ASSESSING THE LEVEL OF TRAFFIC CONGESTION AT FERIGHAT INTERSECTION IN KHULNA METROPOLITAN CITY

Sabok Mondal*[1] and Sazzad Hossain[2]

[1] *Student, Dept. of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh, e-mail: sabok.mondal@gmail.com*

[2] *Professor, Dept. of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh, e-mail: sazzad1999@yahoo.com*

ABSTRACT

Traffic Congestion is an ever growing chronic problem in the transportation system soon after the invention and mass production of automobiles. All major cities both in developed and developing countries are facing the problem due to increasing travel demand which follows economic and population growth. Traffic congestion is a common phenomenon almost in all the cities of Bangladesh. The situation has become to a very critical stage and has already assumed unbearable proportions. This type of study has been conducted in Dhaka but not in Khulna Metropolitan City. Following the economic and population growth in Khulna, traffic congestion problem growing faster. In this study, the level of the traffic congestion in Ferighat Intersection was assessed using travel time approach. But Level of Service (LOS) and Degree of Saturation was estimated by SIDRA software for both Ferighat and Moylapota Intersection in Khulna Metropolitan City. In the study area motorized and non-motorized vehicle creating congestion which has many negative effects. Traffic movement survey, travel time, delay time and total traffic volume has been conducted at Ferighat intersections. In order to assess the level of congestion at Ferighat intersection, this study has carried out. A large number of vehicles mainly non-motorized vehicles occupy the road, reducing roadway capacity and creating congestion.

Keywords: *Transportation system, traffic congestion, unplanned activities, mobility.*

1. INTRODUCTION

Traffic congestion occurs when a city's road network is unable to accommodate the volume of traffic. This situation is caused by rapid growth in motorization and with less than corresponding improvement in the road network, traffic management techniques and related transport facilities. Thus, traffic congestion is a phenomenon that is associated with urban environment all over the world. While traffic congestion has been managed very well in some developed countries, it has continued to defy solutions in the developing world. The forecast of Global Traffic Volume shows that the phenomenon would double between 1990 and year 2020 and again by 2050 (Engwitch, 1992).

Traffic congestion is a common problem almost in all the cities in Bangladesh. The number of traffic is increasing day by day in Khulna city. For this reason, traffic congestion occurs at major intersections in this city and congestion problem growing faster. In order to assess the level of congestion at Ferighat intersection, this study has carried out. Many urban centers in Khulna suffer from inadequate facilities that could ensure smooth urban movement.

Some land use types constitute nodes of desires and fulfilment in any urban area. Transport assists to even out the spatial imbalance in needs. Often, coincidence arises from individual commuter's journey during peak hour periods. This type of coincidence, if not well managed, may lead to traffic crisis that makes traveling burdensome in addition to wasting man-hour productive time. Ways of mitigating this mobility problem and ensuring a smooth flow of urban traffic have been carried out in different studies as exemplified by the work of urban transport scholars. Some of the researches by these scholars were aimed at identifying the causes and dimensions of transport problems (Anjaneyulu et.al. 2009). Others were pre-occupied with various options for solving transport problems (Ameyan, 1996). So far, the conventional approaches to traffic management have not been able to make the desired impact, judging from the traffic congestion patterns in Khulna Metropolitan City.

The congestion problem at major intersections and road sections in Khulna Metropolitan City are growing faster.

The specific objectives of the study are as follows:

a) To identify the peak periods of traffic flow of the day in the study intersection.
b) To measure the Level of Service (LOS) and Degree of Saturation of the intersections by using SIDRA software.
c) To identify the most congested road and period of congestion at the study intersection by using travel time.

1.1 Scope and Limitations

The scope of this study was limited to the two intersections of Khulna and other road sections and intersections were not included in this study. Furthermore, the analysis was segment study rather than area wide or regional study. Hence, it focused mainly on the road segments at the entry of selected intersections and the relative effect of consecutive intersection was not discussed. Since, the main objective of the study is assessment the congestion level, the congestion management procedures and measures were not discussed as it is a wide and need further investigation.

2. LITERATURE REVIEW

Many researchers and professionals in the field of transportation agree that road traffic congestion is an ever growing problem and global phenomenon of major cities throughout the world. Further to this Lomax (1997) showed that traffic congestion is expanding toward the suburbs as commercial activities are being pulled out of the central business districts (Lomax et. al., 1997; Maitra et. al., 1999). In fact, it is almost certain that traffic congestion will also get worse during at least the coming decades mainly due to the increasing population number and the growing economy of nations. Traffic congestion is a negative output of a transportation system which has many detrimental effects on the performance of the road network, the traffic flow, the society, the national economy and the environment. Maitra et. al. (1999) summarizes some of the negative effects of traffic congestion as; considerable loss of travel time, higher fuel consumption, more vehicle emission and associated environmental and health impact, increased accident risk, stress and frustration on commuters and greater transportation cost.

Further to the above; many more researches have been conducted by different researchers and professionals to develop measuring parameters and models (Maitra et. al., 1999; Lomax et. al., 1997; Cottrell, 2001). So far, different congestion measures and models have been proposed and used to determine the extent, severity and duration of congestion and also transport professional are still developing different models for congestion prediction and simulation (Moran et. al., 2010).

2.1 Definition of Traffic Congestion

As a general term, congestion is a phenomenon that occurs almost in all walks of life which demand competition for certain service or supply. The Hand Book of Transportation explain road traffic congestion as a phenomenon resulted when vehicles compete or demand for the available road space and the demand reaches or exceeds the capacity.

Hence, there are many definitions given for traffic congestion based on different parameters. The summarized definitions are:

a) Traffic Congestion is travel time or delay in excess of that normally incurred under light or free flow travel condition.
b) Traffic Congestion is a situation where the traffic demand for the road space exceeds the capacity.
c) Traffic Congestion is an excess of vehicle on the portion of the road way at a particular time resulting in slower speed from normal or free flow speed and mostly characterized by stop or stop-go traffic.

As it can be seen from the above definitions and the diagram below, definitions of traffic congestion generally fall in to two major categories. These are definitions which based on the cause and which based on the impact of traffic congestion.

In traffic engineering, flow is an important parameter that shows the state of the traffic movement. In terms of traffic flow, congestion is usually considered as the state where the speed-flow Figure is reverted or sloped positive. Hence, congestion can be defined as a state in the traffic flow pattern which represents the condition at which demand exceeds capacity or the speed is below acceptable value (Yu et. al., 2010).

Depending on its occurrence congestion can be classified as recurring and non-recurring congestion. Recurring congestion includes congestion due to bottlenecks, traffic signal, and persistent higher demand etc. and they are predictable. Whereas non-recurring congestion is includes those congestion caused by mainly accidents and unprecedented events (Skabardonis et. al., 2003).

2.2 Causes of Traffic Congestion

Different researches and reports identified many interrelated factors that cause traffic congestion in developed and developing countries where the road network and road users behavior are different (Cambridge Systematics, 2005; Aworemi et.al., 2009). Accordingly, the results showed that in the United States of America the cause and their percentage share are; bottleneck (40%), traffic incidents (25%), work zone (10%), bad weather (15%), poor signal timing (5%) and special events contribute 5% of the traffic congestion.

Adedimila (as quoted by Aworemi et.al., 2009) classifies the major causes of traffic congestion in Lagos metropolitan in to five and the summary of his discussion is shown in the Table 2.1.

Table 2.1: Major Causes of Traffic Congestion in Lagos Metropolitan

Item No.	Factors	Causes Described
1	Social & Economic factors	Rising population number together with the rural urban migration Unplanned land use which result unidirectional traffic flow especially at pick hours Increased car ownership in line with the improved living standard
2	Road factors	Smaller number of lane & Narrow road with Lack of side walk which result occupation of traffic lanes by pedestrians Distressed pavement which result in a reduced travel speed Uncontrolled traffic Intersections
3	Vehicle factors	Size of vehicle Age of vehicles
4	Human factors	Perception of drivers Perception of pedestrians
5	Accident	The severity, number and location of accident

Besides Traffic congestion occurs for limited road capacity, road parking, un-integrated urban planning, and lack of mass transit, accident, poor vehicle condition, and road side illegal trade.

2.3 Congestion Indicators

As congestion is a relative measure unlike the other traffic flow parameters and it is defined on the road user's feedback. It is essential to define or have indicators of the presence of congestion in the system. According to many other researchers LOS is the best empirical indicator of congestion in transport system.

2.3.1 Level of Service (LOS) as Congestion Indicator

The objective of High way Capacity Manual is to provide a consistent system and techniques for the evaluation of the quality of service on highways and street facilities. HCM presents LOS as an easy-to-understand methodology of analysis and performance measure for single homogenous road segments.

HCM doesn't specify the boundary LOS for congestion state but clearly states that the LOS F is defined as the worst state of flow and represents congested flow. Though there are some reports using other level of service (D and E) as congested flow, LOS F is generally accepted as a state of traffic flow and hence LOS is the most appropriate congestion indicator.

The LOS criteria of HCM are summarized in Tables 2.2

Table 2.2: Typical Highway Level of Service (LOS) Rating

LOS	Description	Speed (km/hr)	Flow (Veh/hr/ln)	Density (Veh/km)
A	Traffic flows at or above posted speed limit. Motorists have complete mobility between lanes.	Over 96	Under 700	Under 8
B	Slightly congested, with some impingement of maneuverability. Two motorists might be forced to drive side by side, limiting lane changes.	91-96	700-1100	8-13
C	Ability to pass or change lanes is not assured. This is the target LOS for most urban highways	86.5-91	1100-1550	13-19
D	Speeds are somewhat reduced, motorists are hemmed in by other vehicles. Typical urban peak-period highway conditions.	73.5-86.5	1550-1850	19-26
E	Flow becomes irregular, speed vary and rarely reach the posted limit. This is considered a system failure.	48-73.5	1850-2000	26-42
F	Flow is forced; with frequent drops in speed to nearly zero kmph. Travel time is unpredictable.	Under 48	Unstable	42- max

2.4 Performance Measures Using Travel Time

Each of the dimensions of traffic congestion stated before can be measured with different operational characteristics (speed, delay, travel time, density etc.) or volume characteristics (operating traffic volume, volume to capacity ratio, traffic volume per lane, etc.). Many literatures including the NCHRP report 398 "Quantifying Congestion" provide different measures for congestions based on travel time approach. Most of the measures explain only one or two of the dimension of congestion and hence it is necessary to use more than one congestion measure to explain the level of congestion at a road section. Accordingly, there are quite a number of congestion measures suggested in different literatures for each congestion dimension.

Table 2.3: Summary of Congestion Measures (Source: Lomax, et. al. , 1997)

Travel Rate	Travel Rate (minutes/km) = $\frac{\text{Travel Time (minutes)}}{\text{Segment Length (km)}}$
Delay Rate	Delay Rate (minutes/km) = Actual Travel Rate (minutes/km) – Acceptable Travel Rate (minutes/km)
Delay Ratio	Delay Ratio = $\frac{\text{Delay Rate}}{\text{Actual Travel Rate}}$
Delay Per Vehicle	Delay Per Vehicle (annual hours) = [Actual Travel Time (minutes) – Lowest Travel Time (minutes)] × $\frac{\text{250 Weekdays}}{\text{Year}}$ × $\frac{\text{Hour}}{\text{60 minutes}}$
Travel Time	Travel Time (Vehicle-hour) = Actual Travel Rate (minutes/km) × Length(km) × Vehicle Volume (vehicles)
Total Segment Delay	Total Segment Delay (vehicle-minutes) = [Actual Travel Time (minutes) – Travel Time (minutes)] × Vehicle Volume (vehicles)

2.5 Traffic Congestion and Accident

The evidence is mixed on the degree to which congestion reduces the number of traffic accident on a congested road segment. In some cases, traffic accident shows a reduction in less congested road section. The study concludes that shifting vehicle travel from congested to less congested condition tends to reduce traffic accident but increases the accident severity.

Khulna is the industrial and divisional city of Bangladesh. It is the third largest Metropolitan city. The land size of Khulna is 45.65 km^2 and population density is15,429 per km^2. In this city, till to date, research works has not been carried out with a detailed spectrum of analysis of road accidents cost for a full understanding of accident problems and thereby developing effective countermeasures. In Bangladesh, the most scientific and modern research was conducted by Jakir (1997), which provide some important and factual information about the extent and nature of accidents. In urban areas, road fatalities involved with pedestrians is about 60%, while in rural area pedestrians is about 40% of total accidents (Jakir, 1997).

3. METHODOLOGY

The methodology employed for a research work was the critical aspect for ensuring the proper result which aligns with the objective. Hence, this part of the thesis discusses the methodology followed to complete the research work.

3.1 Research Approach

The research approach in this thesis involves quantative approaches. Quantitative data and analysis were used to determine the level of service of intersections and to measure the congestion levels. Observation, direct field measurements were the main sources of quantitative data. Observations, collecting relevant data and subsequent analysis of the data help to generate inductive conclusions on the level of congestion at the observed or considered Intersections and road sections. Though it is impossible to assess the traffic congestion at all intersections and road sections in the city. However, in this research the intersections and road sections considered were only at the Moylapota and Ferighat intersections of the city; which is connecting the highly congested.

The congestion indicator parameters used in this research were Level of Service (LOS). The LOS criterion was according to HCM-2000 and determined using the widely used **SIDRA** software. As travel time approach is easy to understand and interpret by every people and it is easy to convert to other index parameters, the performance measurement parameters used in this research were based on travel time approach.

3.2 Data Collection Technique and Equipments

There were two ways to traffic volume count.

1. By Video recording
2. By Manual traffic volume count

Video capturing techniques is preferred over the manual collection (pen and paper method) because:

a) It provides a permanent, easily-review record and show the traffic conditions at any time;
b) It permits the reading of required parameters in a controlled environment in which plate characters can be closely examined;
c) It provides additional information about traffic flow characteristics such as traffic volume and vehicle headway; and
d) It can provide a time stamp for accurate determination of arrival times.
e) have better accuracy than manual methods; and
f) able to capture a larger sample of the total number of vehicles.

So, the traffic volume data were counted for this research by using video recording directly. Traffic volume were analyzed from the video at 15 minutes interval. In addition, other field measurements were done to gather data on the geometrical features of intersection for capacity analysis. These include, number of lanes, lane width, configurations of lanes, grade, width of median, movement policy etc. These measures were done for the intersections whose level of service is going to be determined.

3.3 Study Location

The study location is Ferighat Intersection
The Ferighat Intersection with all approach legs (Entry and Exit legs) is shown in Figure 3.1:

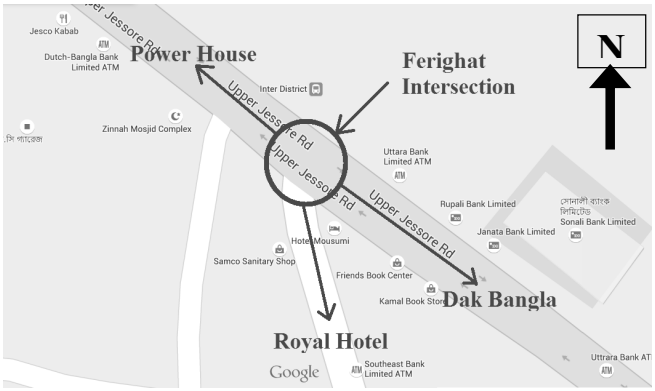

Figure 3.1 : Ferighat Intersection

3.4 Description of the Study Area

Road transport has been serving the major mode of transport for both domestic and international transport services. Khulna is the third-largest and the industrial and divisional city in Bangladesh. Khulna is located in south-western Bangladesh at 22°49′0″N 89°33′0″E. The land size of Khulna is 45.65 km2 and population density is 15,429 per km^2 (KDA Report 2012).

The city has a population of more than 1.4 million people. The most common means of transport is the non-motorized vehicle. Traffic flows on roads of Khulna Metropolitan City are heterogeneous. In many Parts of Khulna, rickshaw and other non-motorized transport (NMT) account for 60% or more of the traffic flow. The number of vehicles operating in Khulna Metropolitan City is more than 20990, comprising about 13360 non-motorized and 7630 motorized vehicles. The average annual growth of motorized vehicles is about 15%. (Uddin and Sen, 2004).

3.4.1 Population Dynamics

The population of Khulna is 1442339 (KDA Report, 2012) and the density 3335 persons/km^2. The population growth rate is nearly 3.8%. The GDP of the people of Khulna increasing with the increasing of population. Table 4 shows the National GDP and Population of Khulna from year 2004-05 to 2012-13.

Table 3.1: National GDP and Population of Khulna

Year	Population (million)	GDP at Current Market Price (billion)
2004-05	1.105	3032.07
2005-06	1.116	3217.86
2006-07	1.123	3406.52
2007-08	1.130	3608.45
2008-09	1.137	3850.50
2009-10	1.144	4093.78
2010-11	1.151	4126.24
2011-12	1.165	4302.57
2012-13	1.172	4415.41

Source: Bangladesh Bureau of Statistics; Bangladesh Bank

Figure 3.2 shows the increasing population from 2004-05 to 2012-13.

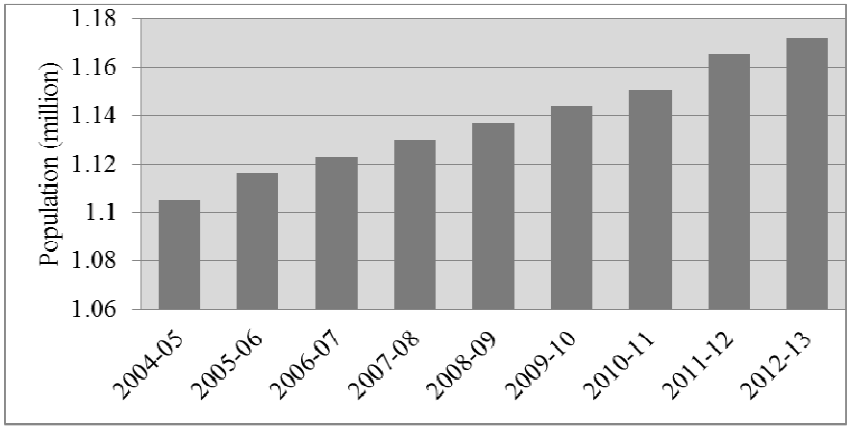

Figure 3.2: Population of Khulna in millions

3.4.2 Economic Activity

According to Bangladesh Bureau of Statistics the real GDP growth of the people of Khulna are summarized in Figure 3.3. The data shows that the GDP is increasing with a uniform rate.

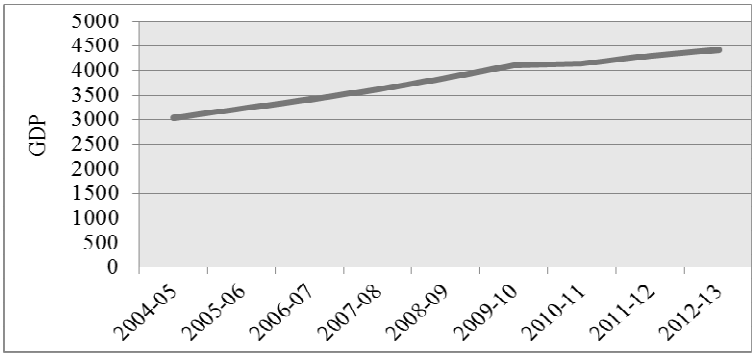

Figure 3.3: GDP Growth of Khulna

3.5 Data Collection

To attain the objectives of this research, different types of quantitative data such as traffic flow or volume data, vehicle occupancy data, travel time data and travel accident data and road users' congestion perception data and causes of traffic congestion were required. But for this research only Traffic volume data and travel time data were collected.

3.5.1 Traffic Volume Data

Traffic volume are very important to determine and understand the flow pattern in the facility, to determine the peak flow rates and peak periods, to assess the relationship between traffic volume and congestion. Furthermore, it is extremely required to analyze the level of service.

The traffic volume count was collected for a period of 10 hours (8:00 am 6:00 pm) on the study day.

- Heavy Vehicles: Bus, Trucks
- Light Vehicles: Cars, Pickup, Mahindra, Easy Bike, Rickshaw, Bi-cycle, Van etc.

The traffic count was directional and hence directional traffic flow characteristics can be easily summarized and studied. As travel time data was averaged for all vehicles type and a single travel time was considered in the 15 min time interval as discussed before, it is also necessary that the vehicle volume count should be converted to passenger's equivalent unit to conduct congestion analysis.

The traffic volume in passenger car unit and the movement of traffic on each approach leg are also essential for the analysis. The passenger car equivalent factors are used to convert the number of vehicles in passenger car unit. The PCU values given in the geometric design of Highways (MoC, 2001) are given in Table 3.2.

Table 3.2: PCU of Different Types of Vehicles in Bangladesh (MoC, 2001)

Categories	PCU
Passenger Car	1.00
Light Good Vehicle	1.00
Bus	3.00
Truck	3.00
Auto-rickshaw / Motorcycle	0.75
Rickshaw / Van	2.00
Bi-cycle	0.50

3.5.2 Travel Time Data

Travel time data was the most important data for the congestion analysis. In order to collect the travel time data at the Ferighat Intersection, 100m segment measured from the center of the intersection for each approaches. Then manually travel time data were counted for every 5 vehicles and averaged. The directional traffic volume for each intersection is shown in the Appendix as an input data for SIDRA analysis.

4. RESULTS AND ILLUSTRATIONS

The analysis was made on the gathered quantitative data to look into the trend of the traffic flow with in the day and identify the peak period and peak hour volumes. The level of service for the identified intersections was analyzed using SIDRA software.

Congestion analysis was also made on the sections where the travel time data was collected and the results interpreted and discussed. In the congestion analysis, parameters for quantifying congestion were calculated based on travel time approach for each section.

4.1 Directional Traffic Volume Analysis

A directional traffic volume analysis was conducted on a traffic volume data which is counted at 15 min interval and for 10 hours (8.00 am - 6.00 pm). The traffic volume analysis is done for both direction and for three approaches along the Ferighat intersection. The road sections were considered

1. Upper Jessore Road (Dak-Bangla–Ferighat approach)
2. Upper Jessore Road (Power House–Ferighat approach)
3. Khanjahan Ali Road (Royal Hotel–Ferighat approach)

Traffic Directional Volume analysis of each approaches are discussed below.

4.1.1 Upper Jessore Road (Dak-Bangla–Ferighat Approach)

From Figure 4.1, it is seen that rickshaw is the most common vehicles in both Dak Bangla to Ferighat and Ferighat to Dak Bangla Approach. The people of Khulna prefer rickshaw to travel as privately. But now a days easy bike is also common vehicle in the city to travel from one place to another. It is also seen that mahindra, easy bike and motor cycle are nearly same for both this two approach. But heavy vehicle bus and truck are a very small in number. The entry of Truck has restricted into the city at 8.00 am to 6.00 pm by Khulna City Corporation. So trucks volume is less in number. On contrast, bus are also limited in number. In Ferighat Mor, only public transport services and buses of different school and colleges are run through the intersection.

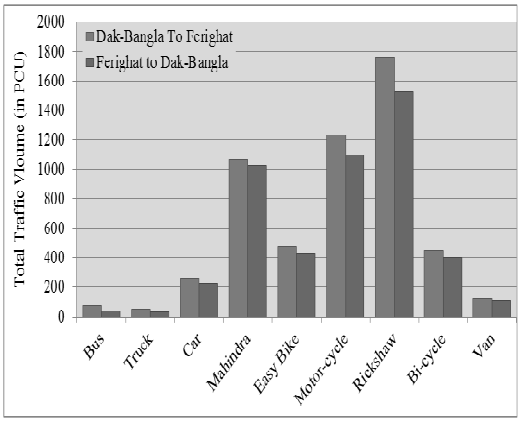

Figure 4.1: Total Traffic Volume by Vehicle Type

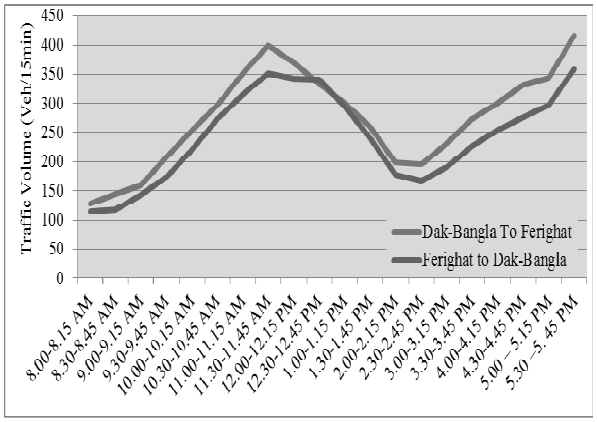

Figure 4.2: Traffic Volume (Veh/15min)

From Figure 4.2, it is seen that both Dak Bangla to Ferighat and Ferighat to Dak Bangla approach, traffic volume is increasing after 10 am and it is maximum at 12.00 pm to 1.00 pm in the morning and 4.00 pm to 6.00 pm in the evening.

4.1.2 Upper Jessore Road (Power House–Ferighat Approach)

At Upper Jessore Road, it is seen the Figure 4.3 that Mahindra, Easy-bike, Motor-cycle and Rickshaw are the common vehicle in both Power House to Ferighat and Ferighat to Power House approach. The number of these vehicles are nearly same. A small number of cars are running through the approach.

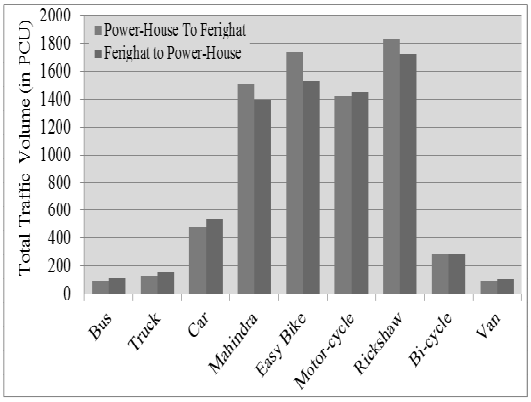

Figure 4.3: Total Traffic Volume by Vehicle Type

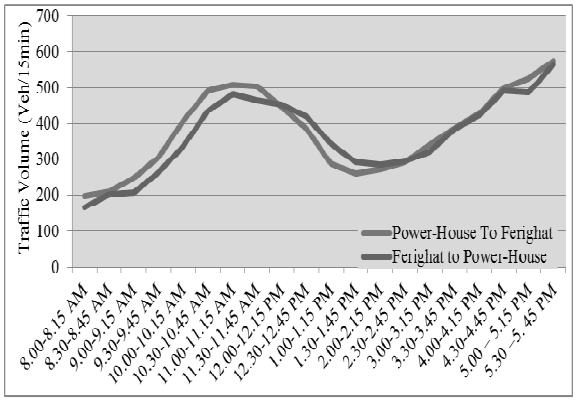

Figure 4.4: Traffic Volume (Veh/15min)

From Figure 4.4, it can be seen that both Power House to Ferighat and Ferighat to Power House approach traffic volume is increasing after 9.30 am and it is maximum at 11.00 am to 12.00 pm in the morning and 4.00 pm to 6.00 pm in the evening. In this peak periods vehicle volume is 450-550.

4.1.3 Khanjahan Ali Road (Royal Hotel–Ferighat Approach)

From Figure 4.5, it can be seen that Easy-bike is the most common vehicle in this Approach. Now a days Easy-bike is also common vehicle in the city to travel from one place to another quickly. Rickshaw, Mahindra, Motor-cycle are nearly same for both this approach. But heavy vehicle Bus and Truck are a very small in number.

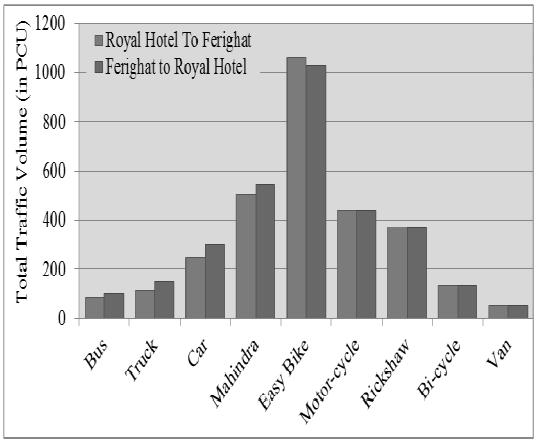

Figure 4.5: Total Traffic Volume by Vehicle Type

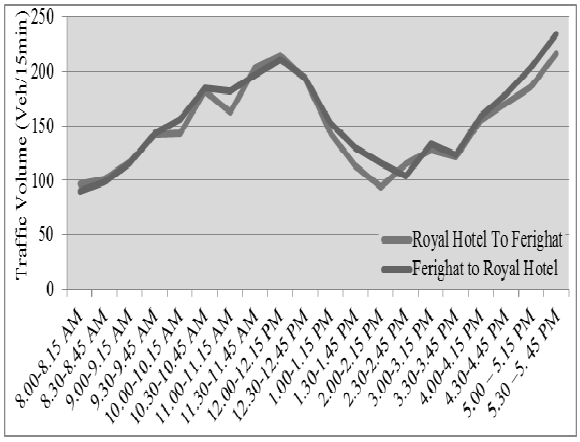

Figure 4.6: Traffic Volume (Veh/15min)

Figure 4.6 shows that the traffic entry and exit is nearly same for this approach. And the peak period is about 11.00 am to 12.00 pm in the morning and 4.00 pm to 6.00 pm in the evening. But overall vehicle volume is less than previous two approaches.

4.2 Comparison of Total Traffic Volumes Among Entry and Exit Legs

The total traffic volume during the 10 hours day time count was summed and both directional volume is shown in Figure 4.7. It shows the volume for Power House to Ferighat direction is the highest and the second highest traffic volume is Dak-Bangla to Ferighat direction. This result indicates that these two roads carry the huge traffic loads from the two ends of residential and commercial areas in Khulna Metropolitan City.

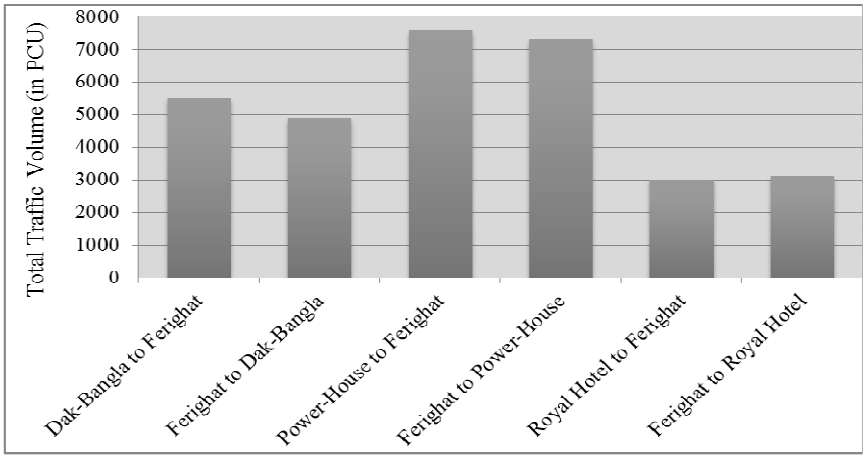

Figure 4.7: Total Directional Vehicle Volume for the 10-hours at Ferighat Intersection

The total traffic volume of both directions for each approach, the trend of the traffic volume with the time of the day it shows a trend at morning and evening peak periods. The total volume of Power House to Ferighat is higher than any of the other approach. The Royal Hotel- Ferighat approach traffic volume shows the lowest value throughout the day periods.

Two Figures 4.8 & 4.9 is given below for the directional traffic volume for both entry and exit legs. The Figure for entry leg showed that traffic volume is maximum in the Power House-Ferighat approach among three approach and nearly 500 vehicle at the morning peak period and greater than 550 vehicle at the evening peak period.

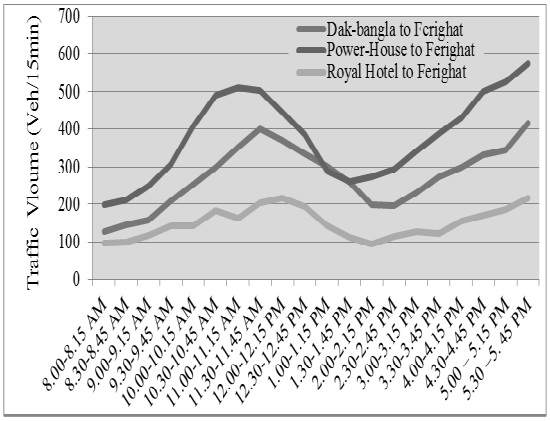

Figure 4.8: Comparison of Traffic Volume (Veh/15min) of Entry Legs for Three Approaches

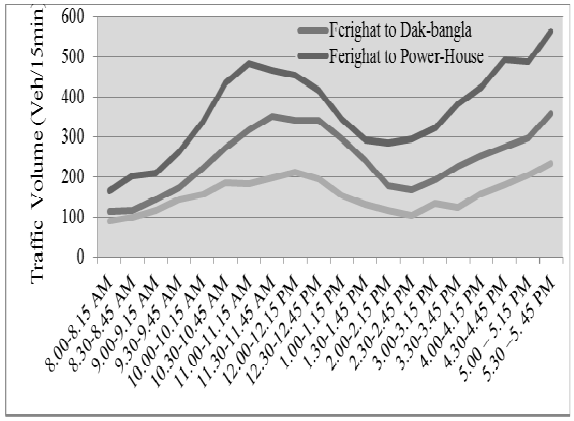

Figure 4.9: Comparison of Traffic Volume (Veh/15min) of Exit Legs for Three Approaches

Figure for exit legs showed that traffic volume is also maximum in the Power House-Ferighat approach among three approach and nearly 400-500 vehicle at the morning peak period and greater than 550 vehicle at the evening peak period.

4.3 Intersections Level of Service (LOS) Estimation

In order to check whether the intersections are congested or not, analysis was made using SIDRA program. In order to analyze the LOS using the program, installation was made with the options left-hand driving rule and HCM 2000 metric version. As only the level of service (LOS) and Degree of saturation will be determined for an indicative result leaving the other outputs of the program, calibration was not taken as an issue for the purpose.In order to conduct the analysis the geometric and directional hourly traffic volume data were prepared as an input for the program as summarized below in Table 4.1. However, recommended and default values were taken for other input data; for instance critical gap,saturated flow.

Table 4.1: Degree of Saturation and Level of Service (LOS) for Each Road of Two Intersection Through SIDRA Software

Intersection	Approach Leg Name	Degree of Saturation (V/C)	LOS
Ferighat Intersection	Upper Jessore Road (From Dak-Bangla)	1.76	F
	Upper Jessore Road (From Power House)	1.32	F
	Khanjahan Ali Road (From Royal Mor)	1.94	F

4.4 Congestion Analysis

The travel time, traffic volume data were used to analyze the congestion along the study intersection. The congestion analysis was based on the travel time approach and hence the following congestion measures were analyzed. These are; Average travel speed, travel rate, delay rate, delay ratio, Delay Per Vehicle and total segment delay. In brief, average travel time and delay rate are described below:

4.4.1 Travel Time and Delay Rate

Figure 4.10 shows the average travel time at 15-min interval for the segments selected. According to the result, the morning and evening peak periods recorded the higher travel time and the lowest travel time recorded. For all the three approaches, all the legs shows that the travel time during the evening peak period is higher than the morning peak period travel time.

From Figure 4.10, It is also seen that, the maximum travel time is required for Power-House approach . It is up to greater than 140 sec in the morning and evening peak period. The lowest travel time is required for Royal Hotel to Ferighat approach and the time is nearly same for the whole day.

The delay calculation was conducted with reference to the daily least travel rate or the travel time recorded during the highest travel speed period which is taken as acceptable or free flow.

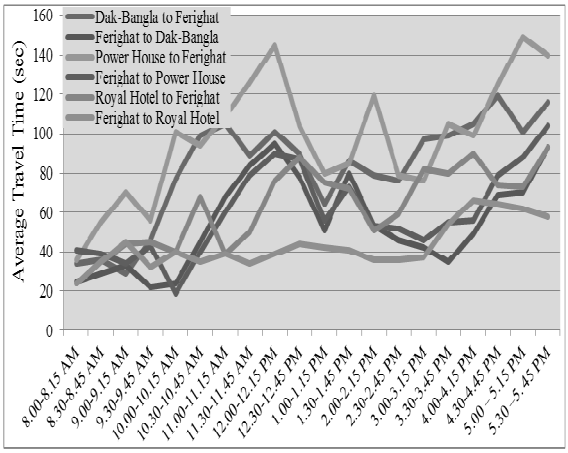

Figure 4.10: Average Travel Time for All Legs

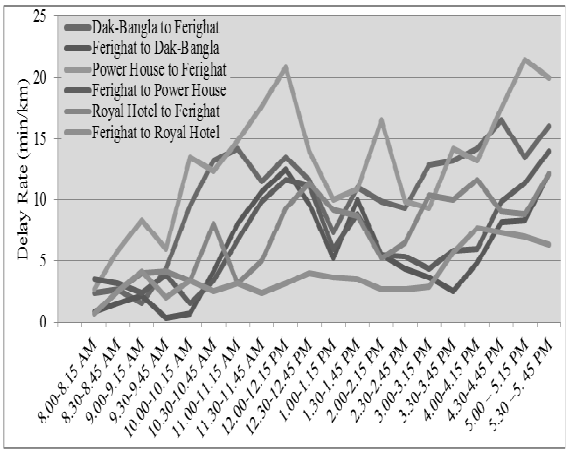

Figure 4.11: Delay Rate for All Legs

5. CONCLUSIONS

The findings of the research work concluded below in brief:

a) The traffic flow from the residential area of the two ends (From Power House and Rupsha) are peak during the morning period (11 am to 12 pm) and only left lane is congested during one of the peak period.

b) Traffic congestion during the evening peak hour (4 pm to 6 pm) is more than the morning peak hours. But at the starting of the day and mid-day the roads are not congested.

c) From LOS and Degree of Saturation analysis, the degree of saturation is almost greater than 1 and the Level of Service is F for all approaches at Ferighat intersection.

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