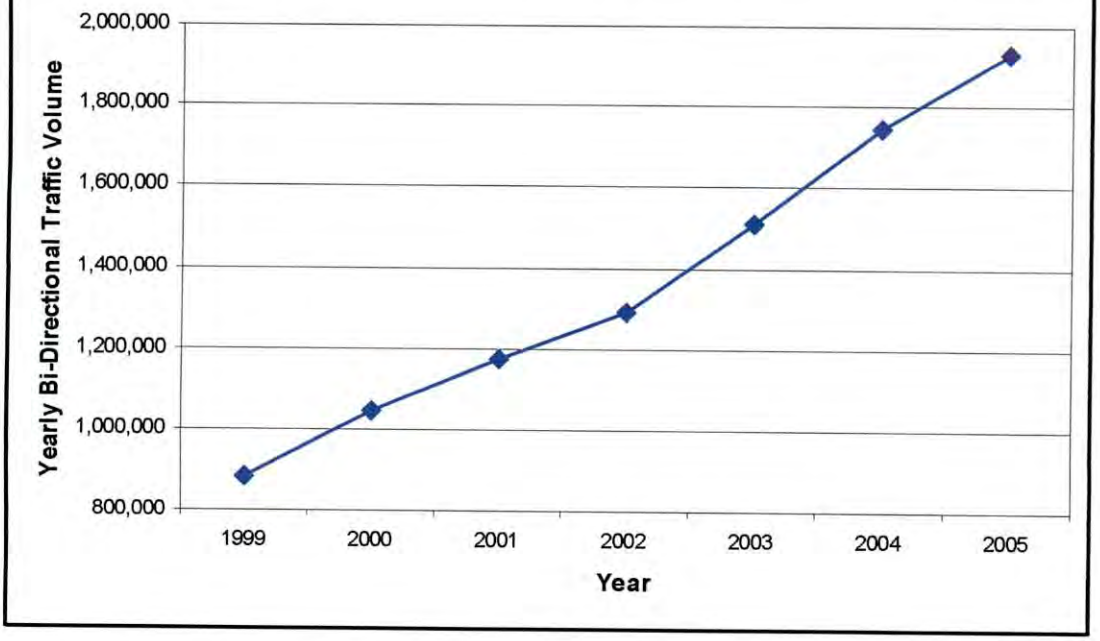


Figure 4.42 plots the total bi-directional yearly traffic volume on Jamuna bridge against respective years from 1999 to 2005. From the graph, it is clearly seen that the yearly traffic growth is almost linear. In 1999, the total yearly traffic volume was 881,966. During the next seven years it has gradually increased and has become near about two million (exact figure - 1,930,313) in 2005. The average growth rate has been found to be 14% per annum, which is higher than average national growth rate (8-10%) used in the Roads and Highways design manual [Pavement Design Guide, Roads & Highways Department, April 2005].

Now, during the analysis of traffic composition described in Article 4.2.6, it was found that, percentage of various vehicle classes with respect to total yearly is not constant throughout the study period (Figure 4.23). Rather, they are changing from year to year at a significant rate. Some vehicle classes are increasing every year while some are decreasing. Therefore, it can be easily understood that, flat growth rate for total traffic is not representative of the actual scenario. This invokes the need for traffic growth pattern analyzed individually for all vehicle classes.

Figure 4.43: Class-wise Yearly Growth Pattern of Traffic on Jamuna Bridge

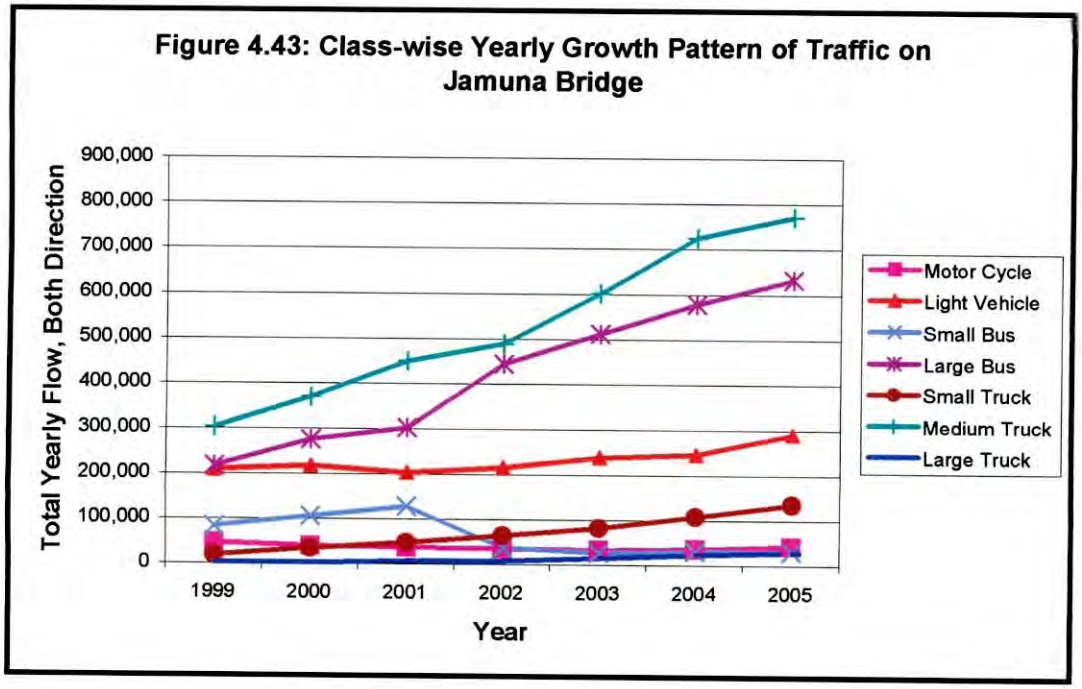
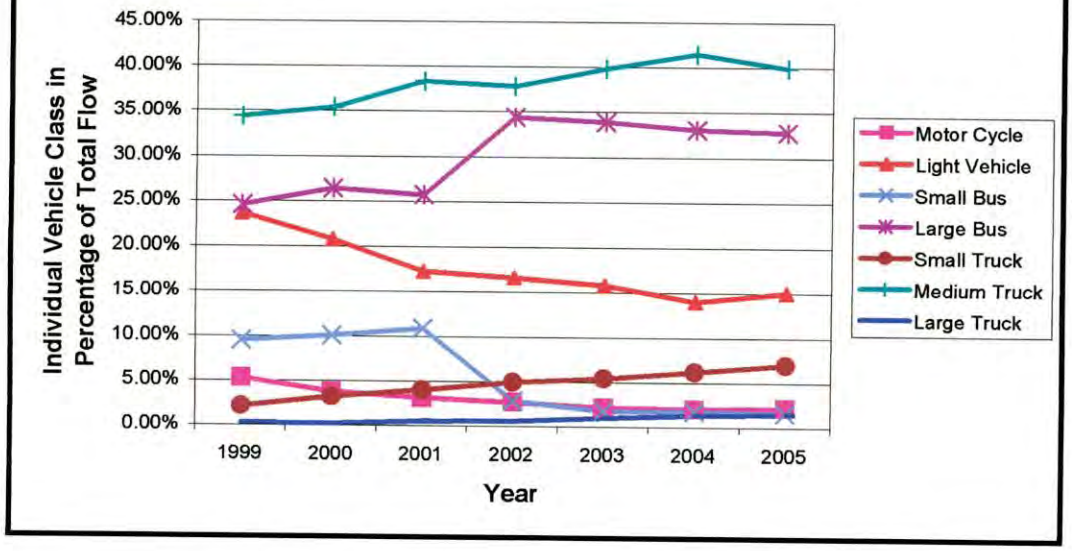


Figure 4.44: Growth Pattern of Individual Vehicle Classes (In Percentage of Yearly Total Volume)



In Figure 4.43, total yearly flow of all seven vehicle classes used in Jamuna bridge is plotted against respective years from 1999 to 2003, while Figure 4.44 shows the yearly variation in percentage of individual vehicle classes with respect to total yearly volume. The observations made from the above graphs, separately for each vehicle class, are described hereunder.

4.2.11.1 Motor Cycle:

In 1999, total yearly volume of this class was 46,875 and in 2005 it became 42,155. During the intermediate years total volume was within a range from 33 to 38 thousand per year. The average yearly volume derived from 7 seven years is 38,532. Although the total yearly volume of Motor Cycle has not changed to great extent during the study period, but percentage of motorcycle with respect to total volume has been reduced considerably. In 1999, the percentage was 5.31% and gradually decreased every year and became 2.18% in 2005. This has happened because of increase in total traffic. Taking the average value during the study period, percentage of motorcycle is 3.06% within the traffic stream.

4.2.11.2 Light Vehicles:

Light vehicles include cars, pickups, microbus, jeep etc. within this class. From Figure 4.43, it can be seen that total yearly volume of Light Vehicles has slightly increased from 2,08,811 in 1999 to 2,89,910 in 2005. In spite of this rise in volume, the percentage has significantly dropped from 23.68% in 1999 to 15.02% in 2005. Average annual drop rate is 1.44% of total yearly volume. The change is quite noticeable in Figure 4.44.

4.2.11.3 Small Bus:

Small bus, which is classed as buses having sitting capacity upto 30, shows prominent slump in volume, as well as in yearly percentage. In 1999 total volume of Small Bus was 84,111, while in 2005 it became only 30,720. Annual percentage dropped from 9.54% to only 1.59%. In Figure 4.44, it is prominent that there has been a significant drop of 10.88% to 2.86% (8.02%) within 2001 to 2002. This might have happened because, the newly elected government rejected license of many old vehicles because of environmental reasons.

4.2.11.4 Large Bus:

As mentioned in the previous article, during 2001-2002 many Small Buses were replaced by Large Luxury Buses. This has caused a simultaneous rise in Large Bus in that particular period having values 25.74% in 2001 and 34.43% in 2002. Figure 4.46 clearly shows this change. Total volume has increased from 2,16,913 to 6,32,938 during the seven years under consideration. Annual percentage has also risen from 24.59% to 32.79%.

4.2.11.5 Small Trucks:

Volume of small trucks is not very significant on the corridor. However, it is increasing at a more or less constant rate. The percentage of this class has risen from 2.17% in 1999 to 6.98% in 2005.

4.2.11.6 Medium Trucks:

As discussed in article covering traffic composition, the class Medium Truck contains the highest percentage of traffic on Jamuna Bridge. In Figure 4.45, annual growth of this class is also found to be quite significant. In the year 1999, total volume was 3,03,488 and it increased to more than double during the nest six years. Although due to consequent increase in total traffic, the growth in annual percentage is not that steep. From 1999 to 2005, the percentage has risen from 34.41% to 39.97%.

4.2.11.7 Large Trucks:

Large Truck contains the minimum percentage of annual traffic. The percentage of this class was 0.30% in 1999. After gradual increase, the same has become 1.47% in 2005. Considering the impact of Large Truck on the pavement, this apparent insignificant class is also to be taken into account.

Summary of Findings:

From the above analysis, it was firmly established that, consideration of flat growth rate for total vehicle is not correct. Rather, growth rate is to be determined for each individual class, which can be used more precisely for traffic flow prediction.

4.3 Comparison Between Flow on Jamuna Bridge and Hatikamrul Road

It has been previously established that, the flow data used in this study is of high quality. This was initially predicted by seeing the repetitive nature of the curve, which is a usual phenomenon in all traffic flow. Yet, some manipulation in data may be possible by the toll collectors to maintain the rhythmic mature. In order to reveal the fact if any such thing has happened or not, a framework has been developed in this study to check the consistency of data in a selected corridor by comparing the daily flow data recorded at two different stations in one corridor. For example, if daily flow data is recorded at Meghna Bridge and at a station at Noakhali on the Dhaka-Chittagong highway, the flow rate at the latter station would certainly be some percentage of the former, provided the

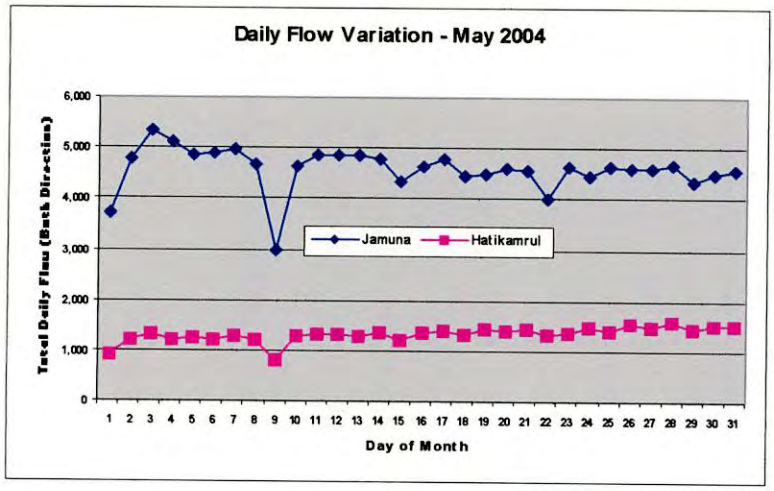
internal flow between Comilla and Noakhali is not significantly high in comparison to the corridor flow.

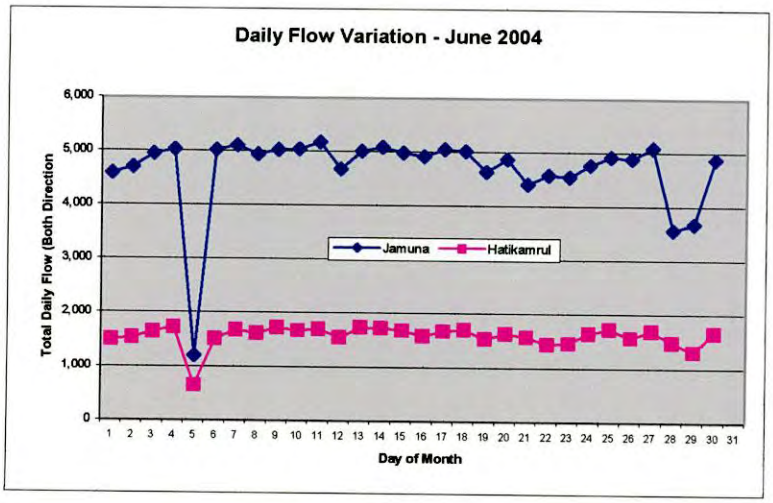
During this study one year daily traffic flow data on North Bengal Corridor at Hatikamrul station has been collected. Nalka-Hatikamrul-Bonpara is a newly opened road which carries the inter-district vehicles towards mainly Rajshahi and Noagaon. The road is owned by the Roads and Highways department and is the first tolled road in Bangladesh. The data has been originally recorded by the toll operator of the road – Pubali-Alloy JV Ltd. Since, the road carries a portion of traffic that pass through the Jamuna bridge, it is expected that the daily traffic flow variation pattern at both the stations will remain same, only the magnitude would differ. To check this, the data collected from both the stations were put in the framework and the following curves were obtained.

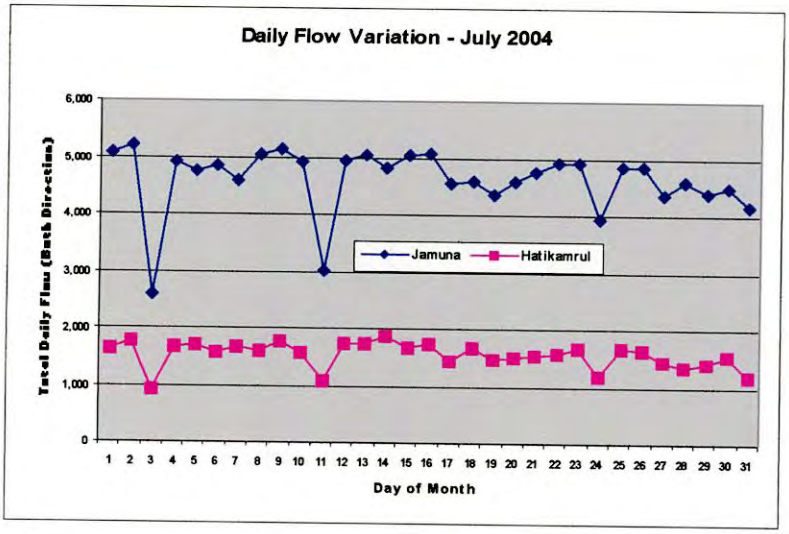
Table 4.22: Flow comparison between Jamuna Bridge and Hatikamrul Road

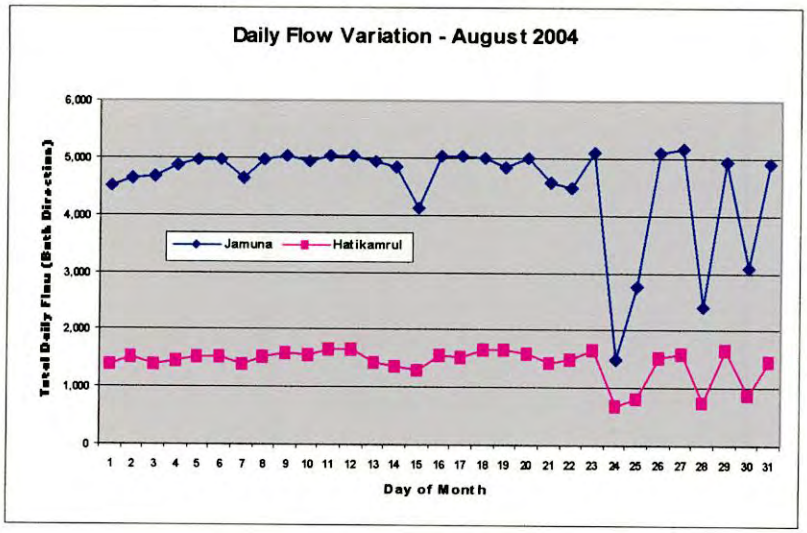
Month	Jamuna Bridge		Hatikamrul Station		Hatikamrul / Jamuna - Percentage	Avg.	Standard Deviation
	Monthly Total Volume	Monthly Percentage	Monthly Total Volume	Monthly Percentage			
May-04	142,297	7.73	41,321	7.02	**29.04%**	**31.97%**	**1.74**
Jun-04	140,345	7.62	47,397	8.05	**33.77%**		
Jul-04	143,343	7.79	48,082	8.17	**33.54%**		
Aug-04	140,924	7.65	44,119	7.49	**31.31%**		
Sep-04	146,481	7.96	45,291	7.69	**30.92%**		
Oct-04	147,180	7.99	47,326	8.04	**32.16%**		
Nov-04	157,491	8.55	52,864	8.98	**33.57%**		
Dec-04	169,018	9.18	57,895	9.83	**34.25%**		
Jan-05	180,426	9.80	59,489	10.10	**32.97%**		
Feb-05	147,964	8.04	47,239	8.02	**31.93%**		
Mar-05	167,355	9.09	48,974	8.32	**29.26%**		
Apr-05	158,215	8.59	48,852	8.30	**30.88%**		

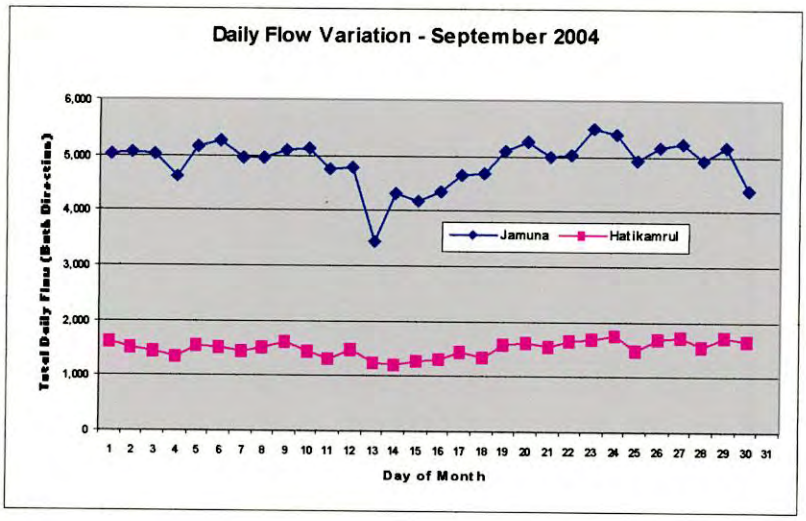
Data Source: MargaNet and Pubali-Alloy JV

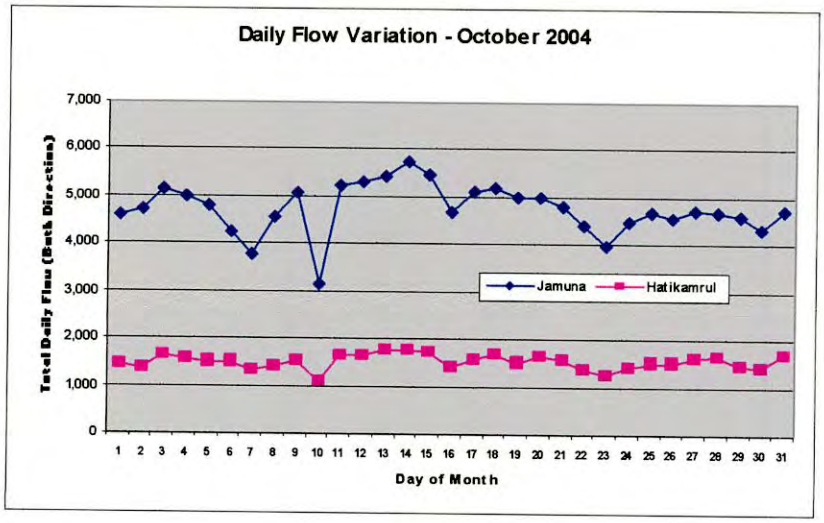

Daily Flow Variation - May 2004
Total Daily Flow (Both Directions)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month

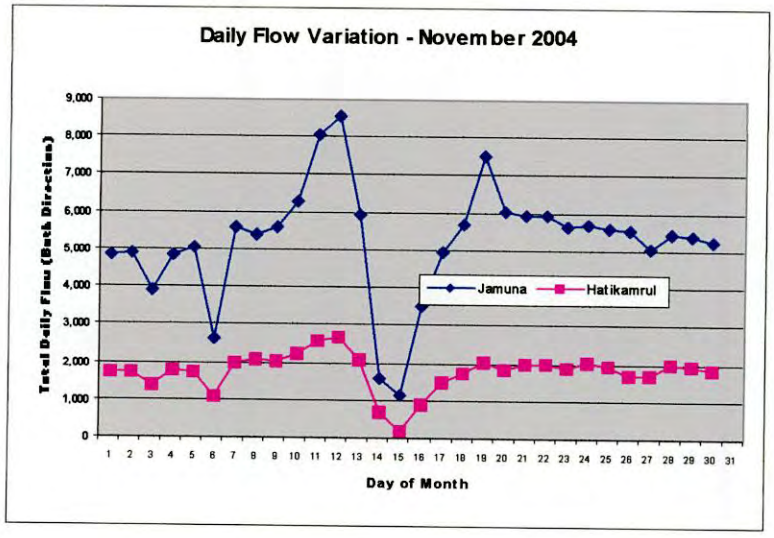

Daily Flow Variation - June 2004
Total Daily Flow (Both Direction
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month

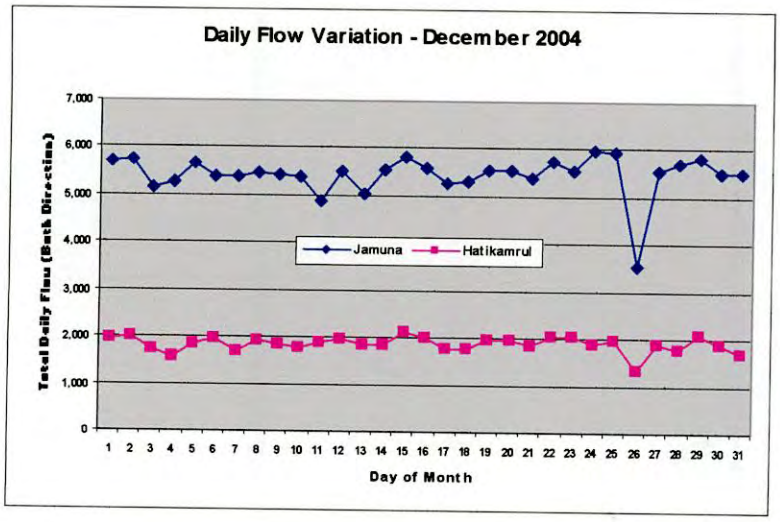

Daily Flow Variation - July 2004
Total Daily Flow (Both Directions)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month

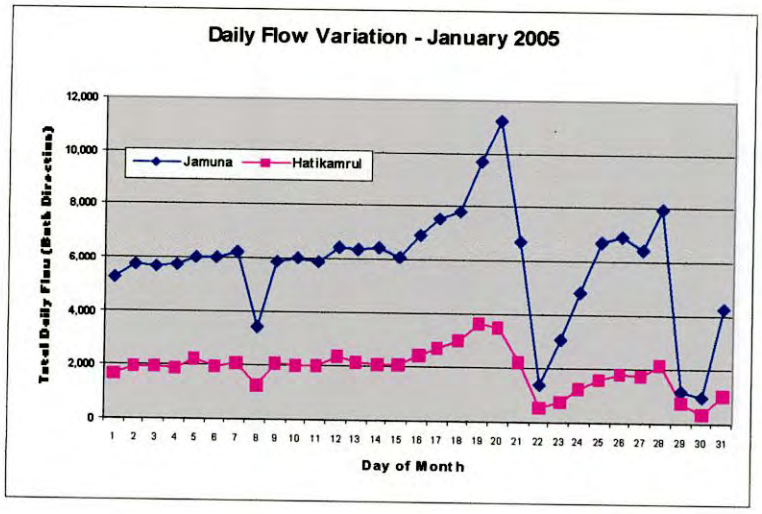

Daily Flow Variation - August 2004
Total Daily Flow (Both Directions)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month

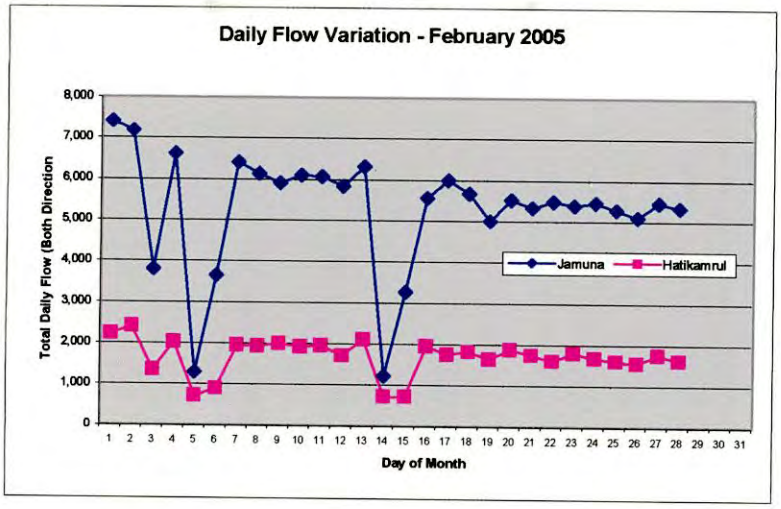

Daily Flow Variation - September 2004
Total Daily Flow (Both Directions)
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month

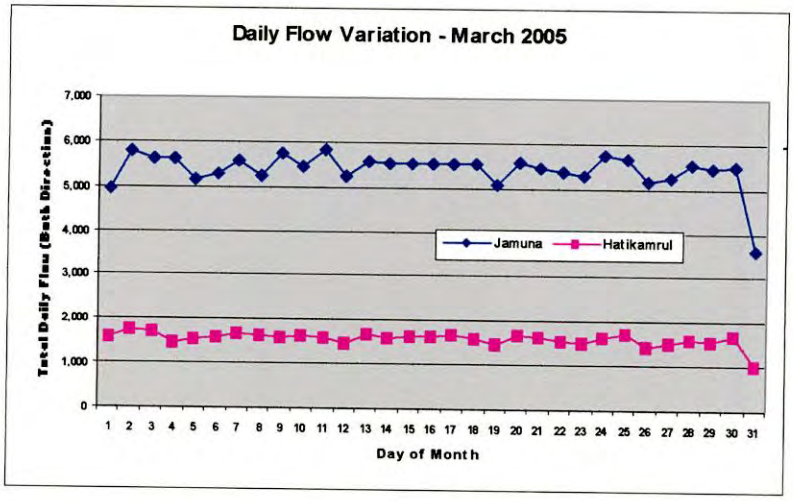

Daily Flow Variation - October 2004
Total Daily Flow (Both Directions)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month

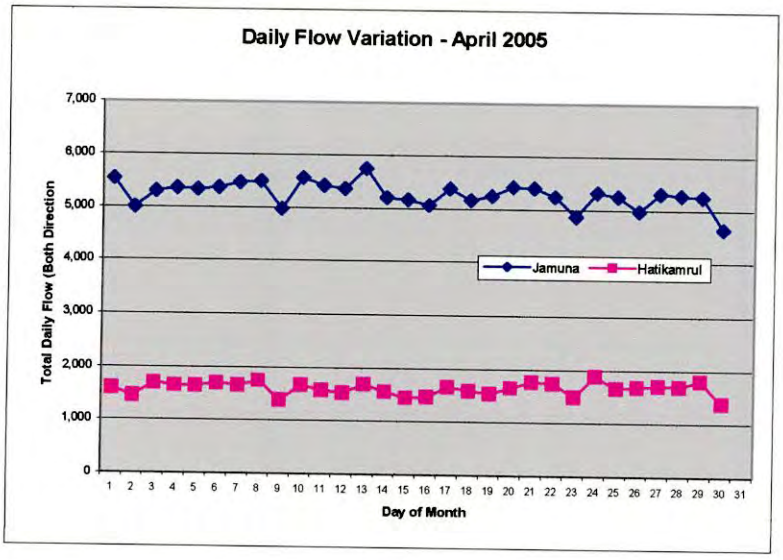

Daily Flow Variation - November 2004
Total Daily Flow (Both Directions)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month


Daily Flow Variation - December 2004
Total Daily Flow (Both Directions)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month

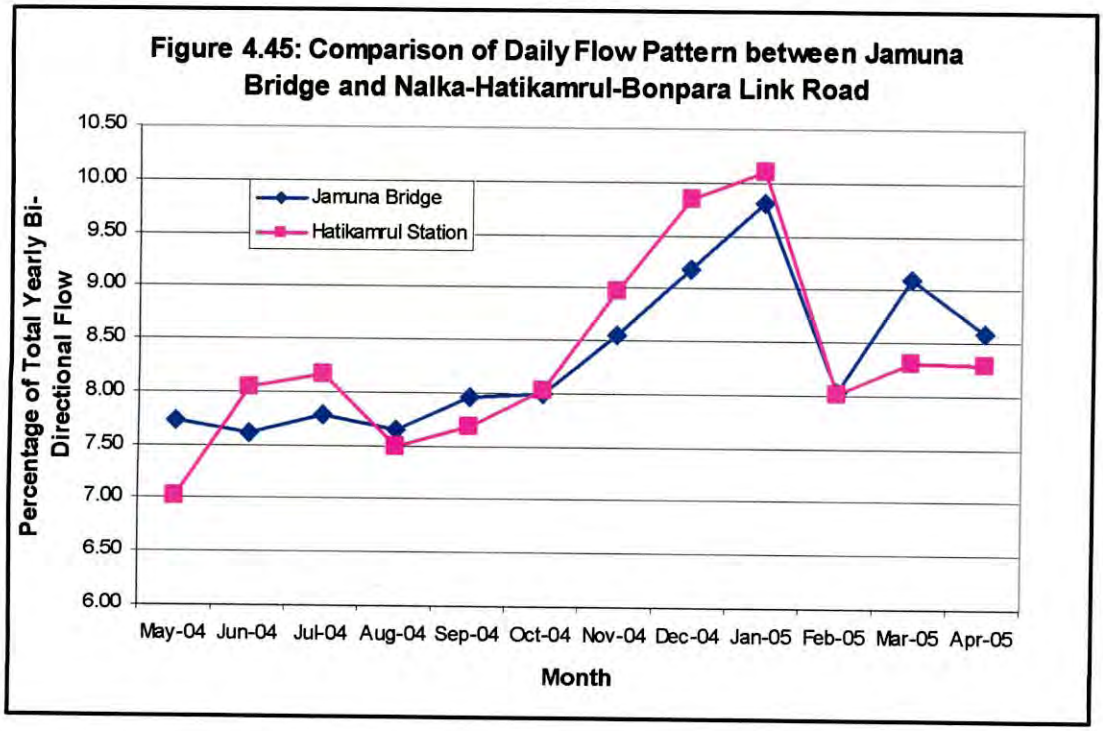

Daily Flow Variation - January 2005
Total Daily Flow (Both Directions)
12,000
10,000
8,000
6,000
4,000
2,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month


Daily Flow Variation - February 2005
Total Daily Flow (Both Direction
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month


Daily Flow Variation - March 2005
Total Daily Flow (Both Directions)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month


Daily Flow Variation - April 2005
Total Daily Flow (Both Direction
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jamuna
Hatikamrul
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month

From the above continuous daily flow patterns, one can easily understand that, Hatikamrul road carries a distinct portion of Jamuna bridge traffic. Despite different toll operator and authorities, the patterns are seen to have significant similarity, which implies that, both the toll operators have been performing well in collecting and recording data. It is also found from the analysis that, Hatilamrul road carries 31.97% of total traffic crossing the Jamuna bridge (as shown in Table 4.22). Further analysis on this might reveal important facts that may be useful for the transport planners for designing a new road facility. The framework can also be used for independent auditing purpose.



The above figure (Figure 4.45) shows the comparison between daily traffic flow patterns recorded in Jamuna Bridge and Nalka-Hatikamrul-Bonpara Link road from May 2004 to April 2005. It is found from the figure that, the two roads maintain very similar daily flow variation pattern, which certainly proves the consistency of data collection and preservation.

4.4 Overview

From the analyses of traffic characteristics made in this chapter, it has been found that, the corridor is stable in terms of traffic flow. The flow exhibits prominent hourly, daily, monthly variations, which are repetitive in nature. Therefore, it can be granted that, these data can be efficiently used for determination of the expansion factors and hence estimation of AADT from short counts. It has also been established that, a factor, named Eid Factor, is to be introduced encountering the impact of Eid festivals on traffic flow, which shall be used to determine the peak flow in a year. From Article 4.5.13, it was found that, the future flow prediction would only be accurate, if separate growth factors are used for different vehicle classes.

In the next chapter determination, calibration and validation of the said expansion factors, as well as Eid factor and growth factor are shown.

CHAPTER 5

ESTIMATION OF AADT FROM SHORT COUNTS

5.1 Introduction

A major objective of this study is to reliably determine the expansion factors or equations on the selected corridor; from which estimate of AADT from short counts can be made. From the previous chapter it has been established that the entry point of the selected North Bengal corridor that is Jamuna bridge is well stabilized. From the analyses made on the previous chapter, it was found that the data being used in this study is very reliable and the flow maintains definite repetitive nature of various flow patterns. Therefore, it is easily possible to determine hourly, daily, monthly expansion factors as well as growth factors and also Eid factor, by which future flow can be predicted by estimating AADT from short counts.

This chapter contains the determination of such factors using summarized traffic flow data on Jamuna bridge. For this purpose 13 weeks hourly data from BUET, 5 years' (1999 to 2003) continuous daily flow data from JOMAC and 2 years' (2004, 2005) continuous flow data from MargaNet has been used.

5.2 Expansion of Short Counts

It has already been discussed in Chapter 2 that, AADT can be estimated from short counts using two methods, namely – Factoring method and Regression Analysis. Both the methods have their own advantages and disadvantages. The accuracy level also varies depending on numerous parameters. The Factoring approach is mainly used in the United States to take the benefit of creating group factors to match the factors of short counts with data of permanent counters best reflecting those. Whereas, regression analysis uses best fit curve to match between short and long counts. However, in this study both factoring and regression analysis has been performed to estimate AADT from short counts and both these methods have been tested for accuracy.

5.3 Expansion Factors

In this section hourly, daily and monthly expansion factors have been established from existing traffic database, which can be used to estimate AADT from short counts.

5.3.1 Hourly Expansion Factors

Hourly Expansion Factors (HEF) has been determined using the 13 weeks hourly traffic flow data on Jamuna Bridge recorded by BUET. It has been previously found in Article 4.5.2 that the hourly flow variation for different vehicle class is different. Therefore, it is easily understood that hourly expansion factors for total vehicle would not be appropriate. Instead, hourly expansion factors for each vehicle class needs to be determined separately. Table 5.1 shows the average hourly flow of all vehicle classes obtained from 13 weeks of flow data. Here, 7 days' data on each survey has been averaged by BUET and those data has again been averaged for 13 weeks. From this, the hourly expansion factors have been determined using the following equation.

$$\text{Hourly Expansion Factor, HEF} = \frac{\text{Total 24 hour volume}}{\text{Volume for particular hour}}$$

The hourly expansion factors calculated as per above formula are given in Table 5.2.

Table 5.1: Hourly Bi-Directional Flow of Traffic (Averaged over 13 weeks)

Hours	L. Bus	M. Truck	L. Vehicle	S. Bus	S. Truck	M. Cycle	L. Truck	Total
	LB	MT	LV	SB	ST	MC	LT	
6 - 7	8	52	8	1	3	2	0	**75**
7 - 8	11	46	14	0	3	4	0	**78**
8 - 9	17	43	19	1	2	6	1	**88**
9 - 10	30	37	24	2	2	6	0	**101**
10-11	63	31	31	2	3	8	0	**137**
11-12	80	25	33	2	2	8	0	**152**
12-13	79	24	36	3	3	9	1	**154**
13-14	74	24	31	3	2	8	0	**142**
14-15	56	23	32	3	2	8	0	**123**
15-16	44	27	33	3	2	9	1	**118**
16-17	36	29	34	3	3	11	0	**117**
17-18	38	36	33	2	3	11	0	**124**
18-19	44	44	31	2	3	9	0	**134**
19-20	31	51	27	1	3	5	0	**119**
20-21	24	57	22	1	3	4	0	**111**
21-22	24	64	17	0	3	2	0	**111**
22-23	30	72	14	0	3	1	0	**122**
23-24	43	70	11	0	3	1	0	**129**
24 - 1	55	64	10	0	3	1	0	**133**
1 - 2	87	58	8	0	3	0	0	**156**
2 - 3	64	58	8	0	2	0	0	**133**
3 - 4	20	57	7	0	3	0	0	**88**
4 - 5	7	51	6	0	2	0	0	**67**
5 - 6	5	49	5	0	3	1	0	**63**
Total	**969**	**1093**	**494**	**31**	**64**	**114**	**8**	**2774**

Table 5.2: Hourly Expansion Factors, HEF (for Bi-Directional Traffic)

Hours	L. Bus	M. Truck	L. Vehicle	S. Bus	S. Truck	M. Cycle	L. Truck	Total
	LB	MT	LV	SB	ST	MC	LT	Vehicle
6 - 7	125.99	20.82	60.23	42.58	20.54	55.16	18.24	**37.11**
7 - 8	87.67	23.77	36.34	67.93	24.00	26.52	20.22	**35.35**
8 - 9	56.00	25.70	25.58	33.96	29.17	20.46	13.60	**31.36**
9 - 10	32.54	29.65	20.88	15.94	31.36	17.67	19.68	**27.41**
10-11	15.39	35.68	16.09	15.42	25.03	14.07	19.18	**20.18**
11-12	12.10	43.34	15.10	12.85	27.26	13.72	17.81	**18.30**
12-13	12.23	45.50	13.85	10.73	22.79	13.36	15.27	**18.04**
13-14	13.10	46.27	16.14	10.49	28.59	14.71	19.18	**19.59**
14-15	17.37	47.50	15.56	12.24	27.64	14.99	24.93	**22.48**
15-16	22.09	40.97	14.92	11.19	27.78	12.82	14.96	**23.46**
16-17	27.25	37.33	14.41	11.64	22.09	10.07	19.18	**23.81**
17-18	25.38	30.42	14.87	13.27	22.61	10.14	17.00	**22.32**
18-19	22.13	24.96	15.72	16.40	19.91	12.41	22.00	**20.74**
19-20	31.40	21.49	18.27	25.94	22.26	21.43	24.13	**23.40**
20-21	40.68	19.03	22.72	43.23	23.52	30.15	31.17	**25.11**
21-22	40.77	17.02	28.42	63.40	23.33	60.65	28.77	**25.04**
22-23	32.12	15.09	34.91	67.93	22.35	92.60	39.37	**22.82**
23-24	22.66	15.57	43.31	105.67	22.43	138.28	44.00	**21.58**
24 - 1	17.51	17.20	47.36	114.12	22.96	225.46	62.33	**20.85**
1 - 2	11.19	18.87	58.97	73.15	23.43	797.77	32.52	**17.73**
2 - 3	15.09	18.81	64.55	219.46	27.13	864.25	124.67	**20.91**
3 - 4	47.72	19.02	72.81	167.82	19.57	797.77	49.87	**31.40**
4 - 5	131.83	21.29	85.38	178.31	26.27	1152.33	49.87	**41.18**
5 - 6	209.98	22.11	99.32	203.79	22.61	188.56	32.52	**44.12**
Peak Hour Factors	11.19	15.09	13.85	10.49	19.57	10.07	13.60	**17.73**
Peak Hour	1-2	22-23	12-13	13-14	3-4	16-17	8-9	**1-2**
Standard Deviation	48.30	10.76	25.28	66.33	3.10	335.51	23.66	**7.36**

Notes:

- The above HEF can be directly used to expand hourly traffic volumes to avg. daily volume.
- Example of Application is given in Article 5.6.

In the above table hourly expansion factors for each vehicle class as well as total traffic in both directions are shown. Peak Hour Factor for total traffic is found to be 17.73 in the hour from 1:00 to 2:00 AM. Also noticeable is the occurrence of different peak hours for individual vehicle class.

From the hourly directional distribution analysis on Jamuna bridge, as given in Article 4.2.8, it has been found that, hourly directional distribution varies within a wide range. Therefore, by using the above expansion factors, one might determine the ADT, consideration of directional split for that particular hour, especially for the predominant vehicles, shall be more appropriate for highway designing and planning.

5.3.2 Daily Expansion Factors

Continuous daily traffic flow data on Jamuna bridge from 1999 to 2005 have been used to determine Daily Expansion Factor. First the raw data has been summarized to determine the average daily flow for each of seven days of week individually for all 7 years. From those summarized data, daily expansion factors for each year have been determined by dividing average weekly by flow average weekday flow. Then, those daily expansion factors representing their respective years have again been averaged to achieve the average Daily Expansion Factors. Table 5.3 shows the daily expansion factors and yearly average flow on each weekdays from 1999 to 2005. Summation of these daily flow for seven weekdays gives average weekly flow, which have been determined individually for every year. From these Daily Expansion Factors have been calculated. Taking the mean value for daily expansion factors for the years 1999 to 2005, average daily expansion factors have been determined. The following formula is used to calculate the daily expansion factors.

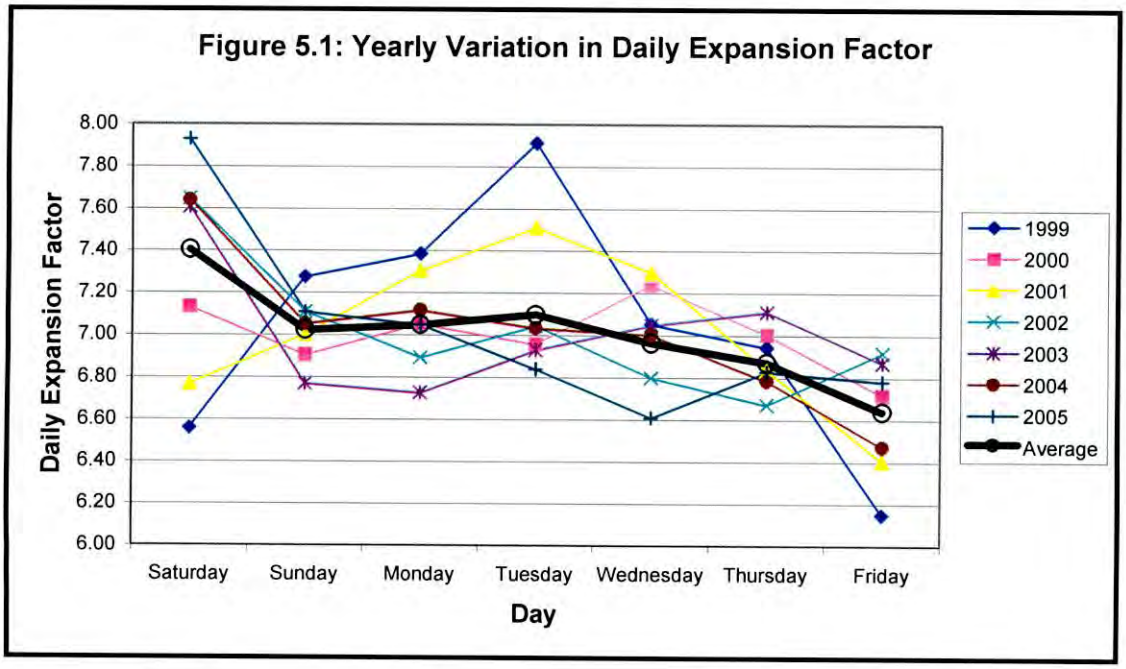
$$\text{Daily Expansion Factor, DEF} = \frac{\text{Average total weekly volume}}{\text{Average volume for particular day}}$$

Table 5.3: Daily Expansion Factors, DEF (for Bi-Directional Traffic)

Day \ Year	1999		2000		2001		2002	
	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF
Saturday	2,578	6.56	2,801	7.13	3,330	6.77	3,241	7.65
Sunday	2,323	7.28	2,892	6.91	3,219	7.00	3,487	7.11
Monday	2,289	7.39	2,832	7.06	3,086	7.31	3,596	6.89
Tuesday	2,136	7.91	2,871	6.96	3,001	7.51	3,519	7.04
Wednesday	2,397	7.05	2,758	7.24	3,089	7.30	3,646	6.80
Thursday	2,435	6.94	2,852	7.01	3,297	6.84	3,717	6.67
Friday	2,749	6.15	2,975	6.72	3,518	6.41	3,583	6.92
Avg. Weekly Flow	16,908		19,980		22,540		24,789	

Day \ Year	2003		2004		2005		Average	
	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF
Saturday	3,803	7.61	4,370	7.64	4,669	7.93	**3,542**	**7.40**
Sunday	4,273	6.77	4,733	7.05	5,210	7.11	**3,734**	**7.02**
Monday	4,299	6.73	4,690	7.12	5,254	7.05	**3,721**	**7.05**
Tuesday	4,173	6.93	4,747	7.03	5,414	6.84	**3,694**	**7.10**
Wednesday	4,103	7.05	4,767	7.00	5,603	6.61	**3,766**	**6.96**
Thursday	4,068	7.11	4,920	6.78	5,422	6.83	**3,816**	**6.87**
Friday	4,211	6.87	5,159	6.47	5,460	6.78	**3,951**	**6.64**
Avg. Weekly Flow	28,930		33,385		37,032		**26,223**	

To observe the variations in daily expansion factors from year to year, the same has been plotted for all seven years in Figure 5.1. It can be seen that in 1999 and 2001, midweek DEF is higher than that on weekend. All the other years show highest DEF on Saturday and lowest DEF on Friday, which implies that maximum flow occurs on Friday. This complies with the daily flow fluctuation analysis given in Article 4.2.3. Accordingly the average DEF have furnished similar variation.



As in the case of hourly expansion factors, since all vehicle classes do not exhibit similar daily flow fluctuation, daily expansion factors need to be determined and used separately for each vehicle class. Table 5.4 shows the classwise daily expansion factors.

Table 5.4: Class-wise Daily Expansion Factors, DEF (for Bi-Directional Traffic)

Day	Large Bus	Medium Truck	Light Vehicles	Small Bus	Small Truck	Motor Cycle	Large Truck	Total Traffic
Saturday	7.22	7.76	7.22	6.84	7.48	6.68	7.81	**7.40**
Sunday	7.07	6.77	7.43	7.10	7.15	7.42	7.08	**7.02**
Monday	7.10	6.80	7.46	7.34	6.87	7.65	6.90	**7.05**
Tuesday	7.12	6.87	7.44	7.65	6.96	7.79	6.83	**7.10**
Wednesday	7.03	6.72	7.36	7.13	6.67	7.91	6.68	**6.96**
Thursday	6.91	6.94	6.75	6.74	6.79	6.69	6.82	**6.87**
Friday	6.58	7.25	5.74	6.36	7.13	5.54	6.99	**6.64**

Notes:

- The above DEF can be directly used to estimate average weekly volume.
- Example of application is given in Article 5.6.

It is to be noted here that, directional distribution does not have any major effect on daily expansion factors because, as found during daily directional distribution analysis, given in Article 4.2.8, the directional split ranges between 48% to 52%, which is not very significant. Therefore, the Average DEF's given in Table 5.4 may be used for estimation of AADT from short counts.

5.3.3 Monthly Expansion Factors

Similar approach has been adopted to determine the monthly or seasonal expansion factors. At first monthly expansion factors for each of concerned year have been calculated. Then those seven factors have been averaged to determine the final monthly expansion factors. Table 5.5 (a, b, c and d) below contains the monthly expansion factors on Jamuna Bridge corridor for each individual year (1999 to 2005), while the average values obtained from these are given in Table 5.6.

The equation used for calculation of monthly expansion factors is:

$$\text{Monthly Expansion Factor, MEF} = \frac{\text{AADT}}{\text{ADT for particular month}}$$

Table 5.5a: Monthly Expansion Factors 1999, 2000

Month \ Year	1999			2000		
	Flow	ADT	MEF	Flow	ADT	MEF
January	90,390	2,916	**0.829**	91,222	2,943	**0.969**
February	74,152	2,648	**0.913**	77,506	2,673	**1.067**
March	91,390	2,948	**0.820**	101,442	3,272	**0.872**
April	81,615	2,721	**0.888**	85,998	2,867	**0.995**
May	68,364	2,205	**1.096**	84,824	2,736	**1.043**
June	69,084	2,303	**1.050**	82,696	2,757	**1.035**
July	68,208	2,200	**1.098**	86,879	2,803	**1.018**
August	62,932	2,030	**1.191**	80,847	2,608	**1.094**
September	60,048	2,002	**1.208**	78,509	2,617	**1.090**
October	65,983	2,128	**1.136**	87,183	2,812	**1.014**
November	65,145	2,172	**1.113**	90,116	3,004	**0.950**
December	84,655	2,731	**0.885**	97,450	3,144	**0.908**
Total		29003			34234	
AADT		2417			2853	

Table 5.5b: Monthly Expansion Factors 2001, 2002

Month \ Year	2001			2002		
	Flow	ADT	MEF	Flow	ADT	MEF
January	104,393	3,368	**0.955**	110,248	3,556	**0.996**
February	88,775	3,171	**1.014**	105,303	3,761	**0.942**
March	114,133	3,682	**0.874**	110,577	3,567	**0.993**
April	84,915	2,831	**1.136**	101,651	3,388	**1.045**
May	100,738	3,250	**0.990**	107,076	3,454	**1.025**
June	96,132	3,204	**1.004**	101,962	3,399	**1.042**
July	106,750	3,444	**0.934**	100,400	3,239	**1.094**
August	99,045	3,195	**1.007**	103,788	3,348	**1.058**
September	78,450	2,615	**1.230**	102,460	3,415	**1.037**
October	93,019	3,001	**1.072**	114,256	3,686	**0.961**
November	95,727	3,191	**1.008**	108,495	3,617	**0.979**
December	113,111	3,649	**0.882**	126,322	4,075	**0.869**
Total		38598			42504	
AADT		3217			3542	

Table 5.5c: Monthly Expansion Factors 2003, 2004

Month \ Year	2003			2004		
	Flow	ADT	MEF	Flow	ADT	MEF
January	118,564	3,825	**1.081**	152,370	4,915	**0.970**
February	119,435	4,266	**0.969**	132,196	4,558	**1.046**
March	115,870	3,738	**1.106**	140,377	4,528	**1.053**
April	115,956	3,865	**1.069**	134,061	4,469	**1.067**
May	124,212	4,007	**1.032**	142,297	4,590	**1.039**
June	125,251	4,175	**0.990**	140,345	4,678	**1.020**
July	135,028	4,356	**0.949**	143,343	4,624	**1.032**
August	126,283	4,074	**1.015**	140,924	4,546	**1.049**
September	128,154	4,272	**0.968**	146,481	4,883	**0.977**
October	134,913	4,352	**0.950**	147,180	4,748	**1.005**
November	124,373	4,146	**0.997**	157,491	5,250	**0.909**
December	140,441	4,530	**0.912**	169,018	5,452	**0.875**
Total		49604			57241	
AADT		4134			4770	

Table 5.5d: Monthly Expansion Factors 2005

Month \ Year	2005		
	Flow	ADT	MEF
January	180,426	5,820	**0.909**
February	147,964	5,284	**1.001**
March	167,355	5,399	**0.980**
April	158,215	5,274	**1.003**
May	157,247	5,072	**1.043**
June	160,719	5,357	**0.987**
July	158,730	5,120	**1.033**
August	153,591	4,955	**1.068**
September	157,462	5,249	**1.008**
October	152,113	4,907	**1.078**
November	165,180	5,506	**0.961**
December	171,311	5,526	**0.957**
Total		63469	
AADT		5289	

Table 5.6: Monthly Expansion Factors, MEF (for Bi-Directional Traffic)

Month	Avg. MEF
January	**0.959**
February	**0.993**
March	**0.957**
April	**1.029**
May	**1.038**
June	**1.018**
July	**1.023**
August	**1.069**
September	**1.074**
October	**1.031**
November	**0.988**
December	**0.898**

Notes:

- The above MEF can be directly used to estimate AADT from Avg. 24-hour volume.
- Example of application is given in Article 5.6.

It is noticeable in the above table that the expansion factors for rainy season months are higher than those for dry season month, which refers that traffic flow in rainy season is lower than in dry season.

It is to be noted here that, from the analysis shown in Article 4.2.5 in this study it was found that no significant dissimilarities in pattern is observed for individual vehicle class and total vehicle. Therefore, monthly expansion factors for individual vehicle class is not necessarily to be used for AADT estimation, rather average factors may be effectively applied.

5.3.4 Growth Factor

In this study an attempt has been made to determine the growth factor on the selected corridor, using which future traffic flow can be estimated by extrapolation method. From

the growth pattern analysis using daily traffic data from 1999 to 2005, as given in Article 4.2.11, it has been firmly established that the traffic growth trend is explicit on Jamuna bridge corridor. Therefore, determination of growth factor utilizing these data might be useful for prediction of future traffic with respect to base year AADT. In the Pavement Design Guide for Roads & Highways Department published in April 2005, traffic growth rate for national road is taken to be 10% per annum. But from the analyses of seven years data, it was found to be 14% per annum for this highway corridor. Moreover, it has been found that, instead of using flat growth rate for total vehicle, separate growth rates for individual vehicle class should be used to improve accuracy of prediction.

Table 5.7: Class-wise Total Yearly Traffic in Both Direction (1999 to 2005)

Year	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	Total Traffic
1999	216,913	303,488	208,811	84,111	19,117	46,875	2,651	**881,966**
2000	275,865	370,233	216,851	105,496	34,279	39,610	2,338	**1,044,672**
2001	302,220	450,639	202,601	127,741	47,419	37,206	6,299	**1,174,125**
2002	445,010	489,274	214,327	37,017	64,047	35,047	7,816	**1,292,538**
2003	511,972	601,367	238,369	26,882	81,718	33,036	15,136	**1,508,480**
2004	577,808	725,230	245,012	30,999	108,079	35,795	23,160	**1,746,083**
2005	632,938	771,500	289,910	30,720	134,709	42,155	28,381	**1,930,313**

Table 5.8: Class-wise Traffic Growth Factors

Year	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	Total Traffic	Average
1999	-	-	-	-	-	-	-	-	
2000	27.18%	21.99%	3.85%	25.42%	79.31%	-15.50%	-11.81%	**18.45%**	
2001	9.55%	21.72%	-6.57%	21.09%	38.33%	-6.07%	169.42%	**12.39%**	
2002	47.25%	8.57%	5.79%	-71.02%	35.07%	-5.80%	24.08%	**10.09%**	**13.99%**
2003	15.05%	22.91%	11.22%	-27.38%	27.59%	-5.74%	93.65%	**16.71%**	
2004	12.86%	20.60%	2.79%	15.32%	32.26%	8.35%	53.01%	**15.75%**	
2005	9.54%	6.38%	18.32%	-0.90%	24.64%	17.77%	22.54%	**10.55%**	
Avg. GF	**20.24%**	**17.03%**	**5.90%**	**-6.25%**	**39.53%**	**-1.16%**	**58.48%**	**13.99%**	
Std. Dvtn.	14.75%	7.47%	8.39%	37.11%	20.11%	12.01%	64.79%	3.46%	

Table 5.7 shows total yearly volume of traffic in both directions for each vehicle class. From this table, the increase or decrease of a particular vehicle class in each year during the study period can easily be found. The amount of increase or decrease in one year expressed in percentage of base year value is the traffic growth rate for that particular year. The growth factors calculated in this manner are shown in Table 5.8. It can be seen that, not all vehicle class follow similar growth pattern. Taking the average value of six growth factors, it has been found that average growth rate of total traffic is 13.99% is pretty consistent during the study period showing standard deviation of only 3.46%. But, for individual class's growth factors, they have been found to be quite erratic which is reflected in their standard deviations. Larger values of standard deviation indicate that the growth factors for individual vehicle classes are not predictable. This may be because of the fact that since Bangladesh is a developing country, the traffic composition has not been stabilized yet. Availability of few more years of data could make it possible to understand a definite trend of class-wise traffic growth. However, from the existing database, it has been found that, growth rate for motorcycle and small bus is negative, while all other classes show positive growth rate. The above-determined growth factors may be used for prediction purpose, particularly for planning any transport facility along this highway corridor.

5.4 Regression Analysis

Although Expansion Factor is easier and hence more popular method for estimation of AADT from short counts and as described earlier in Chapter 2, that it is recommended by AASHTO and Traffic Monitoring Guide and thus mostly adopted in the United States, this study emphasizes on determination of expansion factors for estimation of AADT. But in this study regression analyses of the traffic flow data in the selected corridor have also been made. By regression analysis, some equations have been derived, and also corresponding calibration curves have been drawn in order to calculate AADT using regression approach, for cross checking purpose .

The raw database has first been sorted and summarized for this application. Using the summarized database, the regression analyses have been performed and models have been rendered. This article shows the equations and models derived by regression analyses.

5.4.1 Hourly Regression Model

The hourly regression model has been developed using 13 weeks of hourly flow data on Jamuna bridge collected by BUET. Therefore, against each hourly traffic volume 91 ADT value was available, which resulted a linear regression model with a fair degree of accuracy. Thus, total 24 hourly regression models have been developed, one for each hour of day. Using the regression analysis, ADT can be determined for a given hourly volume using either the curve or the equation. Since, the 13 weeks data that has been used here is scattered all round the year, the regression method estimation approach may be quite reliable.

Here follows the equations along with their respective R^2 values derived for every hour and also the calibration curves that may be used directly to find out ADT from a know hourly volume.

Table 5.9: Hourly Expansion Linear Models (for Bi-Directional Traffic)

Hour	Equation	R^2 value
6 - 7	y = 37.04x - 75.983	0.917
7 - 8	y = 32.625x + 204.88	0.9056
8 - 9	y = 36.296x - 409.69	0.8492
9 - 10	y = 31.866x - 440.01	0.884
10-11	y = 25.894x - 791.1	0.9065
11-12	y = 23.312x - 712.61	0.8813
12-13	y = 17.262x + 109.27	0.8642
13-14	y = 21.607x - 262.08	0.8966
14-15	y = 18.624x + 504.3	0.954
15-16	y = 26.038x - 271.19	0.8745
16-17	y = 29.537x - 581.77	0.9153
17-18	y = 21.266x + 123.9	0.8895
18-19	y = 22.142x - 193.99	0.8485
19-20	y = 24.395x - 124.8	0.9266
20-21	y = 19.45x + 574.27	0.9142
21-22	y = 19.47x + 609.66	0.8443
22-23	y = 17.814x + 601.99	0.7679
23-24	y = 16.36x + 718.67	0.8111
24 - 1	y = 16.229x + 607.88	0.8355
1 - 2	y = 13.436x + 665.04	0.833
2 - 3	y = 10.759x + 1286	0.8562
3 - 4	y = 16.623x + 1284.3	0.8067
4 - 5	y = 21.348x + 1312.5	0.7926
5 - 6	y = 19.359x + 1565.3	0.7202

Where:

x = observed hourly flow (both direction)

y = Average Daily Traffic (ADT)

5.4.2 Daily Regression Model

The Daily regression models for expansion of short counts have been derived using daily traffic flow data on Jamuna bridge from 1999 to 2003 collected by JOMAC. Total 261 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models.

Table 5.10: Daily Expansion Models

Day	Equation	R^2 value
Saturday	y = 6.5503x + 2444.6	0.772
Sunday	y = 6.1008x + 3059.7	0.9124
Monday	y = 5.6664x + 4339.9	0.8854
Tuesday	y = 6.1683x + 3029.1	0.9106
Wednesday	y = 8983x + 3563.7	0.8881
Thursday	y = 6.2087x + 2361	0.8705
Friday	y = 6.0266x + 2585.7	0.8247

Where:

x = observed daily traffic

y = weekly traffic

The daily expansion equations are shown in the above table, while the corresponding curves are presented in the following pages.

5.4.3 Monthly Regression Model

For the regression analysis of monthly or seasonal expansions, five years of flow data on Jamuna Bridge collected by JOMAC have been used. Linear regression has been performed for each of twelve months by plotting monthly flow against respective yearly flow. The equations along with respective R^2 values are shown below in Table 5.11. It can be seen that in all the cases except for March, the R^2 values are quite reliable. This might have happened because of greater existence of external factors in March than in other months of the year during the study period. Further population of data in analysis may give a clear picture.

Table 5.11: Monthly Expansion Models

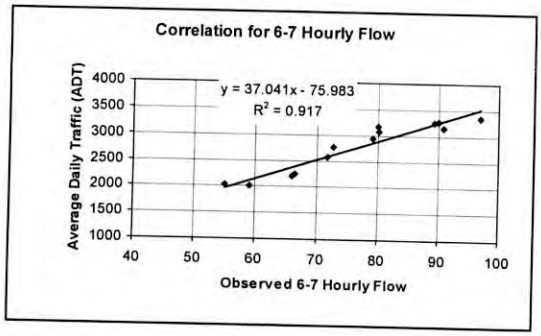
Month	Equation	R^2 value
January	y = 21.049x - 988685	0.9504
February	y = 14.272x - 253605	0.9264
March	y = 19.013x - 860860	0.6407
April	y = 14.166x - 202259	0.8431
May	y = 10.967x + 136367	0.9733
June	y = 10.618x + 184504	0.9878
July	y = 9.2474x + 289399	0.9584
August	y = 9.8884x + 263342	0.9973
September	y = 8.4357x + 450866	0.9112
October	y = 8.669x + 345728	0.9766
November	y = 9.99x + 223829	0.9718
December	y = 10.429x + 4828	0.9646

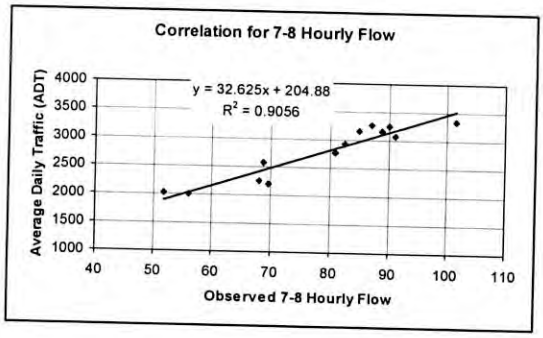
Where:

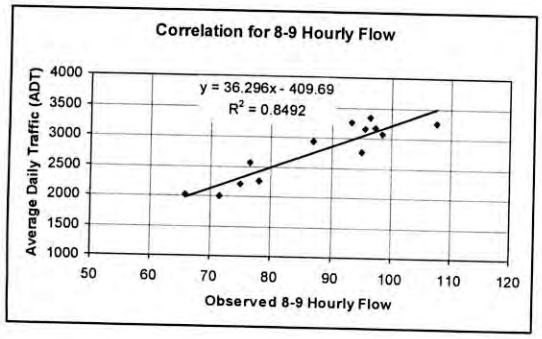
x = observed monthly traffic

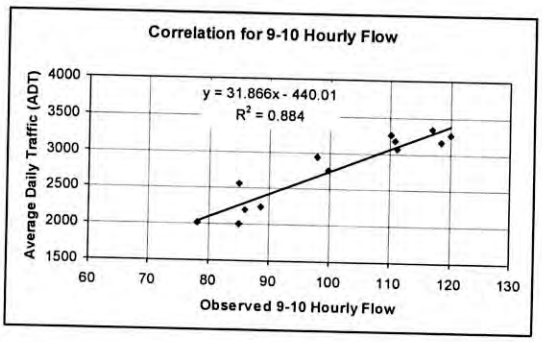
y = yearly traffic volume

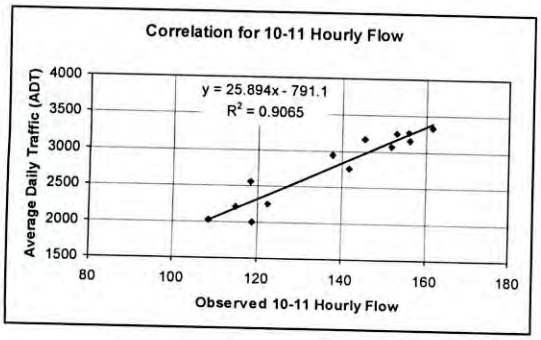
The linear regression curves are given on the following pages. These hourly, daily and monthly calibration curves can be directly used to estimate AADT from hourly flow.

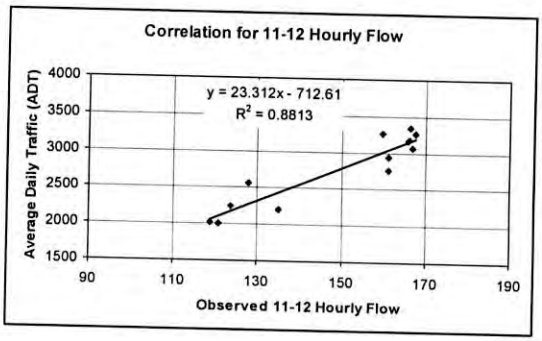

Correlation for 6-7 Hourly Flow
y = 37.041x - 75.983
R² = 0.917
Average Daily Traffic (ADT)
Observed 6-7 Hourly Flow

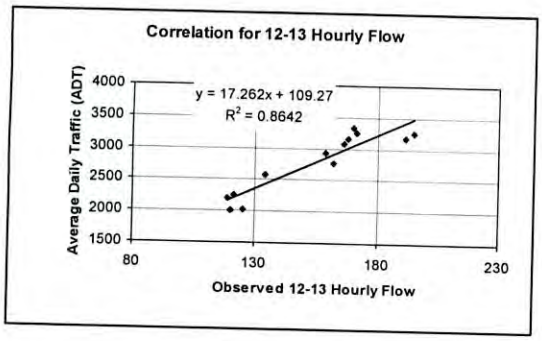

Correlation for 7-8 Hourly Flow
y = 32.625x + 204.88
R² = 0.9056
Average Daily Traffic (ADT)
Observed 7-8 Hourly Flow

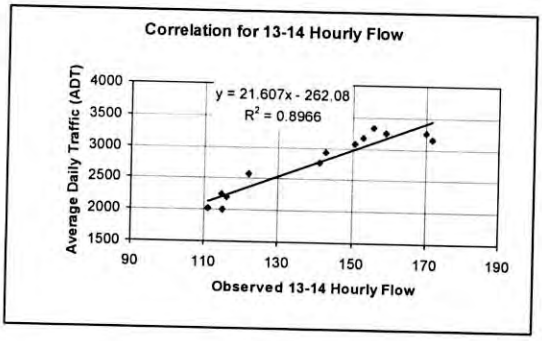

Correlation for 8-9 Hourly Flow
y = 36.296x - 409.69
R² = 0.8492
Average Daily Traffic (ADT)
Observed 8-9 Hourly Flow

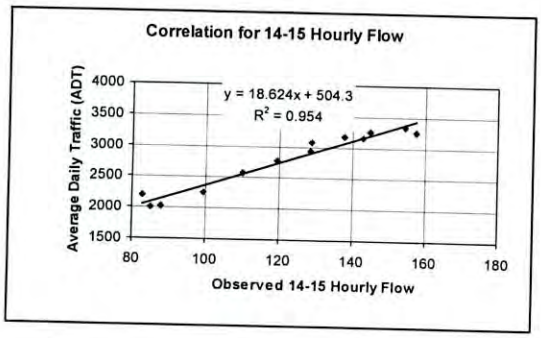

Correlation for 9-10 Hourly Flow
y = 31.866x - 440.01
R² = 0.884
Average Daily Traffic (ADT)
Observed 9-10 Hourly Flow

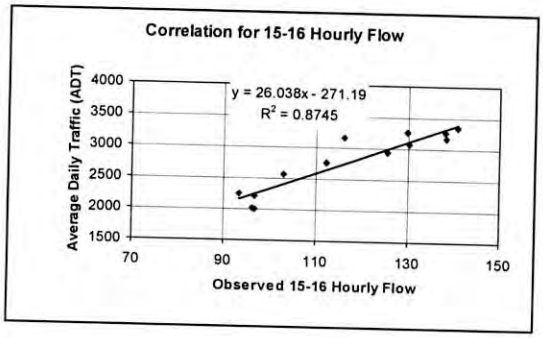

Correlation for 10-11 Hourly Flow
y = 25.894x - 791.1
R² = 0.9065
Average Daily Traffic (ADT)
Observed 10-11 Hourly Flow

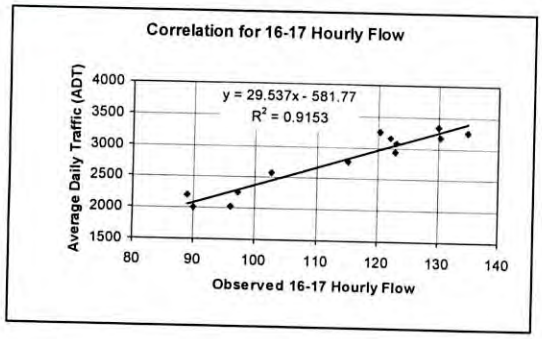

Correlation for 11-12 Hourly Flow
y = 23.312x - 712.61
R² = 0.8813
Average Daily Traffic (ADT)
Observed 11-12 Hourly Flow

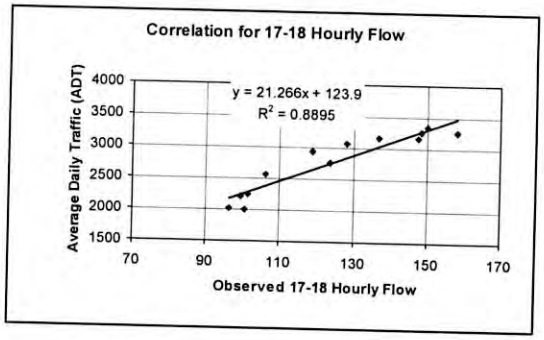

Correlation for 12-13 Hourly Flow
y = 17.262x + 109.27
R² = 0.8642
Average Daily Traffic (ADT)
Observed 12-13 Hourly Flow

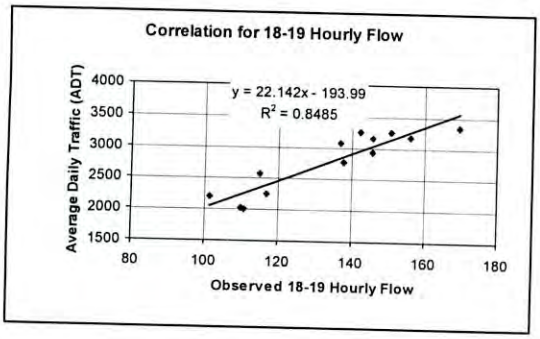

Correlation for 13-14 Hourly Flow
y = 21.607x - 262.08
R² = 0.8966
Average Daily Traffic (ADT)
Observed 13-14 Hourly Flow

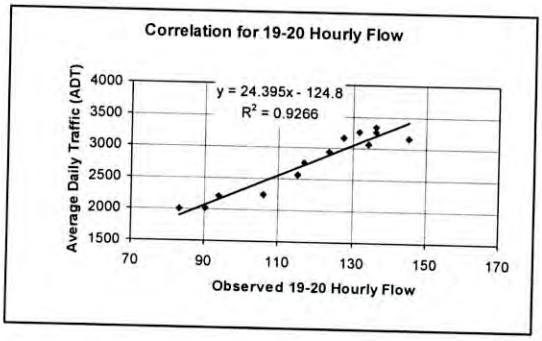

Correlation for 14-15 Hourly Flow
y = 18.624x + 504.3
R² = 0.954
Average Daily Traffic (ADT)
Observed 14-15 Hourly Flow

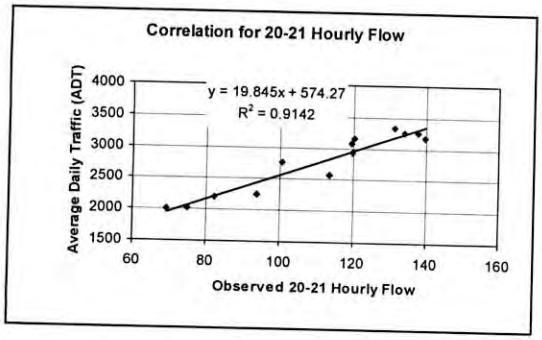

Correlation for 15-16 Hourly Flow
y = 26.038x - 271.19
R² = 0.8745
Average Daily Traffic (ADT)
Observed 15-16 Hourly Flow

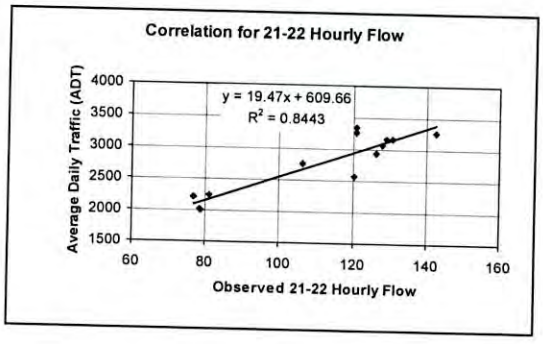

Correlation for 16-17 Hourly Flow
y = 29.537x - 581.77
R² = 0.9153
Average Daily Traffic (ADT)
Observed 16-17 Hourly Flow

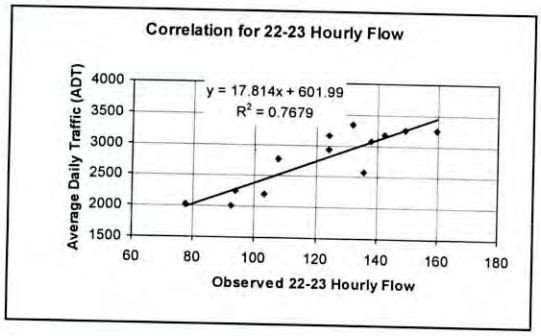

Correlation for 17-18 Hourly Flow
y = 21.266x + 123.9
R² = 0.8895
Average Daily Traffic (ADT)
Observed 17-18 Hourly Flow

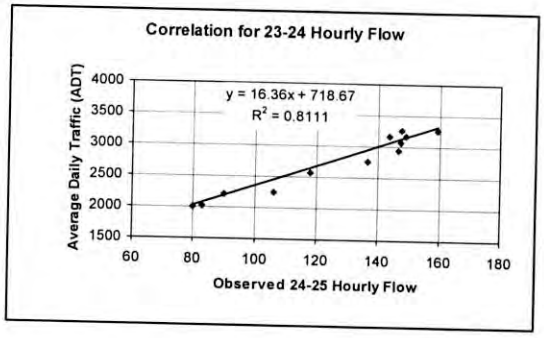

Correlation for 18-19 Hourly Flow
y = 22.142x - 193.99
R² = 0.8485
Average Daily Traffic (ADT)
Observed 18-19 Hourly Flow

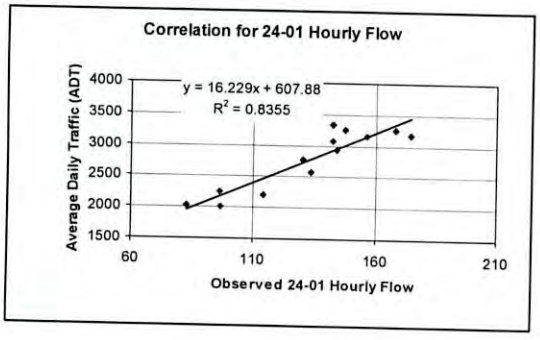

Correlation for 19-20 Hourly Flow
y = 24.395x - 124.8
R² = 0.9266
Average Daily Traffic (ADT)
Observed 19-20 Hourly Flow

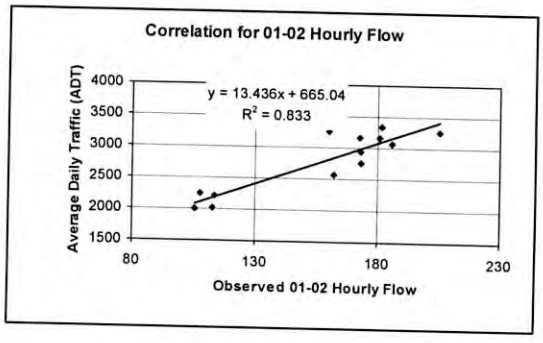

Correlation for 20-21 Hourly Flow
y = 19.845x + 574.27
R² = 0.9142
Average Daily Traffic (ADT)
Observed 20-21 Hourly Flow

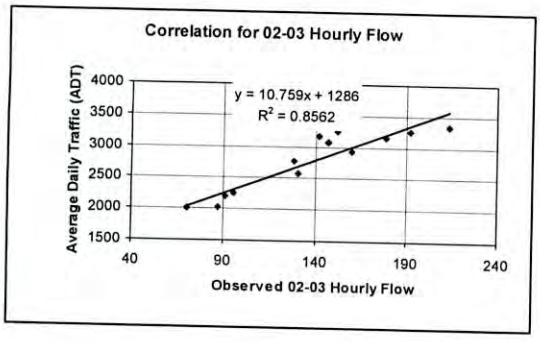

Correlation for 21-22 Hourly Flow
y = 19.47x + 609.66
R² = 0.8443
Average Daily Traffic (ADT)
Observed 21-22 Hourly Flow

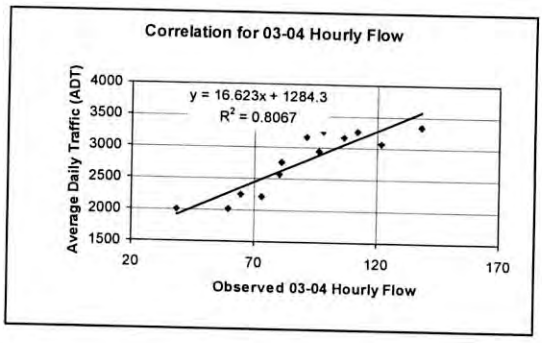

Correlation for 22-23 Hourly Flow
y = 17.814x + 601.99
R² = 0.7679
Average Daily Traffic (ADT)
4000
3500
3000
2500
2000
1500
60
80
100
120
140
160
180
Observed 22-23 Hourly Flow

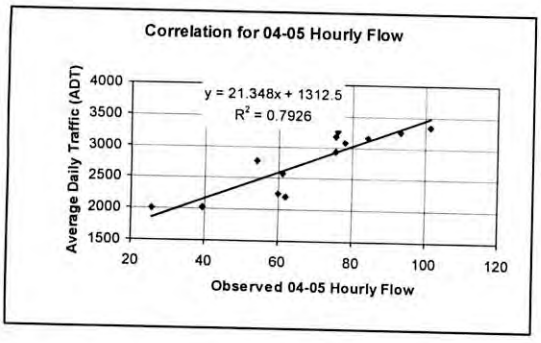

Correlation for 23-24 Hourly Flow
y = 16.36x + 718.67
R² = 0.8111
Average Daily Traffic (ADT)
4000
3500
3000
2500
2000
1500
60
80
100
120
140
160
180
Observed 24-25 Hourly Flow

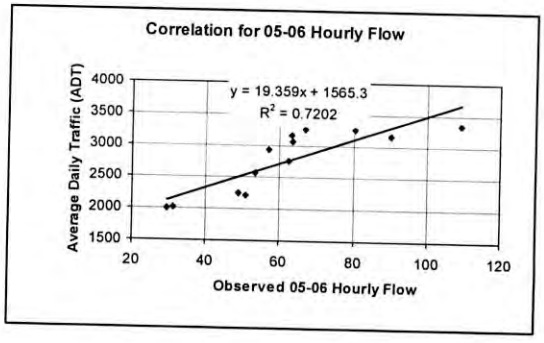

Correlation for 24-01 Hourly Flow
y = 16.229x + 607.88
R² = 0.8355
Average Daily Traffic (ADT)
4000
3500
3000
2500
2000
1500
60
110
160
210
Observed 24-01 Hourly Flow

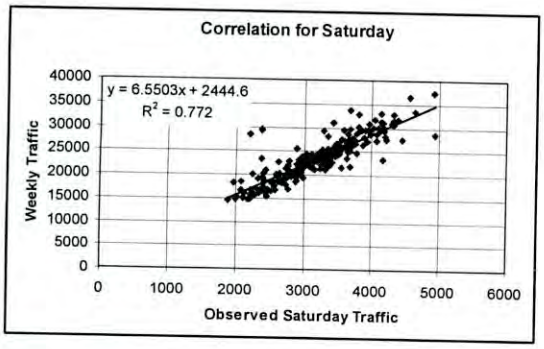

Correlation for 01-02 Hourly Flow
y = 13.436x + 665.04
R² = 0.833
Average Daily Traffic (ADT)
4000
3500
3000
2500
2000
1500
80
130
180
230
Observed 01-02 Hourly Flow

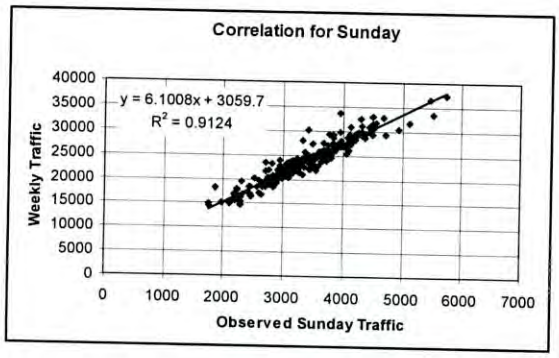

Correlation for 02-03 Hourly Flow
y = 10.759x + 1286
R² = 0.8562
Average Daily Traffic (ADT)
4000
3500
3000
2500
2000
1500
40
90
140
190
240
Observed 02-03 Hourly Flow

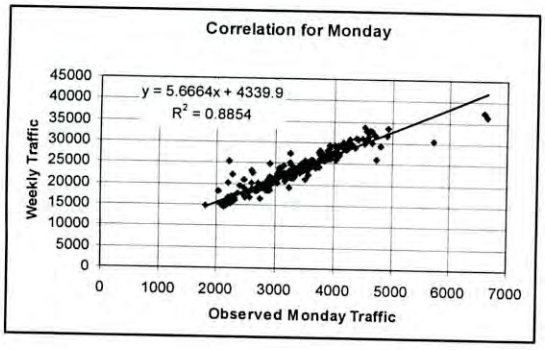

Correlation for 03-04 Hourly Flow
y = 16.623x + 1284.3
R² = 0.8067
Average Daily Traffic (ADT)
4000
3500
3000
2500
2000
1500
20
70
120
170
Observed 03-04 Hourly Flow

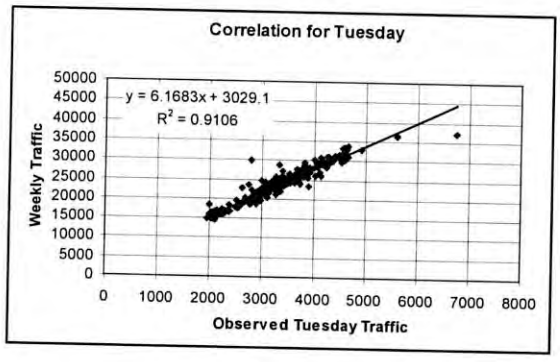

Correlation for 04-05 Hourly Flow
y = 21.348x + 1312.5
R² = 0.7926
Average Daily Traffic (ADT)
4000
3500
3000
2500
2000
1500
20
40
60
80
100
120
Observed 04-05 Hourly Flow

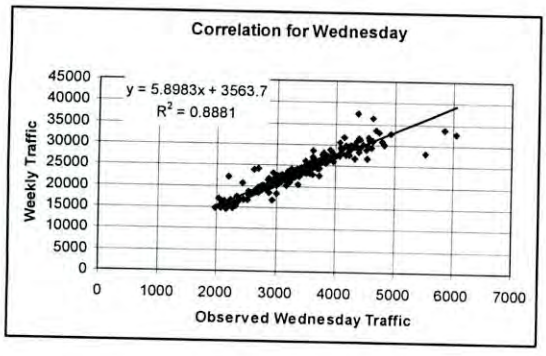

Correlation for 05-06 Hourly Flow
y = 19.359x + 1565.3
R² = 0.7202
Average Daily Traffic (ADT)
4000
3500
3000
2500
2000
1500
20
40
60
80
100
120
Observed 05-06 Hourly Flow

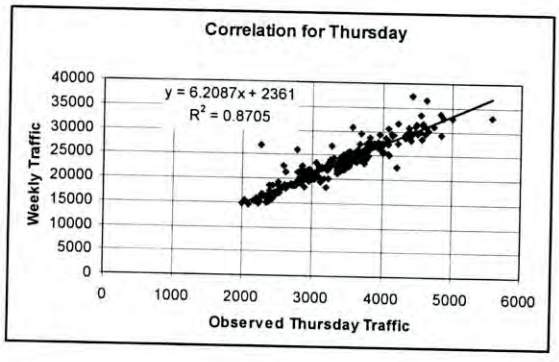

Correlation for Saturday
y = 6.5503x + 2444.6
R² = 0.772
Weekly Traffic
Observed Saturday Traffic

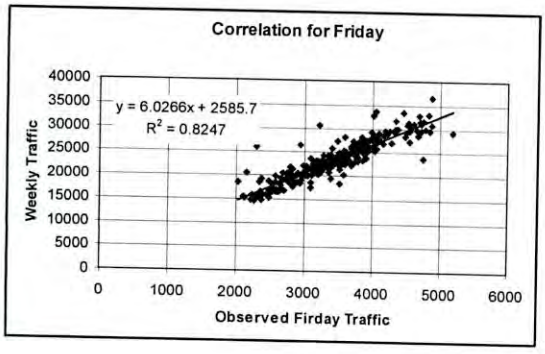

Correlation for Sunday
y = 6.1008x + 3059.7
R² = 0.9124
Weekly Traffic
Observed Sunday Traffic

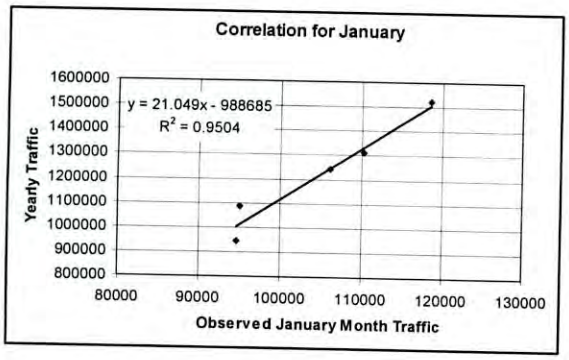

Correlation for Monday
y = 5.6664x + 4339.9
R² = 0.8854
Weekly Traffic
Observed Monday Traffic

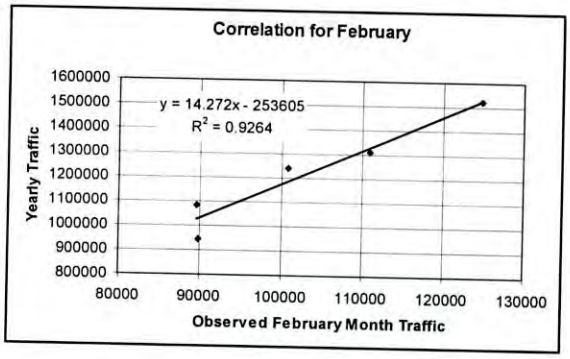

Correlation for Tuesday
y = 6.1683x + 3029.1
R² = 0.9106
Weekly Traffic
Observed Tuesday Traffic

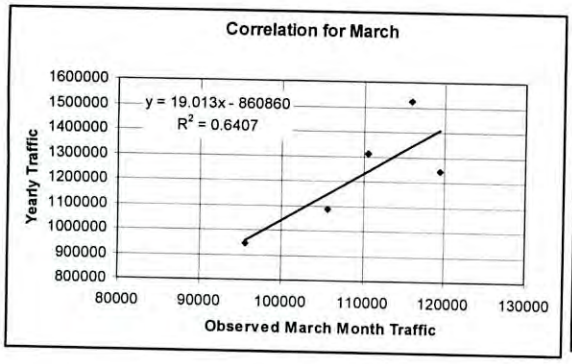

Correlation for Wednesday
y = 5.8983x + 3563.7
R² = 0.8881
Weekly Traffic
Observed Wednesday Traffic

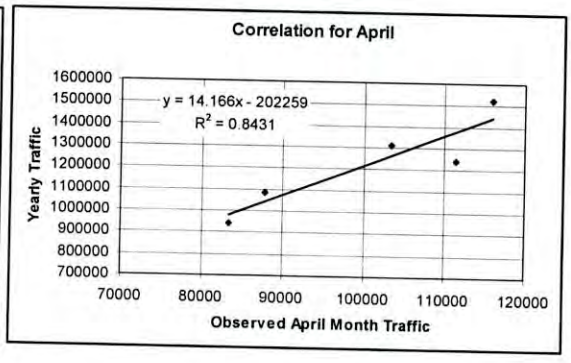

Correlation for Thursday
y = 6.2087x + 2361
R² = 0.8705
Weekly Traffic
Observed Thursday Traffic

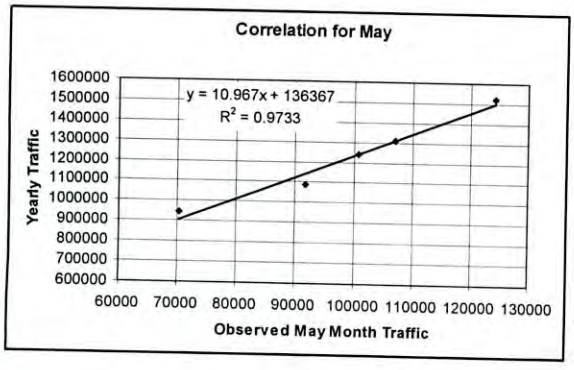

Correlation for Friday
y = 6.0266x + 2585.7
R² = 0.8247
Weekly Traffic
Observed Firday Traffic

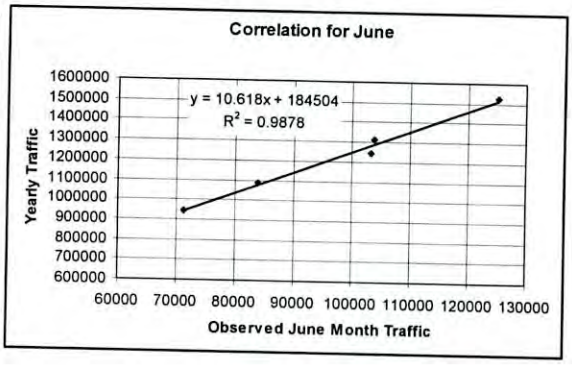

Correlation for January
y = 21.049x - 988685
R² = 0.9504
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
80000
90000
100000
110000
120000
130000
Observed January Month Traffic

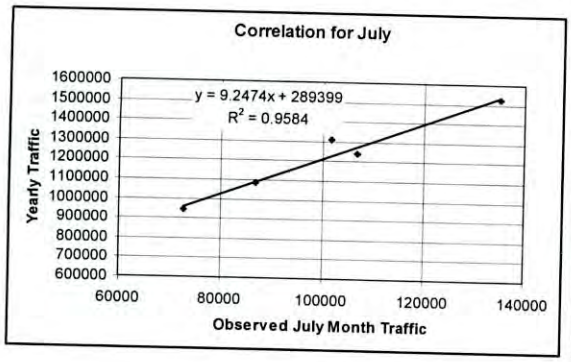

Correlation for February
y = 14.272x - 253605
R² = 0.9264
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
80000
90000
100000
110000
120000
130000
Observed February Month Traffic

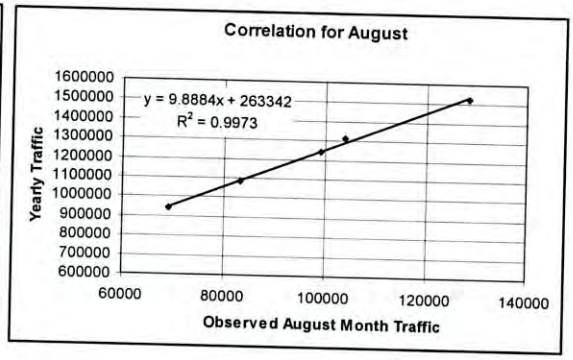

Correlation for March
y = 19.013x - 860860
R² = 0.6407
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
80000
90000
100000
110000
120000
130000
Observed March Month Traffic

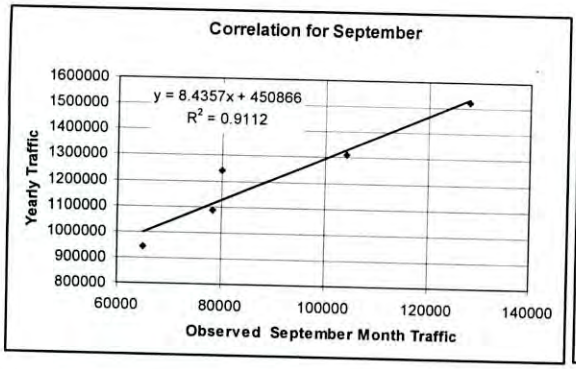

Correlation for April
y = 14.166x - 202259
R² = 0.8431
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
700000
70000
80000
90000
100000
110000
120000
Observed April Month Traffic

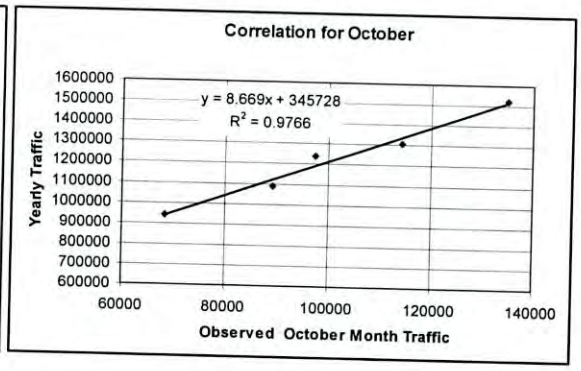

Correlation for May
y = 10.967x + 136367
R² = 0.9733
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
700000
600000
60000
70000
80000
90000
100000
110000
120000
130000
Observed May Month Traffic

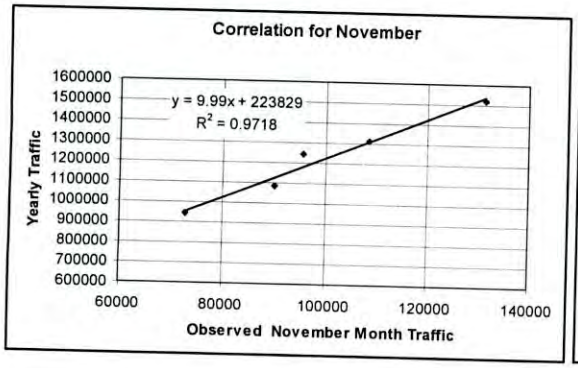

Correlation for June
y = 10.618x + 184504
R² = 0.9878
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
700000
600000
60000
70000
80000
90000
100000
110000
120000
130000
Observed June Month Traffic

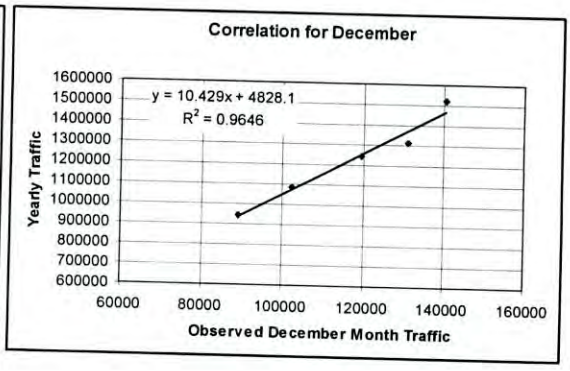

Correlation for July
y = 9.2474x + 289399
R² = 0.9584
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
700000
600000
60000
80000
100000
120000
140000
Observed July Month Traffic


Correlation for August
y = 9.8884x + 263342
R² = 0.9973
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
700000
600000
60000
80000
100000
120000
140000
Observed August Month Traffic


Correlation for September
y = 8.4357x + 450866
R² = 0.9112
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
60000
80000
100000
120000
140000
Observed September Month Traffic


Correlation for October
y = 8.669x + 345728
R² = 0.9766
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
700000
600000
60000
80000
100000
120000
140000
Observed October Month Traffic


Correlation for November
y = 9.99x + 223829
R² = 0.9718
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
700000
600000
60000
80000
100000
120000
140000
Observed November Month Traffic


Correlation for December
y = 10.429x + 4828.1
R² = 0.9646
Yearly Traffic
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
700000
600000
60000
80000
100000
120000
140000
160000
Observed December Month Traffic

5.5 Validation

Calibration and validation work is necessary for any type of newly developed factors or models. During this study hourly, daily, monthly expansion factors as well as models on Jamuna bridge corridor have been established. Validation works have been performed to check the accuracy of these factors and models in estimating AADT from short counts. The validation works have been mostly performed using internal data which has been used for establishing the factors and equations because large amount of external flow data was not available for calibration and validation purpose since most of the available data has been used in establishing factors and model in order to achieve better accuracy. Nevertheless, 8 hours of traffic data, collected independently by LGED Portable Bridge Project for their own purpose, has been collected to check accuracy of the expansion factors and models.

A framework in MSExcel has been developed for validation purpose. Following are the trials using the said framework.

5.5.1 Trial – 1

Trial 1 has been done using internal flow data. Random date and hours has been selected from the study period for this purpose. For this trial 5 hours of flow data from 6:00 to 11:00 hourly is taken from the date 19th October, 2001.

Estimation of ADT using Hourly Expansion Factors:

First each hourly flow is multiplied by the corresponding established hourly expansion factors to obtain the hourly ADT and then they have been averaged to estimate the average ADT. Both average and class-wise hourly expansion factors have been used in this calculation and accuracy has been compared.

The hourly flow data for the specified hours are as follows:

Table 5.12: Trial 1 – Hourly Flow Data Table

Hour	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	Total
6 - 7	7	69	8	0	0	2	1	87
7 - 8	14	51	14	0	2	5	0	86
8 - 9	26	62	27	2	2	4	3	126
9 - 10	31	50	34	0	4	6	0	125
10-11	64	25	33	3	7	7	1	140

The corresponding hourly expansion factors are shown in the following table:

Table 5.13: Trial 1 – Hourly Expansion Factors

Hour	Class-wise Hourly Expansion Factors for the selected hours							Average HEF
	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	
6 - 7	125.99	20.82	60.23	42.58	20.54	55.16	18.24	**37.11**
7 - 8	87.67	23.77	36.34	67.93	24	26.52	20.22	**35.35**
8 - 9	56	25.7	25.58	33.96	29.17	20.46	13.6	**31.36**
9 - 10	32.54	29.65	20.88	15.94	31.36	17.67	19.68	**27.41**
10-11	15.39	35.68	16.09	15.42	25.03	14.07	19.18	**20.18**

Now, the flow values given in Table 5.12 are multiplied by the corresponding expansion factors given in Table 5.13. Both class-wise and average expansion factors have been used for calculation of ADT. The results are given in Table 5.14a and 5.14b.

Table 5.14a: Trial 1 – Calculated ADT using Class-wise Hourly Expansion Factors

Hour	Using Class-wise Hourly Expansion Factors								
	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	Estimated ADT	Standard Deviation
6 - 7	882	1,437	482	0	0	110	18	2,929	487
7 - 8	1,227	1,212	509	0	48	133	0	3,129	
8 - 9	1,456	1,593	691	68	58	82	41	3,989	
9 - 10	1,009	1,483	710	0	125	106	0	3,433	
10-11	985	892	531	46	175	98	19	2,747	
Average ADT	**1,112**	**1,323**	**584**	**23**	**81**	**106**	**16**	**3,245**	

Table 5.14b: Trial 1 – Calculated ADT using Average Hourly Expansion Factors

Hour	Using Average HEF	
	Estimated ADT	Standard Deviation
6 - 7	3,229	430
7 - 8	3,040	
8 - 9	3,951	
9 - 10	3,426	
10-11	2,825	
Average ADT	**3,294**	

Check for Accuracy:

The actual recorded daily traffic volume on the selected day was 3,295. By comparing the estimated ADT values with the actual daily volume, it was found that estimated ADT using class-wise and average Hourly Expansion Factors yield **98.49%** and **99.98%** accuracy respectively.

Estimation of Weekly ADT using Daily Expansion Factors:

Now, the above estimated ADT's are used to determine the weekly ADT using the corresponding daily expansion factors established in this study. The selected day was Friday and the established factors for Friday are multiplied by the estimated daily volumes. The results are given in Table 5.15a and 5.15b.

Table 5.15a: Trial 1 – Calculation of Weekly ADT using Class-wise Daily Expansion Factors

Using Class-wise Daily Expansion Factors							
Class	**Large Bus**	**Medium Truck**	**Light Vehicle**	**Small Bus**	**Small Truck**	**Motor Cycle**	**Large Truck**
Estimated Class-wise ADT using HEF	1,112	1,323	584	23	81	106	16
Class-wise DEF for Friday	6.58	7.25	5.74	6.36	7.13	5.54	6.99
Average Weekly Flow of Each Vehicle Class	7,316	9,594	3,355	145	580	586	109
Estimated Weekly Volume Using Class-wise DEF	21,686						
Weekly ADT	**3,098**						

Table 5.15b: Trial 1 – Calculation of Weekly ADT using Average Daily Expansion Factor

Using Average Daily Expansion Factors	
Estimated ADT using HEF	3,294
Avg. DEF	6.64
Avg. Weekly Traffic	21,874
Estimated Weekly Vol. Using Avg. DEF	21,874
Weekly ADT	**3,125**

Check for Accuracy:

The actual weekly ADT for the selected week was 3,261. Therefore, in this case, the estimated class-wise and average weekly ADT yield **95.00%** and **95.83%** accuracy respectively.

Estimation of AADT using Monthly Expansion Factors:

Since the selected month for this trial is October, AADT has been estimated by multiplying the estimated ADT with the established monthly expansion factor for the month of October. It is to be mentioned here that, monthly expansion factors has not been determined for individual vehicle class; the reason has been explained previously in Article 5.3.3. However, the estimated AADT are given in the following table.

Table 5.16: Trial 1 – Calculation of AADT using Monthly Expansion Factor

	Estimated ADT	MEF	**Estimated AADT**
ADT Estimated by Vehicle Class-wise Approach	3,098	1.031	**3,194**
ADT Estimated by Average Volume Approach	3,125		**3,222**

Check for Accuracy:

The actual AADT for the selected year 2001 was 3220. Therefore, from the above estimated AADT's, it is found that, AADT estimated using ADT calculated from class-wise and average approach have resulted with **99.19%** and **99.95%** respectively.

5.5.2 Trial – 2

Trial 2 also uses internal data and follows similar method of trial 1 to estimate AADT from hourly flow data. For this trial 5 hours of hourly flow data have been randomly selected from 18:00 to 23:00 hours on 25th May, 2002. The flow table and calculations of AADT are shown in the following tables.

Hourly Flow Data Table

Hour	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	Total
18-19	44	49	37	1	6	10	2	149
19-20	33	65	28	1	7	16	0	150
20-21	33	57	24	0	4	4	1	123
21-22	23	55	21	1	9	1	3	113
22-23	40	76	9	1	11	0	0	137

Established Hourly Expansion Factors for the Corresponding Hours

Hour	Class-wise Hourly Expansion Factors for the selected hours							Average HEF
	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	
18-19	22.13	24.96	15.72	16.40	19.91	12.41	22.00	20.74
19-20	31.40	21.49	18.27	25.94	22.26	21.43	24.13	23.40
20-21	40.68	19.03	22.72	43.23	23.52	30.15	31.17	25.11
21-22	40.77	17.02	28.42	63.40	23.33	60.65	28.77	25.04
22-23	32.12	15.09	34.91	67.93	22.35	92.60	39.37	22.82

Calculated ADT using Class-wise Hourly Expansion Factors

Hour	Using Class-wise Hourly Expansion Factors								
	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	Estimated ADT	Standard Deviation
18-19	974	1,223	581	16	119	124	44	**3,082**	216
19-20	1,036	1,397	512	26	156	343	0	**3,469**	
20-21	1,342	1,085	545	0	94	121	31	**3,219**	
21-22	938	936	597	63	210	61	86	**2,891**	
22-23	1,285	1,147	314	68	246	0	0	**3,059**	
Avg. ADT	**1,115**	**1,158**	**510**	**35**	**165**	**130**	**32**	**3,144**	

Hour	Using Average HEF	
	Estimated ADT	Standard Deviation
18-19	3,091	244
19-20	3,510	
20-21	3,088	
21-22	2,829	
22-23	3,127	
Avg. ADT	**3,129**	

Check for Accuracy:

Actual Daily Volume on the selected day	3,227	**Accuracy**
Estimated ADT using Class-wise HEF	3,144	**97.43%**
Estimated ADT using Average HEF	3,129	**96.97%**

Estimation of Weekly ADT using Daily Expansion Factors:

Using Class-wise Daily Expansion Factors							
Class	**Large Bus**	**Medium Truck**	**Light Vehicle**	**Small Bus**	**Small Truck**	**Motor Cycle**	**Large Truck**
Estimated Class-wise ADT using HEF	1,115	1,158	510	35	165	130	32
Class-wise DEF for Saturday	7.22	7.76	7.22	6.84	7.48	6.68	7.81
Average Weekly Flow of Each Vehicle Class	8,050	8,982	3,681	238	1,234	866	252
Estimated Weekly Volume Using Class-wise DEF	23,304						
Weekly ADT	**3,329**						

Using Average Daily Expansion Factors	
Estimated ADT using HEF	3,129
Avg. DEF	7.40
Avg. Weekly Traffic	23,155
Estimated Weekly Vol. Using Avg. DEF	23,155
Weekly ADT	**3,308**

Check for Accuracy:

Actual Weekly ADT on the Selected Week	3,402	**Accuracy**
Estimated Weekly ADT using Class-wise DEF	3,329	**97.86%**
Estimated Weekly ADT using Average DEF	3,308	**97.23%**

Calculation of AADT using Monthly Expansion Factor

	Estimated ADT	MEF	Estimated AADT	Actual AADT	**Accuracy**
ADT Estimated by Vehicle Class-wise Approach	3,329	1.038	3,456	3541	**97.59%**
ADT Estimated by Average Volume Approach	3,308	1.038	3,434	3541	**96.97%**

5.5.3 Trial – 3

This trial also uses internal flow data and follows similar method for validation of established factors using only 3 hours of hourly flow data. Desired accuracy in estimating AADT using lesser duration of short count will refer to better reliability of the expansion factors. The time has been randomly selected to be 24:00 to 3:00 hours of flow data on 6th March, 2000. The flow table and calculations of AADT are shown in the following tables.

Hourly Flow Data Table

Hour	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	Total
24 - 1	51	66	10	0	3	0	0	130
1 - 2	107	94	13	0	1	0	0	215
2 - 3	63	54	9	0	1	0	0	127

Established Hourly Expansion Factors for the Corresponding Hours

Hour	Class-wise Hourly Expansion Factors for the selected hours							Average HEF
	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	
24 - 1	17.51	17.2	47.36	114.12	22.96	225.46	62.33	**20.85**
1 - 2	11.19	18.87	58.97	73.15	23.43	797.77	32.52	**17.73**
2 - 3	15.09	18.81	64.55	219.46	27.13	864.25	124.67	**20.91**

Calculated ADT using Class-wise Hourly Expansion Factors

Hour	Using Class-wise Hourly Expansion Factors								
	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	Estimated ADT	Standard Deviation
24 - 1	893	1,135	474	0	69	0	0	**2,571**	686
1 - 2	1,197	1,774	767	0	23	0	0	**3,761**	
2 - 3	951	1,016	581	0	27	0	0	**2,574**	
Avg. ADT	**1,014**	**1,308**	**607**	**0**	**40**	**0**	**0**	**2,969**	

Hour	Using Average HEF	
	Estimated ADT	Standard Deviation
24 - 1	2,711	652
1 - 2	3,812	
2 - 3	2,656	
Avg. ADT	**3,059**	

Check for Accuracy:

Actual Daily Volume on the selected day	2,914	**Accuracy**
Estimated ADT using Class-wise HEF	2,969	**98.12%**
Estimated ADT using Average HEF	3,059	**95.01%**

Estimation of Weekly ADT using Daily Expansion Factors

Using Class-wise Daily Expansion Factors							
Class	**Large Bus**	**Medium Truck**	**Light Vehicle**	**Small Bus**	**Small Truck**	**Motor Cycle**	**Large Truck**
Estimated Class-wise ADT using HEF	1,014	1,308	607	0	40	0	0
Class-wise DEF for Monday	7.10	6.80	7.46	7.34	6.87	7.65	6.90
Average Weekly Flow of Each Vehicle Class	7,197	8,896	4,529	0	274	0	0
Estimated Weekly Volume Using Class-wise DEF	20,895						
Weekly ADT	**2,985**						

Using Average Daily Expansion Factors	
Estimated ADT using HEF	3,059
Avg. DEF	7.05
Avg. Weekly Traffic	21,568
Estimated Weekly Vol. Using Avg. DEF	21,568
Weekly ADT	**3,081**

Check for Accuracy:

Actual Weekly ADT on the Selected Week	3,069	**Accuracy**
Estimated Weekly ADT using Class-wise DEF	2,985	**97.26%**
Estimated Weekly ADT using Average DEF	3,081	**99.60%**

Calculation of AADT using Monthly Expansion Factor

	Estimated ADT	MEF	**Estimated AADT**	Actual AADT	**Accuracy**
ADT Estimated by Vehicle Class-wise Approach	2,985	0.957	**2,857**	2854	**99.91%**
ADT Estimated by Average Volume Approach	3,081	0.957	**2,949**	2854	**96.68%**

5.5.4 Trial – 4

This trial uses external flow data for validation of the established factors. These hourly flow data has been collected independently by LGED Portable Steel Bridge Project for their own purpose. The data has then been collected from LGED for this study. For this trial 9:00 to 14:00 hours of flow data on 4th May, 2006 has been used. The trial uses both expansion factors and regression models for estimating ADT from hourly flow data and compares the accuracy between the two methods.

Hourly Flow Data Table

Hour	Total
9-10	188
10-11	207
11-12	218
12-13	257
13-14	215

Established Hourly Expansion Factors for the Corresponding Hours

Hour	Average HEF
9-10	27.41
10-11	20.18
11-12	18.30
12-13	18.04
13-14	19.59

Calculated ADT using Class-wise Hourly Expansion Factors

Hour	Using Average HEF	
	Estimated ADT	Standard Deviation
9-10	5,153	467
10-11	4,177	
11-12	3,989	
12-13	4,636	
13-14	4,212	
Average ADT	**4,434**	

Check for Accuracy:

Actual Daily Volume on the selected day	5,759	**Accuracy**
Estimated ADT using Regression Equations	4,684	**81.33%**
Estimated ADT using Average HEF	4,434	**76.99%**

Estimation of Weekly ADT using Daily Expansion Factors:

Using Average Daily Expansion Factors	
Estimated ADT using HEF	4,434
Avg. DEF	6.87
Avg. Weekly Traffic	30,459
Estimated Weekly Vol. Using Avg. DEF	30,459
Weekly ADT	**4,351**

Check for Accuracy:

Actual Weekly ADT on the Selected Week	5,482	**Accuracy**
Estimated Weekly ADT using Regression Equations	4,491	**81.92%**
Estimated Weekly ADT using Average DEF	4,351	**79.37%**

It is to be noted here that, this trial could not be made with class-wise expansion factors since the vehicle classification used by the data source LGED does not match with that of Jamuna Multipurpose Bridge Authority. Also, the AADT has not been estimated because the actual yearly traffic flow in 2006 is not yet available. The flow data for the month of May 2006 has been collected from JMBA.

5.6 Application of the Expansion Factors

In this section the application of the established expansion factors is given with an example. The example shows the process of estimating AADT from short counts using the established factors elaborately in a step-by-step manner.

Example of Calculation for Estimation of AADT:

Say, the following hourly bi-directional traffic flow volume data has been collected from an existing highway on the selected corridor with an intention to estimate AADT from this 5-hour count. The survey day is Saturday and month is October.

Hour	Hourly Vol. (Both Direction)
07-08	67
08-09	75
09-10	108
10-11	117
11-12	129

The corresponding Expansion factors (as established in this study) for the hours, day and month are as follows:

Hour	Corresponding Hourly Expansion Factor
07-08	35.35
08-09	31.36
09-10	27.41
10-11	20.18
11-12	18.30

Daily Expansion Factor for Saturday (as established in this study) = 7.4

Monthly Expansion Factor for October (as established in this study) = 1.031

Solution:

AADT can be estimated by following the steps shown below –

Step – 1: Estimate the 24-hour volume for Saturday using the collected hourly volume and expansion factors:

$$\frac{(67x35.35 + 75x31.36 + 108x27.41 + 117x20.18 + 129x18.3)}{5} = 2480$$

Step – 2: Adjust the 24-hour volume for Saturday to an average volume for the week using the Daily Expansion Factor:

Total 7-day volume = 2480 x 7.4 = 18,352

So, Average 24-hour volume = (18,352 / 7) = 2622

Step – 3: Obtain estimated AADT by using the Monthly Expansion Factor:

AADT = 2622 x 1.031 = 2703

So, the estimated AADT for the corresponding year is 2703. From the above shown example, it can be seen that AADT of a particular corridor can be easily estimated by using the Expansion Factors following three easy steps.

5.7 Overview

From the above calculation, it was found that, fairly reliable estimation of AADT from short counts can be attained using the factors and models derived during this study. The factors have been checked for accuracy using both internal and external data. Internal data resulted with more accurate expansion even with 3 hours of short count (Article 5.5.3 – Trial 3) than external data, although the accuracy of external data collected by LGED could not be verified. Internal data yield around 99% of accurate estimation while the external data yield around 80% of accuracy in estimating ADT. This implies that, for more reliable estimation of AADT from short counts, the factors need to be established using more years of traffic flow data as well as they need to be continuously updated. This is recommended in AASHTO and Traffic Monitoring Guidelines 2001 also. However, the frameworks developed for the evaluation of expansion factors and equations may be used as a demonstration for further development of software for the analysis of traffic characteristics and determination of expansion factors and equations for reliable determination of AADT from short counts.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The major objectives of this study were to analyze various traffic flow characteristics and to estimate AADT from short counts. Considering the availability of long duration high quality traffic flow data, North Bengal corridor has been selected. Because, since the opening of Jamuna Multipurpose Bridge, which is the entry point of this corridor, continuous daily flow data has been systematically recorded and preserved by the operators. Moreover, 13 weeks of hourly traffic flow data on Jamuna Bridge, as well as the Nalka-Hatikamrul-Bonpara Road's daily flow data were also available along this corridor.

During this study, comprehensive analyses have been performed using the collected traffic data and they resulted some important findings on the traffic flow characteristics. Expansion factors and linear regression models have also been established for this corridor. This chapter briefly presents the findings of this study and recommendations for future study.

6.2 Summary of Findings

During this study, some important observations have been made related to the data collection, preservation, vehicle classification system, toll collection system etc. From the analyses of traffic flow data, useful observations have been drawn. This section briefly discusses the important finding from this study.

6.2.1 General Findings

- The repetitive nature of traffic flow pattern reveals that the corridor flow is stable and thus estimation of AADT from short counts can be effectively made for this corridor.
- From the comparative analysis of continuous daily traffic flow on newly opened Nalka-Hatikamrul-Bonpara road with that of Jamuna bridge, it was found that, the Hatikamrul road carries 31.97% of vehicles crossing the Jamuna bridge with a standard deviation of only 1.74, and maintain similar daily flow pattern. This refers that both the operators are keeping record with admirable consistency.
- At present there is no standard vehicle classification system to be followed by the toll operators. As a result, the classification system used by Jamuna Bridge operators and that by Hatikamrul road operators are not same. Therefore, the opportunity to compare class-wise traffic flow between the roads was not available.
- Besides, the government has no policy to collect and preserve traffic flow data generated from different toll plazas of national highways which could be a vitaol source of long duration traffic data.
- In order to collect long duration traffic flow data along various national and regional highways of Bangladesh, so far no permanent traffic counting station is established by the Roads and Highways Department (RHD). Long term traffic count data is essential for reliable prediction of future demand in case of planning, designing and improving transportation facilities.

6.2.2 Flow Characteristics Analyses

Several analyses on various traffic flow parameters have been rendered during this study. These include analyses of hourly, daily, weekly, monthly variation pattern of traffic flow, directional distribution, traffic composition, traffic growth pattern, impact of Eid festivals on traffic flow pattern etc. The important findings from these analyses are summarized below.

6.2.2.1 Hourly Flow Variation

- The flow pattern shows distinct hourly variations, but the hourly variation of total traffic and that of individual vehicle classes are not the same.
- For total bi-directional traffic flow, peak hour occurs at 1:00 to 2:00 and the peak hour carries 5.68% of daily traffic. Lowest flow (2.25%) takes place between 5:00 to 6:00.
- Maximum and minimum flow of Large Bus occurs between 1:00-2:00 and 5:00-6:00 respectively carrying 8.91% and 0.48% of daily volume.
- Maximum and minimum flow of Medium Trucks occurs between 22:00-23:00 and 14:00-15:00 respectively carrying 6.64% and 2.12% of daily volume.
- Maximum and minimum flow of Light Vehicles occurs between 12:00-13:00 and 5:00-6:00 respectively carrying 7.20% and 1.03% of daily volume.

6.2.2.2 Daily Flow Variation

- Daily flow fluctuation is mainly governed by weekend factor; hence the analysis has been performed separately for each direction.
- For East to West direction, maximum and minimum daily flow occurs on Friday carrying 15.16% of weekly volume and Saturday carrying 13.53% of weekly volume respectively.

- For West to East direction also, maximum and minimum daily flow occurs on Friday carrying 15.25% of weekly volume and Tuesday carrying 13.69% of weekly volume respectively.
- In both the directions, the flow pattern sags on midweek.
- As in the case of hourly flow fluctuation, the daily variation of each vehicle class differs from that of total vehicle.

6.2.2.3 Weekly Flow Variation

- The weekly patterns (i.e. four weeks of a month) of traffic flow on the selected corridor do not exhibit any definite pattern.
- It can be concluded that, individual week has no effect on traffic flow on this corridor.

6.2.2.4 Seasonal Variation

- Dry season (Nov. to Apr.) carries 51.48% while Rainy season (May to Oct.) carries 48.52% of total yearly volume.
- From the analysis of 7 years traffic data, it was found that monthly flow pattern is repetitive in nature.
- Maximum flow occurs on December (9.45% of yearly volume)
- Minimum flow occurs on September (7.71 of yearly volume)
- Eid months carry significantly higher traffic than usual months.

6.2.2.5 Day-Night Fluctuation

- Average daytime traffic percentage is 50.64%, while nighttime traffic percentage is 49.36%. Thus, it can be said that, along this corridor the day-night fluctuation of traffic flow is almost equal.
- Maximum daytime traffic occurs on Friday (55.90%).

6.2.2.6 Directional Distribution

- The corridor has almost 50-50 directional split. Averaging all data in this study, it was found to be 50.17% in the direction West to East, and 49.83% in the direction East to West.
- Since the toll amount is not weight basis, it is assumed that, even the empty trucks use the bridge instead of other low cost route.
- Maximum hourly directional flow in West to East is 68.69% at 1:00 – 2:00.
- Maximum hourly directional flow in East to West is 62.10% at 10:00 – 11:00.
- Hourly directional distribution of individual vehicle class defers from that of total vehicle.
- Weekend factor is predominant in daily directional distribution of traffic flow in this corridor. Maximum East to West flow (51.25%) occurs on Thursday while maximum West to East flow (52.12%) takes place on Saturday.
- Months do not have any significant affect on directional distribution on this corridor.

6.2.2.7 Traffic Composition

- In the toll collection of Jamuna bridge the operator divides total traffic into 7 vehicle classes – namely Motor cycle, Light Vehicle, Small Bus, Large Bus, Small Truck, Medium Truck and Large Truck.
- Three classes of vehicles dominate the traffic stream. They are – Medium Truck (38.21%), Large Bus (30.14%), and Light Vehicles (17.59%).
- The traffic composition is gradually changing every year where percentage of heavy vehicles is increasing phenomenally.

6.2.2.8 Percentage of Heavy Vehicles

- Heavy vehicles comprise of buses and trucks.
- Total percentage of trucks in the traffic stream in the year 2005 was 48.42%.

- Total percentage of buses in the traffic stream in the year 2005 was 35.64%.

6.2.2.9 Traffic Growth Pattern

- Average growth rate of total traffic during the 7 years of study period is 14% per annum.
- Flat growth rate of total vehicle is not representative of all vehicle class. Thus growth rate of individual vehicle class should be considered.

6.2.2.10 Impact of Eid Festival on Traffic Flow

- Duration of Eid festival impact on traffic stream: 3-4 days before and 6-7 days after Eid day, total around 10 days.
- Daily flow within Eid effect range is about 70% to 90% higher than average daily flow.
- Daily directional distribution around Eid is 60% to 65%.

6.2.3 Expansion Factors and Regression Models

- In order to estimate AADT from short counts, hourly, daily and monthly expansion factors have been established in this study. The factors have been determined separately for all vehicle classes.
- The factors have been checked for accuracy using both internal and external data.
- In the case of checking the accuracy of proposed expansion factors and regression models in predicting AADT from short counts, with internal data, class wise expansion factors resulted with around 99% accuracy, while the same for total vehicle gave around 95% accurate result.
- In the case of checking the accuracy of expansion factors using external data collected from LGED, around 80% accuracy has been obtained.

- From regression analyses of the traffic data, linear equations have been determined and calibration curves have also been plotted.
- The developed linear regression equations resulted with more accuracy in estimating weekly ADT in comparison to expansion factors. By checking with external data collected from LGED, the regression equation gave around 82% accuracy while the factors gave around 80% accuracy.
- The expansion factors and regression models developed in this study are given in chapter 5.

6.3 Limitations of the Study

Here follows some important aspects related to this study, which could not be performed due to time constraints.

- The developed factors and equations could be checked with more external data for further verification purpose.
- More comprehensive analyses on corridor flow characteristics relating to economic activities, agricultural cycle including harvesting time etc could be made.
- Development of the framework using advanced software such as Visual Basic interlinked with MS Access database in order to make it user friendly.
- The toll free vehicles were not included in the main database.

6.4 Recommendations

- Immediate initiative should be taken by the government to set up permanent counting stations at all important locations all over Bangladesh covering all major corridors.
- A unified vehicle classification system should be set.
- Initiative should be taken to instruct all highway toll operators to keep flow records in hourly basis.
- The expansion factors and equations need to be updated with recent data.

- Similar analyses can be performed using more traffic data to achieve greater accuracy.
- A specified data collection and preservation system in electronic format should be used.
- A software can be developed, by which AADT can be estimated by short counts and thus independent auditing may be possible.
- The transportation planners and designers should use the expansion factors established in this study in designing transportation facilities, particularly along this corridor.
- Similar type of study should be carried out by RHD for other corridors and the factors should be published formally.

REFERENCES

AASHTO [1990], "A Policy on Geometric Design of Highway and Street", USA

Barewood J.E. [1965], "Traffic Engineering Handbook", Third Edition, Institute of Traffic Engineers, Washington D.C., USA

Bureau of Research Testing and Consultation, BUET [1998-2002], "Traffic Survey at Baangabandhu Bridge", Jamuna Multipurpose Bridge Authority, Ministry of Communication, GOB

Development of Geometric Design Standards [1994], "Road Material and Standards Study Bangladesh", Volume VIIA, Roads and Highways Department, GOB

Garber N.J. and Hoel L.A. [1990], "Traffic and Highway Engineering", Revised Second Edition, PWS Publishing, USA

Matson T.M., Smith W.S., Hurd F.W. [1955], "Traffic Engineering", McGraw-Hill Book Company

Pavement Design Guide [2005], Roads and Highways Department, GOB

Pignataro L.J. [1973], "Traffic Engineering, Theory and Practice", Prentice-Hall Inc. Englewood Cliffs, New Jersey, USA

Rahman S.K. [2002], "Study of Vehicular Flow Pattern on Jamuna Multipurpose Bridge Access Road", Dept. of Civil Engineering, MIST

Robichaud K. and Gordon M. [2002], "An Assessment of Data Collection Techniques for Highway Agencies", British Columbia Ministry of Transportation

Traffic Monitoring Guidelines [2001], Federal Highway Administration, U.S. Department of Transport

APPENDIX A

SAMPLES OF TYPICAL TRAFFIC FLOW DATA TABLES

Table A1: Summarized Bi-Directional Hourly Flow on Jamuna Bridge

(Survey 1 - 24th Oct. to 30th Oct., 1998: 7 day's average)

Counting Hours	L. Bus	M. Truck	L. Vehicle	S. Bus	S. Truck	M. Cycle	L. Truck	Total Vol.*	% of
	LB	**MT**	**LV**	**SB**	**ST**	**MC**	**LT**	**per hr.**	**total vol.**
6 - 7	4.7	37.0	8.7	2.7	3.4	1.6	1.0	59.14	2.87
7 - 8	9.1	28.7	12.1	1.3	2.9	6.0	1.4	61.57	2.98
8 - 9	12.7	26.9	18.6	2.3	2.4	6.9	1.9	71.57	3.47
9 - 10	30.1	22.7	20.4	6.3	1.9	9.1	1.4	92.00	4.46
10-11	54.6	17.7	27.0	5.9	1.4	11.0	1.1	118.71	5.75
11-12	63.7	13.3	31.7	7.6	1.6	12.3	1.3	131.43	6.37
12-13	51.9	18.0	32.6	8.7	2.3	12.7	2.7	128.86	6.25
13-14	49.9	18.3	30.3	9.1	1.9	9.9	2.4	121.71	5.90
14-15	35.4	16.7	27.6	7.4	1.6	10.0	0.6	99.29	4.81
15-16	29.7	18.3	29.1	8.4	1.3	8.7	1.1	96.71	4.69
16-17	24.6	20.7	31.4	7.1	2.4	12.6	1.7	100.57	4.88
17-18	24.4	23.1	29.6	5.3	2.4	13.9	1.9	100.57	4.88
18-19	39.3	27.0	28.7	4.3	1.7	8.7	1.0	110.71	5.37
19-20	17.6	34.0	20.6	3.4	2.0	5.3	0.4	83.29	4.04
20-21	13.3	31.6	17.0	0.9	2.6	4.0	0.0	69.29	3.36
21-22	22.1	36.7	15.0	0.7	2.4	1.7	0.1	78.86	3.82
22-23	29.3	44.9	13.1	2.0	1.7	1.4	0.1	92.57	4.49
23-24	34.0	34.6	8.4	1.3	1.1	0.4	0.0	79.86	3.87
24 - 1	54.3	32.0	7.9	0.4	1.9	0.1	0.1	96.71	4.69
1 - 2	58.1	36.3	8.7	0.7	2.0	0.0	0.0	105.86	5.13
2 - 3	24.7	36.4	7.4	0.1	1.6	0.0	0.0	70.29	3.41
3 - 4	3.9	28.0	4.3	0.3	1.9	0.0	0.1	38.43	1.86
4 - 5	1.3	20.3	2.3	0.9	0.7	0.1	0.0	25.57	1.24
5 - 6	0.6	22.0	4.1	0.4	1.9	0.1	0.3	29.43	1.43
Daily Vol.	689	645	437	88	47	137	21	**2063**	**100.00**
% Vehicle	33.41	31.27	21.17	4.24	2.27	6.62	1.01	**100.00**	

** Data Source: BUET; Field data collected and summarized by BUET*

** Toll free vehicles not included*

Table A2: Summarized Bi-Directional Hourly Flow on Jamuna Bridge

(Survey 2 – 16th Dec. to 22nd Dec., 1998: 7 day's average)

Counting Hours	L. Bus **LB**	M. Truck **MT**	L. Vehicle **LV**	S. Bus **SB**	S. Truck **ST**	M. Cycle **MC**	L. Truck **LT**	Total Vol.* **per hr.**	% of **total vol.**
6 - 7	7.9	69.1	6.6	2.1	1.6	2.0	0.1	89	2.76
7 - 8	9.6	57.0	12.6	1.0	1.4	2.9	0.6	85	2.62
8 - 9	20.4	55.1	22.9	0.9	1.7	5.9	0.7	108	3.31
9 - 10	34.7	43.1	30.4	1.9	0.7	8.3	0.9	120	3.70
10-11	52.7	33.4	34.6	0.9	0.9	11.0	0.0	133	4.11
11-12	78.3	27.4	47.1	2.1	0.6	11.9	0.1	168	5.16
12-13	94.9	38.6	57.9	3.7	1.7	13.1	0.0	210	6.47
13-14	71.4	34.6	59.3	2.7	1.7	12.4	0.0	182	5.61
14-15	51.0	33.3	57.4	1.7	0.9	13.0	0.3	158	4.86
15-16	44.9	33.4	59.9	3.4	1.3	15.0	0.3	158	4.87
16-17	38.3	39.7	62.4	3.3	0.7	20.1	0.4	165	5.08
17-18	33.4	44.6	49.3	3.1	1.1	16.7	0.1	148	4.57
18-19	42.7	54.3	40.6	2.6	1.6	8.7	0.1	151	4.64
19-20	32.9	60.1	32.0	1.1	1.6	4.1	0.0	132	4.06
20-21	28.7	77.3	26.6	0.3	1.6	3.1	0.3	138	4.25
21-22	34.3	87.6	17.6	0.9	1.0	1.0	0.4	143	4.40
22-23	45.3	96.3	13.3	1.4	1.4	1.6	0.3	160	4.92
23-24	47.9	97.7	11.1	0.3	2.0	0.4	0.0	159	4.91
24 - 1	57.6	78.3	9.4	0.6	1.7	0.0	0.0	148	4.55
1 - 2	70.7	77.6	8.9	1.6	1.3	0.0	0.0	160	4.93
2 - 3	35.3	76.6	7.0	0.4	2.1	0.3	0.0	122	3.75
3 - 4	12.9	66.3	5.6	0.3	1.3	0.1	0.0	86	2.66
4 - 5	6.1	52.9	5.7	0.4	0.6	0.0	0.1	66	2.03
5 - 6	6.1	47.4	2.7	0.3	0.6	0.1	0.1	57	1.77
Daily Vol.	958	1382	681	37	31	152	5	**3245**	**100.00**
% Vehicle	29.52	42.58	20.98	1.14	0.96	4.68	0.15	**100.00**	

** Data Source: BUET; Field data collected and summarized by BUET*

** Toll free vehicles not included*

Table A3: Summarized Bi-Directional Hourly Flow on Jamuna Bridge

(Survey 8 – 3rd Mar. to 9th Mar., 2000: 7 day's average)

Counting Hours	L. Bus **LB**	M. Truck **MT**	L. Vehicle **LV**	S. Bus **SB**	S. Truck **ST**	M. Cycle **MC**	L. Truck **LT**	Total Vol.* **per hr.**	% of **total vol.**
6 - 7	4.3	65.0	8.9	0.1	1.4	0.6	0.0	80	2.62
7 - 8	9.6	60.3	14.7	1.0	1.6	3.9	0.1	91	2.97
8 - 9	16.7	51.7	21.3	2.0	1.1	5.6	0.1	99	3.21
9 - 10	24.1	49.3	27.1	4.1	1.6	4.9	0.0	111	3.62
10-11	59.3	43.3	35.9	3.9	1.7	7.7	0.0	152	4.94
11-12	86.0	33.0	35.7	5.0	0.9	6.0	0.1	167	5.43
12-13	79.9	29.7	42.0	4.0	3.0	7.6	0.1	166	5.42
13-14	75.1	28.6	35.6	3.1	2.1	6.1	0.0	151	4.91
14-15	54.7	27.7	35.0	3.7	1.3	6.3	0.1	129	4.20
15-16	42.6	34.9	37.3	5.0	1.3	9.0	0.1	130	4.24
16-17	37.9	33.0	36.0	4.4	1.4	10.4	0.0	123	4.01
17-18	36.0	37.7	40.7	3.4	1.1	9.0	0.1	128	4.17
18-19	44.4	45.7	34.3	1.9	2.0	8.6	0.1	137	4.46
19-20	30.9	62.3	34.3	1.6	1.6	3.7	0.0	134	4.37
20-21	24.7	60.3	28.1	1.1	2.1	2.9	0.3	120	3.90
21-22	23.1	78.0	24.1	0.7	0.3	1.1	0.4	128	4.17
22-23	30.1	85.6	19.7	0.9	1.0	0.7	0.0	138	4.50
23-24	42.9	85.1	14.7	1.1	2.9	0.4	0.3	147	4.80
24 - 1	49.7	76.6	13.7	0.6	1.4	0.3	0.1	142	4.64
1 - 2	91.7	81.0	11.1	0.3	1.3	0.1	0.0	186	6.05
2 - 3	66.1	69.4	9.6	0.4	1.7	0.0	0.0	147	4.80
3 - 4	23.7	84.1	10.7	0.1	2.6	0.1	0.0	121	3.96
4 - 5	5.4	62.4	7.6	0.1	2.6	0.0	0.0	78	2.55
5 - 6	2.7	53.4	5.3	0.6	1.4	0.1	0.0	64	2.07
Daily Vol.	962	1338	583	49	39	95	2	**3069**	**100.00**
% Vehicle	31.33	43.60	19.01	1.61	1.28	3.10	0.07	**100.00**	

** Data Source: BUET; Field data collected and summarized by BUET*

** Toll free vehicles not included*

Table A4: Summarized Bi-Directional Hourly Flow on Jamuna Bridge

(Survey 13 - 24th May to 30th May, 2002: 7 day's average)

Counting Hours	L. Bus **LB**	M. Truck **MT**	L. Vehicle **LV**	S. Bus **SB**	S. Truck **ST**	M. Cycle **MC**	L. Truck **LT**	Total Vol.* **per hr.**	% of **total vol.**
6 - 7	12.4	57.6	11.4	0.1	11.3	2.7	1.4	97	2.92
7 - 8	16.3	53.9	16.4	0.3	8.9	4.9	1.0	102	3.05
8 - 9	18.6	43.4	23.4	0.7	3.7	5.4	1.1	96	2.90
9 - 10	45.0	33.0	27.6	0.9	5.0	5.0	0.6	117	3.52
10-11	89.6	25.1	33.1	0.6	5.7	6.1	1.3	162	4.86
11-12	90.6	26.0	35.9	1.1	5.0	6.7	0.9	166	4.99
12-13	87.3	27.1	34.1	1.0	4.4	5.6	0.3	160	4.80
13-14	89.9	25.7	29.1	0.6	4.6	5.0	0.9	156	4.68
14-15	82.7	25.6	32.1	2.4	5.1	5.4	0.9	154	4.64
15-16	63.9	32.3	29.7	2.0	5.3	7.1	0.4	141	4.23
16-17	41.0	29.4	40.4	2.0	9.3	7.6	0.3	130	3.91
17-18	58.9	36.9	39.9	1.3	5.3	7.7	0.3	150	4.51
18-19	54.0	57.0	35.9	1.6	9.6	10.7	0.9	170	5.10
19-20	35.3	57.7	29.0	0.9	7.3	5.9	0.3	136	4.10
20-21	29.6	68.4	22.7	0.7	6.0	3.1	0.6	131	3.94
21-22	28.7	60.7	20.4	0.4	7.3	2.3	1.1	121	3.64
22-23	39.1	70.4	14.7	0.3	7.0	0.1	0.1	132	3.96
23-24	45.7	55.9	11.0	0.0	6.6	0.9	0.9	121	3.63
24 - 1	63.3	60.1	12.7	0.4	5.1	0.3	0.4	142	4.28
1 - 2	102.1	62.1	8.4	0.3	7.1	0.3	1.0	181	5.45
2 - 3	124.6	74.1	10.4	0.3	3.9	0.1	0.3	214	6.42
3 - 4	42.6	79.9	6.7	1.3	6.6	0.3	0.6	138	4.14
4 - 5	12.7	75.6	4.1	0.1	8.3	0.0	0.4	101	3.04
5 - 6	6.6	85.6	6.4	0.3	9.4	0.6	0.6	109	3.29
Daily Vol.	1280	1224	536	20	158	94	16	**3327**	**100.00**
% Vehicle	38.48	36.77	16.10	0.59	4.74	2.82	0.49	**100.00**	

** Data Source: BUET; Field data collected and summarized by BUET*

** Toll free vehicles not included*

Table A5: Daily Traffic Flow Volume in 1999 on Jamuna Bridge (East to West)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
1-Jan-99	Friday	66	289	89	264	11	446	0	1,165
2-Jan-99	Saturday	78	217	94	263	22	409	5	1,088
3-Jan-99	Sunday	61	247	100	314	13	583	5	1,323
4-Jan-99	Monday	51	253	112	356	24	748	2	1,546
5-Jan-99	Tuesday	64	259	115	309	26	545	4	1,322
6-Jan-99	Wednesday	39	256	93	302	31	564	2	1,287
7-Jan-99	Thursday	65	293	121	320	23	563	2	1,387
8-Jan-99	Friday	94	338	98	318	16	509	2	1,375
9-Jan-99	Saturday	63	265	111	311	17	444	3	1,214
10-Jan-99	Sunday	56	245	112	319	22	532	1	1,287
11-Jan-99	Monday	37	296	111	321	24	631	1	1,421
12-Jan-99	Tuesday	65	274	113	325	12	587	3	1,379
13-Jan-99	Wednesday	49	285	104	328	27	569	1	1,363
14-Jan-99	Thursday	70	396	127	352	31	571	3	1,550
15-Jan-99	Friday	76	424	122	373	18	440	0	1,453
16-Jan-99	Saturday	82	425	155	376	18	610	2	1,668
17-Jan-99	Sunday	89	515	234	476	19	433	5	1,771
18-Jan-99	Monday	149	711	291	517	20	415	2	2,105
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30-Jul-99	Friday	94	348	123	328	22	308	2	1,225
31-Jul-99	Saturday	76	276	108	320	32	229	7	1,048
1-Aug-99	Sunday	66	345	156	359	34	469	2	1,431
2-Aug-99	Monday	28	66	1	9	3	20	4	131
3-Aug-99	Tuesday	52	198	36	168	17	233	4	708
4-Aug-99	Wednesday	56	266	126	352	33	300	2	1,135
5-Aug-99	Thursday	74	316	134	353	34	337	5	1,253
6-Aug-99	Friday	92	365	152	334	28	323	2	1,296
7-Aug-99	Saturday	69	262	127	318	28	356	3	1,163
8-Aug-99	Sunday	41	252	159	341	34	442	2	1,271
9-Aug-99	Monday	63	312	149	364	46	445	3	1,382
10-Aug-99	Tuesday	43	199	60	194	15	242	3	756
11-Aug-99	Wednesday	67	235	99	297	28	271	7	1,004
12-Aug-99	Thursday	61	324	135	326	31	292	4	1,173
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23-Dec-99	Thursday	46	307	125	336	39	701	3	1,557
24-Dec-99	Friday	54	316	110	322	29	494	3	1,328
25-Dec-99	Saturday	56	275	111	323	26	345	3	1,139
26-Dec-99	Sunday	42	270	109	327	38	550	1	1,337
27-Dec-99	Monday	30	253	113	333	35	545	2	1,311
28-Dec-99	Tuesday	28	290	111	331	34	438	0	1,232
29-Dec-99	Wednesday	29	278	107	334	40	500	1	1,289
30-Dec-99	Thursday	31	338	123	341	43	578	0	1,454
31-Dec-99	Friday	37	336	129	356	22	535	0	1,415

** Data Source: JOMAC*

** Toll free vehicles not included*

Table A6: Daily Traffic Flow Volume in 1999 on Jamuna Bridge (West to East)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
1-Jan-99	Friday	67	241	95	281	21	502	1	1,208
2-Jan-99	Saturday	70	265	96	280	16	511	6	1,244
3-Jan-99	Sunday	57	276	103	299	17	626	3	1,381
4-Jan-99	Monday	54	270	104	320	25	908	2	1,683
5-Jan-99	Tuesday	72	272	106	299	24	555	3	1,331
6-Jan-99	Wednesday	88	236	103	293	21	697	5	1,443
7-Jan-99	Thursday	83	277	111	301	21	607	2	1,402
8-Jan-99	Friday	85	296	109	306	17	579	3	1,395
9-Jan-99	Saturday	67	321	112	323	19	545	4	1,391
10-Jan-99	Sunday	79	247	111	301	19	551	1	1,309
11-Jan-99	Monday	65	268	112	312	20	565	1	1,343
12-Jan-99	Tuesday	58	257	98	317	11	699	1	1,441
13-Jan-99	Wednesday	79	284	120	323	22	640	3	1,471
14-Jan-99	Thursday	61	288	120	352	18	639	3	1,481
15-Jan-99	Friday	111	344	147	355	18	616	5	1,596
16-Jan-99	Saturday	82	373	159	389	22	571	3	1,599
17-Jan-99	Sunday	121	362	220	415	22	535	4	1,679
18-Jan-99	Monday	130	356	257	404	11	293	6	1,457
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30-Jul-99	Friday	94	342	125	331	24	351	2	1,269
31-Jul-99	Saturday	78	312	124	331	32	397	2	1,276
1-Aug-99	Sunday	59	292	120	298	26	375	1	1,171
2-Aug-99	Monday	34	64	3	4	1	13	4	123
3-Aug-99	Tuesday	55	250	69	215	29	429	3	1,050
4-Aug-99	Wednesday	55	260	146	329	31	486	2	1,309
5-Aug-99	Thursday	70	273	135	325	38	408	3	1,252
6-Aug-99	Friday	94	319	136	336	25	390	1	1,301
7-Aug-99	Saturday	58	305	144	355	30	410	2	1,304
8-Aug-99	Sunday	52	235	144	324	22	416	3	1,196
9-Aug-99	Monday	68	297	129	342	40	486	1	1,363
10-Aug-99	Tuesday	47	189	53	174	12	263	3	741
11-Aug-99	Wednesday	63	231	117	305	21	326	3	1,066
12-Aug-99	Thursday	58	268	137	301	30	308	6	1,108
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23-Dec-99	Thursday	41	242	110	327	47	615	3	1,385
24-Dec-99	Friday	49	273	119	325	25	536	2	1,329
25-Dec-99	Saturday	49	296	116	298	39	471	2	1,271
26-Dec-99	Sunday	48	274	110	360	41	588	1	1,422
27-Dec-99	Monday	27	269	123	319	30	672	2	1,442
28-Dec-99	Tuesday	29	293	105	334	37	610	1	1,409
29-Dec-99	Wednesday	32	323	108	337	33	563	2	1,398
30-Dec-99	Thursday	40	289	119	355	48	528	1	1,380
31-Dec-99	Friday	43	299	118	324	30	502	1	1,317

** Data Source: JOMAC*

** Toll free vehicles not included*

Table A7: Daily Traffic Flow Volume in 2001 on Jamuna Bridge (West to East)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
1-Jan-01	Monday	89	431	237	555	60	538	2	1,912
2-Jan-01	Tuesday	70	401	223	553	53	573	5	1,878
3-Jan-01	Wednesday	55	356	215	543	62	643	8	1,882
4-Jan-01	Thursday	50	357	309	737	62	605	2	2,122
5-Jan-01	Friday	59	450	229	578	62	583	6	1,967
6-Jan-01	Saturday	60	386	197	522	45	614	5	1,829
7-Jan-01	Sunday	47	403	200	502	50	610	4	1,816
8-Jan-01	Monday	37	279	175	470	51	609	4	1,625
9-Jan-01	Tuesday	40	294	185	488	40	650	4	1,701
10-Jan-01	Wednesday	23	261	190	410	42	690	3	1,619
11-Jan-01	Thursday	39	265	174	456	48	700	3	1,685
12-Jan-01	Friday	44	358	174	462	49	654	6	1,747
13-Jan-01	Saturday	52	354	168	431	40	667	8	1,720
14-Jan-01	Sunday	81	331	185	479	52	625	5	1,758
15-Jan-01	Monday	40	356	171	433	45	722	6	1,773
16-Jan-01	Tuesday	53	258	149	427	54	704	5	1,650
17-Jan-01	Wednesday	29	267	168	419	41	649	12	1,585
18-Jan-01	Thursday	40	304	159	421	54	629	6	1,613
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30-Jul-01	Monday	24	227	193	437	62	570	9	1,522
31-Jul-01	Tuesday	32	215	174	409	75	574	6	1,485
1-Aug-01	Wednesday	35	234	180	415	68	570	5	1,507
2-Aug-01	Thursday	44	280	200	445	78	627	6	1,680
3-Aug-01	Friday	53	276	190	458	65	556	2	1,600
4-Aug-01	Saturday	50	257	190	446	66	654	5	1,668
5-Aug-01	Sunday	49	214	192	433	74	621	5	1,588
6-Aug-01	Monday	43	254	177	443	72	716	9	1,714
7-Aug-01	Tuesday	41	250	188	415	81	650	6	1,631
8-Aug-01	Wednesday	37	260	192	425	71	659	6	1,650
9-Aug-01	Thursday	49	251	185	420	68	626	13	1,612
10-Aug-01	Friday	47	274	194	444	56	626	12	1,653
11-Aug-01	Saturday	45	287	194	406	65	626	7	1,630
12-Aug-01	Sunday	44	318	202	460	65	613	5	1,707
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23-Dec-01	Sunday	89	384	253	590	70	671	7	2,064
24-Dec-01	Monday	63	350	232	568	89	703	6	2,011
25-Dec-01	Tuesday	65	441	236	563	81	726	10	2,122
26-Dec-01	Wednesday	49	340	227	541	79	776	7	2,019
27-Dec-01	Thursday	62	311	216	535	93	749	19	1,985
28-Dec-01	Friday	63	426	215	577	69	660	12	2,022
29-Dec-01	Saturday	52	344	202	524	91	688	11	1,912
30-Dec-01	Sunday	35	302	205	534	76	743	4	1,899
31-Dec-01	Monday	34	283	189	512	79	700	8	1,805

** Data Source: JOMAC*

** Toll free vehicles not included*

Table A8: Daily Traffic Flow Volume in 2003 on Jamuna Bridge (East to West)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
1-Jan-03	Wednesday	15	314	35	651	93	711	12	1,831
2-Jan-03	Thursday	22	300	48	679	107	710	16	1,882
3-Jan-03	Friday	25	367	42	659	95	620	20	1,828
4-Jan-03	Saturday	28	258	36	678	105	663	10	1,778
5-Jan-03	Sunday	31	294	36	671	97	814	16	1,959
6-Jan-03	Monday	27	309	38	647	106	844	16	1,987
7-Jan-03	Tuesday	20	319	35	661	106	867	11	2,019
8-Jan-03	Wednesday	13	294	35	644	114	881	20	2,001
9-Jan-03	Thursday	23	283	50	651	104	927	13	2,051
10-Jan-03	Friday	24	386	37	638	110	712	8	1,915
11-Jan-03	Saturday	23	236	36	627	94	645	11	1,672
12-Jan-03	Sunday	18	288	34	610	88	746	18	1,802
13-Jan-03	Monday	19	273	31	647	124	893	18	2,005
14-Jan-03	Tuesday	15	305	34	658	117	1,052	15	2,196
15-Jan-03	Wednesday	21	392	27	585	100	753	15	1,893
16-Jan-03	Thursday	21	261	17	336	82	712	14	1,443
17-Jan-03	Friday	48	412	29	628	122	781	10	2,030
18-Jan-03	Saturday	47	339	33	649	95	668	16	1,847
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14-Mar-03	Friday	40	397	41	688	76	702	17	1,961
15-Mar-03	Saturday	50	304	44	683	66	651	10	1,808
16-Mar-03	Sunday	46	314	37	665	69	783	14	1,928
17-Mar-03	Monday	32	287	34	700	61	814	20	1,948
18-Mar-03	Tuesday	39	310	31	659	60	857	16	1,972
19-Mar-03	Wednesday	36	288	37	642	89	777	18	1,887
20-Mar-03	Thursday	48	339	44	688	79	763	16	1,977
21-Mar-03	Friday	47	338	35	669	70	704	18	1,881
22-Mar-03	Saturday	50	215	17	423	68	626	10	1,409
23-Mar-03	Sunday	35	256	46	644	73	789	17	1,860
24-Mar-03	Monday	49	282	35	647	75	851	14	1,953
25-Mar-03	Tuesday	52	339	37	677	87	808	13	2,013
26-Mar-03	Wednesday	44	345	38	603	86	746	12	1,874
27-Mar-03	Thursday	42	304	47	621	114	649	15	1,792
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20-Oct-03	Monday	43	367	41	713	152	976	24	2,316
21-Oct-03	Tuesday	41	369	40	753	153	1,011	26	2,393
22-Oct-03	Wednesday	37	449	36	730	148	1,018	16	2,434
23-Oct-03	Thursday	48	468	48	771	162	982	20	2,499
24-Oct-03	Friday	54	401	40	728	133	902	23	2,281
25-Oct-03	Saturday	55	278	38	713	146	781	14	2,025
26-Oct-03	Sunday	36	293	36	712	134	956	18	2,185
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30-Dec-03	Tuesday	37	375	37	818	135	940	34	2,376
31-Dec-03	Wednesday	33	370	36	719	147	898	25	2,228

** Data Source: JOMAC*

** Toll free vehicles not included*

Table A9: Daily Traffic Flow Volume in May 2004 on Jamuna Bridge

(Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	Tot Veh
1-May-04	Saturday	139	696	22	939	285	1,591	47	**3,719**
2-May-04	Sunday	131	608	83	1,658	288	1,965	52	**4,785**
3-May-04	Monday	92	800	78	1,617	326	2,368	67	**5,348**
4-May-04	Tuesday	123	724	79	1,657	297	2,163	83	**5,126**
5-May-04	Wednesday	83	550	80	1,511	316	2,249	58	**4,847**
6-May-04	Thursday	109	603	82	1,543	332	2,183	58	**4,910**
7-May-04	Friday	108	753	79	1,596	291	2,085	59	**4,971**
8-May-04	Saturday	120	599	67	1,564	314	1,977	47	**4,688**
9-May-04	Sunday	62	260	9	607	215	1,767	59	**2,979**
10-May-04	Monday	81	576	77	1,550	290	2,002	66	**4,642**
11-May-04	Tuesday	109	606	83	1,555	293	2,147	60	**4,853**
12-May-04	Wednesday	75	539	87	1,541	321	2,222	72	**4,857**
13-May-04	Thursday	112	639	100	1,536	272	2,114	69	**4,842**
14-May-04	Friday	137	715	97	1,544	288	1,953	69	**4,803**
15-May-04	Saturday	100	502	100	1,500	260	1,794	71	**4,327**
16-May-04	Sunday	68	546	98	1,533	255	2,071	73	**4,644**
17-May-04	Monday	113	619	105	1,571	273	2,038	68	**4,787**
18-May-04	Tuesday	83	528	102	1,497	257	1,906	79	**4,452**
19-May-04	Wednesday	58	556	106	1,526	280	1,899	73	**4,498**
20-May-04	Thursday	95	690	121	1,543	275	1,814	77	**4,615**
21-May-04	Friday	111	740	117	1,551	239	1,740	59	**4,557**
22-May-04	Saturday	78	508	104	1,535	226	1,507	59	**4,017**
23-May-04	Sunday	84	564	106	1,555	264	2,021	55	**4,649**
24-May-04	Monday	98	590	104	1,559	255	1,771	69	**4,446**
25-May-04	Tuesday	78	528	97	1,571	271	2,010	66	**4,621**
26-May-04	Wednesday	90	654	114	1,543	307	1,840	61	**4,609**
27-May-04	Thursday	97	694	112	1,570	303	1,784	58	**4,618**
28-May-04	Friday	153	785	118	1,606	281	1,661	54	**4,658**
29-May-04	Saturday	91	579	100	1,564	269	1,668	83	**4,354**
30-May-04	Sunday	64	558	101	1,559	272	1,881	63	**4,498**
31-May-04	Monday	58	575	101	1,584	310	1,877	72	**4,577**
TOTAL		**3,000**	**18,884**	**2,829**	**46,785**	**8,725**	**60,068**	**2,006**	**142,297**

** Data Source: Marga Net One Ltd.*

** Toll free vehicles not included*

Table A10: Daily Traffic Flow Volume in November 2004 on Jamuna Bridge (Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	Tot Veh
1-Nov-04	Monday	75	565	77	1,433	306	2,297	99	**4,852**
2-Nov-04	Tuesday	64	692	80	1,453	342	2,181	84	**4,896**
3-Nov-04	Wednesday	65	430	44	875	296	2,144	68	**3,922**
4-Nov-04	Thursday	107	681	102	1,537	315	2,062	61	**4,865**
5-Nov-04	Friday	76	765	79	1,546	318	2,194	71	**5,049**
6-Nov-04	Saturday	127	555	4	108	208	1,597	46	**2,645**
7-Nov-04	Sunday	72	733	105	1,738	329	2,519	86	**5,582**
8-Nov-04	Monday	79	704	86	1,673	337	2,435	72	**5,386**
9-Nov-04	Tuesday	102	747	83	1,756	382	2,441	92	**5,603**
10-Nov-04	Wednesday	146	889	117	2,201	366	2,451	99	**6,269**
11-Nov-04	Thursday	331	1,451	193	3,175	329	2,484	89	**8,052**
12-Nov-04	Friday	222	1,328	261	4,230	351	2,096	63	**8,551**
13-Nov-04	Saturday	189	1,080	155	3,216	232	1,060	21	**5,953**
14-Nov-04	Sunday	82	399	23	678	101	285	4	**1,572**
15-Nov-04	Monday	296	416	10	297	48	88	0	**1,155**
16-Nov-04	Tuesday	292	1,122	72	1,559	153	299	12	**3,509**
17-Nov-04	Wednesday	269	1,213	121	2,297	203	828	35	**4,966**
18-Nov-04	Thursday	228	1,042	120	2,505	237	1,498	56	**5,686**
19-Nov-04	Friday	374	1,392	187	3,581	241	1,665	62	**7,502**
20-Nov-04	Saturday	207	886	106	2,660	248	1,881	58	**6,046**
21-Nov-04	Sunday	130	710	100	2,327	299	2,292	67	**5,925**
22-Nov-04	Monday	110	738	91	2,211	290	2,405	92	**5,937**
23-Nov-04	Tuesday	84	631	80	2,030	319	2,395	96	**5,635**
24-Nov-04	Wednesday	81	659	96	1,954	346	2,439	126	**5,701**
25-Nov-04	Thursday	109	705	89	1,862	329	2,405	87	**5,586**
26-Nov-04	Friday	139	804	97	1,891	317	2,227	80	**5,555**
27-Nov-04	Saturday	118	591	80	1,765	281	2,116	75	**5,026**
28-Nov-04	Sunday	90	648	106	1,769	324	2,426	89	**5,452**
29-Nov-04	Monday	67	736	88	1,719	347	2,316	101	**5,374**
30-Nov-04	Tuesday	80	692	90	1,732	335	2,205	105	**5,239**
TOTAL		**4,411**	**24,004**	**2,942**	**57,778**	**8,529**	**57,731**	**2,096**	**157,491**

* *Data Source: Marga Net One Ltd.*

* *Toll free vehicles not included*

Table A11: Daily Traffic Flow Volume in February 2005 on Jamuna Bridge (Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	Tot Veh
1-Feb-05	Tuesday	96	1,116	159	2,855	378	2,730	77	**7,411**
2-Feb-05	Wednesday	87	891	137	2,498	437	3,017	112	**7,179**
3-Feb-05	Thursday	81	321	27	862	315	2,137	70	**3,813**
4-Feb-05	Friday	146	1,152	123	2,135	408	2,570	86	**6,620**
5-Feb-05	Saturday	90	292	9	46	146	693	22	**1,298**
6-Feb-05	Sunday	91	343	16	785	257	2,085	83	**3,660**
7-Feb-05	Monday	106	883	94	2073	392	2,781	81	**6,410**
8-Feb-05	Tuesday	82	754	78	1959	341	2,847	77	**6,138**
9-Feb-05	Wednesday	58	737	95	1,876	351	2,709	86	**5,912**
10-Feb-05	Thursday	120	801	92	1,900	360	2,745	87	**6,105**
11-Feb-05	Friday	117	847	115	1,968	359	2,591	79	**6,076**
12-Feb-05	Saturday	101	734	108	1,889	375	2,541	91	**5,839**
13-Feb-05	Sunday	86	897	94	1,893	420	2,848	83	**6,321**
14-Feb-05	Monday	84	220	7	21	171	688	32	**1,223**
15-Feb-05	Tuesday	101	368	15	708	246	1,769	65	**3,272**
16-Feb-05	Wednesday	81	854	117	1,898	335	2,217	62	**5,564**
17-Feb-05	Thursday	128	900	105	1,919	396	2,464	86	**5,998**
18-Feb-05	Friday	117	1,003	95	1,870	294	2,213	88	**5,680**
19-Feb-05	Saturday	91	720	94	1,770	271	2,011	60	**5,017**
20-Feb-05	Sunday	119	876	95	1,687	309	2,352	93	**5,531**
21-Feb-05	Monday	138	1,064	100	1,762	256	1,949	69	**5,338**
22-Feb-05	Tuesday	112	748	83	1,941	295	2,234	77	**5,490**
23-Feb-05	Wednesday	77	726	102	1,783	281	2,358	75	**5,402**
24-Feb-05	Thursday	89	729	95	1,794	312	2,353	91	**5,463**
25-Feb-05	Friday	113	899	91	1,804	260	2,062	61	**5,290**
26-Feb-05	Saturday	96	734	84	1,739	278	2,104	72	**5,107**
27-Feb-05	Sunday	78	721	78	1,773	284	2,458	75	**5,467**
28-Feb-05	Monday	91	750	95	1792	268	2,253	91	**5,340**
TOTAL		**2,776**	**21,080**	**2,403**	**47,000**	**8,795**	**63,779**	**2,131**	**147,964**

* *Data Source: Marga Net One Ltd.*

* *Toll free vehicles not included*

Table A12: Daily Traffic Flow Volume in December 2005 on Jamuna Bridge (Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	Tot Veh
1-Dec-05	Thursday	109	487	26	746	314	1,753	67	**3,502**
2-Dec-05	Friday	150	966	91	1,741	347	1,825	75	**5,195**
3-Dec-05	Saturday	116	748	77	1,673	331	2,076	68	**5,089**
4-Dec-05	Sunday	119	768	70	1,608	363	2,371	86	**5,385**
5-Dec-05	Monday	86	702	71	1,605	355	2,287	79	**5,185**
6-Dec-05	Tuesday	75	740	67	1,578	355	2,390	90	**5,295**
7-Dec-05	Wednesday	97	756	86	1,591	370	2,525	81	**5,506**
8-Dec-05	Thursday	130	772	87	1,661	388	2,253	74	**5,365**
9-Dec-05	Friday	128	903	76	1,633	325	2,106	61	**5,232**
10-Dec-05	Saturday	104	862	73	1,680	322	2,255	70	**5,366**
11-Dec-05	Sunday	112	788	67	1,592	353	2,513	97	**5,522**
12-Dec-05	Monday	91	801	63	1,615	367	2,431	97	**5,465**
13-Dec-05	Tuesday	88	777	72	1,605	367	2,507	92	**5,508**
14-Dec-05	Wednesday	104	825	91	1,677	405	2,437	95	**5,634**
15-Dec-05	Thursday	95	963	79	1,734	420	2,510	84	**5,885**
16-Dec-05	Friday	139	1,040	86	1,622	332	2,043	66	**5,328**
17-Dec-05	Saturday	119	940	83	1,722	309	2,116	78	**5,367**
18-Dec-05	Sunday	114	893	55	1,703	350	2,536	87	**5,738**
19-Dec-05	Monday	87	839	65	1,695	375	2,426	75	**5,562**
20-Dec-05	Tuesday	95	850	77	1,722	357	2,494	82	**5,677**
21-Dec-05	Wednesday	99	882	123	2,055	404	2,610	90	**6,263**
22-Dec-05	Thursday	99	1,020	83	1,763	385	2,358	84	**5,792**
23-Dec-05	Friday	148	1,142	80	1,756	346	2,337	63	**5,872**
24-Dec-05	Saturday	115	916	78	1,657	370	2,325	78	**5,539**
25-Dec-05	Sunday	108	1,116	83	1,728	385	2,618	82	**6,120**
26-Dec-05	Monday	94	828	64	1,710	359	2,376	72	**5,503**
27-Dec-05	Tuesday	89	872	81	1,842	390	2,549	75	**5,898**
28-Dec-05	Wednesday	93	904	107	2,199	432	2,744	70	**6,549**
29-Dec-05	Thursday	104	794	72	1,626	485	2,497	96	**5,674**
30-Dec-05	Friday	108	981	75	1,639	418	2,470	92	**5,783**
31-Dec-05	Saturday	109	811	72	1,611	388	2,434	87	**5,512**
TOTAL		**3,324**	**26,686**	**2,380**	**51,789**	**11,467**	**73,172**	**2,493**	**171,311**

* *Data Source: Marga Net One Ltd.*

* *Toll free vehicles not included*

Table A13: Daily Traffic Flow Volume in May 2004 on Nalka-Hatikamrul-Bonpara Link Road (Both Direction)

Date	Day	Pickup	Car	Minibus	Bus/ Truck	Crane	Large Bus/Truck	Total Vehicle
1-May-04	Saturday	23	167	86	623	0	10	909
2-May-04	Sunday	53	169	191	809	0	5	1,227
3-May-04	Monday	30	182	218	900	0	7	1,337
4-May-04	Tuesday	33	177	182	817	0	10	1,219
5-May-04	Wednesday	39	125	145	943	0	14	1,266
6-May-04	Thursday	41	170	164	843	0	9	1,227
7-May-04	Friday	32	222	183	859	0	10	1,306
8-May-04	Saturday	26	160	166	858	0	7	1,217
9-May-04	Sunday	15	57	65	654	0	11	802
10-May-04	Monday	42	171	224	837	0	14	1,288
11-May-04	Tuesday	46	194	212	871	0	5	1,328
12-May-04	Wednesday	37	139	235	909	0	5	1,325
13-May-04	Thursday	23	178	225	860	0	5	1,291
14-May-04	Friday	29	227	227	863	0	7	1,353
15-May-04	Saturday	31	175	195	794	0	5	1,200
16-May-04	Sunday	46	160	224	909	1	12	1,352
17-May-04	Monday	34	195	232	939	1	8	1,409
18-May-04	Tuesday	31	150	218	913	0	11	1,323
19-May-04	Wednesday	34	190	197	1,010	1	16	1,448
20-May-04	Thursday	36	188	205	977	1	8	1,415
21-May-04	Friday	28	227	260	919	0	18	1,452
22-May-04	Saturday	26	158	220	913	0	12	1,329
23-May-04	Sunday	40	143	205	970	0	11	1,369
24-May-04	Monday	30	175	249	1,017	0	19	1,490
25-May-04	Tuesday	43	155	232	944	0	10	1,384
26-May-04	Wednesday	48	191	251	1,058	0	13	1,561
27-May-04	Thursday	36	194	236	998	0	6	1,470
28-May-04	Friday	36	245	273	994	0	17	1,565
29-May-04	Saturday	58	184	258	915	1	11	1,427
30-May-04	Sunday	33	161	248	1,050	0	24	1,516
31-May-04	Monday	45	176	227	1,056	0	12	1,516
Month Total		**1,104**	**5,405**	**6,453**	**28,022**	**5**	**332**	**41,321**

* *Data Source: Pubali-Alloy JV Ltd.*

Table A14: Daily Traffic Flow Volume in December 2004 on Nalka-Hatikamrul-Bonpara Link Road (Both Direction)

Date	Day	Pickup	Car	Minibus	Bus/ Truck	Crane	Large Bus/Truck	Total Vehicle
1-Dec-04	Wednesday	45	201	299	1,427	0	10	1,982
2-Dec-04	Thursday	46	221	319	1,402	1	14	2,003
3-Dec-04	Friday	38	216	245	1,200	0	17	1,716
4-Dec-04	Saturday	29	170	262	1,096	0	20	1,577
5-Dec-04	Sunday	33	176	336	1,278	3	13	1,839
6-Dec-04	Monday	42	197	313	1,405	1	13	1,971
7-Dec-04	Tuesday	37	205	240	1,197	0	14	1,693
8-Dec-04	Wednesday	46	210	258	1,385	0	22	1,921
9-Dec-04	Thursday	46	216	291	1,302	0	8	1,863
10-Dec-04	Friday	38	326	252	1,134	0	14	1,764
11-Dec-04	Saturday	34	290	412	1,139	0	11	1,886
12-Dec-04	Sunday	52	230	277	1,391	1	9	1,960
13-Dec-04	Monday	53	188	292	1,313	0	5	1,851
14-Dec-04	Tuesday	48	189	256	1,357	0	4	1,854
15-Dec-04	Wednesday	50	252	277	1,523	1	11	2,114
16-Dec-04	Thursday	35	329	240	1,383	0	14	2,001
17-Dec-04	Friday	30	341	235	1,146	0	11	1,763
18-Dec-04	Saturday	37	240	237	1,235	2	13	1,764
19-Dec-04	Sunday	50	215	291	1,378	0	13	1,947
20-Dec-04	Monday	34	212	333	1,367	0	10	1,956
21-Dec-04	Tuesday	33	229	260	1,322	0	13	1,857
22-Dec-04	Wednesday	52	206	281	1,488	1	5	2,033
23-Dec-04	Thursday	47	253	282	1,467	0	5	2,054
24-Dec-04	Friday	45	322	270	1,255	0	11	1,903
25-Dec-04	Saturday	51	309	272	1,320	0	8	1,960
26-Dec-04	Sunday	35	106	167	1,019	1	2	1,330
27-Dec-04	Monday	40	274	307	1,250	0	9	1,880
28-Dec-04	Tuesday	36	220	259	1,261	0	9	1,785
29-Dec-04	Wednesday	50	241	286	1,493	0	7	2,077
30-Dec-04	Thursday	43	189	240	1,413	0	16	1,901
31-Dec-04	Friday	55	274	238	1,114	0	9	1,690
Month Total		**1,310**	**7,247**	**8,527**	**40,460**	**11**	**340**	**57,895**

* *Data Source: Pubali-Alloy JV Ltd.*

Table A15: Daily Traffic Flow Volume in April 2005 on Nalka-Hatikamrul-Bonpara Link Road (Both Direction)

Date	Day	Pickup	Car	Minibus	Bus/ Truck	Crane	Large Bus/Truck	Total Vehicle
1-Apr-05	Friday	45	247	257	1,019	0	33	1,601
2-Apr-05	Saturday	53	146	217	1,034	0	11	1,461
3-Apr-05	Sunday	56	173	204	1,253	0	17	1,703
4-Apr-05	Monday	56	188	240	1,156	1	15	1,656
5-Apr-05	Tuesday	47	207	210	1,176	0	9	1,649
6-Apr-05	Wednesday	62	190	209	1,220	0	18	1,699
7-Apr-05	Thursday	58	207	194	1,182	2	18	1,661
8-Apr-05	Friday	57	331	220	1,115	1	29	1,753
9-Apr-05	Saturday	64	198	198	915	0	10	1,385
10-Apr-05	Sunday	64	230	187	1,166	0	25	1,672
11-Apr-05	Monday	41	198	222	1,089	0	25	1,575
12-Apr-05	Tuesday	48	183	191	1,097	0	12	1,531
13-Apr-05	Wednesday	60	210	219	1,194	1	11	1,695
14-Apr-05	Thursday	66	271	204	998	1	20	1,560
15-Apr-05	Friday	36	261	200	945	1	13	1,456
16-Apr-05	Saturday	61	195	204	993	0	15	1,468
17-Apr-05	Sunday	46	189	205	1,215	0	15	1,670
18-Apr-05	Monday	58	211	213	1,086	1	23	1,592
19-Apr-05	Tuesday	44	171	211	1,096	2	20	1,544
20-Apr-05	Wednesday	63	178	225	1,173	1	17	1,657
21-Apr-05	Thursday	53	226	224	1,252	0	19	1,774
22-Apr-05	Friday	55	255	260	1,153	1	19	1,743
23-Apr-05	Saturday	31	174	240	1,042	0	14	1,501
24-Apr-05	Sunday	39	253	261	1,312	1	22	1,888
25-Apr-05	Monday	57	215	270	1,104	1	17	1,664
26-Apr-05	Tuesday	52	193	259	1,163	2	14	1,683
27-Apr-05	Wednesday	83	199	256	1,160	0	13	1,711
28-Apr-05	Thursday	64	213	242	1,169	0	15	1,703
29-Apr-05	Friday	55	309	260	1,165	0	19	1,808
30-Apr-05	Saturday	40	161	229	950	0	9	1,389
Month Total		**1,614**	**6,382**	**6,731**	**33,592**	**16**	**517**	**48,852**

* *Data Source: Pubali-Alloy JV Ltd.*

APPENDIX B

SUMMARIZED DATA TABLES AND CHARTS

Table B1: Day-wise Bi-Directional Hourly Flow Fluctuation (in Percentage of Daily Volume) on Jamuna Bridge, Averaged Over 13 Surveys

Hour	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Avg. %
6 - 7	2.58	2.53	2.99	2.76	2.85	2.72	2.56	**2.71**
7 - 8	2.61	2.66	2.77	2.71	2.86	3.06	3.05	**2.82**
8 - 9	3.44	2.80	2.93	3.03	3.32	3.32	3.48	**3.19**
9 - 10	3.97	3.32	3.64	3.44	3.54	3.56	4.05	**3.65**
10-11	5.42	5.17	4.58	4.52	5.12	4.95	5.08	**4.98**
11-12	6.26	5.54	5.35	5.11	5.67	5.16	5.21	**5.47**
12-13	6.29	5.50	5.17	4.83	5.59	5.31	5.91	**5.51**
13-14	5.77	5.09	4.57	4.80	5.09	5.12	5.06	**5.07**
14-15	4.91	4.51	4.13	4.07	4.34	4.28	4.47	**4.39**
15-16	4.54	4.54	3.88	3.75	4.16	4.20	4.42	**4.21**
16-17	4.65	4.45	4.04	3.84	3.91	4.14	4.24	**4.18**
17-18	4.96	4.83	4.40	4.41	4.37	4.20	4.13	**4.47**
18-19	5.37	4.83	4.66	4.63	4.57	4.77	4.87	**4.81**
19-20	4.07	4.56	4.27	4.24	4.04	4.37	4.51	**4.29**
20-21	4.10	3.72	3.95	3.95	4.08	4.20	3.88	**3.98**
21-22	3.63	4.00	4.19	4.78	3.91	3.91	3.83	**4.04**
22-23	3.92	4.35	4.53	4.92	4.52	4.38	4.34	**4.42**
23-24	4.01	4.53	4.94	5.08	4.70	4.94	4.53	**4.67**
24 - 1	4.35	4.44	5.27	5.48	4.61	5.05	4.77	**4.85**
1 - 2	5.17	5.60	5.76	6.26	5.71	5.82	5.48	**5.68**
2 - 3	4.38	4.94	5.09	4.76	4.78	4.65	4.53	**4.73**
3 - 4	2.28	3.40	3.52	3.44	3.42	3.36	2.91	**3.19**
4 - 5	1.66	2.60	2.79	2.68	2.74	2.27	2.24	**2.42**
5 - 6	1.68	2.09	2.60	2.52	2.12	2.27	2.45	**2.25**
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

**Data Source: BUET*

Table B2: Hourly Fluctuation of Large Bus on Jamuna Bridge, in Percentage of Daily Volume

(Both Direction, Averaged Over One Week)

Hour	Survey-1	Survey-2	Survey-3	Survey-4	Survey-5	Survey-6	Survey-7	Survey-8	Survey-9	Survey-10	Survey-11	Survey-12	Survey-13	Average
6 - 7	0.68	0.82	0.74	1.27	0.70	0.57	0.59	0.45	0.76	0.58	0.99	1.04	0.97	**0.78**
7 - 8	1.33	1.00	1.42	1.11	1.23	1.25	1.18	1.00	1.07	0.95	0.93	1.20	1.27	**1.15**
8 - 9	1.84	2.13	1.88	1.80	1.74	1.77	1.77	1.74	2.01	1.70	1.99	1.51	1.45	**1.80**
9 - 10	4.37	3.62	2.73	3.35	3.06	3.21	1.95	2.51	3.11	3.03	2.87	2.80	3.51	**3.09**
10-11	7.92	5.50	6.57	7.06	6.96	6.80	6.02	6.16	7.06	5.72	6.23	5.99	7.00	**6.54**
11-12	9.24	8.17	8.37	9.07	8.43	8.35	7.95	8.94	8.60	9.28	7.46	7.42	7.07	**8.34**
12-13	7.52	9.90	9.64	7.53	8.17	8.24	7.12	8.30	8.68	8.39	7.98	8.00	6.82	**8.18**
13-14	7.23	7.46	7.81	7.68	7.21	7.03	7.33	7.81	8.05	7.72	9.03	7.44	7.02	**7.60**
14-15	5.14	5.32	5.11	4.49	5.32	5.71	5.47	5.69	5.60	6.26	6.11	7.01	6.46	**5.67**
15-16	4.31	4.68	4.96	4.66	4.21	4.73	4.21	4.43	4.61	4.60	4.04	4.27	4.99	**4.52**
16-17	3.56	4.00	3.90	3.54	4.11	3.96	3.92	3.94	3.82	3.79	3.47	2.94	3.20	**3.70**
17-18	3.54	3.49	3.99	4.01	4.09	3.94	3.55	3.74	4.02	3.69	4.01	4.15	4.60	**3.91**
18-19	5.70	4.46	5.42	4.01	4.45	4.86	4.47	4.62	4.68	4.40	4.06	3.98	4.22	**4.56**
19-20	2.55	3.43	3.66	2.97	3.94	3.07	3.85	3.21	3.16	3.00	2.99	3.11	2.76	**3.21**
20-21	1.93	3.00	3.37	2.18	2.64	2.44	2.98	2.57	1.85	2.63	2.21	2.05	2.31	**2.47**
21-22	3.21	3.58	2.45	2.12	2.26	2.46	2.41	2.41	2.21	2.51	2.29	2.09	2.24	**2.48**
22-23	4.25	4.73	3.18	4.35	3.28	2.87	3.20	3.13	2.14	2.17	1.81	3.32	3.06	**3.19**
23-24	4.93	5.00	4.42	5.29	4.28	3.91	5.58	4.46	4.34	4.07	4.29	4.09	3.57	**4.48**
24 - 1	7.88	6.01	6.29	5.95	4.66	5.10	5.80	5.17	5.34	5.76	5.90	6.02	4.94	**5.75**
1 - 2	8.44	7.38	8.70	7.51	7.89	9.47	10.53	9.54	10.19	9.51	8.82	9.87	7.98	**8.91**
2 - 3	3.59	3.68	3.49	4.61	6.68	6.63	7.18	6.88	5.92	7.52	9.08	8.20	9.73	**6.40**
3 - 4	0.56	1.34	1.24	2.88	2.30	2.51	1.79	2.47	2.05	1.60	2.50	2.00	3.33	**2.04**
4 - 5	0.19	0.64	0.53	1.44	1.30	0.95	0.64	0.56	0.44	0.67	0.73	0.79	0.99	**0.76**
5 - 6	0.08	0.64	0.13	1.14	1.09	0.17	0.52	0.28	0.30	0.45	0.23	0.73	0.51	**0.48**
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

**Data Source: BUET*

Table B3: Hourly Fluctuation of Medium Truck on Jamuna Bridge, in Percentage of Daily Volume (Both Direction, Averaged Over One Week)

Hour	Survey-1	Survey-2	Survey-3	Survey-4	Survey-5	Survey-6	Survey-7	Survey-8	Survey-9	Survey-10	Survey-11	Survey-12	Survey-13	Average
6 - 7	5.74	5.00	3.73	4.72	5.40	4.47	5.28	4.86	4.87	4.70	4.77	4.79	4.71	**4.85**
7 - 8	4.45	4.13	3.86	4.67	5.20	4.13	4.00	4.51	4.47	4.28	3.64	3.64	4.40	**4.26**
8 - 9	4.16	3.99	3.49	4.22	4.86	4.76	3.45	3.86	4.50	3.48	3.82	3.54	3.55	**3.98**
9 - 10	3.52	3.12	3.55	4.19	3.54	3.75	2.96	3.68	3.38	2.69	4.11	3.10	2.70	**3.41**
10-11	2.75	2.42	2.65	3.80	2.93	2.42	3.08	3.23	2.52	2.80	3.18	2.69	2.05	**2.81**
11-12	2.06	1.99	2.50	2.42	2.13	2.39	2.21	2.47	2.33	2.92	2.75	1.65	2.12	**2.30**
12-13	2.79	2.79	2.82	2.20	1.98	1.79	1.38	2.22	1.76	2.25	2.29	1.78	2.22	**2.18**
13-14	2.83	2.50	1.83	2.25	2.11	2.56	1.83	2.14	1.69	2.16	2.35	2.14	2.10	**2.19**
14-15	2.59	2.41	2.39	2.05	2.28	2.13	1.43	2.07	2.12	1.90	2.36	1.68	2.09	**2.12**
15-16	2.83	2.42	2.44	2.38	2.48	2.85	2.08	2.60	2.11	2.56	2.20	2.44	2.64	**2.46**
16-17	3.21	2.87	2.63	2.48	2.41	3.31	2.43	2.47	3.00	2.59	2.88	2.61	2.41	**2.72**
17-18	3.59	3.23	3.76	3.04	2.93	3.97	3.16	2.82	3.13	2.80	3.51	3.97	3.01	**3.30**
18-19	4.19	3.93	3.80	3.24	4.17	4.74	3.70	3.42	3.90	4.65	4.29	3.74	4.66	**4.03**
19-20	5.27	4.35	5.18	4.17	4.56	5.42	4.72	4.65	4.55	4.42	4.32	4.65	4.72	**4.69**
20-21	4.89	5.59	5.78	4.42	5.09	5.17	5.01	4.51	5.31	5.32	5.05	5.97	5.59	**5.21**
21-22	5.69	6.34	6.14	4.59	5.30	6.48	6.57	5.83	6.55	6.36	5.97	5.46	4.96	**5.86**
22-23	6.95	6.97	6.52	6.06	6.54	6.62	8.32	6.39	6.71	6.56	6.29	6.62	5.76	**6.64**
23-24	5.36	7.07	6.65	6.46	6.84	6.67	7.07	6.36	7.26	7.16	6.00	5.99	4.57	**6.42**
24 - 1	4.96	5.67	7.24	6.26	5.82	4.98	6.38	5.72	5.64	5.52	5.62	6.01	4.92	**5.75**
1 - 2	5.62	5.61	5.53	5.29	4.42	4.18	6.29	6.05	4.82	4.74	4.91	5.51	5.08	**5.23**
2 - 3	5.65	5.54	4.71	5.42	4.52	3.87	5.65	5.19	5.30	5.73	4.62	6.14	6.06	**5.26**
3 - 4	4.34	4.80	4.36	5.93	4.51	5.08	5.06	6.29	4.73	5.75	4.73	5.68	6.53	**5.21**
4 - 5	3.14	3.83	4.42	4.70	4.88	4.21	4.21	4.67	4.20	4.99	4.98	5.64	6.18	**4.62**
5 - 6	3.41	3.43	4.03	5.03	5.11	4.04	3.73	3.99	5.18	3.68	5.38	4.55	6.99	**4.50**
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

**Data Source: BUET*

Table B4: Hourly Fluctuation of Light Vehicles on Jamuna Bridge, in Percentage of Daily Volume

(Both Direction, Averaged Over One Week)

Hour	Survey-1	Survey-2	Survey-3	Survey-4	Survey-5	Survey-6	Survey-7	Survey-8	Survey-9	Survey-10	Survey-11	Survey-12	Survey-13	Average
6 - 7	2.00	0.97	1.39	2.19	1.96	1.40	1.12	1.52	2.43	1.80	1.91	1.16	2.13	**1.69**
7 - 8	2.78	1.85	2.86	2.97	3.23	3.32	2.02	2.52	3.76	2.75	2.28	2.83	3.07	**2.79**
8 - 9	4.25	3.36	4.09	4.82	4.41	4.09	3.45	3.65	4.33	3.44	3.13	3.70	4.37	**3.93**
9 - 10	4.68	4.47	4.43	5.39	5.18	4.96	4.08	4.65	4.67	4.58	5.21	5.24	5.15	**4.82**
10-11	6.18	5.08	5.87	7.18	6.99	6.53	5.39	6.15	6.14	6.64	6.64	6.79	6.19	**6.29**
11-12	7.26	6.93	6.41	7.21	6.36	5.83	6.10	6.12	6.31	7.14	6.74	7.14	6.69	**6.63**
12-13	7.46	8.50	7.69	6.20	6.36	8.62	5.85	7.20	7.78	6.29	7.39	7.82	6.37	**7.20**
13-14	6.93	8.71	6.43	5.59	6.33	5.94	6.62	6.10	5.66	4.87	5.69	4.99	5.44	**6.10**
14-15	6.31	8.44	6.97	4.99	6.24	6.01	7.99	6.00	5.49	6.19	6.37	5.34	6.00	**6.33**
15-16	6.67	8.79	7.03	6.47	6.24	6.01	6.95	6.39	6.43	7.20	6.10	6.34	5.55	**6.63**
16-17	7.20	9.17	6.69	5.86	6.95	7.30	6.35	6.17	6.06	6.79	6.61	6.72	7.54	**6.88**
17-18	6.77	7.24	6.72	5.86	6.55	6.98	5.80	6.98	6.23	6.76	5.99	7.78	7.44	**6.70**
18-19	6.58	5.96	6.79	6.40	6.49	7.05	6.15	5.88	6.34	6.13	6.30	6.24	6.69	**6.39**
19-20	4.71	4.70	5.25	5.83	5.50	5.80	5.36	5.88	5.72	6.29	5.45	5.63	5.41	**5.50**
20-21	3.89	3.90	3.89	4.55	4.50	4.02	5.58	4.82	4.33	4.17	4.67	4.73	4.24	**4.41**
21-22	3.43	2.58	3.37	3.74	2.98	3.28	4.84	4.14	2.75	3.76	3.85	3.38	3.81	**3.53**
22-23	3.01	1.95	3.35	2.93	2.11	2.90	3.09	3.38	3.00	2.91	3.03	3.06	2.75	**2.88**
23-24	1.93	1.64	2.01	2.60	2.83	2.06	2.68	2.52	2.69	2.40	2.55	2.35	2.05	**2.33**
24 - 1	1.80	1.39	2.08	1.92	1.86	1.85	3.01	2.35	2.38	2.43	2.04	1.99	2.37	**2.11**
1 - 2	2.00	1.30	1.80	1.18	1.86	1.29	1.48	1.91	1.90	2.18	2.11	1.58	1.57	**1.70**
2 - 3	1.70	1.03	1.24	1.31	1.12	1.50	2.13	1.64	1.56	1.61	1.84	1.67	1.95	**1.56**
3 - 4	0.98	0.82	1.29	1.62	1.43	1.54	1.53	1.84	1.53	1.48	1.53	1.19	1.25	**1.39**
4 - 5	0.52	0.84	1.42	1.79	1.58	1.08	1.37	1.30	1.33	1.07	1.09	1.16	0.77	**1.18**
5 - 6	0.95	0.40	0.95	1.38	0.93	0.66	1.07	0.91	1.19	1.11	1.46	1.19	1.20	**1.03**
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

**Data Source: BUET*

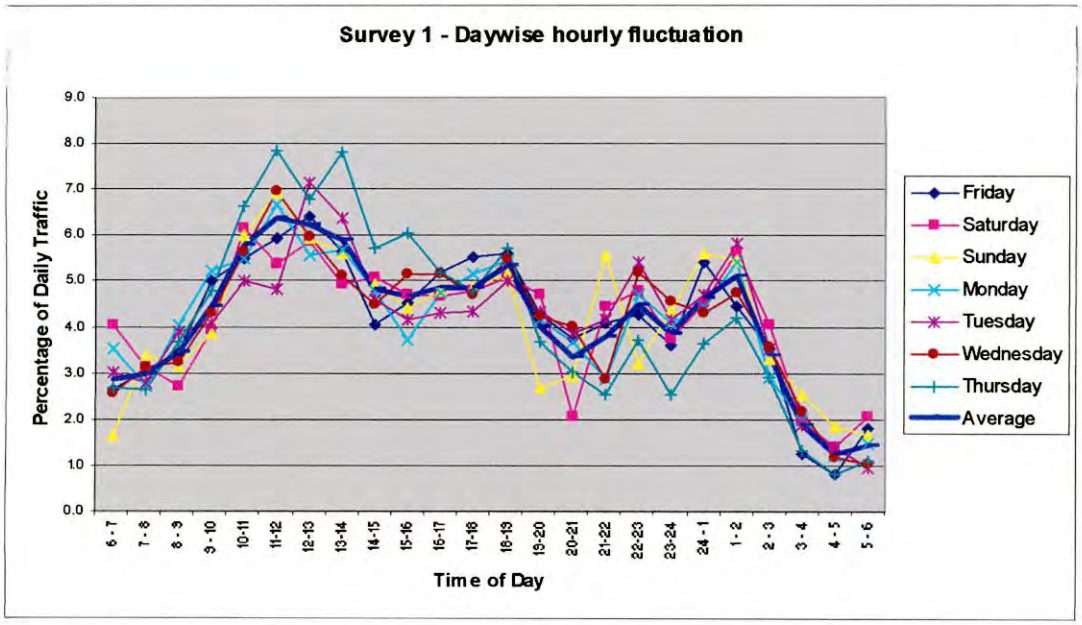

Figure B1: Typical Day-wise Hourly Flow Fluctuation on Jamuna Bridge (BUET Survey 1)

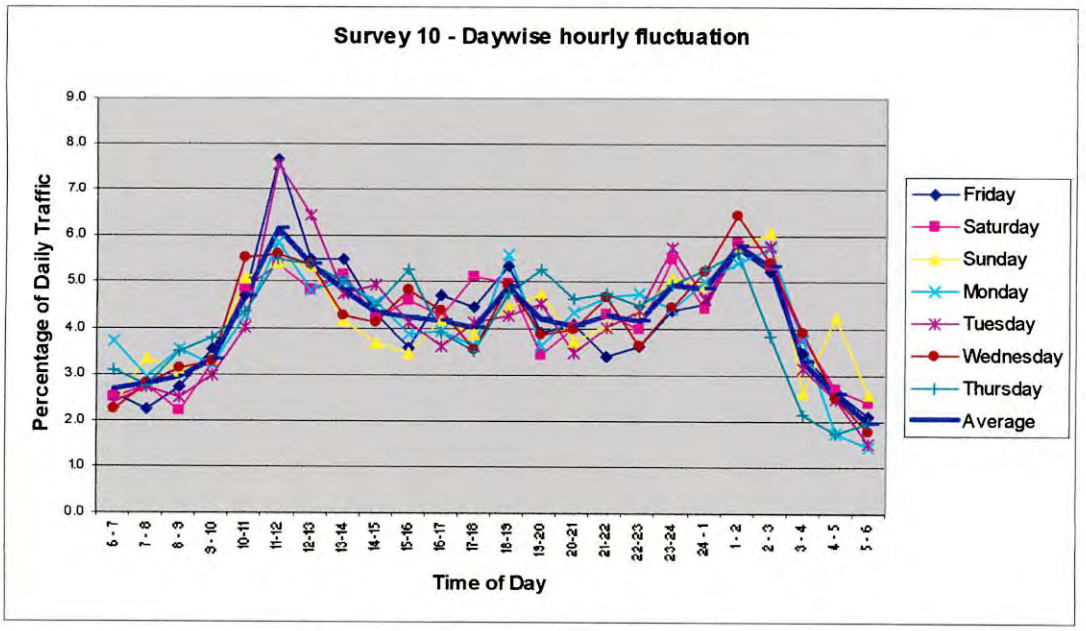

Figure B2: Typical Day-wise Hourly Flow Fluctuation on Jamuna Bridge (BUET Survey 10)

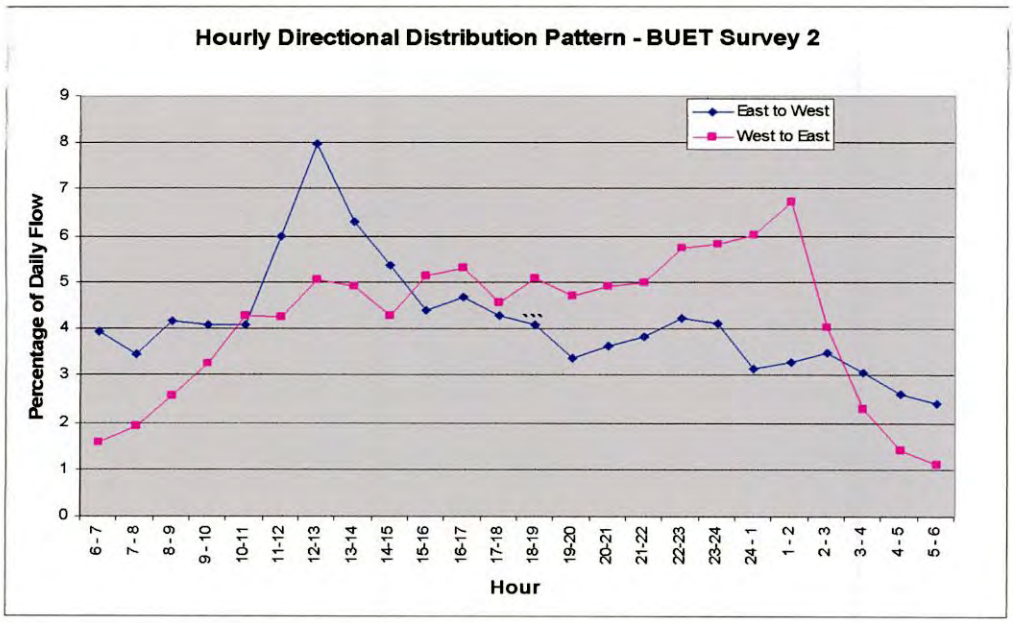

Figure B3: Typical Hourly Directional Distribution of Traffic on Jamuna Bridge (BUET Survey 2)

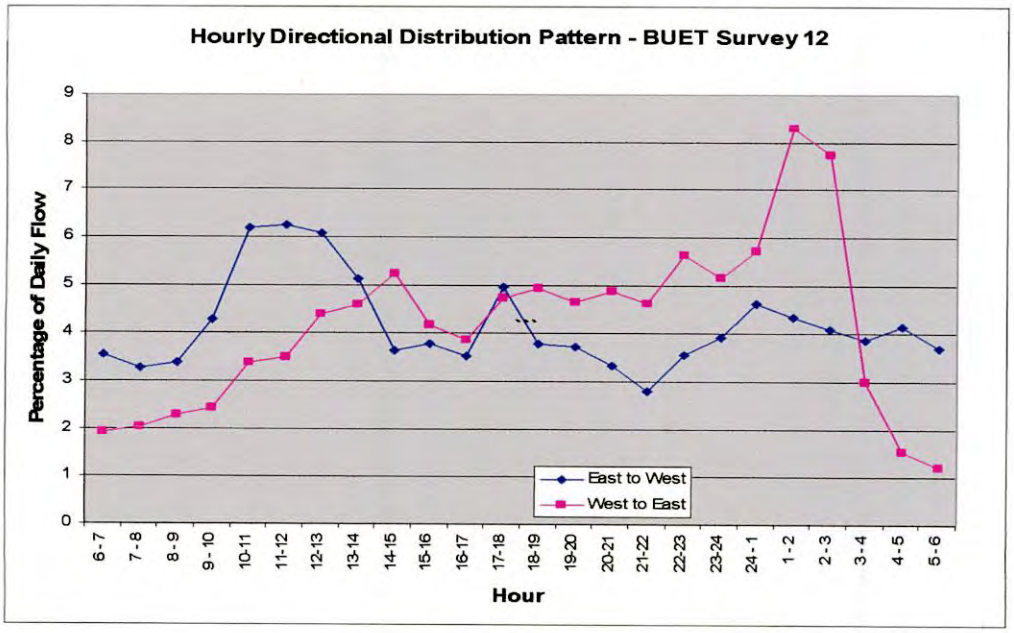

Figure B4: Typical Hourly Directional Distribution of Traffic on Jamuna Bridge (BUET Survey 12)

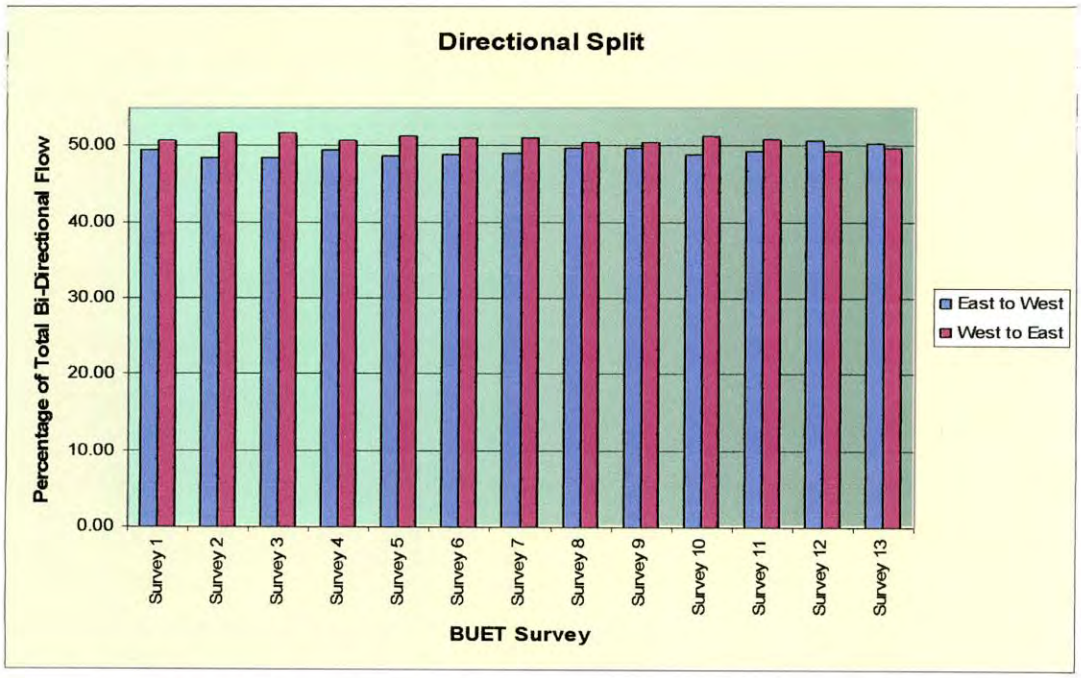

Figure B5: Directional Distribution of Traffic on Jamuna Bridge (BUET 13 Surveys)

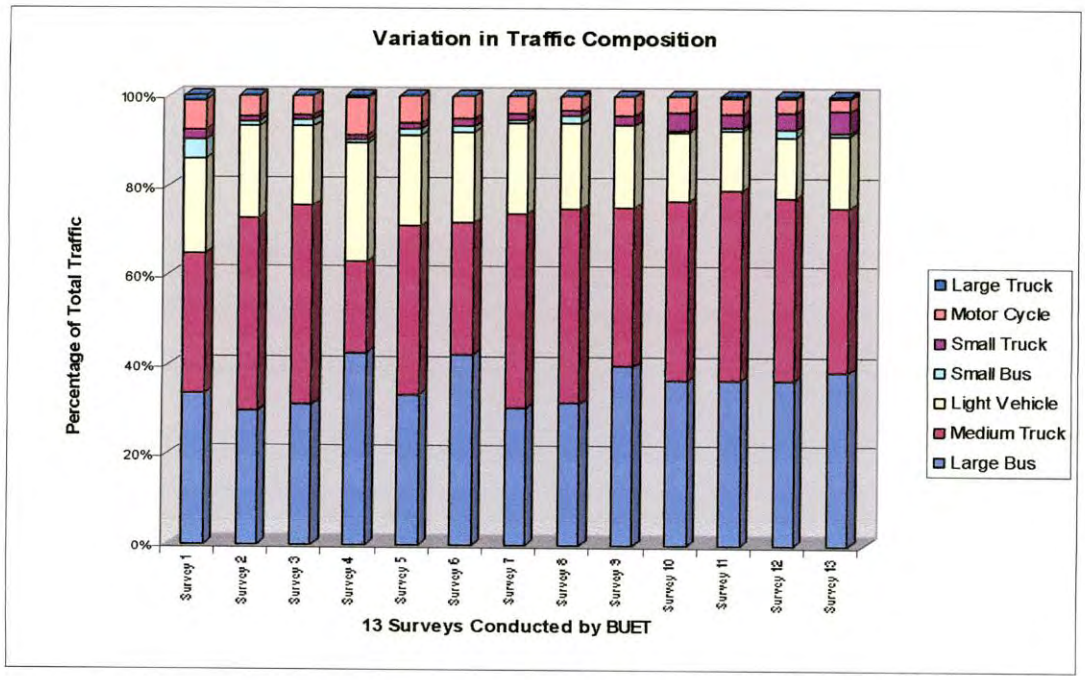

Figure B6: Traffic Composition on Jamuna Bridge (BUET 13 Surveys)

Table B5: Day-wise ADT on Jamuna Bridge (Averaged Over 1999 to 2003)

Day	Average Daily Volume of Traffic		
	East to West	West to East	Bothway
Saturday	1,514	1,648	3,161
Sunday	1,620	1,630	3,250
Monday	1,625	1,607	3,232
Tuesday	1,591	1,563	3,153
Wednesday	1,562	1,592	3,154
Thursday	1,678	1,596	3,274
Friday	1,694	1,724	3,418
Avg. Weekly Vol.	**11,283**	**11,360**	**22,643**
Weekly ADT	**1,612**	**1,623**	**3,235**

**Data Source: JOMAC*

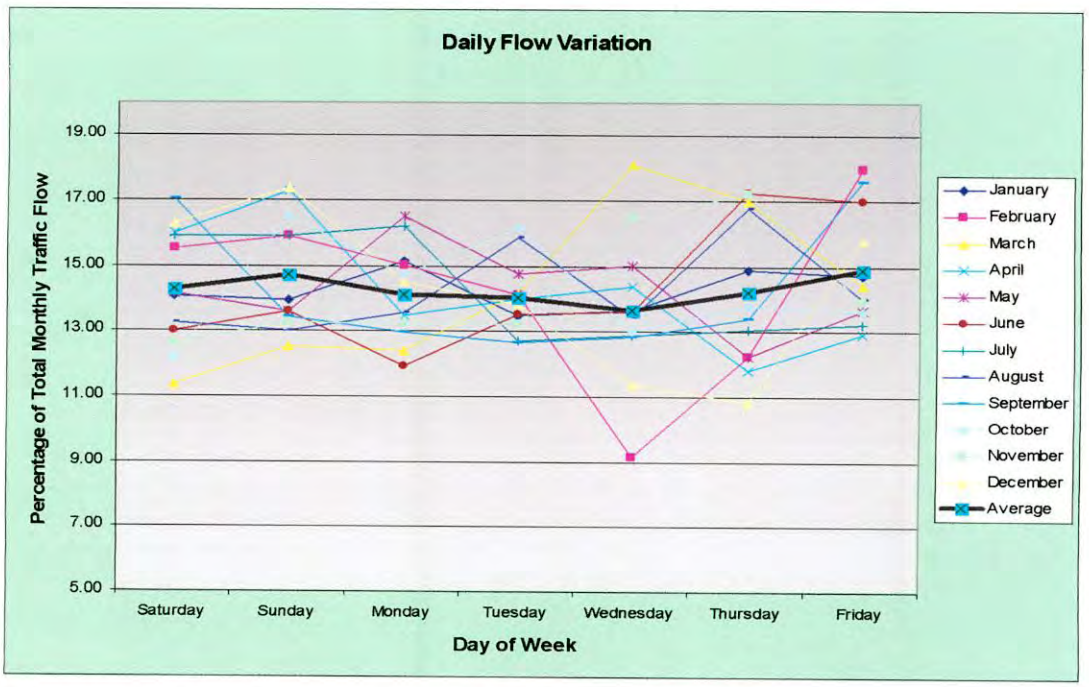

Figure B7: Month-wise Daily Flow Fluctuation on Jamuna Bridge, 2000

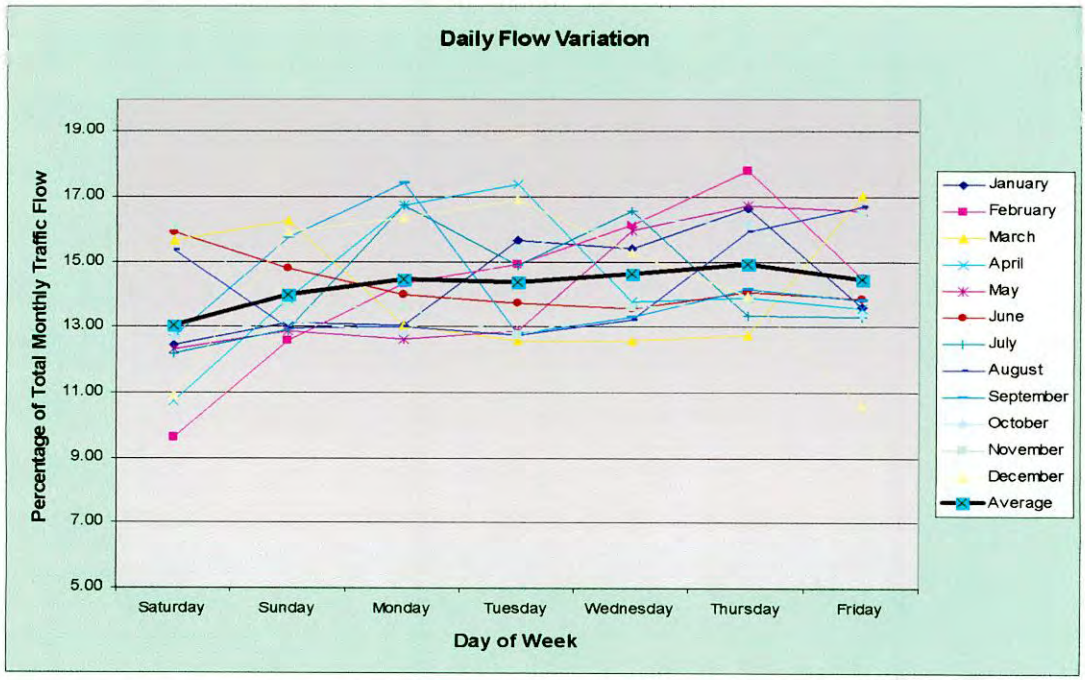

Figure B8: Month-wise Daily Flow Fluctuation on Jamuna Bridge, 2002

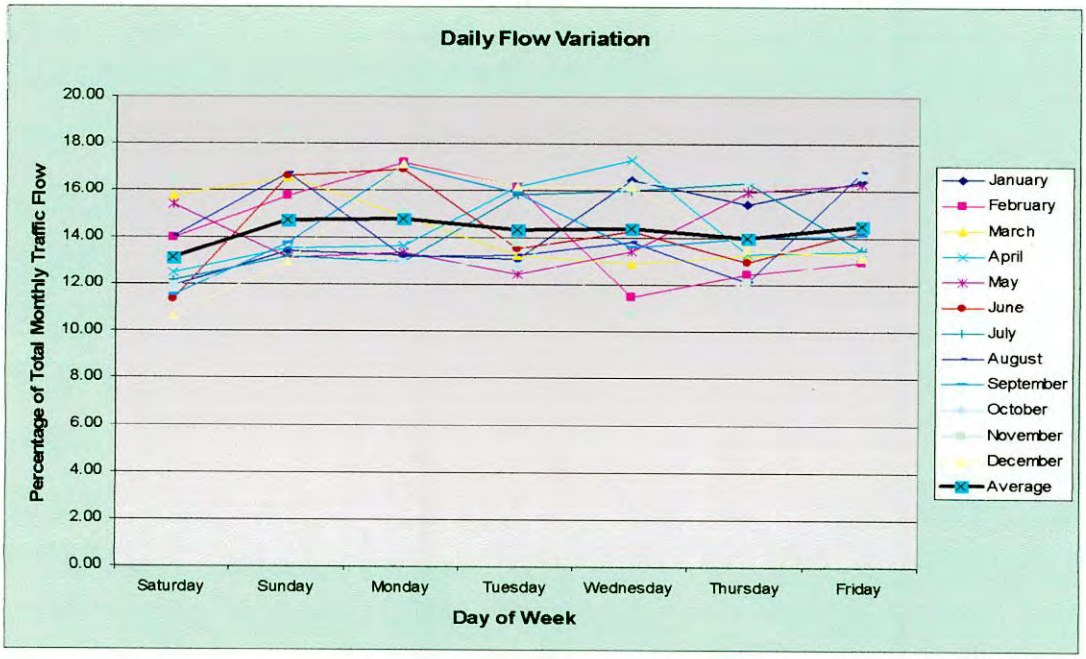

Figure B9: Month-wise Daily Flow Fluctuation on Jamuna Bridge, 2003

Table B6: Day-wise Yearly Traffic Flow on Jamuna Bridge

Day \ Year	1999		2000		2001		2002		2003	
	East to West	West to East	East to West	West to East	East to West	West to East	East to West	West to East	East to West	West to East
Saturday	63,059	70,993	69,578	78,852	83,837	89,319	81,583	86,964	95,455	102,282
Sunday	60,622	60,191	75,615	77,663	84,353	83,055	90,549	90,780	109,982	112,197
Monday	59,050	59,969	73,235	74,026	83,187	80,349	93,994	93,005	113,078	110,491
Tuesday	54,343	56,744	74,445	74,825	79,189	76,854	94,268	92,227	111,394	105,610
Wednesday	60,692	63,975	71,137	72,301	79,673	80,964	94,268	95,317	108,078	109,400
Thursday	63,941	62,664	76,665	71,644	87,495	83,958	99,276	93,985	108,825	102,716
Friday	72,393	73,330	77,412	77,274	91,300	91,655	92,506	93,816	106,881	112,091
TOTAL	**434,100**	**447,866**	**518,087**	**526,585**	**589,034**	**586,154**	**646,444**	**646,094**	**753,693**	**754,787**
TOTAL - BOTH DIRECTION	881,966		1,044,672		1,175,188		1,292,538		1,508,480	

Source Data: JOMAC

Table B7: Average Daily Volume of Three Pre-dominant Vehicle Classes on Jamuna Bridge (1999 to 2003)

Day	Average Daily Volume of Traffic								
	Large Bus			Medium Truck			Light Vehicle		
	East to West	West to East	Bothway	East to West	West to East	Bothway	East to West	West to East	Bothway
Saturday	483	483	**966**	511	611	**1,121**	281	315	**595**
Sunday	483	483	**965**	629	633	**1,262**	278	286	**564**
Monday	487	476	**964**	623	633	**1,257**	285	272	**557**
Tuesday	473	464	**937**	610	615	**1,225**	286	267	**554**
Wednesday	462	464	**926**	596	631	**1,227**	282	270	**553**
Thursday	485	474	**959**	616	608	**1,224**	332	277	**609**
Friday	493	512	**1,005**	580	603	**1,183**	368	349	**717**
Avg. Weekly Vol.	**3,365**	**3,355**	**6,721**	**4,166**	**4,333**	**8,499**	**2,112**	**2,036**	**4,148**

Source Data: JOMAC

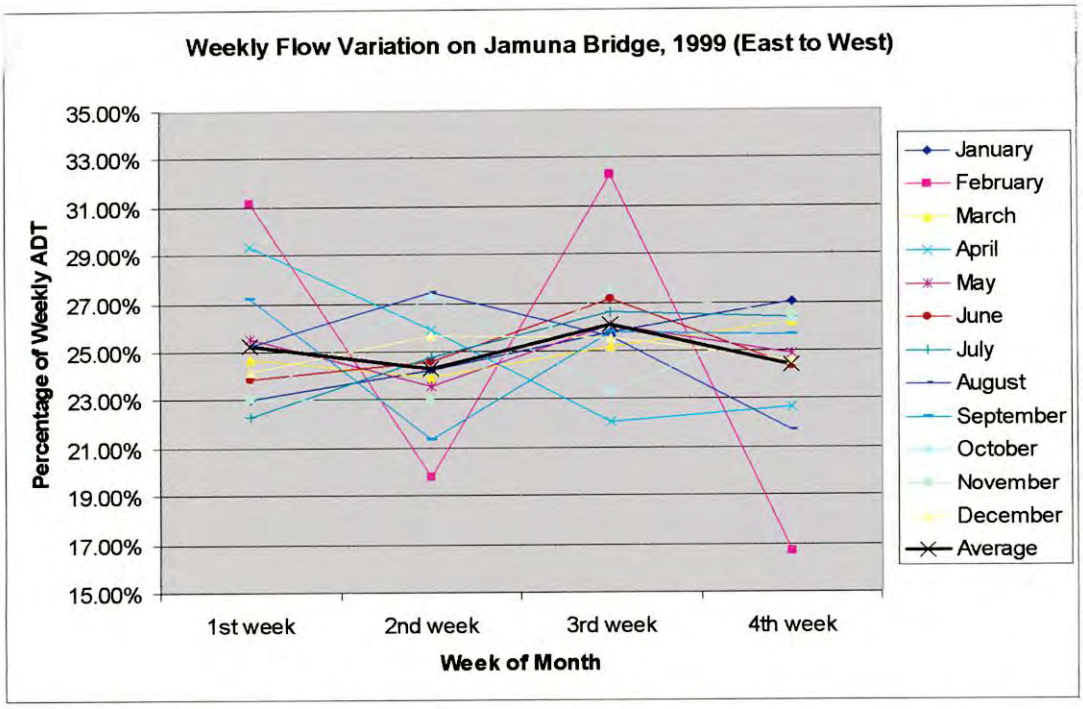

Figure B10: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (East to West), 1999

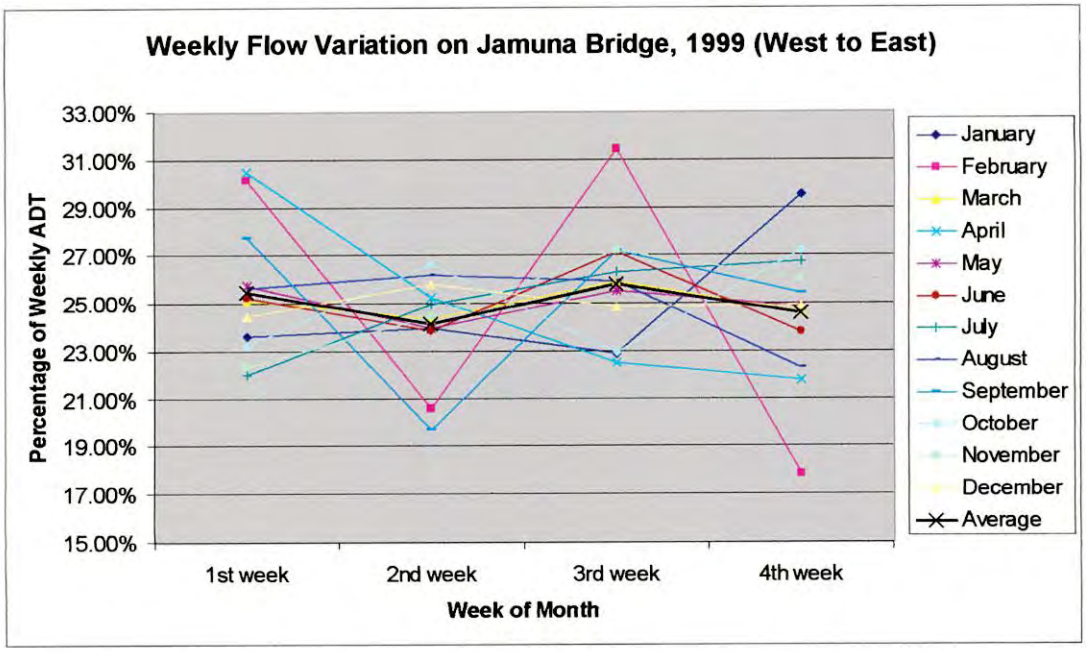

Figure B11: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (West to East), 1999

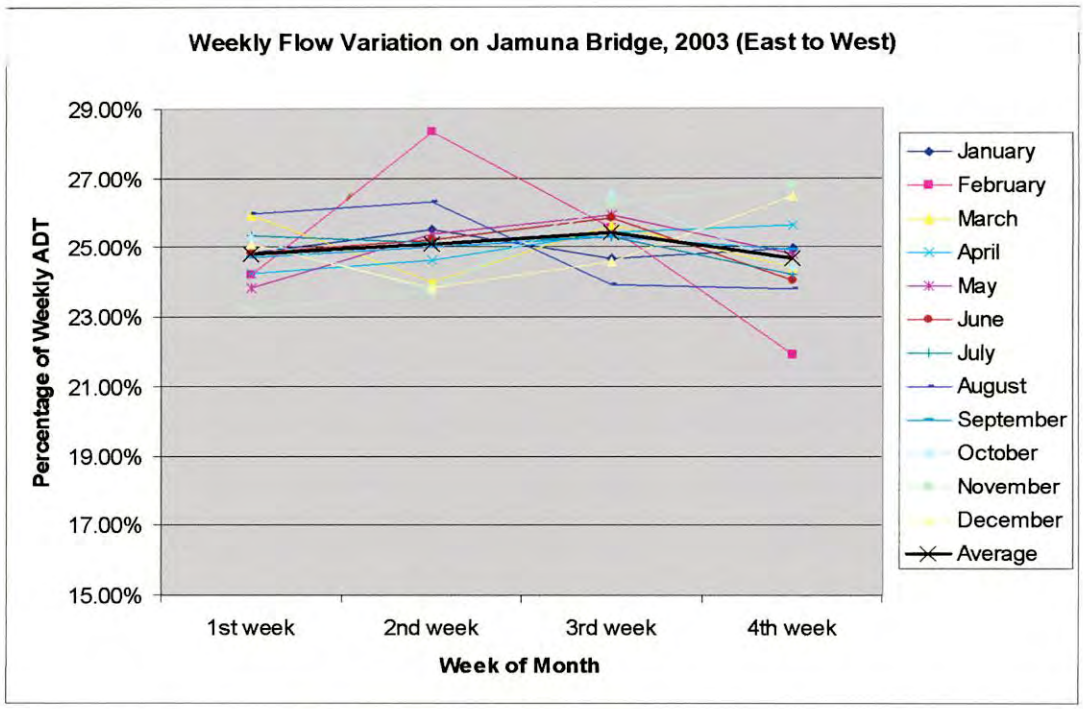

Figure B12: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (East to West), 2003

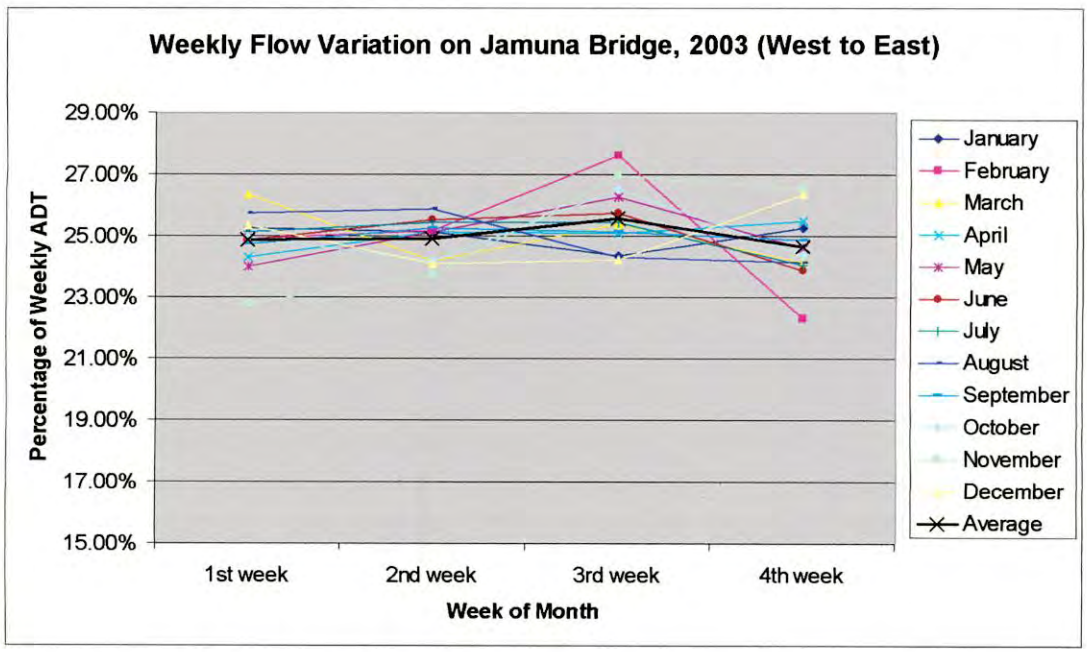

Figure B13: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (West to East), 2003

Table B8: Monthly Bi-Directional Traffic Volume on Jamuna Bridge

Month\Year	1999	2000	2001	2002	2003	2004	2005
Jan	90,390	91,222	104,393	110,248	118,564	152,370	180,426
Feb	74,152	77,506	88,775	105,303	119,435	132,196	147,964
Mar	91,390	101,442	114,133	110,577	115,870	140,377	167,355
Apr	81,615	85,998	84,915	101,651	115,956	134,061	158,215
May	68,364	84,824	100,738	107,076	124,212	142,297	157,247
Jun	69,084	82,696	96,132	101,962	125,251	140,345	160,719
Jul	68,208	86,879	106,750	100,400	135,028	143,343	158,730
Aug	62,932	80,847	99,045	103,788	126,283	140,924	153,591
Sep	60,048	78,509	78,450	102,460	128,154	146,481	157,462
Oct	65,983	87,183	93,019	114,256	134,913	147,180	152,113
Nov	65,145	90,116	95,727	108,495	124,373	157,491	165,180
Dec	84,655	97,450	113,111	126,322	140,441	169,018	171,311
Yearly Volume	**881,966**	**1,044,672**	**1,175,188**	**1,292,538**	**1,508,480**	**1,746,083**	**1,930,313**

Source Data: JOMAC and Marga Net One Ltd.

Table B9: Monthly Bi-Directional Traffic Flow, in Percentage of Yearly Volume

Month\Year	1999	2000	2001	2002	2003	2004	2005	**Average**
Jan	10.25%	8.73%	8.88%	8.53%	7.86%	8.73%	9.35%	**8.90%**
Feb	8.41%	7.42%	7.55%	8.15%	7.92%	7.57%	7.67%	**7.81%**
Mar	10.36%	9.71%	9.71%	8.56%	7.68%	8.04%	8.67%	**8.96%**
Apr	9.25%	8.23%	7.23%	7.86%	7.69%	7.68%	8.20%	**8.02%**
May	7.75%	8.12%	8.57%	8.28%	8.23%	8.15%	8.15%	**8.18%**
Jun	7.83%	7.92%	8.18%	7.89%	8.30%	8.04%	8.33%	**8.07%**
Jul	7.73%	8.32%	9.08%	7.77%	8.95%	8.21%	8.22%	**8.33%**
Aug	7.14%	7.74%	8.43%	8.03%	8.37%	8.07%	7.96%	**7.96%**
Sep	6.81%	7.52%	6.68%	7.93%	8.50%	8.39%	8.16%	**7.71%**
Oct	7.48%	8.35%	7.92%	8.84%	8.94%	8.43%	7.88%	**8.26%**
Nov	7.39%	8.63%	8.15%	8.39%	8.24%	9.02%	8.56%	**8.34%**
Dec	9.60%	9.33%	9.62%	9.77%	9.31%	9.68%	8.87%	**9.46%**
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Maximum	10.36%	9.71%	9.71%	9.77%	9.31%	9.68%	9.35%	9.46%
Minimum	6.81%	7.42%	6.68%	7.77%	7.68%	7.57%	7.67%	7.71%

Source Data: JOMAC and Marga Net One Ltd.

Table B10: Monthly Bi-Directional Traffic Flow on Jamuna Bridge, 1999

Month	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic	Percentage
Jan-99	6128	22529	8534	20313	1075	31636	175	**90390**	**10.25**
Feb-99	4148	17415	6964	15359	1176	28903	187	**74152**	**8.41**
Mar-99	4718	21657	8116	18037	1619	36943	300	**91390**	**10.36**
Apr-99	4556	18093	7603	20558	1515	28985	305	**81615**	**9.25**
May-99	3400	16707	6203	18151	1331	22032	540	**68364**	**7.75**
Jun-99	3651	17014	6584	16891	1469	23238	237	**69084**	**7.83**
Jul-99	4311	16924	6683	16855	1698	21516	221	**68208**	**7.73**
Aug-99	3877	15881	6781	16850	1604	17772	167	**62932**	**7.14**
Sep-99	2968	14131	6664	17617	1771	16788	109	**60048**	**6.81**
Oct-99	3395	15537	6831	19908	1900	18276	136	**65983**	**7.48**
Nov-99	2839	14924	6158	17370	1819	21869	166	**65145**	**7.39**
Dec-99	2884	17999	6990	19004	2140	35530	108	**84655**	**9.60**
TOTAL	**46875**	**208811**	**84111**	**216913**	**19117**	**303488**	**2651**	**881966**	100.00
Percentage	5.31	23.68	9.54	24.59	2.17	34.41	0.30		

Source Data: JOMAC

Table B11: Monthly Bi-Directional Traffic Flow on Jamuna Bridge, 2000

Month	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic	Percentage
Jan-00	4205	22276	10239	23587	1899	28940	76	**91222**	**8.73**
Feb-00	2692	17318	7039	18308	1963	30056	130	**77506**	**7.42**
Mar-00	4486	23154	10432	24615	2166	36439	150	**101442**	**9.71**
Apr-00	2985	17381	7842	20180	2248	35188	174	**85998**	**8.23**
May-00	3408	17201	7460	19577	2847	34080	251	**84824**	**8.12**
Jun-00	3034	17549	9126	22767	2664	27410	146	**82696**	**7.92**
Jul-00	3423	17909	9509	24485	2963	28402	188	**86879**	**8.32**
Aug-00	3211	15960	8908	23213	3088	26246	221	**80847**	**7.74**
Sep-00	2815	15358	8167	24172	3282	24476	239	**78509**	**7.52**
Oct-00	3094	16591	8408	25192	3782	29909	207	**87183**	**8.35**
Nov-00	3010	16514	8524	24304	4127	33390	247	**90116**	**8.63**
Dec-00	3247	19640	9842	25465	3250	35697	309	**97450**	**9.33**
TOTAL	**39610**	**216851**	**105496**	**275865**	**34279**	**370233**	**2338**	**1044672**	100.00
Percentage	3.79	20.76	10.10	26.41	3.28	35.44	0.22		

Source Data: JOMAC

Table B12: Monthly Bi-Directional Traffic Flow on Jamuna Bridge, 2001

Month	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic	Percentage
Jan-01	2917	20344	10795	28128	3025	38855	329	**104393**	**8.88**
Feb-01	2725	15696	7860	20373	2563	39029	529	**88775**	**7.55**
Mar-01	4229	21929	12170	30053	3060	42211	481	**114133**	**9.71**
Apr-01	3173	13906	7977	19235	2983	37116	525	**84915**	**7.23**
May-01	3433	16485	10650	24989	4109	40475	597	**100738**	**8.57**
Jun-01	3441	17224	10835	24763	3881	35429	559	**96132**	**8.18**
Jul-01	3075	16879	12302	27392	4721	41890	491	**106750**	**9.08**
Aug-01	2577	16028	11704	26792	4248	37282	414	**99045**	**8.43**
Sep-01	2144	13537	9169	21841	4018	27275	466	**78450**	**6.68**
Oct-01	2763	14224	10477	24407	4789	35958	401	**93019**	**7.92**
Nov-01	2923	15115	10511	23781	5156	37516	725	**95727**	**8.15**
Dec-01	3830	21398	13226	30466	4935	38497	759	**113111**	**9.62**
TOTAL	**37230**	**202765**	**127676**	**302220**	**47488**	**451533**	**6276**	**1175188**	100.00
Percentage	3.17	17.25	10.86	25.72	4.04	38.42	0.53		

Source Data: JOMAC

Table B13: Monthly Bi-Directional Traffic Flow on Jamuna Bridge, 2002

Month	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic	Percentage
Jan-02	2922	18574	11325	29447	4902	42317	761	**110248**	**8.53**
Feb-02	3800	20721	2671	35746	3795	38017	553	**105303**	**8.15**
Mar-02	3347	18901	2591	39320	4296	41384	738	**110577**	**8.56**
Apr-02	3124	16555	2358	34033	4683	40319	579	**101651**	**7.86**
May-02	3206	18527	2407	36496	5595	40248	597	**107076**	**8.28**
Jun-02	2871	17323	2293	35909	5357	37508	701	**101962**	**7.89**
Jul-02	2972	16908	2237	35893	5614	36258	518	**100400**	**7.77**
Aug-02	3328	16996	2236	37789	6001	37067	371	**103788**	**8.03**
Sep-02	2833	15521	2126	36763	5432	39153	632	**102460**	**7.93**
Oct-02	2550	17278	2200	38682	6729	45968	849	**114256**	**8.84**
Nov-02	1608	14621	1994	34800	6054	48646	772	**108495**	**8.39**
Dec-02	2486	22402	2579	50132	5589	42389	745	**126322**	**9.77**
TOTAL	**35047**	**214327**	**37017**	**445010**	**64047**	**489274**	**7816**	**1292538**	100.00
Percentage	2.71	16.58	2.86	34.43	4.96	37.85	0.60		

Source Data: JOMAC

Table B14: Monthly Bi-Directional Traffic Flow on Jamuna Bridge, 2003

Month	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic	Percentage
Jan-03	1647	19688	2162	38434	6391	49338	904	**118564**	**7.86**
Feb-03	3349	23025	2135	45483	4625	40053	765	**119435**	**7.92**
Mar-03	2607	18936	2350	40536	4773	45629	1039	**115870**	**7.68**
Apr-03	2726	17388	2241	38732	5802	47645	1422	**115956**	**7.69**
May-03	2938	19883	2165	40882	6863	49948	1533	**124212**	**8.23**
Jun-03	2674	19946	2096	41107	7144	50887	1397	**125251**	**8.30**
Jul-03	2851	19857	2528	44247	7528	56947	1070	**135028**	**8.95**
Aug-03	2766	18810	2268	42567	7647	51375	850	**126283**	**8.37**
Sep-03	2561	18067	2129	41836	8490	53579	1492	**128154**	**8.50**
Oct-03	2749	20305	2379	43862	8990	55310	1318	**134913**	**8.94**
Nov-03	3568	20573	2090	44548	6776	45260	1558	**124373**	**8.24**
Dec-03	2600	21891	2339	49738	6689	55396	1788	**140441**	**9.31**
TOTAL	**33036**	**238369**	**26882**	**511972**	**81718**	**601367**	**15136**	**1508480**	100.00
Percentage	2.19	15.80	1.78	33.94	5.42	39.87	1.00		

Source Data: JOMAC

APPENDIX C

SAMPLE OF CORRESPONDENCE FOR DATA COLLECTION

Department of Civil Engineering
Bangladesh University of Engineering & Technology
Dhaka 1000, Bangladesh

পুরকৌশল বিভাগ
বাংলাদেশ প্রকৌশল বিশ্ববিদ্যালয়
ঢাকা -১০০০, বাংলাদেশ

Dr. Md. Shamsul Hoque, Associate Professor
Tel: 9665650-80, 8616833-8, Ext: 7532, Fax: 8613026, shoque@ce.buet.ac.bd

Executive Director
Jamuna Bridge Authority
Dhaka

Date: 29-01-06

নির্বাহী পরিচালকের দপ্তর, যমুনাসেতু
ডাইরী নং ..... তারিখ .....
পরিচালকঃ (প্রশাঃ/কারিঃ/অঃওহিঃ/প্রোওম)
অতিঃপরিঃ (প্রশাঃ/কারিঃ/অঃওহিঃ/প্রোওম)
একান্ত সচিব/ব্যক্তিগত সহকারী
স্বাক্ষরঃ

Subject: Request for Traffic Flow Data

Dear Sir,

I am pleased to inform you that Mr. Hamid-uz-Zaman bearing Student Number 100104420P is presently doing his M.Sc. Engineering thesis work on "Traffic Flow Characteristics and Modelling for Estimation of AADT in Selected Rural Highways" under my supervision. In order to carry out this research work, long duration traffic flow count data is of vital importance.

I have gathered that you have electronic version of traffic flow data which is generated at Jamuna Bridge Toll Plaza. It would be highly appreciated and duly acknowledged if you kindly allow Mr. Hamid-uz-Zaman to get a copy of the traffic flow database particularly collected by MargaNet Company (New JMB O&M Operator).

I am very much optimistic about your cooperation. If you have any query please feel free to contact me.

Thanking you beforehand.

Yours sincerely,

30.01.06

Dr. Md. Shamsul Hoque
Thesis Supervisor
Mobile: 011 080526

Jamuna Multipurpose Bridge Authority
Setu Bhaban, New Airport Road
Banani, Dhaka-1212.

Memo No. Tech/Jb-53/94 (Vol-3) - 98 Date: 09-02 -2006

Operations Director
Marga Net One Ltd (MNOL)
Site Office, Bhuapur
Tangail

Sub: Supply of Data

Dear Sir.

Please find herewith a letter received from the Department of Civil Engineering, BUET, Dhaka. requesting for some traffic flow count data of Jamuna Multipurpose Bridge.

You are therefore requested to provide the necessary data Mr. Mamid-uz-Zaman, a student of M.Sc Engineer, BUET, Dhaka to at an early date.

Thanking You,

Enclo : As stated.

(Md. Faruque Ahmed)
Deputy Director (Admin & State)

CC.
1. Director (Admin/Tech), JMBA, Dhaka.
2. PS to Executive Director, JMBA, Dhaka.
3. Mr. A K Azad /Mr. Ohiduzzaman, Asstt. Engr. , Site Office, Tangail.
4. Mr. Hamid-uz-Zaman, student of M.Sc Engineer Civil Engineering Department, BUET, Dhaka

Yahya English L7