Department of Civil Engineering

Investigation of Traffic Flow Characteristics Parameters in Major National Highways of Bangladesh

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DECLARATION

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: .....

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LIST OF PUBLICATIONS

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ABSTRACT

The behavior of traffic flow is complex and nonlinear. Efficient transportation system mostly depends upon proper traffic monitoring, design and management. Developing country like Bangladesh has no separate traffic engineering parameters set for the major highway corridors. The road agency of Bangladesh has weaknesses in these sectors and more surprisingly there is no long-term traffic data collection and preservation policy. Hence, the research is performed to investigate the detail traffic flow parameters in three major National Highways of Bangladesh. Based on the availability of long term daily traffic data from toll operation and collecting companies, National Highways like NH-1, NH-2 and NH-5 are nominated for this research work. Traffic flow indicators including traffic growth pattern, traffic compositions, directional distribution, truck and bus percentages, seasonal flow variations, weekly and daily flow characteristics, expansion factors, regression models for AADT estimation, and artificial neural network (ANNs) models are analyzed separately for the selected highways in this research work.

Traffic growth pattern among three highway corridors are found different, such as 0.43%, 10.71% and 11.15% per annum respectively for NH-2, NH-1 and NH-5. The study reveals that traffic flow in NH-2 highway is still unstable in nature. The individual vehicle class wise growth pattern and traffic compositions are also calculated. The pavement design need to be modified in those highways due to higher percentages of heavy truck. The traffic management is needed to be incorporated with the traffic composition of individual highways. The directional distributions are found nearly 50% of all highways. Daily traffic flow fluctuations for total traffic and major vehicular classes are determined in this work with wide range of variations. Additionally, weekly and seasonal flow variations are found with several explanations. However, most of the basic traffic flow patterns of these highways are found repetitive in nature. The daily and monthly expansion factors and regression models for AADT estimations demonstrates diverse range of variations among these corridors. Artificial neural network models are also used in the mentioned highways for traffic flow prediction and forecasting.

Traffic data is the foundation of highway transportation planning and is used in making numerous decisions. Since accurate traffic data is a very critical element in the

transportation planning process, understanding and implementing the process precisely can lead to better design and maintenance decisions. The geometric and structural design of any road facility greatly depends on traffic engineering parameters. Bangladesh road authority don’t use updated and long-term traffic data to design and manage road and traffic system. A wide-ranging traffic data analyses have been performed in this thesis for selected highways of Bangladesh. The detail studies will be useful for planning and designing traffic facilities, selecting geometric standards, pavement design and management, economic analyses and vehicle management for congestion control and accident prevention.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

An adequate and efficient country-wide transport system is a pre-requisite for initiating and sustaining economic development. Investment in improving transport efficiency is the key to the expansion and integration of markets like sub-national, national and international. It contributes to the generation of economies of scale, increased competition, reduced costs, systematic urbanization, export-led faster growth and a larger share of international trade. An efficient transport system is an important element of trade logistics cost and as such is a major determinant of export competitiveness. Efficient transport is also critical in enhancing the physical mobility of citizens. Efficient transport reduces the commuting time of public, thereby contributing to their welfare. As the traffic behaves in a complex and nonlinear way, depending on the interactions of many vehicles. Due to the individual reactions of human drivers, vehicles do not interact simply following the laws of mechanics, but rather display cluster formation and shock wave propagation, both forward and backward, depending on vehicle density.

In Bangladesh, the road sector has been playing an increasingly significant role in transporting both passengers and freight. In 1975, the road sector's share of passenger and freight traffic was only 54% and 35% respectively out of a total of 17 billion passenger km and 2.6 billion ton-km. However, as of a 2007 World Bank report (the most recently published data including modal share statistics), the share of road transport in the carriage of passenger and freight traffic has grown significantly and is more than 88% in passenger-km and 80% in ton-km in 2005, making it the most utilized form of transport in Bangladesh. This is most likely due to historically higher levels of investment and better-quality service; for example, the road sector not only provides point-to-point transport but also has the ability to interact with all other modes of transport, such as inland waterways, railways, and airports. The main stakeholders include the Roads and Highways Department (RHD) and the Local Government Engineering Department (LGED). RHD has constructed the major road network in the country, including the national and the

regional highways, and zilla roads, whereas LGED has developed the other roads like upazilla, union and the village roads.

As of 2015, the total length of the road network is 21,481.25 km, of which 18,202.06 km is paved, under the management of Roads and Highways Department at present. Of the total road network under the Department, 3544 km is National Highways (16%), 4278 km Regional Highways (20%) and remaining 13,659 km is Zila roads (64%). Besides, RHD has 7,741 bridges and 13,751 culverts under its jurisdiction. Moreover, RHD has been operating about 134 ferry boats in 55 ferry ghats on its road network throughout the country. It should be mentioned here that the length of road network under RHD did not increase during last few years. However, RHD maintains the quality of different important road segments has been significantly improved through carrying out development/ improvement works of various standards as per requirement.

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. 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.

1.2 STATEMENT OF THE PROBLEM

Bangladesh is one of the world's most densely populated countries, with its people crammed into a delta of rivers that empties into the Bay of Bengal. The poverty is deep and widespread, but Bangladesh has in recent years reduced population growth and improved health and education. Formerly East Pakistan, Bangladesh came into being only in 1971, when the two parts of Pakistan split after a bitter war. However, Bangladesh spent 15 years under military rule and, although democracy was restored in 1990, the political scene remains volatile.

The road network of Bangladesh has developed based upon need based but not in a planned manner with fund scarcity as a burning issue. At the same time, the road infrastructures suffer not only lacks quality material and technology but also traffic congestion, heavy axle loading and natural disasters like heavy rain and flood.

Extensive search of literature reveals that the required indicators for determination of highway construction, planning and management are not available. Rather those of developed or neighboring countries are often used for the purpose. Traffic engineering deals with the functional part of transportation system, except the infrastructures provided. Unfortunately, Bangladesh government road agencies pay less attention in traffic engineering purposes. On the other hand, dynamic elements are now being introduced into road traffic management in developed countries. These include sensors to measure traffic flows and automatic, interconnected, guidance systems to manage traffic (for example, traffic signs which open a lane in different directions depending on the time of day). The first step to enter in intelligent transportation systems includes collection and preservation of traffic data from highways. Yet, the road agencies have not paid enough emphasis on accumulating data related to transport sector. This can pose a problem during strategically planning the maintenance requirements as well as planning of new infrastructure projects. Determination of traffic indicators requires 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.

Highways of Bangladesh deals with mixed traffic with light to heavy vehicles at large quantity in very limited road infrastructures. Recent frequent pavement damages and congestion all over the country requires remedial measures like realistic design of pavements and traffic modelling. Incorrect or assumed data always leads to road networks inadequately facilitated or over designed. Hence, it is mandatory now to prepare reliable traffic pattern based upon long duration continuous traffic data.

1.3 OBJECTIVE OF THE RESEARCH

The main objective of this research is to determine individual highway based vehicular cyclic pattern and characteristics of traffic flows on major corridors of Bangladesh to acquire predictive model. This would be highly beneficial for road agencies as no such practice is observed yet on behalf of Bangladesh government. Furthermore, the traffic design for new highways and linking roads along the selected corridors could be function more efficiently and economically.

The specific objectives of the research are:

i. To study on the general characteristics of vehicular flow

ii. To collect continuous traffic flow data from major National Highways

iii. To determine vehicular traffic flow patterns and their related parameters of different highways

iv. To develop expansion factors, regression models and neural network models for the selected corridors

v. To propose rational traffic design parameters considering actual road traffic condition.

It is expected that outcome of this research work will facilitate identification of different vehicular flow characteristics in particular relation to geometric and structural design of pavement on different corridors of Bangladesh.

1.4 RESEARCH SCOPE

Major national highway corridors like Dhaka to Chittagong (NH-1), Dhaka to Hobiganj (NH-2) and Dhaka to North Bengal (NH-5) highways are studied in this research. Extensive range of traffic flow parameters and models have been established for accurate pavement design and operation methodologies based upon field data.

Artificial neural network method has been applied for traffic modelling and forecasting along the mentioned highways. At the same time, total and class wise traffic growth factors, expansion factors and regression models have also been calculated along the highways. Hence, Similar analyses can be performed to established factors or models for the remaining other corridors of Bangladesh using flow data of particular corridors in future.

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

- Individual highway based total traffic growth factor as well as class wise traffic growth factor can be developed for more accurate traffic design, operations and maintenance.
- Traffic composition pattern for different highways can be sorted out, which is mandatory requirement for traffic management and congestion control.
- Heavy vehicle percentages such as bus and truck percentage for separate highways are beneficial for pavement design and traffic operations.
- Separate highway based daily and monthly directional distribution is plotted for traffic design and lane operations.
- Daily, weekly and monthly traffic flow model can be prepared for separate highways.
- Determination of corridor wise daily and monthly expansion factors is beneficial for estimation of AADT from short counts.
- Development of daily and monthly regression model and calibration curves for specific highways.
- Determination of traffic flow model using Artificial Neural Network (ANN) for different highways.

1.5 SINGNIFICANCE OF THE RESEARCH

Developing country like Bangladesh has low income group population with high density. The infrastructure development and maintenance fund is always a big constrain. The mix type of traffic nature like slow traffic and fast traffic are moving in the same highway without no separate lane for non-motorized vehicles. In addition, Bangladesh is a flood prone country with earth embankment construction and maintenance cost is very high. The concern government highway departments are spending funds for construction and maintenance of highways. The research focused in the issues of traffic engineering parameters of major national highways of Bangladesh, which is completely ignored by the Roads and Highways department of Bangladesh. Unlike developed countries, the highways are built with minor traffic study and traffic operations and maintenance don't have any sort of traffic engineering practice in the field. The author has tried in this research to prepare the detail traffic parameter analyses of the major highways of Bangladesh. Developed country like USA is spending billions of dollars for traffic parameter analyses every year and saves more money in road maintenance and

construction. If the government of Bangladesh put emphasis on long duration traffic flow studies and digitalize the road network, then the traffic flow and operation will be efficient and smooth.

Traffic nature and combinations of Australian roadway and traffic is different than Bangladesh. If Australian government introduce light and slow-moving vehicles with high number of mix traffic, then this research will be helpful for case study analyses. It is surprisingly observed here that if Australian government introduce mix traffic in some roadway section, the transportation cost will be lower. However, travel time and travel quality will be inferior in that case.

1.6 OUTLINE METHODOLOGY

Review of related literatures are the initial task to broaden the understandings of vehicular flow characteristics in relation to geometric and structural design of pavements. Literature review of RHD traffic design specifications, AASHTO pavement design manuals, RHD Pavement design guide (2005) and browsing of internet have broadens the detail understanding. Furthermore, previous research works accomplished to similar topics have also reviewed methodically. The detail literature review is beneficial for future developments or modifications of this topic.

Next step is to select corridors based upon the importance and availability of data. Then the required data is collected from the different corridor locations of Bangladesh. During this research, (i) 15 years of daily flow data collected on Jamuna bridge from different toll operators namely JOMAC, MargaNet, Bangabandhu Bridge Special Organization (BBSO) and GSIC-SEL-UDC JV (GSU JV); (ii) 8 years of daily traffic data collected on NH-1 corridor from RCL and MBEL-ATT JV; (iii) 6 years of daily traffic data from NH-2 corridor from MBEL-ATT JV.

When traffic data are collected continuously for a long period and presented for a number of consecutive days, weeks, months, years etc. then the repetitive nature of the variation is observed, since the pattern of the hourly, weekly, monthly variations are similar for all years, although the actual volumes may not necessary be the same. If there is any external factor, which may influence flow pattern, the cyclic property of yearly flow will not be observed distinctively. As such, before the analysis of vehicular flow, all unusual data

will be eliminated from the database to ensure natural periodic variation of traffic stream flow. To achieve this objective, effort will be made to prepare an event calendar by gathering information related to hartal, transport strike, natural calamity like flood etc. which are very unpredictable in nature and have the potential to affect the normal pattern of traffic flow. In this regard, officials of various tolls collecting agency, Meteorological department of Bangladesh would be contacted and above all daily newspapers would be consulted.

The raw database is formatted in line with the objectives of the research and requirement of statistical software. The features that are analyzed including the determination of traffic growth factor, traffic composition, directional distribution, truck and bus percentage, time series flow patterns, etc. of different selected corridors. Likewise, Artificial Neural Network (ANN) method will be introduced for corridor based traffic flow prediction, analyses and forecasting. At the same time, expansion factors and regression models will be determined for different highways.

The detail traffic indicators for selected corridors will be helpful for accurate estimation in the context of traffic and pavement engineering of Bangladesh. The economic design and management of highway can be achieved from this work. Correspondingly, the results of this research could be the milestone for establishing future corridor wise traffic design control parameters of Bangladesh highways and eventually remaining corridors can traffic parameters can be sorted out by RHD.

The last objective is to recommend highway based traffic design parameters considering road traffic condition of Bangladesh. It is to be mentioned here, the whole calculation and analyzing process will be performed 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 in the flow chart below.

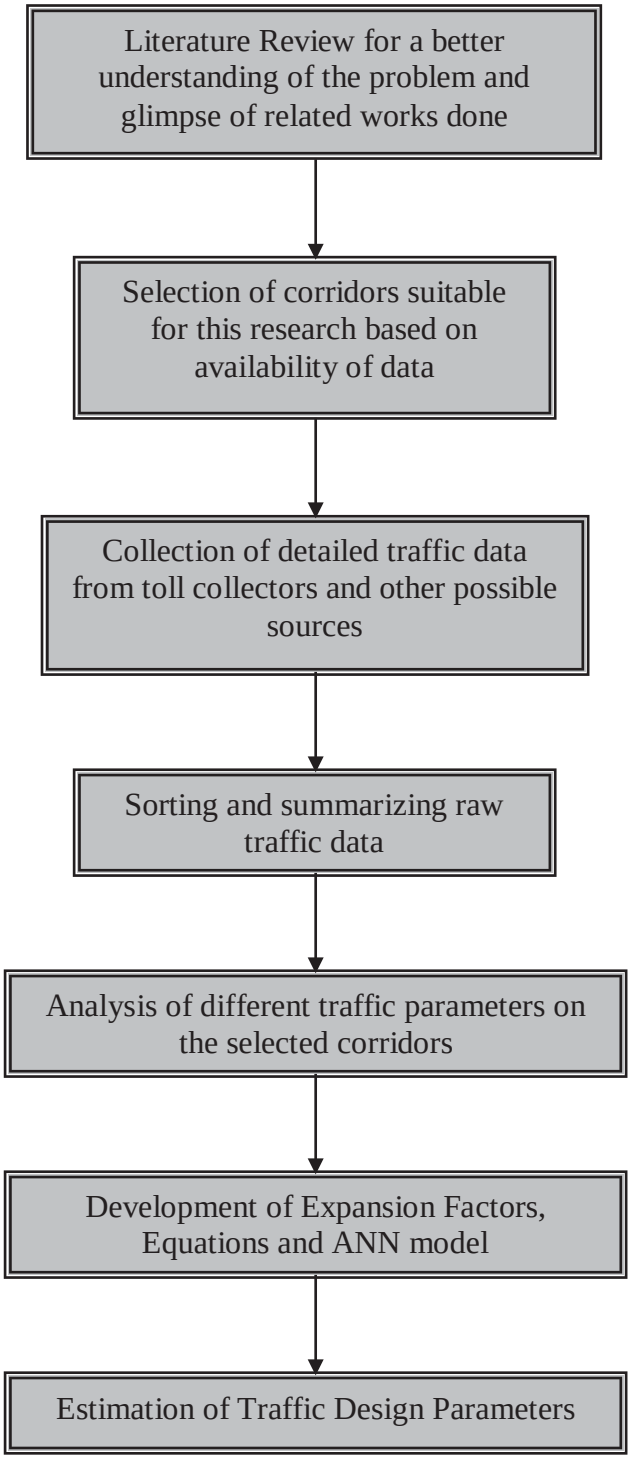


Figure 1.1: Flow chart of the research methodology

1.7 ORGANIZATION OF THE THESIS

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

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

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

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

Chapter 4 to chapter 6 contains the main flow characteristics analyses based upon the corridors. In these chapters the daily, weekly, monthly flow variations as well as directional distribution, traffic composition, truck and bus percentage, traffic growth patterns, regression models, expansion factors, ANN models for traffic analyses and forecasting on the selected corridors are described.

The conclusion of the entire research along with summary of study results is presented in Chapter 7. This Chapter suggests the rational traffic design parameters for different corridors of Bangladesh. The Chapter also contains suggestions and recommendations for future study and limitations of this thesis.

An appendix is attached at the end of this thesis containing necessary data.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The highway traffic nature and its movements are always in shifting dimensions. The traffic information must be frequently updated to cope with realistic transportation demand. To achieve demonstrative information about road traffic, data must be collected and examined methodically. Traffic information is obtained from traffic surveys using manual and automatic machines. Different engineering purposes can be solved straightforwardly by using real time traffic data and their analyses. Different characteristics of highway traffic nature based upon various criteria are immeasurably advantageous for traffic design, operation and maintenance from short term to long term. For instance, road traffic information dynamic route guidance and road message signs, vehicle fleet management, decrease of congestion, reduction of traffic queue, design of roadway, traffic impact assessment, widening of highway, feasibility study, traffic forecasting and modelling, etc. are highly required for smooth traffic operations and management. The enhancements achieve in these areas can affect all the departments relating to transport sectors at different degrees including government sectors like highway and railway authorities, road transport authorities, inland water transport authorities, location based service providers, business organizations relating to transport goods and freights, consultants of different departments and sectors, telecommunications companies, etc. The highway authority should have modern hi-tech hardware and software to acquire uninterrupted and widespread data to observe up-to-date traffic monitoring system, precise understanding and prediction of highway traffic pattern and best value for money in transport sectors for present and futures investments. Different international organizations like Japan International Cooperative Organization (JICA), Asian Development Bank (ADB), World Bank (WB), etc. are investing money in the infrastructure specially transport and environment sectors of Bangladesh. Developed countries have automatic traffic data collection policy in their transport departments and simultaneously the data is used for various traffic analyses. However, road authorities of

Bangladesh don't have data collection and preservation policy and hence, no traffic parameters are set by those departments. This chapter contains brief discussion on the concepts that are used for finding the traffic parameters of major highways of Bangladesh.

2.2 EXPLANATION OF THE ASSOCIATED TERMS

Description of the frequently used terms for the analyses of traffic flow characteristics is stated below for recapitulations and better understandings.

Traffic Volume

Traffic Volume is defined as the number of vehicles crossing a section of road per unit time at any selected period. 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

Annual Average Daily Traffic (AADT) is defined as the number of vehicles passing a point on an average day of the year. There are two methods to calculate AADT. The first one is the "simple average of all 365 days in a given year" (FHWA, 2014). The second method calculates the average of averages (AASHTO, 1990). The TMG recommends the use of the AASHTO procedure which "first computes average monthly days of the week. These 84 values (12 months by 7 days) are then averaged to yield the seven average annual days of the week. These seven values are then averaged to yield the AADT" (FHWA, 2014).

Design Hourly Volume

The Design Hourly Volume (abbreviated as DHV) is a future hourly volume that is used for design. It is usually the 30th 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.

Truck Percentage

For traffic and pavement design operations, Truck Percentage plays a vital role. The percentage of truck traveling along a roadway may vary differently from total vehicle traveling over time and 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. DD is used to convert average daily traffic to directional peak hour traffic.

Tally Sheets

Manual counts can be performed by using tally sheets for data recording. Specific data format is used for recording and collecting data based upon the field criteria. Then the data is recorded in the paper. If the survey has time limits, then a stop watch is required.

Traffic Volume Data Presentation

Traffic volume data can be presented in any of the forms includes (a) ADT of AADT, (b) Trends Charts, (c) Variations Charts, (d) Traffic Flow Maps, (e) Volume Flow Diagram, (f) 30th highest hourly volume.

Automatic Counting Methods

” An automatic survey involves placing a tube or loop across a road which is connected to a box containing the means for storing the information. In this method, vehicles are counted automatically without any human involvement. There are two techniques of automatic counting: (a) Contact system based on pneumatic, mechanical, magnetic or

piezo-electric method and (b) Contactless system based on electrical/optical, ultrasound/infrared radar, micro wave, CCTV/ video image processing method, etc." (Web source: www.slideshare.net)

Artificial Neural Network

The dealing out information of human brain has encouraged computer programmers to simulate artificial neural networks (ANNs). ANN is functioned by sensing the design and affiliation in data and trained through experience, that is not actually called programming. Hundreds of artificial neurons or processing elements (PE) are the units of ANN model, that are connected with coefficients (weights), are creates neural networks. Artificial neural networks are organized in layers and connecting neurons in a network generate neural computations. One output, transfer function and weighted inputs called together one PE. The neurons and its architecture pattern control the behavior of the neural networks. The parameters of weights are modifiable, and the initiation of the neuron establish the weighted sum of the input. Single output of neuron is created by transfer function over activation signal. The non-linearity of the network acquainted with transfer function. At the time of training phase, the connections of inter-unit are adjusted by themselves till prediction errors are lessened and hence definite level of accuracy achieved by the network. The trained and tested network can predict output by offering new input information. The use of neural networks is increasing day by day with different design architectures and every week innovative ANNs are entering the technology world that are designated by the transfer functions which is depends upon the connection formula, learning rule and neurons. Non-linear relationships in the data circles can be modelled by ANN with reasonable accuracy, that can be an excellent tool for civil engineers who are working in transportation sectors. Large data sets can give better results in neural networks where weights adjustments are really plays significant factors, yet data source knowledge is not required by ANNs. It is interestingly observed by the author that experimental data and literature based data can be integrated and combined by neural networks. In the research ANNs are used for pattern recognition, prediction and modelling purposes of traffic parameters in major highways of Bangladesh.

Vehicular Traffic Volume Data

Traffic volumes are the most important data used by traffic engineers (ITE, 2008a), and provides information related to the movement of vehicles (Homburger, et al., 2007).

Volume counts can be performed manually or using automatic traffic recorders (ITE, 2008a). The number of vehicles that arrive at a facility during a given period describes demand, which is the principal measure of a facility's use (TRB, 2000). Additionally, traffic volumes are requirements for road classification (TAC, 1999). Traffic volumes are essential to perform crash analysis (AASHTO, 2010). Daily traffic is also required in transportation planning for the economic analysis of infrastructure projects, maintenance programs, estimation of travel demand, infrastructure planning, road classification, development of traffic historical trends, and to indicate vehicular use (Garber & Hoel, 1997; ITE, 2008b). However, annual average daily traffic (AADT) is not sufficient to characterize traffic (Soriguera & Rosas, 2012). Traffic volume and vehicle classification in terms of AADT or hourly volumes are main inputs in the design of road features and are used to justify the requirement for the upgrading of current facilities (AASHTO, 2004; TAC, 1999). Average daily traffic (ADT) is used in traffic management and in traffic demand analysis (Garber & Hoel, 1997). ADT should not be used directly in geometric design – except for low volume facilities like local and collector roads – because it does not take into consideration temporal variation of traffic (seasonal, day-of-week, hourly) (AASHTO, 2004).

Vehicle Classification

Vehicle classification data are required for pavement (NCHRP, 2005) and bridge design (Chotickai & Bowman, 2006; CSA, 2006), emissions estimates (EPA, 2012; IBI Group, 2011; Patmore, 2012; Transport Canada, 2009), freight planning, transportation and resource allocation policies, and truck size and weight regulations (ITE, 2008b). Additionally, vehicle classification data are used to define turning radii, grades, lane widths, to obtain axle adjustments factors for counts from road tubes, and to obtain conversion factors used in capacity analyses (Garber & Hoel, 1997). Classification counts are necessary to understand truck traffic flows in a road network (AASHTO, 2009). In North America, traffic monitoring efforts related to truck traffic data collection have increased over time (Zhong & Liu, 2007). However, not all agencies have enough resources to collect the required data for pavement design (NCHRP, 2005), and vehicular classification data are still scarce due to physical and budget restrictions (AASHTO, 2009).

Lane and directional distribution

Directional distribution information may be useful for certain applications on a project-specific basis, if classified by vehicle type. Lane distribution may also be useful when summarized by highway functional class. These types of data were not used by the Department at the time of this needs survey. In some cases, directional distribution and lane distribution data were not provided routinely and were available at certain permanent counter and coverage counter locations with some additional data manipulation. In fact, at many permanent counters, data were collected lane by lane, transmitted lane by lane, and then totalled at head office to show all lanes together, discarding the lane-by-lane data without analysis. The new traffic information system should be AADT information by direction where available (generally for divided highways) as well as for the combined directions. When aggregated over the entire year, it would be very unusual for the directional distribution to be unequal in opposing directions outside a very small margin.

2.3 DIFFERENCES IN TRAFFIC FLOW PATTERNS

Highway engineering involves planning, design and management of traffic that needs detail measurement of traffic volumes and its parameters. Three types of traffic surveys including coverage, control and continuous are used for AADT estimation in many countries. Minor segments are selected for 365 days in a year for nonstop surveys. Usually the essential traffic information is collected from this type of technique and eventually encourage to install automatic permanent counters in different potential locations for planning purposes. Usually the data achieved through this process is highly reliable. Any country's actual traffic flow information cannot be obtained without continuous counting. Different combinations are used for seasonal or control counting methods and hence results may vary based upon local road traffic conditions as well as weather conditions. This type of survey is performed several times a year ranging from 2 to 12 times and each survey period varies from 24 hours to two weeks. Seasonal counts are used to support seasonal assignment linkage for factoring short counts to AADT.

This research is inspired by the inclusive guidelines on variability in traffic stream, computation and application of factors to prepare traffic flow pattern of Traffic Monitoring Guide 2001 by Federal Highway Administration of U.S. Department of Transport. This article briefly discusses the variations in traffic stream and important

issues related to expansion factors in light of Traffic Monitoring Guide 2001 (FHA, 2001).

It is an obvious statement that traffic flow varies over time. These variations are observed over many 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 DAILY VARIATION OF TRAFFIC

Highway traffic movement includes the speed, combination and volume of vehicles on roadways. Traffic varies from daily, weekly and seasonal pattern that are dynamic movement by nature. Like hourly fluctuation of traffic flow, there are variations in flow within days of week (Davis, 1997). Day-of-week patterns can be categorized in two different patterns. First pattern involves with traffic volumes decrease a little on weekend and are almost constant at weekdays. These types of patterns are observed mainly in traditional urban areas and main rural areas. The second type of pattern involves traffic flow increase on weekend and stay constant in weekdays with volume lower than weekend. Based upon the requirements of business, the freight carrier like trucks have two patterns as well. The pattern may be different where percentage of through-traffic is high. Traffic monitoring program can be hampered by changes of volume in the traffic stream in a week and it is necessary to define the reasons for variations to the clients and stake holders of the highway. Also, the concern road agency should analyze the reasons for variations and overcome situations like congestion control along the roadway.

Accurate determination of daily traffic pattern is very significant for highway engineers. Likewise, pavement designers can effectively design the pavements if they forecast annual loading rates. In addition, different vehicle class wise accident rate comparison and their remedial measures can be taken from these types of data.

2.3.2 SEASONAL VARIATIONS

Most Branches require information about the monthly or seasonal variation in traffic, estimated annually and summarized by highway classification or route. According to the Traffic Monitoring Guide 2001, four or more seasonal patterns are observed in most of the parts of United States and functional classification of roadway and geographic

location plays a vital role for pattern recognition. Basic traffic pattern of any roads are usually measured by functional and geographical classification. When different parts of an area have different travel pattern, it is recommended to observe the geographic stratification closely. Such as, traffic pattern will vary between areas that have tourism destinations and those who don't have. The guide has observed that truck traffic has different seasonal patterns than other vehicles. Some truck movements are highly seasonal throughout the year while other truck movements are stable. For example, in agricultural areas weight carried by truck varies with season. Various research findings suggest that individual class wise seasonal flow monitoring and adjustments must be done, such as seasonal pattern will must vary between car and truck. Car is considered as small number of passenger carrier, whereas truck carries freight in different locations. In addition, highway seasonal traffic pattern varies depends upon traffic natures, such as seasonal pattern of road segments that have more volume of local freight traffic should be dissimilar with road segments that have through-trucks. Usually highways carry high number of tourist have dominant number of passenger bus and cars. On the other hand, highway connected to business points must have higher volume of truck in the traffic stream. It is highly recommended that road authority of Bangladesh should collect and monitor seasonal variation of class wise traffic. In addition, seasonal variation of traffic in Bangladesh 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.

2.3.3 DIRECTIONAL VARIATION

Some roads such as urban commuter roads involve substantial outgoing traffic after office hours and heavy arriving traffic before office hour starts. Most major sub-urban roads the directional pattern is substitute with heavy peak movements in both directions in both peak periods. The time-of-day pattern for traffic on a road on both ways can differ to those for inbound and outbound traffic, when directional variation is large.

The change of directional variations is detected in the day-of-week traffic patterns as well as time-of-day patterns in the tourism places. Holiday makers always like to visit this places in weekends.

Freight movers like truck volumes and its travel pattern can be calculated in directional distribution. Sylhet zone in Bangladesh is high in mineral resources. In National Highway

No. 2 (NH-2), directional differences are observed with loaded truck coming from Sylhet and in contrast, unburdened trucks enter into Sylhet zone. This type of scenario is found in all major highways of Bangladesh.

Monitoring the directional distributions along the national highways of Bangladesh must be a mandatory program for Roads and Highways Department (RHD) as it is highly needed for planning, design, operations and improvements of existing highways.

2.4 SHORT COUNT EXPANSION METHODS

Robichaud and Gordon 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:

Traffic data collection approaches on the highways are nearly similar in road agencies of USA and Canada. Short-term counts are performed a large number of temporary locations and permanent counting is observed in limited numbers at significantly vital locations.

Counting of traffic volume in short-terms are calculated from 24 hours to 7 days in length. This type of counting is also referred as coverage counts. The specimen periods for traffic data documented in one hour or quarter hour interval. A large number of highway sections can be covered with this method and the concern department can get an idea of traffic patterns along the audited section.

Variations of traffic volumes are measured in permanent counting sites for the whole year. Traffic Volumes are typically recorded in 15 minute or hourly intervals, 7 days a week, 365 days a year. The counters are situated in potential locations around the entire zone to collect vehicle class wise traffic data for urban, rural and recreational flow.

By using seasonal patterns and from the data collected from permanent counters, AADT can be estimated from short-term counts. Different agencies in USA and Canada use variations of a method developed by the Ontario Ministry of Transportation for expanding short-term counts that use regression analysis. Also, different states of USA use a method usually named 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). Development of group factors can be made by data collected from permanent counters that are useful to estimate summary measures from short counts. These guidelines define the approach developed in any agency's jurisdiction from daily and monthly factors to expand short-counts. A day of the week factor reimburses for alterations between the average monthly average daily traffic volume and the average volume on a Monday, Tuesday, Wednesday, etc. In operation, from a 24-hour count MADT volume can be estimated. A total of 84 factors of a year is found from seven days of the week factors for each month. If a short count is taken on a Tuesday in August, then the day-of-the-week factor for a Tuesday in August is used to expand the short count to an average daily traffic volume for the month. Correspondingly, from a total of 12 factors one seasonal factor is found for each month. Using the previous example, an AADT volume can be estimated from the short count by multiplying the MADT estimate by the seasonal factor for August. 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.

The concern highway departments must have a strong concept of all vehicular traffic characteristics and pattern within its authority. The agency must develop an adequate number of clusters for describing each seasonal pattern. If possible, the inconsistency between groups is maximized whereas the unpredictability within each group should be minimized (Office of Highway Information Management, 1995).

Depends upon clustering analysis, the permanent counters are grouped. A minimum dataset is needed for statistical rationality for the determination of daily and seasonal factors. It is observed here that FHWA always sets five to eight separate counters in each group to calculate statistically significant average factors (Office of Highway Information Management, 1995).

Geography, seasonal patterns, levels of surrounding development and functional classification are the features those are reviewed to assign short-term counts for a group. Most of all, skilled decision and a solid knowledge of the concern department's transportation system is vital for the assignment process.

2.4.2 REGRESSION BASED APPROACH

The principal mechanism assumed for all short count expansion is that a dataset of permanent counters with similar variation patterns can deliver seasonal variation of a short count. A short-term count is coordinated to a permanent counter by using regression based system. After data collection, permanent counters data is equated with short-term count during the same period. The technique is to search a permanent counter whose traffic flow volume difference pattern links properly with the short count's variation. This type of assessment can be done on daily or hourly traffic volume.

The most common regression method of comparison is the least squares linear regression. For each permanent-short count regression the coefficient of determination (R^2) is calculated. The highest R^2 value found in permanent counter is designated as the one with a variation in traffic volumes best matching the short count. The equation established from the regression analysis can estimate the winter, summer, monthly and annual average daily traffic volumes (WADT, SADT, MADT, and AADT).

2.5 APPLICATION OF ARTIFICIAL NEURAL NETWORK METHOD

In the recent technological world, many areas are applying Artificial Neural Networks (ANNs) for problem solving. ANNs are introducing at a high rate in commercial mainstream as well as ANN applications are providing excellent results in research sectors.

10 billion to 500 billion neurons are usually containing in any human brain. In figure 2.1 (top), it is found here that a biological neuron consists of dendrites, an axon and a cell body. Each neuron is connected to 100 to 10,000 other neurons, and connections between the neurons are called synapses. A simple task is done by a neuron when executed: offered by a stimulus, the neuron produces an output into other neurons connected to it

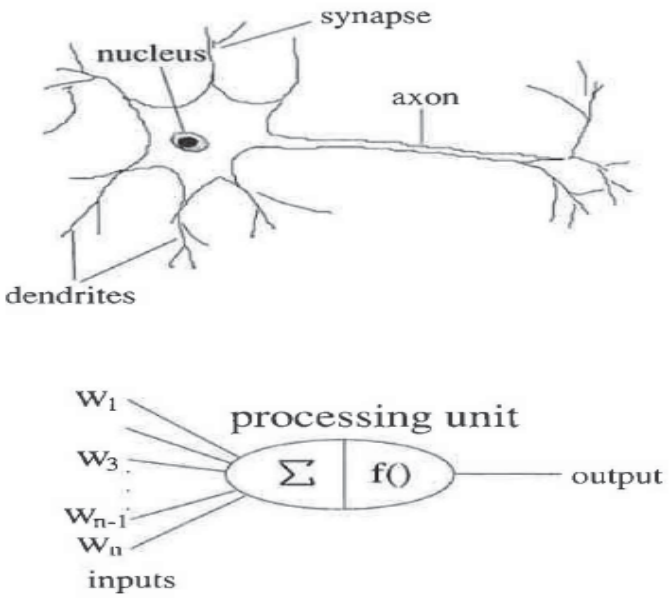


Figure 2.1: Schematic drawing of typical biological neuron and artificial neuron

via the synapses (Nielsen, 1990; Simpson, 1990). The processing elements or processing units are called the artificial neurons, which imitate the functions of biological neurons. The artificial neurons add the inputs presented to them and calculate the total value as an output with a transfer function. The pictorial representation of an artificial neuron is found in figure 2.1 (bottom). Same as biological neurons, the artificial neuron similarly connects to other artificial neurons. The strength of the connections is called weight. Hence, these types of networks are consisting of artificial synapses and artificial neurons that stimulated the activities of the biological neural network. Depending upon the

structures, ANNs can be single layer or multilayer. The theory which can roughly calculate any reasonable function in an ANN is called architecture. The weights are adjustable and the programming for adjusting the weights is called training. The training effect is called learning.

A general definition for an ANN can be given as “a computing system made up of a number of simple, highly interconnected processing elements that process information by dynamic state response to external inputs” (Caudill, 1987). (A variety of applications can be solved by ANN from the special characteristics. Artificial neural network works in such a way that is close to human recognition and perception than traditional methods. ANNs can also give rational results while the situations in which input is incomplete or noisy.

Moreover, neural networks have already established its skills in handling different problems in transportation engineering sectors including design, planning, administrations, operations, and maintenance.

2.6 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 a limited data based study was performed by RHD in 1994, named “Development of Geometric Design Standard”. The 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 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, 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 detail 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, 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.

2.7 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 significant in this study. The Traffic Monitoring Guidelines has provided useful recommendations on types of counts and expansion methodologies. It was found that, Factoring approach and regression models are widely used in the developed countries. Likewise, Neural networks primary concepts and applications have also discussed here. The next chapter will explore the detail methodologies of the research topic.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The developed countries like USA spends substantial investments in traffic counter operations as well as short-term traffic monitoring. Only Texas department of highways have installed and maintained of approximately 350 permanent continuous traffic data collection sites that include collection of volume, classification, speed, and weight data. Also, approximately 75,000 to 85,000 short-term pneumatic tube counts are conducted annually along with short-term manual classification counts at nearly 700 sites. The Texas department of highways began comprehensive program of traffic data collection in 1936 and produced early versions of District Traffic Maps. On the other hand, developing countries like Bangladesh have acute negligence in traffic data collection process and till now not a single traffic counter have established in Bangladesh. The country struggles to maintain road infrastructures due to shortage of fund. However, without accurate and realistic traffic data, design and management of highway with some assumption may lead to fail the structure in immature time. Attempts have been made in this research to organize a methodology for preparing realistic highway based traffic pattern based upon realistic data.

This chapter deliberates below about the process involves during the research period including review of literatures, selection of highways, collection and management of data, preparation of flow patterns and traffic models, and summarization of traffic indicators.

3.2 SELECTION OF HIGHWAY CORRIDORS

Road transport has become a priority sector because of the need to restore regionally balanced living conditions and economic opportunities for all Bangladeshi people. Road network of Bangladesh is dense and well laid-out providing connectivity to the country's population and centers of economic activity. The major road network of Bangladesh consists of National Highways, Regional Highways, and Districts Roads. Transport in Bangladesh is overwhelmingly road-based and a large portion of the network is in a poor

condition and has become an impediment to efficient transport. There are eight national highways of Bangladesh that covers the whole road network of the country. However, each highway corridor has its own characteristics based upon the need and usage of the clients. For instances, 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. Hence, corridor wise traffic flow patterns have been studied based upon significance of highways and availability of data.

Three major highway corridors of Bangladesh are studied in this research below-

- Dhaka-Chittagong Highway (National Highway No. NH1)
- Dhaka-Hobiganj Highway (National Highway No. NH2)
- Dhaka-North Bengal Highway Corridor (National Highway No. NH5 and NH6)

The various types and methods are used to collect traffic data in different countries that provide a good and valuable coverage of the required traffic information for decision making and planning of both development and maintenance of the national road network. Unfortunately, in Bangladesh there is no establishment of regular manual traffic counting program or spontaneous automatic counters along the public highway network. However, in recent years the government of Bangladesh has invited tender to bid an Operation and Management (O&M) contract for five years against a fee after building the major roads and bridges of some selected corridors. The O&M operators maintains the bridge and collects toll on behalf of the government. Electronic toll collection system has not introduced yet in Bangladesh. Nevertheless, the traffic data that have been used in this study for the traffic flow characteristics analysis is primarily collected from the Operation and Management (O&M) Companies of the concern highways. The toll collection systems in some major corridors like Dhaka-Chittagong, Dhaka-Sylhet, etc. are already accustomed to computerizing toll collection technique. Long term data is collected from the toll collecting operators of Jamuna bridge, Meghna-Gomoti bridge and Rustompur toll highway. The Roads and Highways Department of Bangladesh is not preserving any traffic data from computerize toll plaza and as a result, the data may have lost when a new company is employed to collect toll. The new company installs their software to the machines of toll plaza by erasing previous company's software. Thus, the whole past traffic data become lost by the negligence of RHD authority. However, most of the toll

operators in selected corridors possess traffic data of their lease time, and the qualities of those data are found to be high.

3.3 DATA COLLECTION

Roads and Highways Department of Bangladesh do not have any permanent traffic counter station in anywhere of Bangladesh. Due to the absence of realistic traffic data, highway wise no detail traffic guide line have been found in Bangladesh. The very limited traffic parameters such as traffic growth factor, etc. is assumed based upon thumb rule of 10% for the whole country in RHD.

The aim of this research is to prepare highway based detail traffic pattern of Bangladesh that requires long term continuous traffic data. Hence, collection of data for long period of individual highway's is a big challenge of this research. The following sources have been used for data collection:

(1) The Jamuna, one of the three largest rivers in Bangladesh, runs from north to south through central Bangladesh, dividing the country to the east and west. Hence, Jamuna Bridge is situated in Dhaka to North Bengal Highway corridor. The bridge is opened for traffic in June 1998. This was the 11^{th} longest bridge (Length 5.63 km) in the world at the time of construction in 1998 and now 6^{th} longest bridge in South Asia. This bridge strategically connects eastern and western parts of the country. The bridge is in the middle position of Asian Highways and Inter Asian Rail Roads. The Jamuna bridge data have been collected from several toll operators including (i) 5 years (June 1998 to March 2004) of both direction daily flow data recorded in three 8 hourly shifts by JOMAC (Jamuna Operation And Maintenance Company), (ii) 5 years (April 2004 to May 2009) of daily flow data collected by Marga Net One Limited (MNOL), (iii) 1 year (June 2009 to October 2010) of flow data collected by Bangabandhu Bridge Special Organization (BBSO), (iv) 3 years (November 2010 to September 2013) of traffic data from GSIC-SEL-UDC JV (GSU JV).

(2) Meghna Bridge, also known as Japan Bangladesh Friendship Bridge 1, is a highway bridge that is located along Dhaka-Chittagong highway. The bridge is 900-meter-long and lies southeast of Dhaka, across the Meghna channel and opened for traffic in 1991. The Meghna-Gumuti bridge was built in 1994 that is

situated along NH-1 in Daudkandi channel. It is 1,410-meter-long and crosses the Meghna river. Gazaria upazlia in Narayanganj district is located between two channels of the Meghna River. On the eastern side is the Daudkandi channel and on the western side is the Meghna channel of the Meghna River. These two bridges data have been collected from toll operators including (i) 4 years (January 2006 to December 2009) of daily flow data on Meghna and Meghna-Gumuti Bridges toll plaza by Reza Construction Limited (RCL) and (ii) 5 years (January 2010 to December 2014) of traffic data from MBEL-ATT JV Ltd., the then bridge operator and maintenance company.

(3) Rustompur toll plaza is situated in 193rd km of Dhaka-Sylhet Highway (NH-2). This toll road was constructed under RRMP-III project of RHD. The toll collection procure has started on 10th March 2005. However, due to negligence of the road agency, the author has failed to collect data before 2010. However, so far 6 years (January 2010 to December 2015) of traffic data collected from current operator and maintenance company named Mohiuddin Builders and Engineering Limited (MBEL).

All the computerized toll operators 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 of 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 submits the same to the concerned authority.

Accumulation of long term traffic data for this research work from different sources are a tough job. Comprehensive effort has been given for this purpose. The author has visited several times in field offices of the concern toll stations, government organizations (RHD, BBA) and contractors' company for data collection purposes. The most difficult situations the author has experienced for previous toll operators' data extractions in all cases, because previous systems are erased, and new software is installed by the current toll operators.

3.3.1 PROBLEM ENCOUNTERED DURING DATA COLLECTION

Here follows some of the problems encountered while collection of the traffic and axle load data:

- The concerned government authorities of Bangladesh do not keep any systematic record of traffic data in electronic version, which is extremely needed for research purpose.
- RHD should instruct all the toll operators to maintain hourly traffic flow database, which is a basic form of traffic flow tools. Hourly flow pattern is the key structure for traffic monitoring system. But unfortunately, no such data is found from any toll operators rather they show unwillingness to preserve hourly data.
- The operators do not use 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 each corridor has its own vehicle classification system.
- Only tolled vehicles are counted and recorded by the operator. It is to be mentioned here that the government vehicles and maintenance vehicles are exempted from toll and thus considerable amount of government vehicles are not counted and hence leading to minor data errors.
- Large buses carry significant amount of axle load, but the axle load control stations measure axle load of trucks only.

3.4 DATA PROCESSING

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.

3.5 DEVELOPMENT OF FRAMEWORK

The objectives of this research are to develop a framework through which the following analyses can be made for three different highway corridors.

- Yearly Growth Pattern and determination of Growth Factors
- Traffic composition
- Directional Distribution
- Flow pattern of predominant vehicle classes
- Summarizing daily, weekly, monthly & yearly traffic data
- daily, monthly, yearly flow pattern charts
- Calculation of Daily Expansion Factors
- Calculation of Monthly Expansion Factors
- Regression analysis of daily and monthly data and preparation of correlation charts
- Corridor wise vehicle flow pattern analysis
- Artificial Neural Network (ANN) model for traffic analyses and forecasting.

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.

3.5.1 FRAMEWORK FLOW CHART

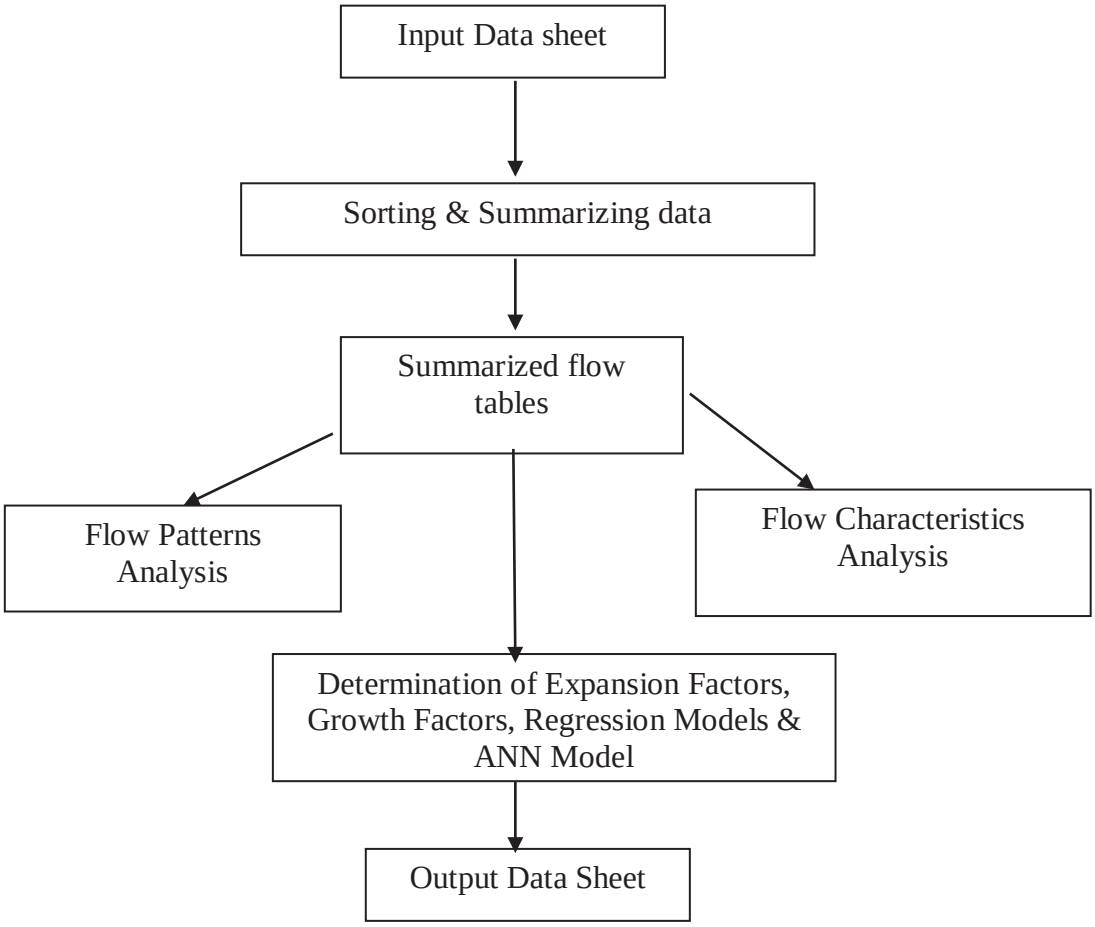


Figure 3.1: Flowchart of the Research framework

3.6 OVERVIEW

This chapter describes the total analysis procedure of this research work starting from selection of corridors, data collection, data processing, and the development of framework for analyses. The type of each framework and the components of the skeleton are illustrated briefly to recognize the research pattern correctly. Nevertheless, the next Chapter will focus on the detail traffic flow parameter analyses of National Highways No. 2 of Bangladesh.

CHAPTER 4

ASSESSMENT OF TRAFFIC FLOW PARAMETERS: NATIONAL HIGHWAY NO. 2 (DHAKA-HOBIGANJ HIGHWAY CORRIDOR)

4.1 INTRODUCTION

The study of various characteristics of road traffic is immensely useful for planning and design of roadway systems and operation of road traffic. As the transportation system is a dynamic system, information about traffic must be regularly updated to keep pace with ever-changing transportation pattern. This chapter aims to establish the traffic pattern of National Highways Number 2 (NH-2) of Bangladesh. The 286 kilometers long and 7.69-meter-wide NH-2 starts from the Bangladeshi capital Dhaka and passing through Narayanganj, Narsingdi, Kishoreganj, Brahmanbaria, Habiganj, Moulavi Bazar and Sylhet districts. Sylhet is a metropolitan city in the northeastern side of Bangladesh. The city is located on the right bank of the Surma river. It is one of the most important city of Bangladesh just after Dhaka and Chittagong because of many reasons like economy, tourism, etc. that makes NH-2 tremendously demanding highway of Bangladesh. Unfortunately, the road has been called the deadliest road in the world due to frequent traffic accidents.

Data scarcity was one of the main hindrance of launching traffic flow model along this corridor as the Roads and Highways department of Bangladesh don't have any data collecting and storing practice. However, vehicle class wise daily traffic data has been collected from the Rustompur Toll Plaza along NH-2 from the year 2010 to 2015.

Through the concise database of the traffic flow along Rustompur Toll Plaza, variety of traffic parameters have been developed along NH-2 of Bangladesh. The following sections are describing the detail pattern of traffic characteristics of Dhaka-Hobiganj Highway of Bangladesh.

4.2 CALCULATION OF TRAFFIC GROWTH FACTOR OF DHAKA-HOBIGANJ HIGHWAY

Accurate estimate of traffic growth factor is essential for proper road and traffic management system. At present, Roads and Highways Department of Bangladesh uses vehicular growth factor of 8%~10% per annum that was established in 2005 based upon as assumption. Nevertheless, the subsequent article considers the six years of daily traffic flow data from 2010 to 2015 to recognize the proper outline of traffic growth.

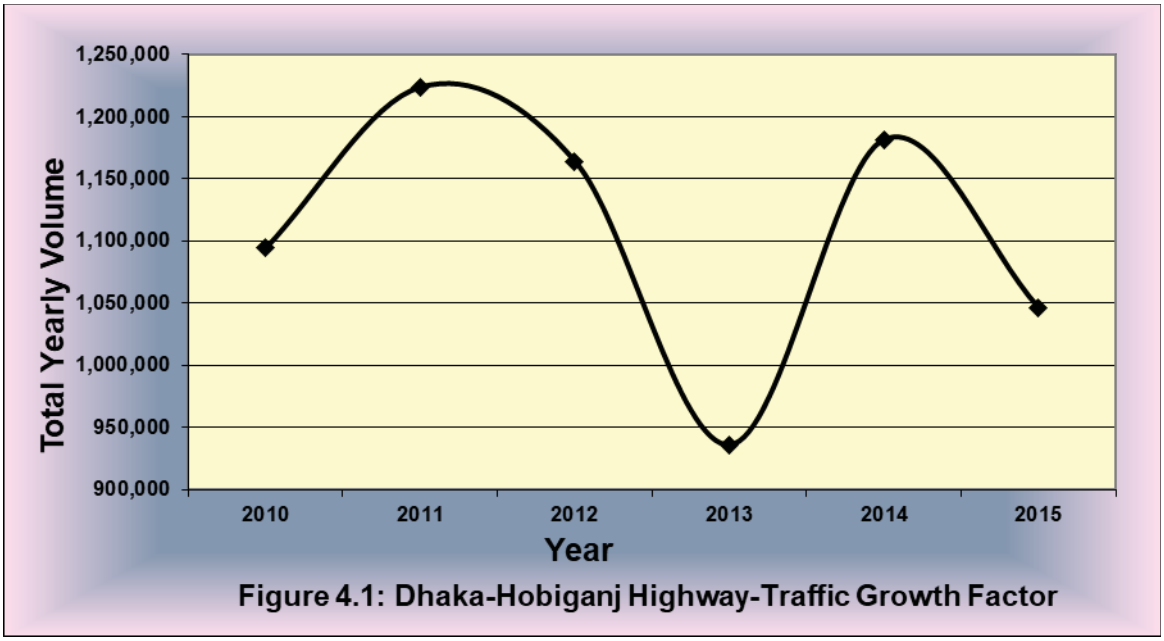


Figure 4.1: Dhaka-Hobiganj Highway-Traffic Growth Factor

The total bi-directional yearly traffic volume along NH-2 is shown on figure 4.1 from the year 2010 to 2015. From the figure, it is found that the yearly traffic growth is not stable yet. In 2010, the total yearly traffic volume was 1,094,437 and the next year the traffic growth rises to 11.81%, comprises traffic volume 1,223,670. Yet, in 2012 and 2013, the traffic growth drops to -4.88% and -19.57% accordingly. Once more, in 2014, yearly traffic volume rockets to 26.22%, encompass vehicular capacity 1,181,625. Finally, the traffic volume drops to 1,046,323 in 2015, which displays growth factor -11.45%. As a final point, the average growth rate has been found to be 0.43% per annum from six years of data, which shows the unstable nature of traffic along this highway corridor and needs to scrutinize for the next couple of years for the expected steadiness of traffic.

Traffic scenarios in Bangladesh are characterized by mix types of traffic. Negligence in traffic studies along national highways effects the motorway with abnormal delay, heavy congestion, recurrent pavement fatigue and accident prone. As each road is unique in

terms of its role in the network, catchment, traffic composition and determinate of future traffic growth; design parameters should ideally be assessed in order to make a road-specific traffic projection as a basis for road design and computation of economic returns. Uniform growth rate for total traffic is not representative for the actual scenario that invokes the need for traffic growth pattern analyzed individually for all vehicle classes. In Figure 4.2, total yearly flow of all nine vehicle classes used in Rustompur toll plaza is plotted against respective years from 2010 to 2015, while Figure 4.3 shows yearly variations 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.

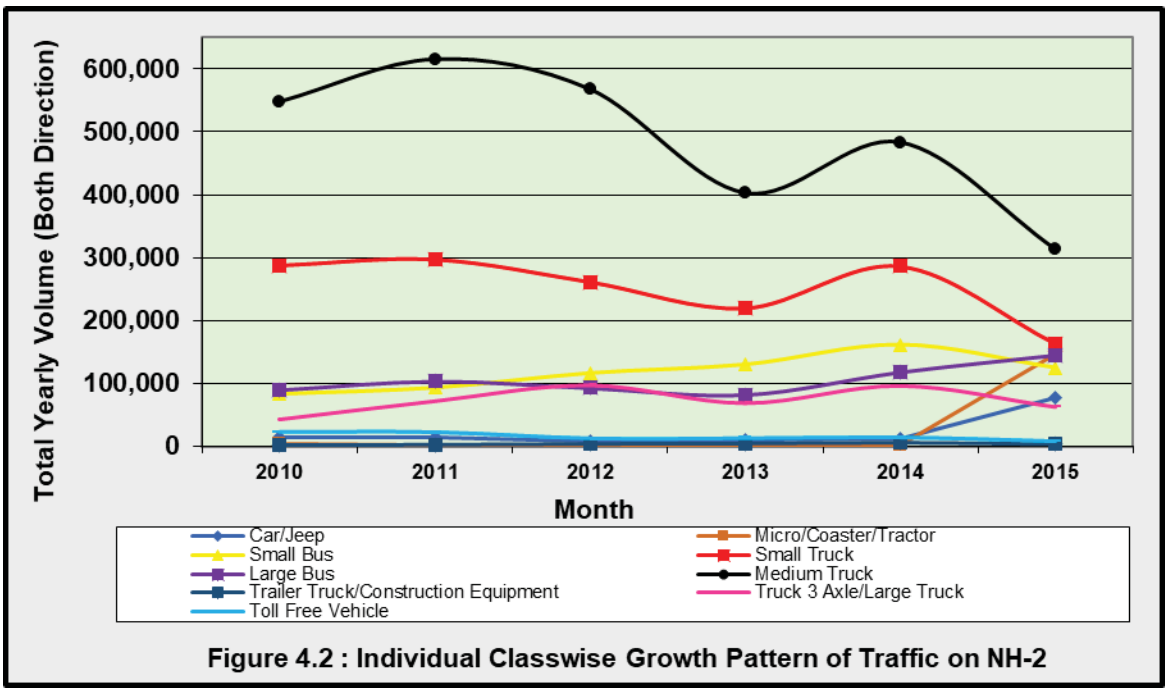


Figure 4.2 : Individual Classwise Growth Pattern of Traffic on NH-2

4.2.1 Medium Trucks:

The class Medium Truck contains the highest percentage of traffic on Dhaka-Hobiganj highway. In Figure 4.2, annual growth of this class is also found to be quite significant. In the year 2010, total volume was 5,47,425 and it increased to 6,14,904 in the next year, leading to 12% growth factor. However, the same class of traffic has decreased for the next consecutive two years resulting traffic growth factor of -8% and -29%. Again, number of medium truck has increased to 4,83,375 in the year 2014 and causing positive growth of 20%. Once again, in the year 2015, medium truck has decreased a lot and producing -35% traffic growth. So far, from 2010 to 2015, the average growth factor is

found -8% with average standard deviation of 24. Also, from 2010 to 2015, the percentage of medium truck has decreases from 50.02% to 30% of total traffic along NH-2.

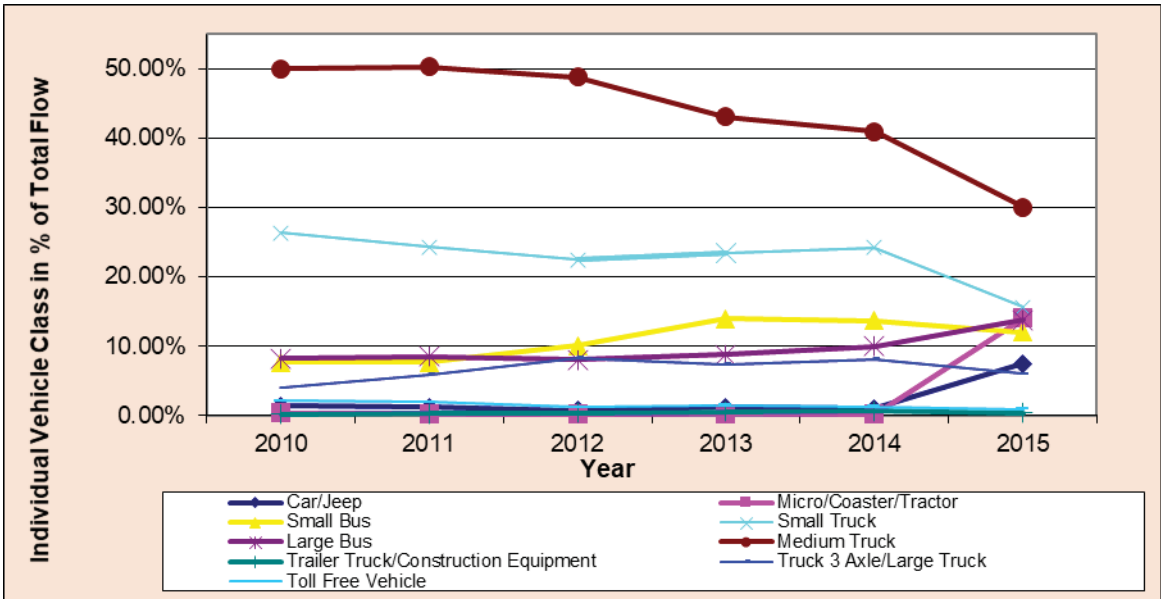


Figure 4.3: Growth Pattern of Individual Vehicle Classes in NH-2 Highway (In %of Yearly Total Volume)

4.2.2 Small Truck

Volume of small trucks is the second largest vehicle class along NH-2. The percentage of small truck varies between 26.29% to 15.57% of total traffic stream from the year 2010 to 2015. 2,87,677 number of small trucks passes through Rustompur toll plaza in the year 2010. The growth factor is found to be 3%, -12%, -16% and 30% respectively from 2011 to 2014. However, there is a massive drop observed in the year 2015 with growth factor -43%. The average percentage is found 22.71% of total traffic and the average growth factor is -7% with standard deviation 27 in the observed period.

4.2.3 Small Bus

Small bus, which is classed as buses having sitting capacity up to 30, is the third major vehicle class in volume, as well as in yearly percentage. In 2010 the total amount of small bus is found 83,402, which is 7.62% of the total traffic stream. The number of this vehicle class has increased throughout the study period except 2015. Until 2014, the volume is 93,336; 116,625; 130,109 and 161,739 from the year 2011 to 2014 respectively with growth factor of 12, 25, 12 and 24. However, the amount drops in 2015, which is 11.97% in the traffic stream, with growth factor of -23% and the quantity is 125,256.

4.2.4 Large Bus

Large bus is the fourth uppermost traffic class in NH-2. Total volume has increased from 89,819 to 144,088 during the six years under consideration. In average, 104,996 number of large bus trip generated each year from 2010 to 2015 on Rustompur toll road jurisdiction. In addition, yearly flow of large bus varies from 8.21% to 13.77% of total traffic stream from 2010 to 2015. The average growth factor of large bus is observed 12% with standard deviation of 23.

4.2.5 Truck 3 Axle/ Large Truck

From 2010 to 2015, the average number of large truck per year is found 73,220. The percentage of large truck varies from 3.92% to 8.14% of total traffic flow with average value of 6.60%. In 2010, 3 axle truck is found 42,880 while it reaches to 97,072 that is more than double in 2012. Conversely, the number of this vehicle class drops to 68,673 in 2013 and again increases to 96,198 in 2014. The average growth factor of 3 axle truck/ large truck is 16 with standard deviation of 45.

4.2.6 Micro/ Coaster/ Tractor

Micro, coaster, tractor includes light vehicles. The average quantity of this vehicle class is found 26,696 from 2010 to 2015 and it is 2.54% of the total traffic stream. Micro and coaster is the major type of passenger carrying vehicle for local people living in that area.

4.2.7 Car/ Jeep

From 2010 to 2015, the average number of car/jeep is found 23,010 along NH-2. 14,539 number of car/jeep is found in 2010 and it reaches to 78,157 in 2015. Average yearly flow is 2.14% of all traffic stream.

4.2.8 Trailer Truck/ Construction Equipment

The average growth factor of this vehicle class is 26 from 2010 to 2015 and the average number of vehicle passing through NH-2 is 4,116 per year in the study time.

Summary of Findings:

As Bangladesh is a densely populated country, movement of traffic is also very compacted. Hence, flat growth rate for all national highways should not be considered. For accurate design of pavement and traffic flow, the growth rate of traffic should be determined separately for each individual vehicle class.

4.3 CALCULATION OF TRAFFIC COMPOSITION OF DHAKA-HOBIGANJ HIGHWAY

Composition of traffic plays a vital role in roadway operation, traffic safety and pavement management. No attempt has been made before to analyze the composition pattern along Dhaka-Hobiganj Highway. In the Rustompur toll road section, total traffic is distributed into nine classes considering vehicle size and capacity as follows.

1. Class I: Car/ Jeep (Individual vehicle class)
2. Class II: Micro/ Coaster/ Tractor
3. Class III: Small Bus (Buses containing upto 29 seats)
4. Class IV: Small Truck (Truck having less than 5 ton carrying capacity)
5. Class V: Large Bus (Buses containing equal to or more than 30 seats)
6. Class VI: Medium Truck (Truck having 5 to 8 ton carrying capacity)
7. Class VII: Trailer Truck/ Construction Equipment
8. Class VIII: Truck 3 Axle/ Large Truck (Truck having more than 8 ton carrying capacity)
9. Class IX: Toll free vehicle.

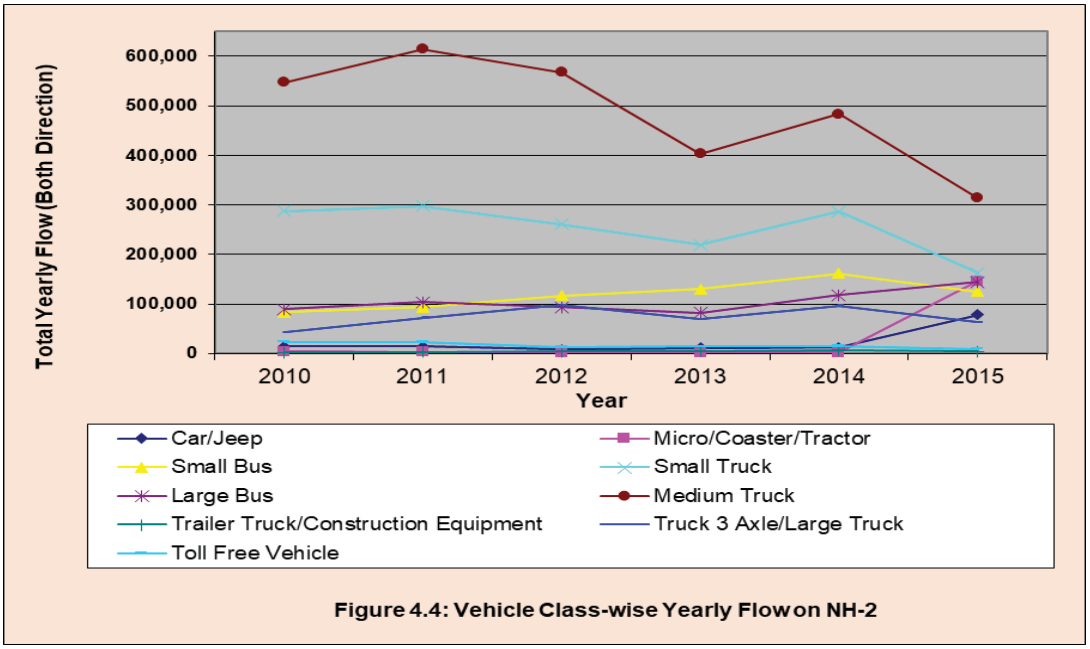


Figure 4.4: Vehicle Class-wise Yearly Flow on NH-2

Figure 4.4 shows the classification wise yearly volume of traffic on Dhaka-Hobiganj Highway from 2010 to 2015. Medium truck, small truck, small bus, large bus is the four

dominant vehicle class along NH-2. The flow fluctuation pattern of medium truck, small truck and large truck seems identical along this corridor due to same nature of freight movement except medium truck have higher intensity. Rustompur toll plaza axle load control station is not under operation since 2013, that cause overloading along NH-2.

Some significant outcomes have been observed from the analyses of traffic composition on Rustompur toll road section, which is discussed below.

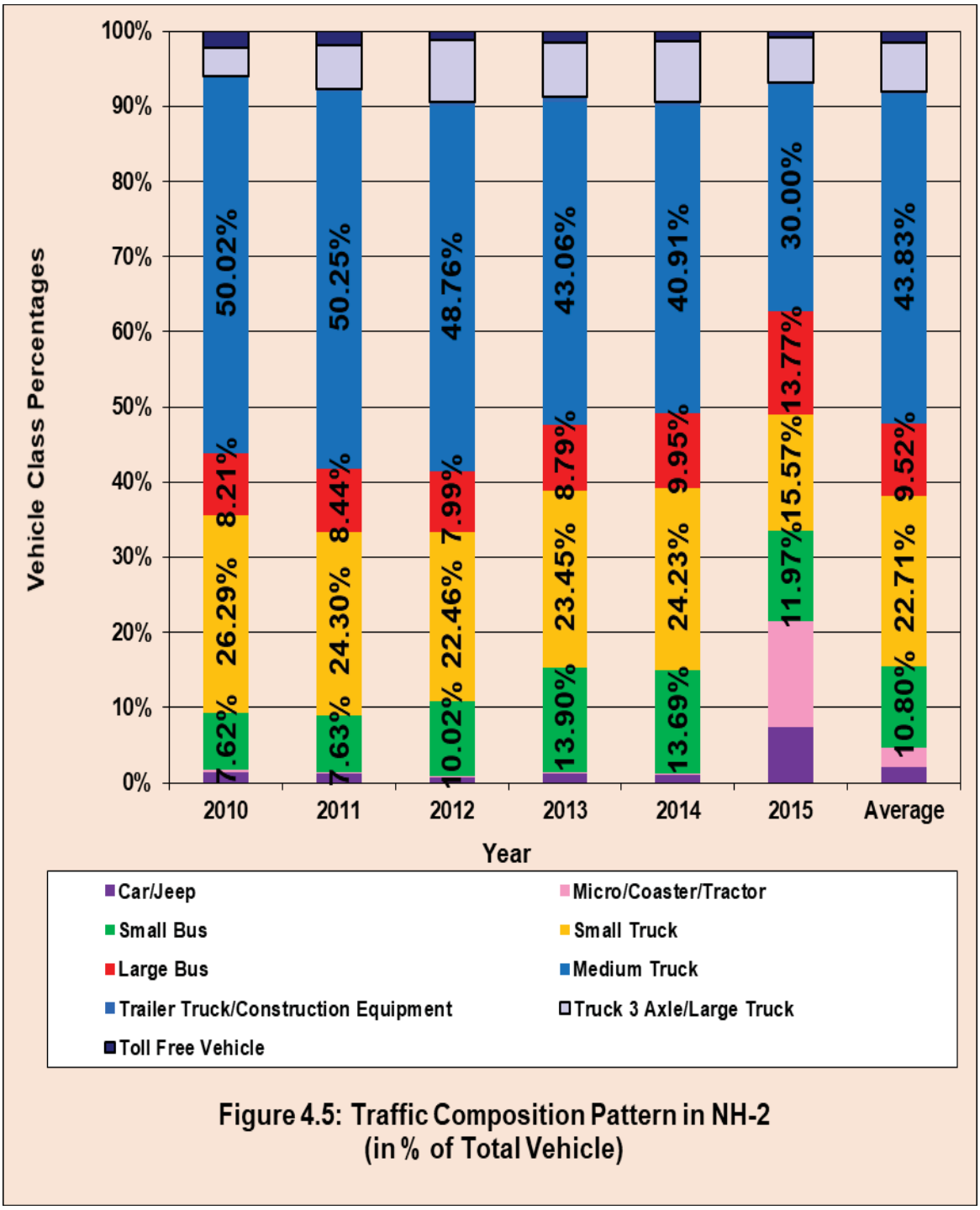


Figure 4.5: Traffic Composition Pattern in NH-2 (in % of Total Vehicle)

Classwise traffic composition along Rustompur toll road in shown in figure 4.5. It is observed that, medium truck has the highest percentage in the traffic stream. From 2010 to 2014, the percentage of medium trucks contains almost half of the total traffic stream. The average percentage of medium truck from 2010 to 2015 is 43.83%. The second highest percentage of vehicle class is small truck, which is almost one fourth percentage of the total traffic stream in the study period. From 2010 to 2015, the average percentage of small truck is 22.71%. The third higher vehicle percentage along NH-2 is small bus. The highest and lowest percentage of small bus through the study period is 13.90% and 7.62% respectively. The average percentage is 10.80% from 2010 to 2015. The next higher percentage of vehicle class is Large Bus. From 2010 to 2014, quantity of large bus covers one tenths of the total traffic stream. However, the maximum percentage is 13.77% and the minimum percentage is 7.99% in the study period and the average percentage is 9.52%. 3 axle Truck/large truck seems significant in terms of axle load along NH-2. In 2010, this vehicle class have the lowest 3.92% of the traffic stream and in 2012, the highest 8.34% is found from the study period. The average percentage is 6.60% of total traffic flow along Dhaka-Hobiganj highway. Besides, the vehicle class Car/Jeep and Micro/Coaster/Tractor both have in average 2~3% traffic flow along the traffic stream. The military vehicles, operator's vehicles and some other VVIP vehicles are counted by the operator since they are toll exempted, although fair quantity (about 1.47% of tolled vehicles) of such vehicles pass the bridge every day.

4.4 CALCULATION OF HEAVY VEHICLE PERCENTAGE OF DHAKA-HOBIGANJ HIGHWAY

Reliable estimates of heavy vehicle percentages are important in a number of transportation applications. Estimates of heavy vehicle percentages are necessary for pavement design and pavement management as well as bridge performance. Truck and bus volumes play a vital role for road safety operations. The number of bus and trucks on the road also influences roadway capacity. Heavy vehicles have more difficulty accelerating and maneuvering than passenger cars and have a lower deceleration in response to braking compared to passenger cars. Therefore, the number of heavy vehicles present in the traffic stream influences traffic operations especially in mix traffic conditions like NH-2. Attempts have been made with this study to establish the actual

heavier vehicle percentage and their travel pattern along NH-2 based on field level data from the year 2010 to 2015.

4.4.1 TRUCK PERCENTAGE

In Rustompur toll road section, according to the vehicle classification, trucks are divided into four classes such as Small Truck, Medium Truck, Trailer Truck/Construction Equipment, Truck 3 Axle/ Large Truck. 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 to 8 tons are classed as Medium trucks. This class is most common in Bangladesh and hence contributor of the highest percentage of traffic. Trailer Truck/Construction Equipment are trucks with more than 3 axles. Truck 3 axle/ Large truck's capacity is more than 8 ton and usually possesses more than two rear axles.

Nevertheless, from the analyses of traffic flow data from 2010 to 2015, taking the average of six years, it is detected that the percentage of all classes of trucks 73.53% of total vehicle. Among this, the percentages of small truck, medium truck, Trailer Truck/Construction Equipment, Truck 3 Axle/ large trucks are 22.71%, 43.83%, 0.38% and 6.60% respectively (figure 4.6). Table 4.1 shows the year-wise truck percentages.

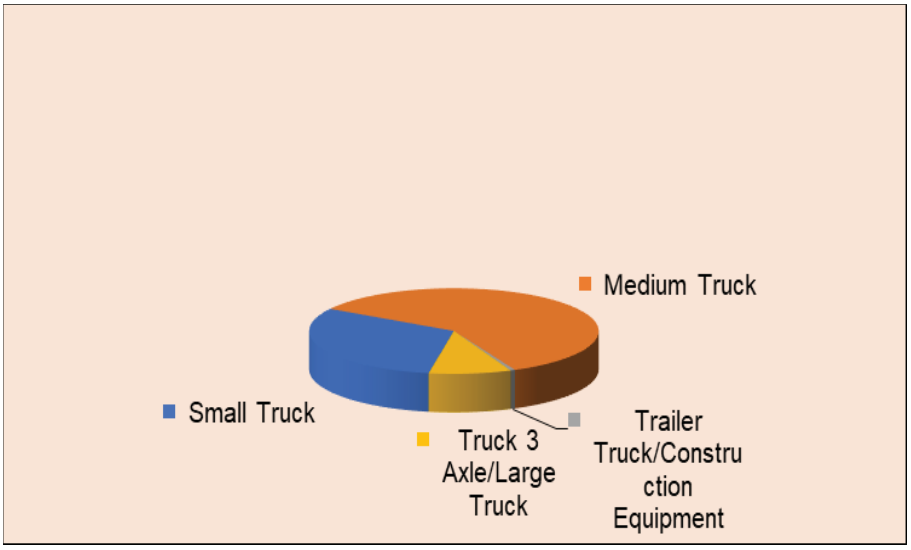


Figure 4.6: Annual Truck Percentages on NH-2 (Average from 2010 to 2015)

Figure 4.7 shows the growth pattern of trucks on NH-2. Table 4.2 shows different class wise trucks growth factor. The growth factor range of different trucks seems very wide

and hence, it can assume that the corridor NH-2 is not stable yet and needs more years of data to expect a stable nature of traffic for pavement design consideration.

Table 4.1: Truck Percentages on NH-2 (Both Direction)

Year	Small Truck	Medium Truck	Trailer Truck/ Construction Equipment	Truck 3 Axle/Large Truck	Total Truck
2010	26.29%	50.02%	0.15%	3.92%	80.38%
2011	24.30%	50.25%	0.22%	5.87%	80.64%
2012	22.46%	48.76%	0.37%	8.34%	79.93%
2013	23.45%	43.06%	0.57%	7.34%	74.42%
2014	24.23%	40.91%	0.60%	8.14%	73.88%
2015	15.57%	30.00%	0.35%	5.99%	51.91%
Average	**22.71%**	**43.83%**	**0.38%**	**6.60%**	**73.53%**

Date Source: MBEL-HOPETECH JV.

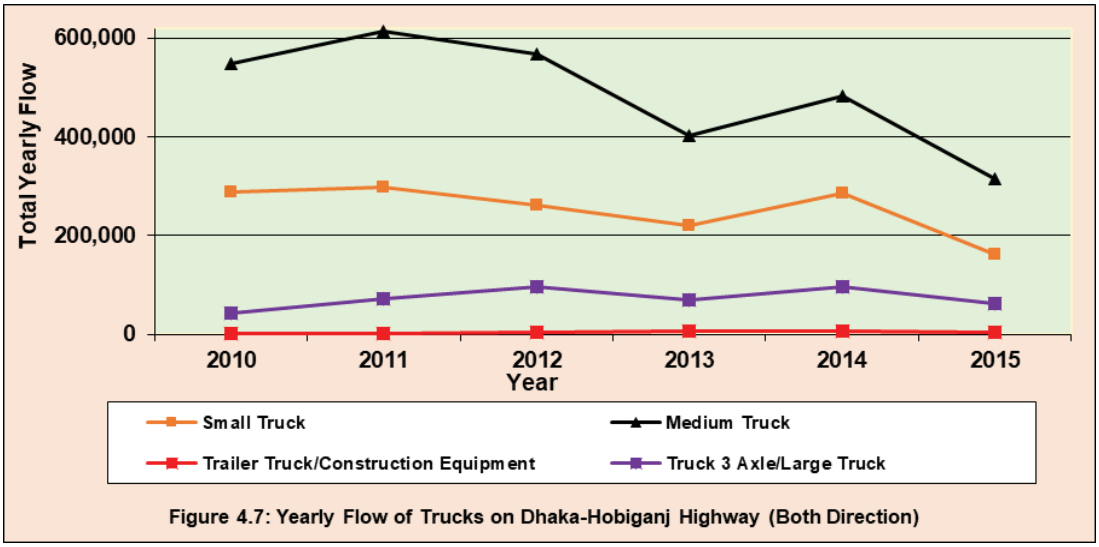


Figure 4.7: Yearly Flow of Trucks on Dhaka-Hobiganj Highway (Both Direction)

Table 4.2: Growth Factor of Truck on NH-2 (Both Direction)

Year	Small Truck	Medium Truck	Trailer Truck/ Construction Equipment	Truck 3 Axle/Large Truck
2010-11	3.35	12.33	57.64	67.54
2011-12	-12.07	-7.70	65.60	35.12
2012-13	-16.04	-28.98	21.64	-29.26

2013-14	30.44	19.92	33.96	40.08
2014-15	-43.10	-35.07	-48.77	-34.87
Average	**-7.48**	**-7.90**	**26.01**	**15.72**

Date Source: MBEL-HOPETECH JV.

4.4.2 BUS PERCENTAGE

Passenger transport services in Bangladesh are provided by various modes and are characterized by high growth rates, its diversity and poor financial and operational performance. However, demand for passenger transport services is already enormous and growing at a rapid rate due to rapid rise of population in the country and the vast majority of the population is still relying on road-based transport system. Hence, precise determination of bus percentage is crucial for structural and geometric design of pavement. The buses travelling through NH-2 are classified into two groups namely Small Bus and large Bus are called 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.

Figure 4.8 depicts the fact that among the bus category passing through NH-2, 47.18% is large bus and 52.82% is small bus. Table 4.3 illustrates the total yearly flow of small and large buses. In addition, from table 4.4 it is found that the average total bus percentage along NH-2 is 20.32% from 2010 to 2015, where average small bus percentage is 10.80 and large bus percentage is 9.52.

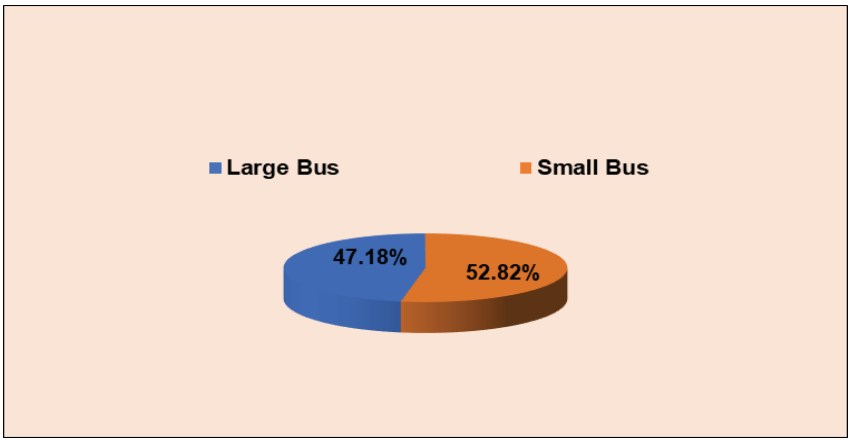


Figure 4.8: Annual Bus Percentages on NH-2 (Average from 2010 to 2015)

Table 4.3: Yearly Flow of Bus on NH-2 (Both Direction)

Year	Small Bus	Large Bus	Total Bus
2010	89,819	83,402	173,221
2011	103,294	93,336	196,630
2012	92,956	116,625	209,581
2013	82,274	130,109	212,383
2014	117,547	161,739	279,286
2015	144,088	125,256	269,344

Date Source: MBEL-HOPETECH JV.

Table 4.4: Bus Percentage on NH-2 (Both Direction)

Year	Small Bus	Large Bus	Total Bus Percentage
2010	7.62%	8.21%	15.83%
2011	7.63%	8.44%	16.07%
2012	10.02%	7.99%	18.01%
2013	13.90%	8.79%	22.69%
2014	13.69%	9.95%	23.64%
2015	11.97%	13.77%	25.74%
Average	**10.80%**	**9.52%**	**20.32%**

Date Source: MBEL-HOPETECH JV.

It is detected from table 4.4 that small bus percentage has increased from 7% to 12% and large bus percentage has also increased from 8% to 14% in the study time. In addition, the total bus percentage has also increased from 15% to 25% from 2010 to 2015 along NH-2.

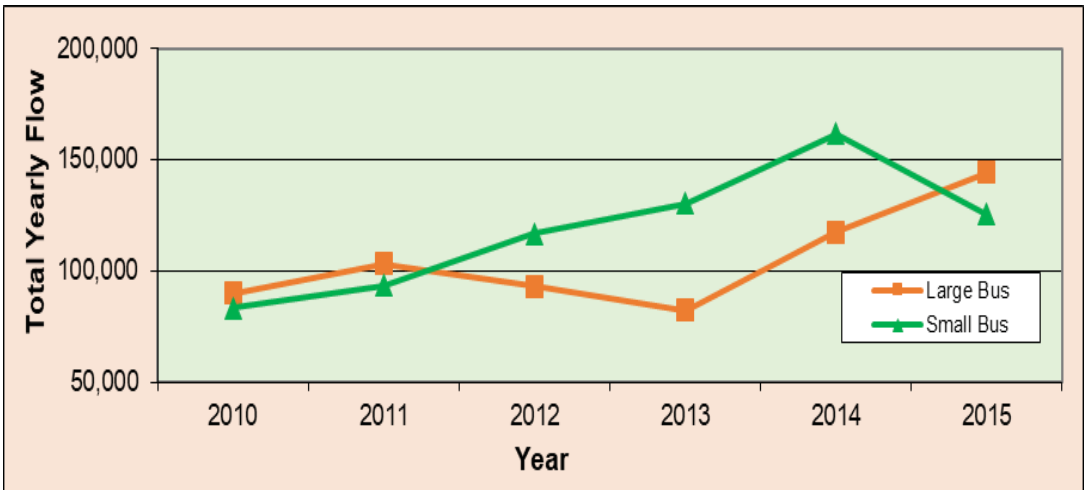


Figure 4.9: Yearly Flow of Bus on NH-2 (Both Direction)

Figure 4.9 shows the pictorial representations of yearly flow of bus on NH-2. The yearly small bus flow has increased from 90 thousand to 150 thousand. Also, the yearly large bus flow has increased from 80 thousand to 160 thousand along NH-2. Hence, the road authority should consider the fact that passenger transportation is increasing rapidly and hereafter, should take remadial measures for the improvement of passenger transportation system.

Table 4.5: Growth Factor of Bus on NH-2 (Both Direction)

Year	Small Bus	Large Bus
2010-11	15.00	11.91
2011-12	-10.01	24.95
2012-13	-11.49	11.56
2013-14	42.87	24.31
2014-15	22.58	-22.56
Average	**11.79**	**10.04**

Table 4.5 shows the growth factor of bus on Dhaka-Hobiganj highway. The maximum growth factor is found for small bus is 42.87 in the year 2013-2014. However, the average growth factor for samll bus in the study period is 11.79%. On the other hand, large bus has the highest growth factor of 24.95 in the year 2011-12 and the average growth factor is 10.04 from 2010 to 2015.

4.5 CALCULATION OF DIRECTIONAL DISTRIBUTION OF DHAKA-HOBIGANJ HIGHWAY

Directional distribution is a vital parameter for traffic engineers' especially for country like Bangladesh due to densely populated area, less land and budget constrain for mega projects. Since the ratio of mixed traffic is high in Bangladesh and hence, directional distribution plays a significant role. The detail analyses of directional distribution in NH-2 corridor are explained below.

4.5.1 DAILY DIRECTIONAL DISTRIBUTION ON DHAKA-HOBIGANJ HIGHWAY

The calculation of directional distribution of traffic on Dhaka-Hobiganj highway is completed using 6 years (2010 to 2015) of traffic data collected by MBEL-HOPETECH

JV. In Table 4.6, the daily directional distribution of traffic from 2010 to 2015 is shown. In addition, the summarized daily directional distribution ADT data are shown in table 4.7. The average daily ADT on each day of week have been determined from 6 years' data.

Table 4.6: Daily Directional Distribution of Traffic on NH-2

Day\Year	2010		2011		2012	
	DK to Hobiganj	Hobiganj to DK	DK to Hobiganj	Hobiganj to DK	DK to Hobiganj	Hobiganj to DK
Saturday	1,375	1,551	1,550	1,760	1,501	1,623
Sunday	1,399	1,476	1,526	1,597	1,468	1,512
Monday	1,461	1,528	1,567	1,637	1,523	1,563
Tuesday	1,399	1,495	1,623	1,714	1,501	1,568
Wednesday	1,428	1,511	1,599	1,698	1,566	1,655
Thursday	1,510	1,536	1,695	1,700	1,607	1,605
Friday	1,632	1,680	1,866	1,937	1,762	1,813
TOTAL	**10,206**	**10,778**	**11,426**	**12,042**	**10,929**	**11,339**
TOTAL - BOTH DIRECTION	**20,983**		**23,468**		**22,268**	
Day\Year	**2013**		**2014**		**2015**	
	DK to Hobiganj	Hobiganj to DK	DK to Hobiganj	Hobiganj to DK	DK to Hobiganj	Hobiganj to DK
Saturday	1,349	1,437	1,550	1,661	1,363	1,432
Sunday	1,184	1,203	1,470	1,549	1,335	1,407
Monday	1,182	1,218	1,501	1,573	1,382	1,420
Tuesday	1,071	1,134	1,575	1,642	1,362	1,414
Wednesday	1,111	1,175	1,579	1,623	1,377	1,457
Thursday	1,287	1,288	1,615	1,656	1,445	1,476
Friday	1,649	1,673	1,822	1,847	1,586	1,610
TOTAL	**8,833**	**9,128**	**11,111**	**11,551**	**9,849**	**10,216**
TOTAL - BOTH DIRECTION	**17,961**		**22,662**		**20,065**	

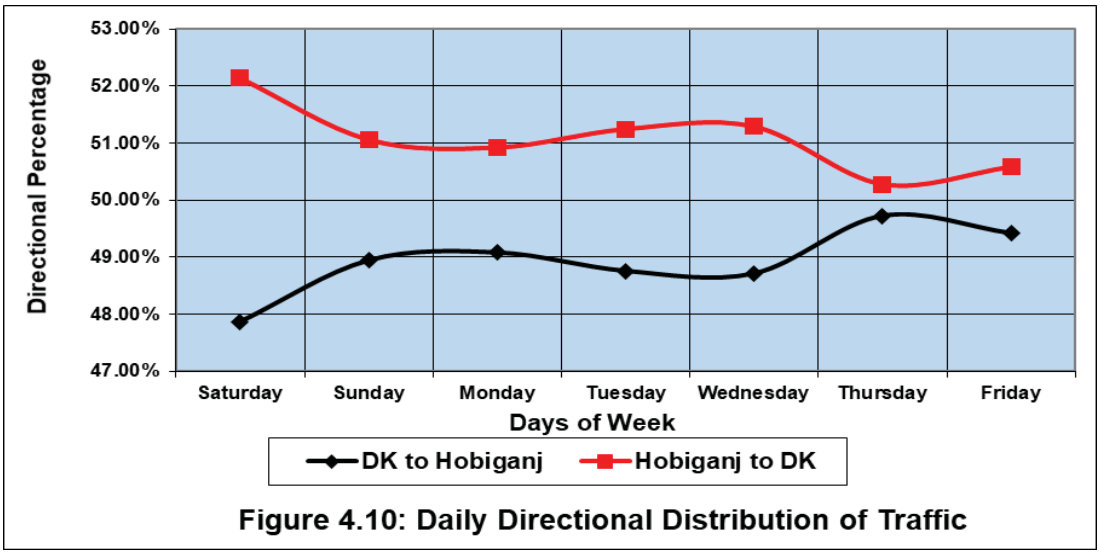


Figure 4.10: Daily Directional Distribution of Traffic

Table 4.7: Average Daily Directional Distribution of Traffic on NH-2

Weekday	Avg. Daily ADT			Directional Split	
	DK to Hobiganj	Hobiganj to DK	Total	DK to Hobiganj	Hobiganj to DK
Saturday	1,448	1,577	3,025	47.86%	52.14%
Sunday	1,397	1,457	2,855	48.94%	51.06%
Monday	1,436	1,490	2,926	49.08%	50.92%
Tuesday	1,422	1,495	2,916	48.75%	51.25%
Wednesday	1,443	1,520	2,963	48.71%	51.29%
Thursday	1,527	1,543	3,070	49.72%	50.28%
Friday	1,720	1,760	3,480	49.42%	50.58%

It is observed from the above figure 4.10 that, daily directional distribution varies from 47.86% to 52.14%. The maximum outbound (Dhaka to Hobiganj) traffic is found on Thursday (49.72%), as people coming to their home district (Hobiganj) from Dhaka due to the start of weekend. In the same way, the inbound (Hobiganj to Dhaka) traffic is found maximum on Satuerday (52.14%), as the people move back to Dhaka for the start of weekdays.

4.5.2 MONTHLY DIRECTIONAL DISTRIBUTION ON DHAKA- HOBIGANJ HIGHWAY

Monthly directional distribution of traffic along Dhaka-Hobiganj highway (NH-2) is shown tabular farmat in table 4.8 and graphical format in figure 4.11. The directional split is shared in two equal parts along NH-2. It is evident that, there is no alternative roadway corridor available for the users of this highway. The overall directional distribution, averaged over 6 years monthly traffic flow data, is found to 48.96% in the Dhaka to Hobiganj direction and 51.04% in the Hobiganj to Dhaka Direction. Figure 4.12 shows the overall directional distribution of traffic on Dhaka-Hobiganj highway.

Table 4.8: Monthly Directional Distribution of Traffic on NH-2

Month	Average Monthly Volume (2010 to 2015)			Directional Split	
	DK to Hobiganj	Hobiganj to DK	Total	DK to Hobiganj	Hobiganj to DK
Jan	46,872	49,146	96,018	48.82%	51.18%
Feb	48,067	50,360	98,427	48.84%	51.16%
Mar	52,335	55,583	107,917	48.50%	51.50%
Apr	44,562	48,022	92,583	48.13%	51.87%
May	48,288	50,517	98,805	48.87%	51.13%

Jun	42,926	44,141	87,067	49.30%	50.70%
Jul	41,335	43,215	84,550	48.89%	51.11%
Aug	41,150	42,308	83,458	49.31%	50.69%
Sep	42,083	42,901	84,984	49.52%	50.48%
Oct	43,209	45,093	88,302	48.93%	51.07%
Nov	43,226	44,477	87,703	49.29%	50.71%
Dec	48,466	49,832	98,298	49.30%	50.70%
Average	45,210	47,133	92,343	**48.96%**	**51.04%**

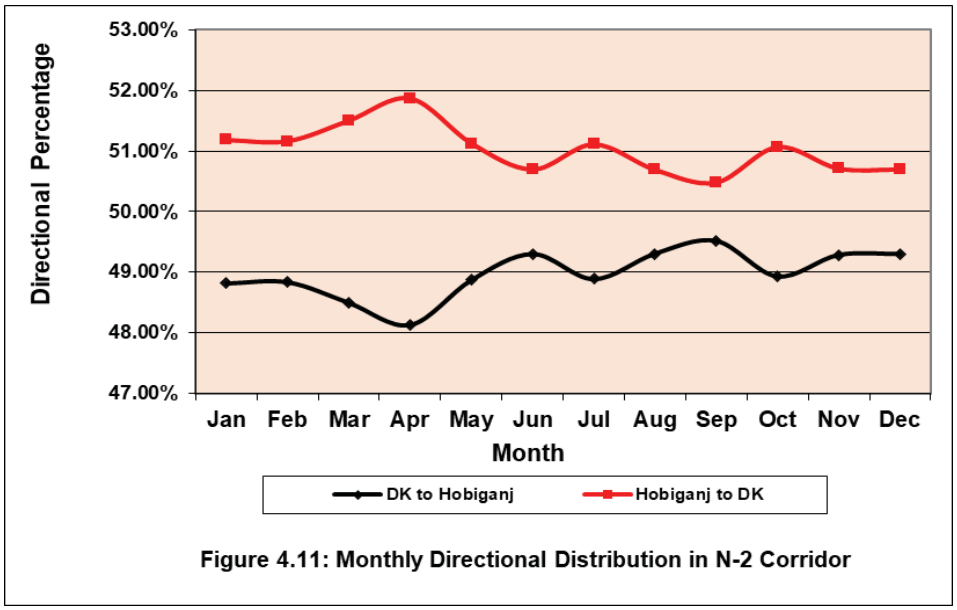


Figure 4.11: Monthly Directional Distribution in N-2 Corridor

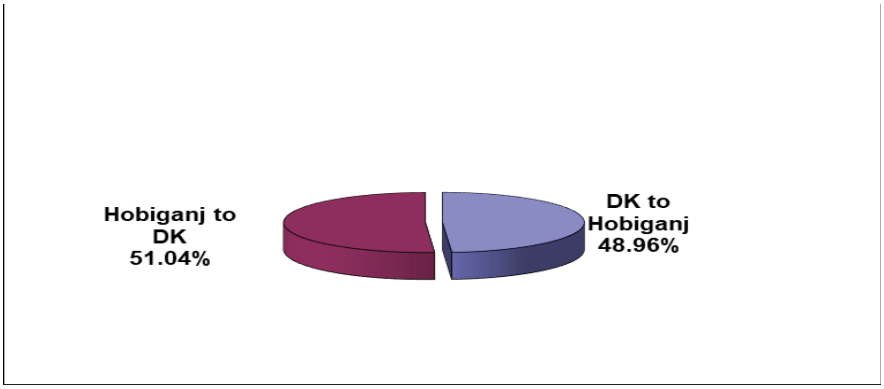


Figure 4.12: Average Monthly Directional Distribution of Traffic on NH-2

4.6 ESTIMATION OF TRAFFIC FLOW PATTERN ON DHAKA-HOBIGANJ HIGHWAY

Vehicular movement phenomena are complex and nonlinear, depending on the interactions of different vehicles. Due to the individual reactions of human drivers,

vehicles do not interact simply following the laws of mechanics. In a free-flowing network, traffic flow theory refers to the traffic stream variables of speed, flow and concentration. These relationships are mainly concerned with uninterrupted traffic flow. However, in real life situation, traffic flow varies according to different characteristics. For efficient pavement design, traffic flow studies play a vital role. Different traffic flow natures along Dhaka-Hobiganj highway is discussed in the following sections.

4.6.1 ASSESSMENT OF DAILY TRAFFIC FLOW VARIATIONS IN NH-2

Daily flow fluctuation on highways is an important factor of flow characteristics where the variation of flow in days-of-week is observed. From the analyses of 6 years data collected from MBEL-HOPETECH JV (2010 to 2015), distinct flow natures have been observed. In Figures 4.13a & b, the average daily flow fluctuation, in either direction, in percentage of total weekly volume have been designed against respective days of the week. The daily flow variation for incoming (Dhaka to Hobiganj) and outgoing (Hobiganj to Dhaka) traffic shows comparable shape.

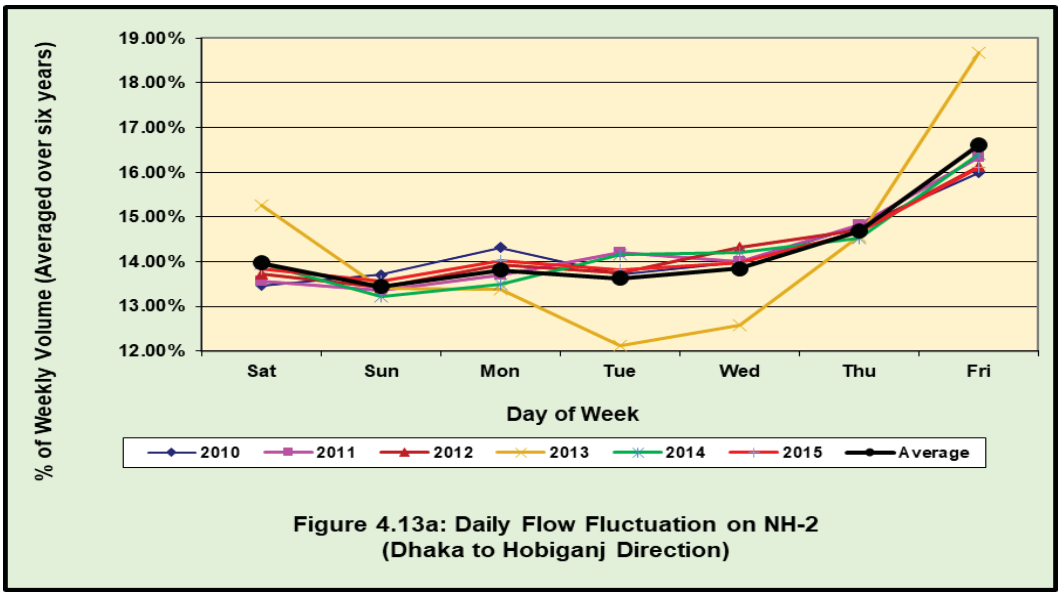


Figure 4.13a: Daily Flow Fluctuation on NH-2 (Dhaka to Hobiganj Direction)

Figure 4.13a shows the traffic flow variations from Dhaka to Hobiganj direction. It is observed that the average maximum flow occurs on Friday (16.60%) and Thursday (14.69%). An increase in vehicular movement is observed due to the weekend factor as people moves from Dhaka to Sylhet corridor due to the weekly holidays that increase more trips along NH-2. However, the average daily flow variations are ranges from 13% to 15% of weekly volume along NH-2 from the daily traffic data of 2010 to 2015. The daily traffic fluctuation pattern for the year 2013 seems different than others, as that year

the politican disturbance in Bangladesh was extreme, which hampered regular traffic and freight movement abruptly.

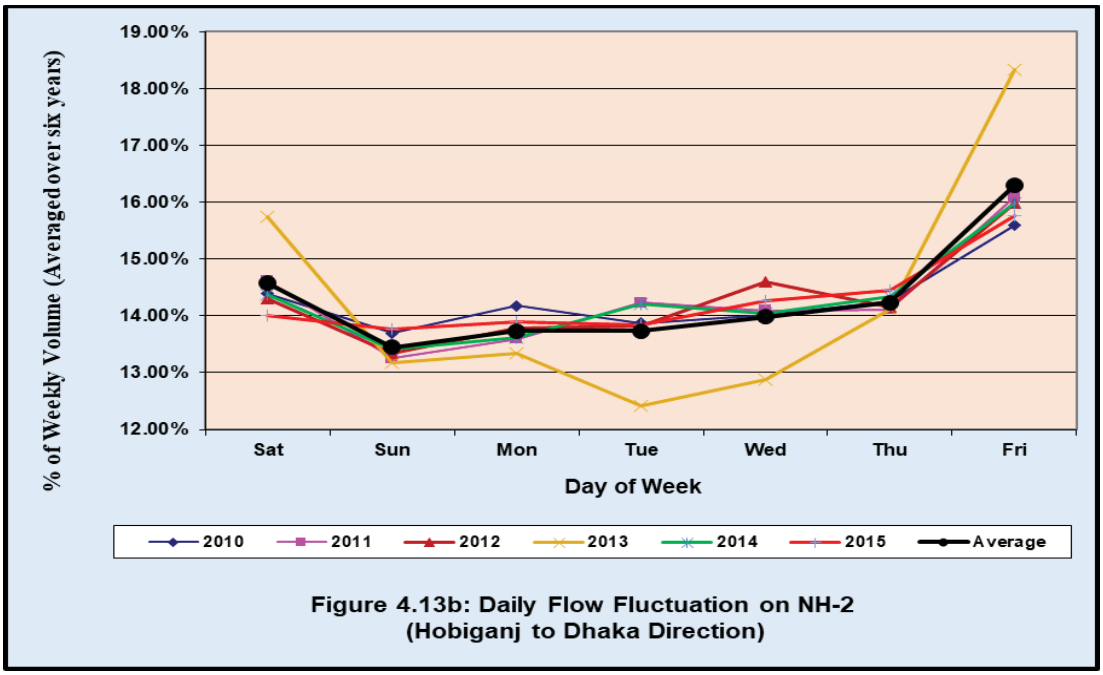


Figure 4.13b: Daily Flow Fluctuation on NH-2 (Hobiganj to Dhaka Direction)

Similarly, figure 4.13b shows the traffic flow variations from Hobiganj to Dhaka direction. The maximum flow found on Friday (16.29%) and Saturday (14.58%). The same weekend factor is governing in this situation as well and trips are increase due to weekly holidays. Yet, the average daily flow variations are ranges from 13% to 14.50% of weekly volume from the six years of daily traffic data.

The detail analyses of daily flow fluctuations in Dhaka-Hobiganj highway have been examined in the following sections where large bus, medium truck and light vehicle classwise plots are described.

Daily flow fluctuation of medium trucks are shown for incoming and outgoing traffic respectively in Figure 4.14a & 4.14b. Figure 4.14a depicts that the average daily flow variations from Dhaka to Hobiganj directions is 14% of weekly volume from Saturday to Thursday. In Friday, the medium truck flow variation is increased to 15.65%. Hereafter, the graph indicates that in weekends the freight movement don't decrease due to office holidays rather it increases to it's maximum on Friday.

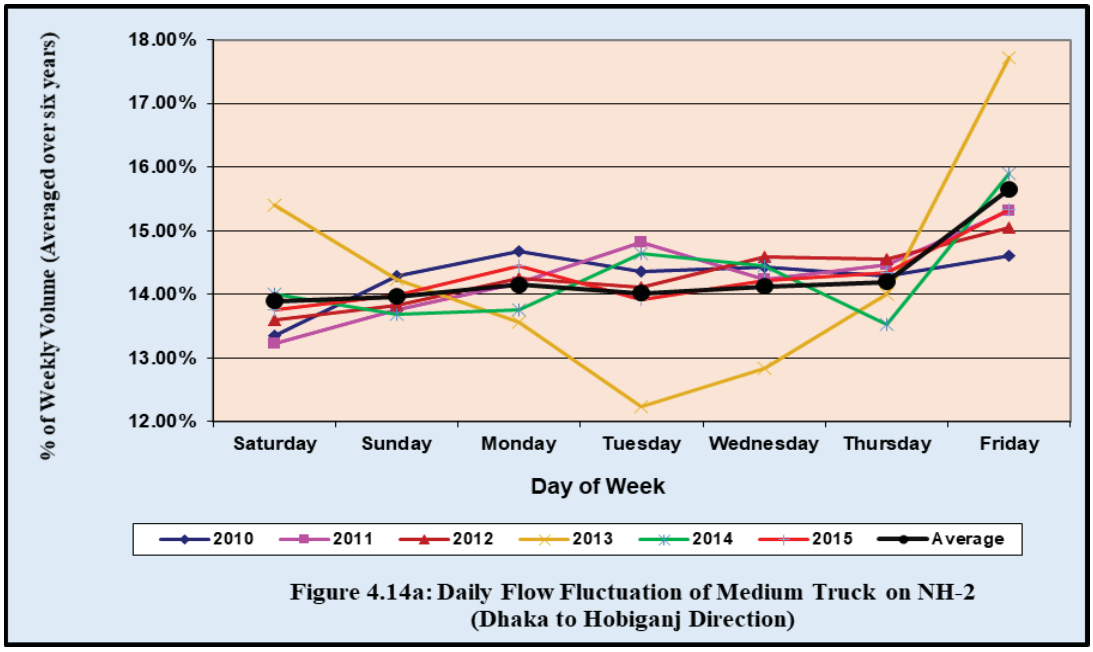


Figure 4.14a: Daily Flow Fluctuation of Medium Truck on NH-2 (Dhaka to Hobiganj Direction)

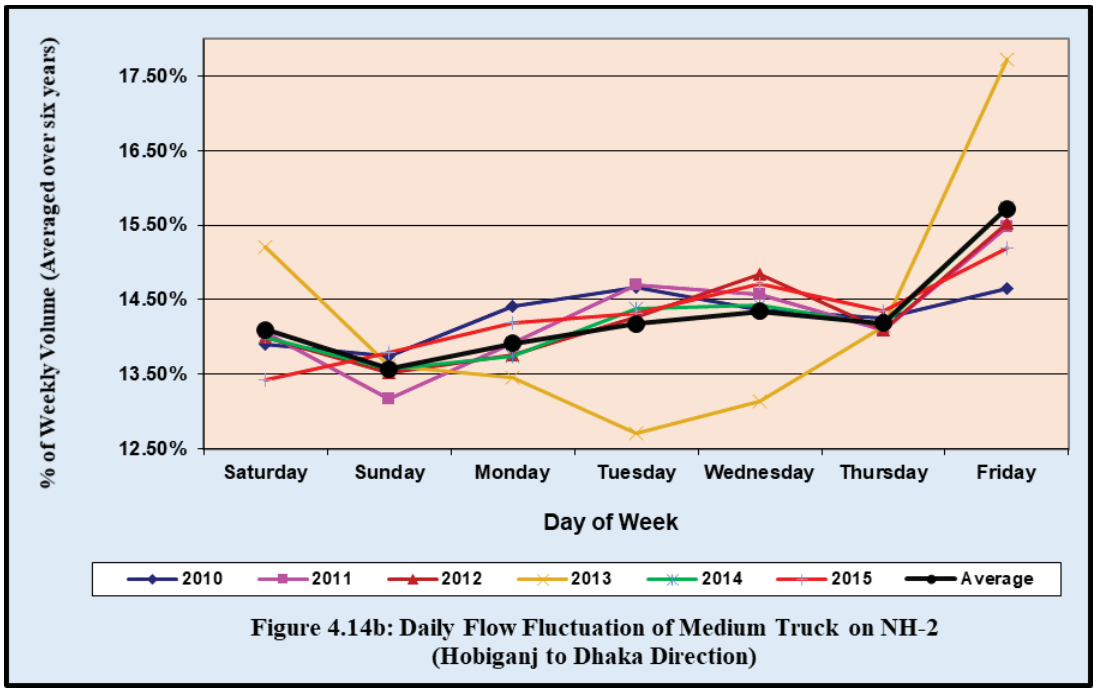


Figure 4.14b: Daily Flow Fluctuation of Medium Truck on NH-2 (Hobiganj to Dhaka Direction)

In figure 4.14b, daily flow fluctuation of medium truck in NH-2 is shown along Hobigonj to Dhaka direction. The minimum average daily flow fluctuation is found on Sunday (13.57% of weekly volume). Though from Monday to Friday, there is a trend of increasing daily flow patter and on Friday it reaches to its peak limit (15.72% of weekly volume). Also, the daily flow pattern varies from 13.50% to 14.50% of weekly volume in weekdays towards Dhaka direction in NH-2.

The daily flow fluctuation of Large Bus (Dhaka to Hobiganj direction) on NH-2 is illustrated in Figure 4.15a. The flow of large bus has tendency of increasing from Saturday (13.51% of weekly volume) and it reaches to maximum in Friday (15.98% of weekly volume). Again, the flow pattern of Large Bus (Hobiganj to Dhaka direction) is shown in Figure 4.15b. The minimum and maximum flow is found on Sunday (13.57% of weekly volume) and Friday (16.18% of weekly volume) respectively. However, the flow pattern of inbound and outbound traffic of large bus is showing similar pattern. In both graph, second highest flow is found on Thursday and there is a slight rise of traffic pattern on Monday. In both cases, average flow variations of large bus in weekdays ranges from 12.50% to 14.50% of weekly volume in NH-2.

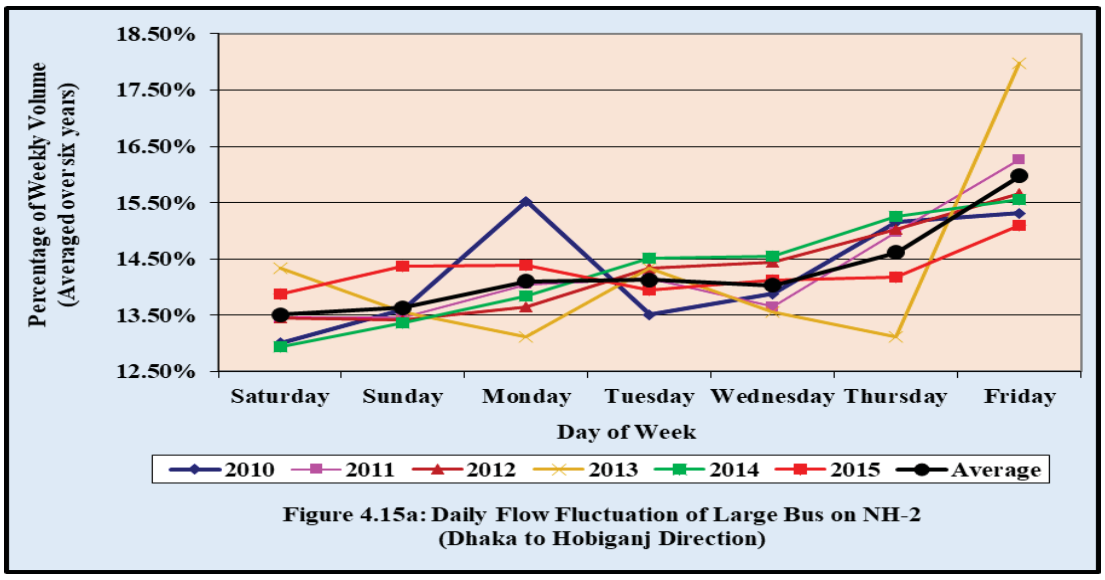


Figure 4.15a: Daily Flow Fluctuation of Large Bus on NH-2 (Dhaka to Hobiganj Direction)

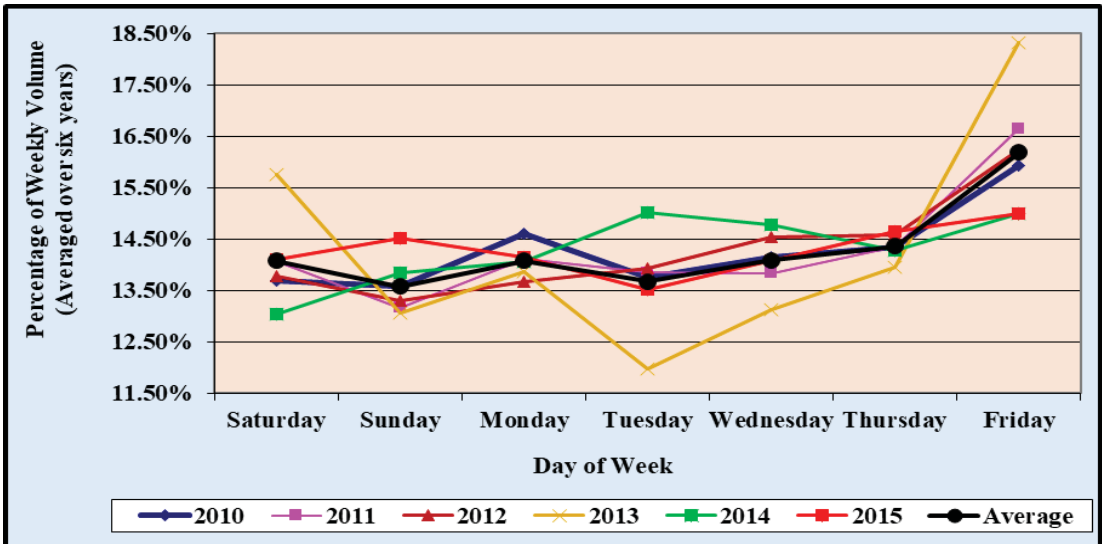


Figure 4.15b: Daily Flow Fluctuation of Large Bus on NH-2 (Hobiganj to Dhaka Direction)

Daily flow fluctuation pattern of light vehicles on NH-2 in either direction is shown in Figure 4.16a & b. From Dhaka to Hobiganj direction in Figure 4.16a, there is a sharp increase of traffic observed in Thursday (15.23%), Friday (18.06%) and Saturday (14.03%) due to weekend factor. Likewise, from Hobiganj to Dhaka direction in Figure 4.16b, huge rise of traffic is found on Thursday (14.28%), Friday (17.39%) and Saturday (15.23%). In both cases, light vehicular traffic is much higher in comparison to the other major vehicle classes. In weekdays, light vehicular flow patterns varies from 12% to 13% of weekly volume, especially from Sunday to Wednesday.

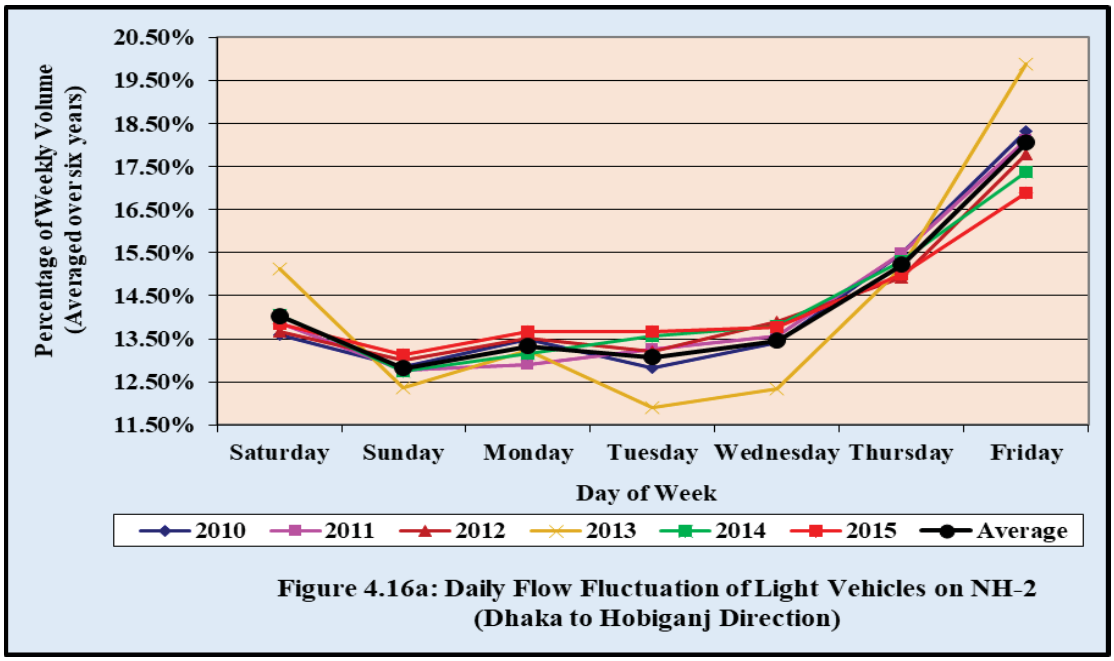


Figure 4.16a: Daily Flow Fluctuation of Light Vehicles on NH-2 (Dhaka to Hobiganj Direction)

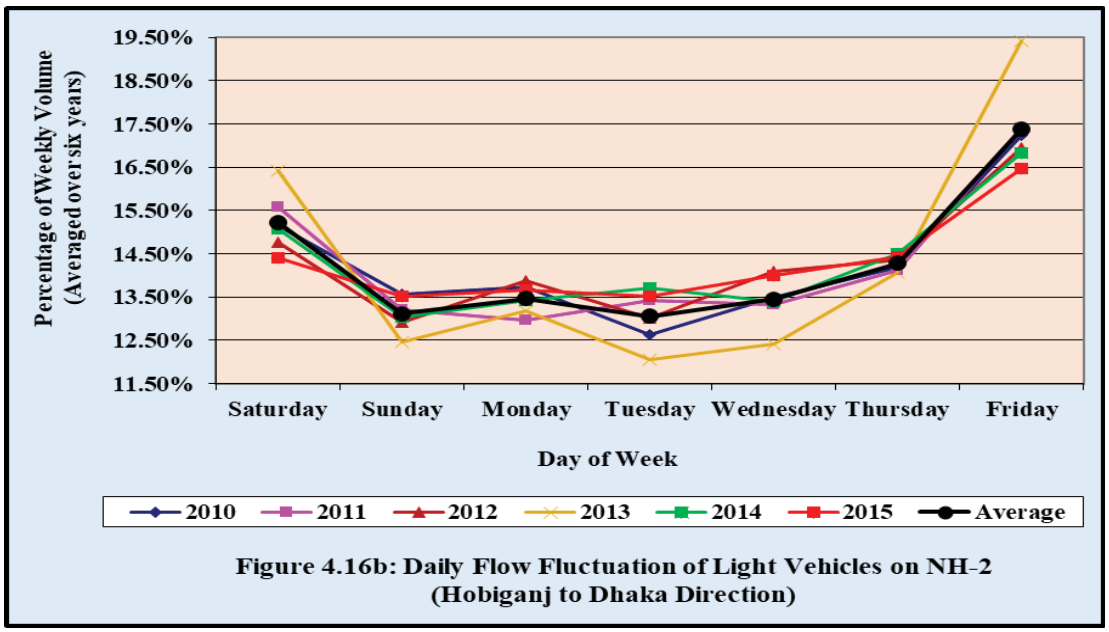


Figure 4.16b: Daily Flow Fluctuation of Light Vehicles on NH-2 (Hobiganj to Dhaka Direction)

The Figure below summarizes the pattern of large bus, medium truck and light vehicle classes in NH-2. The volume of large bus and medium truck appears 5 to 7 times higher than light vehicles in NH-2.

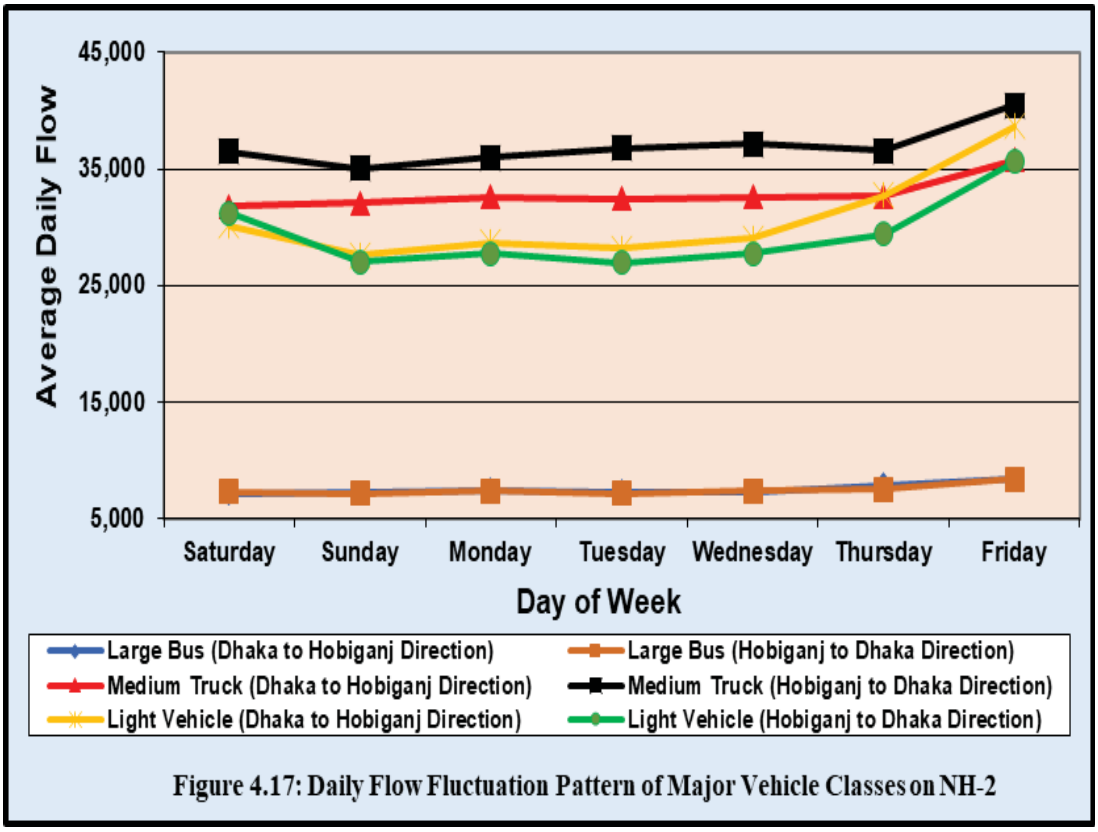


Figure 4.17: Daily Flow Fluctuation Pattern of Major Vehicle Classes on NH-2

Analyses have been done in the following sections regarding how each month of year affects this daily flow fluctuation. Month wise 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 4.18 and Figure 4.19, where the average daily flow variation patterns are found to conform those obtained from the previous analyses. In 2010 from Figure 4.18, it is detected that month wise daily traffic flow variations ranges from 11% to 18% of total monthly flow. The 12 months' average curves mostly follow 14% of monthly traffic flow. The similar type of observation is obtained from Figure 4.19 for the year 2014, where month wise daily traffic flow variations ranges from 10% to 19% of total monthly flow and the 12 months' average curves follows 14% of monthly traffic flow like 2010.

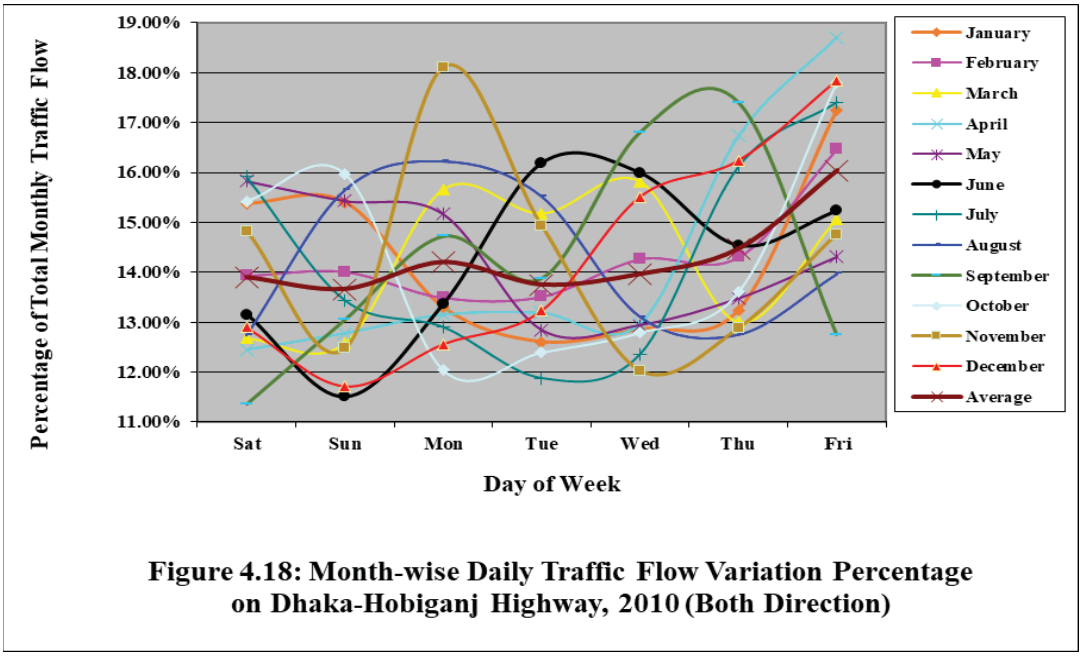


Figure 4.18: Month-wise Daily Traffic Flow Variation Percentage on Dhaka-Hobiganj Highway, 2010 (Both Direction)

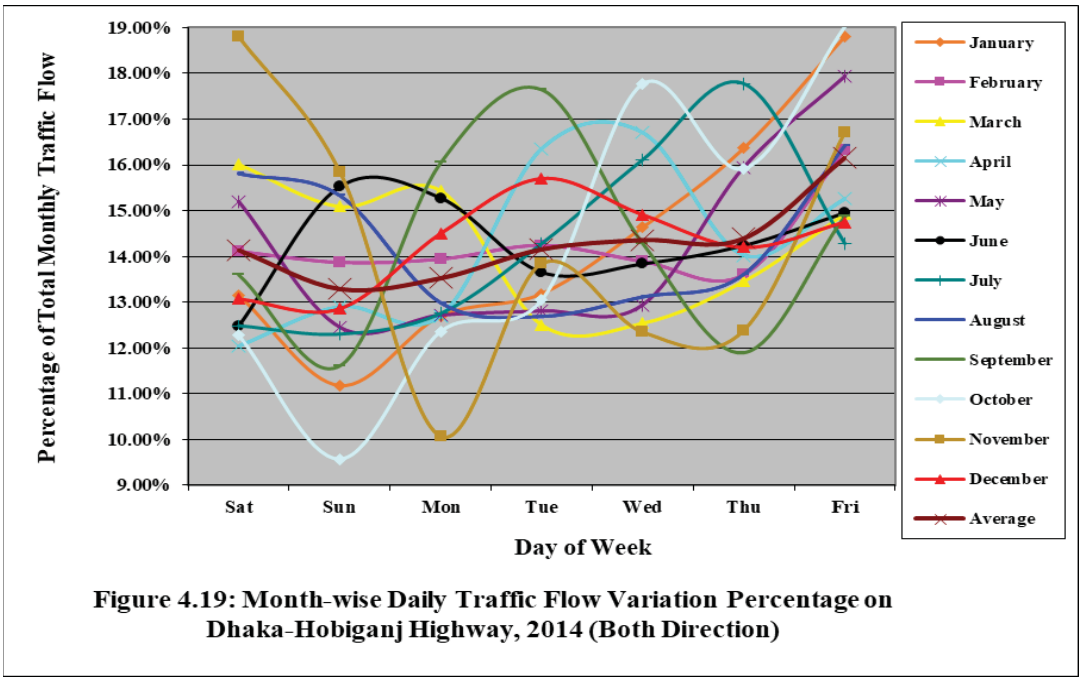


Figure 4.19: Month-wise Daily Traffic Flow Variation Percentage on Dhaka-Hobiganj Highway, 2014 (Both Direction)

It is to be noted here that, only two years (2010 and 2014) of month-wise daily flow variation pattern have been shown above.

Summary of Findings:

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

Table 4.9: Summery of Daily Flow Variation of different vehicle class in NH-2

Vehicle Class	Flow Direction	Maximum Flow		Minimum Flow	
		Day of Week	Percentage of Weekly Volume	Day of Week	Percentage of Weekly Volume
Total Traffic	Towards Hobiganj	Friday	16.60%	Sunday	13.45%
	Towards Dhaka	Friday	16.29%	Sunday	13.44%
Large Bus	Towards Hobiganj	Friday	15.98%	Saturday	13.51%
	Towards Dhaka	Friday	16.18%	Sunday	13.57%
Medium Truck	Towards Hobiganj	Friday	15.65%	Saturday	13.89%
	Towards Dhaka	Friday	15.72%	Sunday	13.57%
Light Vehicle	Towards Hobiganj	Friday	18.06%	Sunday	12.81%
	Towards Dhaka	Friday	17.39%	Sunday	13.12%

The table above confirms the fact that Friday possess the maximum flow percentage of weekly volume in either direction. In addition, minimum flow occurs mostly in Sunday.

4.6.2 APPRAISAL OF WEEKLY TRAFFIC FLOW VARIATIONS IN NH-2

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 NH-2, weekly flow analyses have been done in this section. 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 2010 to December 2015. A typical table of weekly flow variation analyses is shown in Table 4.10, 4.10a, 4.10b. Curves have been plotted in Figure 4.20a, 4.20b & 4.20c showing variation in weekly flow on NH-2 in the year 2010. From the chart, it is seen that, the

weekly flow percentages of most of the month maintain significant pattern in a year. Individual two or three month shows different characteristics due to political turbulence like hartal, festival like Eid ul fitr, Eid ul azha, etc.

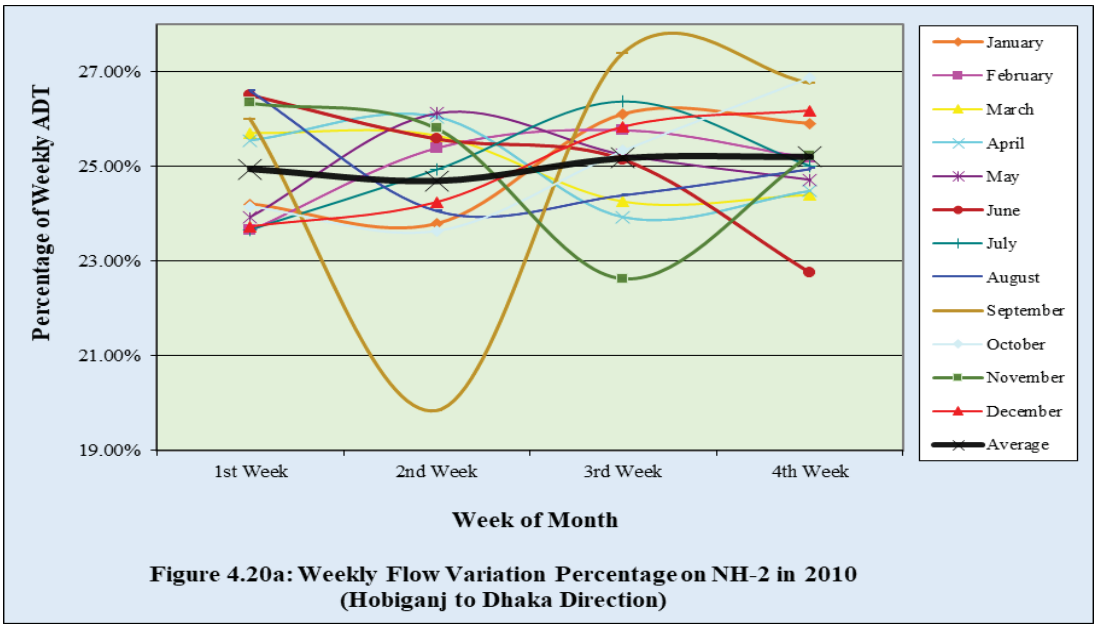


Figure 4.20a: Weekly Flow Variation Percentage on NH-2 in 2010 (Hobiganj to Dhaka Direction)

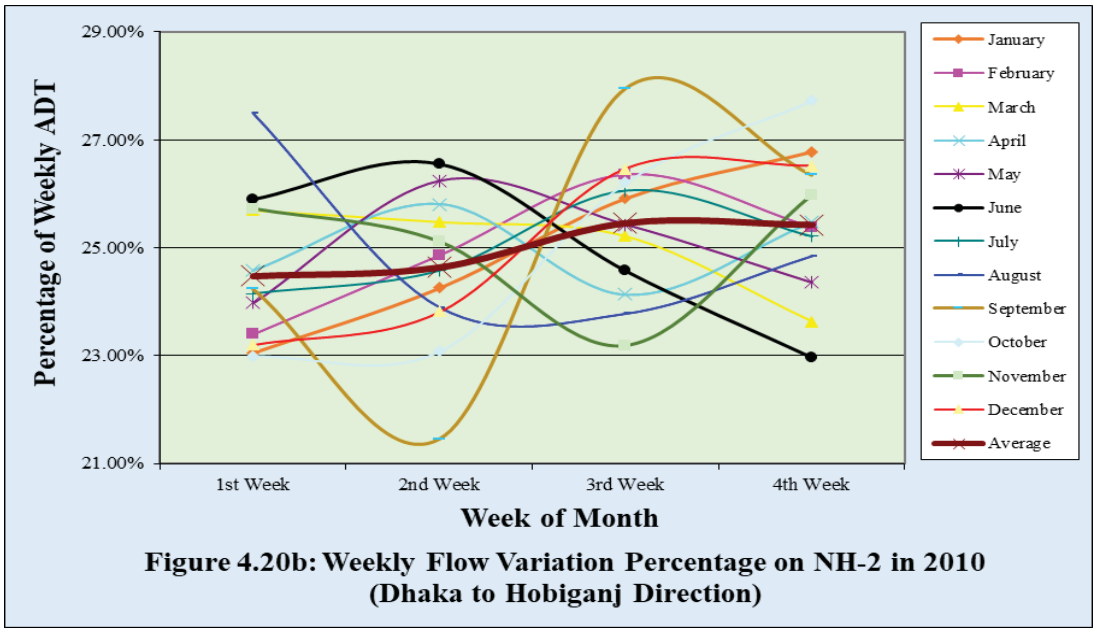


Figure 4.20b: Weekly Flow Variation Percentage on NH-2 in 2010 (Dhaka to Hobiganj Direction)

In Figure 4.20a & b, weekly flow variations in either direction on NH-2 in 2010 is plotted. Both cases, the weekly flow varies between mostly 23% to 27% of monthly volume and the average is quite close to 25% of monthly volume.

However, in Figure 4.20c, weekly flow variations in both directions on NH-2 in 2010 is designed, where traffic flow fluctuates between mostly 24% to 26% and the average is close to 25% of monthly volume.

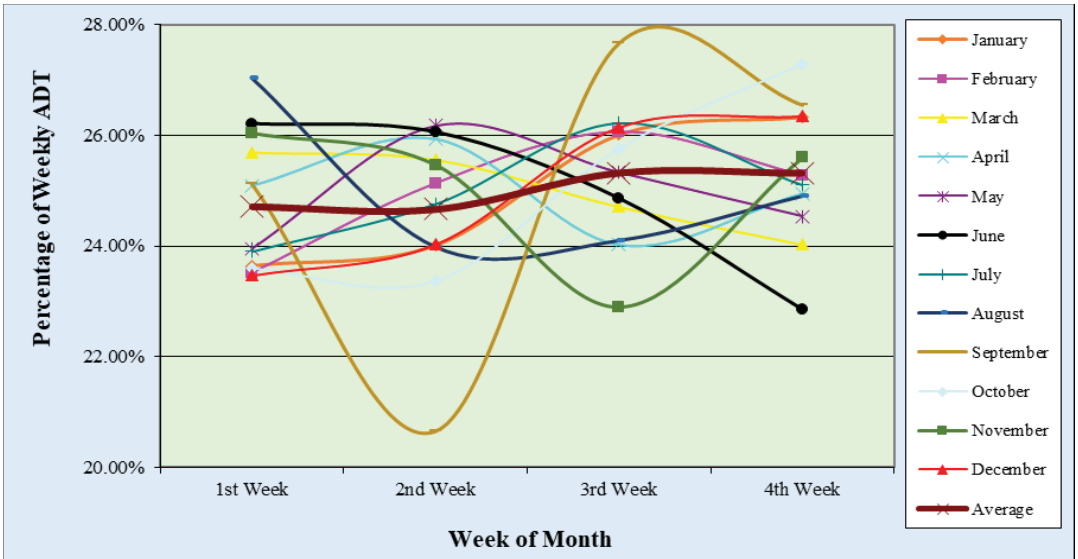


Figure 4.20c: Weekly Flow Variation Percentage on NH-2 in 2010 (Both Direction)

Similarly, in Figure 4.21 a, b & c, weekly flow variations on NH-2 in 2015 are plotted. In all cases, the flow varies between mostly 22.5% to 27% of monthly volume and the average is quite close to 25% of monthly volume.

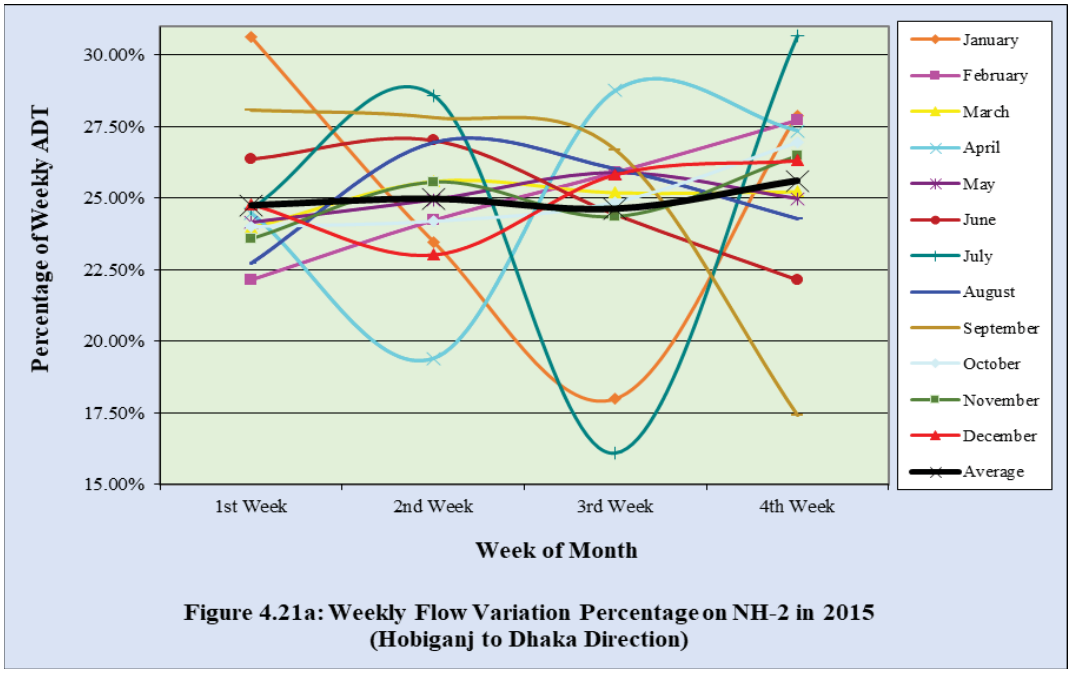


Figure 4.21a: Weekly Flow Variation Percentage on NH-2 in 2015 (Hobiganj to Dhaka Direction)

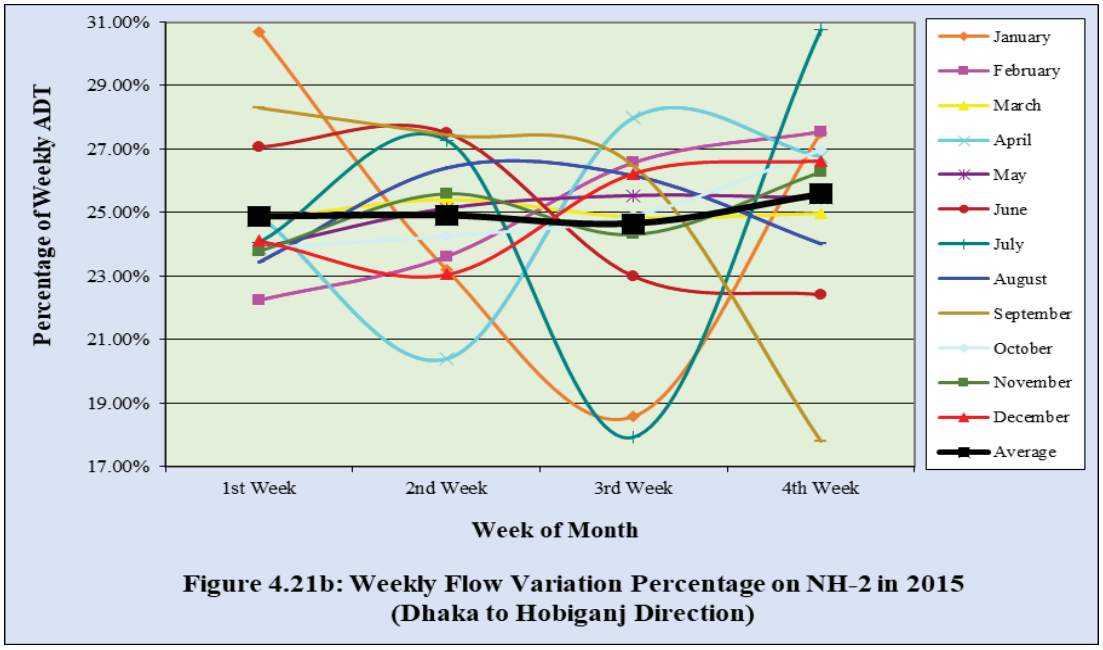


Figure 4.21b: Weekly Flow Variation Percentage on NH-2 in 2015 (Dhaka to Hobiganj Direction)

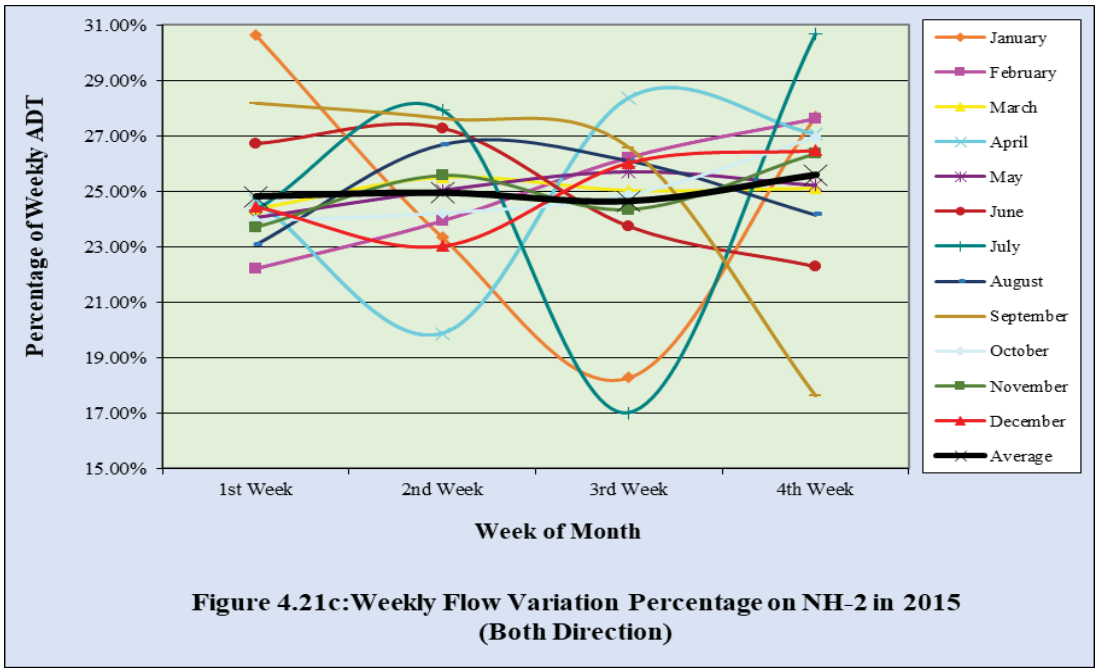


Figure 4.21c:Weekly Flow Variation Percentage on NH-2 in 2015 (Both Direction)

Figure 4.22 suggests that, National Highway No. 2 (NH-2) have specific weekly flow variation pattern. The average curve (from 2010 to 2015) demonstrations that, there is a trend of increasing traffic linearly from first week to fourth week of each month. So, the weekly flow is expected to be higher while last weeks in each month.

Table 4.10 and figure 4.22 summaries weekly flow variations along Dhaka to Hobiganj highway from 2010 to 2015 in both directions. The average weekly flows varies between 24% to 26% of monthly volume.

Table 4.10: Summary of Weekly Flow Variation (Both Direction)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2010	24.71%	24.67%	25.31%	25.31%
2011	23.91%	24.49%	25.58%	26.02%
2012	25.47%	25.56%	24.46%	24.50%
2013	24.88%	24.14%	23.74%	27.24%
2014	22.81%	25.51%	25.96%	25.72%
2015	24.82%	24.95%	24.64%	25.60%
Average	24.43%	24.89%	24.95%	25.73%

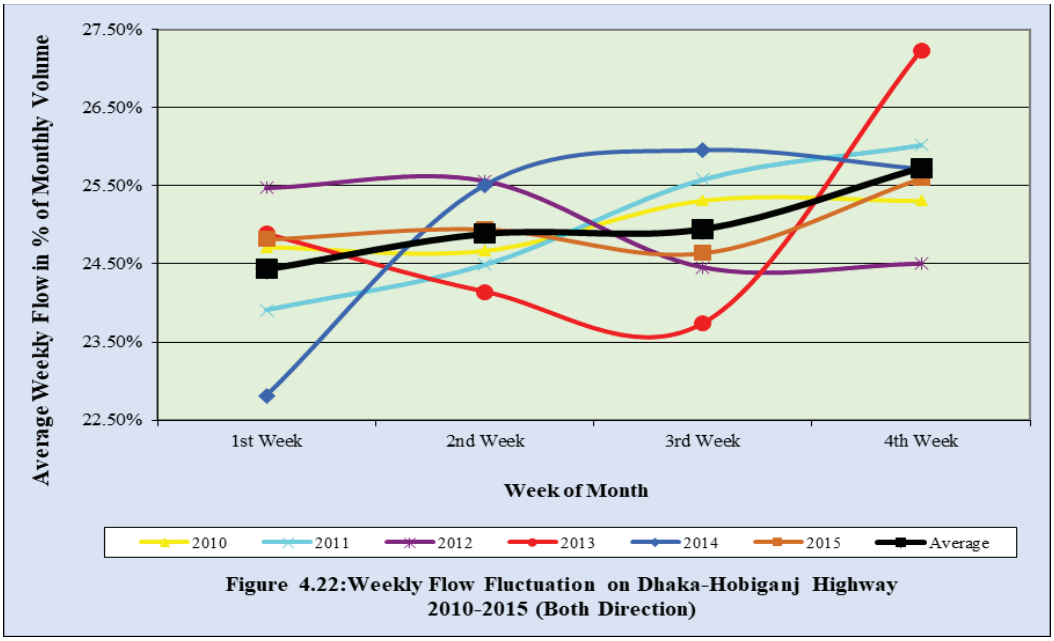


Figure 4.22:Weekly Flow Fluctuation on Dhaka-Hobiganj Highway 2010-2015 (Both Direction)

Likewise, Table 4.10a and figure 4.22a summaries weekly flow variations along Dhaka to Hobiganj highway from 2010 to 2015 towards Hobiganj direction. The average weekly flows varies between 23.5% to 25.5% of monthly volume.

Table 4.10a: Summary of Weekly Flow Variation

(Dhaka to Hobiganj Direction)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2010	24.47%	24.64%	25.46%	25.43%
2011	23.84%	24.69%	25.57%	25.90%
2012	25.43%	25.46%	24.30%	24.81%
2013	24.81%	24.04%	23.97%	27.18%
2014	22.81%	25.57%	25.95%	25.67%
2015	24.87%	24.91%	24.64%	25.58%
Average	24.37%	24.88%	24.98%	25.76%

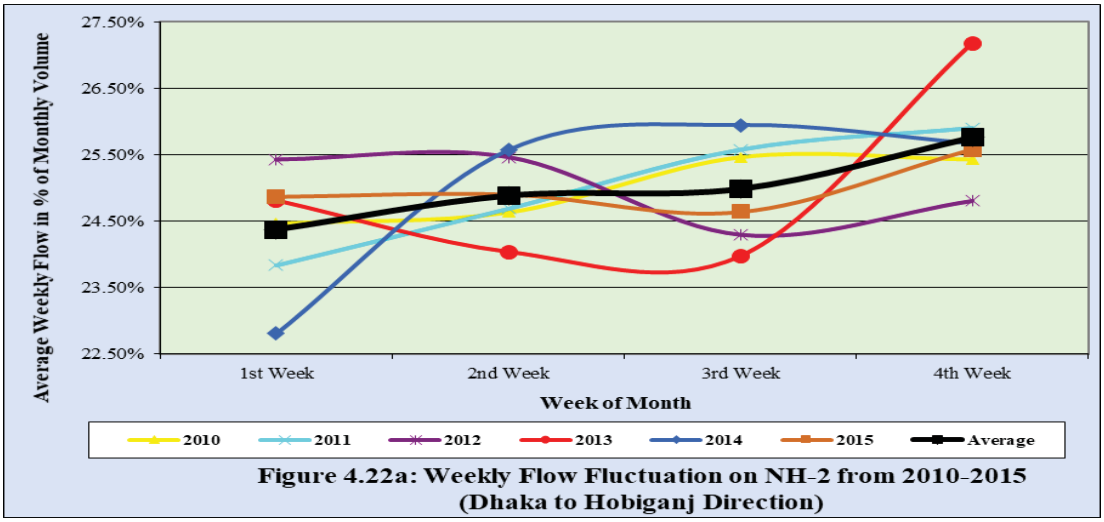


Figure 4.22a: Weekly Flow Fluctuation on NH-2 from 2010-2015 (Dhaka to Hobiganj Direction)

Also, Table 4.10b and figure 4.22b synopses weekly flow variations from 2010 to 2015 towards Dhaka direction. The average weekly flows fluctuates between 24% to 26% of monthly volume and there is a trend of increasing traffic from first week to fourth week of every month.

Table 4.10b: Summary of Weekly Flow Variation (Hobiganj to Dhaka Direction)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2010	24.94%	24.69%	25.17%	25.20%
2011	23.97%	24.30%	25.59%	26.14%
2012	25.52%	25.66%	24.60%	24.21%
2013	24.96%	24.24%	23.51%	27.29%
2014	22.82%	25.45%	25.97%	25.76%
2015	24.76%	24.99%	24.64%	25.61%
Average	24.49%	24.89%	24.91%	25.70%

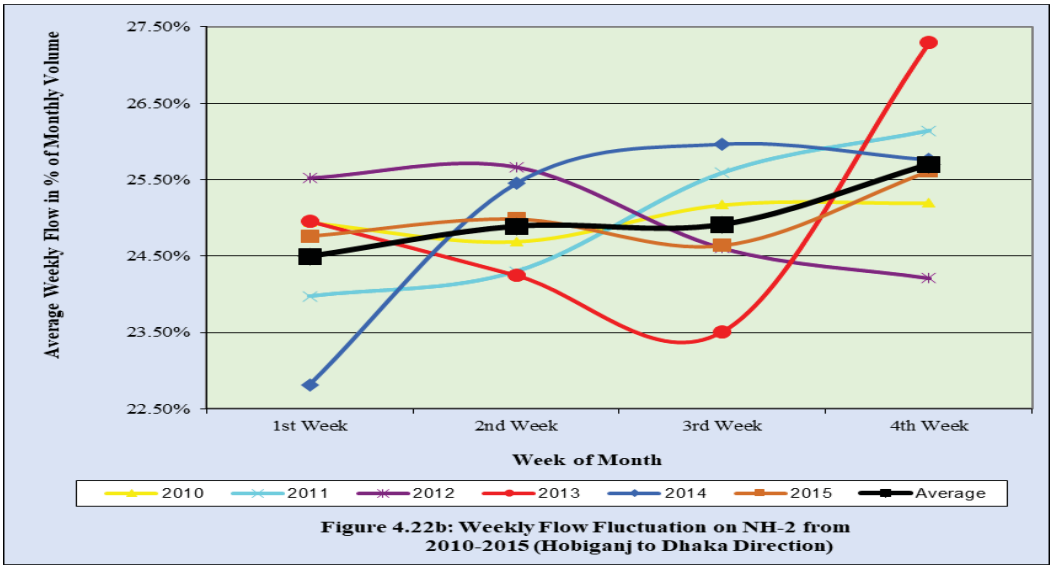


Figure 4.22b: Weekly Flow Fluctuation on NH-2 from 2010-2015 (Hobiganj to Dhaka Direction)

4.6.3 MONTHLY TRAFFIC FLOW VARIATIONS IN NH-2

Six years of daily traffic data on Rustompur toll plaza is used for establishing monthly flow variation along Dhaka-Hobiganj highway (NH-2). The seasonal flow variation is an important parameter for predicting traffic pattern along any corrdior. The monthly flow fluctuation pattern indicate a complete understanding of the nature of traffic flow variation in different month of a year. The monthly traffic flow variation curve from 2010 to 2015 of Dhaka-Hobiganj highway is shown on figure 4.23. Interestingly the characteristics curve along NH-2 has shown the different nature of traffic flow for bi-directional traffic. It is detected here that the probability of traffic is expected to be higher from November to May, whereas from June to October the likelihood of traffic seems comperatively less in this corridor. The subsequent table 4.11 shows the monthly flow analyses on Dhaka to Hobiganj highway from the years 2010 to 2015.

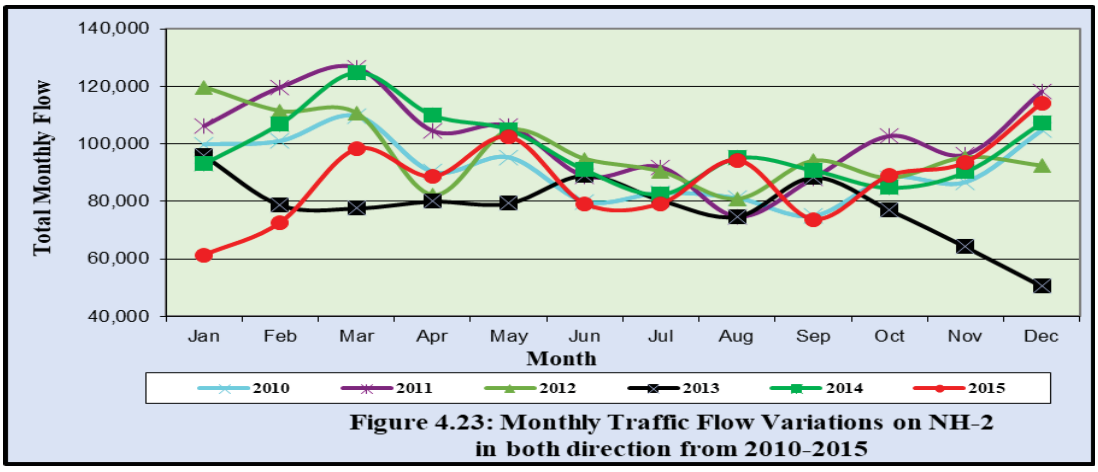


Figure 4.23: Monthly Traffic Flow Variations on NH-2 in both direction from 2010-2015

Table 4.11: Monthly Traffic Flow Analyses on Dhaka to Hobiganj Highway (2010-2015)

Month\ Year	2010	2011	2012	2013	2014	2015
Jan	99,841	106,253	119,598	95,920	93,187	61,308
Feb	101,044	119,758	111,334	78,740	107,007	72,681
Mar	109,776	126,581	110,602	77,651	124,710	98,184
Apr	90,269	104,508	82,183	80,028	109,916	88,594
May	95,296	106,248	104,558	79,379	104,933	102,414
Jun	79,853	88,657	94,699	89,108	90,985	79,102
Jul	82,906	91,830	90,336	80,462	82,517	79,250
Aug	81,057	74,622	80,853	74,785	95,129	94,299
Sep	74,844	88,005	94,048	88,410	90,858	73,738
Oct	88,155	102,732	88,100	77,026	84,833	88,964
Nov	86,691	96,236	95,267	64,185	90,273	93,565
Dec	104,705	118,240	92,404	50,474	107,277	114,224
Yearly Volume	**1,094,437**	**1,223,670**	**1,163,982**	**936,168**	**1,181,625**	**1,046,323**

The following figure 4.24 represents seasonal traffic flow fluctuations in percentage of yearly volume for bi-directional traffic along NH-2 from 2010 to 2015. It is established in this research that monthly traffic varies from 7% to 10% of yearly traffic volume along NH-2. However, December and January shows maximum fluctuation from 5% to 11% of yearly flow.

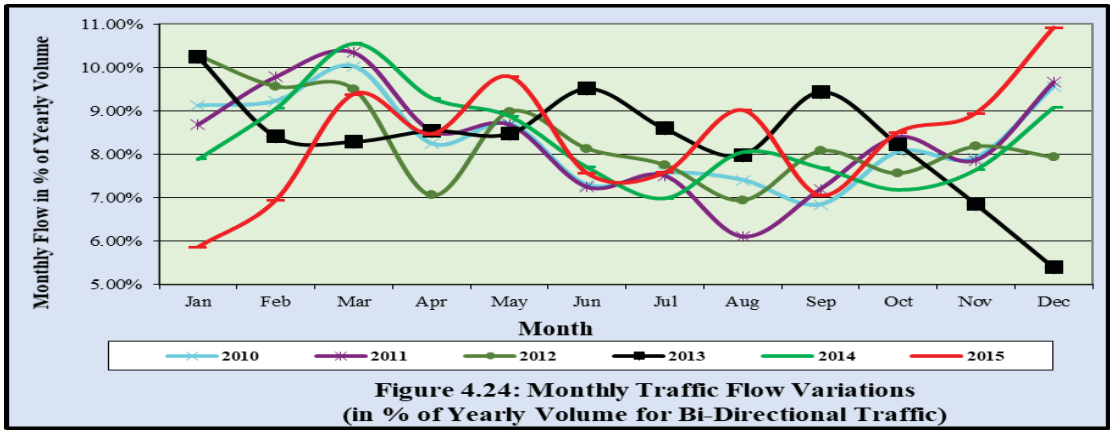


Figure 4.24: Monthly Traffic Flow Variations (in % of Yearly Volume for Bi-Directional Traffic)

Table 4.12: Highest & Lowest Monthly Traffic Flow Table in NH-2

Month/Year	2010	2011	2012	2013	2014	2015	Average
Jan	9.12%	8.68%	**10.27%**	**10.25%**	7.89%	**5.86%**	8.68%
Feb	9.23%	9.79%	9.56%	8.41%	9.06%	6.95%	8.83%
Mar	**10.03%**	**10.34%**	9.50%	8.29%	**10.55%**	9.38%	**9.68%**
Apr	8.25%	8.54%	7.06%	8.55%	9.30%	8.47%	8.36%
May	8.71%	8.68%	8.98%	8.48%	8.88%	9.79%	8.92%
Jun	7.30%	7.25%	8.14%	9.52%	7.70%	7.56%	7.91%
Jul	7.58%	7.50%	7.76%	8.59%	**6.98%**	7.57%	7.67%
Aug	7.41%	**6.10%**	**6.95%**	7.99%	8.05%	9.01%	**7.58%**
Sep	**6.84%**	7.19%	8.08%	9.44%	7.69%	7.05%	7.72%
Oct	8.05%	8.40%	7.57%	8.23%	7.18%	8.50%	7.99%
Nov	7.92%	7.86%	8.18%	6.86%	7.64%	8.94%	7.90%
Dec	9.57%	9.66%	7.94%	**5.39%**	9.08%	**10.92%**	8.76%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Max.	**10.03%**	**10.34%**	**10.27%**	**10.25%**	**10.55%**	**10.92%**	**9.68%**
Min.	**6.84%**	**6.10%**	**6.95%**	**5.39%**	**6.98%**	**5.86%**	**7.58%**

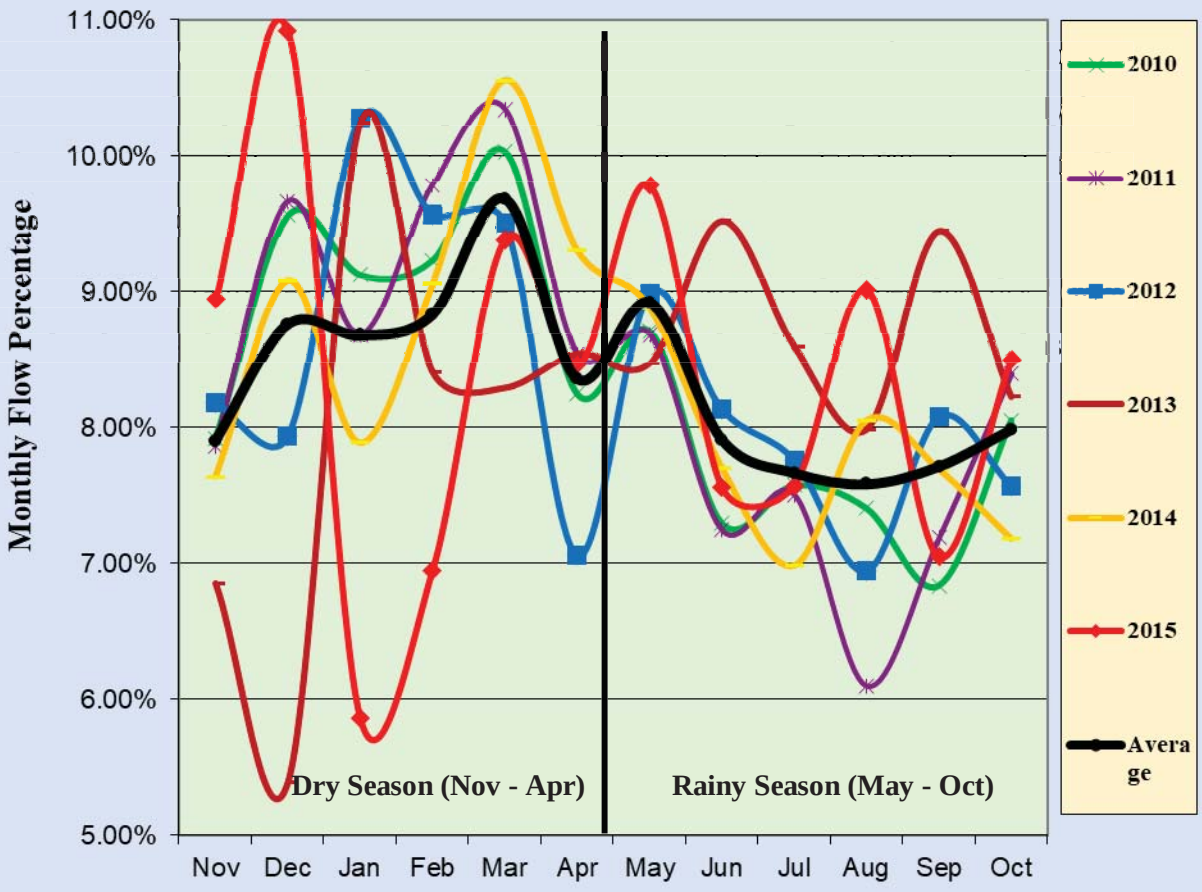


Figure 4.25: Seasonal Flow Variation on NH-2 2010-2015 (Bothway)

In addition, Table 4.12 displays the highest and lowest monthly flow percentage. Highest and lowest flow is marked in red and blue correspondingly. According to the table, the highest flow ranges near to 10% and the lowest flow ranges close to 6% of yearly traffic. It is also observed here that the maximum flow mainly occurs in the month of January and March. In contrast, the minimum flow mainly occurs in the month of July, August and September. Again, the average maximum monthly flow is found 9.68% and the average minimum monthly flow is found 7.58% of yearly traffic along Dhaka-Hobiganj highway (NH-2).

In Bangladesh, rainy season covers the month from May to October and dry season includes the month from November to April. The seasonal traffic flow variations has been divided into dry and rainy seasons and a comparative graph is plotted in figure 4.25. The traffic flow percentage seems less in rainy season compared to dry season due to alternate

water transportation route in Bangladesh. In rainy seasons, the monthly traffic flow percentage mostly varies from 7% to 9%, whereas in dry seasons the flow percentages raises to 8% to 10.5% typically.

The numerical presentation of average seasonal flow variations from six years of daily traffic data is shown in table 4.13 below. The dry season contains 52.22% of traffic flow and wet season contains 47.78% of traffic flow of seasonal variations. The graphical presentation is shown below in figure 4.26.

Table 4.13: Summarized Seasonal Flow Variation Table

Dry Season		Rainy Season	
Month	**Flow % in Season**	**Month**	**Flow % in Season**
Nov	7.90%	May	8.92%
Dec	8.76%	Jun	7.91%
Jan	8.68%	Jul	7.67%
Feb	8.83%	Aug	7.58%
Mar	9.68%	Sep	7.72%
Apr	8.36%	Oct	7.99%
Total	52.22%	Total	47.78%

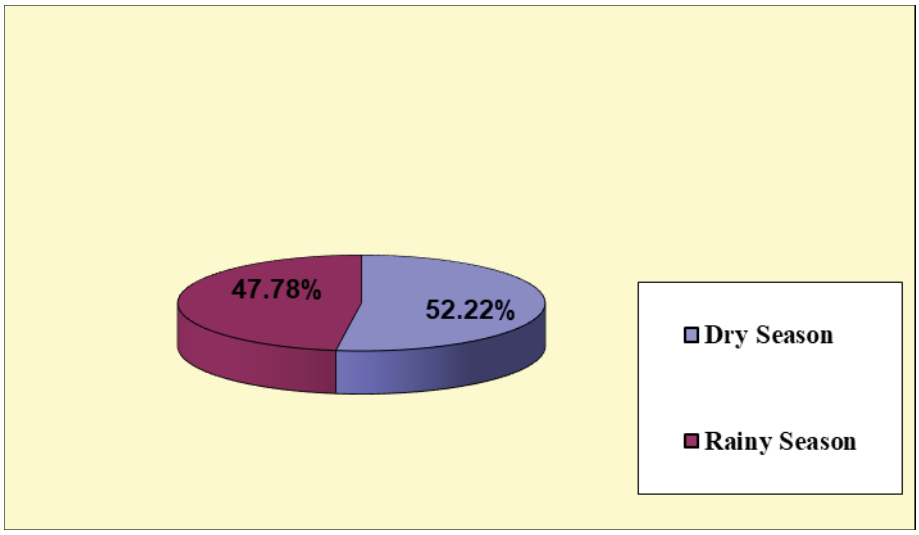


Figure 4.26: Seasonal Distribution of Traffic on NH-2 (Bothway), 2010-2015

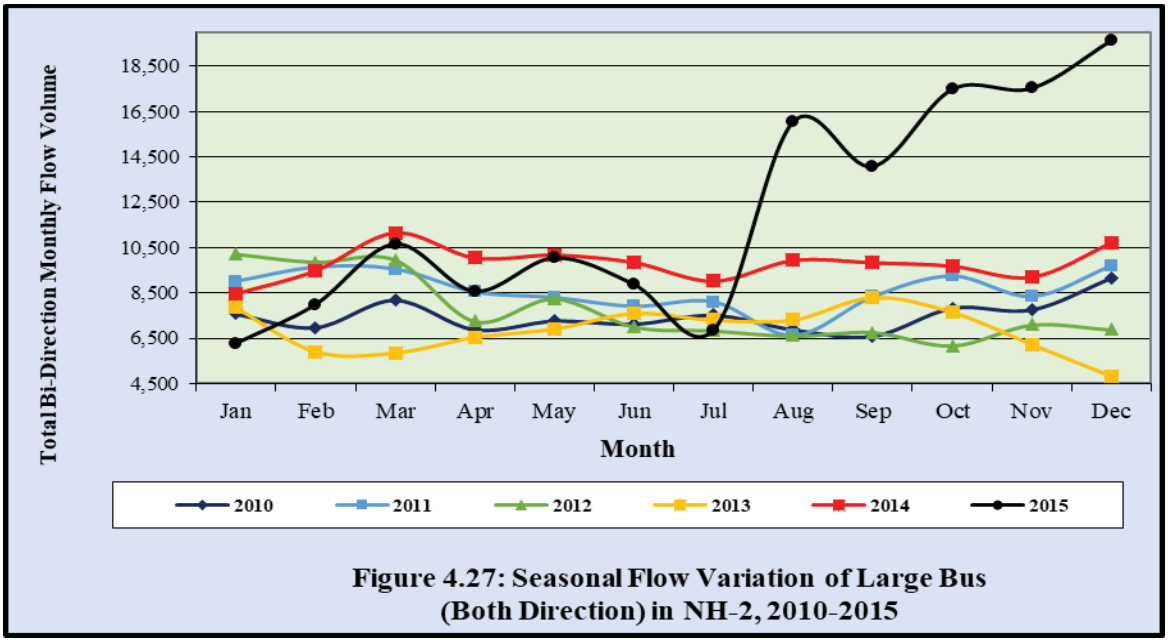


Figure 4.27: Seasonal Flow Variation of Large Bus (Both Direction) in NH-2, 2010-2015

In the figure 4.27 above, total both directional monthly flow variation of large bus along Dhaka to Hobiganj highway is plotted from the year 2010 to 2015. It is observed here that, the majority volume of large bus is ranges from 4500 to 11000 per anuum in NH-2. The yearwise monthly curve of large bus shows similar and repetitive nature.

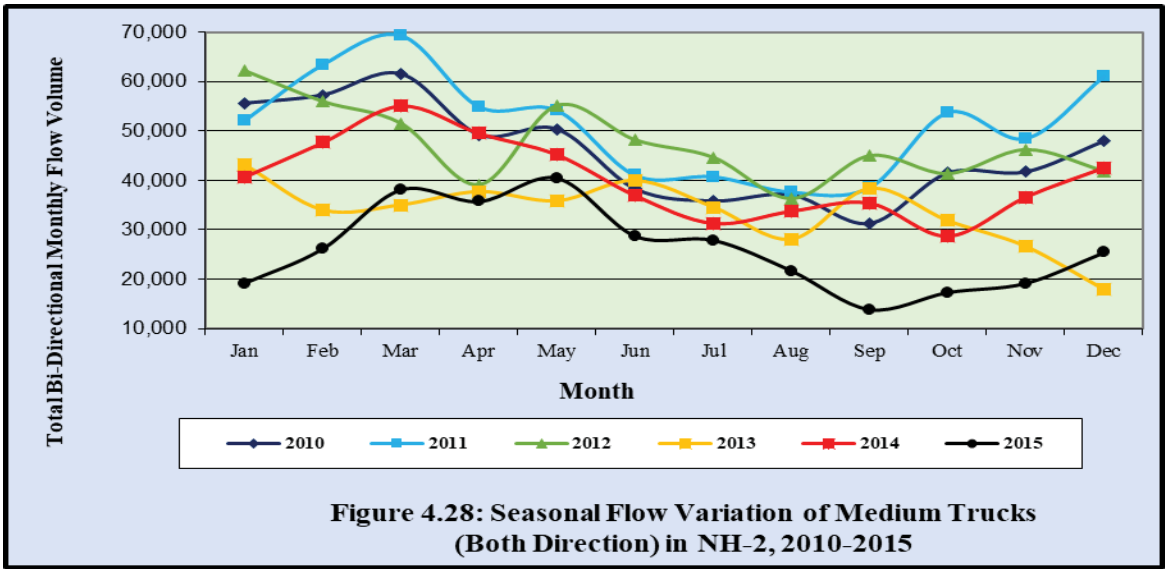
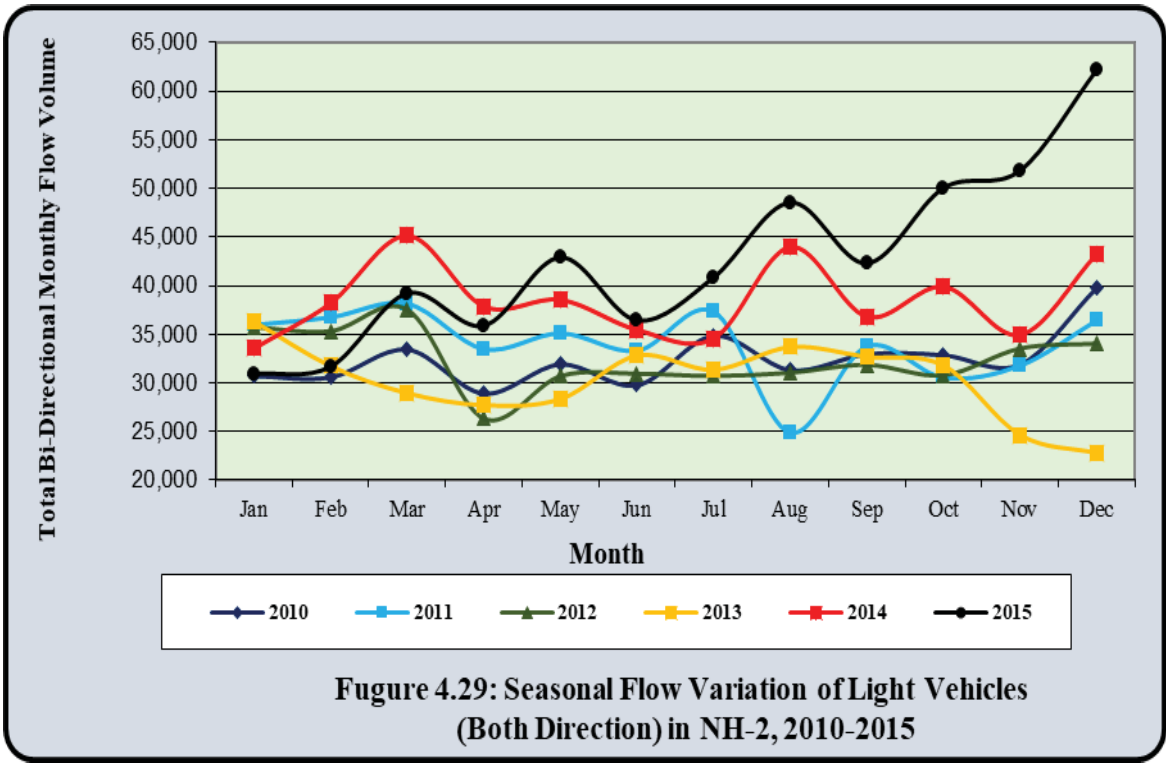


Figure 4.28: Seasonal Flow Variation of Medium Trucks (Both Direction) in NH-2, 2010-2015

Figure 4.28 above illustrated total both directional monthly flow variation of medium truck along NH-2 from 2010 to 2015. The curve pattern interestingly depicted that medium truck has a tendency of increasing voulme from October to March, especially the peak flow is observed in December and March. However, there is a trend of decreasing volume from May to September along Dhaka to Hobiganj highway.



Fugure 4.29: Seasonal Flow Variation of Light Vehicles (Both Direction) in NH-2, 2010-2015

Seasonal flow variation of light vehicles for both directions along NH-2 from 2010 to 2015 is shown in figure 4.29. Yearly expected light vehicles are found along this corridor from 25,000 to 40,000 in the study period. However, the curves illustrate that there is a trend of increasing this vehicle class for the last two years of 2014 and 2015.

Summary of Findings:

Following are the summarized findings from the seasonal flow analyses in NH-2.

Table 4.14: Summary Table - Seasonal Flow Variation (average of six years)

Vehicle Class	Maximum Flow		Minimum Flow	
	Month	Percentage of Yearly Volume	Month	Percentage of Yearly Volume
Total Traffic	March	9.68%	August	7.58%
Medium Truck	March	10.64%	August	6.69%
Large Bus	December	9.26%	July	7.48%
Light Vehicles	December	9.28%	April	7.54%

4.7 CALCULATION OF EXPANSION FACTORS OF DHAKA-HOBIGANJ HIGHWAY

The daily and monthly expansion factors is calculated from 6 years of database along Dhaka-Hobiganj Highway, that is useful for traffic design and estimation of AADT from short counts.

4.7.1 CALCULATION OF DAILY EXPANSION FACTORS IN NH-2

Daily traffic data on Dhaka-Hobiganj Highway from 2010 to 2015 have been used to determine Daily Expansion Factor. First the raw data have been summarized to determine the average daily flow for each of seven days of week individually for all 6 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 4.15 shows the daily expansion factors and yearly average flow on each weekday from 2010 to 2015. Summation of these daily flows for seven weekdays gives average weekly flow, which have been determined individually for every year. From these data, Daily Expansion Factors are calculated. Taking the mean value for daily expansion factors for the years 2010 to 2015, average daily expansion factors have been determined.

Table 4.15: Daily Expansion Factors, DEF (for Bi-Directional Traffic) for NH-2

Day \ Year	2010		2011		2012		2013	
	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF
Saturday	2,926	7.17	3,309	7.09	3,124	7.13	2,786	6.45
Sunday	2,876	7.30	3,123	7.52	2,981	7.47	2,387	7.52
Monday	2,989	7.02	3,204	7.32	3,086	7.22	2,400	7.48
Tuesday	2,895	7.25	3,337	7.03	3,069	7.25	2,205	8.15
Wednesday	2,939	7.14	3,297	7.12	3,221	6.91	2,286	7.86
Thursday	3,046	6.89	3,395	6.91	3,212	6.93	2,575	6.97
Friday	3,313	6.33	3,803	6.17	3,575	6.23	3,322	5.41
Avg. Weekly Flow	20,983		23,468		22,268		17,961	
Day \ Year	**2014**		**2015**		**Average**			

	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF
Saturday	3,212	7.06	2,794	7.18	3,025	**7.02**
Sunday	3,019	7.51	2,742	7.32	2,855	**7.44**
Monday	3,073	7.37	2,801	7.16	2,926	**7.26**
Tuesday	3,217	7.05	2,776	7.23	2,916	**7.28**
Wednesday	3,201	7.08	2,834	7.08	2,963	**7.17**
Thursday	3,270	6.93	2,922	6.87	3,070	**6.92**
Friday	3,669	6.18	3,196	6.28	3,480	**6.10**
Avg. Weekly Flow	22,662		20,065		21,235	

Daily expansion factors along Dhaka-Hobiganj highway is plotted below in figure 4.30 from the six years of daily traffic data. The average lowest DEF is found in Friday, which indicates that maximum traffic flow experience in Friday. On the other hand, average maximum DEF is found in Sunday that indicates minimum flow occurs on Sunday.

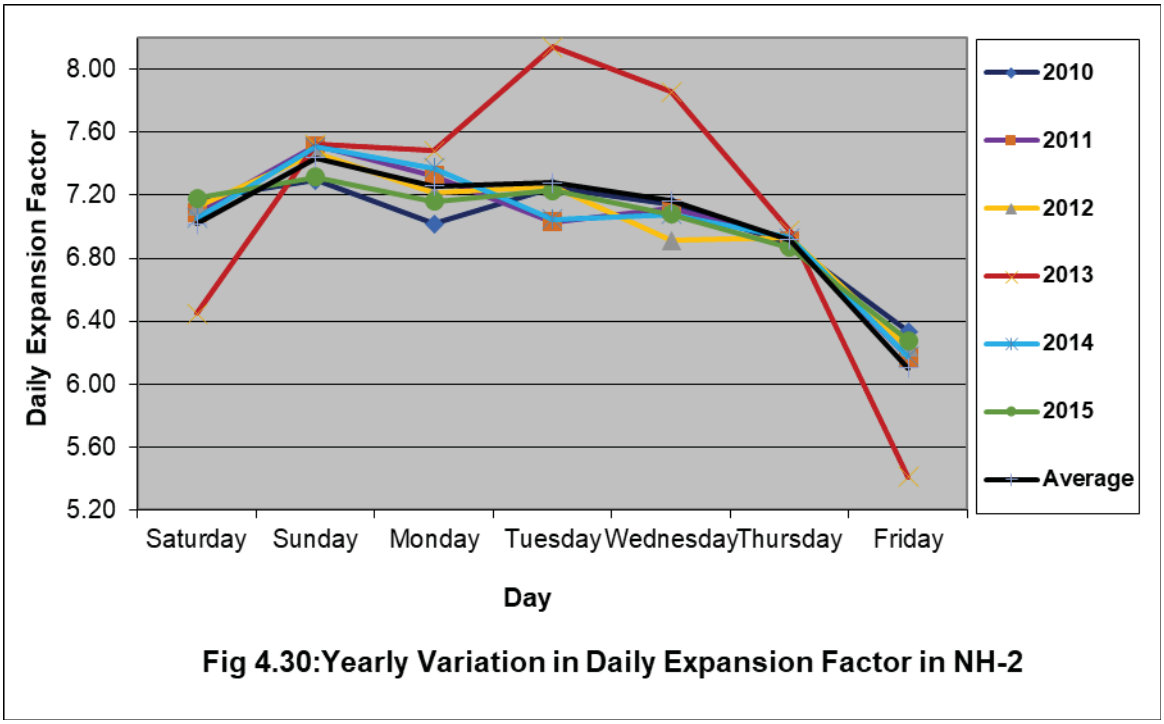


Fig 4.30:Yearly Variation in Daily Expansion Factor in NH-2

All vehicle classes do not exhibit similar daily flow fluctuation, so daily expansion factors need to be determined and used separately for each vehicle class. Table 4.16 shows the class wise daily expansion factors.

Table 4.16: Class-wise Daily Expansion Factors, DEF (for Bi-Directional Traffic)

Day	Car/Jeep	Micro/ Coaster/ Tractor	Small Bus	Small Truck	Large Bus	Medium Truck	Trailer Truck/ Construction Equipment	Truck 3 Axle/ Large Truck	Toll Free Vehicle	Total Traffic
Saturday	6.98	7.19	6.89	6.80	7.25	7.16	6.94	6.81	6.65	7.02
Sunday	7.40	7.33	7.86	7.70	7.30	7.28	7.96	7.28	7.20	7.44
Monday	7.26	7.32	6.92	7.78	7.08	7.12	7.60	7.28	7.24	7.26
Tuesday	7.45	6.87	7.14	7.99	7.25	7.06	7.06	7.10	7.15	7.29
Wednesday	7.22	6.97	7.11	7.62	7.15	7.00	6.92	6.98	7.15	7.16
Thursday	6.80	6.66	6.49	6.91	6.82	7.05	6.77	7.07	6.90	6.92
Friday	6.10	6.73	6.73	5.17	6.26	6.40	6.06	6.55	6.77	6.10

Notes:

- The above DEF can be directly used to estimate average weekly volume.

4.7.2 CALCULATION OF MONTHLY EXPANSION FACTORS IN NH-2

Average monthly expansion factors are extracted by calculating each year's MEF. Table 4.17 below contains the monthly expansion factors on Dhaka-Hobiganj highway corridor for each individual year from 2010 to 2015, which helps to obtain the average monthly expansion factors in table 4.18.

Table 4.17: Monthly Expansion Factors in NH-2

Month \ Year	2010			2011		
	Flow	ADT	MEF	Flow	ADT	MEF
January	99,841	3,221	**0.932**	106,253	3,428	**0.980**
February	101,044	3,609	**0.832**	119,758	4,277	**0.785**
March	109,776	3,541	**0.847**	126,581	4,083	**0.822**
April	90,269	3,009	**0.997**	104,508	3,484	**0.964**
May	95,296	3,074	**0.976**	106,248	3,427	**0.980**
June	79,853	2,662	**1.127**	88,657	2,955	**1.136**
July	82,906	2,674	**1.122**	91,830	2,962	**1.134**
August	81,057	2,615	**1.148**	74,622	2,407	**1.395**
September	74,844	2,495	**1.203**	88,005	2,934	**1.145**
October	88,155	2,844	**1.055**	102,732	3,314	**1.013**
November	86,691	2,890	**1.038**	96,236	3,208	**1.047**
December	104,705	3,378	**0.888**	118,240	3,814	**0.880**
Total		36010			40293	

AADT		3001			3358	
Month \ Year	**2012**			**2013**		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	119,598	3,858	**0.825**	95,920	3,094	**0.830**
February	111,334	3,839	**0.829**	78,740	2,812	**0.913**
March	110,602	3,568	**0.892**	77,651	2,505	**1.025**
April	82,183	2,739	**1.162**	80,028	2,668	**0.963**
May	104,558	3,373	**0.944**	79,379	2,561	**1.003**
June	94,699	3,157	**1.008**	89,108	2,970	**0.865**
July	90,336	2,914	**1.092**	80,462	2,596	**0.989**
August	80,853	2,608	**1.220**	74,785	2,412	**1.065**
September	94,048	3,135	**1.015**	88,410	2,947	**0.871**
October	88,100	2,842	**1.120**	77,026	2,485	**1.034**
November	95,267	3,176	**1.002**	64,185	2,140	**1.200**
December	92,404	2,981	**1.068**	50,474	1,628	**1.577**
Total		38189			30817	
AADT		3182			2568	
Month \ Year	**2014**			**2015**		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	93,187	3,006	**1.078**	61,308	1,978	**1.448**
February	107,007	3,822	**0.848**	72,681	2,596	**1.103**
March	124,710	4,023	**0.806**	98,184	3,167	**0.904**
April	109,916	3,664	**0.885**	88,594	2,953	**0.970**
May	104,933	3,385	**0.958**	102,414	3,304	**0.867**
June	90,985	3,033	**1.069**	79,102	2,637	**1.086**
July	82,517	2,662	**1.218**	79,250	2,556	**1.120**
August	95,129	3,069	**1.056**	94,299	3,042	**0.941**
September	90,858	3,029	**1.070**	73,738	2,458	**1.165**
October	84,833	2,737	**1.185**	88,964	2,870	**0.998**
November	90,273	3,009	**1.077**	93,565	3,119	**0.918**
December	107,277	3,461	**0.937**	114,224	3,685	**0.777**
Total		38898			34364	
AADT		3241			2864	

Table 4.18: Monthly Expansion Factors, MEF (for Bi-Directional Traffic)

Month	Avg. MEF
January	**1.015**
February	**0.885**
March	**0.883**
April	**0.990**
May	**0.954**
June	**1.049**
July	**1.113**
August	**1.137**
September	**1.078**
October	**1.067**
November	**1.047**
December	**1.021**

Notes:

- The above MEF can be directly used to estimate AADT from Avg. 24-hour volume.

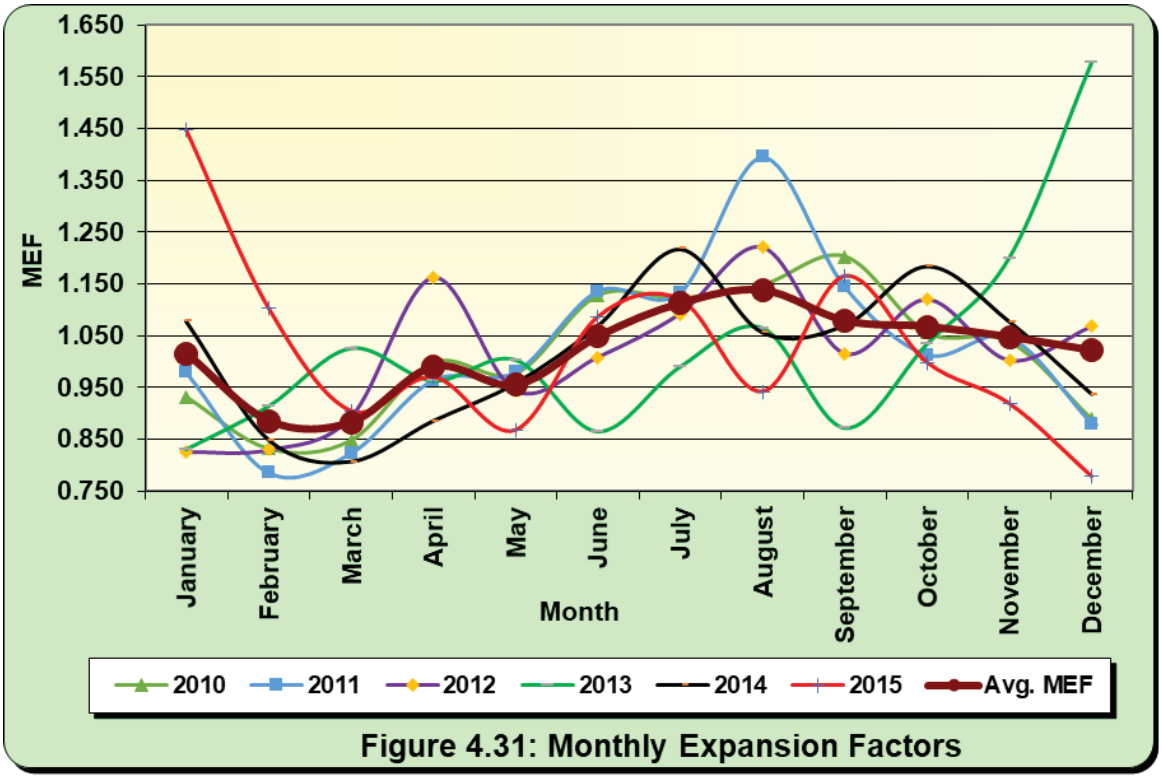


Figure 4.31: Monthly Expansion Factors

The monthly expansion factors are ranging from 0.75 to 1.25 in NH-2. The average MEF is found slightly higher from June to October due to rainy seasons in Bangladesh. More years of data can get a more specific MEF in this corridor.

4.8 CALCULATION OF INDIVIDUAL VEHICLE CLASS WISE GROWTH FACTOR OF DHAKA- HOBIGANJ HIGHWAY

The growth factor of all vehicles in NH-2 is found unstable from the daily traffic data of 2010 to 2015. In the year 2011 and 2014, the growth factor is calculated 11.808 and 26.219. However, in the year 2012, 2013 and 2015, the growth factor is found -4.878, -19.572 and -11.451, which is unusual for the densely populated country like Bangladesh. A separate growth rate for individual vehicle class is shown below for more accuracy.

Table 4.19: Class-wise Total Yearly Traffic in Both Direction (2010 to 2015)

Year	Car/ Jeep	Micro/ Coaster/ Tractor	Small Bus	Small Truck	Large Bus	Medium Truck	Trailer Truck/ Construction Equipment	Truck 3 Axle/ Large Truck	Toll Free Vehicle	Total Traffic
2010	14,539	3,621	83,402	287,677	89,819	547,425	1,669	42,880	23,405	1,094,437
2011	14,274	2,806	93,336	297,325	103,294	614,904	2,631	71,843	23,257	1,223,670
2012	8,244	2,161	116,625	261,430	92,956	567,541	4,357	97,072	13,596	1,163,982
2013	11,033	2,409	130,109	219,491	82,274	403,077	5,300	68,673	13,802	936,168
2014	11,813	2,476	161,739	286,312	117,547	483,375	7,100	96,198	15,065	1,181,625
2015	78,157	146,701	125,256	162,907	144,088	313,864	3,637	62,652	9,061	1,046,323

Table 4.20: Class-wise Traffic Growth Factors

Year	Car/ Jeep	Micro/ Coaster/ Tractor	Small Bus	Small Truck	Large Bus	Medium Truck	Trailer Truck/ Construction Equipment	Truck 3 Axle/ Large Truck	Toll Free Vehicle	Total Traffic
2010										
2011	-2	-23	12	3	15	12	58	68	-1	12
2012	-42	-23	25	-12	-10	-8	66	35	-42	-5
2013	34	11	12	-16	-11	-29	22	-29	2	-20
2014	7	3	24	30	43	20	34	40	9	26
2015	562	5,825	-23	-43	23	-35	-49	-35	-40	-11
Avg. GF	112	1,159	10	-7	12	-8	26	16	-14	0
Std. Dvtn.	253	2,609	19	27	23	24	45	45	24	18

Table 4.19 shows total yearly volume of traffic in both directions for each vehicle class. Individual vehicle class wise growth factor is shown in Table 4.20. It is visible that, all

vehicle class do not follow similar growth pattern. In addition, growth factor for individual vehicle classes are quite inconsistent that is reflected in their standard deviations. It is assumed here that the NH-2 corridor is not stable yet and more years of data could make possible to determine the movement pattern in this highway.

4.9 REGRESSION ANALYSIS OF TRAFFIC IN DHAKA- HOBIGANJ HIGHWAY

Utilizing regression analyses on daily traffic data of NH-2, daily and monthly regression model is derived in the following sections.

4.9.1 DAILY REGRESSION MODEL FOR NH-2 CORRIDOR

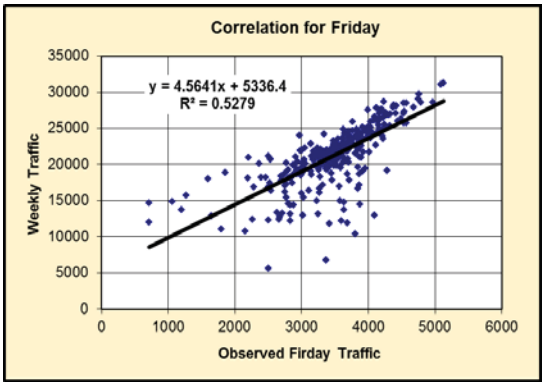
The daily traffic data of Rustompur toll plaza from 2010 to 2015 provides daily regression models for expansion of short counts. Total 312 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models.

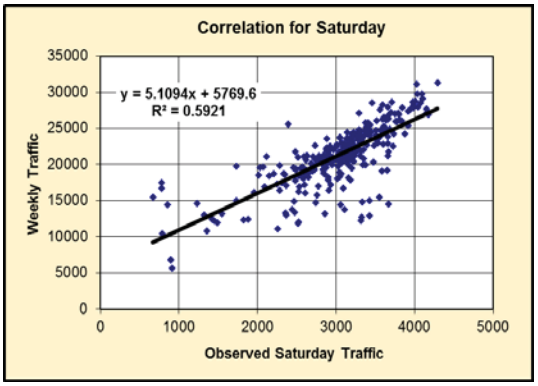
Table 4.21: Daily Regression Models for NH-2

Day	Equation	R^2 value
Saturday	y = 5.1094x + 5769.6	0.5921
Sunday	y = 4.5466x + 8253.2	0.6854
Monday	y = 4.5263x + 7988.5	0.7038
Tuesday	y = 4.5635x + 7936.7	0.7381
Wednesday	y = 4.6292x + 7506.7	0.736
Thursday	y = 4.3374x + 7914.5	0.6137
Friday	y = 4.5641x + 5336.4	0.5279

Where: x = observed daily traffic, y = weekly traffic

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





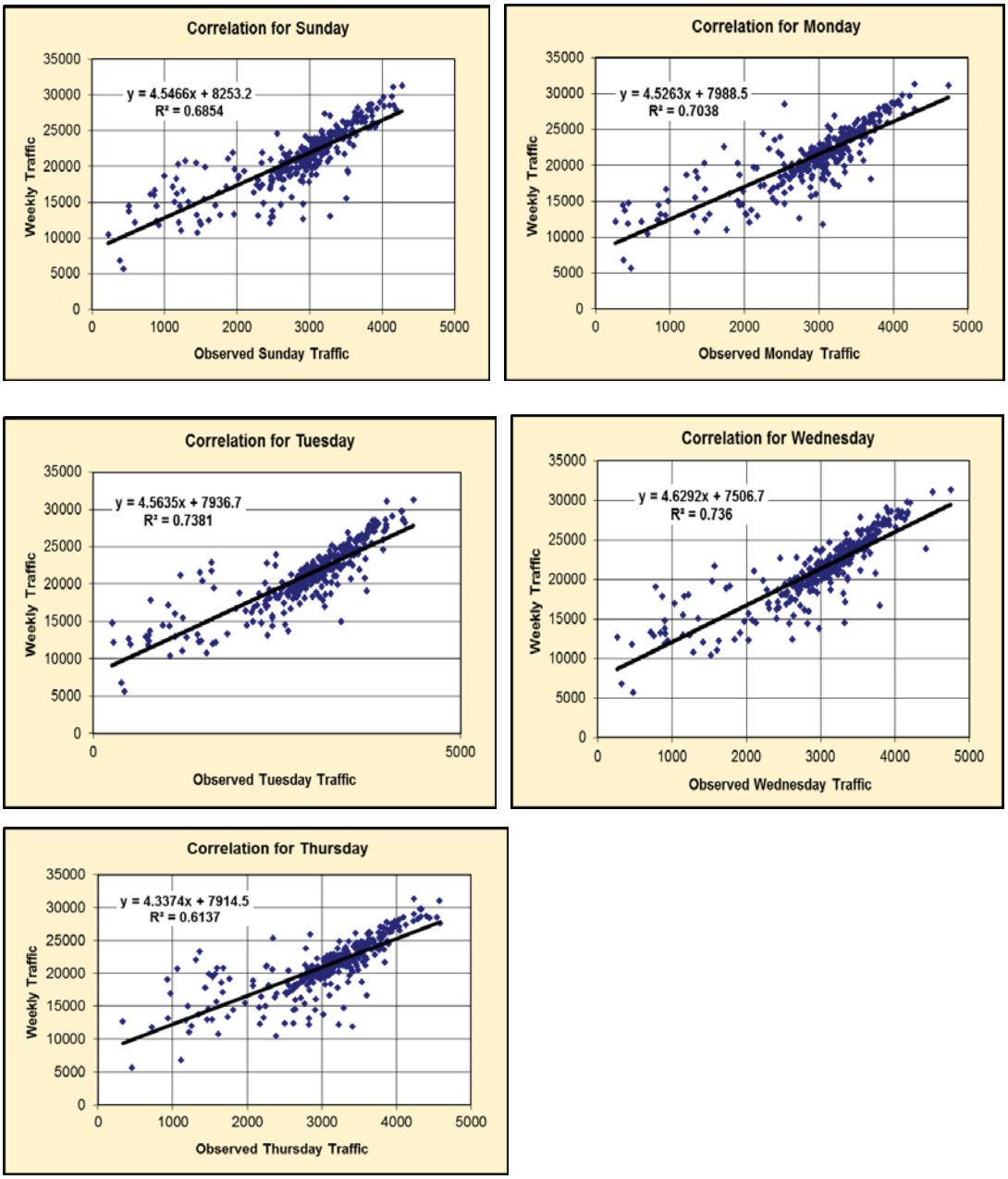


Figure 4.32: Daily regression models for NH-2.

4.9.2 MONTHLY REGRESSION MODEL FOR NH-2 CORRIDOR

Monthly regression or seasonal expansion models are calculated from six years of daily traffic data. 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 4.22.

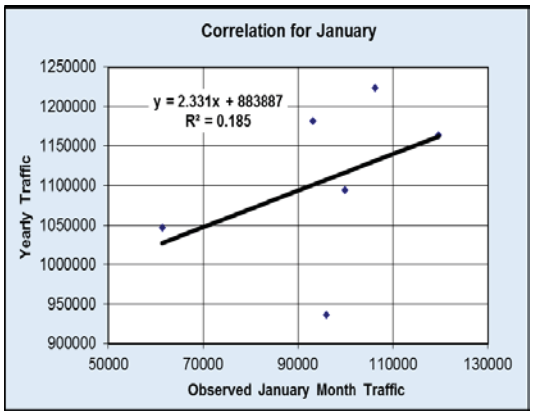
Table 4.22: Monthly Regression Models for NH-2

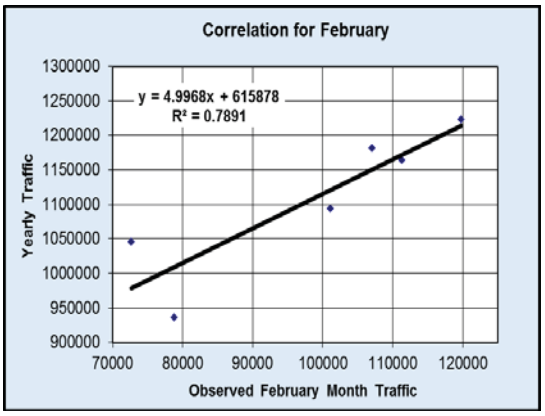
Month	Equation	R^2 value
January	y = 2.331x + 883887	0.185

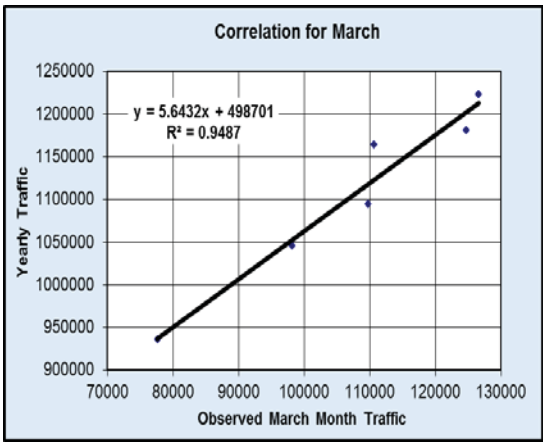
February	y = 4.9968x + 615878	0.7891
March	y = 5.6432x + 498701	0.9487
April	y = 6.178x + 535721	0.5023
May	y = 9.0726x + 211287	0.7849
June	y = 5.8129x + 601585	0.1193
July	y = 14.973x - 158249	0.5584
August	y = 1.3003x + 999177	0.0128
September	y = 4.1759x + 752817	0.1154
October	y = 9.4886x + 269845	0.5649
November	y = 7.2995x + 467511	0.6968
December	y = 3.1629x + 798091	0.5582

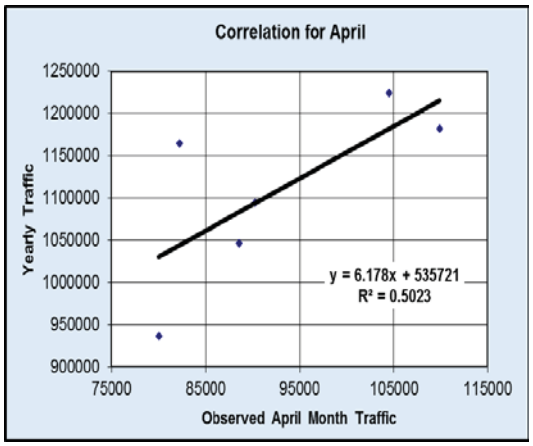
Where: x = observed monthly traffic, y = yearly traffic volume

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









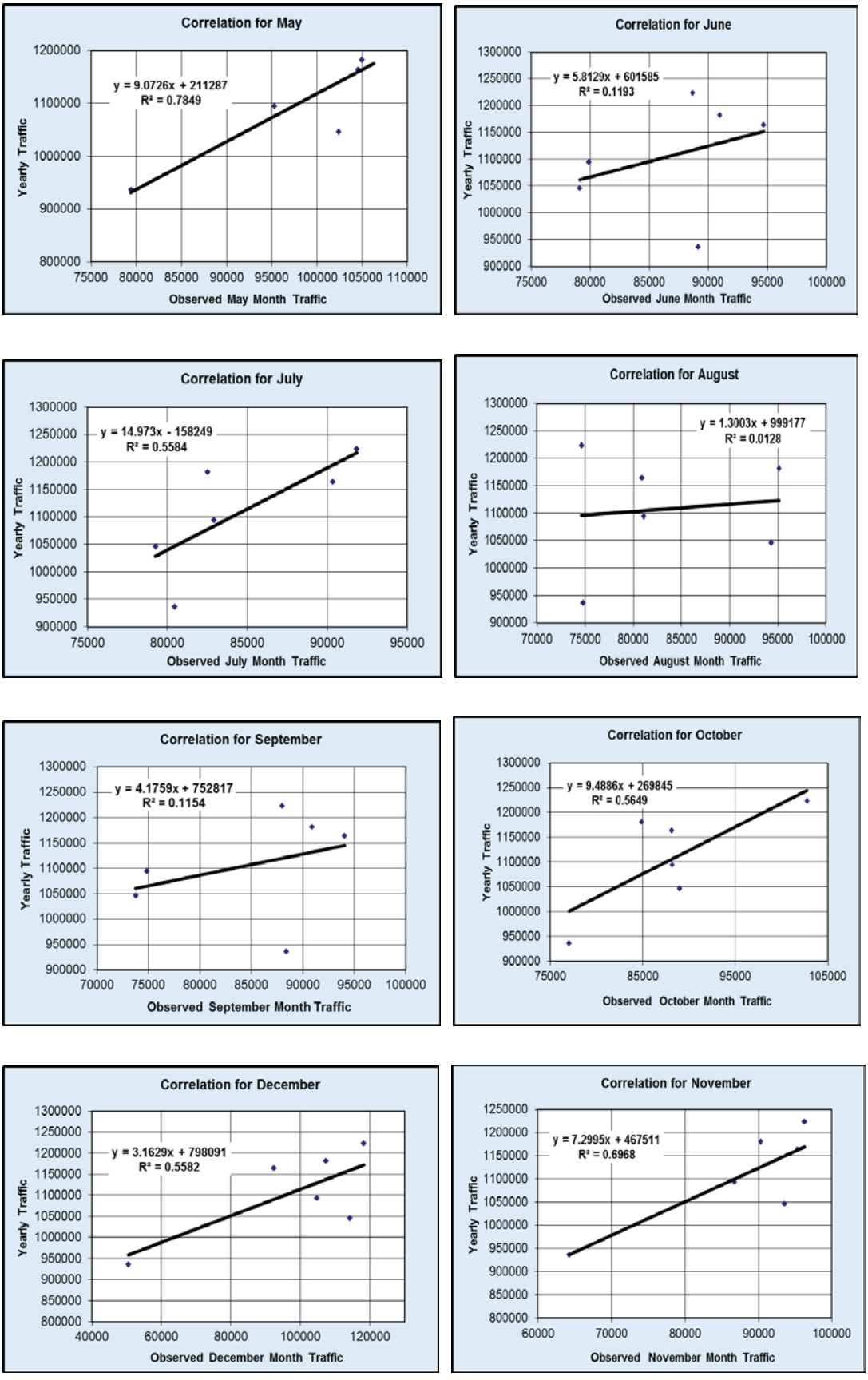


Figure 4.33: Monthly regression models for NH-2.

4.10 DETERMINATION OF TRAFFIC FLOW MODEL USING ARTIFICIAL NEURAL NETWORK IN DHAKA- HOBIGANJ HIGHWAY

Artificial neural network is a mathematical bundle intended to give experts and researchers the apparatus to train, predict, visualize and evaluate neural network models. A neural network is a structure that can be conformed to create a mapping from a given arrangement of data components or connections among the data. The model is trained using the set of data as input, commonly alluded as training set. After effective training, the neural system will have the capacity to perform forecasting, estimation, classification and reproduction of new data from the given set of data. In recent years, artificial neural network is used in a wide range of

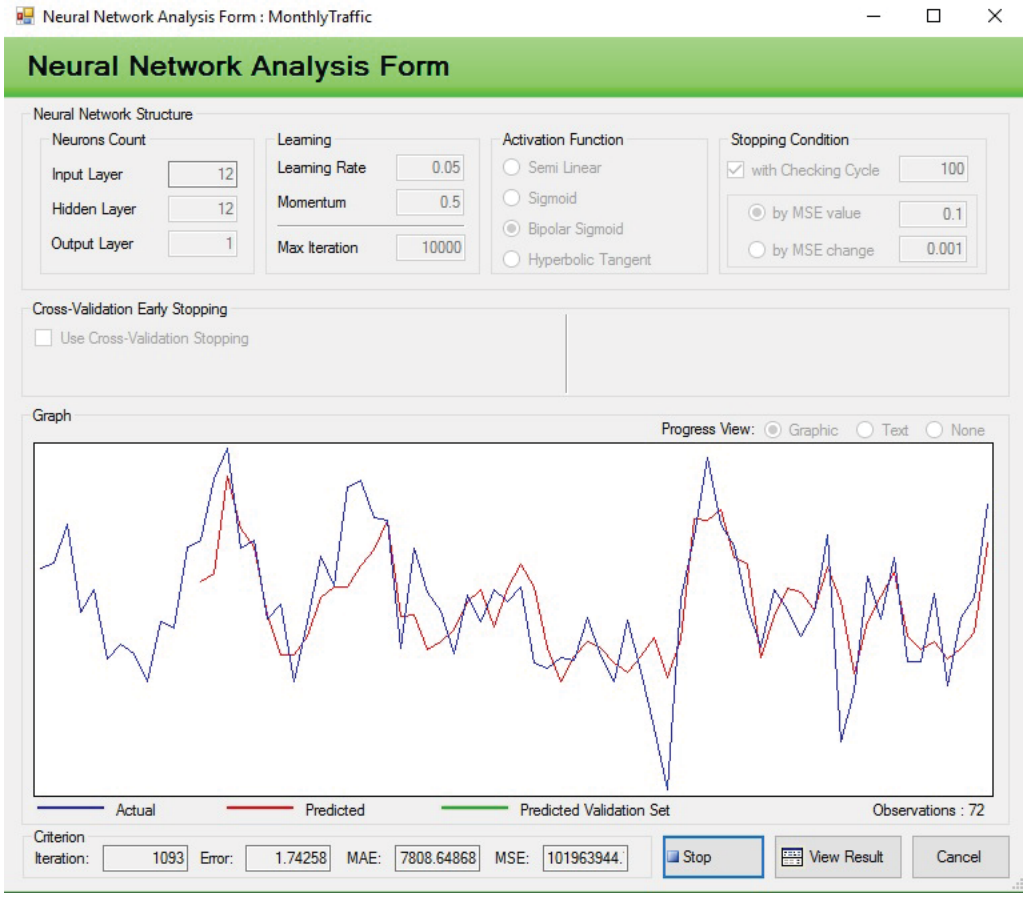


Figure 4.34: Artificial Neural Network Model Interface for Traffic Prediction in NH-2

applications involving non-parametric pattern recognition, nonlinear filters and statistical regression model. ANN has variety of applications related to traffic engineering. ANN is used for identifying traffic pattern, traffic forecasting, pavement maintenance, etc. Hence, attempts have been made through this research to evaluate traffic parameters using ANN model. A non-commercial software for research related study purpose called “Zaitun time

series" is used in this regard. The neural network analysis interface is shown in figure 4.34. The program uses a general form of back propagation algorithm to the network to the input and output data. Monthly traffic volume is used as variable called "TrafficData". There are 72 number of observations is trained for this study. Bipolar sigmoid function is used with 12 input layer neurons, 12 hidden layer neurons and 1 output layer neurons. Back propagation learning method with learning rate 0.05 and momentum 0.5 is set in this model.

Data training is completed by the actual traffic of the concern year and then, predicted traffic volume of corresponding months are carried out to realize and understand the predicting capability of ANN. The details of monthly actual traffic and predicted traffic from 2010 to 2015 is shown below as sample in table 4.23 below. It is surprising to observe that the ANN model of the traffic data is accurate enough to capture the trend of the data over the months of traffic volume measurement. Figure 4.35 and 4.36 is illustrating actual vs predicted traffic flow along NH-2. This has been a check to find out how the ANN captures the data pattern.

Table 4.23: Monthly Traffic Data Prediction by using ANN model

Months	Actual Traffic	Predicted Traffic	Months	Actual Traffic	Predicted Traffic	Months	Actual Traffic	Predicted Traffic
Jan-13	95920	96057	**Jan-14**	93187	92797	**Jan-15**	61308	62042
Feb-13	78740	78605	**Feb-14**	107007	106944	**Feb-15**	72681	72620
Mar-13	77651	77410	**Mar-14**	124710	125142	**Mar-15**	98184	98186
Apr-13	80028	79903	**Apr-14**	109916	109851	**Apr-15**	88594	88454
May-13	79379	79413	**May-14**	104933	104857	**May-15**	102414	102705
Jun-13	89108	88786	**Jun-14**	90985	90871	**Jun-15**	79102	79148
Jul-13	80462	80078	**Jul-14**	82517	82492	**Jul-15**	79250	79335
Aug-13	74785	74520	**Aug-14**	95129	95227	**Aug-15**	94299	94338
Sep-13	88410	88669	**Sep-14**	90858	90624	**Sep-15**	73738	73781
Oct-13	77026	77096	**Oct-14**	84833	84779	**Oct-15**	88964	89221
Nov-13	64185	63322	**Nov-14**	90273	90232	**Nov-15**	93565	93447
Dec-13	50474	52450	**Dec-14**	107277	107052	**Dec-15**	114224	114750
Months	**Actual Traffic**	**Predicted Traffic**	**Months**	**Actual Traffic**	**Predicted Traffic**			
Jan-11	106253	106191	**Jan-12**	119598	119719			
Feb-11	119758	119919	**Feb-12**	111334	111171			
Mar-11	126581	124839	**Mar-12**	110602	110532			
Apr-11	104508	104825	**Apr-12**	82183	82158			
May-11	106248	105887	**May-12**	104558	104624			
Jun-11	88657	88746	**Jun-12**	94699	94745			

Jul-11	91830	91677	**Jul-12**	90336	90559	
Aug-11	74622	74695	**Aug-12**	80853	80586	
Sep-11	88005	87756	**Sep-12**	94048	94343	
Oct-11	102732	102976	**Oct-12**	88100	87971	
Nov-11	96236	96199	**Nov-12**	95267	94866	
Dec-11	118240	117776	**Dec-12**	92404	92460	

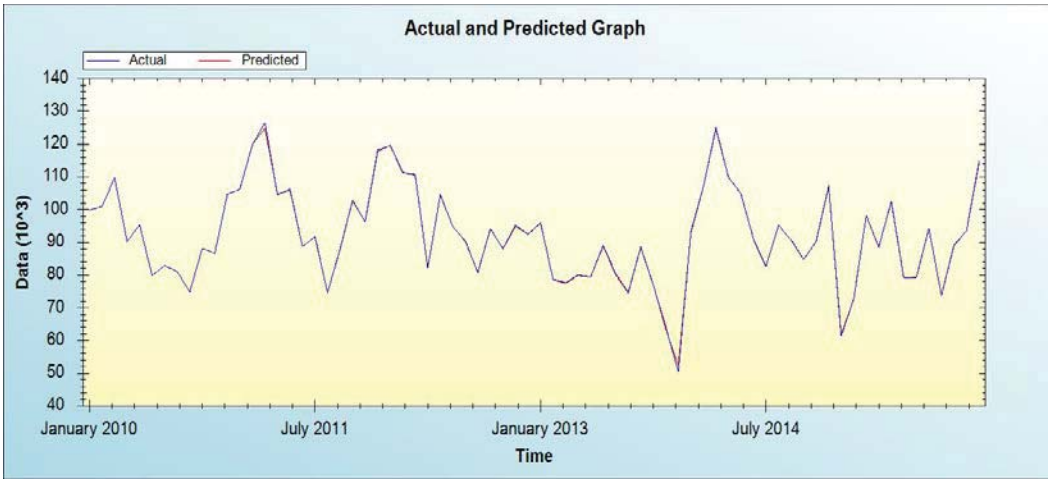


Figure 4.35: Artificial Neural Network Model-Actual and Predicted traffic in NH-2

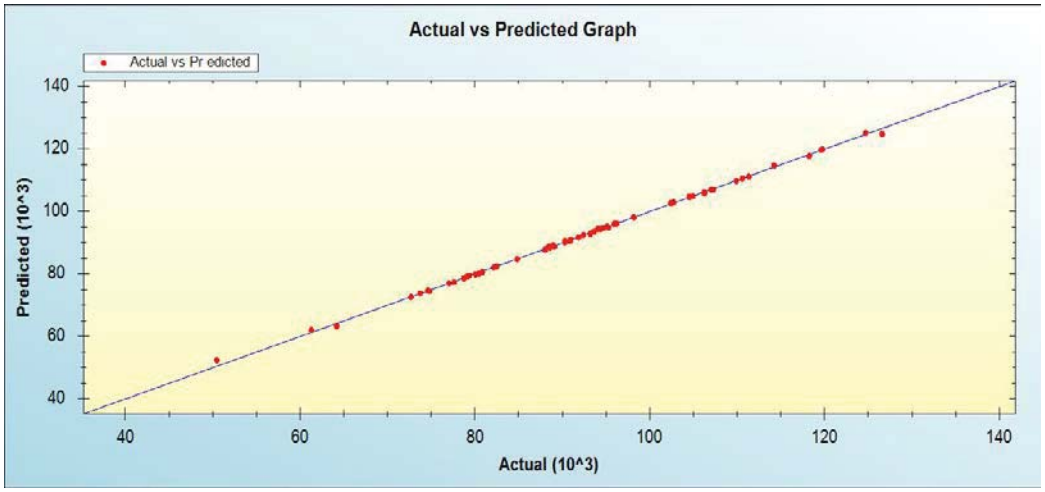


Figure 4.36: Artificial Neural Network Model-Comparison of Actual VS Predicted Traffic in NH-2

Traffic forecasting have been studied through ANN model in Dhaka-Hobiganj highway. Monthly traffic data have been trained from 2010 to 2015 in the neural network model. Traffic forecasting is observed in figure 4.37 and table 4.24. Artificial neural networks (ANNs) have proven to be an important development in a variety of problem solving areas. Increasing research activity in ANN applications has been accompanied by equally rapid growth in the commercial mainstream use of ANNs. The special characteristics make ANNs especially useful in a variety of applications. An ANN can provide an approach that is closer to human perception and recognition than traditional

methods. In situations in which input is noisy or incomplete, ANNs can still produce reasonable results. The forecasted residual traffic in NH-2 have been found in figure 4.38 below.

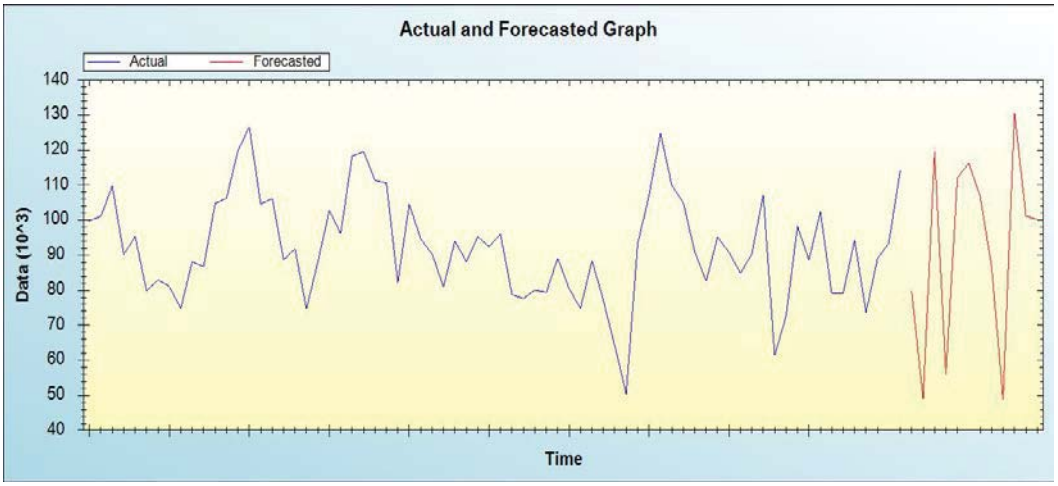


Figure 4.37: Artificial Neural Network Model-Actual and Forecasted traffic in NH-2

Figure 4.24: Traffic Forecasting using ANN model along NH-2

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Forecasting of Monthly Traffic	79,618	49,159	119,401	56,008	112,097	116,236
Month	**Jul-16**	**Aug-16**	**Sep-16**	**Oct-16**	**Nov-16**	**Dec-16**
Forecasting of Monthly Traffic	106,715	86,659	48,923	130,629	101,135	100,182

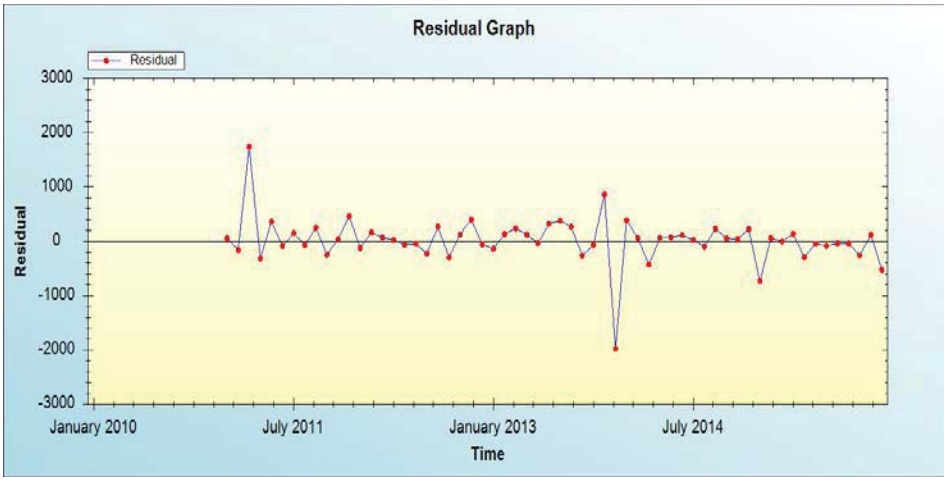


Figure 4.38: Artificial Neural Network Model-Residual Traffic in NH-2

4.11 OVERVIEW OF TRAFFIC FLOW ANALYSES IN NATIONAL HIGHWAY NO.2 (DHAKA- HOBIGANJ HIGHWAY)

As currently in Bangladesh road agencies have set 10% traffic growth factor per year for all national highways and no traffic survey or detail parametric analyses have done by

GoB engineering agencies till now. However, the following outcome have been rendered in this chapter of the research:

- The average traffic growth factor is found 0.43% per annum. However, the traffic nature seems unstable. It is recommended to add more years of data before setting the parameter.
- Individual vehicle class wise traffic growth factors are also calculated in this chapter.
- Traffic composition patterns have been established along NH-2.
- Heavy vehicle percentages like Truck percentage and Bus percentage is calculated in this corridor.
- Daily and Monthly directional distributions are designed in NH-2.
- The in-depth daily, weekly and seasonal traffic nature have been established.
- Daily and monthly traffic expansion factors and regression models are calculated for this highway.
- Traffic flow and prediction models have been prepared based on artificial neural network.

More efficient and realistic pavement and traffic design, operation and maintenance can be achieved if these parameters are considered for NH-2. Nevertheless, the next chapter will discuss detail traffic flow analyses of National Highway No. 1 of Bangladesh.

CHAPTER 5

ASSESSMENT OF TRAFFIC FLOW PARAMETERS: NATIONAL HIGHWAY NO. 1 (DHAKA-CHITTAGONG HIGHWAY CORRIDOR)

5.1 INTRODUCTION

Dhaka and Chittagong are the two major metropolitan areas of Bangladesh. Dhaka is the main commercial and administrative center of the country; Chittagong is the primary seaport, accounting for about 90% of imports and exports. About a quarter of Bangladesh's population lives in the Dhaka-Chittagong corridor. The government's Seventh Five-Year Plan, 2016-2020 assigns the highest priority to increase the capacity of the existing National Highway No.1 (NH-1). Construction of a larger Dhaka-Chittagong expressway has been proposed already under Public Private Partnership (PPP) to decrease congested traffic on this highway. Besides, NH-1 will be a part of the Asian Highway that connects with neighboring countries. The detail traffic flow analyses are badly needed for future planning as with recent high-level intergovernmental consultations and agreements that will allow better access for Bhutan, India and Nepal to Chittagong port. The additional traffic of goods and passengers will use Dhaka-Chittagong corridor and has to be considered when planning the road capacity between Dhaka and Chittagong. It should be mentioned here that, specific time series analyses of traffic flow in any highway are considered as one of the most important parameter where those provides essential efforts for traffic model developments and calibration exercises that can be used for the planning of new road construction, existing road for widening, determination of roadway geometry, congestion management, pavement design, and many others. During the planning, design, construction and maintenance period of any road network, traffic flow analyses becomes an essential element in decision-making, and therefore the format and the accuracy of data collection and analyses is as well critical.

The NH-1 highway is solely supervised and maintained by Roads & Highways Department (RHD) of Bangladesh. No study has been done by the Government of Bangladesh (GoB) and RHD regarding detail traffic flow pattern on NH-1 before. An attempt is taken through this study to explore the detail traffic analyses of this highway.

This study has been performed based on daily traffic data of Meghna and Gumuti bridges, which are the entry and exit points of Dhaka-Chittagong highway corridor. Gazaria upazila in Narayanganj district is located between two channels of the Meghna river. On the eastern side is the Daudkandi channel and on the western side is the Meghna channel of the Meghna river. The Gumuti bridge over the Daudkandi channel and Meghna bridge over the Meghna channel.

5.2 CALCULATION OF TRAFFIC GROWTH FACTOR OF DHAKA-CHITTAGONG HIGHWAY

Daily traffic data from the year 2006 to 2014 is used in this article to comprehend the correct outline of traffic growth in Dhaka-Chittagong (NH-1) highway corridor. Recently NH-1 is experiencing travel delay and traffic congestion that requires proper investigation of traffic growth pattern and expansion of road infrastructures. The following analyses will focus on the traffic development pattern along NH-1.

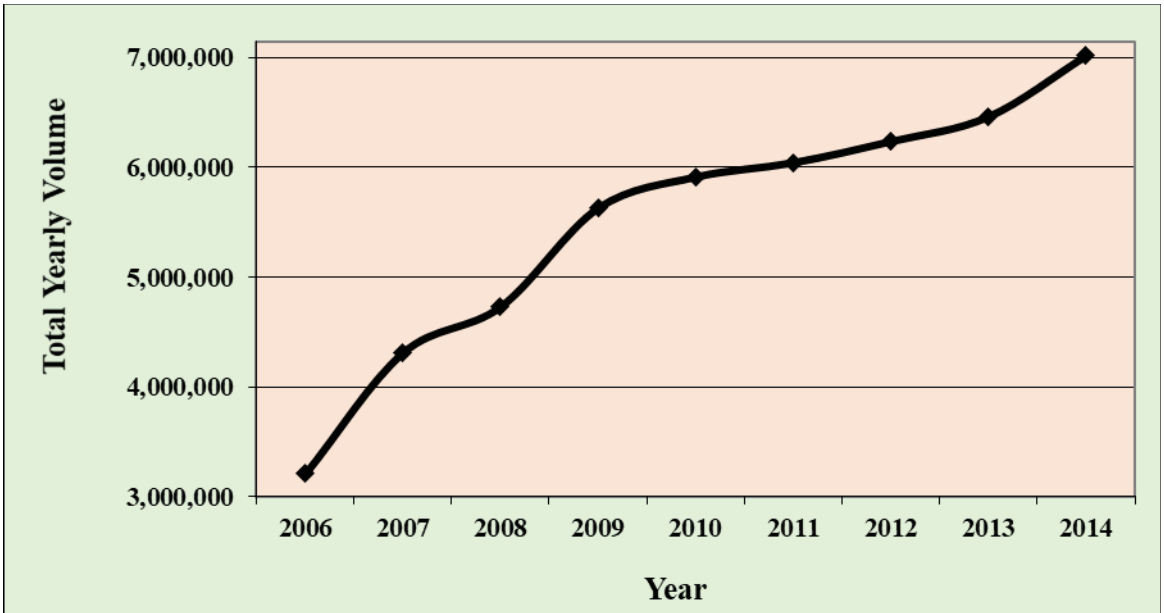


Figure 5.1: Yearly Traffic Growth on NH-1 Corridor

Figure 5.1 demonstrates total both directional yearly traffic volume in NH-1 compared to corresponding years from 2006 to 2014. It is assessed from the graph that the traffic long this highway is increasing at a linear rate. In case of preliminary year's data in 2006, total bi-directional traffic volume was 3.21 million and the next year the traffic volume is found 4.31 million with annual growth factor of 34.37, which seems for a while unusual due to enormous jump in the growth factor. Yet, it should be noted that, any new highway

corridor needs time to be stable and hence, high jump should be observed carefully. In this context, the bi-directional traffic volume is detected 4.73 million with growth factor of 9.72 in the year 2008. Again, a jump in growth factor of 19.01 is observed in the year 2009 with vehicle volume of 5.63 million. However, the highway corridor appears stable from the year 2010 onwards. In 2010, the traffic volume is found 5.91 million with growth factor of 5.01. The next three consecutive years the growth factor is found 2.20, 3.19 and 3.61 respectively. Nevertheless, traffic growth factor is observed a bit higher in 2014 of 8.57 with both directional volumes of 7.01 million. The average growth factor is found 10.71 from nine years of daily traffic data. Interestingly it is examined here that, the traffic volume has increased 2.18 times in the study period of 2006 to 2014 along Dhaka-Chittagong highway. Month wise traffic growth factor is analyzed below to get clear idea about flow pattern.

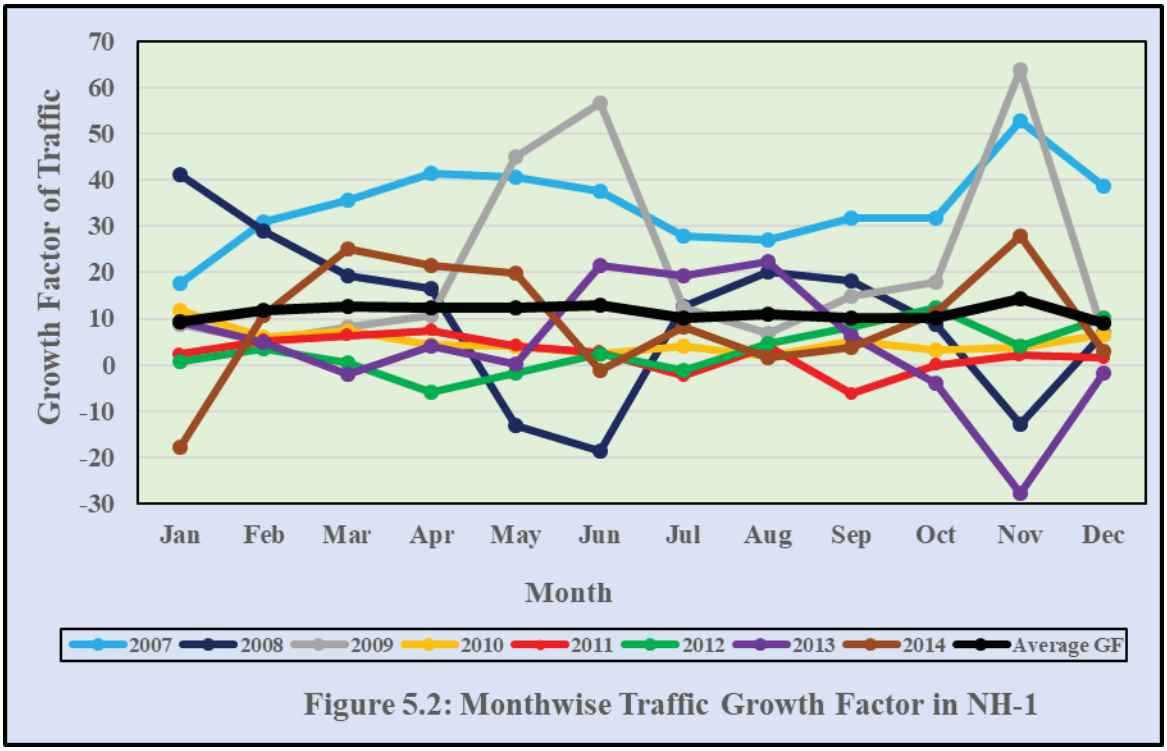


Figure 5.2: Monthwise Traffic Growth Factor in NH-1

Figure 5.2 explains that month wise traffic growth factor usually ranges from -10% to 25% along Dhaka-Chittagong highway. The maximum growth factor is detected so far in November 2009 of 63.73, though the minimum growth factor is found in November 2013 of -27.77. Wide range of fluctuations in growth pattern is observed in January and November. In addition, a stable graphical shape is found from 2010 onwards for the month wise growth pattern curves.

The figure 5.3 and 5.4 below shows that the percentage of various vehicle classes with respect to total yearly is not constant throughout the nine years of study period. 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 raises the need for traffic growth pattern analyzed individually for all vehicle classes.

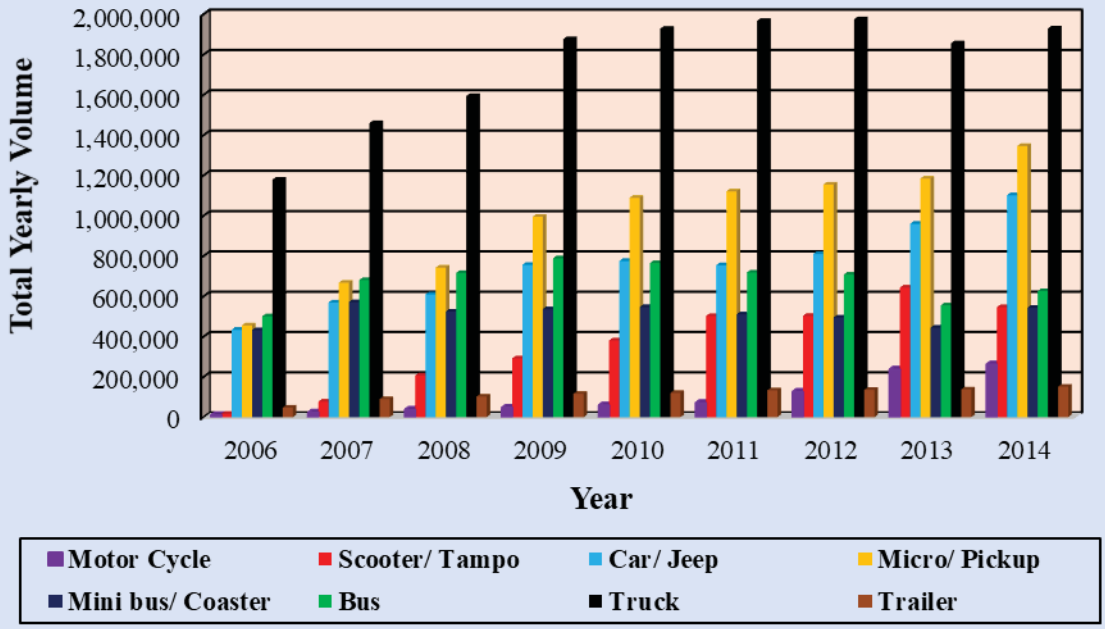


Figure 5.3: Vehicle Classwise Yearly Traffic Growth on NH-1

In Figure 5.3, total yearly flow of all eight vehicle classes used in Meghna-Gumuti bridges are plotted against respective years from 2006 to 2014, while Figure 5.4 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.

Trucks:

The vehicle class of Truck comprises the highest percentage of traffic on NH-1 highway. The average growth factor of medium truck is found 7 with standard deviation of 10 from daily traffic data of 2006 to 2014. Year wise growth factor of trucks seems higher from 2006 to 2009 such as 24, 9, 18 respectively. However, growth factors of trucks seem steady in the later years. The truck volume increase twice in the nine years of study period. Yet, due to subsequent increase in total traffic, the growth in annual percentage is

declining. From 2006 to 2014, the percentage has dropped from 36.77% to 27.49%. The average truck percentage in the study period is found 32.29%. Unfortunately, the NH-1 highway is now suffering from heavy axle load trucks as the axle load control stations are not operating smoothly. The excessive axle loadings are decreasing the pavement life rapidly.

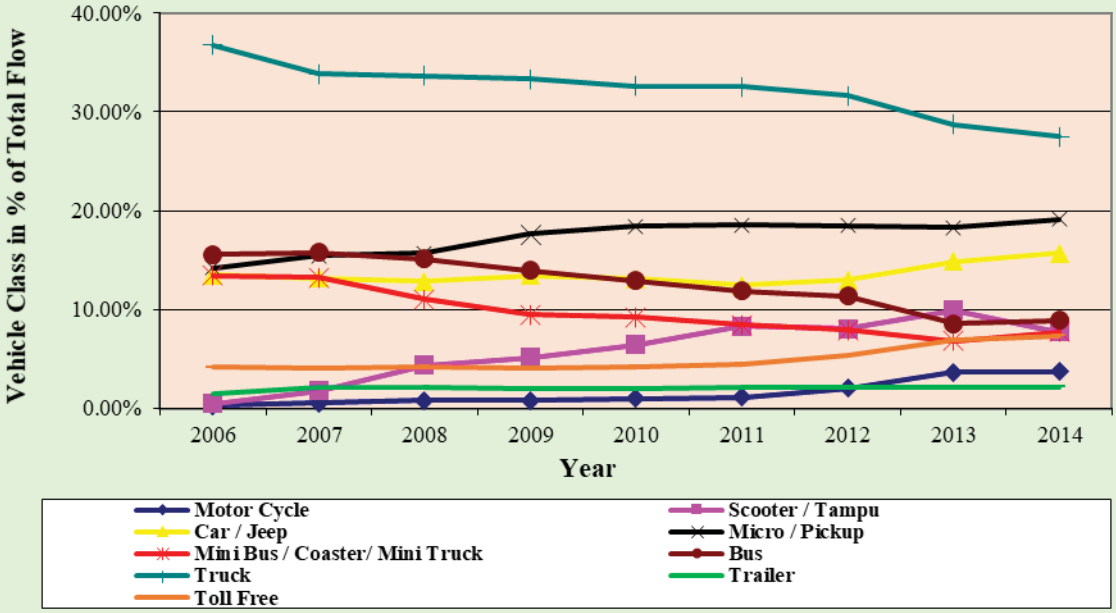


Figure 5.4: Growth Pattern of Seperate Vehicle Classes on NH-1 Highway (in % of Yearly Total Volume)

Micro/Pickup:

Micro/Pickup is the second largest vehicle class in NH-1 highway. From nine years of data, the average growth factor of Micro/Pickup is found 15 with standard deviation of 16. In 2006, this vehicle class volume was 0.45 million and in 2014, it is found 1.34 million, which states that Micro/Pickup volume has increased three times in nine years. The average volume of 0.97 million Micro/Pickup travels through NH-1 per annum. The class wise vehicle percentage is ranges from 14.20% to 19.17% per annum from 2006 to 2014. The average Micro/Pickup is 17.33% of total yearly volume in NH-1.

Car/Jeep:

Car/Jeep is the third dominant vehicle class in NH-1. From Figure 5.2 and 5.3, the average growth factor is found 13 with standard deviation of 11. The average volume of 0.75 million Car/Jeep travels through the highway annually. The Car/Jeep volume was 0.43 million in 2006 and it reaches 1.1 million in 2014. So, the traffic class has increased

three times in nine years of study period. The traffic growth pattern of this vehicle class follows wide ranges, for instance growth pattern is found 15, 19, 24, 31 respectively for the years 2014, 2013, 2009 and 2007. The class wise vehicle percentage is ranges from 12.48% to 15.70% per annum from 2006 to 2014. The average Car/Jeep is 13.57% of total yearly volume in NH-1.

Bus:

In average 0.67 million number of Bus travel through NH-1 per year from 2006 to 2014. The average growth factor per annum is 4 which appears less for the busiest highway of Bangladesh. Due to the abnormal congestion and delay of travel time along NH-1, inter district passenger carrier like bus seems less popular choice of people and they are looking for alternate route like rail road and aviation based transport. In 2006, the volume of bus is found 0.5 million and eight years later in 2014, the volume is found 0.62 million which is not satisfactory growth for highway like NH-1. Additionally, the annual bus percentage has also dropped from 15.60% to 8.91%. The average bus is 12.68% of total yearly volume in NH-1.

Mini Bus/ Coaster/ Mini Truck:

In 2006 Mini Bus/ Coaster/ Mini Truck volume was 0.43 million and in 2014 it became 0.54 million. The average volume from 2006 to 2014 is 0.51 million per annum. The average growth factor for this vehicle class is 4. However, highest and lowest yearly growth factor is observed 32 and -10 in 2006 and 2013 respectively. Annual percentage dropped from 13.46% to 7.73% in nine years. Average percentage of Mini Bus/Coaster/Mini Truck is 9.72% within the traffic stream from the year 2006 to 2014.

Scooter/ Tampu:

Figure 5.3 & 5.4 above explains that, the volume of Scooter/Tampu has increased from 0.016 million in 2006 to 0.54 million in 2014. The average volume of Scooter/Tampu make trips to NH-1 is 0.35 million per annum in the study period. Scooter/Tampu has increased from 0.50% in 2006 to 7.77% in 2014 of total traffic flow. There are lots of connecting rural roads along NH-1 makes the massive increase of Scooter/Tampu volume increase due to cheap and frequent passenger movement service. However, this slow-moving light vehicle class is making NH-1 extremely accident prone. An individual slow-

moving lane should be introduced for this vehicle class and black spot identification and rectification is highly suggested in this study.

Trailer:

The average growth factor of Trailer is 18 and the average volume of trailer travels per annum is found 0.11 million from the data of 2006 to 2014. The number of trailers has increased 3.2 times in the nine years of study data. There is a tendency of carrying excessive over loading in these trailers that decrease pavement life hastily. Trailer vehicle class covers 1.47% to 2.17% of the total volume of traffic.

Motor Cycle:

The average volume of motor cycle per year is found 0.096 million from 2006 to 2014. The average volume of motor cycle is 1.56% of total traffic flow.

Toll Free Vehicle:

From the above figure 5.3 & 5.4, it can be seen that total yearly volume of Toll Free vehicle has increased from 0.13 million in 2006 to 0.51 million in 2014. The percentage of this class has increased from 4.17% in 2006 to 7.35% in 2014.

Summary of Findings:

Different vehicular class is having separate traffic growth rates. So, in order to ensure optimum traffic flow along NH-1, pavement and traffic designer should consider realistic traffic growth rate.

The above analyses should introduce in RHD traffic design manual for further improvement and application in Dhaka-Chittagong Highway.

5.3 CALCULATION OF TRAFFIC COMPOSITION PATTERN ON DHAKA-CHITTAGONG HIGHWAY

Traffic composition patterns plays very important role for accurate transportation and traffic design and operations. In Meghna and Gumuti bridges along Dhaka-Chittagong Highway (NH-1), total traffic is divided into nine vehicular classes considering vehicle size and capacity as follows.

1. Class 1: Motor Cycle
2. Class 2: Scooter / Tampu

3. Class 3: Car / Jeep
4. Class 4: Micro / Pickup
5. Class 5: Mini Bus / Coaster/ Mini Truck
6. Class 6: Bus
7. Class 7: Truck
8. Class 8: Trailer
9. Class 9: Toll Free

Significant comments have been extracted from the detail analyses of the traffic composition pattern on Meghna-Gumuti bridges which are discussed below in this section.

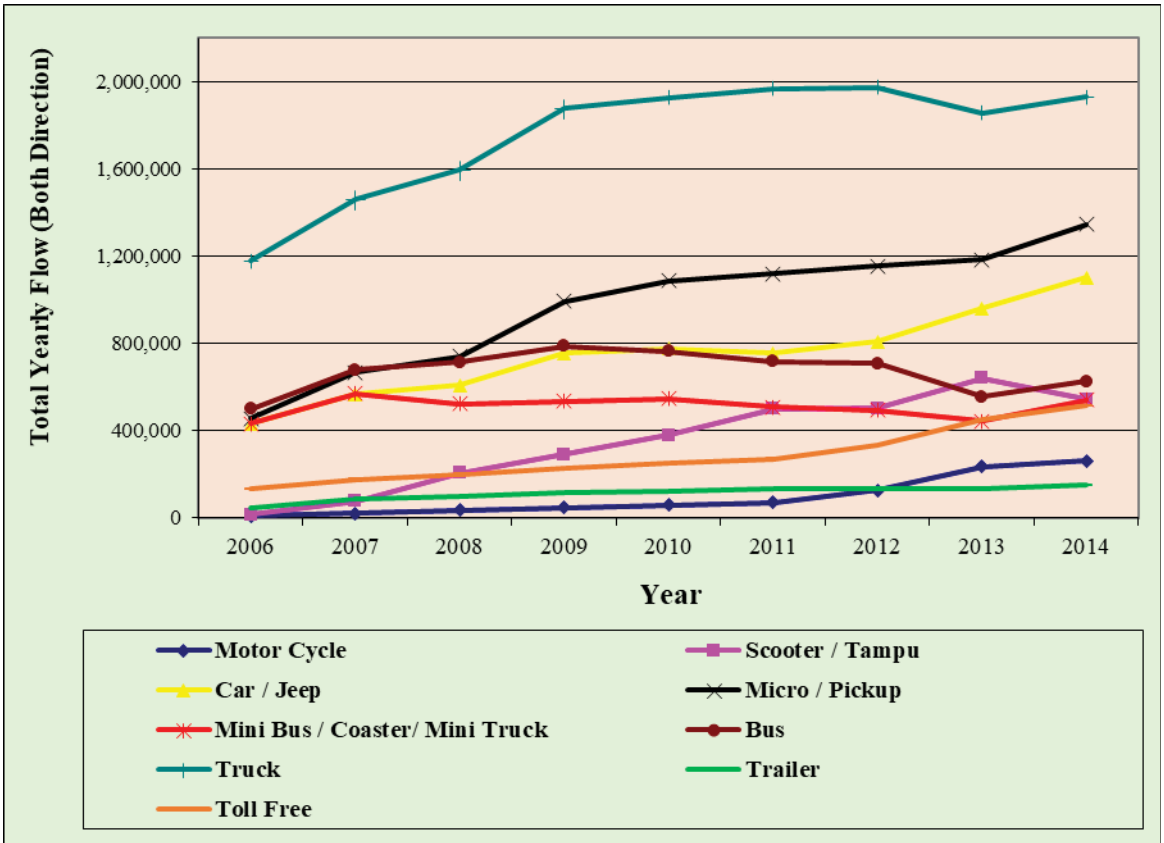


Figure 5.5: Yearly Class Wise Flow on Dhaka-Chittagong Highway

Classification wise yearly volume of traffic along Dhaka-Chittagong highway (NH-1) is plotted above in figure 5.5, whereas traffic composition pattern of the same highway from 2006 to 2014 is illustrated below in figure 5.6. The above figure 5.5 shows that the most predominant vehicle class is Truck. The total yearly flow of trucks varies from 1,178,966 to 1,974,868 with average number of 1,751,672 per year from 2006 to 2014. Also, the

next major traffic category is Micro/ Pickup, which has 455,243 to 1,345,817 number of yearly trips with average value of 972,490 that is nearly half of the volume of Trucks. The graph indicates that special consideration should be taken at the time of pavement design, construction and maintenance of this corridor as the probability of pavement damage may be highest due to maximum movement of truck. The third highest vehicle class is Car/ Jeep, which ranges from 433,710 to 1,101,779 in the study period with average volume of 752,250 per year. The trip quantity of this vehicle class is also having a rising trend, which could produce traffic congestion and accident at the same time due to mix traffic nature. The fourth vehicle class is Bus with average value of 672,808 per year.

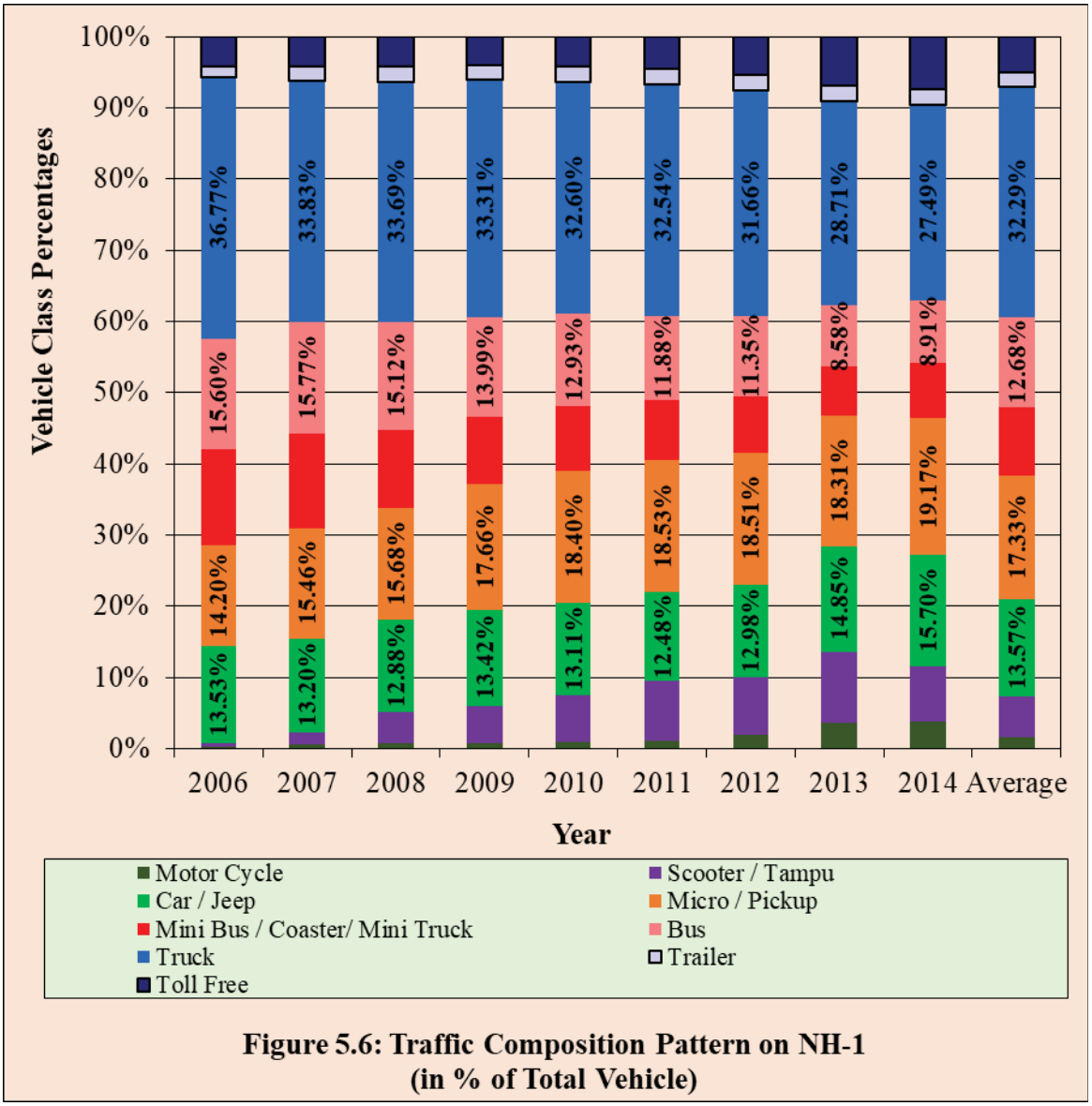


Figure 5.6: Traffic Composition Pattern on NH-1 (in % of Total Vehicle)

The detail traffic composition pattern is shown above in figure 5.6 of NH-1 from the year 2006 to 2014. It is established in this study that, along this corridor vehicular class

number 7 i.e. Truck has the topmost proportion in the traffic flow. In 2006, the percentage was 36.77% and during the next years the proportion is virtually same, but the trip quantity has increased. The average percentage of truck from 2006 to 2014 is 32.29%. The subsequent highest percentage of vehicle class is Micro/Pick-up, the fraction of which was 14.20% in 2006 and 19.17% in 2014. The average proportion of Micro/Pick-up from 2006 to 2014 is 17.33%. The third highest contributing class to the total traffic flow is car/jeep. In 2006, its percentage was 13.53% and it became 15.70% in the year 2014, the average is found to be 13.57%. The fourth utmost vehicle class is bus, which has 15.60% in 2006 and 8.91% in 2014 making average from 2006 to 2014 is 12.68%. Analyzing the traffic flow data on Meghna-Gumuti bridges from 2006 to 2014, it is found that these four pre-dominant vehicle classes comprise of total 75.87% of total traffic flow. Rest 24.13% is shared between minibus/coaster/Mini Truck (9.72%), motorcycle (1.56%), scooter/tampu (5.81%), trailer (2.05%) and toll free (5.00%). The study shows that individual class wise traffic composition along NH-1 are maintaining a stable pattern and hence should be incorporated in geometric design standards manual of Roads and Highways department, Bangladesh for accurate and durable pavement design.

5.4 ASSESSMENT OF HEAVY VEHICLE PERCENTAGE IN DHAKA-CHITTAGONG HIGHWAY

The wheel loads of heavy vehicles contribute to various forms of pavement distress including fatigue (which leads to cracking) and permanent deformation (rutting). The heavy vehicles are the major consumers of the pavement network in Bangladesh, applying the heaviest loads to the pavement. Truck, trailer and bus loads are transferred to the pavements through various combinations of axle configurations. However, all heavy vehicles do not cause equal damage because of differences in wheel loads, number and location of axles, types of suspensions and tires, and other factors. Furthermore, the damage is specific to the properties of the pavement, operating conditions, and environmental factors. Henceforth, detail traffic studies of heavy vehicles have great importance in terms of durable pavement construction and management.

5.4.1 TRUCK PERCENTAGE

Heavy trucks are increasing in the diversity of their design and use. New configurations, new suspensions, new tire types, and higher inflation pressures are changing the loads

imposed on the pavement surface. Although relevant truck properties (weights, axle loads, dimensions, etc.) are properly regulated in Bangladesh, it has been recognized in recent years that there is a lack of detailed or conclusive information on characteristics of heavy vehicles relevant to pavement longevity. Likewise, many variables of the pavement affect the behavior of the truck and the response of the roadway structure. These include such properties as surface roughness, construction material, structural design, environmental factors, geometry, and traffic mix. These pavement variables, in combinations with the diversity in heavy vehicle characteristics, require a reassessment of input parameters to pavement design and analysis practice. A need exists for procedures and techniques for optimizing pavement and heavy-vehicle designs to provide efficient operation of rural and urban roadways. This knowledge is essential to better management of the highway transportation network. Detail understanding of the interaction of trucks with pavement structure will facilitate more rational regulation of truck traffic. Such knowledge will also allow highway engineers to make more informed design decisions regarding initial and long-term costs under the diversity of traffic, materials, and environmental factors. It may be anticipated over the long term that as the knowledge of pavement damage mechanisms reaches maturity, the appropriation of costs to road users will be in proportion to consumption of a road's service utility. Actual truck percentage calculation is introductory condition for realistic pavement design and management of NH-1. According to the vehicle classification system used by the operators, vehicle having capacity of 5 ton to 8 ton are classed as trucks. This class is most common in Bangladesh and hence contributor of the highest percentage of traffic. Also, some 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.

Table 5.1: Truck Percentages on NH-1 (Both Direction)

Year	Truck	Trailer	Total Trucks & Trailers
2006	36.77%	1.47%	38.24%
2007	33.83%	2.08%	35.91%
2008	33.69%	2.15%	35.84%
2009	33.31%	2.06%	35.37%
2010	32.60%	2.03%	34.63%
2011	32.54%	2.20%	34.74%
2012	31.66%	2.17%	33.82%
2013	28.71%	2.12%	30.84%

2014	27.49%	2.15%	29.64%
Average	**32.29%**	**2.05%**	**34.34%**

Date Source: RCL, MBEL-ATT JV.

Table 5.2: Yearly Flow of Trucks and Trailers on NH-1 (Both Direction)

Year	Truck	Trailer	Total Trucks & Trailers
2006	1,182,337	47,491	1,229,828
2007	1,459,489	89,800	1,549,289
2008	1,594,506	101,870	1,696,376
2009	1,876,198	115,995	1,992,193
2010	1,928,190	120,155	2,048,345
2011	1,967,304	132,892	2,100,196
2012	1,974,868	135,201	2,110,069
2013	1,856,116	137,258	1,993,374
2014	1,929,411	150,717	2,080,128
Average	**1,752,047**	**114,598**	**1,866,644**

Date Source: RCL, MBEL-ATT JV.

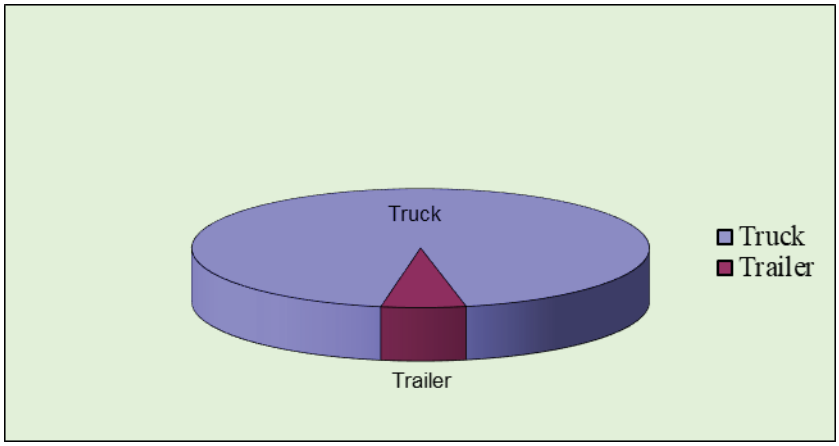


Figure 5.7: Annual Truck Percentages on NH-1 (Average from 2006 to 2014)

It is observed in class wise daily traffic flow data of nine years from 2006 to 2014 along NH-1, the percentage of all classes of trucks 34.34% of total vehicles. Among this, the percentage of trucks and trailers are 32.29% and 2.05% respectively. Table 5.1 shows year-wise truck percentages. The truck percentage is slightly deceasing with upcoming years. Yet, table 5.2 illustrates that the volume of truck has increased 1.63 times and the trailers volume has increased 3.17 times in the nine years' period. It is to be mentioned here that though the traffic has increased a lot but the highway infrastructures volume and capacity remains same in this study period. Significant over loading of trucks have been observed in this highway. Two axle loading stations have been identified along this

corridor, but the implementation of those stations are not continuous due to local political and economic situations. Figure 5.7 shows the annual truck percentage along NH-1. Also, figure 5.8 shows the growth pattern of truck and trailer in Dhaka-Chittagong highway. The truck volume seems much higher than the trailer. The average growth factor of truck is found 7 during the study period. During the first 4 years, the growth factor seems much higher; however, the truck growth factor has been stable in the last five years. On the other hand, the growth factor of trailer is found 18 during the study period.

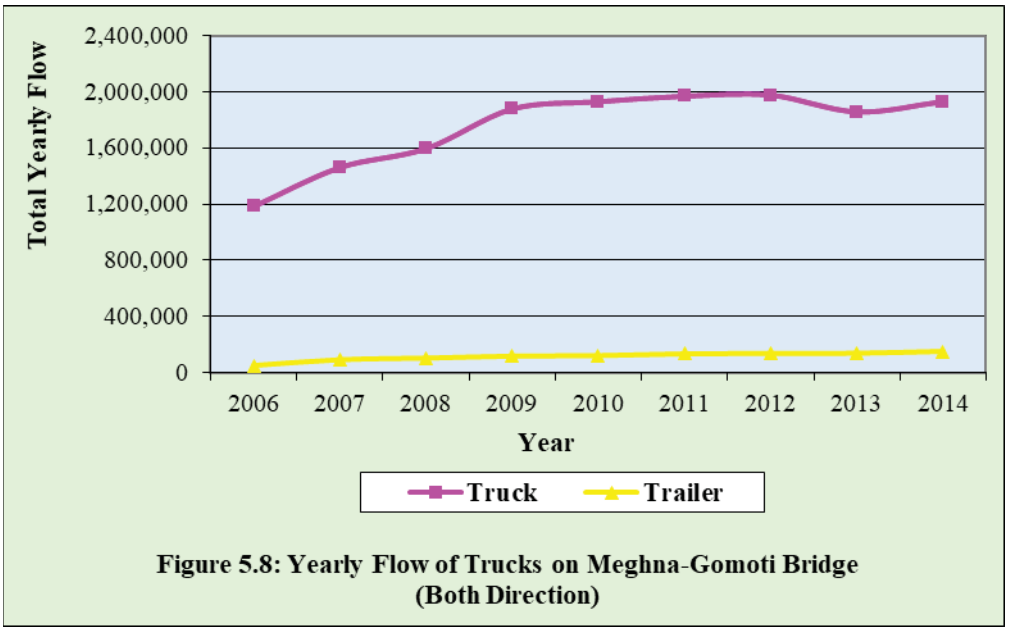


Figure 5.8: Yearly Flow of Trucks on Meghna-Gomoti Bridge (Both Direction)

5.4.2 BUS PERCENTAGE

Traffic and public transport condition along NH-1 have seriously deteriorated, characterized by daily traffic jams, traffic congestion, long delays and high incidence of road accidents. The public transport in NH-1 is provided by an extensive network of operating modes including buses, coasters and minibuses. Buses passing through NH-1 are classified into two groups namely Mini Bus/ Coaster/ Mini Truck and large Bus are called Bus. Large buses are considered to be ten meters or more in length and having more than 30 seats capacity. Most mini buses are around eight meters in length and having capacity of 30 seats or less are classed as mini bus. Micro buses are often called as ‘human haulers’ in Bangladesh. Human haulers are converted from pickup trucks with two benches paralleled have 9 to 15 seats.

Table 5.3: Yearly Flow of Bus on NH-1 (Both Direction)

Year	Mini Bus/ Coaster	Bus	Total Buses
2006	431,839	497,938	929,777
2007	570,851	680,413	1,251,264
2008	524,010	715,618	1,239,628
2009	535,970	788,149	1,324,119
2010	546,567	764,866	1,311,433
2011	510,201	717,949	1,228,150
2012	494,438	707,788	1,202,226
2013	443,782	554,718	998,500
2014	542,612	625,547	1,168,159
Average	**511,141**	**672,554**	**1,183,695**

Date Source: RCL, MBEL-ATT JV.

Table 5.4: Bus Percentages on NH-1 (Both Direction)

Year	Mini Bus/ Coaster	Bus	Total Buses
2006	13.46%	15.60%	**29.06%**
2007	13.23%	15.77%	**29.01%**
2008	11.07%	15.12%	**26.19%**
2009	9.52%	13.99%	**23.51%**
2010	9.24%	12.93%	**22.17%**
2011	8.44%	11.88%	**20.31%**
2012	7.93%	11.35%	**19.27%**
2013	6.86%	8.58%	**15.45%**
2014	7.73%	8.91%	**16.64%**
Average	**9.72%**	**12.68%**	**22.40%**

Date Source: RCL, MBEL-ATT JV.

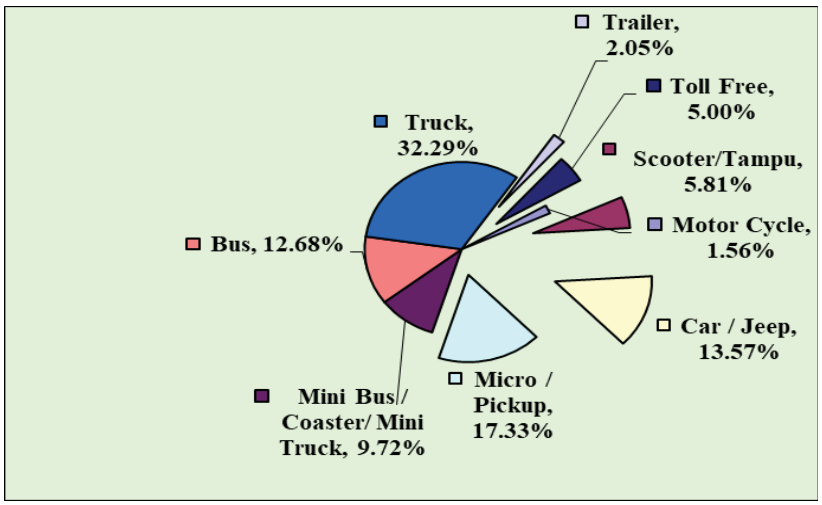


Figure 5.9: Annual Bus Percentages on NH-1 (Average over 9 years)

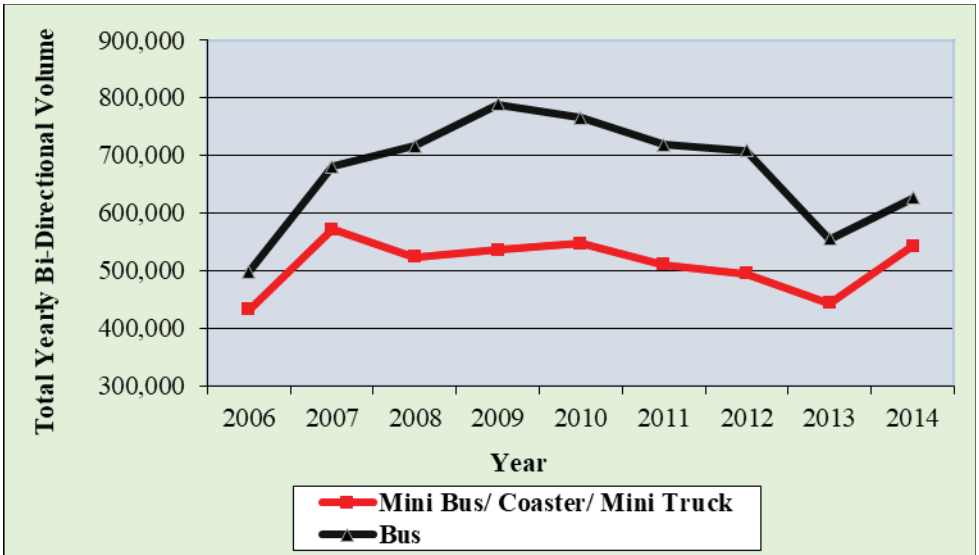


Figure 5.10: Growth Pattern of Buses on NH-1 (Both Direction)

From figure 5.9, it is found that total 22.40% of total annual flow (taking average from 2006 to 2014) comprises of buses. Among this, 12.68% is large bus and 9.72% is mini bus/coaster. Annual increase pattern of total number buses is shown in Figure 5.10. Although the total number is increasing at a quite high rate, but from Table 5.4, the percentage of bus has slightly decreasing with respect to total traffic (15.60% in 2006 and 8.91% in 2014). Mini bus/coaster/mini truck has decreased from 13.46% to 7.73% and large bus as well decrease from 15.60% to 8.91% in the study period. Furthermore, the total bus percentage has also decreased from 29.06% to 16.64%. The volume of public transport is increased but it seems decreasing with respect to other vehicle classes. The growth factor of large bus from the year 2006 to 2014 is varies between 36.65% to -21.63% (from table 5.5), and growth factor of mini bus varies from 32.19% to -10.25%. This highway is experiencing severe traffic jam and delays due to insufficient traffic lanes and bottleneck problems. The public transport demand along this highway is much higher, but due to lack of road infrastructures and delay, passengers use alternate transport modes like railways, waterways and airways. Hence, public transport growth pattern is not stable yet along this highway. Likewise, the average volume of large bus and mini bus/coaster/mini truck have nearly equal percentage, which brings a new research topic along NH-1 like public transport safety.

Table 5.5: Growth Factor of Bus on NH-1 (Both Direction)

Year	Mini Bus/ Mini Truck/ Coaster	Bus
2006-07	32.19	36.65
2007-08	-8.21	5.17
2008-09	2.28	10.14
2009-10	1.98	-2.95
2010-11	-6.65	-6.13
2011-12	-3.09	-1.42
2012-13	-10.25	-21.63
2013-14	22.27	12.77
Average	**3.82**	**4.07**

5.5 CALCULATION OF VEHICULAR FLOW PATTERN OF DHAKA-CHITTAGONG HIGHWAY (NH-1)

Dhaka-Chittagong highway, which is one of the main transportation artery for the economy of Bangladesh. The 257 kilometers NH-1 is a top development priority and is the most demanding road in Bangladesh. Recent enormous congestion, long traffic queue and road accidents ascertains

that the highway was built based on non-engineered way or else proper traffic study was not performed during the construction of that highways. Regrettably no extensive traffic studies have been completed on NH-1 by the Government of Bangladesh till now. However, an attempt is made through this research to establish daily, weekly and monthly traffic flow factors along NH-1. Usually traffic data collection and analysis follow varying trends and plays an important role in the evaluation and management of road network schemes. Traffic flow pattern is highly required for different purposes by different ministries and organizations in Bangladesh. The major areas for which this type of study is required are planning prioritization, project initiation, project design, planning maintenance, national transport statistics, road safety measures and traffic control. The daily, weekly and monthly traffic flow arrangements of Dhaka-Chittagong highway have been observed separately in this study.

5.5.1 CALCULATION OF DAILY TRAFFIC FLOW VARIATIONS IN NH-1

To facilitate the valuation of present and future traffic demands, for the development of need-based infrastructure accurate information and continuous monitoring of traffic by appropriate methods are necessary. Implementing authorities like RHD must therefore ensure that sufficient and appropriate data is available to undertake necessary planning, design, construction and maintenance of the country's road network, which is aimed at meeting the prevailing traffic flow, future traffic growth and loading without considerable deterioration in the quality of service. Detailed knowledge of traffic flow variations on a highway system is critical for the maintenance, operation, and expansion of the system. Traditionally, traffic volume is measured using automatic traffic recorders (ATRs) placed along the roadways. However, nonstop road traffic volume study is ignored in road implementing agencies in Bangladesh and no ATRs have been installed along any highway of Bangladesh. Nevertheless, individual vehicle class wise data have been collected from toll collecting operators of RCL and MBEL-ATT JV from 2006 to 2014, where different daily flow variation patterns have been achieved. Data preservation is not practiced in road agencies of Bangladesh, and that's why the author can't manage to collect data before 2006. Also, the toll operators haven't preserve the data for inbound and outbound traffic separately. Directional distribution pattern analyses have been omitted for this highway due to lack of data.

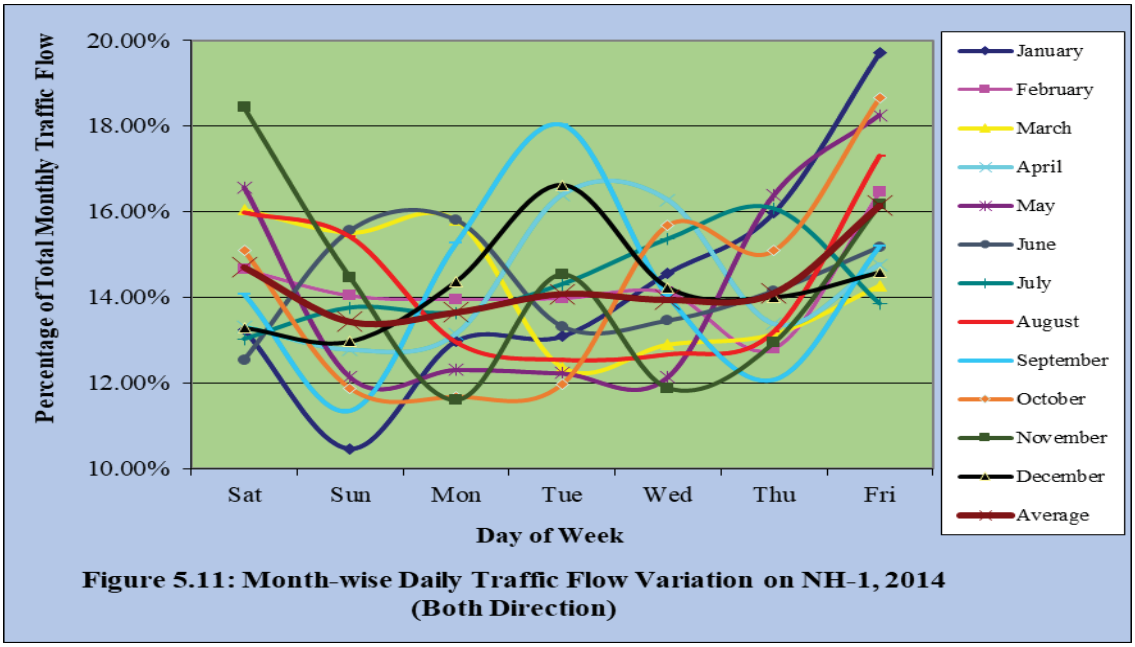


Figure 5.11: Month-wise Daily Traffic Flow Variation on NH-1, 2014 (Both Direction)

From the daily traffic analyses, it is observed in pictorial representations that every month has its own daily traffic flow variation pattern. Daily flow fluctuation patterns are observed in

month wise of a year during the research. Figure 5.11 and 5.12 shows below the bi-directional month wise traffic flow variations along Dhaka-Chittagong highway for the year 2014 and 2011. Figure 5.11 distinguished that month wise daily traffic flow variations in 2014 ranges from 10% to 18% of total monthly flow. The 12 months' average curves mostly follow 14% of monthly traffic flow. The similar type of observation is obtained from Figure 5.12 for the year 2011, where month wise daily traffic flow variations ranges from 10% to 17% of total monthly flow and the 12 months' average curves follows again 14% of monthly traffic flow.

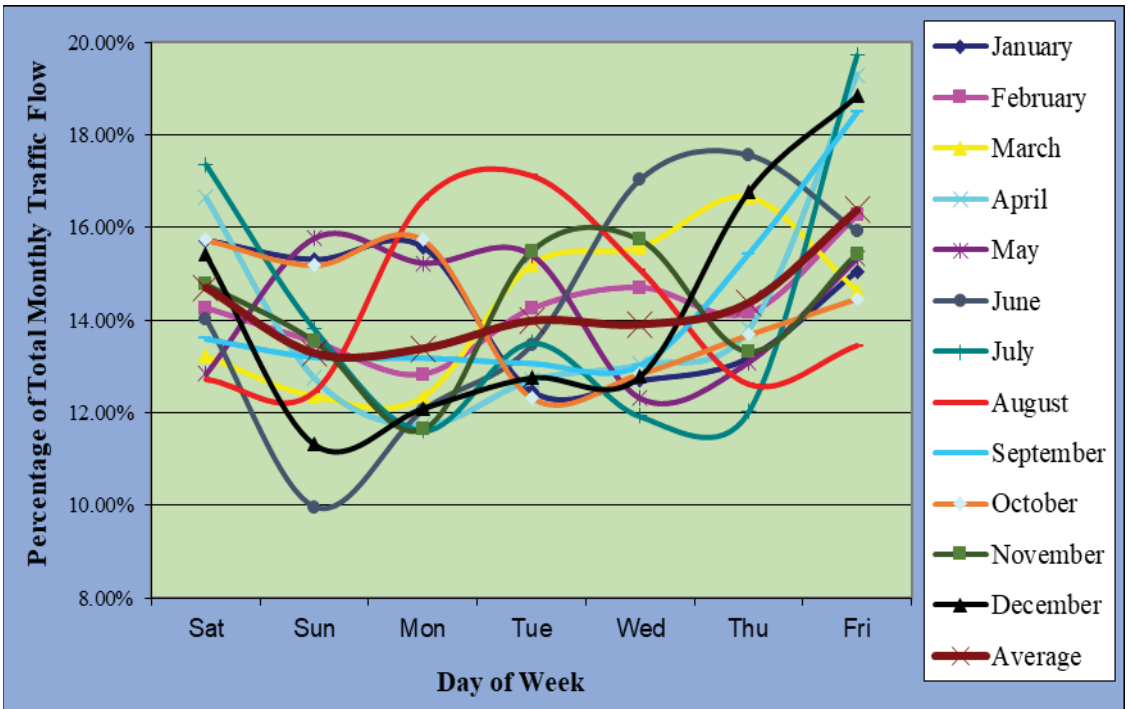


Figure 5.12: Month-wise Daily Traffic Flow Variation on NH-1, 2011 (Both Direction)

Out of nine years, individual two years (2014, 2011) of month-wise daily flow variation pattern have been revealed above.

Summary of Findings:

The following significant flow characteristics parameters have been obtained from the daily traffic flow analyses, where it is obvious that Friday keeps maximum traffic flow of 16.20% of weekly volume in NH-1 corridor. Furthermore, Thursday and Saturday has second and third highest traffic volume of 14.80% and 14.08% of weekly volume respectively in NH-1. Instead, from Sunday to Tuesday the average daily traffic flow varies from 13.51% to 13.82% of weekly volume. Sunday has the minimum traffic flow of 13.51% of the weekly volume. This analysis indicates that the flow pattern sags from Sunday to Tuesday. The weekend factor appears governing along Dhaka-Chittagong highway.

Table 5.6: Summary Table - Daily Flow Variation

Day	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
Sat	14.29%	13.59%	13.61%	13.62%	13.79%	14.70%	13.32%	15.06%	14.70%	**14.08%**
Sun	13.51%	13.34%	13.64%	13.51%	13.30%	13.28%	13.84%	13.76%	13.42%	**13.51%**
Mon	13.64%	13.80%	13.51%	13.51%	13.75%	13.38%	13.34%	13.74%	13.64%	**13.59%**
Tue	13.52%	13.71%	13.95%	13.96%	13.89%	13.98%	14.04%	13.21%	14.07%	**13.82%**
Wed	13.50%	14.48%	14.33%	14.03%	14.10%	13.90%	14.60%	13.10%	13.94%	**14.00%**
Thu	14.77%	14.92%	14.71%	15.03%	14.65%	14.37%	16.12%	14.56%	14.09%	**14.80%**
Fri	16.78%	16.15%	16.24%	16.32%	16.52%	16.38%	14.74%	16.56%	16.13%	**16.20%**

5.5.2 CALCULATION OF WEEKLY TRAFFIC FLOW VARIATIONS IN NH-1

Weekly traffic flow variations play a significant role for traffic demand modelling and forecasting. The traffic flow is divided into four weeks in a month and the flow differs in weeks. Detail weekly flow variations have been observed in this section. The first three weeks have seven days each and the fourth week, except February, has 9 to 10 days depending on the months. It is expected that the fourth week will naturally contain more traffic. This model uses weekly ADT to minimize this error and compares between the four weekly ADTs of each month from January 2006 to December 2014. A distinctive table of weekly flow variation analyses for the study period are shown in Table 5.7. The graphical representation is shown below in Figure 5.13.

Table 5.7: Summary of Weekly Flow Variation (Both Direction)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2006	24.81%	24.52%	25.17%	25.50%
2007	24.68%	24.89%	25.32%	25.11%
2008	25.30%	25.19%	24.13%	25.38%
2009	24.45%	25.10%	25.50%	24.95%
2010	24.56%	25.25%	25.60%	24.58%
2011	24.67%	24.72%	25.16%	25.45%
2012	24.55%	24.73%	25.45%	25.27%
2013	24.44%	24.62%	26.15%	24.80%
2014	23.47%	25.47%	25.55%	25.50%
Average	**24.55%**	**24.94%**	**25.34%**	**25.17%**

In figure 5.13, weekly flow variations on NH-1 in 2014 are plotted. In all cases except January, the flow varies between 23% to 28% of monthly volume. The month January shows abnormal traffic curve due to extreme political crisis and turbulence in Bangladesh at that time and however, the upper limit and lower limit of weekly traffic data curve should be in considerations for traffic engineers of Bangladesh.

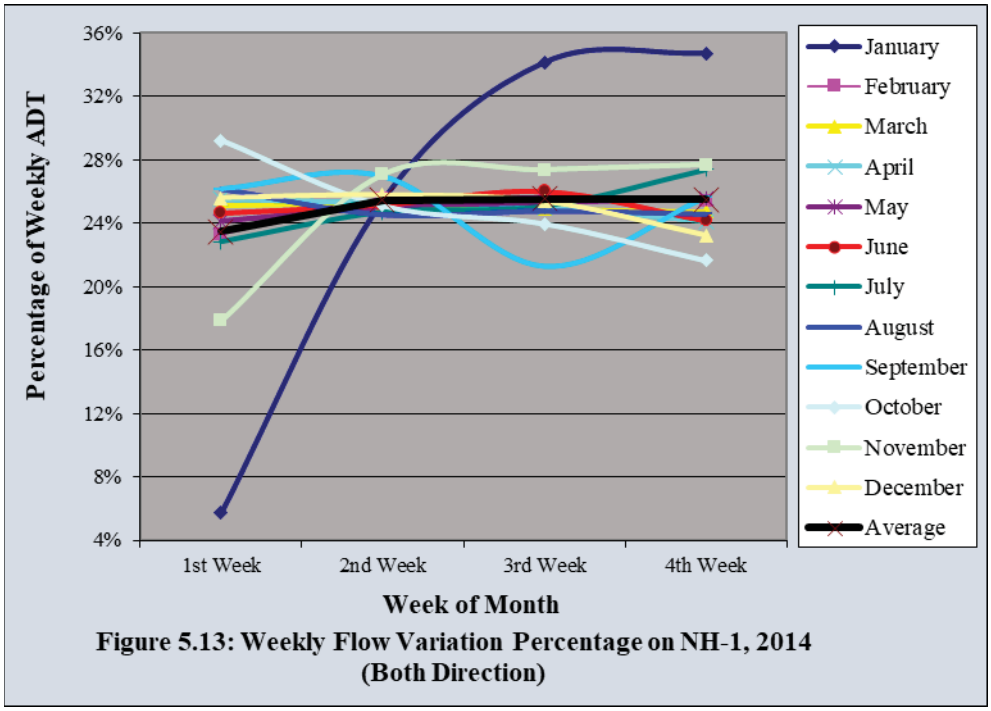


Figure 5.13: Weekly Flow Variation Percentage on NH-1, 2014 (Both Direction)

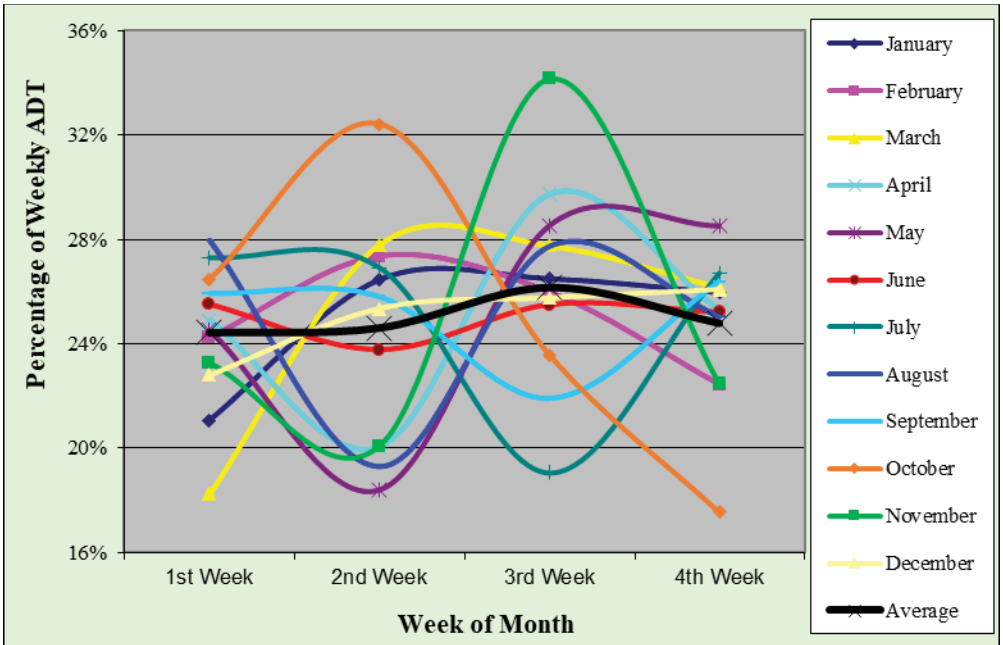


Figure 5.14: Weekly Flow Variation Percentage on NH-1, 2013 (Both Direction)

Figure 5.14 shows the weekly ADT flow variations in percentage of monthly volume for the year 2013. The weekly flow nearly varies between 18% to 32% of monthly volume along NH-1.

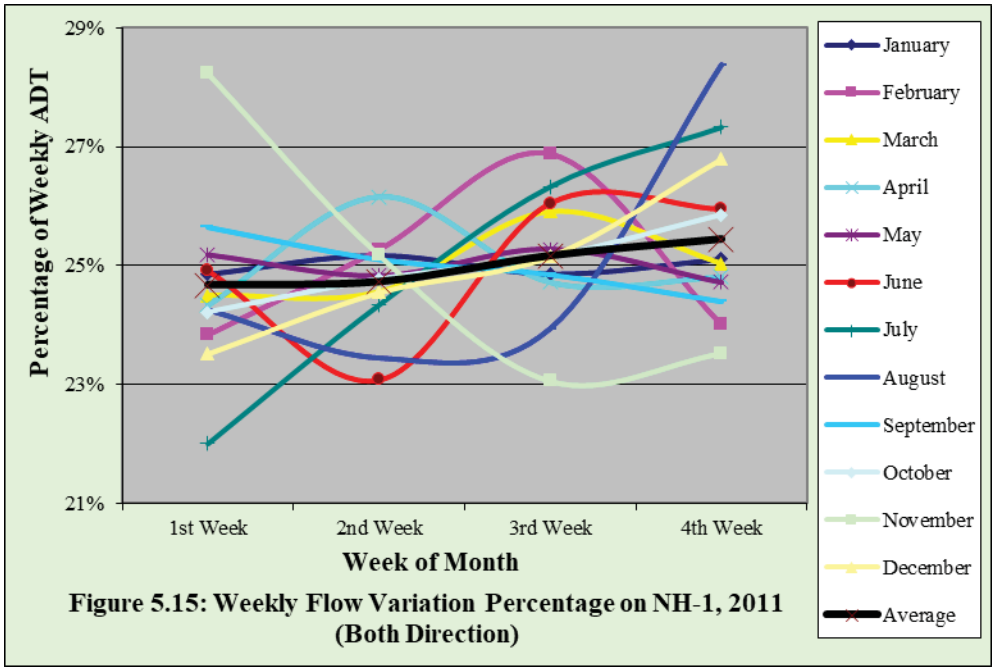


Figure 5.15: Weekly Flow Variation Percentage on NH-1, 2011 (Both Direction)

The weekly flow variations lie between 23% to 27% of monthly volume for the year 2011 in Figure 5.15. The average curve shows that there is a trend of increasing traffic from the first week to fourth week along NH-1.

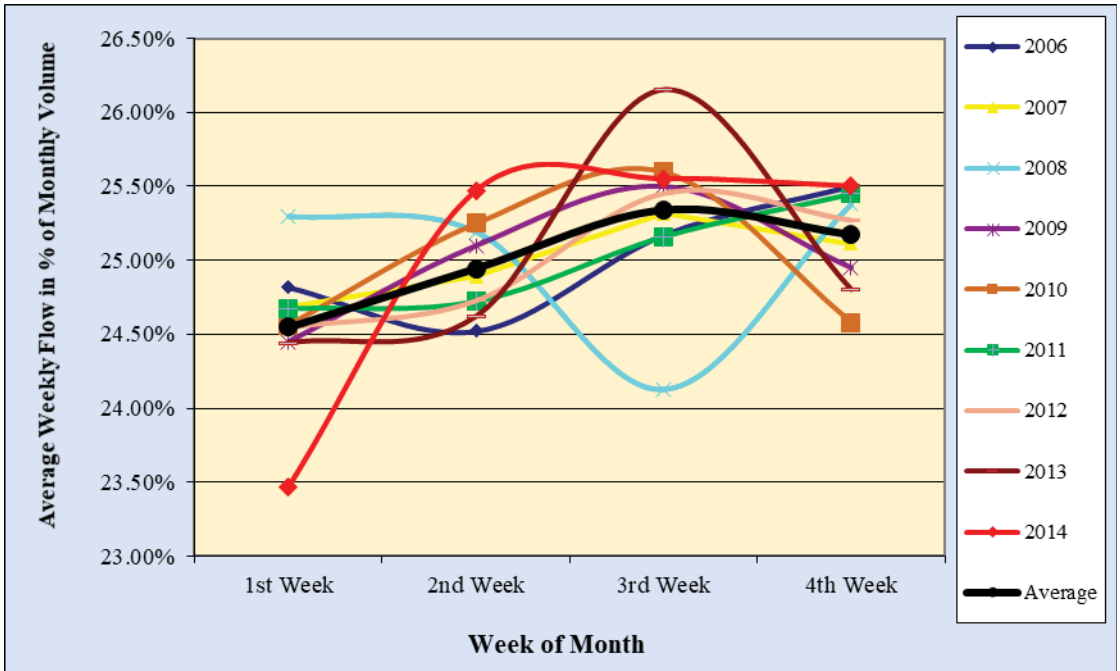


Figure 5.16:Weekly Flow Fluctuation on NH-1 2006-2014 (Both Direction)

Figure 5.16 shows that, there exists specific weekly flow variation pattern. The average curve (for the year 2006 to 2014) shows that, the first three week of a month, there is a trend of increasing traffic slightly and the last week of the month traffic decrease slightly.

Most of the cases, the average weekly flow varies between 24.50% to 25.50% of total monthly flow.

5.5.3 CALCULATION OF MONTHLY TRAFFIC FLOW PATTERNS IN NH-1

Traffic data collection and projections of traffic volume are basic requirements for planning of road development and management schemes. Traffic data forms an integral part in the science of descriptive national economics and such knowledge is essential in drawing up a rational transport policy for movement of passengers and goods by both government and private sectors. Monthly traffic flow calculations play in important role in project design, planning maintenance, national transport statistics and many others. Monthly traffic flow model along Dhaka-Chittagong highway (NH-1) have been designed using nine years of class wise daily traffic data of Meghna and Gumuti bridges. Specific traffic patterns have been observed in National Highway No.1. Monthly traffic flow variation shows direct relationship between different months of a year. Figure 5.17 below shows monthly bi-directional traffic flow variations along NH-1 from 2006 to 2014. 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 NH-1.

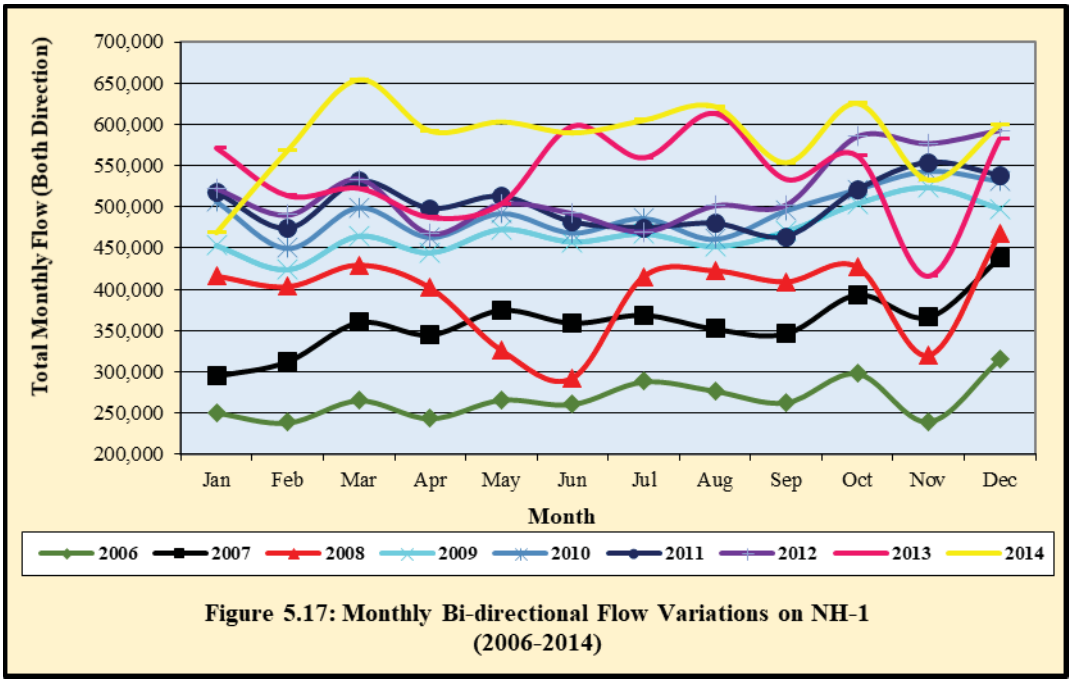


Figure 5.17: Monthly Bi-directional Flow Variations on NH-1 (2006-2014)

Figure 5.18 below illustrated monthly vehicular flow variation in percentage of yearly volume for both directional traffic along Dhaka-Chittagong highway. Monthly traffic

flow is found between 7 to 10% of yearly traffic volume along NH-1. The average of nine years monthly traffic flow is found approximately 8% of yearly volume.

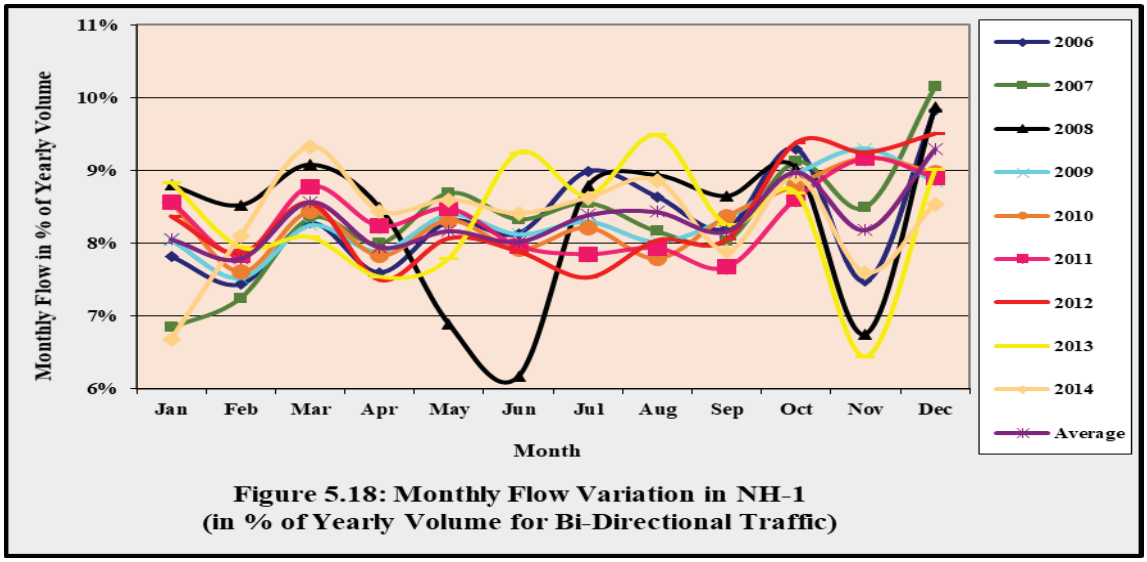


Figure 5.18: Monthly Flow Variation in NH-1 (in % of Yearly Volume for Bi-Directional Traffic)

The following table 5.8 shows the monthly flow variation on NH-1 corridor from the years 2006 to 2014. Table 5.9 shows year wise the maximum and minimum monthly flow percentage. Maximum and minimum flow is marked in red and blue respectively.

Table 5.8: Monthly Traffic Flow Analyses on NH-1 (2006-2014)

Month\ Year	**2006**	**2007**	**2008**	**2009**	**2010**
Jan	250,988	295,193	416,396	453,185	506,324
Feb	238,820	312,740	403,447	424,170	450,000
Mar	265,789	360,112	429,778	464,702	498,985
Apr	243,965	345,105	402,048	444,537	463,220
May	266,474	375,049	326,242	472,871	491,998
Jun	261,144	359,441	292,239	457,681	468,513
Jul	288,475	369,120	415,725	467,515	485,985
Aug	277,259	352,299	422,798	452,142	460,937
Sep	263,283	346,617	409,367	470,306	495,200
Oct	298,482	393,615	427,631	503,949	520,837
Nov	240,141	366,653	319,814	523,644	542,724
Dec	315,590	437,893	467,464	498,096	530,778
Yearly Volume	**3,210,410**	**4,313,837**	**4,732,949**	**5,632,798**	**5,915,501**
Month\ Year	**2011**	**2012**	**2013**	**2014**	
Jan	517,868	522,201	571,349	469,000	
Feb	473,737	490,460	513,774	568,800	
Mar	530,898	533,794	522,770	654,660	
Apr	497,869	467,980	487,590	592,488	

May	512,614	503,448	503,899	603,622
Jun	481,405	492,290	597,735	590,175
Jul	474,700	469,951	559,599	605,453
Aug	479,789	501,742	613,240	622,103
Sep	463,908	502,540	533,527	554,010
Oct	520,681	585,166	561,955	625,965
Nov	553,986	576,798	416,639	533,088
Dec	538,364	592,804	582,487	599,619
Yearly Volume	**6,045,819**	**6,239,174**	**6,464,564**	**7,018,983**

Source Data: RCL, MBEL-ATT JV.

Table 5.9: Highest & Lowest Monthly Traffic Flow in NH-1

Month\ Year	**2006**	**2007**	**2008**	**2009**	**2010**
Jan	7.82%	6.84%	8.80%	8.05%	8.56%
Feb	7.44%	7.25%	8.52%	7.53%	7.61%
Mar	8.28%	8.35%	9.08%	8.25%	8.44%
Apr	7.60%	8.00%	8.49%	7.89%	7.83%
May	8.30%	8.69%	6.89%	8.39%	8.32%
Jun	8.13%	8.33%	6.17%	8.13%	7.92%
Jul	8.99%	8.56%	8.78%	8.30%	8.22%
Aug	8.64%	8.17%	8.93%	8.03%	7.79%
Sep	8.20%	8.04%	8.65%	8.35%	8.37%
Oct	9.30%	9.12%	9.04%	8.95%	8.80%
Nov	7.48%	8.50%	6.76%	9.30%	9.17%
Dec	9.83%	10.15%	9.88%	8.84%	8.97%
Total	100.00%	100.00%	100.00%	100.00%	100.00%
Max.	9.83%	10.15%	9.88%	9.30%	9.17%
Min.	7.44%	6.84%	6.17%	7.53%	7.61%
Month\ Year	**2011**	**2012**	**2013**	**2014**	**Average (2006-2014)**
Jan	8.57%	8.37%	8.84%	6.68%	**8.06%**
Feb	7.84%	7.86%	7.95%	8.10%	**7.79%**
Mar	8.78%	8.56%	8.09%	9.33%	**8.57%**
Apr	8.23%	7.50%	7.54%	8.44%	**7.95%**
May	8.48%	8.07%	7.79%	8.60%	**8.17%**
Jun	7.96%	7.89%	9.25%	8.41%	**8.02%**
Jul	7.85%	7.53%	8.66%	8.63%	**8.39%**
Aug	7.94%	8.04%	9.49%	8.86%	**8.43%**
Sep	7.67%	8.05%	8.25%	7.89%	**8.16%**
Oct	8.61%	9.38%	8.69%	8.92%	**8.98%**
Nov	9.16%	9.24%	6.44%	7.59%	**8.18%**
Dec	8.90%	9.50%	9.01%	8.54%	**9.29%**
Total	100.00%	100.00%	100.00%	100.00%	**100.00%**
Max.	9.16%	9.50%	9.49%	9.33%	**9.29%**
Min.	7.67%	7.50%	6.44%	6.68%	**7.79%**

Source Data: RCL, MBEL-ATT JV.

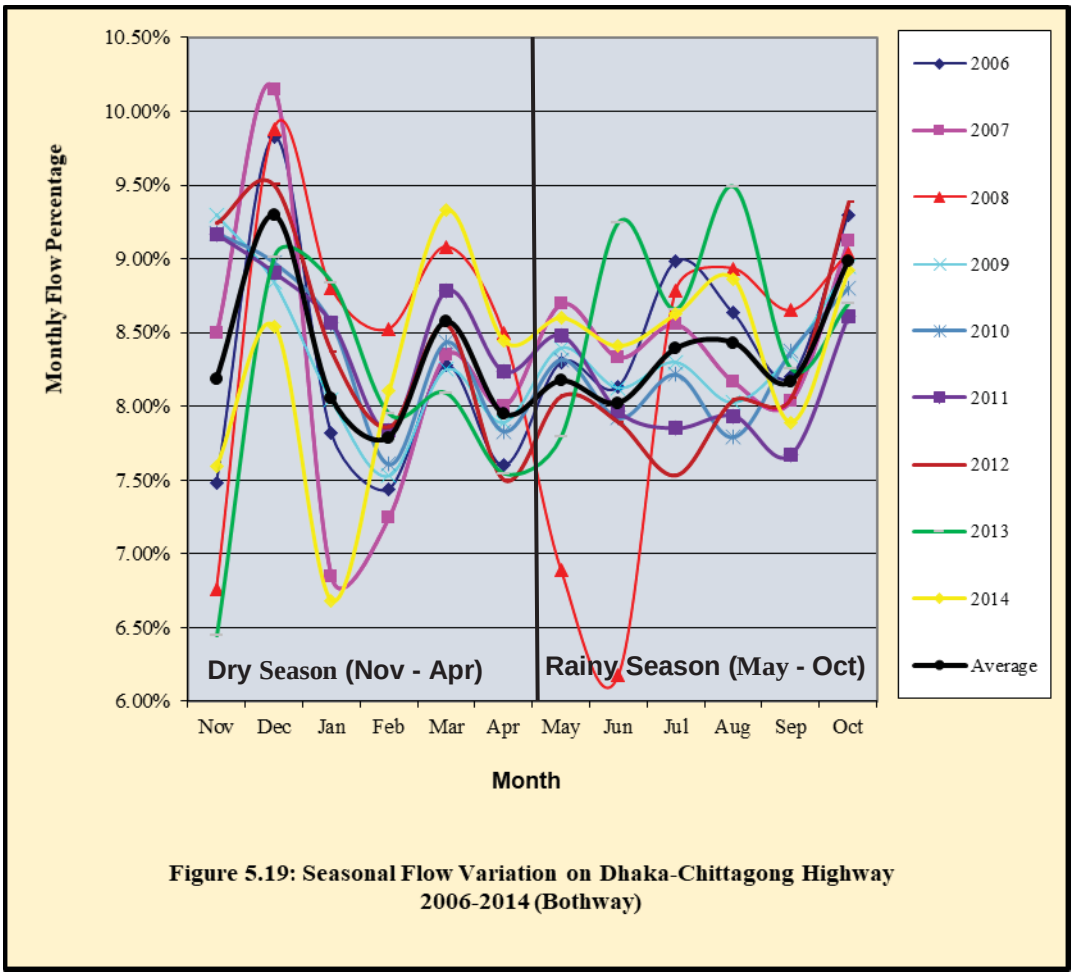


Figure 5.19: Seasonal Flow Variation on Dhaka-Chittagong Highway 2006-2014 (Bothway)

Monthly model of NH-1 reveals that, the average maximum monthly flow percentage occurs more frequently on November and December while the average maximum flow occurs on December. Instead, January and February carry minimum flow. Average minimum flow occurs in February (7.79%) and maximum flow occurs in December (9.29%). In rainy season, the traffic flow is higher with respect to dry season. The seasonal traffic flow percentage varies between 6.5% to 10% in dry season and 7.5% to 9.5% in rainy season. From table 5.10 and figure 5.19, it is originating that traffic flow is higher on rainy season (50.16%) than on dry season (49.84%).

Dry season is considered from the month November to April and rainy season falls between May to October. Due to Chittagong port, more freight movement on waterways during the rainy season making the traffic flow percentage on NH-1 is higher. The seasonal distribution pattern is found in figure 5.20.

Table 5.10: Summarized Seasonal Flow Variation in NH-1

Dry Season		Rainy Season	
Month	**Flow % in Season**	**Month**	**Flow % in Season**
Nov	8.18%	May	8.17%
Dec	9.29%	Jun	8.02%
Jan	8.06%	Jul	8.39%
Feb	7.79%	Aug	8.43%
Mar	8.57%	Sep	8.16%
Apr	7.95%	Oct	8.98%
Total	49.84%	Total	50.16%

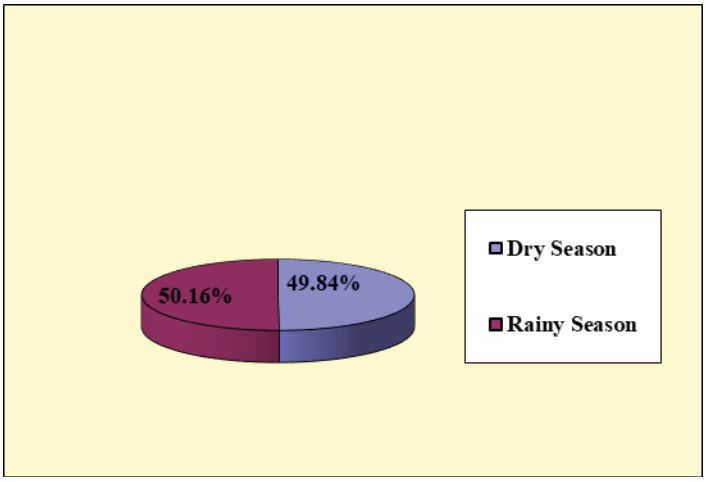


Figure 5.20: Seasonal Distribution of Traffic on NH-1 (Bothway), 2006-2014

From figure 5.21 and table 5.11 below, it is observed that maximum monthly large bus flow variations vary from 9% to 10% of total yearly flow. Yet, minimum monthly large bus flow variations vary from 4% to 8% of total yearly flow. From the average of nine years of study data, maximum flow is found in December (9.00%) and minimum flow is found in November (7.59%). The magnitude of large buses numbers is increasing every year. Hereafter, the considerable amount of passenger bus is travelling through NH-1 all over the year. It recommended in this research that, provision of wayside amenities with facilities like parking lots, drinking water, toilet, snack bars, restaurants, rest rooms, petrol pumps with service and repair and communication facilities should be introduced at certain intervals for highway modernization. These facilities should be provided and run by the private sectors, which must be encouraged and supported by the Government of

Bangladesh. Intelligent transport systems (ITS) should be acquaint with along NH-1 for providing highway police petrol, medical aid posts and arrangements for tow truck service to remove accidental vehicle from the site and to provide immediate medical attention to victims. It is also recommended that, a comprehensive highway act should be enacted by RHD and the concern ministries for efficient land and traffic management including effective control on ribbon development and prevention of encroachment to cover roads under their respective jurisdiction. The highway authorities should be made responsible for removal of under the act encroachment.

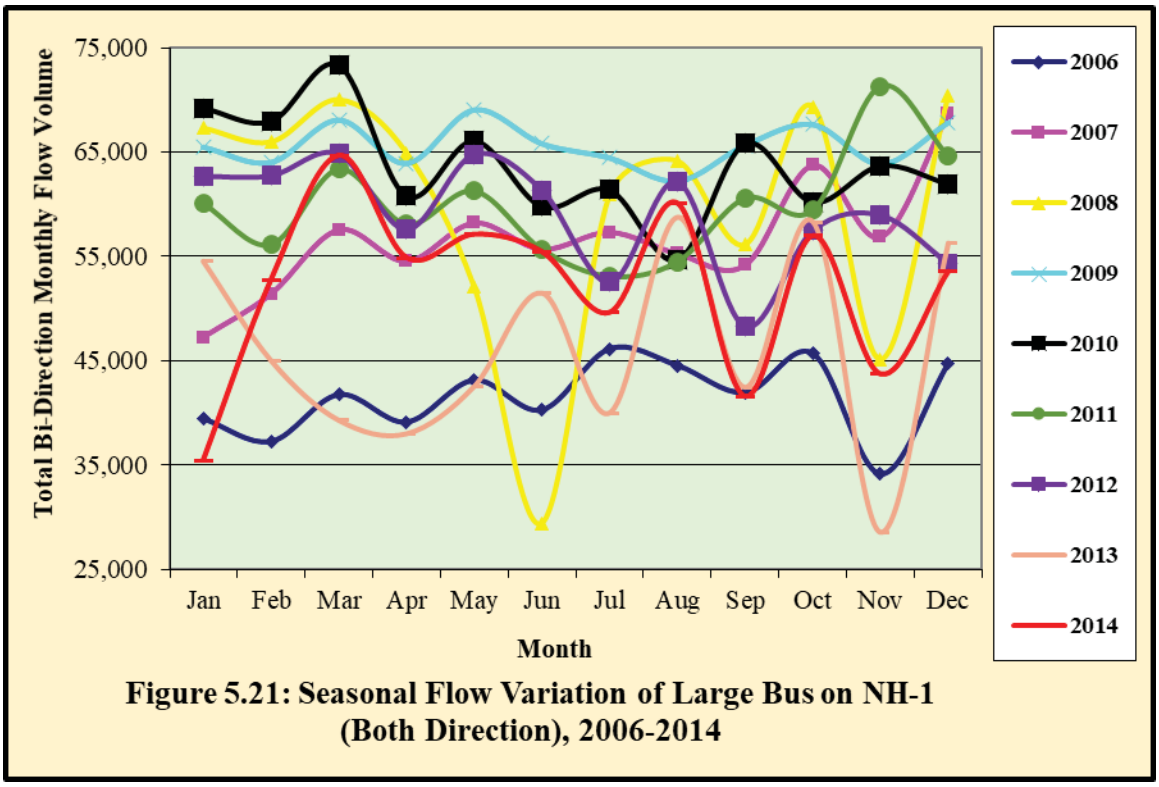


Figure 5.21: Seasonal Flow Variation of Large Bus on NH-1 (Both Direction), 2006-2014

Table 5.11: Monthly Flow Variation of Large Bus on NH-1

Month\ Year	2006	2007	2008	2009	2010
Jan	7.92%	6.94%	9.40%	8.31%	9.05%
Feb	7.48%	7.55%	9.22%	8.12%	8.88%
Mar	8.38%	8.46%	9.78%	8.64%	9.59%
Apr	7.85%	8.01%	9.07%	8.11%	7.95%
May	8.66%	8.55%	7.27%	8.77%	8.64%
Jun	8.09%	8.18%	4.11%	8.35%	7.82%
Jul	9.26%	8.42%	8.51%	8.18%	8.02%
Aug	8.94%	8.12%	8.96%	7.89%	7.14%
Sep	8.42%	7.96%	7.84%	8.33%	8.61%
Oct	9.17%	9.37%	9.69%	8.59%	7.87%

Nov	6.85%	8.35%	6.30%	8.10%	8.33%
Dec	8.98%	10.09%	9.84%	8.61%	8.10%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max.	9.26%	10.09%	9.84%	8.77%	9.59%
Min.	6.85%	6.94%	4.11%	7.89%	7.14%
Month\ Year	**2011**	**2012**	**2013**	**2014**	**Average (2006-2014)**
Jan	8.37%	8.86%	9.82%	5.66%	**8.26%**
Feb	7.82%	8.86%	8.11%	8.43%	**8.27%**
Mar	8.83%	9.16%	7.08%	10.34%	**8.92%**
Apr	8.09%	8.14%	6.84%	8.77%	**8.09%**
May	8.53%	9.15%	7.66%	9.13%	**8.49%**
Jun	7.75%	8.67%	9.27%	8.86%	**7.90%**
Jul	7.39%	7.42%	7.20%	7.93%	**8.04%**
Aug	7.59%	8.78%	10.58%	9.60%	**8.62%**
Sep	8.44%	6.83%	7.64%	6.64%	**7.86%**
Oct	8.28%	8.12%	10.50%	9.10%	**8.97%**
Nov	9.93%	8.33%	5.14%	6.98%	7.59%
Dec	9.00%	7.68%	10.14%	8.56%	**9.00%**
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max.	9.93%	9.16%	10.58%	10.34%	9.00%
Min.	7.39%	6.83%	5.14%	5.66%	7.59%

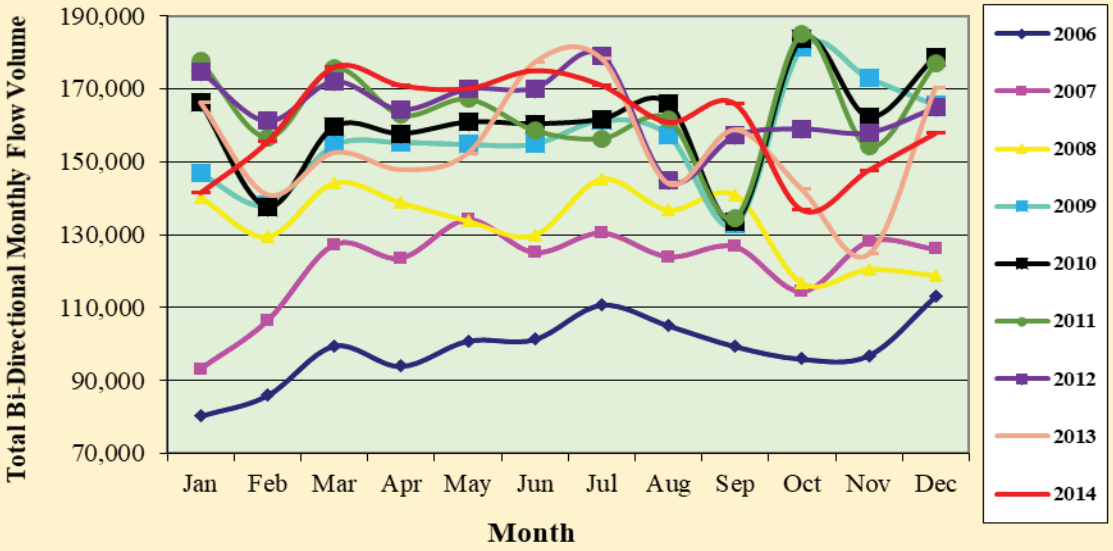


Figure 5.22: Seasonal Flow Variation of Medium Trucks on NH-1 (Both Direction), 2006-2014

Maximum monthly medium truck flow is found approximately 9% of yearly traffic and minimum flow is observed from 6% to 7% of yearly traffic from figure 5.22 and table 5.12. From the average of nine years of study data, maximum flow is found in July (8.88%) and minimum flow is found in February (7.66%). The number of medium trucks, which are accused of severe overloading in most of the cases, are increasing in quantity

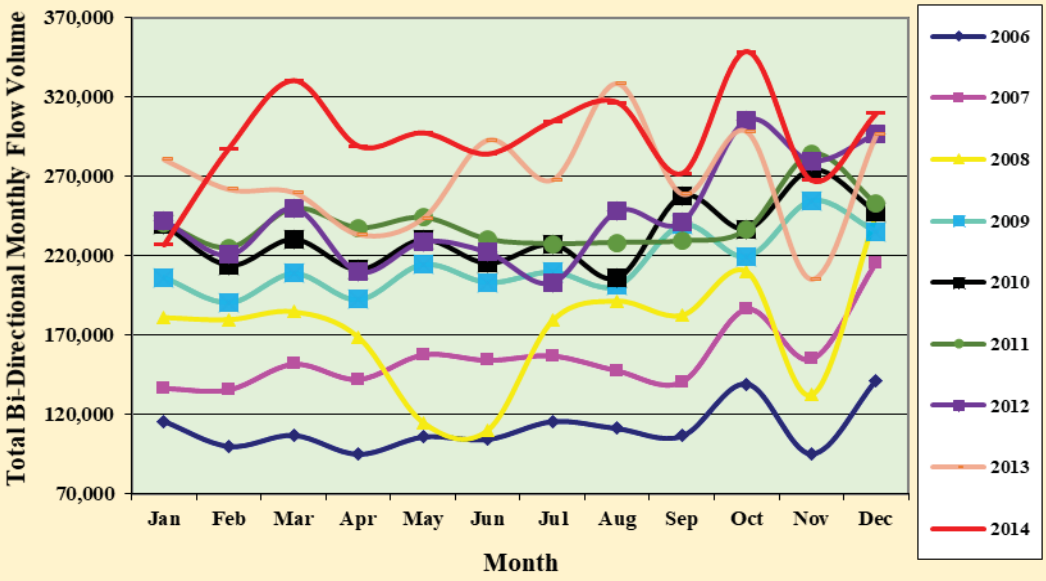
from approximately 90,000 to 180,000 in the last nine years at the same highway infrastructures. It is highly recommended to upgrade the highways into eight lanes in order to increase its capacity and simultaneously the structural design of the pavement should be amended based on the realistic condition, if overloading can't be restricted.

Table 5.12: Monthly Flow Variation of Medium Truck on NH-1

Month\ Year	2006	2007	2008	2009	2010
Jan	6.79%	6.38%	8.79%	7.82%	8.62%
Feb	7.26%	7.28%	8.12%	7.36%	7.14%
Mar	8.41%	8.72%	9.04%	8.24%	8.28%
Apr	7.94%	8.47%	8.70%	8.28%	8.18%
May	8.53%	9.19%	8.38%	8.25%	8.34%
Jun	8.56%	8.58%	8.14%	8.26%	8.32%
Jul	9.36%	8.94%	9.11%	8.60%	8.38%
Aug	8.88%	8.49%	8.58%	8.39%	8.61%
Sep	8.40%	8.68%	8.83%	7.07%	6.93%
Oct	8.11%	7.84%	7.31%	9.66%	9.52%
Nov	8.19%	8.78%	7.55%	9.22%	8.42%
Dec	9.56%	8.64%	7.44%	8.83%	9.27%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max.	9.56%	9.19%	9.11%	9.66%	9.52%
Min.	6.79%	6.38%	7.31%	7.07%	6.93%
Month\ Year	**2011**	**2012**	**2013**	**2014**	**Average (2006-2014)**
Jan	9.02%	8.85%	8.96%	7.33%	**8.06%**
Feb	7.97%	8.16%	7.60%	8.06%	**7.66%**
Mar	8.93%	8.71%	8.22%	9.12%	**8.63%**
Apr	8.28%	8.32%	7.97%	8.86%	**8.33%**
May	8.50%	8.60%	8.21%	8.82%	**8.54%**
Jun	8.06%	8.61%	9.55%	9.07%	**8.57%**
Jul	7.95%	9.07%	9.61%	8.87%	**8.88%**
Aug	8.22%	7.33%	7.76%	8.34%	**8.29%**
Sep	6.84%	7.96%	8.55%	8.60%	**7.99%**
Oct	9.40%	8.05%	7.67%	7.09%	**8.30%**
Nov	7.83%	8.00%	6.72%	7.66%	**8.04%**
Dec	8.99%	8.34%	9.18%	8.18%	**8.71%**
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max.	9.40%	9.07%	9.61%	9.12%	8.88%
Min.	6.84%	7.33%	6.72%	7.09%	7.66%

From figure 5.23 and table 5.13, it is observed that maximum monthly flow of light vehicles fluctuates from 9.5% to 12% of total yearly flow. Yet, minimum monthly flow of light vehicles differs from 5.30% to 7.80% of total yearly flow. From the average of nine years of study data, maximum flow is found in December (9.85%) and minimum flow is

found in April (7.62%). The numbers of light vehicles have increased approximately three times in the nine years' study data. Light vehicles are very accident prone in this congested NH-1 and need to improve geometric design and road safety along this corridor.



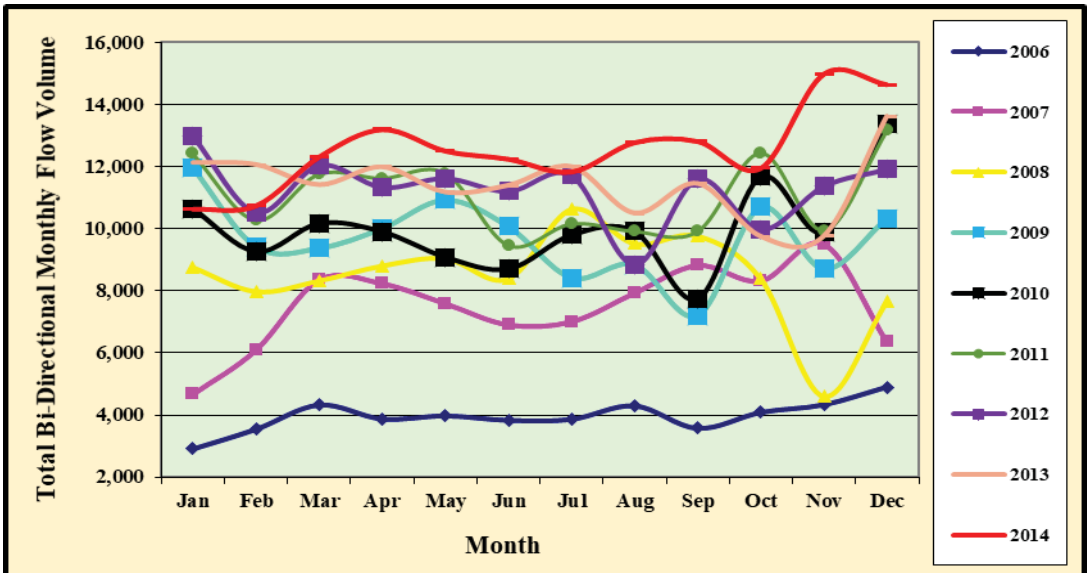
Fugure 5.23: Seasonal Flow Variation of Light Vehicles on NH-1 (Both Direction), 2006-2014

Table 5.13: Monthly Flow Variation of Light Vehicle on NH-1

Month\ Year	2006	2007	2008	2009	2010
Jan	8.65%	7.27%	8.70%	8.01%	8.58%
Feb	7.49%	7.22%	8.64%	7.40%	7.67%
Mar	8.00%	8.07%	8.88%	8.11%	8.26%
Apr	7.12%	7.56%	8.10%	7.47%	7.58%
May	7.92%	8.38%	5.53%	8.33%	8.25%
Jun	7.81%	8.20%	5.30%	7.89%	7.72%
Jul	8.64%	8.35%	8.61%	8.15%	8.14%
Aug	8.31%	7.85%	9.20%	7.81%	7.39%
Sep	7.96%	7.48%	8.77%	9.29%	9.23%
Oct	10.40%	9.91%	10.08%	8.52%	8.49%
Nov	7.14%	8.24%	6.36%	9.88%	9.83%
Dec	10.57%	11.46%	11.83%	9.12%	8.87%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max.	10.57%	11.46%	11.83%	9.88%	9.83%
Min.	7.12%	7.22%	5.30%	7.40%	7.39%
Month\ Year	**2011**	**2012**	**2013**	**2014**	**Average (2006-2014)**
Jan	8.33%	8.22%	8.69%	6.43%	**8.10%**
Feb	7.80%	7.48%	8.11%	8.14%	**7.77%**

Mar	8.66%	8.48%	8.05%	9.34%	**8.43%**
Apr	8.23%	7.12%	7.24%	8.18%	**7.62%**
May	8.46%	7.76%	7.55%	8.41%	**7.84%**
Jun	7.98%	7.54%	9.08%	8.04%	**7.73%**
Jul	7.88%	6.89%	8.30%	8.62%	**8.18%**
Aug	7.91%	8.42%	10.18%	8.95%	**8.45%**
Sep	7.94%	8.18%	8.02%	7.69%	**8.29%**
Oct	8.19%	10.36%	9.24%	9.86%	**9.45%**
Nov	9.85%	9.49%	6.36%	7.57%	**8.30%**
Dec	8.76%	10.06%	9.18%	8.76%	**9.85%**
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max.	9.85%	10.36%	10.18%	9.86%	9.85%
Min.	7.80%	6.89%	6.36%	6.43%	7.62%

Maximum monthly trailers flow is found approximately 9% to 11% of yearly traffic and minimum flow is observed from 4% to 7% of yearly traffic from figure 5.24 and table 5.14. From the average of nine years of study data, maximum flow is found in December (9.26%) and minimum flow is found in February (7.71%). The number of trailers have increased four times along NH-1 in the study period from 2006 to 2014.



Fugure 5.24: Seasonal Flow Variation of Trailer on NH-1 (Both Direction), 2006-2014

Table 5.14: Monthly Flow Variation of Trailers on NH-1

Month\ Year	2006	2007	2008	2009	2010
Jan	6.13%	5.20%	8.59%	10.32%	8.86%
Feb	7.46%	6.79%	7.83%	8.12%	7.71%
Mar	9.10%	9.31%	8.18%	8.08%	8.47%
Apr	8.15%	9.17%	8.65%	8.63%	8.24%

May	8.37%	8.45%	8.88%	9.43%	7.56%
Jun	8.06%	7.69%	8.24%	8.69%	7.24%
Jul	8.13%	7.80%	10.44%	7.26%	8.16%
Aug	9.05%	8.83%	9.35%	7.62%	8.25%
Sep	7.52%	9.82%	9.59%	6.20%	6.43%
Oct	8.60%	9.26%	8.24%	9.23%	9.72%
Nov	9.12%	10.59%	4.51%	7.51%	8.23%
Dec	10.32%	7.08%	7.51%	8.91%	11.13%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max.	10.32%	10.59%	10.44%	10.32%	11.13%
Min.	6.13%	5.20%	4.51%	6.20%	6.43%
Month\ Year	**2011**	**2012**	**2013**	**2014**	**Average (2006-2014)**
Jan	9.35%	9.60%	8.84%	7.06%	**8.22%**
Feb	7.73%	7.79%	8.79%	7.14%	**7.71%**
Mar	8.84%	8.92%	8.32%	8.18%	**8.60%**
Apr	8.75%	8.39%	8.73%	8.76%	**8.61%**
May	8.87%	8.60%	8.14%	8.30%	**8.51%**
Jun	7.12%	8.29%	8.30%	8.13%	**7.97%**
Jul	7.64%	8.67%	8.74%	7.86%	**8.30%**
Aug	7.46%	6.54%	7.65%	8.48%	**8.14%**
Sep	7.46%	8.58%	8.34%	8.51%	**8.05%**
Oct	9.36%	7.38%	7.10%	7.93%	**8.54%**
Nov	7.49%	8.41%	7.11%	9.94%	**8.10%**
Dec	9.92%	8.82%	9.93%	9.72%	**9.26%**
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max.	9.92%	9.60%	9.93%	9.94%	9.26%
Min.	7.12%	6.54%	7.10%	7.06%	7.71%

Summary of Findings:

Following are the summarized findings from the seasonal flow analyses in NH-1.

Table 5.15: Summary Table - Seasonal Flow Variation (average of nine years)

Vehicle Class	Maximum Flow		Minimum Flow	
	Month	Percentage of Yearly Volume	Month	Percentage of Yearly Volume
Total Traffic	December	9.29%	February	7.79%
Medium Truck	July	8.88%	February	7.66%
Large Bus	December	9.00%	November	7.59%
Light Vehicles	December	9.85%	April	7.62%
Trailers	December	9.26%	February	7.71%

5.6 CALCULATION OF EXPANSION FACTORS OF DHAKA-CHITTAGONG HIGHWAY

Daily and monthly expansion factors have been established in the section below from study traffic database of Meghna and Gumuti bridges which can be used to estimate AADT from short counts.

5.6.1 CALCULATION OF DAILY EXPANSION FACTORS IN NH-1

Attempts have been made in this study to determine daily expansion factors of National Highway No. 1 from the daily traffic data of 2006 to 2014. The crude data have been processed to determine the average daily flow for each of seven days of week individually for all nine years. Daily expansion factors for each year have been determined from dividing average weekly flow by average weekday flow. At that point, those daily expansion factors representing their respective years have again been averaged to achieve the average Daily Expansion Factors. Table 5.16 displays the daily expansion factors and yearly average flow on each weekday from 2006 to 2014. Summation of these daily flows for seven weekdays gives average weekly flow, which have been determined individually for every year. From these data, Daily Expansion Factors are calculated. Taking the mean value for daily expansion factors for the years 2006 to 2014, 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 5.16: Daily Expansion Factors in NH-1

Day \ Year	2006		2007		2008		2009	
	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF
Saturday	8,824	6.97	11,274	7.34	12,391	7.31	14,758	7.32
Sunday	8,181	7.52	11,067	7.48	12,416	7.29	14,633	7.38
Monday	8,339	7.38	11,235	7.36	12,295	7.36	14,637	7.38
Tuesday	8,349	7.37	11,375	7.27	12,461	7.27	15,126	7.14
Wednesday	8,334	7.38	12,014	6.89	12,795	7.08	15,202	7.11
Thursday	9,116	6.75	12,378	6.68	13,390	6.76	15,978	6.76

Friday	10,358	5.94	13,399	6.18	14,784	6.12	17,681	6.11
Avg. Weekly Flow	61,502		82,742		90,533		108,016	

Day \ Year	2010		2011		2012		2013	
	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF
Saturday	15,689	7.23	16,769	6.91	17,311	6.89	18,722	6.62
Sunday	15,121	7.50	15,440	7.51	15,879	7.52	17,108	7.25
Monday	15,642	7.25	15,558	7.45	16,232	7.35	17,087	7.26
Tuesday	15,807	7.17	16,259	7.13	16,070	7.43	16,114	7.70
Wednesday	16,039	7.07	16,166	7.17	16,897	7.06	16,291	7.61
Thursday	16,664	6.80	16,708	6.94	17,414	6.85	18,096	6.85
Friday	18,437	6.15	19,044	6.09	19,552	6.10	20,591	6.02
Avg. Weekly Flow	113,398		115,943		119,357		124,009	

Day \ Year	2014		Average	
	Avg. Flow	DEF	Avg. Flow	DEF
Saturday	19,841	6.79	15,064	7.01
Sunday	18,121	7.43	14,218	7.42
Monday	18,417	7.31	14,382	7.34
Tuesday	18,996	7.09	14,506	7.28
Wednesday	18,458	7.29	14,688	7.19
Thursday	19,016	7.08	15,418	6.85
Friday	21,778	6.18	17,292	6.11
Avg. Weekly Flow	134,625		105,569	

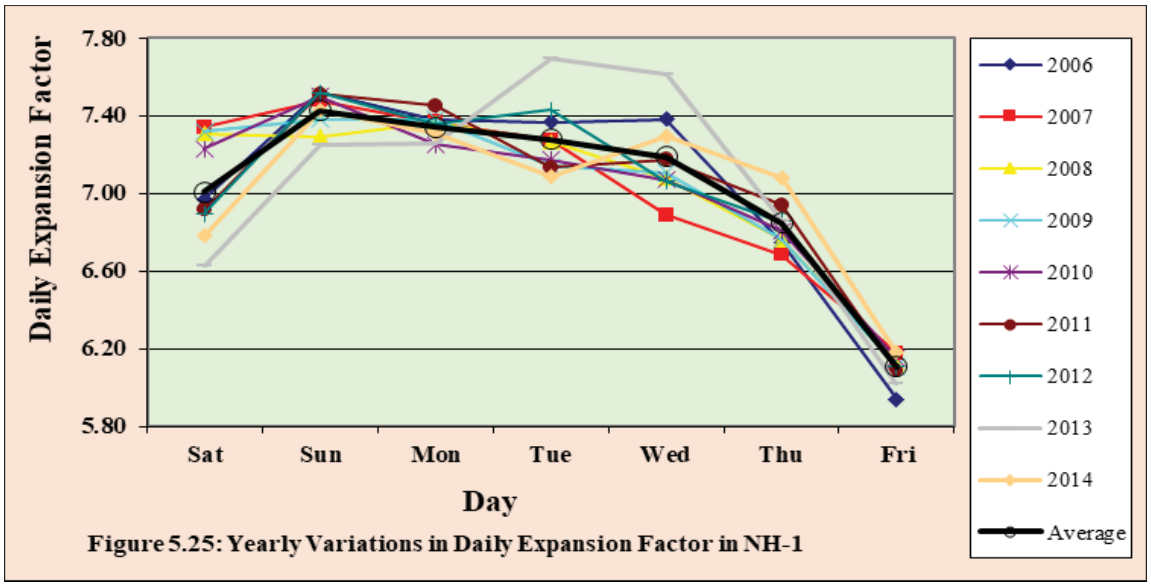


Figure 5.25: Yearly Variations in Daily Expansion Factor in NH-1

Nine years' yearly variations of daily expansion factors along Dhaka-Chittagong highway is designed in figure 5.25. The average highest DEF is found on Sunday (7.42) and the average lowest DEF is on Friday (6.11). The analyses indicate that the minimum flow should be found on Sunday and maximum flow supposes to be on Friday.

All vehicle classes do not exhibit similar daily flow fluctuation, so daily expansion factors need to be determined and used separately for each vehicle class. Table 5.17 shows the class wise daily expansion factors.

Table 5.17: Class-wise Daily Expansion Factors in NH-1

Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
Saturday	6.47	6.88	6.26	6.62	6.65	6.44	8.26	8.23	6.36	7.01
Sunday	7.44	7.43	7.90	7.51	7.18	7.01	7.45	7.66	7.15	7.42
Monday	7.47	7.42	7.99	7.46	7.17	7.16	7.09	7.75	7.25	7.33
Tuesday	7.79	7.30	8.12	7.58	7.29	7.40	6.74	6.82	7.43	7.27
Wednesday	7.69	7.41	8.03	7.53	7.30	7.43	6.57	6.55	7.19	7.18
Thursday	6.91	6.72	7.08	7.12	6.79	6.94	6.64	6.42	7.02	6.86
Friday	5.75	6.08	5.01	5.66	6.70	6.73	6.55	6.11	6.72	6.11

5.6.2 CALCULATION OF MONTHLY EXPANSION FACTORS IN NH-1

Each of concerned years has been calculated at first to determine monthly expansion factors. Then those expansion factors have been averaged to determine the final monthly expansion factors. Table 5.18 (a, b, c, d & e) below contains the monthly expansion factors on Meghna-Gumuti bridges corridor for each individual year from 2006 to 2014, while the average values obtained from these are given in the later part of the table.

Table 5.18a: Monthly Expansion Factors in 2014 & 2013

Month \ Year	2014			2013		
	Flow	ADT	MEF	Flow	ADT	MEF
January	469,000	15,129	**1.271**	571,349	18,431	**0.961**
February	568,800	20,314	**0.947**	513,774	18,349	**0.965**
March	654,660	21,118	**0.911**	522,770	16,864	**1.050**
April	592,488	19,750	**0.974**	487,590	16,253	**1.090**
May	603,622	19,472	**0.988**	503,899	16,255	**1.089**
June	590,175	19,673	**0.978**	597,735	19,925	**0.889**

July	605,453	19,531	**0.985**	559,599	18,052	**0.981**
August	622,103	20,068	**0.959**	613,240	19,782	**0.895**
September	554,010	18,467	**1.042**	533,527	17,784	**0.996**
October	625,965	20,192	**0.953**	561,955	18,128	**0.977**
November	533,088	17,770	**1.082**	416,639	13,888	**1.275**
December	599,619	19,343	**0.994**	582,487	18,790	**0.942**
Total		230825			212499	
AADT		19235			17708	

Table 5.18b: Monthly Expansion Factors in 2012 & 2011

Month \ Year	**2012**			**2011**		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	522,201	16,845	**1.012**	517,868	16,705	**0.992**
February	490,460	16,912	**1.008**	473,737	16,919	**0.979**
March	533,640	17,214	**0.990**	530,898	17,126	**0.967**
April	467,980	15,599	**1.093**	497,869	16,596	**0.998**
May	503,448	16,240	**1.050**	512,614	16,536	**1.002**
June	492,290	16,410	**1.039**	481,405	16,047	**1.032**
July	469,585	15,148	**1.125**	474,700	15,313	**1.082**
August	501,742	16,185	**1.053**	479,789	15,477	**1.070**
September	502,540	16,751	**1.017**	463,908	15,464	**1.071**
October	585,166	18,876	**0.903**	520,681	16,796	**0.986**
November	576,798	19,227	**0.886**	553,986	18,466	**0.897**
December	592,804	19,123	**0.891**	538,364	17,367	**0.954**
Total		204531			198811	
AADT		17044			16568	

Table 5.18c: Monthly Expansion Factors in 2010 & 2009

Month \ Year	**2010**			**2009**		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	506,324	16,333	**0.992**	453,185	14,619	**1.056**
February	450,000	16,071	**1.008**	424,170	15,149	**1.019**
March	498,985	16,096	**1.007**	464,702	14,990	**1.030**
April	463,220	15,441	**1.050**	444,537	14,818	**1.042**
May	491,998	15,871	**1.021**	472,871	15,254	**1.012**
June	468,513	15,617	**1.038**	457,681	15,256	**1.012**
July	485,985	15,677	**1.034**	467,515	15,081	**1.023**
August	460,937	14,869	**1.090**	452,142	14,585	**1.058**

September	495,200	16,507	**0.982**	470,306	15,677	**0.985**
October	520,469	16,789	**0.965**	503,949	16,256	**0.949**
November	542,724	18,091	**0.896**	523,644	17,455	**0.884**
December	530,778	17,122	**0.947**	498,096	16,068	**0.961**
Total		194484			185208	
AADT		16207			15434	

Table 5.18d: Monthly Expansion Factors in 2008 & 2007

Month \ Year	**2008**			**2007**		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	416,396	13,432	**0.962**	295,193	9,522	**1.241**
February	403,447	13,912	**0.929**	312,740	11,169	**1.058**
March	429,778	13,864	**0.932**	360,112	11,617	**1.017**
April	402,048	13,402	**0.964**	345,105	11,504	**1.027**
May	326,242	10,524	**1.228**	375,049	12,098	**0.976**
June	292,239	9,741	**1.327**	359,441	11,981	**0.986**
July	415,725	13,410	**0.964**	369,120	11,907	**0.992**
August	422,798	13,639	**0.948**	352,299	11,364	**1.040**
September	409,367	13,646	**0.947**	346,617	11,554	**1.022**
October	427,631	13,795	**0.937**	393,615	12,697	**0.930**
November	319,814	10,660	**1.212**	366,653	12,222	**0.967**
December	467,464	15,079	**0.857**	437,893	14,126	**0.836**
Total		155104			141761	
AADT		12925			15434	

Table 5.18e: Monthly Expansion Factors in 2006 & ”Average MEF (2006-2014)”

Month \ Year	**2006**			**Average (2006 to 2014)**
	Flow	**ADT**	**MEF**	**MEF**
January	250,988	8,096	**1.083**	**1.241**
February	238,820	8,235	**1.064**	**1.058**
March	265,789	8,574	**1.022**	**1.017**
April	243,965	8,132	**1.078**	**1.027**
May	266,474	8,596	**1.020**	**0.976**
June	261,144	8,705	**1.007**	**0.986**
July	288,475	9,306	**0.942**	**0.992**
August	277,259	8,944	**0.980**	**1.040**
September	263,283	8,776	**0.999**	**1.022**
October	298,482	9,628	**0.910**	**0.930**

November	240,141	8,005	**1.095**	**0.967**
December	315,590	10,180	**0.861**	**0.836**
Total		105177		
AADT		8765		

Notes:

- The above MEF can be directly used to estimate AADT from Avg. 24-hour volume.

Monthly expansion factors are found between 0.90 to 1.1 along NH-1 in figure 5.26 below. More years of data is needed to bring certain correlations between MEF and seasonal traffic flow in this corridor. However, no significant difference pattern is observed for individual vehicle class and total vehicle in NH-1 corridor yet. Therefore, at this stage monthly expansion factors for individual vehicle class is not necessarily to be used for AADT estimation, rather average factors may be effectively applied.

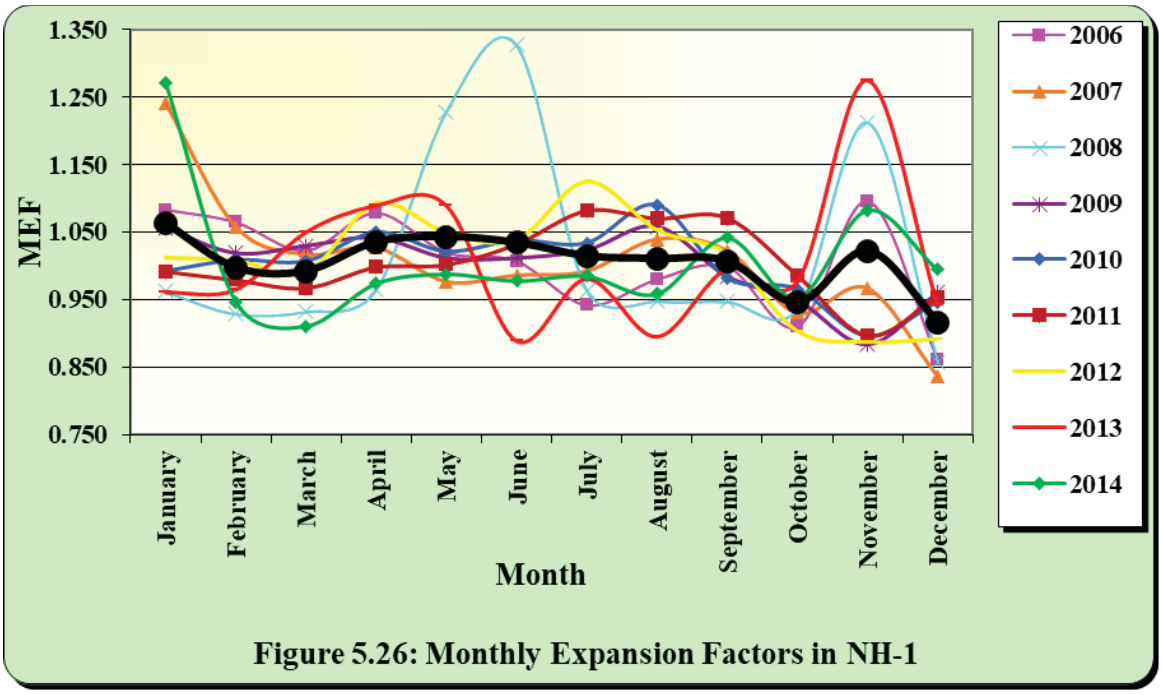


Figure 5.26: Monthly Expansion Factors in NH-1

5.7 CALCULATION OF INDIVIDUAL VEHICLE CLASS WISE GROWTH FACTOR OF DHAKA-CHITTAGONG HIGHWAY

Individual vehicular class wise growth pattern has been studied in this research for NH-1. Each vehicle has its own traffic growth pattern and it is highly recommended to design and maintain this highway based upon the individual traffic pattern to get the realistic outcome to cope with road safety and traffic operations. Free flow of traffic is only achieved when actual traffic data is used for highway simulations and road operations.

Table 5.19: Class-wise Total Yearly Traffic in Both Direction (2006 to 2014)

Year	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
2006	9,743	15976	433710	455243	431617	500227	1178966	47118	133677	**3,206,277**
2007	22,729	76496	569262	667038	570851	680413	1459489	89800	177759	**4,313,837**
2008	36,975	206866	609759	742149	524010	715618	1594506	101870	201196	**4,732,949**
2009	46,896	291080	756199	994568	535970	788149	1876198	115995	227743	**5,632,798**
2010	58,592	380482	775542	1088516	546567	764866	1928190	120155	252223	**5,915,501**
2011	70,288	501759	754280	1120458	510201	717949	1967304	132892	270688	**6,045,819**
2012	126,136	502090	809729	1154688	494438	707788	1974868	135201	333716	**6,239,174**
2013	236,482	642679	959988	1183931	443782	554718	1856116	137258	449610	**6,464,564**
2014	261,774	545643	1101779	1345817	542612	625547	1929411	150717	515683	**7,018,983**
Average	96,624	351,452	752,250	972,490	511,116	672,808	1,751,672	114,556	284,699	5,507,767

Distinct traffic growth pattern is observed in table 5.20 below. The growth pattern seems stabilizing along this highway from 2011 to 2014. More years of data is needed to predict class wise growth factor along NH-1. Road authority of Bangladesh should monitor individual vehicular class wise growth factor for next upcoming years and may come to some distinct conclusions in future. Proper traffic monitoring is the only solutions to overcome this hurdle.

Table 5.20: Class-wise Traffic Growth Factors

Year	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
2006	-	-	-	-	-	-	-	-	-	-
2007	133	379	31	47	32	36	24	91	33	35
2008	63	170	7	11	-8	5	9	13	13	10
2009	27	41	24	34	2	10	18	14	13	19
2010	25	31	3	9	2	-3	3	4	11	5
2011	20	32	-3	3	-7	-6	2	11	7	2
2012	79	0	7	3	-3	-1	0	2	23	3
2013	87	28	19	3	-10	-22	-6	2	35	4
2014	11	-15	15	14	22	13	4	10	15	9
Avg. GF	56%	83%	13%	15%	4%	4%	7%	18%	19%	11%
Std. Dvtn.	43	132	11	16	15	17	10	30	10	11

5.8 REGRESSION ANALYSIS OF TRAFFIC IN DHAKA-CHITTAGONG HIGHWAY

Regression analyses of traffic flow is performed in NH-1 and specific equations have been developed and corresponding calibration curves are drawn to calculate AADT.

Traffic database have been sorted and concise for regression analyses. Using the summarized database, the regression analyses have been performed and models have been rendered. The article below shows the equations and models derived by regression analyses in Dhaka-Chittagong highway.

5.8.1 DAILY REGRESSION MODEL FOR NH-1 CORRIDOR

The daily traffic flow data on NH-1 from 2006 to 2014 collected by RCL and MBEL-ATT JV provides daily regression models for expansion of short counts. Total 468 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models.

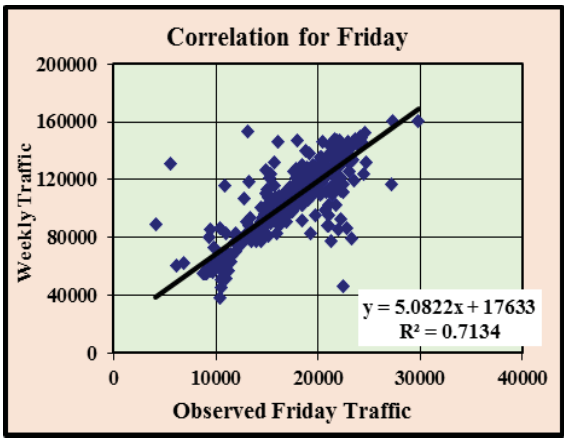
Table 5.21: Daily Regression Models for NH-1

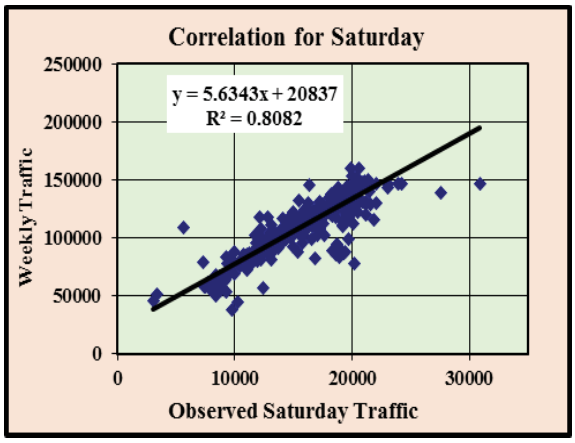
Day	Equation	R^2 value
Saturday	y = 5.6343x + 20837	0.8082
Sunday	y = 5.3319x + 29913	0.7571
Monday	y = 5.2743x + 29586	0.7825
Tuesday	y = 5.218x + 29976	0.7473
Wednesday	y = 5.4798x + 24993	0.7731
Thursday	y = 5.2256x + 25038	0.7397
Friday	y = 5.0822x + 17633	0.7134

Where:

x = observed daily traffic, y = weekly traffic

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





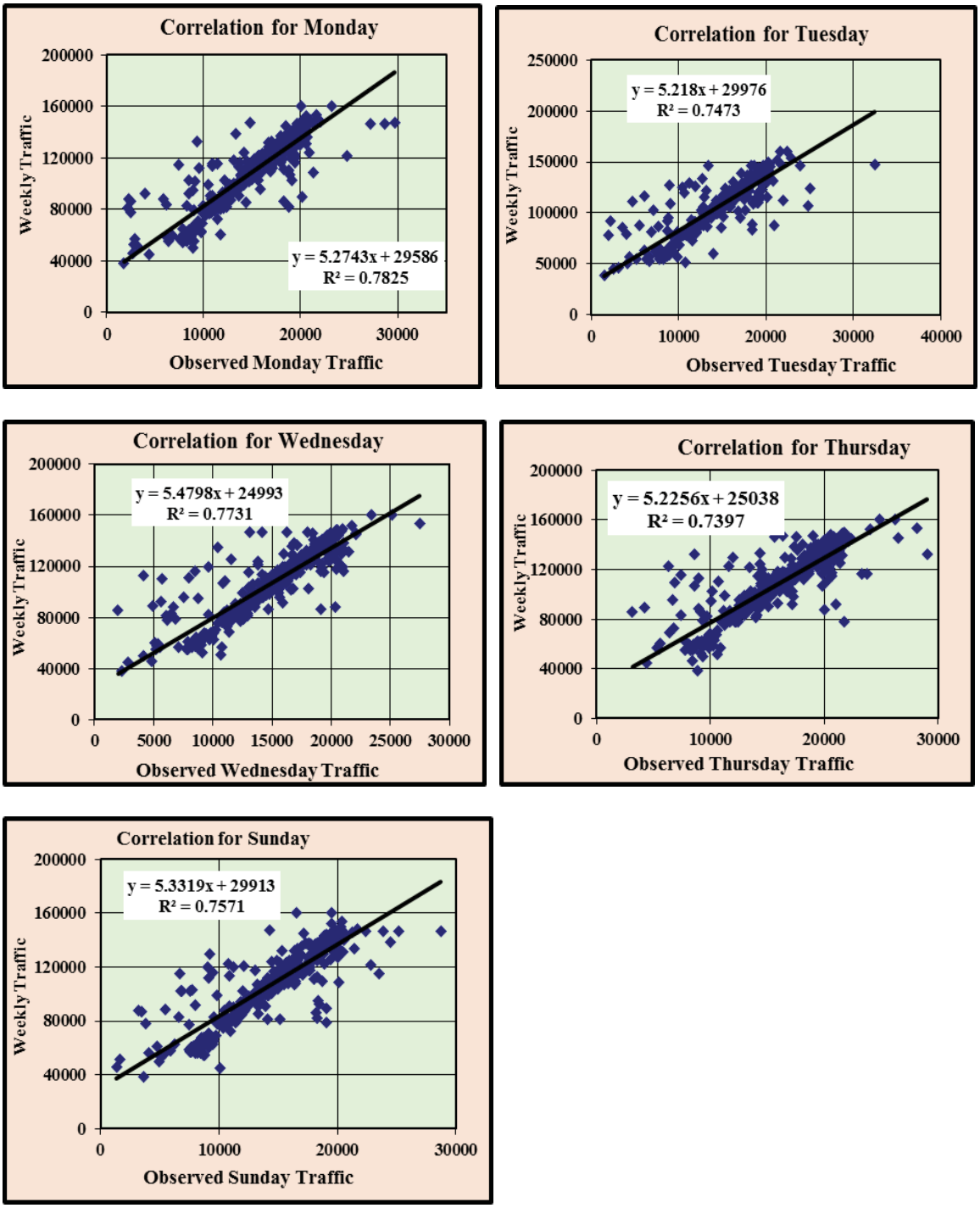


Figure 5.27: Daily regression models for NH-1

5.8.2 MONTHLY REGRESSION MODEL FOR NH-1 CORRIDOR

For the regression analysis of monthly or seasonal expansions, nine years of flow data on Meghna-Gomoti Bridge collected by RCL and MBEL-ATT JV have been used. Linear regression has been performed for each of twelve months by plotting monthly flow

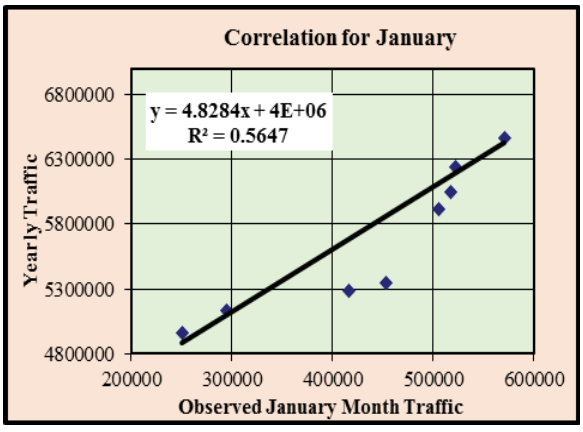
against respective yearly flow. The equations along with respective R^2 values are shown below in Table 5.22.

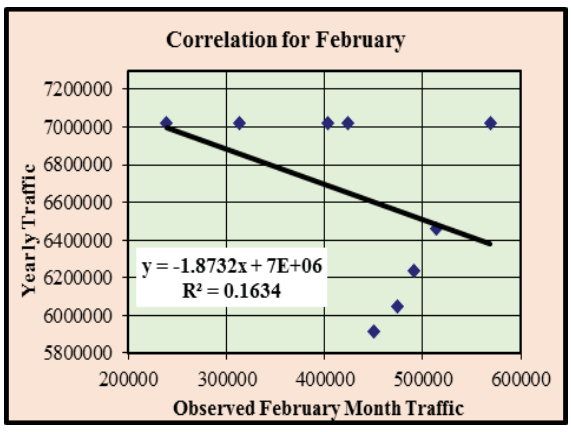
Table 5.22: Monthly Regression Models for NH-1

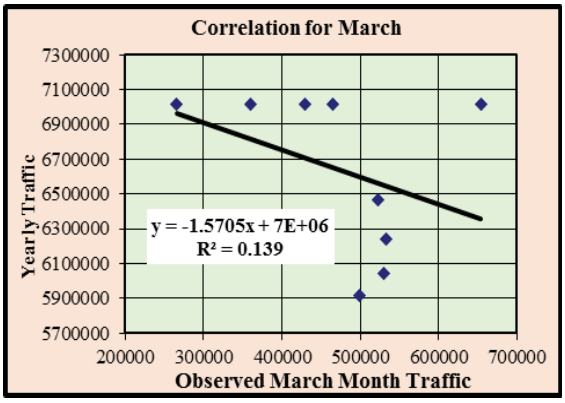
Month	Equation	R^2 value
January	y = 4.8284x + 4E+06	0.5647
February	y = -1.8732x + 7E+06	0.1634
March	y = -1.5705x + 7E+06	0.139
April	y = -1.7193x + 7E+06	0.1307
May	y = -1.9575x + 8E+06	0.1932
June	y = -1.6319x + 7E+06	0.1685
July	y = -1.4932x + 7E+06	0.0895
August	y = -1.241x + 7E+06	0.0845
September	y = -2.2019x + 8E+06	0.1908
October	y = -1.9757x + 8E+06	0.1846
November	y = -2.3552x + 8E+06	0.3623
December	y = -2.499x + 8E+06	0.2313

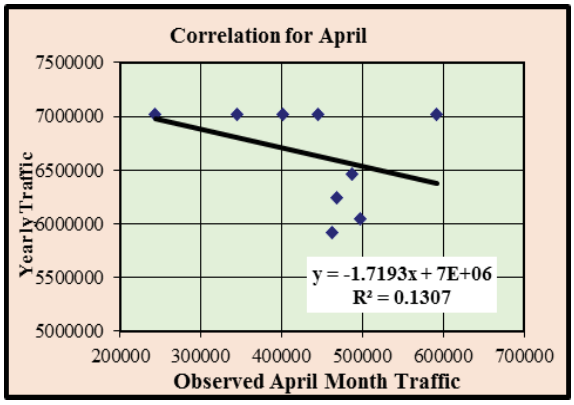
Where: x = observed monthly traffic, y = yearly traffic volume

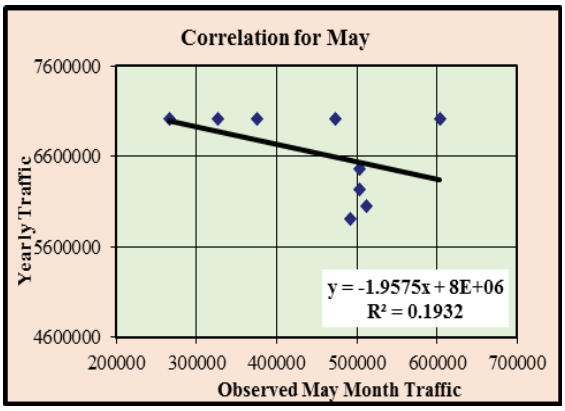
The linear regression curves are given on the following pages. These daily and monthly calibration curves can be directly used to estimate AADT from daily flow.

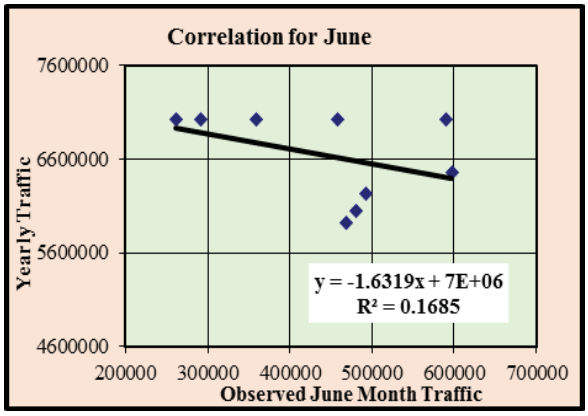


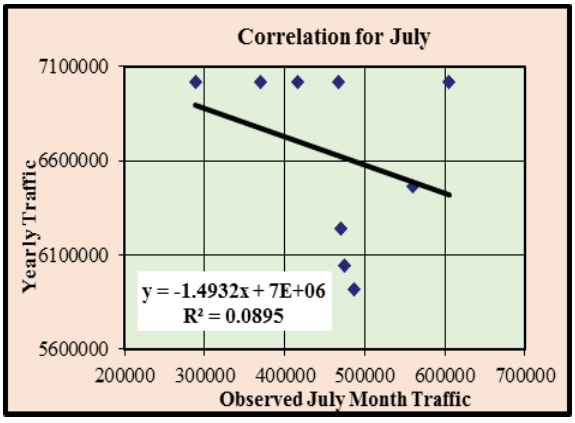


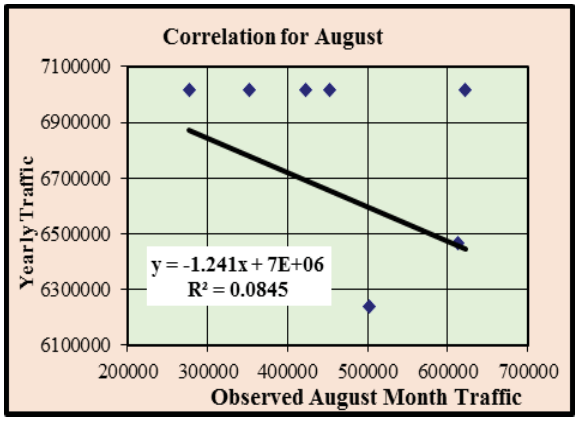

Correlation for March
Yearly Traffic
Observed March Month Traffic
y = -1.5705x + 7E+06
R² = 0.139

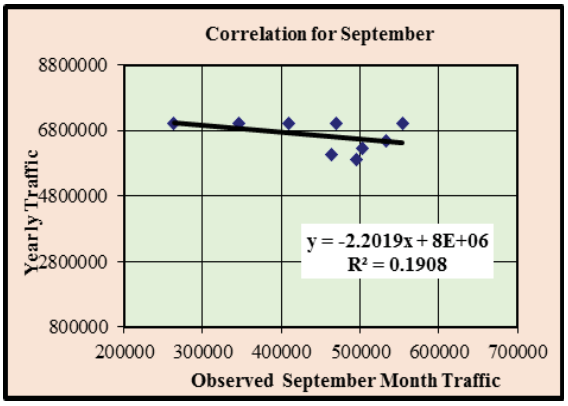

Correlation for April
Yearly Traffic
Observed April Month Traffic
y = -1.7193x + 7E+06
R² = 0.1307

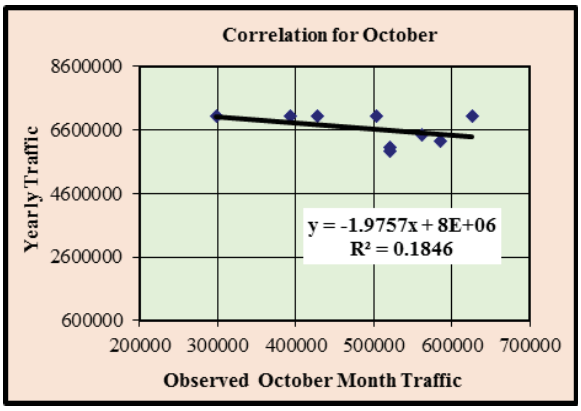

Correlation for May
Yearly Traffic
Observed May Month Traffic
y = -1.9575x + 8E+06
R² = 0.1932


Correlation for June
Yearly Traffic
Observed June Month Traffic
y = -1.6319x + 7E+06
R² = 0.1685


Correlation for July
Yearly Traffic
Observed July Month Traffic
y = -1.4932x + 7E+06
R² = 0.0895


Correlation for August
Yearly Traffic
Observed August Month Traffic
y = -1.241x + 7E+06
R² = 0.0845


Correlation for September
Yearly Traffic
Observed September Month Traffic
y = -2.2019x + 8E+06
R² = 0.1908


Correlation for October
Yearly Traffic
Observed October Month Traffic
y = -1.9757x + 8E+06
R² = 0.1846

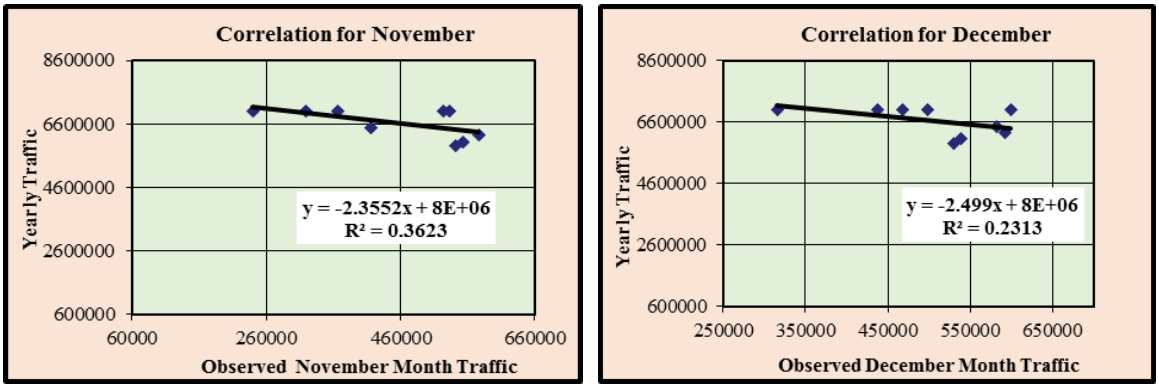


Figure 5.28: Monthly regression models for NH-1

5.9 DETERMINATION OF TRAFFIC FLOW MODEL USING ARTIFICIAL NEURAL NETWORK IN DHAKA-CHITTAGONG HIGHWAY

"Zaitun time series" software is used to prepare ANN model for NH-1. The neural network analysis interface is shown below in figure 5.29.

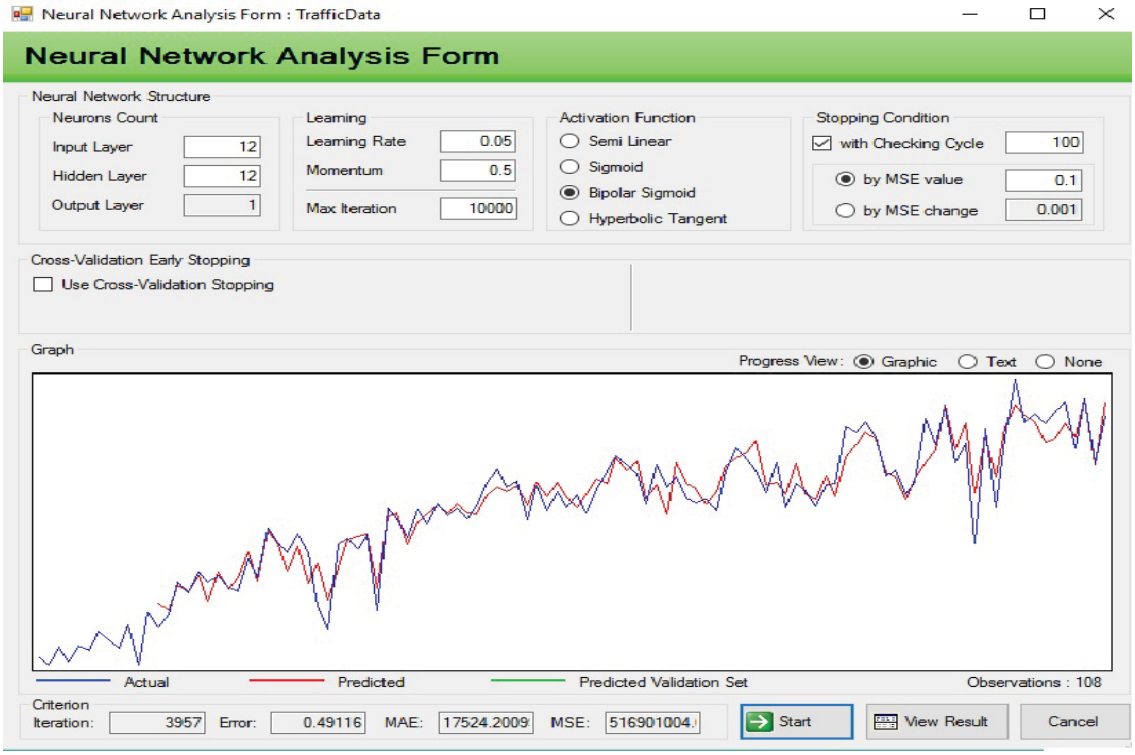


Figure 5.29: Artificial Neural Network Model Interface for Traffic Prediction in NH-1

The mentioned software uses a general form of back propagation algorithm to the network to the input and output data. Monthly traffic volume is used as variable called "TrafficData". There are 108 number of observations are trained for this study. Bipolar sigmoid function is used with 12 input layer neurons, 12 hidden layer neurons and 1 output layer neurons. Back propagation learning method with learning rate 0.05 and

momentum 0.5 is set in this model. Data training is completed by the actual traffic of the concern year and then, predicted traffic volume of corresponding months is carried out to realize and understand the predicting capability of ANN. The details of monthly actual traffic and predicted traffic from 2009 to 2014 is shown as sample in table 5.23. It is surprising to observe that the ANN model of the traffic data is accurate enough to capture the trend of the data over the months of traffic volume measurement. Figure 5.30 and 5.31 is illustrating actual vs predicted traffic flow along NH-1. This has been a check to find out how the ANN captures the data pattern.

Table 5.23: Monthly Traffic Data Prediction by using ANN model

Months	Actual Traffic	Predicted Traffic	Months	Actual Traffic	Predicted Traffic	Months	Actual Traffic	Predicted Traffic
Jan-12	522,201	545,791	**Jan-13**	571,349	567,154	**Jan-14**	469,000	489,772
Feb-12	490,460	494,196	**Feb-13**	513,774	506,642	**Feb-14**	568,800	580,268
Mar-12	533,640	503,220	**Mar-13**	522,770	533,799	**Mar-14**	654,660	626,823
Apr-12	467,980	488,271	**Apr-13**	487,590	505,572	**Apr-14**	592,488	588,607
May-12	503,448	503,345	**May-13**	503,899	503,402	**May-14**	603,622	604,026
Jun-12	492,290	503,362	**Jun-13**	597,735	540,156	**Jun-14**	590,175	575,526
Jul-12	469,585	483,662	**Jul-13**	559,599	578,262	**Jul-14**	605,453	579,589
Aug-12	501,742	483,660	**Aug-13**	613,240	607,324	**Aug-14**	622,103	619,907
Sep-12	502,540	490,266	**Sep-13**	533,527	554,162	**Sep-14**	554,010	554,293
Oct-12	585,166	571,681	**Oct-13**	561,955	585,246	**Oct-14**	625,965	636,400
Nov-12	576,798	558,093	**Nov-13**	416,639	441,883	**Nov-14**	533,088	527,435
Dec-12	592,804	579,808	**Dec-13**	582,487	577,846	**Dec-14**	599,619	609,743
Months	**Actual Traffic**	**Predicted Traffic**	**Months**	**Actual Traffic**	**Predicted Traffic**	**Months**	**Actual Traffic**	**Predicted Traffic**
Jan-09	453,185	457,684	**Jan-10**	506,324	496,639	**Jan-11**	517,868	523,851
Feb-09	424,170	420,488	**Feb-10**	450,000	462,446	**Feb-11**	473,737	472,402
Mar-09	464,702	459,705	**Mar-10**	498,985	517,573	**Mar-11**	530,898	521,703
Apr-09	444,537	456,226	**Apr-10**	463,220	481,713	**Apr-11**	497,869	458,463
May-09	472,871	472,453	**May-10**	491,998	501,184	**May-11**	512,614	519,941
Jun-09	457,681	461,319	**Jun-10**	468,513	473,642	**Jun-11**	481,405	508,932
Jul-09	467,515	469,629	**Jul-10**	485,985	466,716	**Jul-11**	474,700	490,952
Aug-09	452,142	453,822	**Aug-10**	460,937	495,050	**Aug-11**	479,789	475,339
Sep-09	470,306	460,034	**Sep-10**	495,200	512,407	**Sep-11**	463,908	479,783
Oct-09	503,949	496,666	**Oct-10**	520,837	516,537	**Oct-11**	520,681	536,279
Nov-09	523,644	507,595	**Nov-10**	542,724	544,068	**Nov-11**	553,986	548,470
Dec-09	498,096	496,686	**Dec-10**	530,778	528,429	**Dec-11**	538,364	570,229

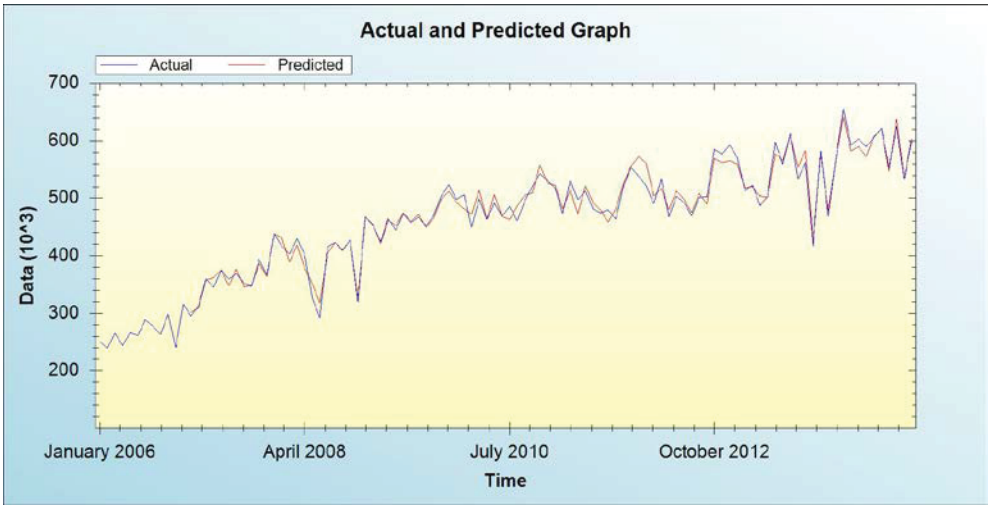


Figure 5.30: Artificial Neural Network Model-Actual and Predicted traffic in NH-1

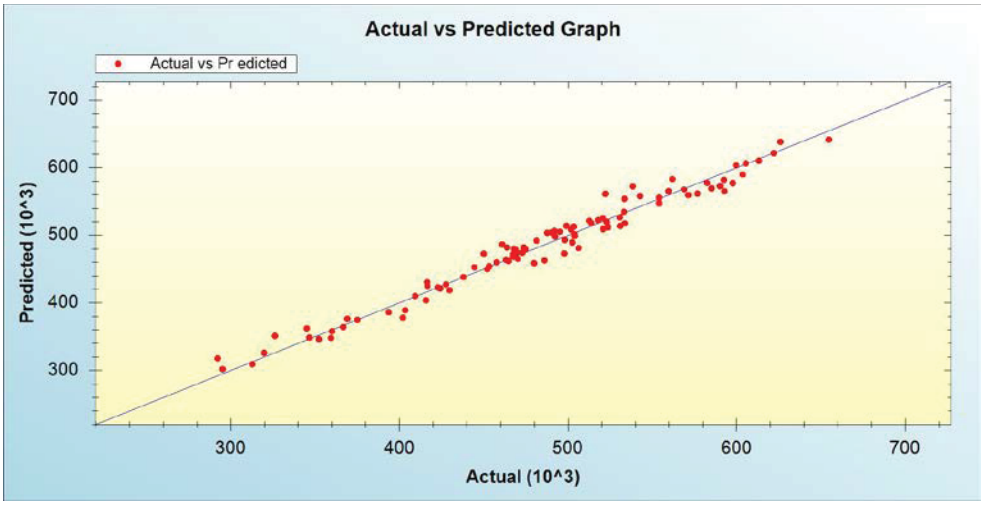


Figure 5.31: Artificial Neural Network Model-Comparison of Actual VS Predicted traffic in NH-1

Traffic forecasting have been studied through ANN model in Dhaka-Chittagong highway. Monthly traffic data have been trained from 2006 to 2014 in the neural network model. Traffic forecasting is observed in figure 5.32 and table 5.24. Artificial neural networks (ANNs) have proven to be an important development in a variety of problem solving areas. Increasing research activity in ANN applications has been accompanied by equally rapid growth in the commercial mainstream use of ANNs. The special characteristics make ANNs especially useful in a variety of applications. An ANN can provide an approach that is closer to human perception and recognition than traditional methods. In situations in which input is noisy or incomplete, ANNs can still produce reasonable results. The forecasted residual traffic in NH-1 have been found in figure 5.33.

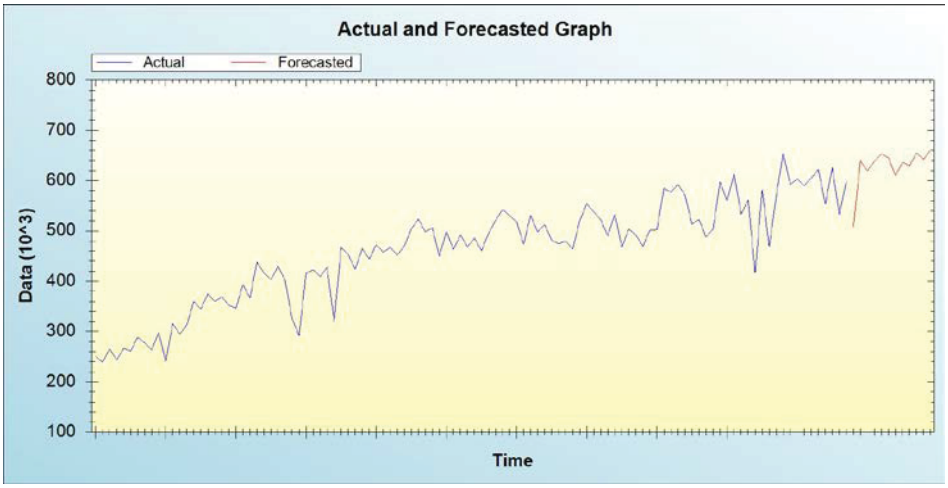


Figure 5.32: Artificial Neural Network Model-Actual and Forecasted traffic in NH-1

Table 5.24: Traffic Forecasting using ANN model along NH-1

Month	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15
Forecasting of Monthly Traffic	508,455	639,477	619,487	638,522	653,189	645,580
Month	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15
Forecasting of Monthly Traffic	610,015	636,647	629,555	655,006	642,534	661,218

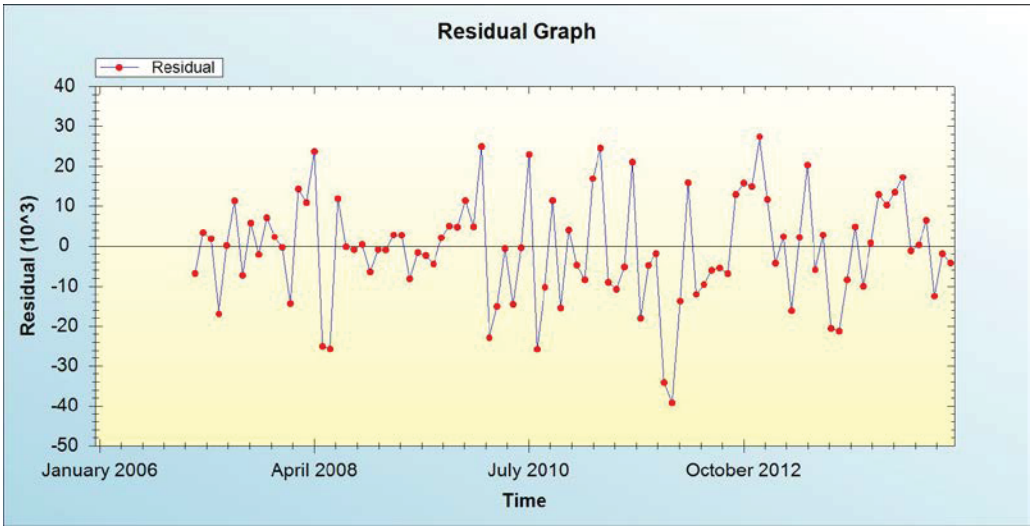


Figure 5.33: Artificial Neural Network Model-Residual Traffic in NH-1

5.10 OVERVIEW OF TRAFFIC FLOW ANALYSES IN NATIONAL HIGHWAY NO.1 (DHAKA-CHITTAGONG HIGHWAY)

Detail traffic flow analyses of National Highway No.1 is discussed in this chapter based upon nine years of vehicle class wise daily traffic data that put emphasis on different

traffic flow parameters. More realistic pavement design, vehicle operations and traffic planning can be achieved through this research. As currently in Bangladesh road agencies have set 10% traffic growth factor per year for all national highways and no traffic survey or detail parametric analyses have done by GoB engineering agencies till now. However, the following outcome have been extracted in this chapter of the research:

- The average traffic growth factor is found 10.71% per annum.
- Individual vehicle class wise traffic growth factors are also calculated in this chapter.
- Traffic composition patterns have been established along NH-1.
- Heavy vehicle percentages like Truck percentage and Bus percentage is calculated in this corridor.
- Daily and Monthly directional distributions are designed in NH-1.
- The in-depth daily, weekly and seasonal traffic nature have been established.
- Daily and monthly traffic expansion factors and regression models are calculated for this highway.
- Traffic flow and prediction models have been prepared based on artificial neural network.

The next chapter will discuss detail traffic flow analyses of National Highway No. 5 of Bangladesh.

CHAPTER 6

ASSESSMENT OF TRAFFIC FLOW PARAMETERS: NATIONAL HIGHWAY NO. 5 (DHAKA-NORTH BENGAL HIGHWAY CORRIDOR)

6.1 INTRODUCTION

The National Highway No.5 connects the capital Dhaka to the town of Banglabandha on the Bangladesh-India border. This national highway is the backbone of the road infrastructure connecting the North Bengal districts of Bangladesh with the capital Dhaka. Attempts have been made through this study to prepare traffic flow parameters along NH-5 of Bangladesh. Daily traffic data have been collected from Bangabandhu bridge, commonly called the Jamuna Multi-Purpose Bridge is a bridge opened in Bangladesh in June 1998. It connects Bhuapur on the Jamuna River's east bank to Sirajganj on its west bank. It was the 11th longest bridge in the world when constructed in 1998 and currently the 6th longest bridge in South Asia. It was constructed over the Jamuna River, one of the three major rivers of Bangladesh, and fifth largest in the world in discharge volume. This chapter deliberates detail traffic data analyses and flow characteristics along Dhaka to North Bengal Highway corridor.

6.2 CALCULATION OF TRAFFIC GROWTH FACTOR OF DHAKA-NORTH BENGAL HIGHWAY

Accurate determination of traffic growth factor plays a vital role for efficient traffic design and operations. Countries like Bangladesh have high volume of mix traffic within less land, limited resources and fewer amount of road infrastructures. The extent of traffic flow is growing every successive year along Dhaka to North Bengal highway corridor in terms of passenger and freight movement. The study focusses on the determination of traffic growth factor after the inaugurations of the largest bridge of Bangladesh till the year 2013, based on the daily traffic data of the tolled bridge. Hence, a true pattern of traffic growth is obtained below in figure 6.1 by the class wise daily traffic data of fifteen years from 1999 to 2013.

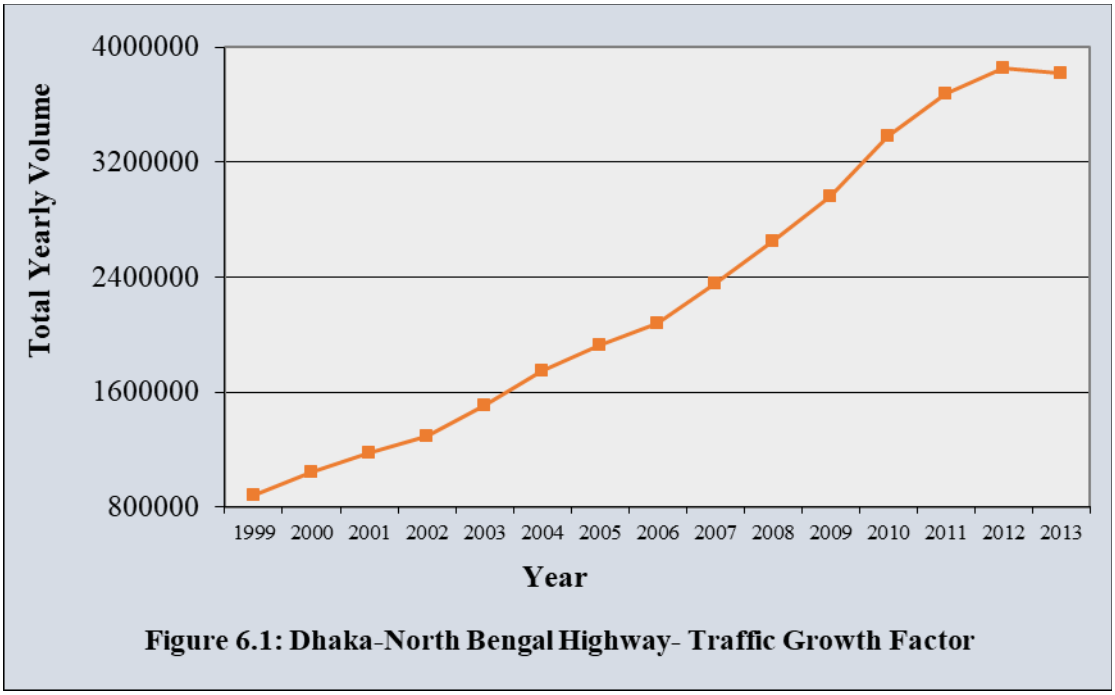


Figure 6.1: Dhaka-North Bengal Highway- Traffic Growth Factor

The above figure 6.1 plots the total both way yearly traffic volume on Dhaka to North Bengal highway against corresponding years from 1999 to 2013. The traffic volume is found 0.88 million in the year 1999. During the next three years, the yearly traffic has increased substantially with growth factor of 18.44, 12.49 and 9.99 respectively. Due to the opening of this bridge, highest growth factor of 18.44 is observed in the year 2000. From 2003 to 2005, the traffic growth factor is detected between 10 to 16% with large increase of traffic along this corridor. The traffic is observed 2.08 million, 2.35 million and 2.64 million from the year 2006 to 2008 correspondingly. The yearly traffic has increased 3 times from 1999 to 2008, which proves the necessity of Jamuna bridge along this corridor. The rise of traffic is continuing to 2.96 million, 3.38 million and 3.67 million from 2009 to 2011. The growth factor of the corresponding years is 11.87, 14.04 and 8.87. Furthermore, traffic growth factor is observed 4.71 and -0.74 in the year 2012 and 2013 with traffic volume of 3.85 million and 3.82 million. Lastly, the average traffic growth factor is calculated from 15 years of daily traffic volume is 11.15 along Jamuna bridge corridor. The annual traffic has increased 4.34 times within this study period of 15 years, however adequate road infrastructures have not been expanded in this highway which rapidly triggered traffic delay and road accidents in this highway corridor.

Individual vehicle class wise traffic growth factor has been calculated in this study from the year 1999 to 2013. It is predicted that the percentage of various vehicle classes with respect to total yearly flow will not be constant throughout the study period. The

individual class wise vehicle growth rate changes from year to year and should be monitor properly for efficient traffic management and planning. Hence, attempts have been made in this study to introduce individual vehicular class wise traffic growth pattern analyses in Dhaka-North Bengal highway corridor and a pictorial representation is shown below in figure 6.2 (i) for motor cycle, small bus and large truck's annual growth pattern curve.

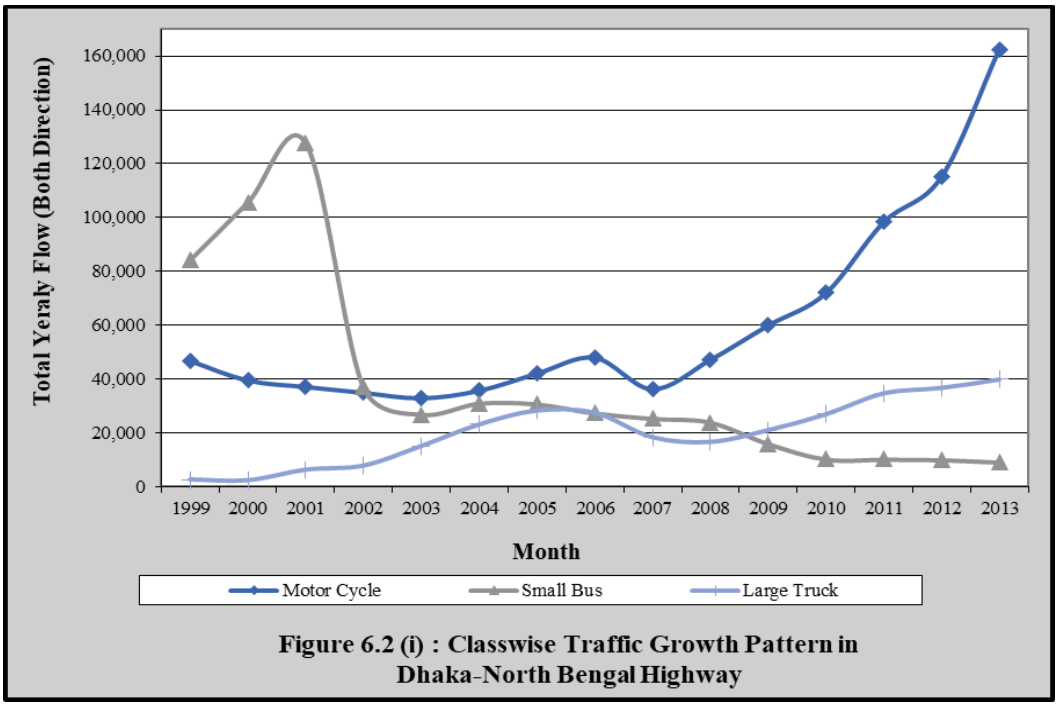


Figure 6.2 (i) : Classwise Traffic Growth Pattern in Dhaka-North Bengal Highway

Motor Cycle:

Total yearly volume of motor cycle is found 46,875 in 1999 that is 5.31% of the total flow. In the next three years, the yearly volume is observed as 39610, 37230 and 35047 which is 3.79%, 3.17% and 2.71% of total yearly traffic flow. Also, the growth factor of motor cycle seems less each year from 2000 to 2003 with value of -15%, -6%, -6% and -6%. Nevertheless, the growth factor suddenly increase to 8%, 18% and 14% from 2004 to 2006. But the percentage of yearly flow compared to total traffic appears fewer with value of 2.05%, 2.18% and 2.31%. However, the number of motor cycle increase considerably from the year 2009 to 2013 with growth factor of 27%, 20%, 37%, 17% and 41%. The average yearly volume of motor cycle is found from the daily traffic data of 1999 to 2013 is 60,631 with average growth factor of 11 that is 2.63% of total traffic flow along this highway corridor.

Small Bus:

The number of small bus has increased in the first 3 years after the inauguration of Jamuna bridge. But however, small bus percentage has decreased since then due to the nature and demand of traffic and passengers. The small bus percentage holds nearly 10% of yearly total traffic from 1999 to 2001. This ratio has decreased to 2.86% in the year 2002 and continues to lower the ratio till 2013. The last five years (2009 to 2013) average is 0.32% of yearly total traffic. The average volume of small bus per annum from 1999 to 2013 is 38,354 that is 3.09% of total traffic. The average growth factor of small bus is -10% from 1999 to 2013.

Large Truck:

The growth pattern of large truck is found in figure 6.2 (i). The number of large truck has increased in recent years compared to first five years. The average number of this vehicle class per annum is 31,923 from 2009 to 2013. The average growth factor of large truck is 29% from 1999 to 2013, which indicates that the pavement structures should be designed adequately to cope with heavy truck loads.

Light Vehicles:

In Jamuna bridge toll plaza, vehicular class ”Light vehicles” includes car, jeep, pickup and microbus; that is the third highest vehicular class along this highway corridor. In 1999, the number of light vehicles are found 208,811 which is 23.68% of the total traffic stream. From 1999 to 2005, this vehicle class has yearly volume between 0.2 to 0.3 million. However, from 2006 to 2013 the volume of light vehicles have increased considerably. In 2006, the light vehicles yearly volume is found 0.32 million with 15.65% of total traffic flow. The volume is increased to 0.85 million in 2013 with 22.14% of total traffic flow. The average volume of light vehicles are calculated 0.43 million from 1999 to 2013 that is 18.07% of the total traffic stream. The average growth factor is 11% of light vehicles in the 15 years of study period. The characteristics curve is shown below in figure 6.2 (ii).

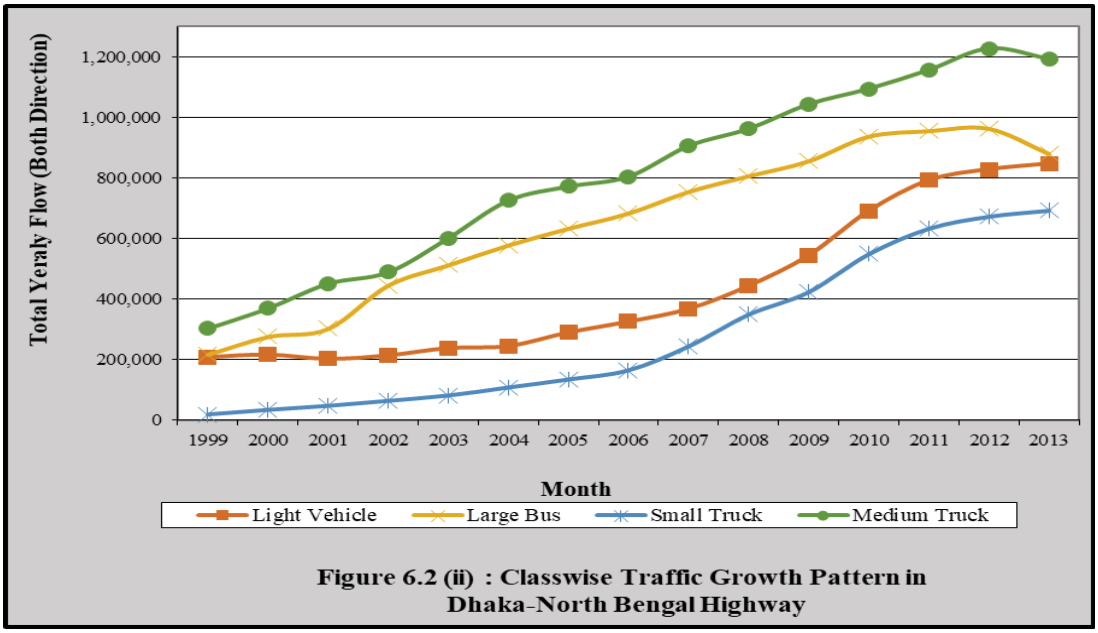


Figure 6.2 (ii) : Classwise Traffic Growth Pattern in Dhaka-North Bengal Highway

Large Bus:

Large bus containing 32 seats or more along Dhaka-North Bengal highway corridor. It is the second highest vehicle class in this corridor that carries passenger to the north bengal districts from the capital Dhaka. In 1999, the yearly volume is observed 0.21 million which is 24.59% of total traffic flow. Each year the volume has increased significantly and found highest 0.96 million in 2012 that is 4.43 times higher from the base year. The average volume in the 15 years of study period is found 0.65 million per annum that is 29.56% of total traffic flow. Large bus average traffic growth factor is 11% in the 15 years of study period. The maximum growth factor is observed 47% in 2002 and minimum growth factor is found -9% in 2013. The characteristics curve for large bus is shown above in figure 6.2 (ii).

Medium Truck:

Medium truck is the largest volume of vehicle class along Jamuna bridge corridor. From the average of 15 years of daily traffic data, medium truck contains 36.56% of total traffic flow and its urgency is incomparable in terms of freight movement from the capital Dhaka to Rangpur and Rajshahi division. Medium truck is found 0.3 million in 1999 and it reaches to double volume (0.6 million) in 2003. The yearly flow varies between 34.41% to 39.87% of total flow in this time with average growth factor of 19%. The volume of medium truck continues to rise and reaches to 1.04 million with 35.20% of total traffic in 2009, yet the road infrastructures remain same for the massive traffic. The average

growth factor is found from 2004 to 2009 is 10% that indicates the highway reaches its maximum capacity. Road accidents and congestion forces the users to carry freight through alternate ways like railways and waterways. Due to lack of traffic study, government of Bangladesh has invested their efforts in highway police patrol and congestion control. However, the traffic pattern is indicating the extreme need for road expansion along this corridor since 2005. In addition, Medium truck is found 1.09, 1.15, 1.23 and 1.2 million respectively from 2010 to 2013. The average medium truck volume from 1999 to 2013 is found 0.81 million per annum with growth factor of 11%.

Small Truck:

Small truck has fourth highest traffic volume alone this highway corridor. The volume has increased from 19,117 to 692,445 per annum from 1999 to 2013. From 2010 to 2013, the average yearly volume is found 636,527. On the other hand, from 2000 to 2003, the average volume us found 56,883 per annum. From the average of 15 years of data, it is found that small truck contains 9.26% of total traffic flow and the average growth factor is found 30%.

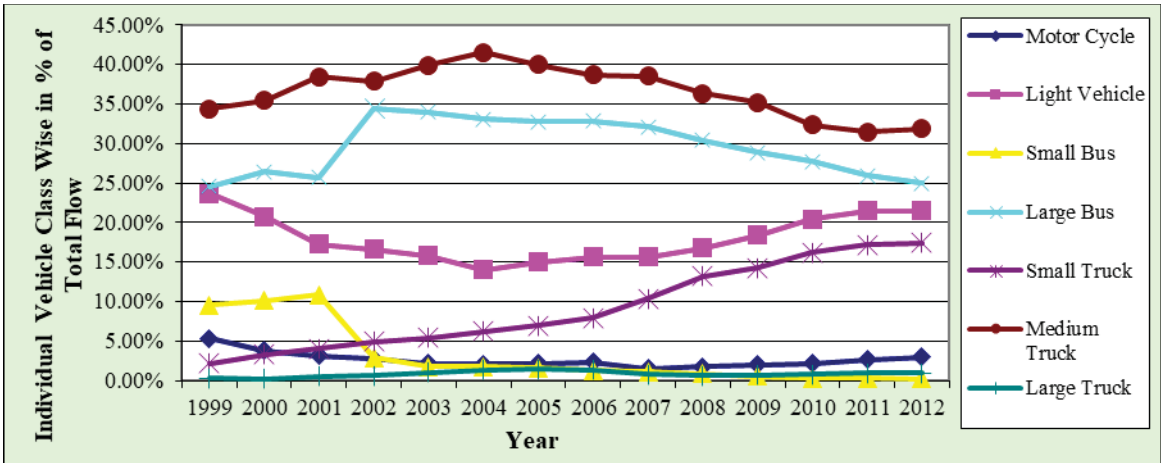


Figure 6.3: Growth Pattern of Individual Vehicle Classes (In Percentage of Yearly Total Volume)

Figure 6.3 shows above the yearly variation in percentage of individual vehicle classes with respect to total yearly volume along Dhaka-North Bengal highway corridor.

6.3 CALCULATION OF TRAFFIC COMPOSITION OF DHAKA-NORTH BENGAL HIGHWAY

Traffic composition pattern is an important parameter for geometric and structural design of highways. Efficient traffic design and operation largely depends upon traffic

composition pattern. So, it is vital to learn the traffic composition pattern of Dhaka-North Bengal highway to make accurate decision for traffic and pavement management.

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 29 seats
4. Large Bus: Buses containing equal to or 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 having more than 8 ton carrying capacity.

Figure 6.4 shows the traffic composition pattern from 1999 to 2013 on Jamuna Bridge corridor. Medium truck has the highest percentage (36.56%) along the traffic stream. The percentage of medium truck falls between 30~40% of total traffic flow in the study period. Large bus is the second highest vehicle percentage; whose proportion varies from 23~35% of total traffic flow. The average percentage of this vehicle class from 1999 to 2013 is 29.56%. Light vehicles are the next dominating vehicular class, which varies from 14~24% of total traffic flow. The average percentage is calculated 18.07% from the study period. Small truck is the fourth largest traffic category that fluctuates from 3~19% of total flow. In recent years, small truck's percentage have increased due to freight movement demand in the short distances. The average percentage is calculated 9.26%. The next

vehicular class is small bus whose average percentage is 3.09% and surprising to know that the demand of small bus is decreasing in recent years. In addition, motor cycle and large truck holds 2.63% and 0.83% of total traffic flow along Jamuna bridge corridor.

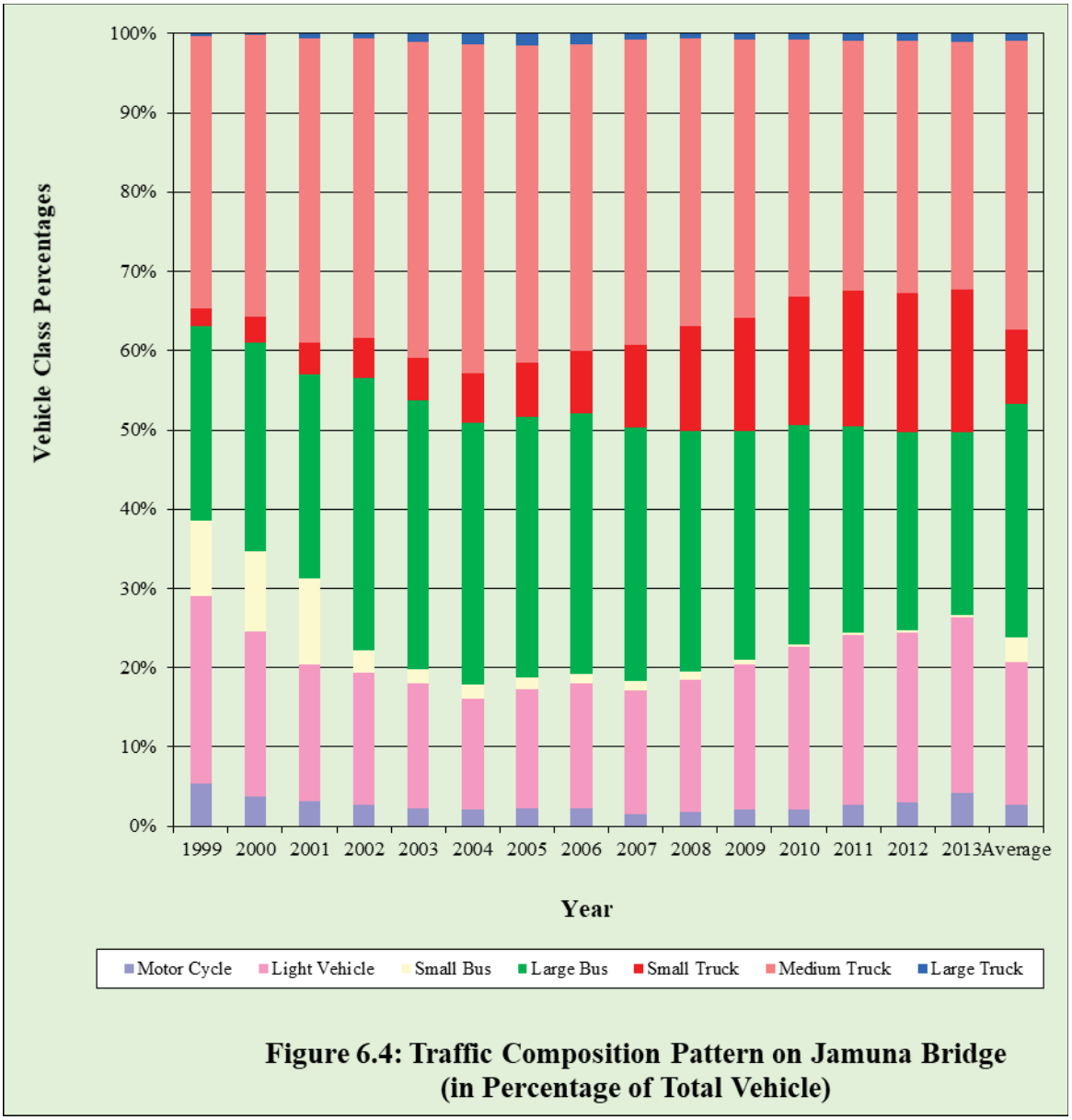


Figure 6.4: Traffic Composition Pattern on Jamuna Bridge (in Percentage of Total Vehicle)

Figure 6.5 shows the classification wise yearly volume of traffic on Jamuna Bridge. It is seen from the graph that most predominant vehicle classes are medium truck, large bus, light vehicle and small truck. The proportion of medium truck is the highest quantity and have been increasing every year with average growth factor of 11. The second highest vehicle category is large bus, which has increasing trend as same as medium truck. These two vehicle class have high importance in terms of freight and passenger movement. The third and fourth highest vehicle category includes light vehicles and small truck respectively whose volume have increased per annum substantially.

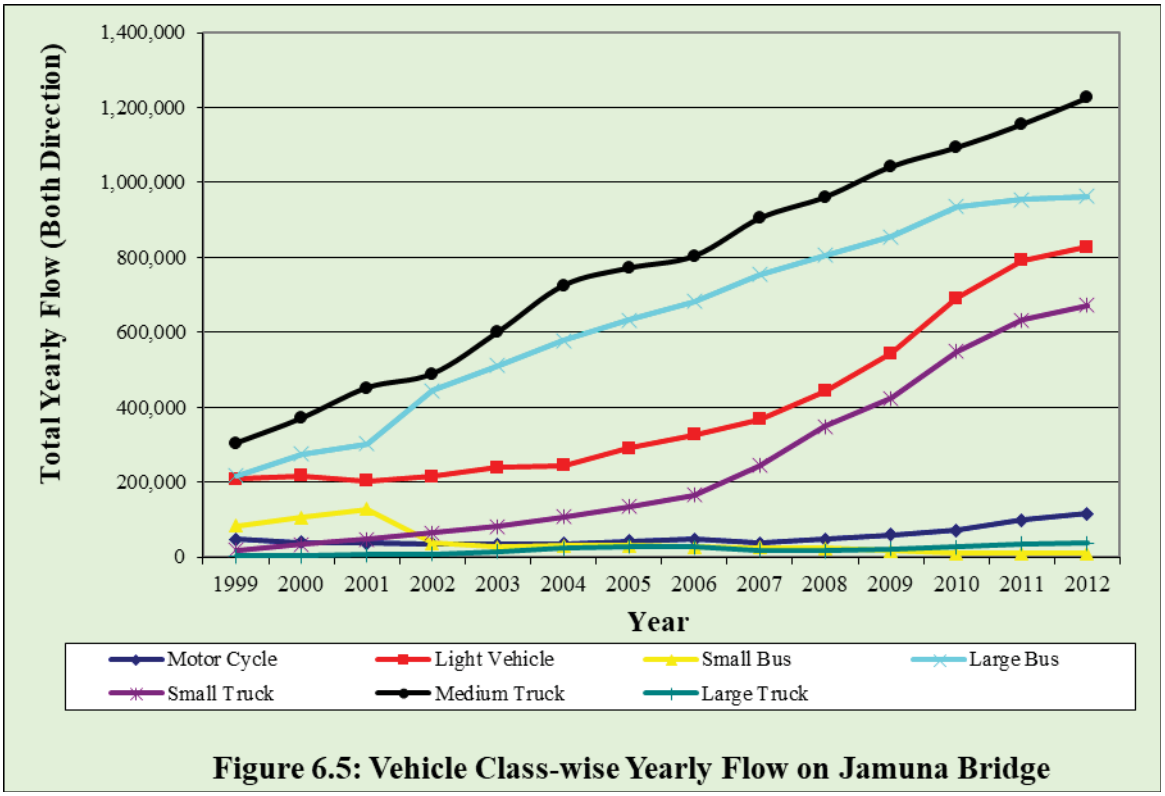


Figure 6.5: Vehicle Class-wise Yearly Flow on Jamuna Bridge

6.4 CALCULATION OF HEAVY VEHICLE PERCENTAGE OF DHAKA-NORTH BENGAL HIGHWAY

Heavy vehicle percentage is an important traffic parameter for structural and geometric design of pavement. Heavy vehicles cause more damages to the roadway. Percentage of heavy vehicles refers to the percentage of truck and bus in a traffic stream. The following section discusses the proportion of heavier vehicles on Jamuna bridge flow and their travel pattern.

6.4.1 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 analyses of traffic flow data from 1999 to 2013 on Jamuna bridge, taking the average of 15 years, it is found that the percentage of all classes of trucks 46.65% of total vehicle. Among this, the percentages of small truck, medium truck and large trucks are 9.26%, 36.56% and 0.83% respectively (Figure 6.6). Table 6.1 shows the year-wise truck percentages. Figure 6.7 shows the growth pattern of trucks on North Bengal Corridor.

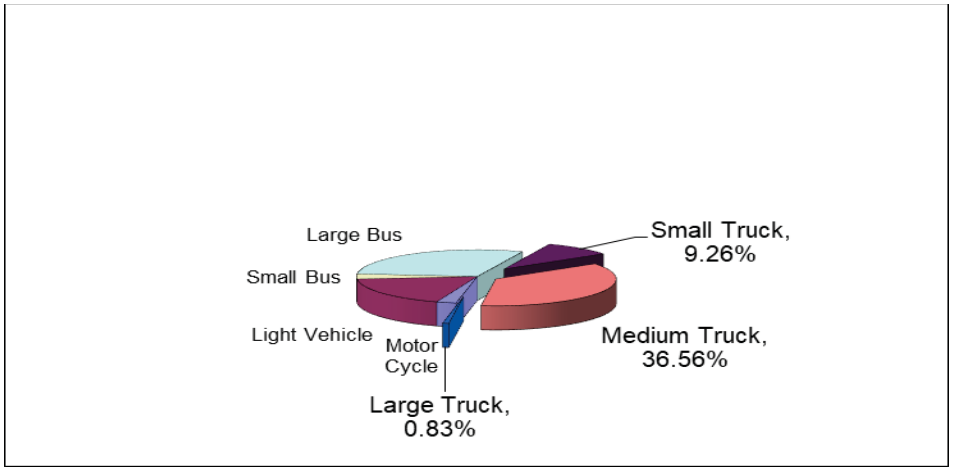


Figure 6.6: Annual Truck Percentages on Jamuna Bridge (Average from 1999 to 2013)

Table 6.1: Truck Percentages on NH-5 (Both Direction)

Year	Small Truck	Medium Truck	Large Truck	Total Truck
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%**
2006	7.92%	38.65%	1.32%	**47.89%**
2007	10.37%	38.51%	0.78%	**49.66%**
2008	13.17%	36.32%	0.63%	**50.12%**
2009	14.28%	35.20%	0.71%	**50.20%**
2010	16.24%	32.37%	0.80%	**49.41%**
2011	17.20%	31.42%	0.95%	**49.57%**
2012	17.46%	31.85%	0.96%	**50.27%**
2013	18.11%	31.19%	1.05%	**50.35%**
Average	**9.26%**	**36.56%**	**0.83%**	**46.65%**

Date Source: JOMAC, MargaNet, BBSO, BBA.

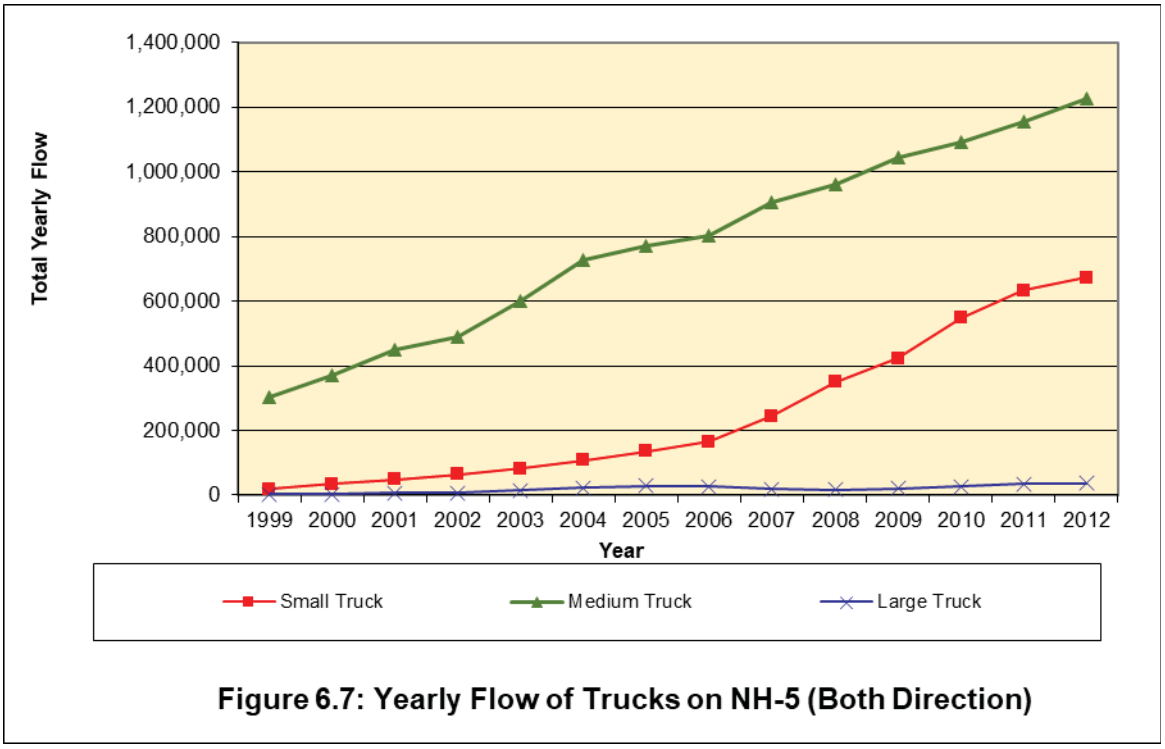


Figure 6.7: Yearly Flow of Trucks on NH-5 (Both Direction)

6.4.2 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.

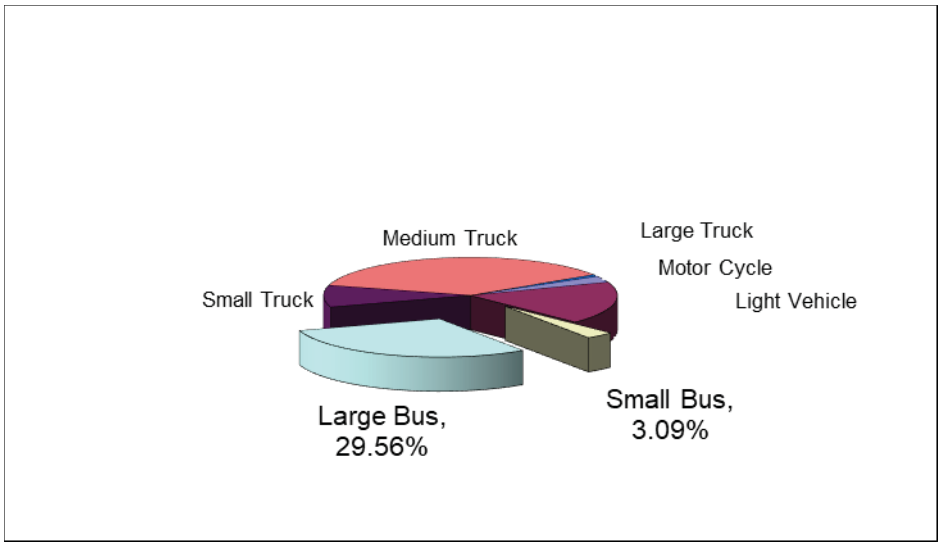


Figure 6.8: Annual Bus Percentages on Jamuna Bridge
(Averaged over 15 years)

Table 6.2: Yearly Flow of Buses on NH-5 (Both Direction)

Year	Small Bus	Large Bus	Total Bus
1999	84111	216913	301024
2000	105496	275865	381361
2001	127676	302220	429896
2002	37017	445010	482027
2003	26882	511972	538854
2004	30999	577808	608807
2005	30,720	632,938	663658
2006	27,376	683,070	710446
2007	25,362	754,136	779498
2008	23,967	805,991	829958
2009	16,025	855,390	871415
2010	10,271	936,410	946,681
2011	10,216	954,772	964,988
2012	10,045	962,547	972,592
2013	9,149	879,828	888,977
Average	**38,354**	**652,991**	**691,345**

Date Source: JOMAC, MargaNet, BBSO, BBA.

Table 6.3: Bus Percentage on NH-5 (Both Direction)

Year	Small Bus	Large Bus	Total Bus
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%**
2006	1.32%	32.83%	**34.15%**
2007	1.08%	32.08%	**33.16%**
2008	0.91%	30.44%	**31.34%**
2009	0.54%	28.88%	**29.42%**
2010	0.30%	27.72%	**28.02%**
2011	0.28%	25.96%	**26.24%**
2012	0.26%	24.99%	**25.25%**
2013	0.24%	23.02%	**23.26%**
Average	**3.09%**	**29.56%**	**32.65%**

Date Source: JOMAC, MargaNet, BBSO, BBA.

From Figure 6.8, it is seen that total 32.65% of total annual flow (taking average from 1999 to 2013) comprises of buses. Among this, 29.56% is large bus and 3.09% is small bus. Annual increase pattern of total number buses is shown in Figure 6.9. Although the total number is increasing at a high rate, but from Table 6.3, it can be seen that the

percentage of bus has decreasing with respect to total traffic (34.13% in 1999 and 23.26% in 2013). Table 6.4 and figure 6.9 shows below the growth factor of buses on Dhaka-North Bengal highway. The maximum negative growth factor is found for small bus is -71.01 in the year 2001-2002. However, the average growth factor for samll bus in the study period is -10.10% that indicates rapid decrease of small bus along this corridor. On the other hand, large bus has the highest growth factor of 47.25 in the year 2001-02 and the average growth factor is 12.69 from 1999 to 2013.

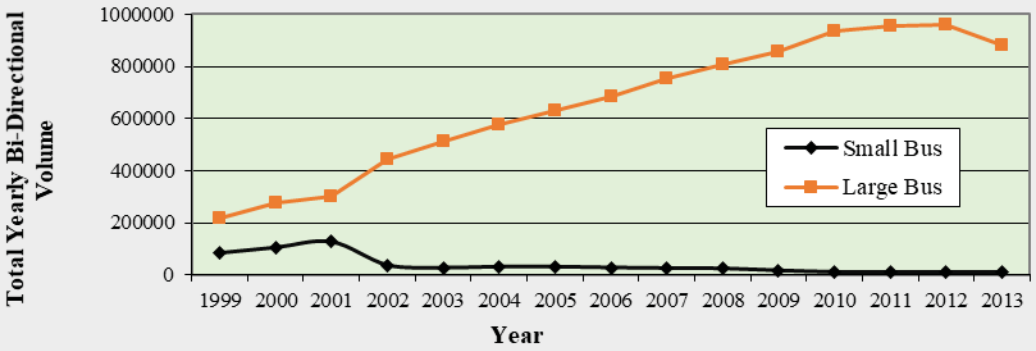


Figure 6.9: Growth Pattern of Buses on Jamuna Bridge (Both Direction)

Table 6.4: Growth Factor of Bus on NH-5 (Both Direction)

Year	Small Bus	Large Bus
1999-00	25.42	27.18
2000-01	21.02	9.55
2001-02	-71.01	47.25
2002-03	-27.38	15.05
2003-04	15.32	12.86
2004-05	-0.90	9.54
2005-06	-10.89	7.92
2006-07	-7.36	10.40
2007-08	-5.50	6.88
2008-09	-33.14	6.13
2009-10	-35.91	9.47
2010-11	-0.54	1.96
2011-12	-1.67	0.81
2012-13	-8.92	-8.59
Average	**-10.10**	**12.69**

6.5 CALCULATION OF DIRECTIONAL DISTRIBUTION OF DHAKA-NORTH BENGAL HIGHWAY

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]. The significance of directional distribution along Dhaka-North Bengal highway is discussed below for comprehensive understanding of traffic flow characteristics.

6.5.1 DAILY DIRECTIONAL DISTRIBUTION ON DHAKA- NORTH BENGAL HIGHWAY

The daily directional distribution of traffic in Dhaka North Bengal highway have been analyzed consuming 15 years of daily traffic data of Jamuna bridge corridor. Table 6.5 below displays the summarized daily directional data. The average daily traffic (ADT) on each day of week have been determined from 15 years of data.

Table 6.5: Daily Directional Distribution of Traffic on NH-5

Day\Year	1999		2000		2001	
	E-W	W-E	E-W	W-E	E-W	W-E
Saturday	1,213	1,365	1,313	1,488	1,612	1,718
Sunday	1,166	1,158	1,427	1,465	1,622	1,597
Monday	1,136	1,153	1,408	1,424	1,570	1,516
Tuesday	1,045	1,091	1,432	1,439	1,523	1,478
Wednesday	1,167	1,230	1,368	1,390	1,532	1,557
Thursday	1,230	1,205	1,474	1,378	1,683	1,615
Friday	1,366	1,384	1,489	1,486	1,756	1,763
TOTAL	**8,322**	**8,586**	**9,911**	**10,070**	**11,297**	**11,243**
TOTAL - BOTH DIRECTION	**16,908**		**19,980**		**22,540**	
Day\Year	**2002**		**2003**		**2004**	
	E-W	W-E	E-W	W-E	E-W	W-E
Saturday	1,569	1,672	1,836	1,967	2,150	2,220
Sunday	1,741	1,746	2,115	2,158	2,341	2,392
Monday	1,808	1,789	2,175	2,125	2,371	2,319
Tuesday	1,779	1,740	2,142	2,031	2,409	2,337
Wednesday	1,813	1,833	2,039	2,064	2,350	2,417
Thursday	1,909	1,807	2,093	1,975	2,524	2,397
Friday	1,779	1,804	2,055	2,156	2,536	2,622
TOTAL	**12,397**	**12,391**	**14,455**	**14,475**	**16,681**	**16,703**
TOTAL - BOTH	**24,789**		**28,930**		**33,385**	

DIRECTION						
Day\Year	**2005**		**2006**		**2007**	
	E-W	W-E	E-W	W-E	E-W	W-E
Saturday	2,297	2,371	2,839	2,986	3,038	3,177
Sunday	2,552	2,658	2,850	2,746	3,095	3,110
Monday	2,621	2,633	2,805	2,758	3,128	3,112
Tuesday	2,692	2,722	2,788	2,710	3,183	3,266
Wednesday	2,759	2,844	2,706	2,784	3,313	3,367
Thursday	2,839	2,583	2,929	2,853	3,452	3,247
Friday	2,705	2,755	3,032	3,115	3,309	3,290
TOTAL	**18,465**	**18,566**	**19,949**	**19,952**	**22,518**	**22,569**
TOTAL - BOTH DIRECTION	**37,031**		**39,901**		**45,087**	
Day\Year	**2008**		**2009**		**2010**	
	E-W	W-E	E-W	W-E	E-W	W-E
Saturday	3,424	3,650	3,733	3,994	4,283	4,648
Sunday	3,613	3,687	3,942	3,925	4,475	4,542
Monday	3,679	3,564	3,912	4,028	4,655	4,648
Tuesday	3,567	3,559	3,968	4,134	4,681	4,620
Wednesday	3,557	3,614	4,067	4,226	4,586	4,676
Thursday	3,703	3,570	4,319	4,074	4,824	4,623
Friday	3,730	3,730	4,389	4,094	4,806	4,715
TOTAL	**25,273**	**25,374**	**28,330**	**28,475**	**32,308**	**32,471**
TOTAL - BOTH DIRECTION	**50,647**		**56,805**		**64,779**	
Day\Year	**2011**		**2012**		**2013**	
	E-W	W-E	E-W	W-E	E-W	W-E
Saturday	4,954	5,100	5,047	5,204	5,730	4,624
Sunday	4,828	5,016	4,860	5,011	5,173	4,915
Monday	4,822	4,880	4,995	5,074	4,820	5,259
Tuesday	5,024	4,994	5,077	5,170	4,541	6,135
Wednesday	4,935	5,119	5,375	5,381	4,834	5,611
Thursday	5,181	4,951	5,615	5,399	5,313	5,253
Friday	5,422	5,308	5,902	5,568	6,231	4,896
TOTAL	**35,165**	**35,368**	**36,871**	**36,807**	**36,642**	**36,692**
TOTAL - BOTH DIRECTION	**70,533**		**73,678**		**73,334**	

Table 6.6 below shows the average of 15 years of ADT on NH-5. The directional splits have been summarized below.

Table 6.6: Average Daily Directional Distribution of Traffic on NH-5

Weekday	Avg. Daily ADT			Directional Split	
	E-W	W-E	Total	E-W	W-E
Saturday	3,002	3,079	6,081	49.37%	50.63%
Sunday	3,053	3,075	6,128	49.82%	50.18%
Monday	3,060	3,085	6,146	49.80%	50.20%
Tuesday	3,057	3,162	6,219	49.16%	50.84%
Wednesday	3,093	3,208	6,301	49.09%	50.91%
Thursday	3,272	3,129	6,401	51.12%	48.88%
Friday	3,367	3,246	6,613	50.92%	49.08%

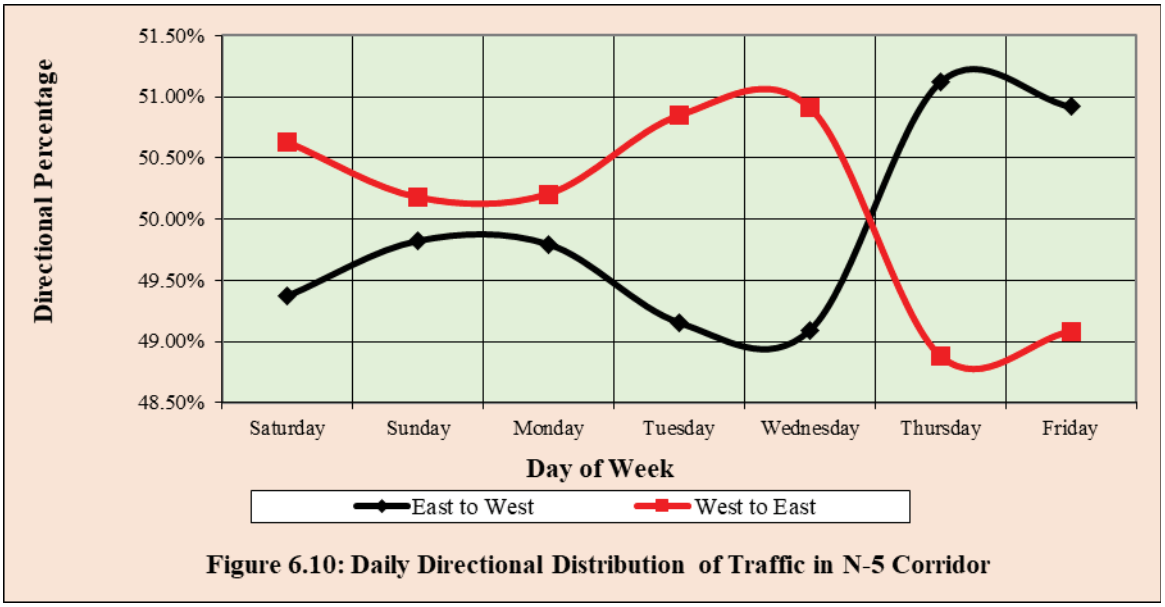


Figure 6.10: Daily Directional Distribution of Traffic in N-5 Corridor

Figure 6.10 illustrates that, the daily directional distribution varies from around 48.88% to 51.12%. The maximum outbound (East to West) flow occurs on Thursday, which is 51.12% as it is the last working day of a week in Bangladesh. The maximum passenger and freight movement usually happens in Thursday due to weekend factor as people working in and around capital Dhaka tend to visit their native town/village on the weekend. Also, the maximum inbound (west to east) traffic (50.91%) occurs on Wednesday. The maximum freight movement is observed on Wednesday from North Bengal districts to Dhaka city.

6.5.2 MONTHLY DIRECTIONAL DISTRIBUTION ON DHAKA- NORTH BENGAL HIGHWAY

Month-wise directional distribution of traffic on Jamuna bridge is shown in Table 6.7. Figure 6.11 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 15 years monthly traffic flow data, is found to 50.09% in the West to East direction and 49.91% in the East to West Direction. Figure 6.11 and 6.12 shows the overall directional distribution of traffic on Jamuna bridge.

Table 6.7: Monthly Directional Distribution of Traffic on NH-5

Month	Average Monthly Volume (1999 to 2013)			Directional Split	
	E-W	W-E	Total	E-W	W-E
Jan	96,608	97,403	194,011	49.80%	50.20%
Feb	87,237	87,359	174,596	49.96%	50.04%
Mar	94,973	94,949	189,922	50.01%	49.99%
Apr	88,635	87,864	176,499	50.22%	49.78%
May	93,645	93,777	187,422	49.96%	50.04%
Jun	97,097	97,255	194,352	49.96%	50.04%
Jul	96,104	96,542	192,646	49.89%	50.11%
Aug	95,298	94,636	189,934	50.17%	49.83%
Sep	93,130	94,256	187,386	49.70%	50.30%
Oct	100,731	101,651	202,382	49.77%	50.23%
Nov	96,833	97,122	193,955	49.93%	50.07%
Dec	102,689	104,220	206,909	49.63%	50.37%
Average	**95,248**	**95,586**	**190,835**	**49.91%**	**50.09%**

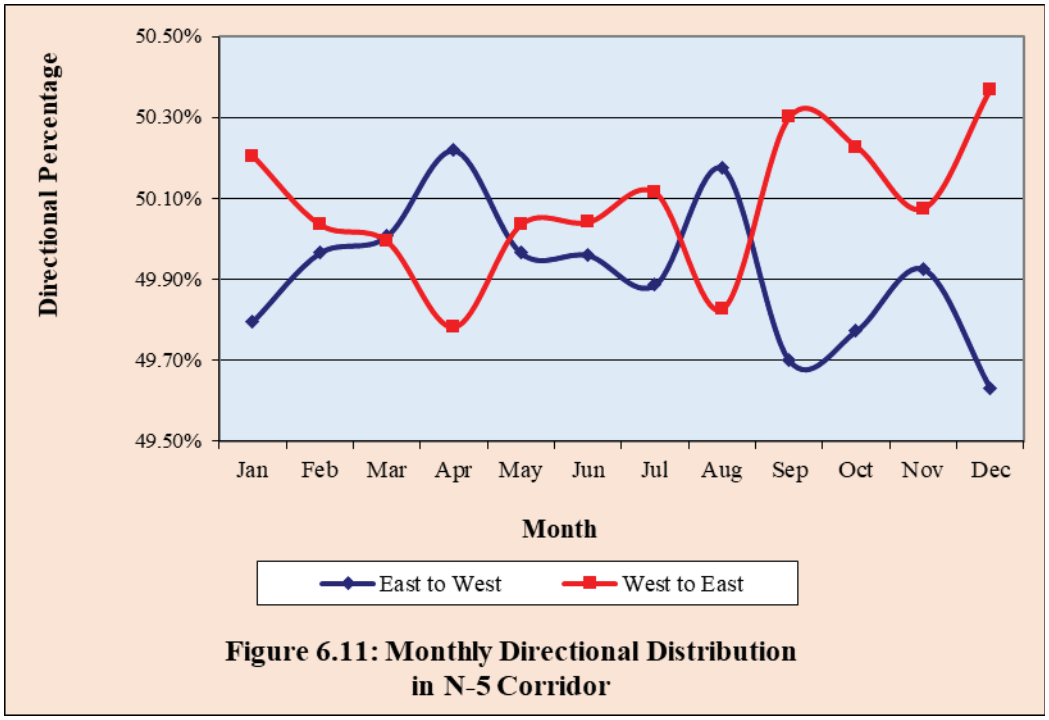


Figure 6.11: Monthly Directional Distribution in N-5 Corridor

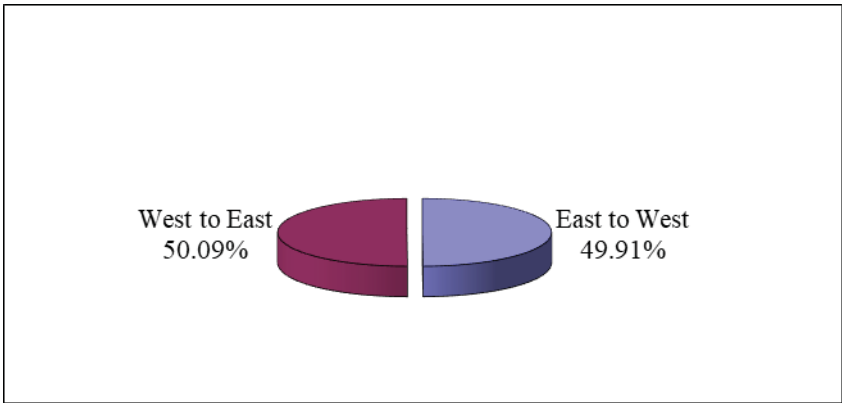


Figure 6.12: Average Directional Distribution of Traffic on Jamuna Bridge

6.6 ESTIMATION OF TRAFFIC FLOW PATTERN ON DHAKA-NORTH BENGAL HIGHWAY

A range of analyses on traffic flow pattern have been accomplished along Dhaka-North Bengal highway corridor based upon the data collected from Jamuna bridge corridor. The daily, weekly and seasonal flow variations are established for evaluation in the sections below.

6.6.1 ASSESSMENT OF DAILY TRAFFIC FLOW VARIATIONS IN NH-5

Daily traffic flow variation is a basic form of analyses to indicate pavement design parameters correctly. 15 years of daily traffic data have been collected to establish daily flow fluctuation on NH-5 from east to west direction. The graph in figure 6.13a clearly shows the daily traffic flow pattern along Jamuna bridge corridor for outbound traffic. The average traffic curve is showing higher traffic (15% of weekly volume) on Thursday and Friday. Traffic is less in Saturday (13.5% of weekly volume). However, daily traffic volume is usually found 14% of weekly volume for weekdays from Sunday to Wednesday.

Figure 6.13b demonstrates the daily traffic flow variations from West to East directions from 15 years of daily traffic data. The average cuvre indicates distinct traffic pattern for inbound traffic along NH-5, where Friday possess maximum traffic (15% of weekly volume) due to weekend factor. In addition, daily traffic flow varies from 14% to 14.50% of weekly volume in rest of the other days on Jamuna bridge corridor.

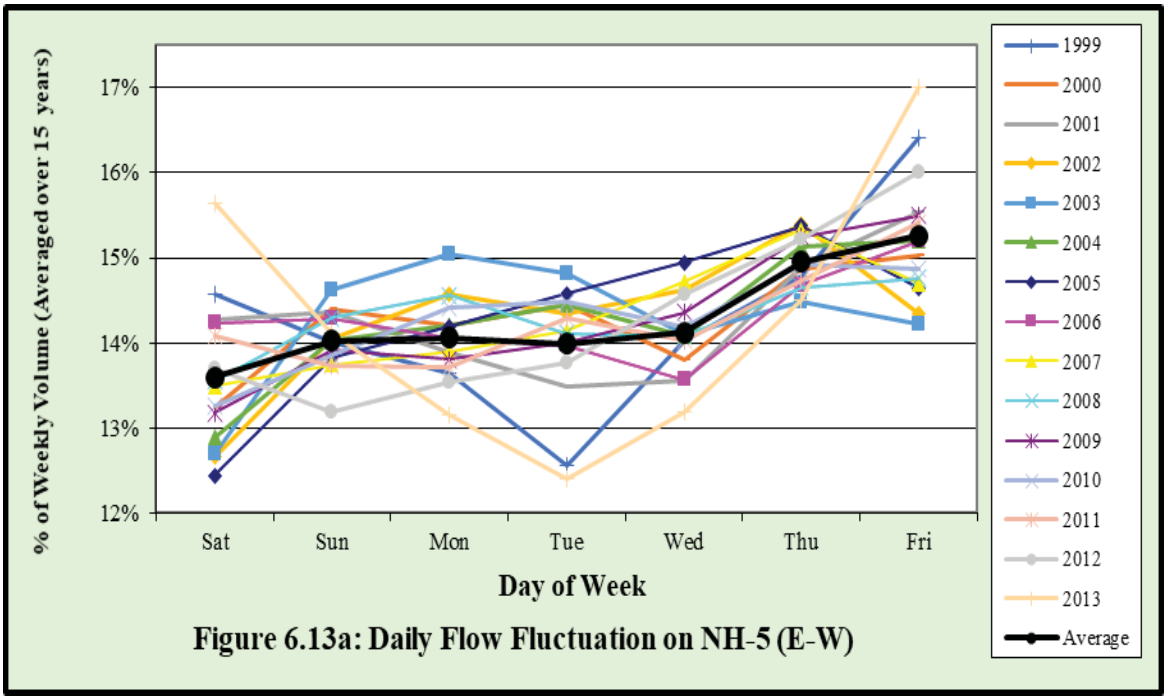


Figure 6.13a: Daily Flow Fluctuation on NH-5 (E-W)

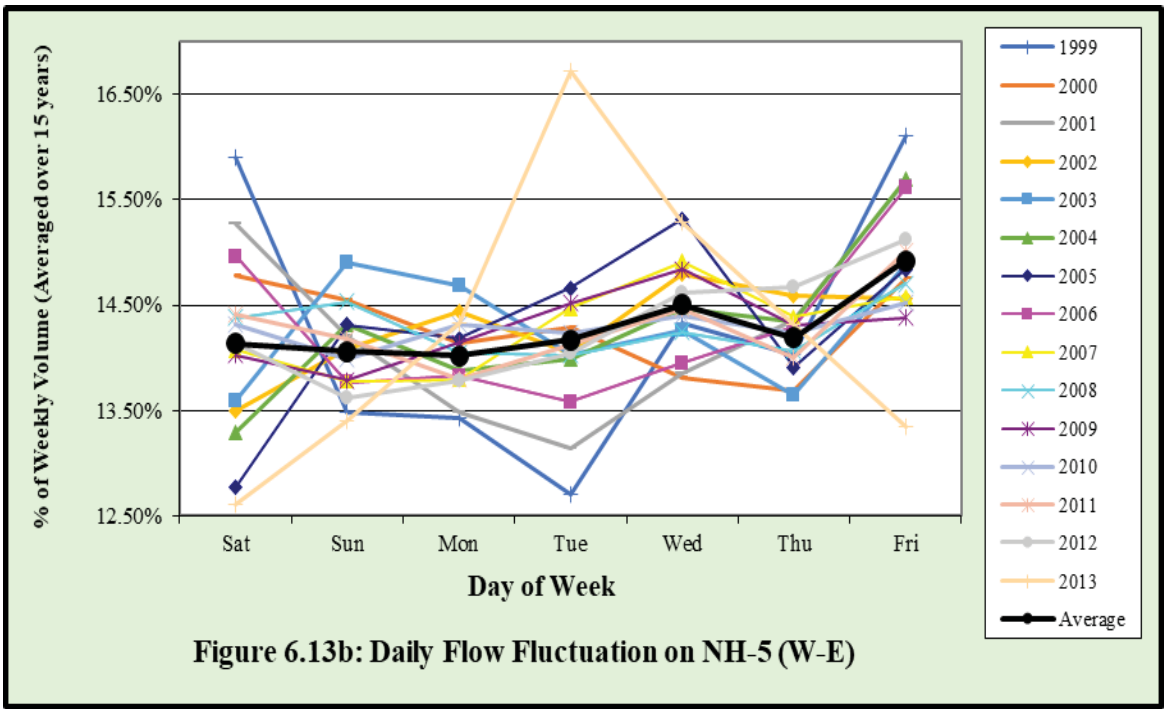


Figure 6.13b: Daily Flow Fluctuation on NH-5 (W-E)

Figure 6.14 a & b illustrates the daily traffic flow fluctuations of medium truck along NH-5 for inbound and outbound traffic. Daily flow of freight movements from east to west direction is relatively equal on all weekdays and expected to 14.50% of weekly volume. However, freight movement is lower on Fridays and found lowest on Saturday (12.75% of weekly volume). On the other hand, freight movement shape from west to east direction express different pattern. Medium truck volume is increase from Sunday to

reach its peak on Wednesday. However, rapid drop in movement is observed from Thursday to Saturday.

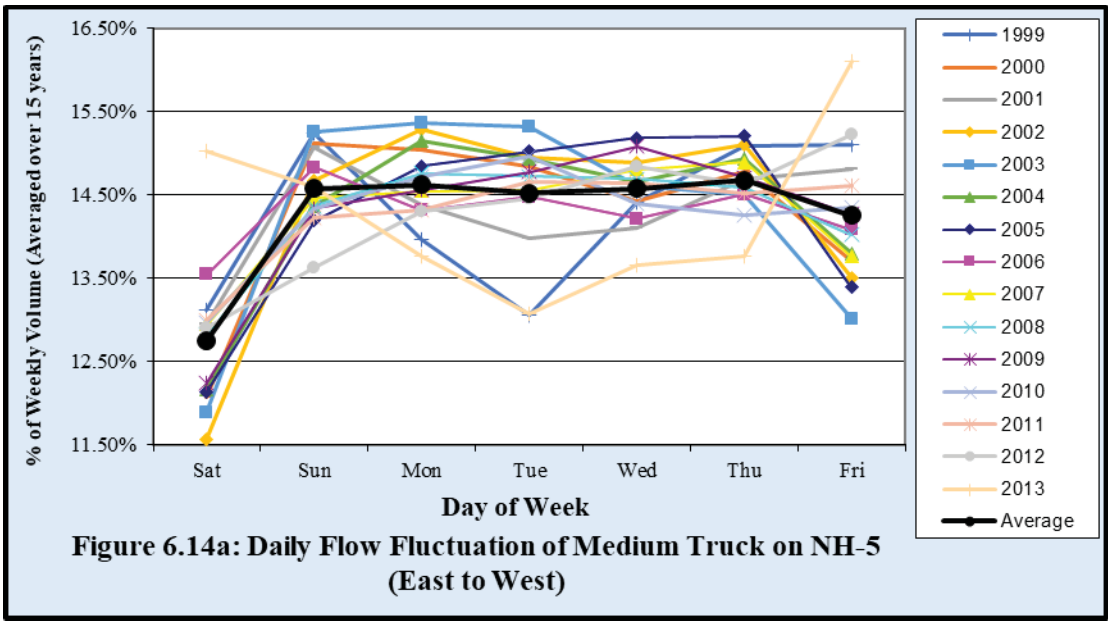


Figure 6.14a: Daily Flow Fluctuation of Medium Truck on NH-5 (East to West)

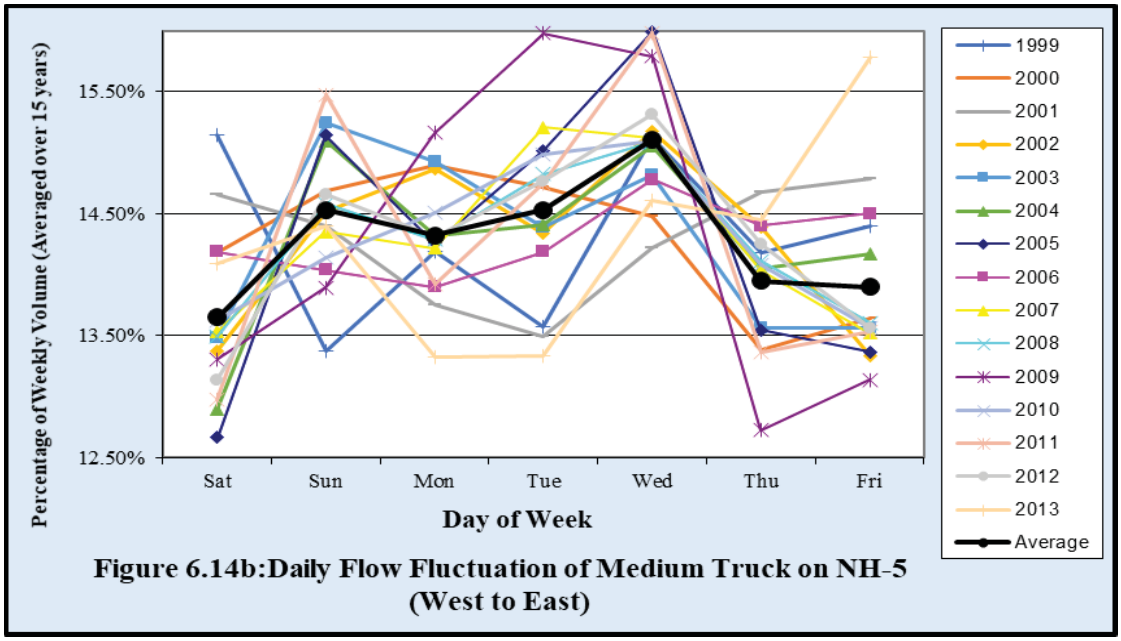


Figure 6.14b:Daily Flow Fluctuation of Medium Truck on NH-5 (West to East)

Major passenger movement through large bus is established from figure 6.15 a & b. In figure 6.15a, there is a trend of decreasing large bus traffic from Saturday to Wednesday. Though, large bus traffic is higher on Thursday and Friday. In addition, figure 6.15b below illustrates that the traffic flow nature is identical to sag vertical curve for traffic east to west direction. The traffic is lower in mid week days.

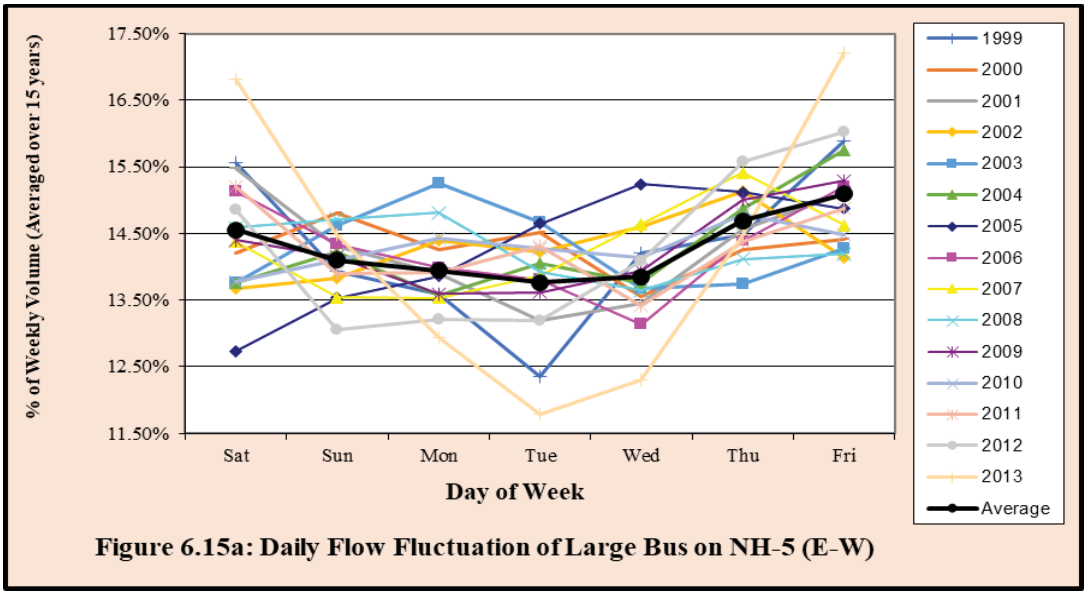


Figure 6.15a: Daily Flow Fluctuation of Large Bus on NH-5 (E-W)

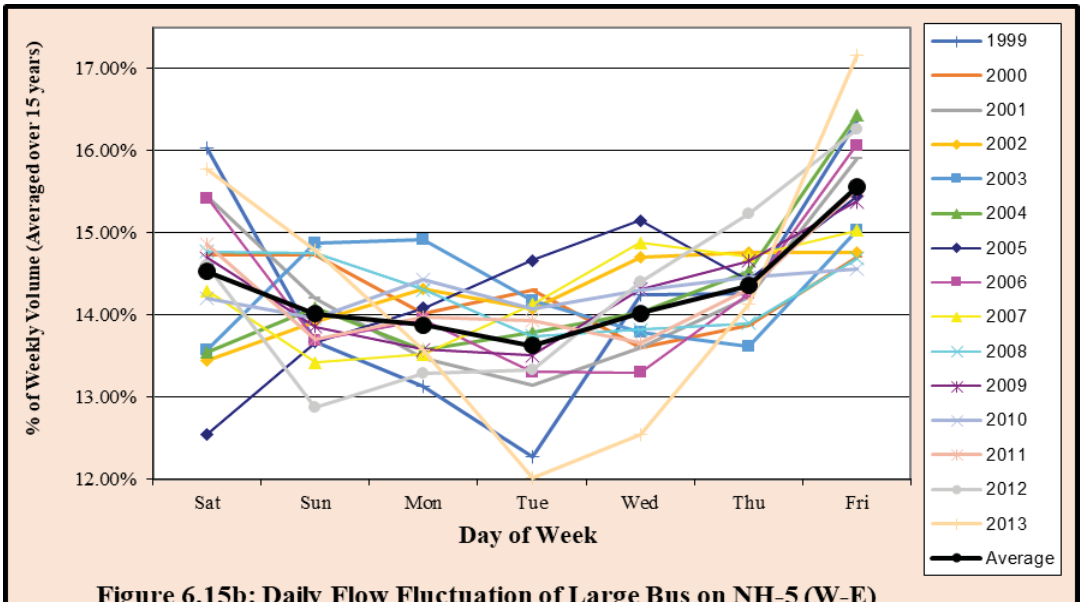


Figure 6.15b: Daily Flow Fluctuation of Large Bus on NH-5 (W-E)

Figure 6.16 a & b shows the daily flow pattern of light vehicles on NH-5 for outbound and inbound traffic. Both graph shows different characteristics of light vehicles for different directions. The daily traffic nature of light vehicles shown in figure 6.16a exhibits that Thursday and Friday have higher volume light vehicles than the other days of week due to recreational vehicles and 'weekend factor'. The percentage of weekly flow increase from 13.50% to 18% in Thursday and Friday. However, figure 6.16b indicates that light vehicles are minimun in weekdays (13~14% of weekly volume) but reach maximum in weekends.

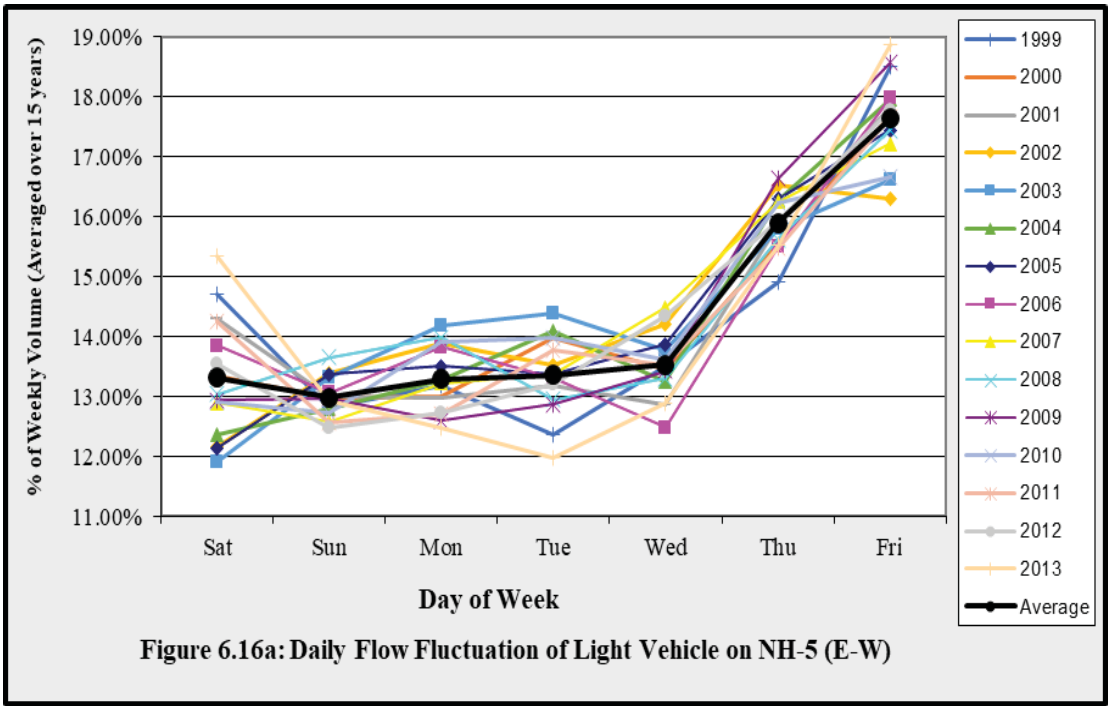


Figure 6.16a: Daily Flow Fluctuation of Light Vehicle on NH-5 (E-W)

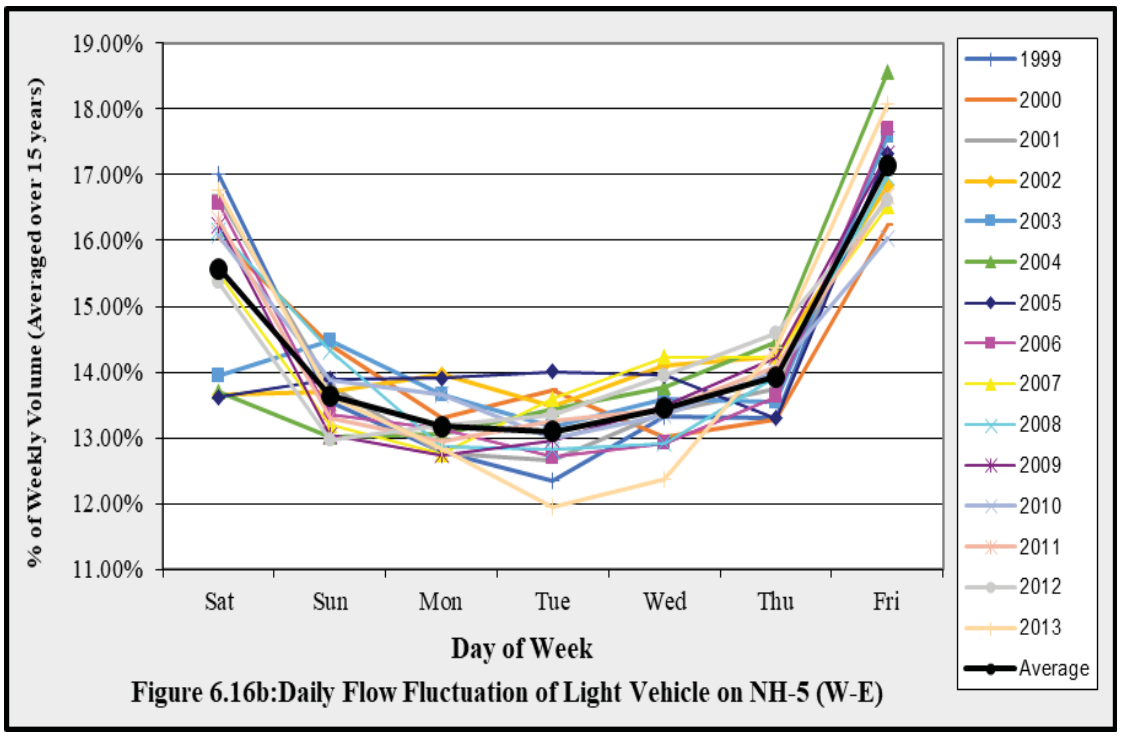


Figure 6.16b:Daily Flow Fluctuation of Light Vehicle on NH-5 (W-E)

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

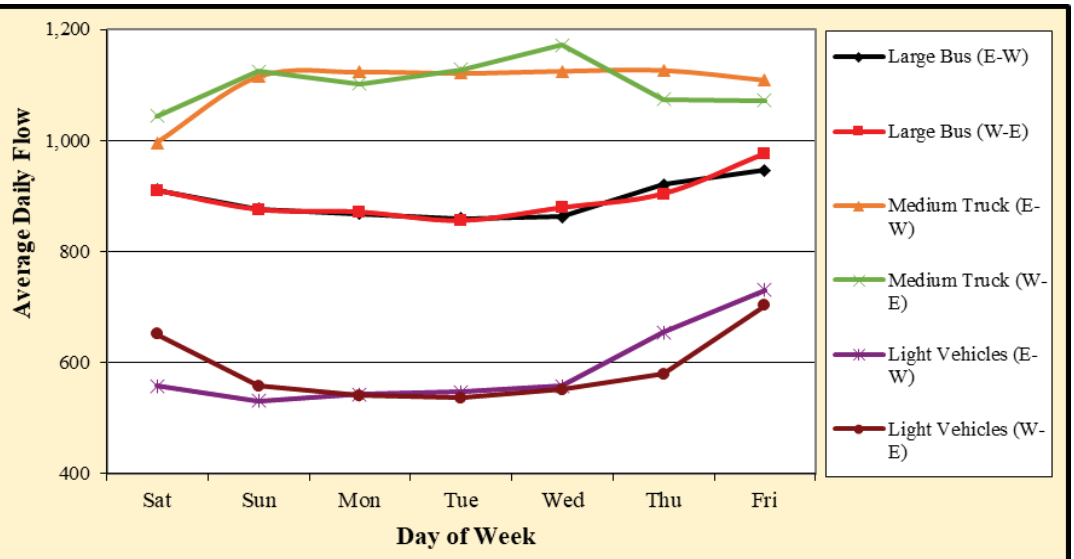


Figure 6.17: Daily Flow Fluctuation Pattern of Major Vehicle Classes on Jamuna Bridge

In Jamuna bridge corridor, monthly traffic flow variation shows different characteristics then daily flow variations. To examine these, 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 6.18 and Figure 6.19, where the average daily flow variation pattern is found to conform to those obtained from the previous analyses.

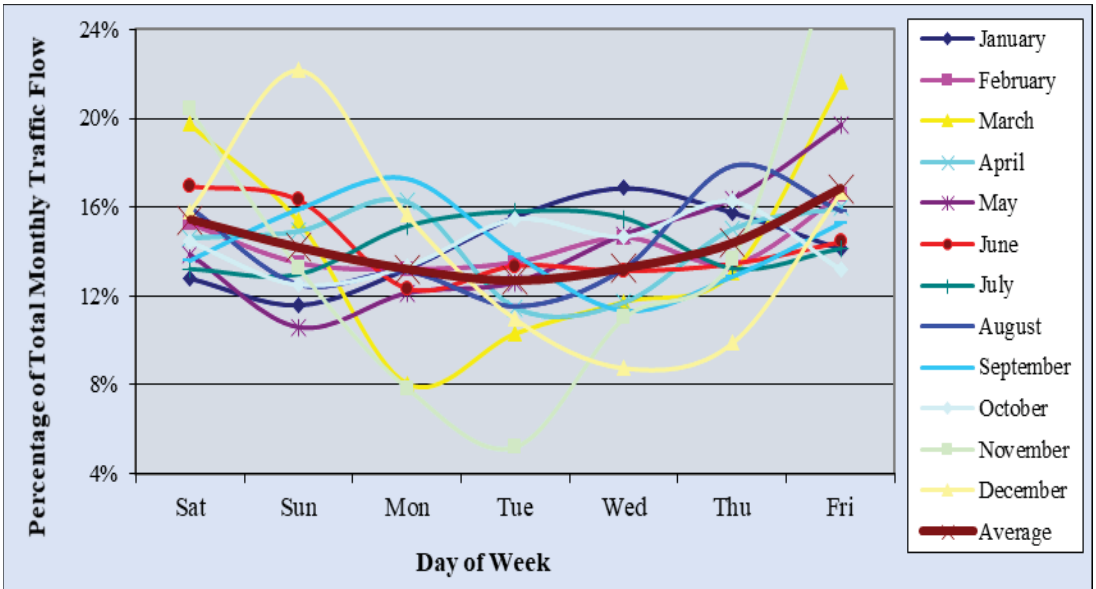


Figure 6.18:Month-wise Daily Traffic Flow Variation on Jamuna Bridge, 2013 (Both Direction)

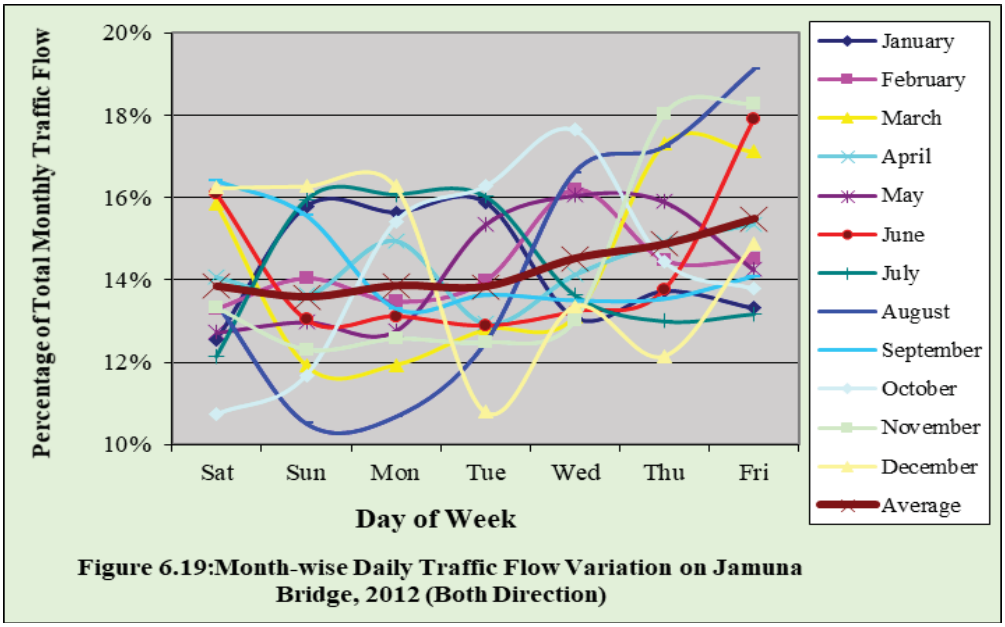


Figure 6.19:Month-wise Daily Traffic Flow Variation on Jamuna Bridge, 2012 (Both Direction)

Summary of Findings:

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

Table 6.8: Summery of Daily Flow Variation of different vehicle class in NH-5

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	15.26%	Saturday	13.59%
	West to East	Friday	14.92%	Monday	14.02%
Medium Truck	East to West	Thursday	14.68%	Saturday	12.76%
	West to East	Wednesday	15.11%	Saturday	13.65%
Large Bus	East to West	Friday	15.09%	Tuesday	13.76%
	West to East	Friday	15.55%	Tuesday	13.63%
Light Vehicle	East to West	Friday	17.63%	Sunday	12.98%
	West to East	Friday	17.14%	Tuesday	13.10%

6.6.2 APPRAISAL OF WEEKLY TRAFFIC FLOW VARIATIONS IN NH-5

Aspects of weekly flow pattern have been studied in this section. Each month of a year 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 predicted that the fourth week will naturally contain more traffic. To compensate this possible error, the model uses weekly ADT and then compares between the four weekly ADTs of each month from January 1999 to December 2013. A typical table of weekly flow variation analysis is shown in Table 6.9, 6.10 and 6.11. Graphs are plotted below in Figure 6.20a, 6.20b and 6.20c showing variation in weekly flow on Jamuna bridge for the year 2013. From the chart, it is seen that, the weekly flow percentages of most of the month maintain significant pattern in a year.

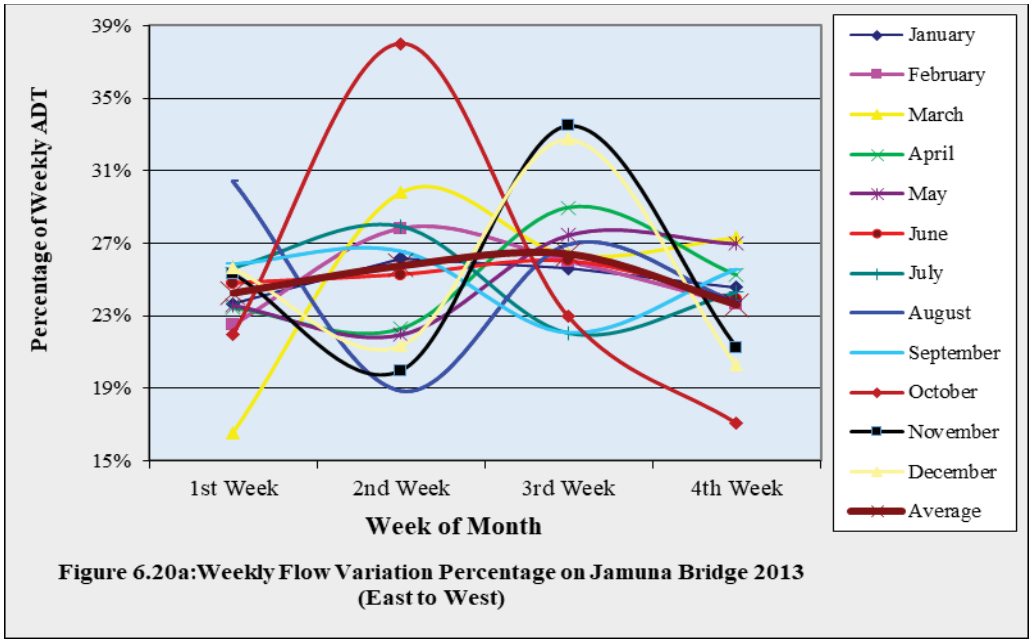


Figure 6.20a:Weekly Flow Variation Percentage on Jamuna Bridge 2013 (East to West)

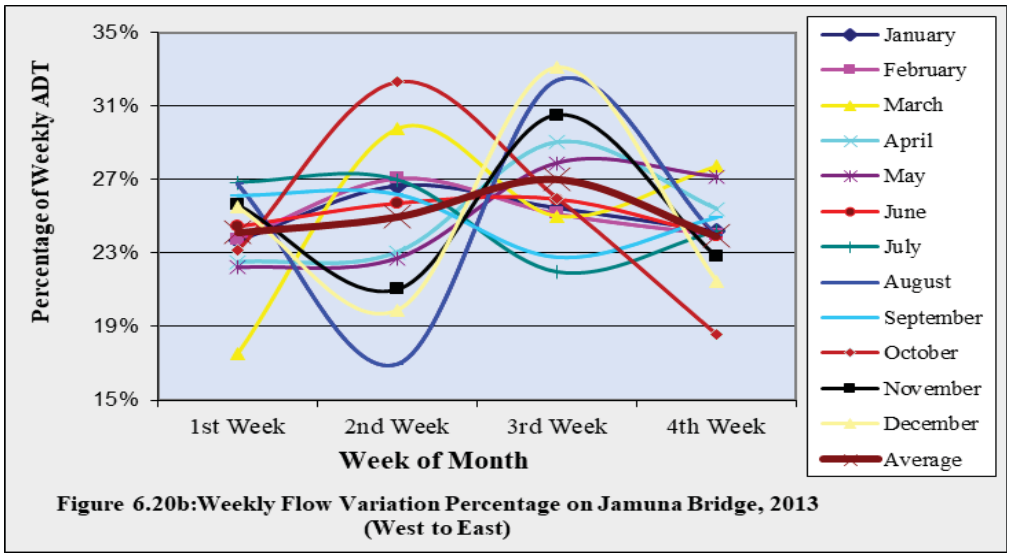


Figure 6.20b:Weekly Flow Variation Percentage on Jamuna Bridge, 2013 (West to East)

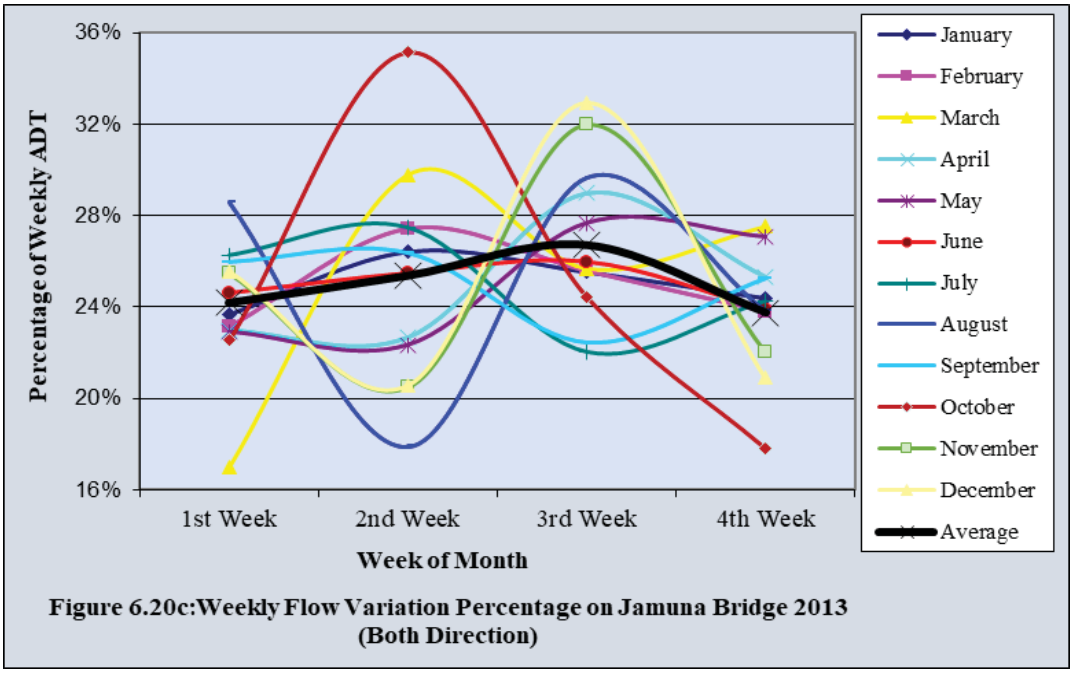


Figure 6.20c:Weekly Flow Variation Percentage on Jamuna Bridge 2013 (Both Direction)

Table 6.9 summarizes the weekly flow variation on Jamuna Bridge for fifteen years and the average values are seen in the last row of the table.

Table 6.9: Summary of Weekly Flow Variation (Both Direction)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
1999	25.44%	24.20%	25.91%	24.45%
2000	24.63%	25.18%	24.91%	25.28%
2001	24.48%	25.45%	25.14%	24.93%
2002	24.73%	25.28%	25.32%	24.68%
2003	24.83%	24.99%	25.50%	24.68%
2004	24.30%	25.62%	25.25%	24.82%
2005	24.80%	25.47%	25.28%	24.45%
2006	24.90%	24.38%	25.51%	25.21%
2007	24.40%	25.17%	25.70%	24.73%
2008	25.47%	25.28%	24.74%	24.51%
2009	24.57%	25.11%	25.45%	24.86%
2010	24.52%	25.66%	25.41%	24.41%
2011	24.48%	25.06%	25.37%	25.08%
2012	24.46%	24.94%	25.58%	25.02%
2013	24.17%	25.37%	26.71%	23.75%
Average	**24.68%**	**25.14%**	**25.45%**	**24.72%**

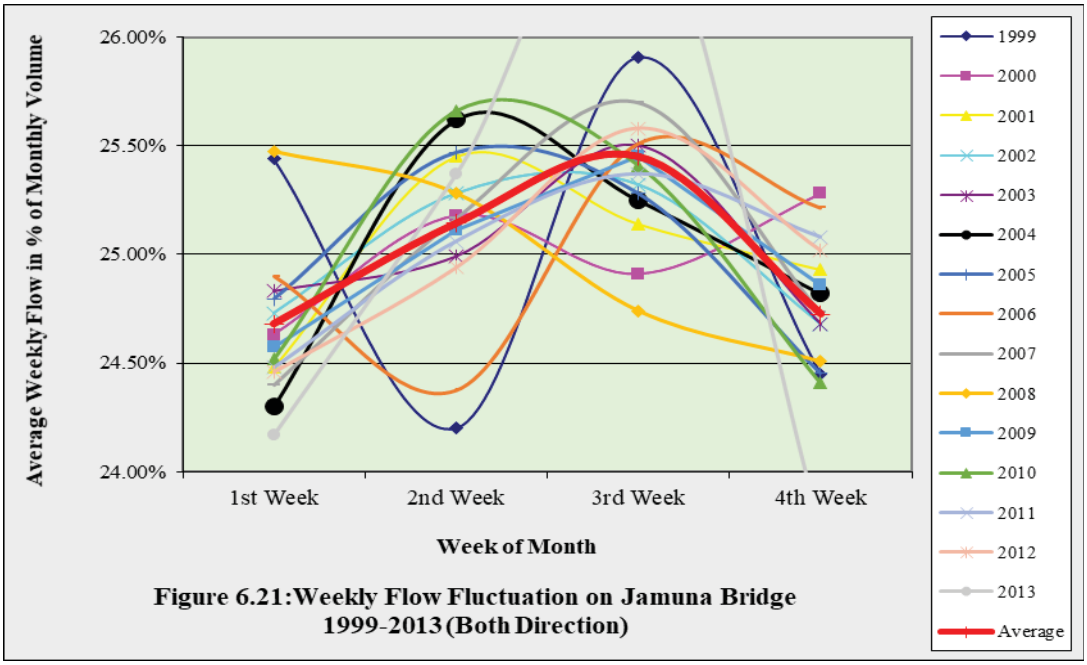


Figure 6.21:Weekly Flow Fluctuation on Jamuna Bridge 1999-2013 (Both Direction)

From Figure 6.21, 6.21a & 6.21b, it implies that, from Dhaka to North Bengal corridor of Bangladesh, there exists specific weekly flow variation pattern. The average curve (from the year 1999-2013) shows in all graphs that first, second and mid third week of a month, there is a trend of increasing traffic slightly and the rest mid third and fourth week of month traffic decrease rapidly.

Table 6.10: Summary of Weekly Flow Variation (East to West)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
1999	25.30%	24.26%	26.08%	24.36%
2000	24.68%	25.10%	24.94%	25.28%
2001	24.33%	25.46%	25.12%	25.09%
2002	24.81%	25.16%	25.42%	24.61%
2003	24.80%	25.08%	25.42%	24.70%
2004	24.40%	25.62%	25.10%	24.88%
2005	24.86%	25.40%	25.48%	24.25%
2006	24.74%	24.63%	25.31%	25.32%
2007	24.20%	25.29%	25.95%	24.57%
2008	25.27%	25.35%	24.71%	24.67%
2009	24.18%	25.05%	25.84%	24.93%
2010	24.45%	25.88%	25.32%	24.35%
2011	24.69%	24.66%	25.30%	25.35%
2012	24.22%	24.85%	25.90%	25.04%
2013	24.24%	25.76%	26.42%	23.58%
Average	**24.61%**	**25.17%**	**25.49%**	**24.73%**

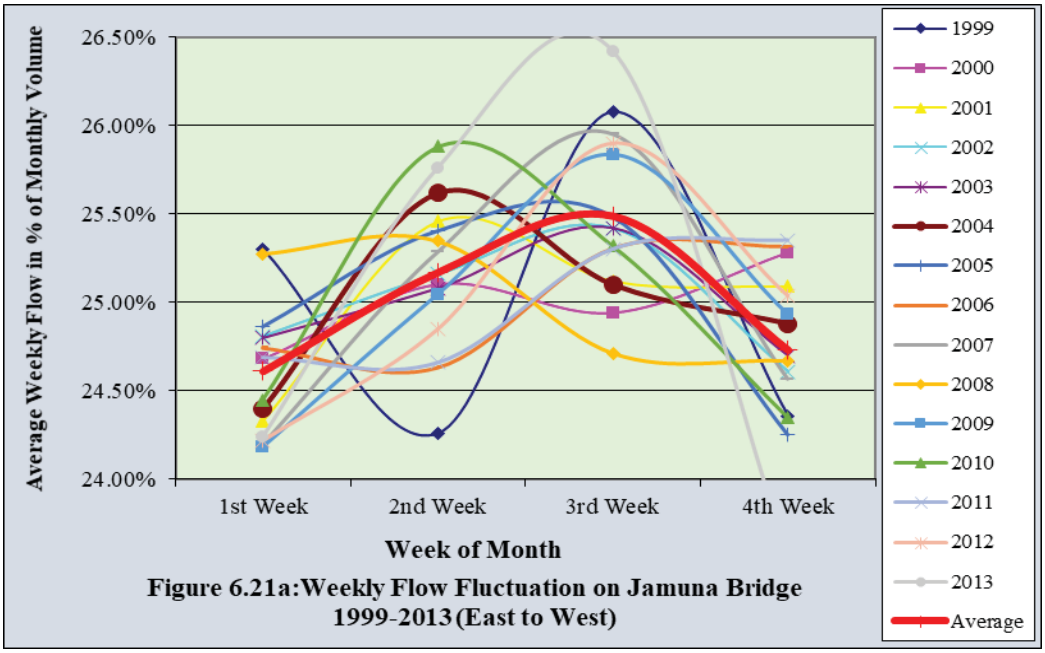


Figure 6.21a:Weekly Flow Fluctuation on Jamuna Bridge 1999-2013 (East to West)

Table 6.11: Summary of Weekly Flow Variation (West to East)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
1999	25.56%	24.15%	25.74%	24.54%
2000	24.58%	25.26%	24.88%	25.28%
2001	24.64%	25.44%	25.16%	24.76%
2002	24.64%	25.39%	25.21%	24.75%
2003	24.87%	24.89%	25.58%	24.66%
2004	24.21%	25.62%	25.40%	24.77%
2005	24.73%	25.54%	25.08%	24.65%
2006	25.06%	24.12%	25.71%	25.11%
2007	24.60%	25.05%	25.45%	24.90%
2008	25.67%	25.21%	24.77%	24.35%
2009	24.96%	25.17%	25.07%	24.79%
2010	24.58%	25.44%	25.50%	24.47%
2011	24.28%	25.46%	25.44%	24.82%
2012	24.69%	25.04%	25.26%	25.01%
2013	24.11%	24.97%	27.01%	23.91%
Average	**24.75%**	**25.12%**	**25.42%**	**24.72%**

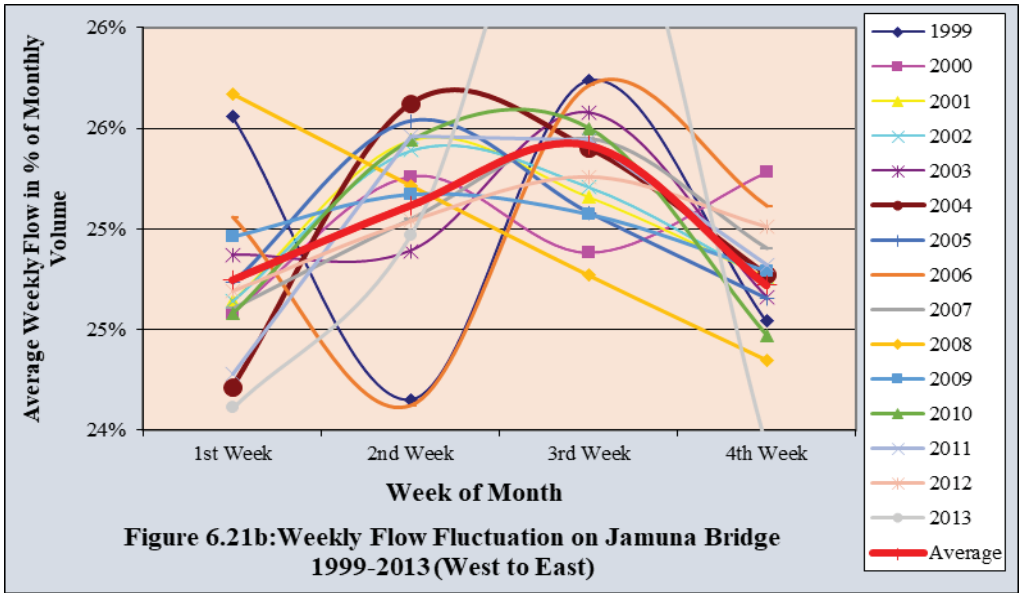


Figure 6.21b:Weekly Flow Fluctuation on Jamuna Bridge 1999-2013 (West to East)

6.6.3 MONTHLY TRAFFIC FLOW VARIATIONS IN NH-5

Monthly traffic flow pattern plays a vital role for long term traffic design of a pavement. 15 years of daily traffic flow data on Jamuna bridge is used for determination of seasonal traffic flow pattern for NH-5. A thorough understanding of the nature of traffic flow variation in different months of a year can be observed along NH-5.

Characteristics curves showing monthly flow variation is shown in Figure 6.22. 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.

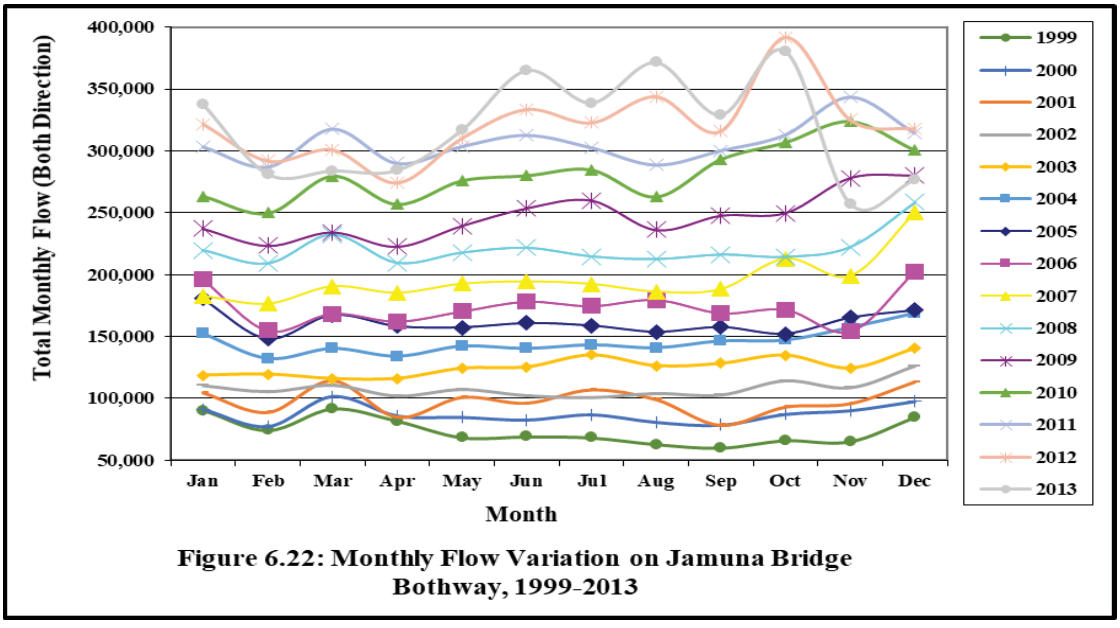


Figure 6.22: Monthly Flow Variation on Jamuna Bridge Bothway, 1999-2013

The following table (Table 6.12) shows the monthly flow analyses on Jamuna bridge.

Table 6.12: Monthly Traffic Flow Analyses on Dhaka to North Bengal Highway (1999-2013)

Month\ Year	1999	2000	2001	2002	2003	2004
Jan	90,390	91,222	104,393	110,248	118,564	152,370
Feb	74,152	77,506	88,775	105,303	119,435	132,196
Mar	91,390	101,442	114,133	110,577	115,870	140,377
Apr	81,615	85,998	84,915	101,651	115,956	134,061
May	68,364	84,824	100,738	107,076	124,212	142,297
Jun	69,084	82,696	96,132	101,962	125,251	140,345
Jul	68,208	86,879	106,750	100,400	135,028	143,343
Aug	62,932	80,847	99,045	103,788	126,283	140,924
Sep	60,048	78,509	78,450	102,460	128,154	146,481
Oct	65,983	87,183	93,019	114,256	134,913	147,180
Nov	65,145	90,116	95,727	108,495	124,373	157,491
Dec	84,655	97,450	113,111	126,322	140,441	169,018
Yearly Volume	**881,966**	**1,044,672**	**1,175,188**	**1,292,538**	**1,508,480**	**1,746,083**
Month\ Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Jan	180,426	196,278	182,787	219,713	237,308	263,519
Feb	147,964	154,703	176,282	208,812	223,575	249,863
Mar	167,355	168,354	190,420	232,404	234,368	279,730
Apr	158,215	162,053	185,136	209,366	222,787	256,986
May	157,247	170,153	192,508	217,671	239,455	276,022
Jun	160,719	178,056	194,433	221,612	253,497	280,050
Jul	158,730	174,472	192,399	214,606	259,745	284,713
Aug	153,591	179,494	186,088	212,331	236,128	263,028
Sep	157,462	168,778	188,161	216,116	247,680	293,097
Oct	152,113	171,521	212,973	214,256	249,826	306,731
Nov	165,180	154,014	199,045	222,333	277,905	323,736
Dec	171,311	202,618	250,577	258,719	279,918	300,563
Yearly Volume	**1,930,313**	**2,080,494**	**2,350,809**	**2,647,939**	**2,962,192**	**3,378,038**
Month\ Year	**2011**	**2012**	**2013**			
Jan	303,402	321,827	337,724			
Feb	287,295	292,009	281,066			
Mar	317,676	300,983	283,756			
Apr	290,143	274,368	284,239			
May	303,725	310,332	316,706			
Jun	312,701	333,667	365,068			
Jul	302,699	322,870	338,842			
Aug	288,904	343,998	371,625			
Sep	300,352	315,990	329,058			

Oct	313,090	391,954	380,739
Nov	343,271	325,298	257,199
Dec	314,519	317,889	276,520
Yearly Volume	**3,677,777**	**3,851,185**	**3,822,542**

The highest and lowest monthly traffic flow in percentage of total yearly volume from 1999 to 2013 is calculated below in table 6.13. The Maximum and minimum flow along NH-5 is marked in red and blue color respectively. The graphical representation is shown below Figure 6.23.

Table 6.13: Highest & Lowest Monthly Traffic Flow Table in NH-5

Month\ Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Jan	10.25%	8.73%	8.88%	8.53%	7.86%	8.73%
Feb	8.41%	7.42%	7.55%	8.15%	7.92%	7.57%
Mar	10.36%	9.71%	9.71%	8.56%	7.68%	8.04%
Apr	9.25%	8.23%	7.23%	7.86%	7.69%	7.68%
May	7.75%	8.12%	8.57%	8.28%	8.23%	8.15%
Jun	7.83%	7.92%	8.18%	7.89%	8.30%	8.04%
Jul	7.73%	8.32%	9.08%	7.77%	8.95%	8.21%
Aug	7.14%	7.74%	8.43%	8.03%	8.37%	8.07%
Sep	6.81%	7.52%	6.68%	7.93%	8.50%	8.39%
Oct	7.48%	8.35%	7.92%	8.84%	8.94%	8.43%
Nov	7.39%	8.63%	8.15%	8.39%	8.24%	9.02%
Dec	9.60%	9.33%	9.62%	9.77%	9.31%	9.68%
Yearly Volume	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Max.	**10.36%**	**9.71%**	**9.71%**	**9.77%**	**9.31%**	**9.68%**
Min.	**6.81%**	**7.42%**	**6.68%**	**7.77%**	**7.68%**	**7.57%**
Month\ Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Jan	9.35%	9.43%	7.78%	8.30%	8.01%	7.80%
Feb	7.67%	7.44%	7.50%	7.89%	7.55%	7.40%
Mar	8.67%	8.09%	8.10%	8.78%	7.91%	8.28%
Apr	8.20%	7.79%	7.88%	7.91%	7.52%	7.61%
May	8.15%	8.18%	8.19%	8.22%	8.08%	8.17%
Jun	8.33%	8.56%	8.27%	8.37%	8.56%	8.29%
Jul	8.22%	8.39%	8.18%	8.10%	8.77%	8.43%
Aug	7.96%	8.63%	7.92%	8.02%	7.97%	7.79%
Sep	8.16%	8.11%	8.00%	8.16%	8.36%	8.68%
Oct	7.88%	8.24%	9.06%	8.09%	8.43%	9.08%
Nov	8.56%	7.40%	8.47%	8.40%	9.38%	9.58%
Dec	8.87%	9.74%	10.66%	9.77%	9.45%	8.90%
Yearly Volume	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Max.	**9.35%**	**9.74%**	**10.66%**	**9.77%**	**9.45%**	**9.58%**

Min.	**7.67%**	**7.40%**	**7.50%**	**7.89%**	**7.52%**	**7.40%**

Month\ Year	**2011**	**2012**	**2013**
Jan	8.25%	8.36%	8.84%
Feb	7.81%	7.58%	7.35%
Mar	8.64%	7.82%	7.42%
Apr	7.89%	7.12%	7.44%
May	8.26%	8.06%	8.29%
Jun	8.50%	8.66%	9.55%
Jul	8.23%	8.38%	8.86%
Aug	7.86%	8.93%	9.72%
Sep	8.17%	8.21%	8.61%
Oct	8.51%	10.18%	9.96%
Nov	9.33%	8.45%	6.73%
Dec	8.55%	8.25%	7.23%
Yearly Volume	100.00%	100.00%	100.00%
Max.	**9.33%**	**10.18%**	**9.96%**
Min.	**7.81%**	**7.12%**	**6.73%**

The above table indicates a thorough understanding of NH-5 traffic monthly variations in percentage of yearly volume. The average maximum monthly flow percentage occurs more frequently on November and December. The 15 years average maximum monthly flow befalls in December along NH-5. Nevertheless, minimum flow take place more recurrently in February.

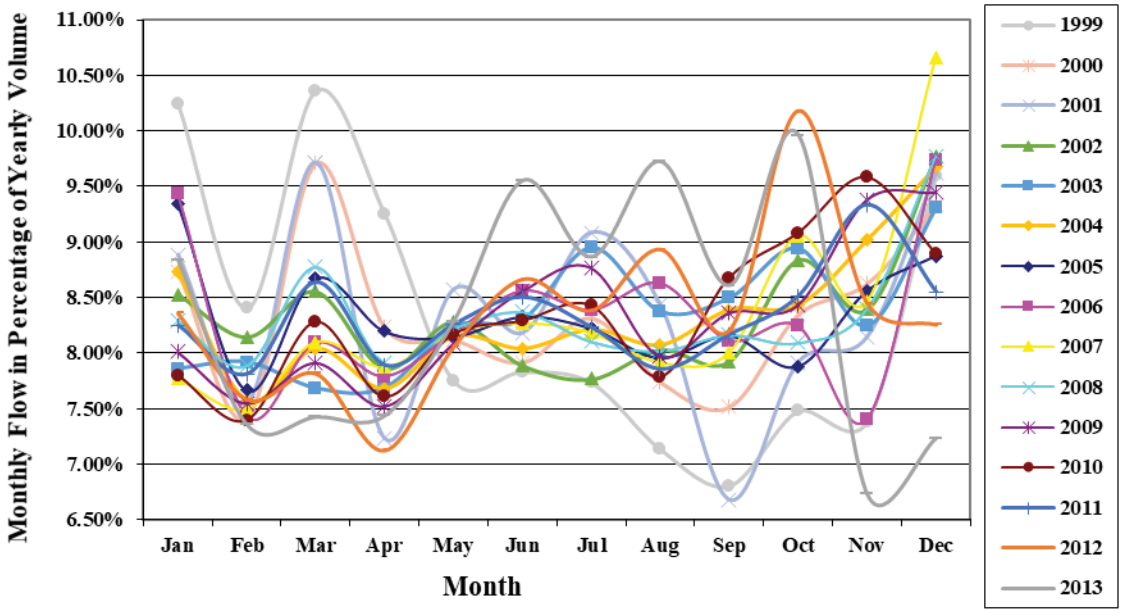


Figure 6.23: Monthly Flow Variation (in percentage of Yearly Volume for Bi-Directional Traffic)

Table 6.14: Summarized Seasonal Flow Variation Table

Dry Season		Rainy Season	
Month	**Flow % in Season**	**Month**	**Flow % in Season**
Nov	8.41%	May	8.18%
Dec	9.25%	Jun	8.35%
Jan	8.61%	Jul	8.38%
Feb	7.68%	Aug	8.17%
Mar	8.52%	Sep	8.02%
Apr	7.82%	Oct	8.63%
Total	50.28%	Total	49.72%

It is shown in table 6.14 and figure 6.25 that more flow occurs on dry season (50.28%) than on the wet season (49.72%). Bangladesh has a subtropical monsoon climate characterized by wide seasonal variations in rainfall. The dry season is considered from November to April, and rainy season is measured from May to October. The infrastructure construction works are mainly happening in dry season that increase more freight movement in dry seasons. The seasonal distribution chart for Jamuna Bridge corridor is shown below in figure 6.24.

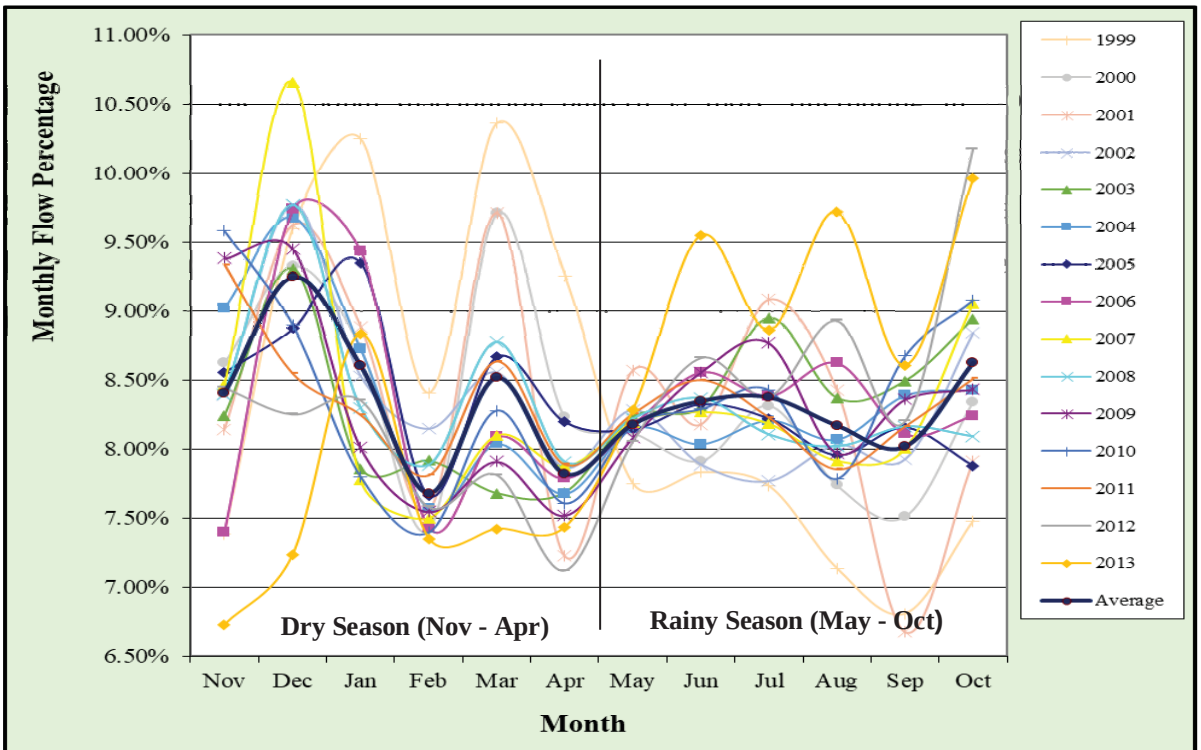


Figure 6.24: Seasonal Flow Variation on Jamuna Bridge 1999-2013 (Bothway)

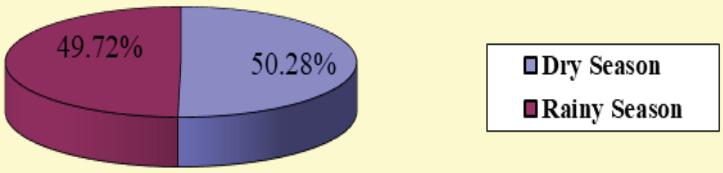


Figure 6.25: Seasonal Distribution of Traffic on Jamuna Bridge (Bothway), 1999-2013

The figure 6.26, 6.27 & 6.28 below depicts the seasonal variations of large bus, medium truck and light vehicles in NH-5 corridor from 1999 to 2013.

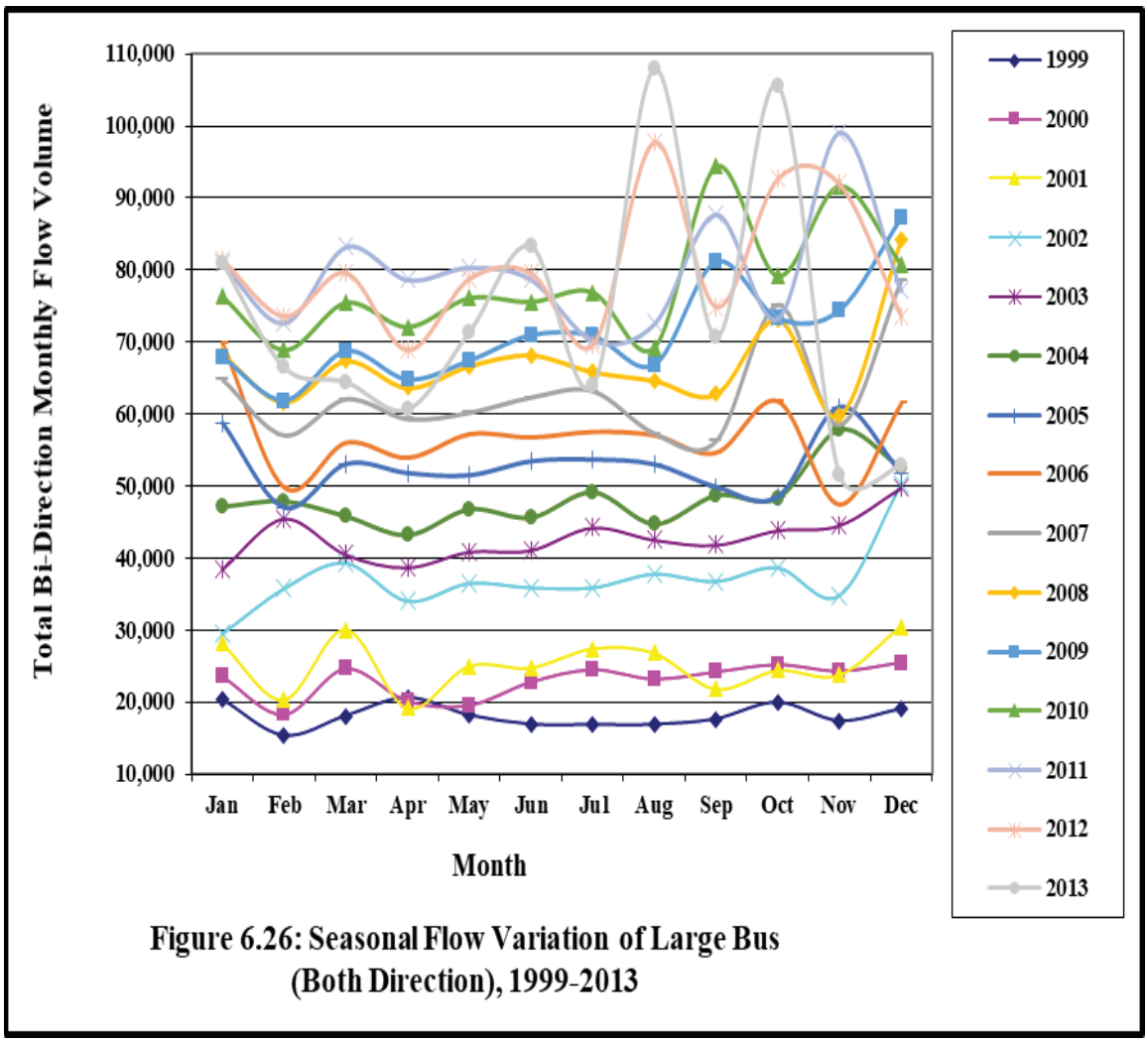


Figure 6.26: Seasonal Flow Variation of Large Bus (Both Direction), 1999-2013

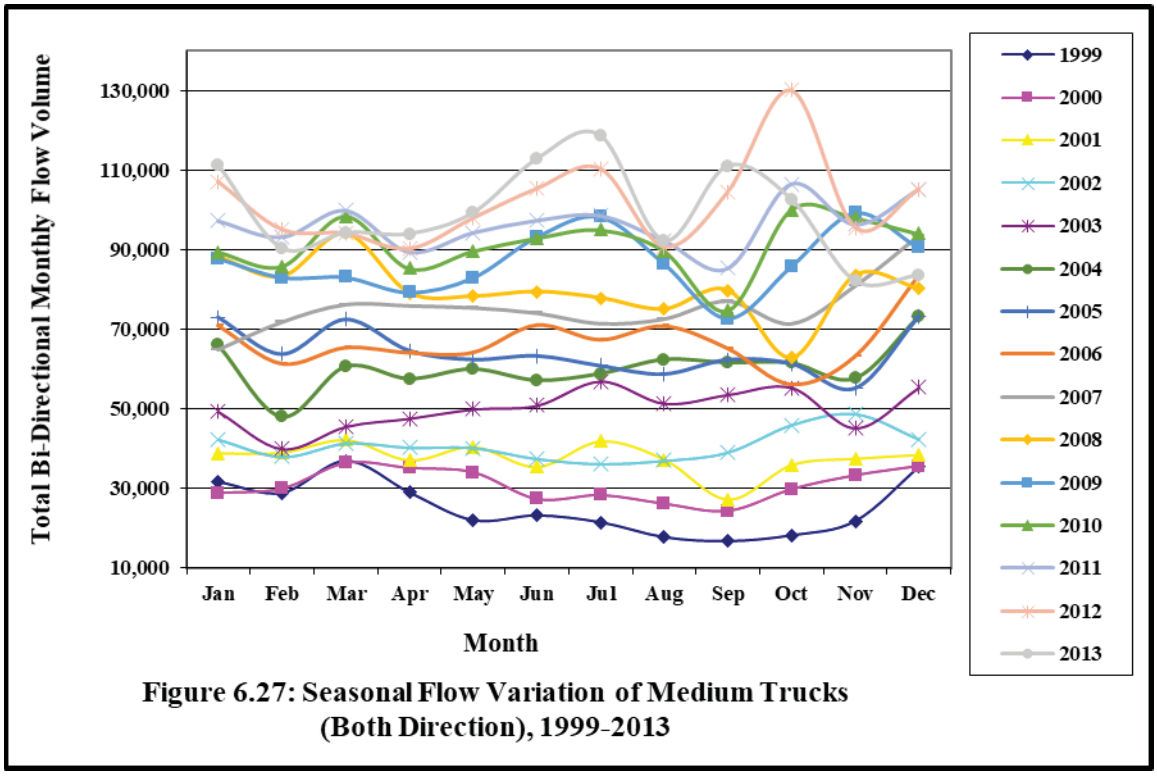
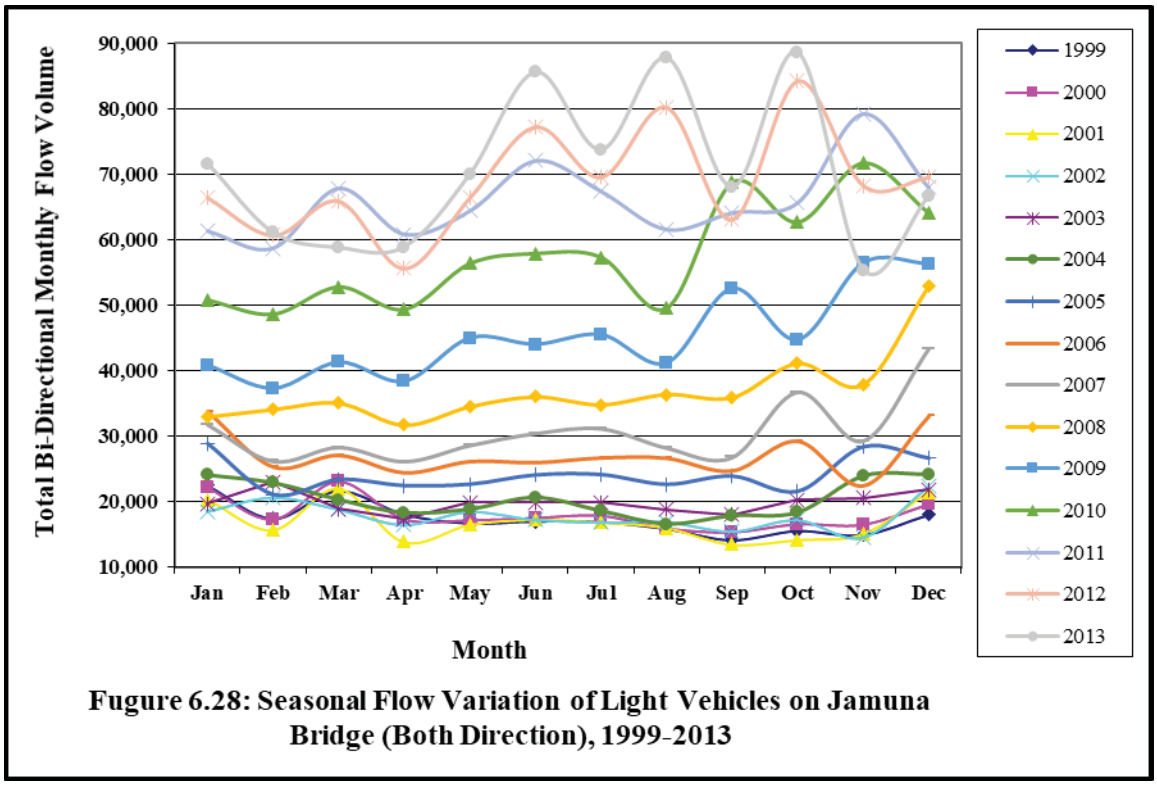


Figure 6.27: Seasonal Flow Variation of Medium Trucks (Both Direction), 1999-2013



Fugure 6.28: Seasonal Flow Variation of Light Vehicles on Jamuna Bridge (Both Direction), 1999-2013

Summary of Findings:

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

Table 6.15: Summary Table - Seasonal Flow Variation (average of 15 years)

Vehicle Class	Maximum Flow		Minimum Flow	
	Month	Percentage of Yearly Volume	Month	Percentage of Yearly Volume
Total Traffic	December	9.25%	February	7.68%
Large Bus	December	9.12%	February	7.53%
Medium Truck	December	9.22%	September	7.71%
Light Vehicles	December	9.69%	April	7.41%

6.7 CALCULATION OF EXPANSION FACTORS OF DHAKA-NORTH BENGAL HIGHWAY

The daily and monthly expansion factors is calculated from 15 years of database of Jamuna bridge, that is useful for traffic design and estimation of AADT from short counts.

6.7.1 CALCULATION OF DAILY EXPANSION FACTORS IN NH-5

Daily traffic data on Jamuna bridge from 1999 to 2013 have been used to determine Daily Expansion Factor. First the raw data have been summarized to determine the average daily flow for each of seven days of week individually for all 15 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 6.16 shows the daily expansion factors and yearly average flow on each weekday from 1999 to 2013. Summation of these daily flows for seven weekdays gives average weekly flow, which have been determined individually for every year. From these data, Daily Expansion Factors are calculated. Taking the mean value

for daily expansion factors for the years 1999 to 2013, average daily expansion factors have been determined.

Table 6.16: Daily Expansion Factors, DEF (for Bi-Directional Traffic) for NH-5

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**		**2006**	
	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	5,825	6.85
Sunday	4,273	6.77	4,733	7.05	5,210	7.11	5,597	7.13
Monday	4,299	6.73	4,690	7.12	5,254	7.05	5,563	7.17
Tuesday	4,173	6.93	4,747	7.03	5,414	6.84	5,498	7.26
Wednesday	4,103	7.05	4,767	7.00	5,603	6.61	5,490	7.27
Thursday	4,068	7.11	4,920	6.78	5,422	6.83	5,783	6.90
Friday	4,211	6.87	5,159	6.47	5,460	6.78	6,147	6.49
Avg. Weekly Flow	28,930		33,385		37,032		39,902	
Day \ Year	**2007**		**2008**		**2009**		**2010**	
	Avg. Flow	**DEF**	**Avg. Flow**	**DEF**	**Avg. Flow**	**DEF**	**Avg. Flow**	**DEF**
Saturday	6,214	7.26	7,074	7.14	7,819	7.26	8,930	7.25
Sunday	6,206	7.27	7,300	6.92	7,885	7.20	9,016	7.18
Monday	6,240	7.23	7,244	6.97	7,893	7.20	9,303	6.96
Tuesday	6,450	6.99	7,126	7.09	8,027	7.08	9,301	6.97
Wednesday	6,680	6.75	7,036	7.18	8,223	6.91	9,262	6.99
Thursday	6,700	6.73	7,273	6.95	8,370	6.79	9,446	6.86
Friday	6,599	6.83	7,460	6.77	8,587	6.62	9,521	6.80
Avg. Weekly Flow	45,088		50,512		56,804		64,779	
Day \ Year	**2011**		**2012**		**2013**		**Average**	

	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF
Saturday	10,053	7.02	10,251	7.19	11,341	6.47	6,153	**7.45**
Sunday	9,844	7.17	9,871	7.46	10,426	7.03	6,152	**7.46**
Monday	9,702	7.27	10,068	7.32	9,716	7.55	6,118	**7.50**
Tuesday	10,019	7.04	10,248	7.19	9,165	8.00	6,113	**7.50**
Wednesday	10,053	7.02	10,756	6.85	9,748	7.52	6,241	**7.35**
Thursday	10,132	6.96	11,014	6.69	10,572	6.94	6,400	**7.17**
Friday	10,730	6.57	11,470	6.42	12,367	5.93	6,702	**6.84**
Avg. Weekly Flow	70,533		73,678		73,334		45,867	

The pictorial representation of daily expansion factors of 15 years has been plotted in figure 6.29. The daily expansion factor varies from 5.85 to 8.00. The minimum average expansion factor is found on Friday, that indicates maximum flow occurs on Friday. Also, maximum average expansion factors are found on Monday and Tuesday, which implies that minimum flow occurs in these two days.

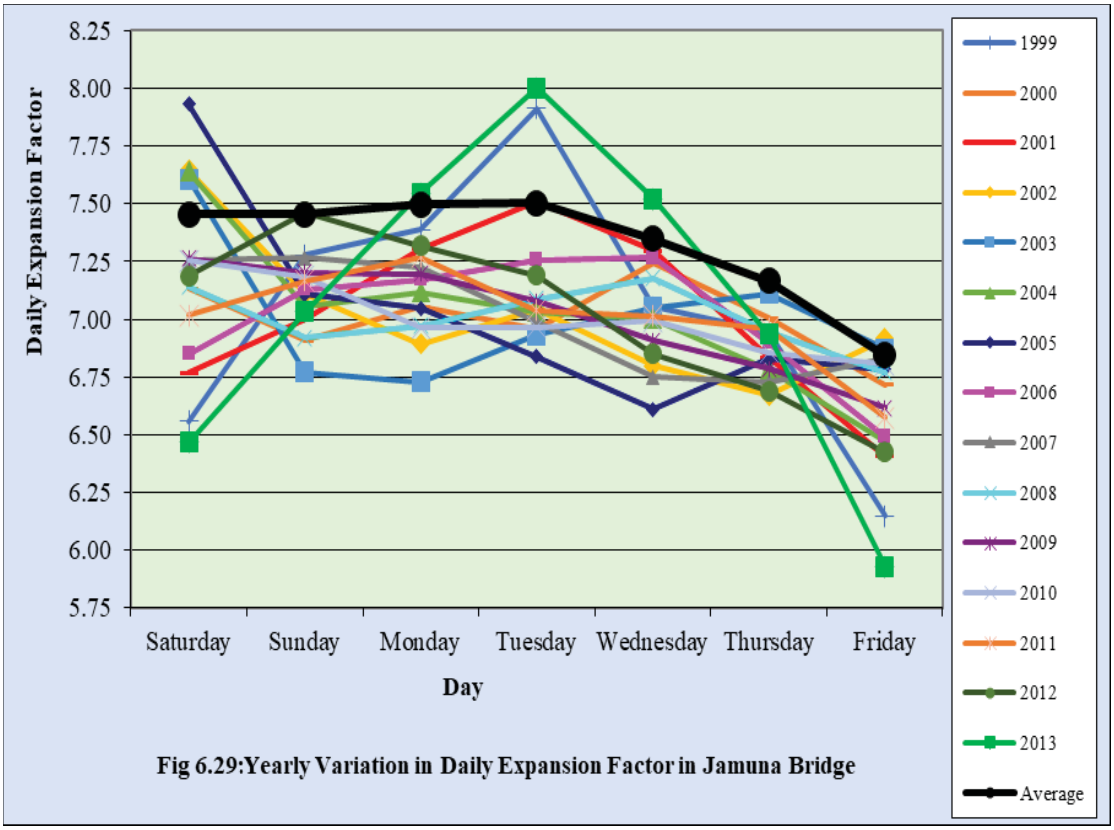


Fig 6.29:Yearly Variation in Daily Expansion Factor in Jamuna Bridge

Different vehicle class have different daily flow fluctuation pattern. Hence, attempts have been made to calculate class wise expansion factors on NH-5 based upon 15 years of data. Table 6.17 shows the class wise daily expansion factors.

Table 6.17: Class-wise Daily Expansion Factors, DEF (for Bi-Directional Traffic)

Day	Motor Cycle	Light Vehicles	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
Saturday	6.54	6.81	6.96	6.87	7.23	7.56	7.43	**7.13**
Sunday	7.57	7.56	7.44	7.14	7.09	6.88	7.32	**7.13**
Monday	7.78	7.60	7.46	7.19	7.00	6.94	7.12	**7.17**
Tuesday	7.96	7.60	7.40	7.29	7.04	6.86	6.98	**7.17**
Wednesday	7.94	7.45	6.77	7.20	6.87	6.74	6.70	**7.04**
Thursday	6.49	6.68	6.80	6.86	6.87	6.99	6.84	**6.86**
Friday	5.53	5.75	6.34	6.51	6.92	7.08	6.68	**6.55**

Notes:

- The above DEF can be directly used to estimate average weekly volume.

6.7.2 CALCULATION OF MONTHLY EXPANSION FACTORS IN NH-5

Monthly expansion factor of NH-5 is calculated in this section. The monthly expansion factors for each of concerned year have been calculated. Then those factors are averaged to determine the final monthly expansion factors. Table 6.18 below contains monthly expansion factor of Jamuna Bridge corridor for each individual year (1999 to 2013).

Table 6.18: Monthly Expansion Factors in NH-5

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	

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	
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	
Month \ Year	**2005**			**2006**		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**

January	180,426	5,820	**0.909**	196,278	6,332	**0.897**
February	147,964	5,284	**1.001**	154,703	5,335	**1.065**
March	167,355	5,399	**0.980**	168,354	5,431	**1.046**
April	158,215	5,274	**1.003**	162,053	5,402	**1.052**
May	157,247	5,072	**1.043**	170,153	5,489	**1.035**
June	160,719	5,357	**0.987**	178,056	5,935	**0.957**
July	158,730	5,120	**1.033**	174,472	5,628	**1.009**
August	153,591	4,955	**1.068**	179,494	5,790	**0.981**
September	157,462	5,249	**1.008**	168,778	5,626	**1.010**
October	152,113	4,907	**1.078**	171,521	5,533	**1.027**
November	165,180	5,506	**0.961**	154,014	5,134	**1.107**
December	171,311	5,526	**0.957**	202,618	6,536	**0.869**
Total		63469			68170	
AADT		5289			5681	
Month \ Year	**2007**			**2008**		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	182,787	5,896	**1.092**	219,713	7,088	**1.024**
February	176,282	6,296	**1.023**	208,812	7,458	**0.973**
March	190,420	6,143	**1.048**	232,404	7,497	**0.968**
April	185,136	6,171	**1.043**	209,366	6,979	**1.040**
May	192,508	6,210	**1.037**	217,671	7,022	**1.033**
June	194,433	6,481	**0.993**	221,612	7,387	**0.982**
July	192,399	6,206	**1.037**	214,606	6,923	**1.048**
August	186,088	6,003	**1.073**	212,331	6,849	**1.059**
September	188,161	6,272	**1.027**	216,116	7,204	**1.007**
October	212,973	6,870	**0.937**	214,256	6,911	**1.050**
November	199,045	6,635	**0.970**	222,333	7,411	**0.979**
December	250,577	8,083	**0.797**	258,719	8,346	**0.869**
Total		77266			87074	
AADT		6439			7256	
Month \ Year	**2009**			**2010**		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	237,308	7,655	1.060	263,519	8,501	1.089
February	223,575	7,985	1.017	249,863	8,924	1.037

March	234,368	7,560	1.074	279,730	9,024	1.026
April	222,787	7,426	1.093	256,986	8,566	1.081
May	239,455	7,724	1.051	276,022	8,904	1.040
June	253,497	8,450	0.961	280,050	9,335	0.992
July	259,745	8,379	0.969	284,713	9,184	1.008
August	236,128	7,617	1.066	263,028	8,485	1.091
September	247,680	8,256	0.983	293,097	9,770	0.947
October	249,826	8,059	1.007	306,731	9,895	0.935
November	277,905	9,264	0.876	323,736	10,791	0.858
December	279,918	9,030	0.899	300,563	9,696	0.955
Total		97405			111073	
AADT		8117			9256	
Month \ Year	**2011**			**2012**		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	303,402	9,787	**1.030**	321,827	10,382	**1.013**
February	287,295	10,261	**0.982**	292,009	10,069	**1.045**
March	317,676	10,248	**0.984**	300,983	9,709	**1.083**
April	290,143	9,671	**1.042**	274,368	9,146	**1.150**
May	303,725	9,798	**1.029**	310,332	10,011	**1.051**
June	312,701	10,423	**0.967**	333,667	11,122	**0.946**
July	302,699	9,764	**1.032**	322,870	10,415	**1.010**
August	288,904	9,319	**1.082**	343,998	11,097	**0.948**
September	300,352	10,012	**1.007**	315,990	10,533	**0.999**
October	313,090	10,100	**0.998**	391,954	12,644	**0.832**
November	343,271	11,442	**0.881**	325,298	10,843	**0.970**
December	314,519	10,146	**0.994**	317,889	10,254	**1.026**
Total		120971			126225	
AADT		10081			10519	
Month \ Year	**2013**			**Average MEF**		
	Flow	**ADT**	**MEF**			
January	337,724	10,894	**0.961**	**0.992**		
February	281,066	10,038	**1.043**	**1.009**		
March	283,756	9,153	**1.144**	**1.005**		
April	284,239	9,475	**1.105**	**1.054**		

May	316,706	10,216	**1.025**	**1.038**
June	365,068	12,169	**0.860**	**0.986**
July	338,842	10,930	**0.958**	**1.015**
August	371,625	11,988	**0.873**	**1.044**
September	329,058	10,969	**0.954**	**1.030**
October	380,739	12,282	**0.852**	**0.990**
November	257,199	8,573	**1.221**	**0.985**
December	276,520	8,920	**1.173**	**0.925**
Total		125608		
AADT		10467		

Notes:

- The above MEF can be directly used to estimate AADT from Avg. 24-hour volume.

The equation used for calculation of monthly expansion factors is:

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

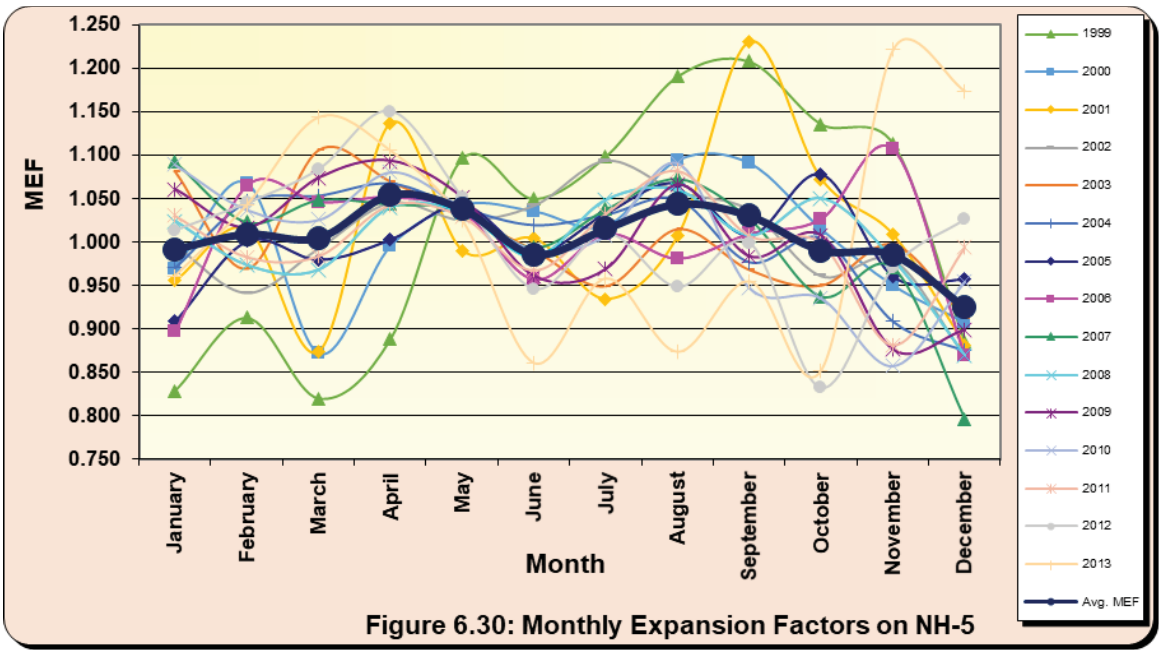


Figure 6.30: Monthly Expansion Factors on NH-5

Figure 6.30 illustrates 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. However, no substantial variations in pattern is observed for different

vehicular class and total traffic. Thus, monthly expansion factors for individual vehicle class is not necessarily to be used for AADT estimation, rather average factors may be effectively applied.

6.8 CALCULATION OF INDIVIDUAL VEHICLE CLASS WISE GROWTH FACTOR OF DHAKA-NORTH BENGAL HIGHWAY

Separate vehicular class wise traffic growth in Jamuna bridge corridor is calculated in this section. Table 6.19 shows individual class wise yearly bi-directional traffic from 1999 to 2013 and, traffic growth is also found in Table 6.20.

Table 6.19: Class-wise Total Yearly Traffic in Both Direction (1999 to 2013)

Year	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
1999	46,875	208,811	84,111	216,913	19,117	303,488	2,651	881,966
2000	39,610	216,851	105,496	275,865	34,279	370,233	2,338	1,044,672
2001	37,230	202,765	127,676	302,220	47,488	451,533	6,276	1,175,188
2002	35,047	214,327	37,017	445,010	64,047	489,274	7,816	1,292,538
2003	33,036	238,369	26,882	511,972	81,718	601,367	15,136	1,508,480
2004	35,795	245,012	30,999	577,808	108,079	725,230	23,160	1,746,083
2005	42,155	289,910	30,720	632,938	134,709	771,500	28,381	1,930,313
2006	48,078	325,570	27,376	683,070	164,791	804,071	27,538	2,080,494
2007	36,380	367,540	25,362	754,136	243,766	905,213	18,412	2,350,809
2008	47,220	443,507	23,967	805,991	348,843	961,743	16,668	2,647,939
2009	60,012	543,832	16,025	855,390	423,137	1,042,748	21,048	2,962,192
2010	71,999	690,335	10,271	936,410	548,463	1,093,588	26,972	3,378,038
2011	98,334	791,307	10,216	954,772	632,664	1,155,678	34,806	3,677,777
2012	115,161	827,498	10,045	962,547	672,534	1,226,565	36,835	3,851,185
2013	162,528	846,285	9,149	879,828	692,445	1,192,351	39,956	3,822,542

Table 6.20: Class-wise Traffic Growth in Both Direction (1999 to 2013)

Year	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
1999	-	-	-	-	-	-	-	-
2000	-15	4	25	27	79	22	-12	18
2001	-6	-6	21	10	39	22	168	12
2002	-6	6	-71	47	35	8	25	10
2003	-6	11	-27	15	28	23	94	17
2004	8	3	15	13	32	21	53	16
2005	18	18	-1	10	25	6	23	11
2006	14	12	-11	8	22	4	-3	8
2007	-24	13	-7	10	48	13	-33	13
2008	30	21	-6	7	43	6	-9	13
2009	27	23	-33	6	21	8	26	12
2010	20	27	-36	9	30	5	28	14

2011	37	15	-1	2	15	6	29	9
2012	17	5	-2	1	6	6	6	5
2013	41	2	-9	-9	3	-3	8	-1
Avg. GF	11	11	-10	11	30	11	29	11
Std. Dvtn	20	9	25	13	19	8	51	5

Present RHD design manual states that, traffic growth trend in Bangladesh was assumed 10% per annum. However, it reveals from 15 years of field data that traffic growth factor is varying with time and likewise class wise growth factor is changing with time (Table 6.20). It is recommended from this research that road authority of Bangladesh should introduce separate growth rate for individual vehicle class instead of total traffic based upon realistic data.

6.9 REGRESSION ANALYSIS OF TRAFFIC IN DHAKA-NORTH BENGAL

Regression analyses of traffic is calculated in this section for NH-5. Specific regression equations are designed and corresponding calibration curves have been drawn in order to calculate AADT using regression approach.

6.9.1 DAILY REGRESSION MODEL FOR NH-5 CORRIDOR

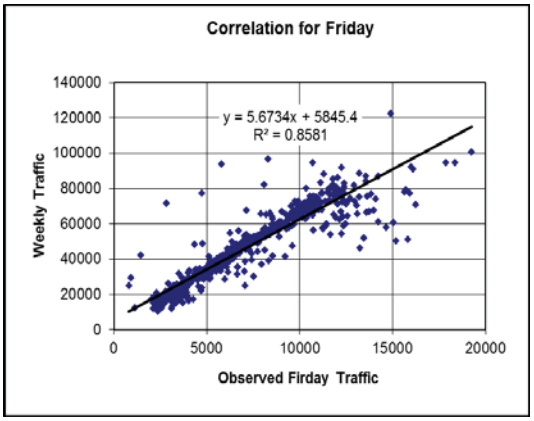
The daily traffic flow data on Jamuna bridge from 1999 to 2013 collected by toll operators provide daily regression models for expansion of short counts. Total 780 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models. The R^2 values are quite reliable in the table 6.21 below.

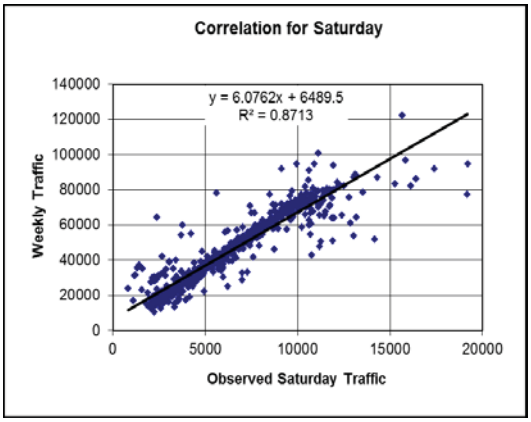
Table 6.21: Daily Regression Models for NH-5

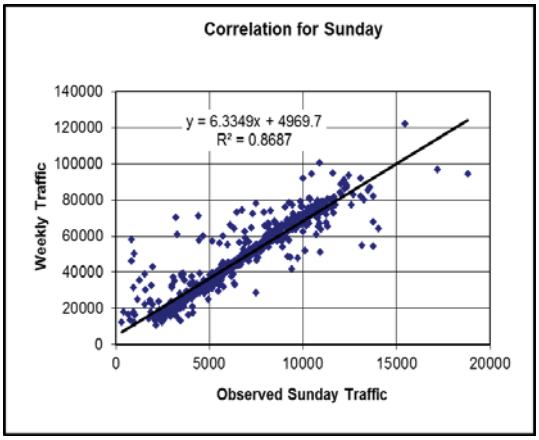
Day	Equation	R^2 value
Saturday	y = 6.0762x + 6489.5	0.8713
Sunday	y = 6.3349x + 4969.7	0.8687
Monday	y = 6.1947x + 5982.4	0.8622
Tuesday	y = 6.3435x + 5096.4	0.8905
Wednesday	y = 6.1495x + 5458.9	0.8755
Thursday	y = 6.1611x + 4447.8	0.9012
Friday	y = 5.6734x + 5845.4	0.8581

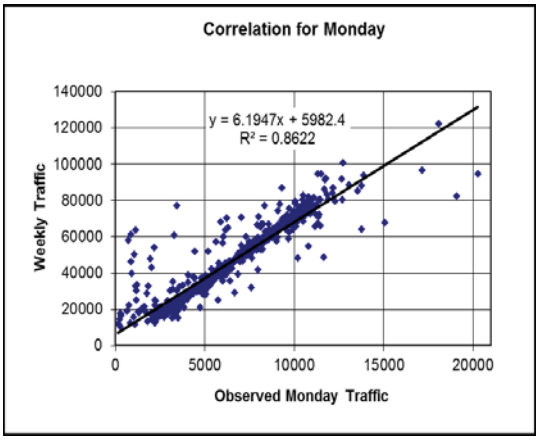
Where: x = observed daily traffic, y = weekly traffic

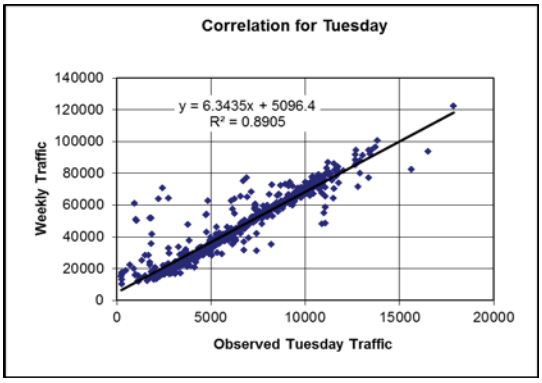
The daily expansion equations are shown in the above table, while the corresponding curves are presented in the following pages.

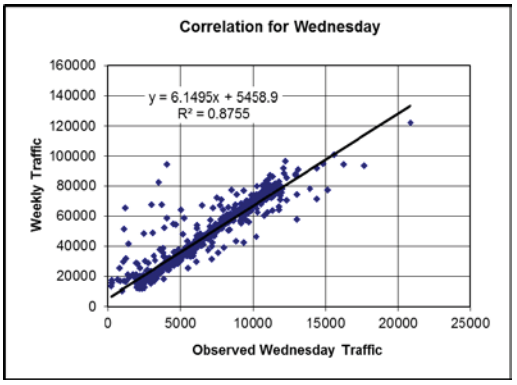












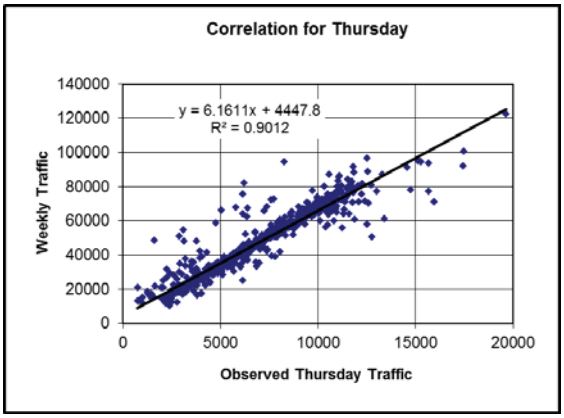


Figure 6.31: Daily regression models for NH-5.

6.9.2 MONTHLY REGRESSION MODEL FOR NH-5 CORRIDOR

For the regression analysis of monthly or seasonal expansions, 15 years of flow data on Jamuna Bridge 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 6.22. In all the cases the R^2 values are quite reliable.

Table 6.22: Monthly Regression Models for NH-5

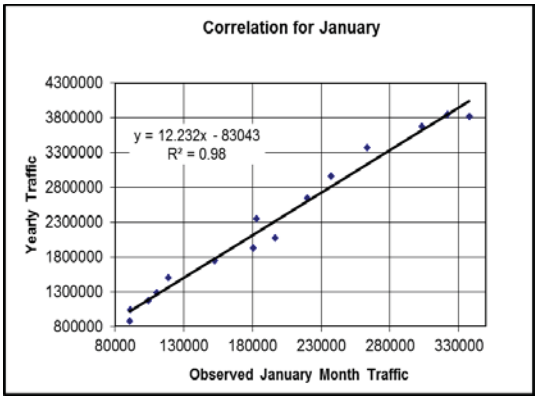
Month	Equation	R^2 value
January	y = 12.232x - 83043	0.98
February	y = 13.427x - 54243	0.9959
March	y = 13.068x - 191907	0.978
April	y = 13.688x - 125864	0.9908
May	y = 12.209x + 1830.3	0.9991
June	y = 10.821x + 186982	0.9897
July	y = 11.573x + 60574	0.9932
August	y = 10.848x + 229600	0.9682
September	y = 11.341x + 164910	0.9948
October	y = 9.7764x + 311433	0.9731
November	y = 10.856x + 184392	0.9317
December	y = 12.202x - 234767	0.9401

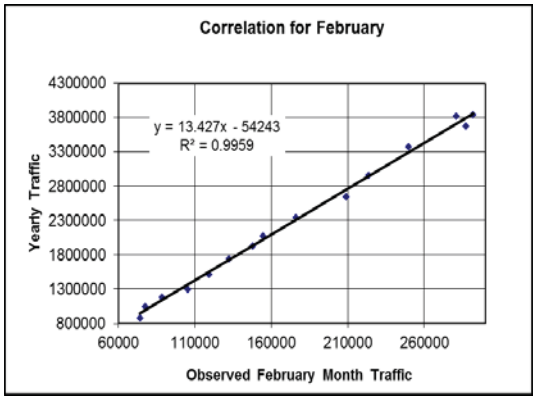
Where:

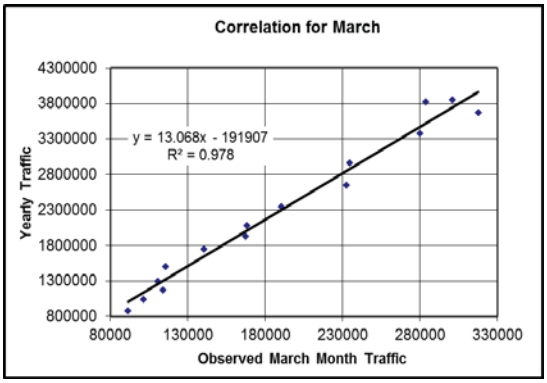
x = observed monthly traffic

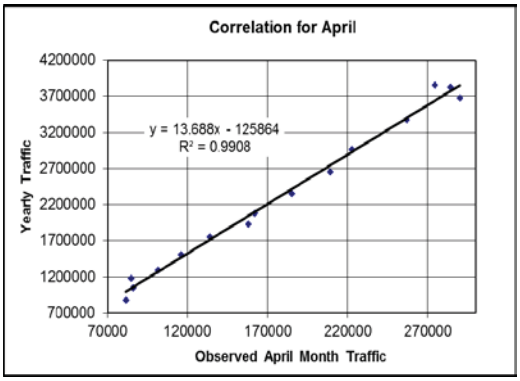
y = yearly traffic volume

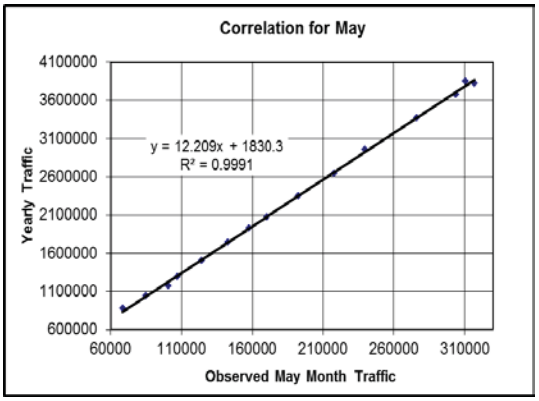
The linear regression curves are given below. These monthly calibration curves can be directly used to estimate AADT from daily flow.

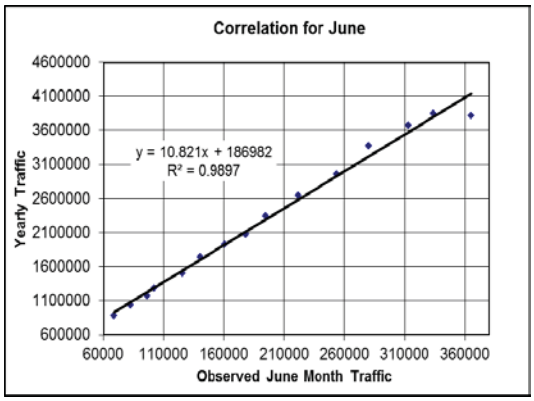












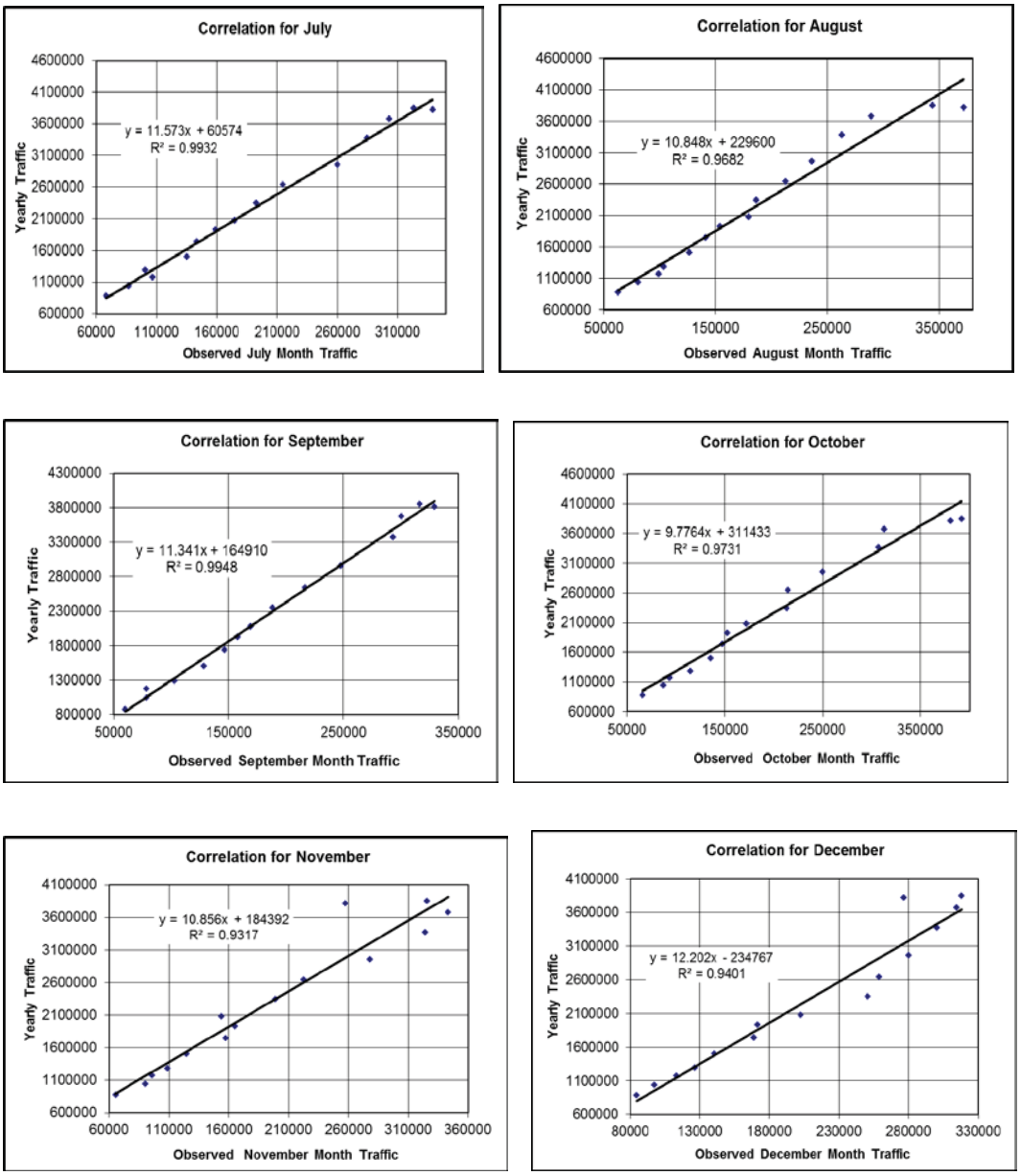


Figure 6.32: Monthly regression models for NH-5.

6.10 DETERMINATION OF TRAFFIC FLOW MODEL USING ARTIFICIAL NEURAL NETWORK IN DHAKA-NORTH BENGAL HIGHWAY

"Zaitun time series" software is used to prepare ANN model for Jamuna bridge corridor. The neural network analysis interface is shown below in figure 6.33. The program uses a general form of back propagation algorithm to the network to the input and output data. Monthly traffic volume is used as variable called "TrafficData". There are 180 number of observations is trained for this study. Bipolar sigmoid function is used with 12 input layer neurons, 12 hidden layer neurons and 1 output layer neurons. Back propagation learning method with learning rate 0.05 and momentum 0.5 is set in this model.

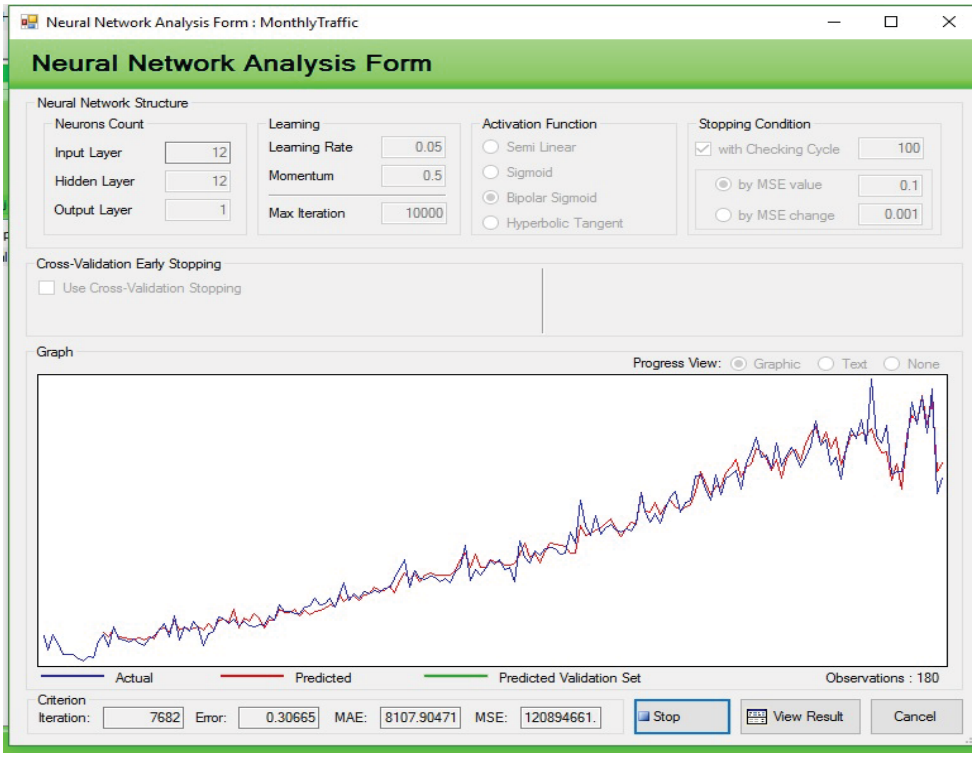


Figure 6.33: Artificial Neural Network Model Interface for Traffic Prediction in NH-5

Data training is completed by the actual traffic of the concern year and then, predicted traffic volume of corresponding months are carried out to realize and understand the predicting capability of ANN. The details of monthly actual traffic and predicted traffic from 2008 to 2013 is shown below as sample in table 6.23 below. It is surprising to observe that the ANN model of the traffic data is accurate enough to capture the trend of the data over the months of traffic volume measurement. Figure 6.34 and 6.35 is illustrating actual vs predicted traffic flow along NH-5. This has been a check to find out how the ANN captures the data pattern.

Table 6.23: Monthly Traffic Data Prediction by using ANN model

Months	Actual Traffic	Predicted Traffic	Months	Actual Traffic	Predicted Traffic	Months	Actual Traffic	Predicted Traffic
Jan-11	303402	300283	**Jan-12**	321827	332187	**Jan-13**	337724	309461
Feb-11	287295	286426	**Feb-12**	292009	312129	**Feb-13**	281066	272533
Mar-11	317676	300776	**Mar-12**	300983	324409	**Mar-13**	283756	290948
Apr-11	290143	279204	**Apr-12**	274368	290984	**Apr-13**	284239	261038
May-11	303725	301561	**May-12**	310332	309856	**May-13**	316706	323265
Jun-11	312701	309084	**Jun-12**	333667	328070	**Jun-13**	365068	351414
Jul-11	302699	310701	**Jul-12**	322870	325985	**Jul-13**	338842	341283
Aug-11	288904	296095	**Aug-12**	343998	329368	**Aug-13**	371625	375950
Sep-11	300352	315744	**Sep-12**	315990	324642	**Sep-13**	329058	341413
Oct-11	313090	330690	**Oct-12**	391954	335600	**Oct-13**	380739	371104

Nov-11	343271	338591	**Nov-12**	325298	317122	**Nov-13**	257199	280129
Dec-11	314519	316461	**Dec-12**	317889	305539	**Dec-13**	276520	293214
Months	**Actual Traffic**	**Predicted Traffic**	**Months**	**Actual Traffic**	**Predicted Traffic**	**Months**	**Actual Traffic**	**Predicted Traffic**
Jan-08	219713	211293	**Jan-09**	237308	236816	**Jan-10**	263519	265746
Feb-08	208812	211898	**Feb-09**	223575	236114	**Feb-10**	249863	252385
Mar-08	232404	216930	**Mar-09**	234368	247237	**Mar-10**	279730	266843
Apr-08	209366	218505	**Apr-09**	222787	233143	**Apr-10**	256986	267669
May-08	217671	222552	**May-09**	239455	242556	**May-10**	276022	283706
Jun-08	221612	229935	**Jun-09**	253497	249579	**Jun-10**	280050	287996
Jul-08	214606	218980	**Jul-09**	259745	240391	**Jul-10**	284713	296651
Aug-08	212331	208580	**Aug-09**	236128	236272	**Aug-10**	263028	274244
Sep-08	216116	218085	**Sep-09**	247680	240345	**Sep-10**	293097	290669
Oct-08	214256	224585	**Oct-09**	249826	245189	**Oct-10**	306731	293727
Nov-08	222333	222935	**Nov-09**	277905	260949	**Nov-10**	323736	313675
Dec-08	258719	258665	**Dec-09**	279918	280809	**Dec-10**	300563	306273

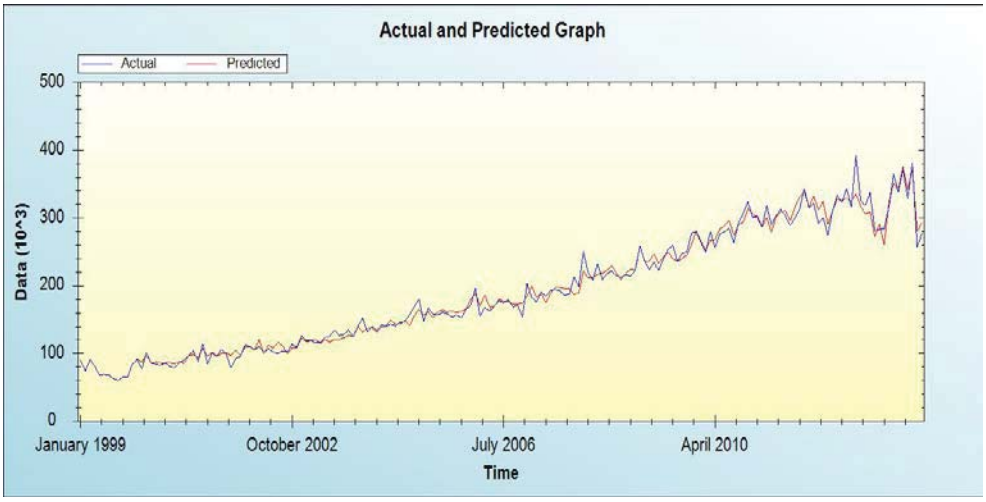


Figure 6.34: ANN Model-Actual and Predicted traffic in NH-5

Traffic forecasting have been studied through ANN model in Dhaka-North Bengal highway. Monthly traffic data have been trained from 1999 to 2013 in the neural network model. Traffic forecasting is observed in figure 6.36 and table 6.24. Artificial neural networks (ANNs) have proven to be an important development in a variety of problem solving areas. Increasing research activity in ANN applications has been accompanied by equally rapid growth in the commercial mainstream use of ANNs. The special characteristics make ANNs especially useful in a variety of applications. An ANN can provide an approach that is closer to human perception and recognition than traditional methods. In situations in which input is noisy or incomplete, ANNs can still produce reasonable results. The forecasted residual traffic in NH-1 have been found in figure 6.37 below.

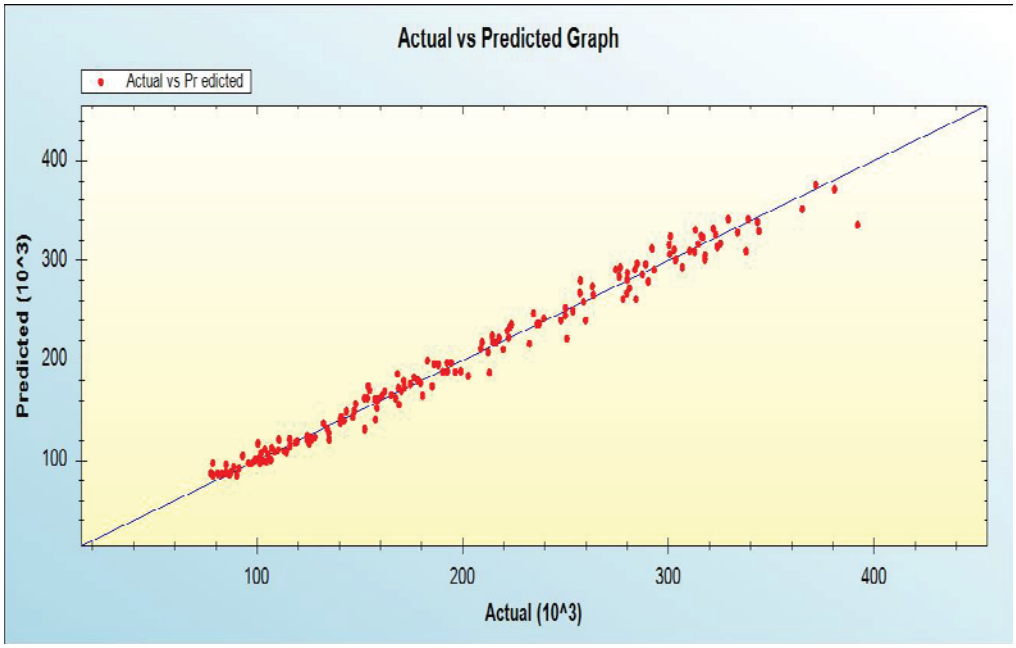


Figure 6.35: ANN Model-Comparison of Actual VS Predicted traffic in NH-5

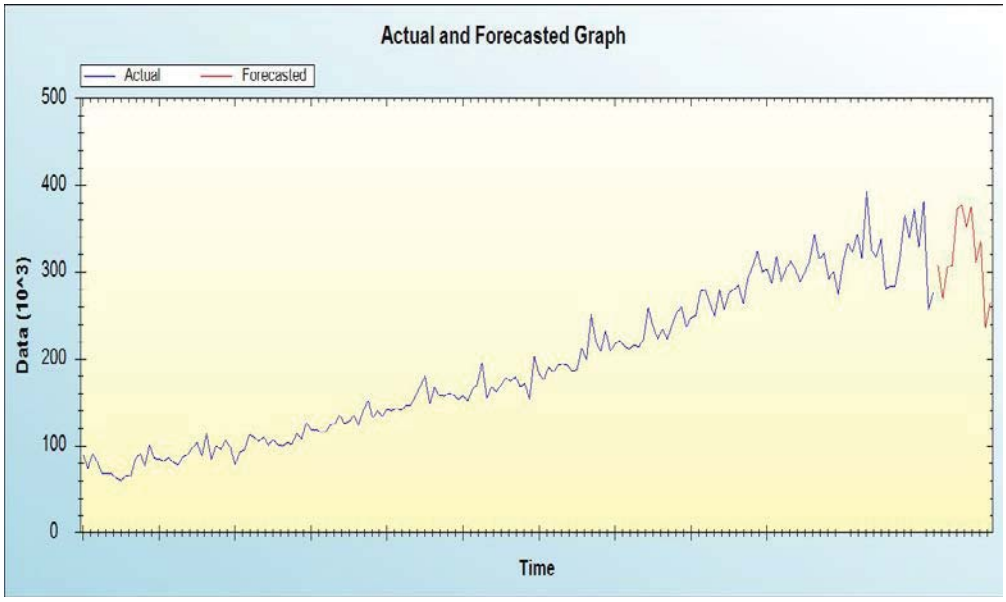


Figure 6.36: Artificial Neural Network Model-Actual and Forecasted traffic in NH-5

Figure 6.24: Traffic Forecasting using ANN model along NH-5

Month	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14
Forecasting of Monthly Traffic	308,012	269,933	306,191	307,504	371,779	377,649
Month	**Jul-14**	**Aug-14**	**Sep-14**	**Oct-14**	**Nov-14**	**Dec-14**
Forecasting of Monthly Traffic	352,039	374,749	311,712	335,417	235,435	264,709

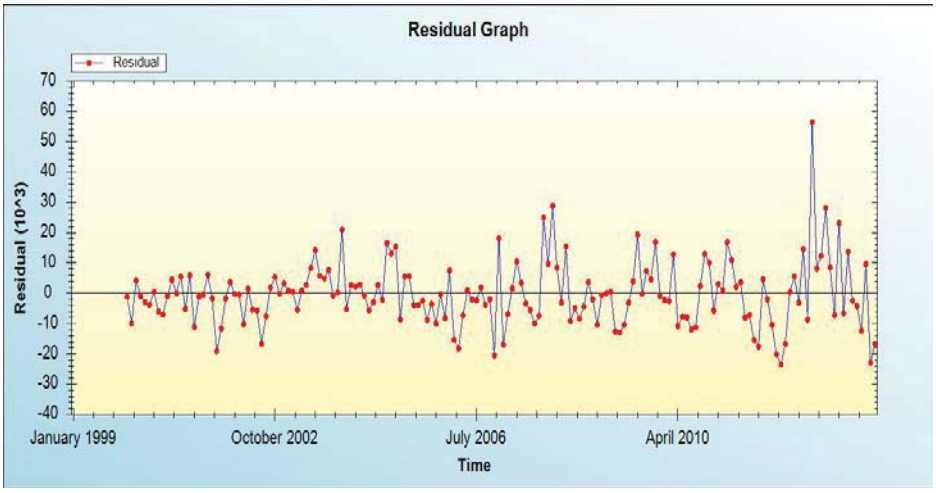


Figure 6.37: Artificial Neural Network Model-Residual Traffic in NH-5

6.11 OVERVIEW OF TRAFFIC FLOW ANALYSES IN NATIONAL HIGHWAY NO.5 (DHAKA-NORTH BENGAL HIGHWAY)

Detail traffic flow analyses of National Highway No.5 is discussed in this chapter based upon fifteen years of vehicle class wise daily traffic data that put emphasis on different traffic flow parameters. More realistic pavement design, vehicle operations and traffic planning can be achieved through this research. As currently in Bangladesh road agencies have set 10% traffic growth factor per year for all national highways and no traffic survey or detail parametric analyses have done by GoB engineering agencies till now. However, the following outcome have been extracted in this chapter of the research:

- The average traffic growth factor is found 11.15% per annum.
- Individual vehicle class wise traffic growth factors are also calculated in this chapter.
- Traffic composition patterns have been established along Dhaka-North Bengal corridor.
- Heavy vehicle percentages like Truck percentage and Bus percentage is calculated.
- Daily and Monthly directional distributions are designed for NH-5.
- The in-depth daily, weekly and seasonal traffic nature have been established.

- Daily and monthly traffic expansion factors and regression models are calculated for this highway.

- Traffic flow and prediction models have been prepared based on artificial neural network.

The next chapter will summarize the results achieved through this research for three major highway corridors of Bangladesh.

CHAPTER 7

CONCLUSIONS

7.1 INTRODUCTION

The aim of this research is to establish traffic flow related parameters of major highway corridors of Bangladesh. Data insufficiency is the major hindrance of this work initially. However, long duration round the year data have been collected from toll plazas of three vital highway corridors based upon data obtainability, namely- (1) National Highway No. 1 (NH-1), (2) National Highway No. 2 (NH-2), and (3) National Highway No. 5 (NH-5). Detail literature review confirms that Bangladesh road agencies have extreme negligence in the sector of traffic engineering. This research has focused to establish the detail traffic related parameters of selected highways of Bangladesh from using the collected traffic data. Due to the population density and mixed nature of traffic in Bangladesh, the study of traffic along highway corridors are immensely important. Artificial neural network models, regression models and expansion factors are also prepared for the selected highways to get better understandings about traffic patterns. This chapter briefly presents the findings of this research and recommendations for future study.

7.2 SUMMARY OF THE FINDINGS

The research has observed some important findings related to the traffic parameters along highways of Bangladesh. The highway traffic natures are summarized that are discussed below

7.2.1 TRAFFIC FLOW PARAMETERS OF DHAKA-HOBIGANJ HIGHWAY (NH-2)

Detail daily traffic flow analyses in Dhaka-Hobiganj highway (NH-2) explores different traffic flow indicators including traffic growth pattern, traffic compositions, directional distribution, seasonal flow variations, expansion factors, regression models for AADT estimation, ANN models, etc. The major findings are summarized below.

TRAFFIC GROWTH PATTERN:

- Average growth rate of total traffic during the 6 years of study period is 0.43% per annum. The traffic growth pattern curve seems unstable nature of traffic along NH-2 and needs to be scrutinized for the next couple of years for the expected steadiness of traffic.
- Growth rate of individual vehicle class have been calculated and is publicized in chapter 4 (article 4.2 and 4.4).

TRAFFIC COMPOSITION:

- In the Rustompur toll road section, total traffic is distributed into nine classes considering vehicle size and capacity- namely Car/ Jeep, Micro/ Coaster/ Tractor, Small Bus, Small Truck, Large Bus, Medium Truck, Trailer Truck/ Construction Equipment, Truck 3 Axle/ Large Truck, Toll free vehicle.
- Four classes of vehicles dominate the traffic stream. They are – Medium Truck (43.83%), Small Truck (22.71%), Small Bus (10.80%) and Large Bus (9.52%).

PERCENTAGES OF HEAVY VEHICLE

- Heavy vehicles include of buses and trucks.
- Total truck percentage in the traffic stream from 2010 to 2015 is 73.53% (averaged over 6 years).
- Total percentage of buses in the traffic stream from 2010 to 2015 is 20.32% (averaged over 6 years).

DIRECTIONAL DISTRIBUTION

- The corridor has almost 50-50 directional split. Averaging all data in this study, it was found to be 51.04% in the direction from Hobiganj to Dhaka, and 48.96% in the direction from Dhaka to Hobiganj.
- Daily directional distribution varies from 47.86% to 52.14%.
- Weekend factor is predominant in daily directional distribution of traffic flow in this corridor. Maximum flow towards Hobiganj (49.72%) occurs on Thursday while maximum flow towards Dhaka (52.14%) takes place on Saturday.

DAILY TRAFFIC FLOW VARIATIONS

- The average daily flow variations are ranges from 13% to 15% of weekly volume along NH-2 from the daily traffic data of 2010 to 2015.
- Daily flow fluctuation is ruled by weekend factor; hence the analysis has been performed separately for each direction.
- From Dhaka to Hobiganj direction, maximum daily flow occurs on Friday carrying 16.60% of weekly volume and minimum flow occurs on Sunday carrying 13.45% of weekly volume respectively.
- From Hobiganj to Dhaka direction, maximum daily flow occurs on Friday carrying 16.29% of weekly volume and minimum daily flow occurs on Sunday carrying 13.44% of weekly volume respectively.
- In both the directions, the flow pattern sags on midweek.
- The daily variation of each vehicle class differs from that of total vehicle.
- Detail daily traffic flow patterns for Medium truck, Large bus and Light vehicles are also calculated in Chapter 4 (article 4.6.1).
- Friday possess the maximum flow percentage of weekly volume in either direction and minimum flow occurs mostly in Sunday for major vehicle categories.

WEEKLY FLOW VARIATION

- There is a trend of decreasing traffic in first week and increasing traffic in fourth week of the month.
- The traffic volume become steady in the second and third week of a month.
- Individual week has its unique characteristics of traffic flow in NH-2 corridor.
- Weekly traffic flow fluctuates between mostly 24% to 26% and the average is close to 25% of monthly volume in NH-2.

SEASONAL FLOW VARIATION

- In Bangladesh, rainy season covers the month from May to October and dry season includes the month from November to April. Rainy season (May to Oct.) carries 47.78% while Dry season (Nov. to Apr.) carries 52.22% of total yearly volume.

- From the investigation of 6 years' traffic data, it was found that monthly flow pattern is repetitive in nature.
- Monthly traffic varies from 7% to 10% of yearly traffic volume in NH-2.
- In rainy seasons, the monthly traffic flow percentage mostly varies from 7% to 9% of yearly volume.
- In dry seasons the flow percentages raises to 8% to 10.5% typically of yearly volume.
- Medium truck has a tendency of increasing voulme from October to March, especially the peak flow is observed in December and March.
- For total traffic, maximum monthly flow occurs in March (9.68% of yearly volume) and minimum monthly flow occurs in August (7.58% of yearly volume).
- For medium truck, maximum monthly flow occurs in March (10.64% of yearly volume) and minimum monthly flow occurs in August (6.69% of yearly volume).
- For large bus, maximum monthly flow occurs in December (9.26% of yearly volume) and minimum monthly flow occurs in July (7.48% of yearly volume).

EXPANSION FACTOR

- The average lowest DEF is found in Friday, which indicates that maximum traffic flow experience in Friday. Medium truck has a tendency of increasing voulme from October to March, especially the peak flow is observed in December and March.
- The average minimum monthly expansion factors (MEF) are found in February and March. However, the average maximum MEF's are found in July and August.
- The monthly expansion factors are ranging from 0.75 to 1.25 in NH-2.

REGRESSION MODEL

- Total 312 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models. The daily and monthly regression models are calculated in chapter 4 (article 4.9.1).

ARTIFICIAL NEURAL NETWORK (ANN) MODEL

- Monthly traffic data have been plotted and predicted from 2010 to 2016 in NH-2. In addition, a model is prepared and traffic forecasting is calculated for one year along NH-2. The detail analyses are found in chapter 4 (article 4.10).

7.2.2 TRAFFIC FLOW PARAMETERS OF DHAKA-CHITTAGANJ HIGHWAY (NH-1)

Aspects of traffic flow analyses in Dhaka-Chittaganj highway (NH-1) explores different traffic flow parameters, which are as follows:

TRAFFIC GROWTH PATTERN:

- Average growth rate of total traffic during the 9 years of study period is 10.71% per annum.
- Flat growth rate of total vehicle is not representative of all vehicle class. Growth rate of individual vehicle class have been calculated and is revealed in chapter 5 (article 5.2 and 5.7).

TRAFFIC COMPOSITION:

- Along NH-1 for toll collecting purpose of Meghna and Meghna-Gumuti bridges, RHD divides total traffic into 9 vehicle classes – namely Motor cycle, Scooter / Tampu, Car / Jeep, Micro / Pickup, Mini Bus / Coaster/ Mini Truck, Bus, Truck, Trailer and Toll Free.
- Five classes of vehicles dominate the traffic stream. They are – Truck (32.29%), Micro/Pick-up (17.33%), Car/Jeep (13.57%), Bus (12.68%), Mini bus/ Coaster/ Mini Truck (9.72%).
- Individual class wise traffic composition pattern along NH-1 are maintaining a stable pattern and should be immediately incorporated in geometric design standard manual of Roads and Highways department, Bangladesh for accurate and durable pavement design.

PERCENTAGES OF HEAVY VEHICLE

- Heavy vehicles comprise of buses and trucks.
- Average percentage of trucks and trailers in the traffic stream is 34.34% (averaged over nine years).
- Average percentage of buses in the traffic stream is 22.40%, which includes mini bus/ coaster (9.72%) and Bus (12.68%) (averaged over nine years).

DAILY TRAFFIC FLOW VARIATIONS

- Friday possess maximum traffic flow of 16.20% of weekly volume.
- Sunday has the minimum traffic flow of 13.51% of the weekly volume
- The flow pattern sags on midweek.

WEEKLY FLOW VARIATION

- There exists specific weekly flow variation pattern in NH-1 corridor.
- The average weekly traffic varies from 24.50% to 25.50% of monthly volume along NH-1 and maintain stable pattern from first to fourth week of each month.

SEASONAL FLOW VARIATION

- Rainy season (May to Oct.) carries 50.16% while Dry season (Nov. to Apr.) carries 49.84% of total yearly volume.
- From the investigation of 9 years' traffic data, it is found that monthly flow pattern is repetitive in nature.
- Average maximum flow occurs on December (9.29% of yearly volume)
- Average minimum flow occurs on February (7.79% of yearly volume)
- Monthly traffic flow is found between 7 to 10% of yearly traffic volume along NH-1.
- The average of nine years' monthly traffic flow is found approximately 8% of yearly volume.

EXPANSION FACTOR

- The nine years average highest DEF is found on Sunday (7.42) and the average lowest DEF is on Friday (6.11).
- The analyses indicate that the minimum flow should be found on Sunday and maximum flow supposes to be on Friday.
- Monthly expansion factors are found between 0.90 to 1.1 along NH-1.

REGRESSION MODEL

- Total 468 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models. The daily and monthly regression models are calculated in chapter 5 (article 5.8).

ARTIFICIAL NEURAL NETWORK (ANN) MODEL

- Monthly traffic data have been plotted and predicted from 2008 to 2014 in NH-1. In addition, a model is prepared and traffic forecasting is calculated for one year along NH-1. The detail analyses are found in chapter 5 (article 5.9).

7.2.3 TRAFFIC FLOW PARAMETERS OF DHAKA-NORTH BENGAL HIGHWAY (NH-5)

Detail traffic flow analyses in Dhaka-North Bengal highway (NH-5) discovers different traffic flow parameters, which are as follows:

TRAFFIC GROWTH PATTERN

- The annual traffic has increased 4.34 times within this study period. The average growth rate of total traffic during the 15 years of study period is found 11.15% per annum.
- Flat growth rate of total vehicle is not representative of all vehicle class. The individual class wise vehicle growth rate changes from year to year and is calculated in chapter 6 (article 6.2 and 6.8).

TRAFFIC COMPOSITION

- In the toll collection of Jamuna bridge Bangladesh Bridge Authority (BBA) divides total traffic into 7 vehicle classes – namely Motor cycle, Light Vehicle, Small Bus, Large Bus, Small Truck, Medium Truck and Large Truck.
- Four classes of vehicles dominate the traffic stream. They are – Medium Truck (36.56%), Large Bus (29.56%), Light Vehicles (18.07%) and Small Truck (9.26%).
- The percentage of medium truck falls between 30~40% of total traffic flow in the study period. Large bus proportion varies from 23~35% of total flow. Light vehicles vary from 14~24% and Small truck category fluctuates from 3~19% of total flow.
- The traffic composition is gradually changing every year where percentage of heavy vehicles is increasing phenomenally.

PERCENTAGES OF HEAVY VEHICLE

- The average total percentage of trucks in the traffic stream is found 46.65% (averaged over 15 years) where medium truck percentage is 36.56%.
- The average total percentage of buses in the traffic stream is found 32.65% where large bus percentage is 29.56%.

DIRECTIONAL DISTRIBUTION

- The directional split is very close to 50% in this corridor. Averaging all data in this study, it was found to be 50.09% in the direction West to East, and 49.91% in the direction East to West.
- Daily directional distribution varies from 48.88% to 51.12%.
- Maximum outbound (east to west) flow (51.12%) occurs on Thursday while maximum inbound (west to east) flow (50.91%) takes place on Wednesday.

DAILY TRAFFIC FLOW VARIATIONS

- Daily traffic volume is usually found 14% of weekly volume for weekdays from Sunday to Wednesday.
- For East to West direction, maximum and minimum daily flow occurs on Friday carrying 15.26% of weekly volume and Saturday carrying 13.59% of weekly volume respectively.
- For West to East direction also, maximum and minimum daily flow occurs on Friday carrying 14.92% of weekly volume and Monday carrying 14.02% of weekly volume respectively.
- Vehicular class wise daily flow variations are shown in Chapter 6 (article 6.6.1) as the daily variation of each vehicle class differs from that of total vehicle.

WEEKLY TRAFFIC FLOW VARIATIONS

- The weekly traffic flows have a specific trend along this highway. The traffic is increased from first week to third week of each month and decrease in the fourth week with high slope.
- The detail weekly traffic flow patterns are shown in Chapter 6 (article 6.6.2).

SEASONAL FLOW VARIATION

- 15 years of daily traffic data reveals that the monthly flow pattern is repetitive in nature.
- Seasonal distribution seems stable in rainy season with average monthly flow of 8% to 8.50% of yearly volume. However, the pattern is more fluctuating in November to February.
- Dry season (Nov. to Apr.) carries 50.28% while Rainy season (May to Oct.) carries 49.72% of total yearly volume.
- Maximum flow for total traffic is found on December (9.25% of yearly volume). In addition, December carries maximum traffic for large bus, medium truck and light vehicles with value of 9.12%, 9.22% and 9.69% of yearly volume.
- Minimum flow for total traffic is found on February (7.68% of yearly volume). Similarly, minimum large bus flow is observed in February (7.53% of yearly volume), minimum medium truck flow is detected in September (7.71% of yearly volume) and minimum light vehicles flow is noticed in April (7.41% of yearly volume).
- Dhaka-Hobiganj highway (NH-2) and Dhaka-Chittagong highway (NH-1) have seasonal effects in traffic flow and hence, traffic data in a certain month could not be used to predict annual traffic. On the other hand, Dhaka-North Bengal highway (NH-5) appeared to have no seasonal effects, and hereafter the traffic data in a certain month can be used to predict the annual traffic reasonably.

EXPANSION FACTOR

- 15 years average highest DEF is found on Monday and Tuesday (7.50) and the average lowest DEF is on Friday (6.84).
- The daily expansion factor varies from 5.85 to 8.00.
- The analyses indicate that the minimum flow should be found on Monday and Tuesday; and maximum flow supposes to be on Friday.
- Monthly expansion factors are found between 0.925 to 1.054 along this corridor.
- 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.

REGRESSION MODEL

- Total 780 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models. The daily and monthly regression models are calculated in chapter 6 (article 6.9).

ARTIFICIAL NEURAL NETWORK (ANN) MODEL

- Monthly traffic data have been plotted and predicted from 1999 to 2013 in NH-5. In addition, a model is prepared and traffic forecasting is calculated for one year along NH-5. The detail analyses are found in chapter 6 (article 6.10).

7.3 LIMITATIONS OF THE STUDY

Some important features related to this research are stated below that could not be completed due to time and scope limitations.

- Pavement design parameters like sub grade soil properties, pavement layer co-efficient, etc. need empirical study and hence out of scope of this thesis.
- The developed factors, equations and models 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 commercial advanced software is required for long time monitoring.
- Valuable traffic flow parameters can be established if hourly flow data were found from toll operators.
- The analyses in this research have done based on limited number of data. Accumulation of long term data will provide more stable and accurate results.

7.4 RECOMMENDATIONS

- Automatic traffic counter should be installed for data collection and data preservation along all national highways of Bangladesh. In due course, regional highways should be integrated for better traffic design and operations. On the other hand, computer operated toll plazas could be vital source of data collection centers if establishment of automatic traffic counter stations are delayed.

- Bangladesh highway authority should introduce standard vehicle classification systems for all highways of Bangladesh. In that case, class wise traffic of highway corridors can be linked for better analyses.
- Bangladesh highways are prone to frequent overloading of trucks and trailers. Hence, axle load control stations should be installed and operated without delay with the help of highway law enforcing agencies. All strategic locations like sea port, land port, ferry ghat, etc. should be furnished with axle load control stations. Similarly, overload control station can be established in major truck terminals as a preventive measure to control axle load from source.
- Collection of hourly flow of traffic data is the most precious information of any corridor. Hourly flow pattern provides the genuine characteristics of traffic flow in a corridor. But unfortunately, no such data have been found from in any toll operators or concern RHD offices.
- Strong policy should be required for Roads and highways department of Bangladesh for maintaining historic pavement and traffic patterns of all highways. The author has identified significant weakness in electronic filing system in RHD as well.

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APPENDIX

SAMPLES OF TYPICAL TRAFFIC FLOW DATA TABLES

Table A1: Daily Traffic Flow Volume in 2015 on NH-2 (Dhaka to Hobiganj direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
01-Jan-15	Thursday	13	1	186	172	44	292	1	49	28	786
02-Jan-15	Friday	30	0	332	751	168	729	4	132	26	2172
03-Jan-15	Saturday	20	5	251	405	166	729	3	124	28	1731
04-Jan-15	Sunday	26	2	247	420	125	716	5	138	31	1710
05-Jan-15	Monday	23	1	116	139	70	203	0	37	36	625
06-Jan-15	Tuesday	21	5	163	111	41	188	0	33	25	587
07-Jan-15	Wednesday	25	1	122	118	55	171	0	38	17	547
08-Jan-15	Thursday	38	1	228	291	42	175	2	30	25	832
09-Jan-15	Friday	31	4	246	467	186	343	4	63	21	1365
10-Jan-15	Saturday	15	1	233	362	172	150	5	42	23	1003
11-Jan-15	Sunday	34	3	130	215	52	178	2	38	18	670
12-Jan-15	Monday	38	4	261	352	125	144	4	24	29	981
13-Jan-15	Tuesday	27	4	133	128	64	195	1	30	28	610
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13-May-15	Wednesday	20	1	260	368	166	620	9	105	23	1572
17-May-15	Sunday	24	6	261	401	166	444	4	66	14	1386
18-May-15	Monday	16	8	260	375	135	612	2	125	24	1557
19-May-15	Tuesday	30	5	316	382	123	621	4	127	23	1631
20-May-15	Wednesday	20	7	283	454	120	625	4	123	5	1641
21-May-15	Thursday	30	3	325	552	171	607	1	124	17	1830
22-May-15	Friday	26	5	258	661	193	698	5	121	16	1983
23-May-15	Saturday	20	0	224	401	131	628	3	125	11	1543
24-May-15	Sunday	21	5	215	398	144	620	0	110	6	1519
25-May-15	Monday	35	1	303	372	161	618	2	123	6	1621
26-May-15	Tuesday	13	0	258	335	142	619	3	123	5	1498
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17-Nov-15	Tuesday	288	458	59	84	298	279	5	54	1	1526
18-Nov-15	Wednesday	263	449	65	75	290	337	6	68	3	1556
19-Nov-15	Thursday	186	364	45	57	202	203	4	47	3	1111
20-Nov-15	Friday	219	573	140	44	327	326	15	92	0	1736
21-Nov-15	Saturday	231	507	76	54	303	316	6	68	1	1562
22-Nov-15	Sunday	224	490	55	24	304	307	6	72	4	1486
23-Nov-15	Monday	291	318	45	35	189	242	4	41	6	1171
24-Nov-15	Tuesday	269	468	67	55	298	372	7	80	4	1620
25-Nov-15	Wednesday	261	468	70	79	323	350	3	73	1	1628

** Data Source: MBEL-HOPETECH JV.*

** Class I= Car/ Jeep, Class II= Micro/ Coaster/ Tractor, ClassIII= Small Bus, Class IV= Small Truck, Class V=Large Bus, Class VI=Medium Truck, Class VII= Trailer Truck/ Construction Equipment, Class VIII=Truck 3 Axle/ Large Truck, Class IX=Toll Free Vehicles.*

Table A2: Daily Traffic Flow Volume in 2014 on NH-2 (Hobiganj to Dhaka Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
01-Jan-14	Wednesday	15	4	67	77	38	164	3	26	11	**405**
02-Jan-14	Thursday	16	2	178	158	80	278	3	35	16	**766**
03-Jan-14	Friday	16	3	88	166	47	230	5	44	16	**615**
04-Jan-14	Saturday	13	4	148	97	21	85	5	11	16	**400**
05-Jan-14	Sunday	14	0	30	28	8	35	1	5	6	**127**
06-Jan-14	Monday	19	5	85	82	17	128	5	6	15	**362**
07-Jan-14	Tuesday	17	3	166	153	71	102	3	18	12	**545**
08-Jan-14	Wednesday	19	3	208	192	86	206	6	29	14	**763**
09-Jan-14	Thursday	16	4	246	260	158	527	10	72	16	**1309**
10-Jan-14	Friday	7	4	281	457	165	896	11	128	9	**1958**
11-Jan-14	Saturday	14	4	287	366	203	731	23	164	15	**1807**
12-Jan-14	Sunday	19	5	190	175	124	590	25	142	13	**1283**
13-Jan-14	Monday	13	2	239	295	161	835	26	175	17	**1763**
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11-May-14	Sunday	8	5	175	329	148	822	14	168	20	**1689**
12-May-14	Monday	8	7	220	338	203	638	13	118	19	**1564**
13-May-14	Tuesday	5	3	184	335	111	766	20	155	19	**1598**
17-May-14	Saturday	7	2	167	334	130	790	14	168	12	**1624**
18-May-14	Sunday	14	2	206	351	123	751	10	137	12	**1606**
19-May-14	Monday	6	4	231	328	168	842	10	138	23	**1750**
20-May-14	Tuesday	11	3	262	315	195	722	12	176	16	**1712**
21-May-14	Wednesday	8	4	221	337	195	763	19	136	10	**1693**
22-May-14	Thursday	6	1	156	244	139	883	9	167	13	**1618**
23-May-14	Friday	14	5	231	548	242	774	10	122	30	**1976**
24-May-14	Saturday	8	1	205	394	138	767	7	151	22	**1693**
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17-Nov-14	Monday	12	5	206	215	123	288	9	40	13	**911**
18-Nov-14	Tuesday	9	6	233	314	193	814	5	158	13	**1745**
19-Nov-14	Wednesday	11	2	216	351	156	765	7	152	20	**1680**
20-Nov-14	Thursday	12	2	256	345	174	638	32	180	22	**1661**
21-Nov-14	Friday	15	5	239	501	169	852	9	155	23	**1968**
22-Nov-14	Saturday	18	4	224	330	144	731	8	172	26	**1657**
23-Nov-14	Sunday	21	4	217	348	164	745	15	142	23	**1679**
24-Nov-14	Monday	8	2	223	330	171	734	6	150	28	**1652**
25-Nov-14	Tuesday	6	4	239	335	153	751	18	151	8	**1665**

** Data Source: MBEL-HOPETECH JV.*

** Class I= Car/ Jeep, Class II= Micro/ Coaster/ Tractor, ClassIII= Small Bus, Class IV= Small Truck, Class V=Large Bus, Class VI=Medium Truck, Class VII= Trailer Truck/ Construction Equipment, Class VIII=Truck 3 Axle/ Large Truck, Class IX=Toll Free Vehicles.*

Table A3: Daily Traffic Flow Volume in 2013 on NH-2 (Dhaka to Hobiganj Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
01-Jan-13	Tuesday	11	4	218	381	99	591	9	131	14	1458
02-Jan-13	Wednesday	14	1	217	385	118	667	7	193	22	1624
03-Jan-13	Thursday	9	3	204	424	109	667	4	151	16	1587
04-Jan-13	Friday	12	2	204	463	141	586	5	62	15	1490
05-Jan-13	Saturday	12	1	195	392	120	188	3	7	10	928
06-Jan-13	Sunday	17	5	96	190	71	80	2	8	13	482
07-Jan-13	Monday	10	3	224	451	78	214	1	10	14	1005
08-Jan-13	Tuesday	9	2	203	375	140	351	7	22	17	1126
09-Jan-13	Wednesday	10	2	191	418	109	446	12	57	15	1260
10-Jan-13	Thursday	5	1	166	434	167	626	7	49	16	1471
11-Jan-13	Friday	10	2	177	507	126	650	4	80	18	1574
12-Jan-13	Saturday	14	1	205	456	151	533	2	62	16	1440
13-Jan-13	Sunday	18	1	190	399	180	696	5	76	10	1575
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11-Aug-13	Sunday	43	3	121	561	166	176	2	1	14	1087
12-Aug-13	Monday	39	2	153	447	107	172	7	5	29	961
13-Aug-13	Tuesday	22	5	100	170	34	88	0	8	10	437
17-Aug-13	Saturday	44	5	174	471	136	463	4	36	18	1351
18-Aug-13	Sunday	17	2	141	297	125	673	0	62	12	1329
19-Aug-13	Monday	19	10	212	381	139	638	6	101	23	1529
20-Aug-13	Tuesday	10	4	170	341	143	622	5	88	17	1400
21-Aug-13	Wednesday	20	3	189	360	150	599	5	108	19	1453
22-Aug-13	Thursday	17	2	236	440	162	542	5	107	26	1537
23-Aug-13	Friday	28	2	188	534	129	635	6	111	23	1656
24-Aug-13	Saturday	22	5	182	402	117	704	1	101	22	1556
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12-Dec-13	Thursday	22	2	78	70	17	58	2	15	15	279
13-Dec-13	Friday	21	3	334	425	134	305	8	47	14	1291
14-Dec-13	Saturday	21	0	231	190	116	497	24	66	20	1165
15-Dec-13	Sunday	15	3	135	83	70	136	0	18	6	466
16-Dec-13	Monday	24	7	274	334	151	509	20	83	13	1415
17-Dec-13	Tuesday	22	4	119	108	33	87	1	14	7	395
18-Dec-13	Wednesday	25	1	106	31	5	53	1	5	8	235
19-Dec-13	Thursday	18	8	82	53	29	88	1	24	5	308
20-Dec-13	Friday	38	5	339	458	199	467	11	77	32	1626

** Data Source: MBEL-HOPETECH JV.*

** Class I= Car/ Jeep, Class II= Micro/ Coaster/ Tractor, ClassIII= Small Bus, Class IV= Small Truck, Class V=Large Bus, Class VI=Medium Truck, Class VII= Trailer Truck/ Construction Equipment, Class VIII=Truck 3 Axle/ Large Truck, Class IX=Toll Free Vehicles.*

Table A4: Daily Traffic Flow Volume in 2012 on NH-2 (Hobiganj to Dhaka Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
01-Jan-12	Sunday	11	5	139	399	141	1107	9	138	8	**1957**
02-Jan-12	Monday	6	5	152	374	138	1007	3	159	29	**1873**
03-Jan-12	Tuesday	5	2	184	337	158	1018	3	184	28	**1919**
04-Jan-12	Wednesday	11	1	162	394	145	967	12	173	27	**1892**
05-Jan-12	Thursday	11	3	172	383	173	1019	7	157	15	**1940**
06-Jan-12	Friday	15	1	141	470	130	1173	3	211	33	**2177**
07-Jan-12	Saturday	7	7	129	414	143	970	4	187	32	**1893**
08-Jan-12	Sunday	5	3	130	369	145	1020	5	218	35	**1930**
09-Jan-12	Monday	10	1	133	356	146	1047	4	189	20	**1906**
10-Jan-12	Tuesday	11	1	122	394	186	1088	2	217	29	**2050**
11-Jan-12	Wednesday	13	3	159	413	224	1112	6	176	33	**2139**
12-Jan-12	Thursday	8	3	176	417	236	1199	8	162	29	**2238**
13-Jan-12	Friday	7	1	136	538	165	1165	8	183	21	**2224**
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11-Jul-12	Wednesday	11	4	179	356	114	812	1	124	20	**1621**
12-Jul-12	Thursday	9	3	197	389	105	730	4	115	22	**1574**
13-Jul-12	Friday	16	1	157	466	117	833	3	113	31	**1737**
14-Jul-12	Saturday	7	6	161	417	102	781	2	155	23	**1654**
15-Jul-12	Sunday	7	3	173	400	94	692	3	129	21	**1522**
19-Jul-12	Thursday	12	0	184	403	104	733	5	122	25	**1588**
20-Jul-12	Friday	17	4	180	396	108	805	3	129	23	**1665**
21-Jul-12	Saturday	6	3	138	190	84	633	3	101	14	**1172**
22-Jul-12	Sunday	6	7	135	198	100	777	0	112	15	**1350**
23-Jul-12	Monday	8	4	150	232	71	709	4	132	17	**1327**
24-Jul-12	Tuesday	6	3	165	203	113	805	6	118	22	**1441**
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14-Dec-12	Friday	10	4	186	484	143	966	11	122	17	**1943**
15-Dec-12	Saturday	8	1	122	231	84	894	10	178	11	**1539**
16-Dec-12	Sunday	9	3	165	510	151	774	14	121	21	**1768**
17-Dec-12	Monday	5	4	162	364	139	723	2	154	17	**1570**
18-Dec-12	Tuesday	15	3	116	183	79	421	3	53	9	**882**
19-Dec-12	Wednesday	13	0	165	313	94	533	7	119	18	**1262**
20-Dec-12	Thursday	11	0	116	203	70	346	6	47	10	**809**
21-Dec-12	Friday	8	2	180	541	158	927	8	177	19	**2020**
22-Dec-12	Saturday	7	1	206	485	154	790	11	162	23	**1839**

** Data Source: MBEL-HOPETECH JV.*

** Class I= Car/ Jeep, Class II= Micro/ Coaster/ Tractor, ClassIII= Small Bus, Class IV= Small Truck, Class V=Large Bus, Class VI=Medium Truck, Class VII= Trailer Truck/ Construction Equipment, Class VIII=Truck 3 Axle/ Large Truck, Class IX=Toll Free Vehicles.*

Table A5: Daily Traffic Flow Volume in 2015 on NH-2 (Both Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
01-Jan-15	Thursday	27	2	383	429	140	615	3	109	53	**1761**
02-Jan-15	Friday	49	3	616	1325	349	1576	9	281	72	**4280**
03-Jan-15	Saturday	33	8	515	825	348	1467	8	280	69	**3553**
04-Jan-15	Sunday	36	5	491	925	225	1481	9	287	51	**3510**
05-Jan-15	Monday	37	4	220	314	134	480	1	85	61	**1336**
06-Jan-15	Tuesday	50	9	336	227	80	386	0	73	56	**1217**
07-Jan-15	Wednesday	43	6	224	252	136	351	1	99	33	**1145**
08-Jan-15	Thursday	49	5	462	582	279	456	4	91	44	**1972**
09-Jan-15	Friday	47	6	459	947	361	752	8	141	42	**2763**
10-Jan-15	Saturday	27	2	445	939	345	346	8	96	47	**2255**
11-Jan-15	Sunday	49	8	259	378	108	323	3	67	34	**1229**
12-Jan-15	Monday	47	11	501	571	221	294	10	59	46	**1760**
13-Jan-15	Tuesday	41	7	247	264	124	402	3	62	64	**1214**
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01-Jun-15	Monday	43	11	608	553	387	1125	5	199	14	2945
05-Jun-15	Friday	53	6	619	871	444	1165	7	235	24	3424
06-Jun-15	Saturday	33	6	590	772	357	1136	5	158	26	3083
07-Jun-15	Sunday	27	4	535	597	330	1034	8	160	21	2716
08-Jun-15	Monday	7	2	405	754	366	1256	1	188	6	2985
09-Jun-15	Tuesday	36	5	564	648	500	1056	6	219	5	3039
10-Jun-15	Wednesday	45	7	540	774	475	846	5	161	5	2858
11-Jun-15	Thursday	29	2	567	863	347	921	3	105	18	2855
12-Jun-15	Friday	59	7	483	1235	379	958	14	139	27	3301
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24-Aug-15	Monday	269	942	112	151	569	793	24	210	19	3089
25-Aug-15	Tuesday	295	931	120	145	573	784	11	250	14	3123
26-Aug-15	Wednesday	313	969	112	178	552	810	20	230	10	3194
27-Aug-15	Thursday	328	1030	127	142	604	889	22	229	14	3385
28-Aug-15	Friday	347	910	147	122	233	306	9	106	20	2200
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14-Dec-15	Monday	581	826	127	76	501	300	7	47	12	2477
15-Dec-15	Tuesday	628	824	105	103	385	357	5	68	10	2485

** Data Source: MBEL-HOPETECH JV.*

** Class I= Car/ Jeep, Class II= Micro/ Coaster/ Tractor, ClassIII= Small Bus, Class IV= Small Truck, Class V=Large Bus, Class VI=Medium Truck, Class VII= Trailer Truck/ Construction Equipment, Class VIII=Truck 3 Axle/ Large Truck, Class IX=Toll Free Vehicles.*

Table A6: Daily Traffic Flow Volume in 2014 on NH-2 (Both Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
15-Jan-14	Wednesday	41	7	403	678	270	1682	61	358	33	3533
16-Jan-14	Thursday	32	7	465	723	273	1765	28	368	37	3698
17-Jan-14	Friday	36	7	445	1001	246	1914	44	290	39	4022
18-Jan-14	Saturday	37	11	445	776	306	1705	62	396	64	3802
19-Jan-14	Sunday	20	16	425	727	317	1834	61	356	22	3778
20-Jan-14	Monday	27	7	487	697	327	1781	61	385	49	3821
21-Jan-14	Tuesday	14	14	352	561	300	1721	52	411	38	3463
22-Jan-14	Wednesday	34	7	453	674	432	1774	46	364	47	3831
23-Jan-14	Thursday	29	12	474	789	397	1753	50	407	30	3941
24-Jan-14	Friday	33	3	501	1076	381	1830	26	389	61	4300
25-Jan-14	Saturday	33	2	449	1087	290	1756	32	442	62	4153
26-Jan-14	Sunday	36	10	347	861	319	1815	42	364	63	3857
27-Jan-14	Monday	26	12	464	787	490	1664	50	378	38	3909
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01-Sep-14	Monday	28	11	516	882	313	1160	12	244	55	3221
02-Sep-14	Tuesday	31	23	448	858	349	1244	7	244	54	3258
03-Sep-14	Wednesday	24	3	475	867	368	1262	13	249	41	3302
07-Sep-14	Sunday	33	6	471	781	347	1138	8	248	31	3063
08-Sep-14	Monday	25	11	464	742	361	1361	17	276	40	3297
09-Sep-14	Tuesday	37	7	468	667	324	1304	11	262	50	3130
10-Sep-14	Wednesday	23	5	483	696	366	1367	11	273	45	3269
11-Sep-14	Thursday	22	10	499	805	270	1505	10	294	67	3482
12-Sep-14	Friday	31	1	466	1082	293	1507	8	257	43	3688
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04-Nov-14	Tuesday	43	18	536	761	314	1407	8	247	40	3374
05-Nov-14	Wednesday	55	8	359	171	111	477	3	135	28	1347
06-Nov-14	Thursday	37	8	323	168	91	416	1	124	35	1203
07-Nov-14	Friday	44	6	508	1133	391	1115	18	321	40	3576
08-Nov-14	Saturday	41	4	597	850	391	1328	16	317	53	3597
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08-Dec-14	Monday	19	3	491	706	367	1415	13	335	31	3380
09-Dec-14	Tuesday	22	8	531	711	309	1427	34	320	30	3392

** Data Source: MBEL-HOPETECH JV.*

** Class I= Car/ Jeep, Class II= Micro/ Coaster/ Tractor, ClassIII= Small Bus, Class IV= Small Truck, Class V=Large Bus, Class VI=Medium Truck, Class VII= Trailer Truck/ Construction Equipment, Class VIII=Truck 3 Axle/ Large Truck, Class IX=Toll Free Vehicles.*

Table A7: Daily Traffic Flow Volume in March 2013 on NH-2 (Both Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
01-Mar-13	Friday	40	3	440	818	293	1704	9	357	27	3691
02-Mar-13	Saturday	21	3	526	758	251	1736	20	310	43	3668
03-Mar-13	Sunday	21	3	150	184	30	90	1	4	26	509
04-Mar-13	Monday	13	5	142	97	20	58	0	4	32	371
05-Mar-13	Tuesday	14	8	245	305	68	225	5	59	16	945
06-Mar-13	Wednesday	20	6	485	688	330	1475	17	253	46	3320
07-Mar-13	Thursday	25	3	357	386	133	765	20	89	34	1812
08-Mar-13	Friday	54	4	524	962	315	1572	29	365	45	3870
09-Mar-13	Saturday	27	4	462	794	285	1651	36	340	59	3658
10-Mar-13	Sunday	24	5	409	539	233	1690	21	322	40	3283
11-Mar-13	Monday	21	6	433	565	232	1798	19	301	48	3423
12-Mar-13	Tuesday	17	2	107	128	34	711	8	162	21	1190
13-Mar-13	Wednesday	19	13	400	746	259	1705	30	326	36	3534
14-Mar-13	Thursday	35	4	479	753	297	1679	27	245	66	3585
15-Mar-13	Friday	50	5	434	1049	274	585	13	27	64	2501
16-Mar-13	Saturday	41	4	417	403	181	330	10	39	61	1486
17-Mar-13	Sunday	37	9	415	423	135	389	15	14	64	1501
18-Mar-13	Monday	26	7	150	97	55	74	3	3	19	434
19-Mar-13	Tuesday	26	9	213	122	35	52	4	2	46	509
20-Mar-13	Wednesday	37	1	343	244	54	158	8	19	35	899
21-Mar-13	Thursday	29	5	458	689	295	1683	20	177	52	3408
22-Mar-13	Friday	23	3	365	802	226	1892	24	307	44	3686
23-Mar-13	Saturday	34	4	400	910	248	1643	26	269	53	3587
24-Mar-13	Sunday	29	5	262	453	172	1542	14	325	28	2830
25-Mar-13	Monday	20	2	361	559	230	1800	8	323	46	3349
26-Mar-13	Tuesday	32	8	376	723	230	1958	14	347	30	3718
27-Mar-13	Wednesday	27	2	91	125	45	382	7	75	22	776
28-Mar-13	Thursday	40	1	130	171	40	417	8	96	30	933
29-Mar-13	Friday	25	12	464	951	254	1849	22	301	36	3914
30-Mar-13	Saturday	24	11	466	778	276	1669	16	359	57	3656
31-Mar-13	Sunday	27	3	463	730	316	1750	15	263	38	3605
TOTAL		**878**	**160**	**10967**	**16952**	**5846**	**35032**	**469**	**6083**	**1264**	**77651**

** Data Source: MBEL-HOPETECH JV.*

** Class I= Car/ Jeep, Class II= Micro/ Coaster/ Tractor, ClassIII= Small Bus, Class IV= Small Truck, Class V=Large Bus, Class VI=Medium Truck, Class VII= Trailer Truck/ Construction Equipment, Class VIII=Truck 3 Axle/ Large Truck, Class IX=Toll Free Vehicles.*

Table A8: Daily Traffic Flow Volume in October 2012 on NH-2 (Both Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
01-Oct-12	Monday	21	4	310	501	163	1338	32	370	24	2763
02-Oct-12	Tuesday	21	5	355	575	208	1453	18	347	21	3003
03-Oct-12	Wednesday	13	5	315	602	240	1726	9	436	22	3368
04-Oct-12	Thursday	24	9	356	666	220	1697	10	384	38	3404
05-Oct-12	Friday	19	7	289	953	228	1552	6	346	36	3436
06-Oct-12	Saturday	18	10	344	757	241	1410	14	340	39	3173
07-Oct-12	Sunday	21	9	303	641	257	1586	6	316	23	3162
08-Oct-12	Monday	15	7	347	536	186	1434	9	385	22	2941
09-Oct-12	Tuesday	24	4	357	499	227	1636	10	374	24	3155
10-Oct-12	Wednesday	9	3	351	520	204	1649	27	417	19	3199
11-Oct-12	Thursday	22	2	270	611	215	1710	2	364	28	3224
12-Oct-12	Friday	36	6	306	753	225	1743	21	407	37	3534
13-Oct-12	Saturday	21	1	419	618	186	1493	22	349	36	3145
14-Oct-12	Sunday	10	2	313	451	188	1525	12	370	22	2893
15-Oct-12	Monday	24	4	362	489	191	1520	14	404	29	3037
16-Oct-12	Tuesday	16	7	384	595	231	1649	11	404	37	3334
17-Oct-12	Wednesday	26	4	327	441	223	1694	3	440	29	3187
18-Oct-12	Thursday	19	3	394	573	223	1758	8	426	37	3441
19-Oct-12	Friday	19	9	429	704	197	1877	7	362	41	3645
20-Oct-12	Saturday	23	7	393	465	169	1515	5	408	31	3016
21-Oct-12	Sunday	22	4	372	580	222	1357	6	278	36	2877
22-Oct-12	Monday	23	8	482	579	217	1501	3	234	27	3074
23-Oct-12	Tuesday	21	8	400	546	225	1317	15	154	30	2716
24-Oct-12	Wednesday	23	4	307	505	188	1334	27	51	33	2472
25-Oct-12	Thursday	33	4	412	594	211	971	12	16	41	2294
26-Oct-12	Friday	41	3	334	777	78	308	8	9	39	1597
27-Oct-12	Saturday	36	0	115	408	103	164	0	0	27	853
28-Oct-12	Sunday	54	3	173	525	131	292	0	0	33	1211
29-Oct-12	Monday	78	2	171	1160	129	348	3	4	34	1929
30-Oct-12	Tuesday	52	3	215	1106	237	749	10	8	58	2438
31-Oct-12	Wednesday	57	2	277	891	214	1054	13	28	43	2579
TOTAL		**841**	**149**	**10182**	**19621**	**6177**	**41360**	**343**	**8431**	**996**	**88100**

** Data Source: MBEL-HOPETECH JV.*

** Class I= Car/ Jeep, Class II= Micro/ Coaster/ Tractor, ClassIII= Small Bus, Class IV= Small Truck, Class V=Large Bus, Class VI=Medium Truck, Class VII= Trailer Truck/ Construction Equipment, Class VIII=Truck 3 Axle/ Large Truck, Class IX=Toll Free Vehicles.*

Table A9: Daily Traffic Flow Volume in 2014 on NH-1 (Both Direction)

Date	Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
01-Jan-14	Wednesday	101	720	314	620	344	82	2049	188	516	4934
02-Jan-14	Thursday	115	540	441	682	369	57	1371	76	547	4198
03-Jan-14	Friday	60	485	456	572	314	88	1458	133	534	4100
04-Jan-14	Saturday	84	519	272	418	199	18	869	50	592	3021
05-Jan-14	Sunday	33	306	135	222	77	3	334	17	225	1352
06-Jan-14	Monday	108	461	260	475	234	17	649	30	422	2656
07-Jan-14	Tuesday	76	371	252	525	277	33	1047	81	452	3114
08-Jan-14	Wednesday	76	675	369	691	430	111	1854	106	560	4872
09-Jan-14	Thursday	186	916	890	1412	826	371	2981	218	634	8434
10-Jan-14	Friday	843	2558	3578	4080	1501	1317	6841	521	1254	22493
11-Jan-14	Saturday	800	1738	3077	3674	1389	1651	5281	399	1670	19679
12-Jan-14	Sunday	141	772	736	1264	675	390	4338	290	627	9233
13-Jan-14	Monday	777	1698	2847	3323	1375	1349	6141	412	1504	19426
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10-May-14	Saturday	780	1571	3273	3642	1410	2051	4827	389	1534	19477
11-May-14	Sunday	705	1502	2891	3422	1330	1943	5322	428	1493	19036
12-May-14	Monday	748	1467	2964	3472	1402	1836	5506	349	1369	19113
18-May-14	Sunday	683	1505	2814	3129	1325	1880	5261	386	1340	18323
19-May-14	Monday	747	1584	3007	3202	1301	1722	5687	355	1328	18933
20-May-14	Tuesday	698	1454	2770	3378	1324	1707	5830	401	1277	18839
21-May-14	Wednesday	677	1451	2812	3317	1321	1727	5940	447	1276	18968
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18-Sep-14	Thursday	111	565	551	1038	571	282	2494	173	519	6304
19-Sep-14	Friday	775	1662	3632	4380	1350	1124	4815	422	1350	19510
20-Sep-14	Saturday	650	1422	3215	4089	1389	1628	5231	401	1227	19252
21-Sep-14	Sunday	109	527	710	1223	583	210	2656	169	525	6712
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24-Dec-14	Wednesday	732	1385	3531	4181	1820	1891	5172	464	1444	20620
25-Dec-14	Thursday	810	1470	4418	4631	1835	1866	5522	423	1411	22386
26-Dec-14	Friday	819	1410	4628	4713	1833	1973	5120	616	1373	22485
27-Dec-14	Saturday	733	1086	4195	4714	1886	2412	3927	436	1433	20822
28-Dec-14	Sunday	715	984	3599	4281	1839	2189	4683	391	1328	20009
29-Dec-14	Monday	62	263	688	1189	661	582	2920	201	401	6967
30-Dec-14	Tuesday	684	1137	3547	4364	1827	2082	5505	349	1318	20813

** Data Source: MBEL-ATT JV.*

Table A10: Daily Traffic Flow Volume in 2013 on NH-1 (Both Direction)

Date	Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
01-Jan-13	Tuesday	679	1798	2934	4005	1520	1908	5854	500	1573	20771
02-Jan-13	Wednesday	691	1900	3164	4113	1477	2067	6037	452	1543	21444
03-Jan-13	Thursday	702	1865	3219	4016	1504	1964	6363	478	1459	21570
04-Jan-13	Friday	10	17	1444	1171	139	311	2227	86	126	5531
05-Jan-13	Saturday	65	254	2059	2309	1523	2293	3560	197	590	12850
06-Jan-13	Sunday	57	240	1506	2104	1593	2298	4299	323	644	13064
07-Jan-13	Monday	54	259	1582	2266	1576	2203	4341	260	575	13116
08-Jan-13	Tuesday	671	1566	2476	2725	921	1165	4513	111	1283	15431
09-Jan-13	Wednesday	659	1538	3153	3864	1344	2182	6111	267	1352	20470
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29-Mar-13	Friday	822	2209	3607	4181	1506	1626	6374	563	1368	22256
30-Mar-13	Saturday	813	2362	3095	3821	1449	1731	5132	423	1433	20259
31-Mar-13	Sunday	813	2690	2598	3241	1455	1509	5760	423	1541	20030
01-Apr-13	Monday	807	2061	2546	3235	1426	1474	5854	489	1392	19284
02-Apr-13	Tuesday	374	1212	1159	1434	446	258	2967	187	903	8940
03-Apr-13	Wednesday	716	1922	2653	3356	1406	1808	5999	575	1486	19921
04-Apr-13	Thursday	783	1953	2855	3708	1473	1833	6329	481	1421	20836
05-Apr-13	Friday	788	2264	2945	3096	955	761	5376	401	1307	17893
06-Apr-13	Saturday	427	1030	1223	1217	351	346	1965	174	566	7299
07-Apr-13	Sunday	728	1851	2555	3147	1561	1763	5522	472	1486	19085
08-Apr-13	Monday	359	1121	1051	1233	416	334	3564	173	748	8999
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06-Aug-13	Tuesday	851	2395	4008	5018	1276	1839	5754	296	1394	22831
07-Aug-13	Wednesday	1159	3605	4613	6707	1919	2993	4350	197	1928	27471
08-Aug-13	Thursday	1235	4745	5527	7255	2244	3064	2061	67	1921	28119
09-Aug-13	Friday	765	2329	2879	3400	853	1654	400	6	893	13179
10-Aug-13	Saturday	1058	2747	4256	3958	1146	1585	374	15	1647	16786
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16-Dec-13	Monday	723	1258	2954	2931	2377	1121	5326	479	855	18024
17-Dec-13	Tuesday	709	1248	2147	3891	1807	1789	5926	467	942	18926
18-Dec-13	Wednesday	698	1429	3698	3649	1840	2074	6186	458	838	20870
19-Dec-13	Thursday	336	2258	3903	3858	1457	1890	4826	437	740	19705
20-Dec-13	Friday	683	2410	2764	3931	1248	2074	5981	531	762	20384
21-Dec-13	Saturday	683	1903	2387	3408	1511	2150	5605	458	839	18944
22-Dec-13	Sunday	679	2218	3083	3625	1375	1862	5827	553	867	20089

** Data Source: MBEL-ATT JV.*

Table A11: Daily Traffic Flow Volume in June 2012 on NH-1(Both Direction)

Date	Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
01-Jun-12	Friday	264	1373	2897	3719	1548	2160	5934	401	632	18928
02-Jun-12	Saturday	220	1310	2469	3218	1507	2406	4517	360	786	16793
03-Jun-12	Sunday	213	1141	1833	2773	1462	2211	5134	353	773	15893
04-Jun-12	Monday	166	1129	1602	2787	1395	2076	5532	375	687	15749
05-Jun-12	Tuesday	180	1118	1643	2697	1289	2015	5862	367	682	15853
06-Jun-12	Wednesday	173	1026	1567	2822	1214	1756	6180	467	605	15810
07-Jun-12	Thursday	249	1415	1984	2969	1544	2246	5886	405	729	17427
08-Jun-12	Friday	289	1235	3089	3619	1462	2210	5994	437	669	19004
09-Jun-12	Saturday	241	1225	2233	2846	1488	2129	4781	379	881	16203
10-Jun-12	Sunday	177	929	1603	2637	1457	2145	5092	402	717	15159
11-Jun-12	Monday	153	1065	1265	2178	1128	1586	5270	383	609	13637
12-Jun-12	Tuesday	179	1263	1604	2767	1425	2051	5779	382	798	16248
13-Jun-12	Wednesday	180	1199	1617	2706	1384	2017	5961	451	715	16230
14-Jun-12	Thursday	206	1244	1889	2672	1531	2143	6045	411	698	16839
15-Jun-12	Friday	246	1502	2624	3439	1357	2099	6119	458	580	18424
16-Jun-12	Saturday	201	1314	2266	3205	1431	2298	4959	265	786	16725
17-Jun-12	Sunday	171	1210	1664	2672	1383	2188	5404	308	753	15753
18-Jun-12	Monday	181	1136	1722	2705	1301	2057	5778	326	687	15893
19-Jun-12	Tuesday	171	1185	1590	2644	1234	1899	5948	448	711	15830
20-Jun-12	Wednesday	160	1214	1642	2622	1244	1870	6344	385	755	16236
21-Jun-12	Thursday	188	1302	1883	2771	1441	2033	6245	387	734	16984
22-Jun-12	Friday	254	1201	2339	3051	1259	1815	6400	422	558	17299
23-Jun-12	Saturday	200	1187	2236	3029	1393	2220	4863	296	890	16314
24-Jun-12	Sunday	110	980	1588	2567	1307	1960	5416	315	611	14854
25-Jun-12	Monday	98	856	1550	2619	1272	1956	5588	348	614	14901
26-Jun-12	Tuesday	132	1226	1578	2639	1380	1899	5736	377	760	15727
27-Jun-12	Wednesday	124	1123	1715	2887	1473	1926	5785	295	703	16031
28-Jun-12	Thursday	180	1296	1797	2840	1482	2011	6110	344	681	16741
29-Jun-12	Friday	255	1260	2521	3497	1378	1992	6423	359	690	18375
30-Jun-12	Saturday	192	1236	2083	3238	1469	1989	5022	306	895	16430
TOTAL		**5753**	**35900**	**58093**	**86835**	**41638**	**61363**	**170107**	**11212**	**21389**	**492290**

** Data Source: MBEL-ATT JV.*

Table A12: Daily Traffic Flow Volume in October 2013 on NH-1 (Both Direction)

Date	Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
01-Oct-11	Saturday	170	1345	1943	3037	1375	2000	4589	287	792	15538
02-Oct-11	Sunday	167	1185	1505	2730	1234	1910	4921	396	610	14658
03-Oct-11	Monday	164	1319	1805	3037	1250	1821	5094	412	671	15573
04-Oct-11	Tuesday	180	1285	1639	2710	1140	1606	5723	482	461	15226
05-Oct-11	Wednesday	191	1472	2080	3212	1315	1963	5739	410	651	17033
06-Oct-11	Thursday	263	1515	2618	3423	1458	1962	5592	440	813	18084
07-Oct-11	Friday	297	1497	2897	3704	1344	2042	4493	393	735	17402
08-Oct-11	Saturday	286	1521	2440	3311	1496	2341	3707	259	964	16325
09-Oct-11	Sunday	183	1356	1645	2931	1341	2176	5245	379	739	15995
10-Oct-11	Monday	158	1334	1665	2960	1294	2026	5961	321	692	16411
11-Oct-11	Tuesday	156	1350	1489	2826	1211	1795	6165	460	556	16008
12-Oct-11	Wednesday	160	1291	1566	2517	1249	1954	6404	471	747	16359
13-Oct-11	Thursday	187	1376	1707	2920	1295	1867	6484	444	652	16932
14-Oct-11	Friday	283	1581	2399	3304	1241	1907	6232	484	676	18107
15-Oct-11	Saturday	201	1371	2086	3359	1349	2182	4773	326	782	16429
16-Oct-11	Sunday	175	1260	1657	2911	1273	1966	5419	396	729	15786
17-Oct-11	Monday	165	1171	1536	3081	1264	1919	6021	344	689	16190
18-Oct-11	Tuesday	130	1167	1466	2838	1232	1739	6372	394	617	15955
19-Oct-11	Wednesday	143	1119	1378	2580	1245	1794	6704	387	678	16028
20-Oct-11	Thursday	197	1347	1713	3206	1389	1953	6823	469	737	17834
21-Oct-11	Friday	289	1408	2531	3790	1404	1947	7042	472	790	19673
22-Oct-11	Saturday	185	1239	1932	3480	1380	2058	5036	321	779	16410
23-Oct-11	Sunday	164	1197	1610	2991	1237	1832	6070	408	650	16159
24-Oct-11	Monday	158	1187	1686	3392	1293	1945	6364	364	724	17113
25-Oct-11	Tuesday	132	1199	1531	3319	1254	1717	6746	404	700	17002
26-Oct-11	Wednesday	140	1135	1626	3048	1294	1757	7381	491	570	17442
27-Oct-11	Thursday	187	1303	1877	3152	1467	1901	7329	450	748	18414
28-Oct-11	Friday	209	1407	2542	3954	1401	1930	7534	424	747	20148
29-Oct-11	Saturday	161	1283	2134	3528	1424	1966	5751	284	753	17284
30-Oct-11	Sunday	117	1176	1519	3254	1282	1773	6196	502	698	16517
31-Oct-11	Monday	152	1161	1416	3111	1228	1668	7014	368	528	16646
TOTAL		**5750**	**40557**	**57638**	**97616**	**40659**	**59417**	**184924**	**12442**	**21678**	**520681**

** Data Source: MBEL-ATT JV.*

Table A13: Daily Traffic Flow Volume in 2013 on Jamuna Bridge (East Toll Plaza)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
01-Jan-13	Tuesday	115	1146	10	1314	1031	1923	66	5605
02-Jan-13	Wednesday	108	1091	21	1261	1021	1842	35	5379
03-Jan-13	Thursday	155	1314	2	1361	993	1856	53	5734
04-Jan-13	Friday	186	1554	14	1411	942	1737	62	5906
05-Jan-13	Saturday	251	1411	7	1401	1025	1533	48	5676
06-Jan-13	Sunday	92	538	4	538	683	1219	47	3121
07-Jan-13	Monday	125	1172	8	1297	870	1515	45	5032
08-Jan-13	Tuesday	92	1045	15	1249	696	1250	50	4397
09-Jan-13	Wednesday	102	1178	32	1576	1095	2259	99	6341
10-Jan-13	Thursday	107	1293	17	1473	983	1750	95	5718
11-Jan-13	Friday	123	1333	11	1398	1130	2267	50	6312
12-Jan-13	Saturday	115	1239	9	1371	991	1870	66	5661
13-Jan-13	Sunday	128	1008	71	1741	896	1748	48	5640
14-Jan-13	Monday	129	1183	7	1486	1142	2205	86	6238
15-Jan-13	Tuesday	125	1247	13	1186	1140	2145	54	5910
16-Jan-13	Wednesday	129	931	20	942	927	1767	58	4774
17-Jan-13	Thursday	199	1392	7	1455	997	1653	37	5740
18-Jan-13	Friday	191	1513	17	1450	1136	2119	62	6488
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07-Jun-13	Friday	237	1814	6	1432	1156	1945	50	6640
08-Jun-13	Saturday	201	1436	22	1625	1160	1794	72	6310
09-Jun-13	Sunday	145	1413	5	1446	1272	1969	60	6310
10-Jun-13	Monday	192	956	2	801	957	1748	44	4700
11-Jun-13	Tuesday	177	1477	10	1470	1143	1853	57	6187
12-Jun-13	Wednesday	165	1467	21	1491	1217	2161	83	6605
13-Jun-13	Thursday	210	1595	3	1552	1171	1971	45	6547
14-Jun-13	Friday	234	1679	7	1505	1169	2074	81	6749
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12-Oct-13	Saturday	510	1994	13	1677	1341	3465	235	9235
13-Oct-13	Sunday	1156	2810	47	2925	1159	2364	123	10584
14-Oct-13	Monday	1398	3876	189	4110	1101	2824	74	13572
15-Oct-13	Tuesday	737	2162	42	3535	979	2408	95	9958
16-Oct-13	Wednesday	413	756	7	769	70	148	3	2166
17-Oct-13	Thursday	916	1848	2	1520	99	69	2	4456
18-Oct-13	Friday	613	1555	12	1900	192	114	15	4401
19-Oct-13	Saturday	618	1658	46	3015	376	253	13	5979
20-Oct-13	Sunday	386	1604	131	3351	653	651	17	6793

** Data Source: GSIC-SEL-UDC JV (GSU JV).*

** Toll free vehicles not included*

Table A14: Daily Traffic Flow Volume in 2012 on Jamuna Bridge (West Toll Plaza)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
01-Feb-12	Wednesday	95	990	9	1207	905	1793	34	5033
02-Feb-12	Thursday	113	1142	5	1317	903	1713	33	5226
03-Feb-12	Friday	137	1181	13	1313	885	1515	39	5083
04-Feb-12	Saturday	116	1105	9	1211	879	1558	56	4934
05-Feb-12	Sunday	148	1429	5	1360	885	1814	50	5691
06-Feb-12	Monday	112	921	8	1242	898	1619	32	4832
07-Feb-12	Tuesday	104	938	18	1258	1006	1614	41	4979
08-Feb-12	Wednesday	91	961	10	1266	908	1756	34	5026
09-Feb-12	Thursday	109	1129	5	1349	969	1669	40	5270
10-Feb-12	Friday	154	1235	18	1351	883	1530	36	5207
11-Feb-12	Saturday	134	1063	8	1288	857	1471	33	4854
12-Feb-12	Sunday	105	914	3	1262	916	1724	42	4966
13-Feb-12	Monday	106	899	9	1241	944	1591	42	4832
14-Feb-12	Tuesday	157	947	27	1342	1057	1904	45	5479
15-Feb-12	Wednesday	79	946	7	1351	946	2026	53	5408
16-Feb-12	Thursday	131	1119	5	1399	922	1654	52	5282
17-Feb-12	Friday	146	1204	17	1415	849	1401	38	5070
18-Feb-12	Saturday	142	1072	9	1380	839	1432	34	4908
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07-Jul-12	Saturday	186	1440	7	1361	940	1525	61	5520
08-Jul-12	Sunday	143	1324	6	786	1062	1959	78	5358
09-Jul-12	Monday	115	1360	14	891	1134	1879	62	5455
10-Jul-12	Tuesday	106	1395	18	1072	1030	1893	76	5590
11-Jul-12	Wednesday	122	1260	12	1331	1007	1988	62	5782
12-Jul-12	Thursday	129	1207	6	1367	1007	1667	66	5449
13-Jul-12	Friday	174	1498	11	1460	968	1836	60	6007
14-Jul-12	Saturday	131	1379	7	1376	973	1699	52	5617
15-Jul-12	Sunday	102	1296	2	1271	1051	2009	66	5797
16-Jul-12	Monday	114	1158	7	1292	966	1594	59	5190
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23-Dec-12	Sunday	104	1175	4	1314	1079	2101	44	5821
24-Dec-12	Monday	124	1171	10	1301	880	1725	31	5242
25-Dec-12	Tuesday	108	1412	16	1399	1203	2321	49	6508
26-Dec-12	Wednesday	111	1095	7	1199	1022	1841	57	5332
27-Dec-12	Thursday	104	1227	5	1297	984	1671	34	5322
28-Dec-12	Friday	157	1503	10	1494	969	1657	54	5844
29-Dec-12	Saturday	128	1387	7	1364	945	1617	39	5487
30-Dec-12	Sunday	113	1185	4	1350	1091	2199	53	5995
31-Dec-12	Monday	125	1104	10	1296	1072	1835	44	5486

** Data Source: GSIC-SEL-UDC JV (GSU JV).*

** Toll free vehicles not included*

Table A15: Daily Traffic Flow Volume in 2010 on Jamuna Bridge (West Toll Plaza)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
01-Jan-10	Friday	90	1046	19	1252	540	1185	27	4159
02-Jan-10	Saturday	74	882	11	1164	544	1343	32	4050
03-Jan-10	Sunday	99	892	10	1326	641	1530	33	4531
04-Jan-10	Monday	57	729	14	1231	660	1693	26	4410
05-Jan-10	Tuesday	39	740	17	1167	668	1686	32	4349
06-Jan-10	Wednesday	54	772	9	1143	638	1588	31	4235
07-Jan-10	Thursday	73	823	11	1205	660	1443	37	4252
08-Jan-10	Friday	89	966	16	1231	564	1326	45	4237
09-Jan-10	Saturday	76	915	9	1175	608	1493	44	4320
10-Jan-10	Sunday	60	801	10	1150	667	1568	46	4302
11-Jan-10	Monday	56	731	23	1177	683	1520	41	4231
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01-Jun-10	Tuesday	65	899	20	1264	859	1697	63	4867
02-Jun-10	Wednesday	63	970	14	1235	849	1544	51	4726
03-Jun-10	Thursday	85	979	14	1320	887	1642	38	4965
04-Jun-10	Friday	84	1131	14	1355	749	1579	36	4948
05-Jun-10	Saturday	77	1131	8	1285	755	1505	42	4803
06-Jun-10	Sunday	59	1032	8	1244	798	1557	33	4731
07-Jun-10	Monday	84	875	11	1162	766	1499	19	4416
08-Jun-10	Tuesday	73	915	20	1413	933	1958	46	5358
09-Jun-10	Wednesday	53	931	13	1222	877	1723	32	4851
10-Jun-10	Thursday	105	1015	16	1336	859	1684	40	5055
11-Jun-10	Friday	85	1153	13	1432	855	1629	38	5205
12-Jun-10	Saturday	86	1101	9	1377	764	1561	30	4928
13-Jun-10	Sunday	80	946	8	1301	816	1737	47	4935
14-Jun-10	Monday	72	934	11	1375	865	1670	39	4966
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23-Dec-10	Thursday	90	1103	7	1351	939	1459	21	4970
24-Dec-10	Friday	120	1275	12	1341	784	1378	31	4941
25-Dec-10	Saturday	114	1428	11	1333	815	1348	35	5084
26-Dec-10	Sunday	73	852	3	1172	882	1579	20	4581
27-Dec-10	Monday	78	1006	13	1299	880	1418	24	4718
28-Dec-10	Tuesday	73	1017	18	1140	946	1450	31	4675
29-Dec-10	Wednesday	72	1034	13	1312	962	1607	54	5054
30-Dec-10	Thursday	98	1146	9	1237	955	1567	28	5040
31-Dec-10	Friday	118	1224	16	1328	840	1274	35	4835

** Data Source: GSIC-SEL-UDC JV (GSU JV).*

** Toll free vehicles not included*

Table A16: Daily Traffic Flow Volume in 2011 on Jamuna Bridge (East Toll Plaza)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
01-Feb-11	Tuesday	73	936	13	1283	930	1583	62	4880
02-Feb-11	Wednesday	66	945	26	1269	925	1633	71	4935
03-Feb-11	Thursday	108	1094	11	1301	865	1505	52	4936
04-Feb-11	Friday	114	1305	16	1291	942	1780	78	5526
05-Feb-11	Saturday	112	970	10	1232	874	1420	51	4669
06-Feb-11	Sunday	94	1024	9	1344	1009	1807	49	5336
07-Feb-11	Monday	69	426	2	517	673	1242	23	2952
08-Feb-11	Tuesday	90	995	13	1253	900	1438	38	4727
09-Feb-11	Wednesday	81	993	25	1300	929	1726	54	5108
10-Feb-11	Thursday	122	1107	10	1374	1000	1662	61	5336
11-Feb-11	Friday	154	1258	14	1401	985	1816	64	5692
12-Feb-11	Saturday	102	939	13	1289	926	1506	56	4831
13-Feb-11	Sunday	92	852	11	1306	971	1777	42	5051
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14-Apr-11	Thursday	293	1288	14	1516	934	1815	48	5908
15-Apr-11	Friday	193	1123	16	1443	692	1293	44	4804
16-Apr-11	Saturday	137	926	14	1489	746	1181	65	4558
17-Apr-11	Sunday	110	846	5	1413	880	1532	58	4844
18-Apr-11	Monday	88	934	7	1386	818	1617	59	4909
19-Apr-11	Tuesday	93	824	15	1279	834	1587	56	4688
20-Apr-11	Wednesday	90	912	23	1287	898	1657	58	4925
21-Apr-11	Thursday	104	1079	8	1346	941	1657	69	5204
22-Apr-11	Friday	138	1171	11	1343	912	1506	60	5141
23-Apr-11	Saturday	107	818	8	1258	741	1274	48	4254
24-Apr-11	Sunday	95	904	7	1291	854	1510	49	4710
25-Apr-11	Monday	92	884	6	1257	919	1530	44	4732
26-Apr-11	Tuesday	92	904	14	1276	919	1666	44	4915
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10-Oct-11	Monday	105	947	9	1262	878	1747	42	4990
11-Oct-11	Tuesday	92	962	12	1213	920	1747	45	4991
12-Oct-11	Wednesday	97	987	23	1169	953	1807	60	5096
13-Oct-11	Thursday	131	1020	11	1245	938	1608	34	4987
14-Oct-11	Friday	150	1201	7	1305	873	1750	45	5331
15-Oct-11	Saturday	118	938	8	1224	842	1456	40	4626
16-Oct-11	Sunday	83	881	5	1154	845	1408	32	4408
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01-Dec-11	Thursday	137	1148	9	1239	923	1605	59	5120
02-Dec-11	Friday	159	1179	11	1276	849	1641	47	5162

** Data Source: GSIC-SEL-UDC JV (GSU JV)*

** Toll free vehicles not included*

Table A17: Daily Traffic Flow Volume in May 2013 on Jamuna Bridge (Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	**Tot Veh**
01-May-13	Wednesday	439	2168	69	1743	1889	3461	113	**9882**
02-May-13	Thursday	361	1975	13	2634	1884	2992	111	**9970**
03-May-13	Friday	477	2736	14	2881	2000	3628	111	**11847**
04-May-13	Saturday	391	2166	7	2473	1984	3097	114	**10232**
05-May-13	Sunday	312	1310	3	830	1660	2698	110	**6923**
06-May-13	Monday	244	1697	13	1591	1689	2639	74	**7947**
07-May-13	Tuesday	349	1687	32	1488	1651	2948	80	**8235**
08-May-13	Wednesday	436	1104	22	722	1105	1758	74	**5221**
09-May-13	Thursday	484	1646	9	1559	1506	2602	95	**7901**
10-May-13	Friday	442	3062	17	3262	2100	3352	121	**12356**
11-May-13	Saturday	420	2484	12	2793	2110	3331	113	**11263**
12-May-13	Sunday	377	1232	2	1351	1491	2789	82	**7324**
13-May-13	Monday	352	2199	9	2705	1959	3282	141	**10647**
14-May-13	Tuesday	383	1436	25	1480	1848	3419	112	**8703**
15-May-13	Wednesday	324	2284	32	2714	2061	3657	130	**11202**
16-May-13	Thursday	321	2256	13	2847	2140	3447	155	**11179**
17-May-13	Friday	468	2919	20	3075	2104	3554	128	**12268**
18-May-13	Saturday	390	2465	10	2958	1969	3097	128	**11017**
19-May-13	Sunday	332	2218	4	2761	2076	3451	130	**10972**
20-May-13	Monday	216	2207	11	2611	2107	3423	125	**10700**
21-May-13	Tuesday	284	2404	28	2719	2134	3467	148	**11184**
22-May-13	Wednesday	470	2514	28	2494	2228	3707	179	**11620**
23-May-13	Thursday	334	3121	15	2861	2136	3374	154	**11995**
24-May-13	Friday	353	2995	18	2989	2117	3243	138	**11853**
25-May-13	Saturday	483	3082	12	2824	1969	2938	91	**11399**
26-May-13	Sunday	422	1674	2	1441	1711	2925	89	**8264**
27-May-13	Monday	356	2291	12	1813	1737	2743	115	**9067**
28-May-13	Tuesday	496	2666	38	2123	2358	3952	146	**11779**
29-May-13	Wednesday	364	1798	25	1433	1892	3194	139	**8845**
30-May-13	Thursday	318	2768	12	2830	1947	2808	134	**10817**
31-May-13	Friday	347	3458	24	3389	2501	4246	129	**14094**
TOTAL		**11745**	**70022**	**551**	**71394**	**60063**	**99222**	**3709**	**316706**

** Data Source: GSIC-SEL-UDC JV (GSU JV)*

** Toll free vehicles not included*

Table A18: Daily Traffic Flow Volume in October 2012 on Jamuna Bridge (Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	**Tot Veh**
01-Oct-12	Monday	250	2033	9	2255	2058	3775	104	**10484**
02-Oct-12	Tuesday	256	2050	36	2171	2073	3710	128	**10424**
03-Oct-12	Wednesday	207	2051	35	2186	2139	3674	98	**10390**
04-Oct-12	Thursday	227	2213	15	2352	2128	3590	103	**10628**
05-Oct-12	Friday	360	2571	7	2516	2005	3399	97	**10955**
06-Oct-12	Saturday	270	2252	12	2455	1971	3152	80	**10192**
07-Oct-12	Sunday	250	2107	7	2502	2026	3675	75	**10642**
08-Oct-12	Monday	236	2141	13	2455	2187	3847	118	**10997**
09-Oct-12	Tuesday	201	2048	30	2360	2142	3951	118	**10850**
10-Oct-12	Wednesday	173	2125	29	2398	2115	3918	104	**10862**
11-Oct-12	Thursday	285	2263	11	2598	2444	4136	104	**11841**
12-Oct-12	Friday	325	2584	22	2493	2347	4233	105	**12109**
13-Oct-12	Saturday	283	2052	14	2377	2117	3685	91	**10619**
14-Oct-12	Sunday	166	2181	12	2439	2482	4781	128	**12189**
15-Oct-12	Monday	198	2419	16	2359	2301	4314	110	**11717**
16-Oct-12	Tuesday	211	2359	27	2324	2606	5377	126	**13030**
17-Oct-12	Wednesday	229	2420	26	2321	2444	5561	108	**13109**
18-Oct-12	Thursday	265	2748	9	2574	2768	6027	157	**14548**
19-Oct-12	Friday	342	3077	16	2738	2832	6912	190	**16107**
20-Oct-12	Saturday	290	2844	10	2667	2705	6942	211	**15669**
21-Oct-12	Sunday	312	2761	8	2537	2595	6981	258	**15452**
22-Oct-12	Monday	394	3138	21	2891	3004	8226	387	**18061**
23-Oct-12	Tuesday	774	3419	71	3085	2594	7534	388	**17865**
24-Oct-12	Wednesday	1135	4981	368	5344	2512	6190	327	**20857**
25-Oct-12	Thursday	1466	5439	507	7119	1648	3310	133	**19622**
26-Oct-12	Friday	1058	3855	178	5158	1134	3378	119	**14880**
27-Oct-12	Saturday	623	1413	4	1473	387	1618	86	**5604**
28-Oct-12	Sunday	1456	2688	19	2833	252	228	13	**7489**
29-Oct-12	Monday	1418	3239	12	3441	497	568	16	**9191**
30-Oct-12	Tuesday	1244	3381	57	4586	968	1368	28	**11632**
31-Oct-12	Wednesday	936	3392	277	5717	1446	2103	68	**13939**
TOTAL		**15840**	**84244**	**1878**	**92724**	**62927**	**130163**	**4178**	**391954**

** Data Source: GSIC-SEL-UDC JV (GSU JV)*

** Toll free vehicles not included*

Table A19: Daily Traffic Flow Volume in March 2011 on Jamuna Bridge (Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	**Tot Veh**
01-Mar-11	Tuesday	163	1911	53	2647	1873	3508	155	**10310**
02-Mar-11	Wednesday	187	2079	47	2538	1862	3436	142	**10291**
03-Mar-11	Thursday	264	2305	26	2765	1901	3149	128	**10538**
04-Mar-11	Friday	354	2460	44	2731	1792	2923	121	**10425**
05-Mar-11	Saturday	321	2100	24	2607	1755	2752	83	**9642**
06-Mar-11	Sunday	214	1950	21	2582	1971	3648	98	**10484**
07-Mar-11	Monday	187	1938	23	2581	1925	3340	86	**10080**
08-Mar-11	Tuesday	176	2071	33	2639	1985	3494	90	**10488**
09-Mar-11	Wednesday	179	2138	32	2715	1963	3654	163	**10844**
10-Mar-11	Thursday	242	2263	22	2857	1860	3251	101	**10596**
11-Mar-11	Friday	310	2605	43	2530	1626	2544	106	**9764**
12-Mar-11	Saturday	273	2218	33	2870	1884	3204	78	**10560**
13-Mar-11	Sunday	200	2081	29	2672	1833	3374	65	**10254**
14-Mar-11	Monday	260	2051	20	2668	1873	3334	114	**10320**
15-Mar-11	Tuesday	197	2210	32	2618	1779	3087	88	**10011**
16-Mar-11	Wednesday	295	2681	53	2845	1938	3599	98	**11509**
17-Mar-11	Thursday	295	2950	23	2826	1897	3393	111	**11495**
18-Mar-11	Friday	309	2690	30	2811	1685	2956	93	**10574**
19-Mar-11	Saturday	322	2640	26	2807	1715	2789	75	**10374**
20-Mar-11	Sunday	258	2081	13	2729	1733	3413	64	**10291**
21-Mar-11	Monday	177	1969	15	2635	1814	3376	85	**10071**
22-Mar-11	Tuesday	150	2010	32	2593	1788	3349	101	**10023**
23-Mar-11	Wednesday	167	1978	31	2541	1754	3632	103	**10206**
24-Mar-11	Thursday	282	2247	31	2924	1740	3260	93	**10577**
25-Mar-11	Friday	321	2536	33	2800	1619	2948	134	**10391**
26-Mar-11	Saturday	261	2229	35	2854	1396	2482	73	**9330**
27-Mar-11	Sunday	218	1947	21	2716	1602	3182	94	**9780**
28-Mar-11	Monday	174	1836	20	2661	1696	3117	97	**9601**
29-Mar-11	Tuesday	189	1805	25	2485	1729	3206	98	**9537**
30-Mar-11	Wednesday	159	1778	33	2457	1656	3482	145	**9710**
31-Mar-11	Thursday	219	2122	17	2522	1642	2963	115	**9600**
TOTAL		**7323**	**67879**	**920**	**83226**	**55286**	**99845**	**3197**	**317676**

** Data Source: GSIC-SEL-UDC JV (GSU JV)*

** Toll free vehicles not included*