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EVALUATING OPERATIONAL CHARACTERISTICS OF PUBLIC TRANSPORT SYSTEM OF KHULNA- JESSORE HIGHWAY, BANGLADESH: A CASE STUDY ON PHULTALA TO AFIL GATE MID-BLOCK

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ABSTRACT

This study aimsatevaluating the operational characteristics of public transportation system from Phultala to Afil Gate mid-block in Khulna-Jessore highway, Khulna. For achieving this, the study focuses on three core studies related to the speed for evaluating the existing situation: (i) spot speed, (ii) running speed and (iii) journey speed. This research is based on primary source data in the form of both physical and social survey; collected from users, drivers and traffic polices; and a GIS based secondary analysis of the study area has been carried out later on. Different indices; PHF (Peak-Hour Factors) and Lindley's Index, have been used for comparing the obtainedvalues to the standard values. The outcomes of this study suggest that the speed fluctuation of the study area of different vehicles isn't likely to differ from the standard value. The LOS found for the study area is A, where volume to capacity ratio has been located less than 0.6 and the delay time is less than 10 sec.;which indicates it allows free flow with low volume and high speeds.PHF value is 0.67 and according to Lindley's index V/C <0.77; which also remarks that Congestion phenomenon isn't presentin the study area.

Keywords: *Traffic congestion, Speed performance, Road network, Traffic control and Management*

1. INTRODUCTION

Public transportation is a shared passenger-transport service which is available for use by the general public. A well planned public transportation provides economic opportunities and drives community growth revitalization (Akmal Abdelfatah, 2015). The common modes of public transportation in Khulna are rickshaw, baby taxi,battery bike etc. There is also a public bus service named Nagor Paribahan which runs frequently within Khulna city. Recently BRTC bus services have been also introduced to carry traffic volume along the Khulna-Jessore Highway. In respect of Khulna division's transportation system, Khulna-Jessore Highway is the most important road network for both intra and intercity connectivity. Besides after the completion of Padma Bridge transportation between Khulna region and Dhaka region will become even easier which will increase the economic activities of Khulna. To support this economic growth and future public demand a well-planned transportation system is prerequisite(Akmal Abdelfatah, 2015).

The objective of the research is to evaluate the operational characteristics of public transportation system from Phultala to Afil Gate mid-block in Khulna- Jessore highway, Khulna. In order to evaluate the operational characteristics several traffic studies e.g. volume study, speed study etc. have been carried out. The speed study will help to enforce control systems ensuring safe, rapid and convenient transit of people and goods. It will also help determining nodes where proper management is necessary. Thus, this study will help to develop a proper transportation system. Finally, the output of the project may be helpful in further projects related to the Khulna-Jessore Highway.

2. LITERATURE REVIEW

Traffic speed analysis is a compulsory part for a proper transportation planning. Accident analysis, road maintenance, and congestion are the modern fields of traffic engineer, which uses speed data as the basic input(Tyburski, 1989).The designing of road geometry requires the speed study. To assume the proper location of signs, signals, safe speed and speed-zones, speed study is required.

A study conducted in Barcelona evaluated the level of reduction in the number of road collisions, number of injuries, and number of cars affected by an accident due to the presence of speed cameras on Barcelona's obeltway. The study compared accidents on two road segments, where one road had no speed cameras installed and one with speed cameras installed. The analyses of the study were based on collisions and accidents' data. The results of the study concluded that speed cameras are effective in reducing the number of accidents and, therefore, the number of injured people (Perez et al, 2007).

In another study in London, UK, (Walter et al, 2011) presented the impact of increasing the police enforcement within an urban area. The researchers reported the effect of setting speed radars and more static and mobile police enforcement that are easily recognizable by the drivers. The authors concluded that there was a systematic speed reduction along the considered corridor due to the application of the enforcement measures. However, there was no effect of these enforcement measures on the use of seatbelts and mobile phones.

In a study at Vidya Path in Chandigarh (Amanpreet Kaur, 2014) the objective was to analyze the speed characteristics along the study stretch and to determine the speed percentiles, which were useful in designing and regulating the traffic. The data gathered in spot speed studies are used to determine vehicle speed percentiles, which are useful in making many speed-related decisions. And the outputs of the study were the maximum speed limit on the road is equal to 58 Kmph for 2-wheelers as well as for 4-wheelers. All the 2-wheelers and 4-wheelers plying on the road moved with a speed ranging between 13-58 Kmph. Maximum 2-wheelers moved with the average speed of 31 Kmph and maximum number of 4-wheelrs moved with an average speed of 26 Kmph. The 85th percentile speed i.e. the critical speed for 2-wheelers is 42 Kmph and for 4-wheelers is 40 Kmph. The 15th percentile speed i.e the minimum speed for 2 wheelers is 22 Kmph and for 4- wheelers is 16 Kmph.

So, the highway services can be divided in six categories which ranked as Level of service(LOS)is a qualitative measure used to relate the quality of traffic service, used to analyze highways by categorizing traffic flow and assigning quality levels of traffic based on performance measure like speed, density etc. LOS describes the quality of operational condition within a traffic stream. Six LOS are defined according to the Volume to Capacity Ratio or V/C) –if V/C ≤ 0.6, then it indicates Level of service (LOS) "A". Similarly LOSB≤ 0.7, LOS C≤ 0.8, LOSD≤ 0.9, LOSE≤1 and LOSF>1 (Kadiyali, 1978)

3. STUDY AREA AND METHODOLOGY

3.1 Study Area

Khulna city was selected as the study area. Khulna is a low-lying city which has developed in a linear pattern alongside the Bhairab and Rupsha Rivers in south western Bangladesh. The linkages of Khulna city with other towns and growth centers can enhance the importance of the city.

"Phultala to Afil Gate" (Figure: 1) section which is in the Khulna-Jessore Highway was selected as our study area. The section is about 4.8 km long and is a two lane road. The

study area is about 52.5 km away from Jessore, 1.7 km from Jahanabad Cantonmentand 16.2 km from Khulna city center. Two renowned Jute mills named Alim jute mill and Eastern jute mill are located along the highway. There exists two influential industriesso that a large number of attraction and distribution factors functioned here. The section of the study area is too busy as it is linked with By-pass.

3.2 Methods

After the selection of the study area, preliminary data was collected through the desktop research and reconnaissance survey. Where the physical features were measured by using measuring tape. Here the volume study was conducted by using tally system for counting different types of vehicle on a weekday and aweekend at 3 peak periods and 2 off-peak periods to measure flow fluctuation by calculating PCU.

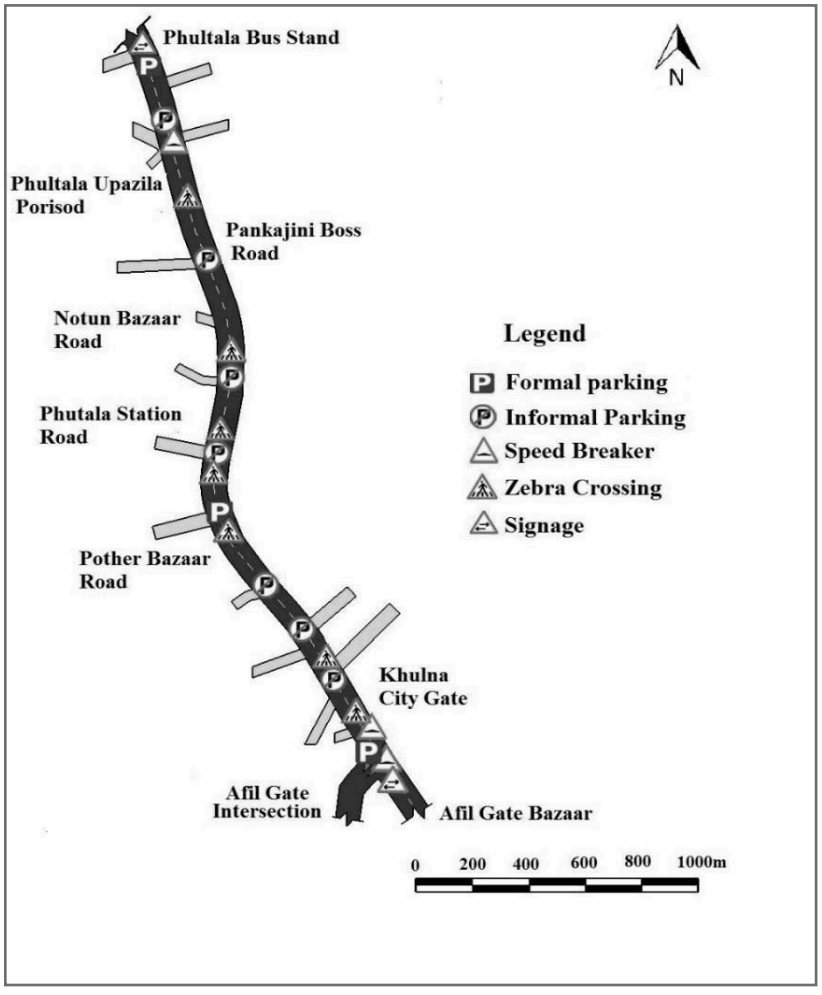

Figure 1: Study Area, Phultala to Afil Gate (Author, 2017)

Spot speed of different vehicles running on the stream was calculated from the time required to complete a distance of 60 ft(Kadiyali, 1978).

$$\text{Spot Speed} = \frac{\text{Distance}}{\text{Time taken by vehicle to pass the distance}} \quad \text{Km/hr.(Kadiyali, 1978)}$$

After that, speed survey was conducted by using a test car and bus from Afil Gate to Phultala in both direction to calculate journey speed and running speed along with opinion survey of 100 users, 7 drivers and 4 traffic polices.

The data collection for journey speed and running speed was conducted by Moving Observer Method (Kadiyali, 1978). The calculation is given below –

The Passenger Car Unit (PCU) for North bound, $q_n = (\frac{x+y_n}{t_a + t_w})$ PCUs/min

The Passenger Car Unit for South bound, $q_s = (\frac{x+y_s}{t_n + t_s})$ PCUs/min

Where, x = Total PCU of that bound

$y_n = y_s$ = Number of overtaking vehicles – Number of overtaken vehicles of each bound

$t_a = t_n$ = Total journey time of south bound (Minute)

$t_w = t_s$ = Total journey time of north bound (Minute)

Now, $\bar{t_n} = (t_n - \frac{y_n}{q_n})$ minute

And $\bar{t_s} = (t_s - \frac{y_s}{q_s})$ minute

Mean journey speed in north bound direction = $\frac{d}{\bar{t_n}}$ Km/min

Mean journey speed in north bound direction = $\frac{d}{\bar{t_s}}$ Km/min

Where, d = Total road distance

Mean running time in north bound direction = $\bar{t_n}$ – stopped time

Mean running time in north bound direction = $\bar{t_s}$ – stopped time.

Finally, collected data had been analyzed to measure capacity and level of service (LOS) and some indices had been set to measure congestion i.e. flow rate of vehicles . At last, some recommendations had been provided based on some policy and physical measures for free flow of vehicles.

4. ANALYSIS & INTERPRETATION

Cross sectional elements have a great impact on the speed of the vehicles. If the cross sectional elements like Right of way, Carriage way, Side walk, Shoulder, Parking space are kept in the road, then smooth and efficient flow will be ensured. From (Table 1), it is seen that almost all of elements are present in Phultala to Afil Gate road section as per their need except formal parking provision.

Table 1: Road way geometry at a glance

Name of the intersection	Right of way (feet)	Carriage way (feet)	Sidewalk (feet)	Shoulder (feet)	Bicycle route (feet)	Parking space (feet)	Extra space (feet)
Phultala bus stand	87.4	34.6	14	3	12	10	
Pother bazar	61	35		3			10
Khulna-Jessore bypass	50	34	5	3			
Alim gate	42	30	3	3			
Afil gate bazar	72	34	6	3			10

(Field Survey, 2016)

4.1 Formal and informal parking

One of the main reasons for speed fluctuation is the presence of parking space. Where parking space is available i.e. formal, no congestion arise in this section. On the other hand, informal parking causes congestion as well as decreases speeds of vehicle.

Within our study area, formal parking as well as informal parking were found. There had been found three formal parking provision whereas seven found informal. All of these informal parking cause congestion in these nodes of the surrounding area (Figure 1). It also leads to decrease in vehicle speed which affects in the productivity of goods and causes unexpected delay as well as loss for serious patients inside ambulance.

4.2 Vehicle composition

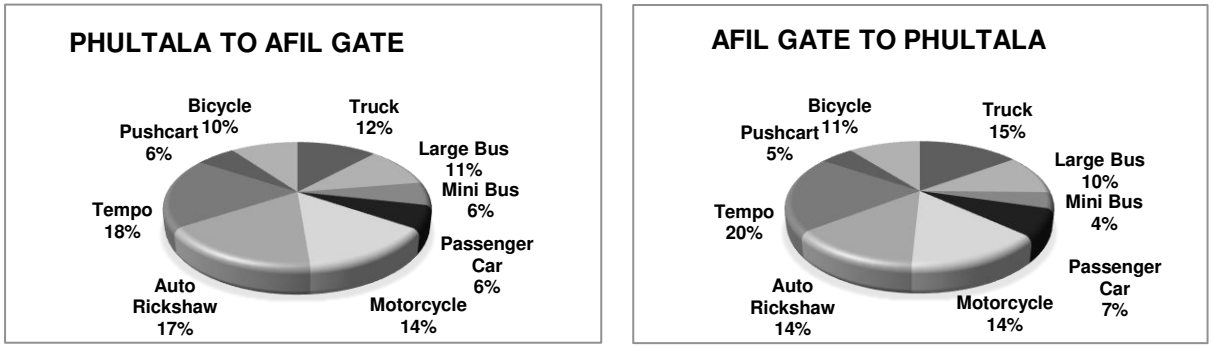

Figure 2: Comparison between Compositions of Traffic in both Direction (Source: Field Survey, 2016)

From the (Figure 2) from both direction that tempo and auto rickshaw are the most popular vehicle in the road section for their comfortless and availability though they are more costly than others. As a result, there arises congestion in the stream though total PCU value generated from these two vehicles is not so much. Again, speed of these three wheelers are also low. On the other hand, public transport i.e. bus are lower in number though these could be helpful in fulfilling majority public demand with its higher speed as well as lower cost.

It can be concluded that the spot speed (Table 2) of motorcycle is very high in Afil Gate to Phultala but in Phultala to Afil Gate passenger car's spot speed is very high. The speed of bus is moderate in both direction.

Table 2: Spot speed in both direction

Vehicle Type	Spot Speed for Afil Gate to Phultala (KPH)	Time (Second)	Spot Speed for Phultala to Afil Gate (KPH)	Time (Second)
Passenger Car	51.62	4.18	49.34	4.33
Truck	35.08	6.16	36.76	5.88
Bus	38.74	5.58	37.83	5.71
Tempo	27.54	7.84	26.68	8.10
Motorcycle	53.38	4.05	47.45	4.55
Easy bike	24.56	8.79	21.43	10.08

(Field Survey, 2016)

Almost all the vehicles travel in the road section in their own design speeds which indicates an efficient traffic flow. Reason behind this is that volume of traffic moving in the stream is lower than the capacity of the road section.
Another reason might be due to having two traffic police boxes in this road section, one for bus, truck and another for tempo, auto; speed of the vehicles is maintained as per rules.

4.3 Journey Speed & Running Speed

For analyzing journey speed and running speed a survey was conducted by car and bus from Afil Gate to Phultala in both directions.

Table 3: Running and Journey speed in both direction

Bus	
Vehicle per minute, q	8
Mean Journey Time(min)	8.12
Mean Journey Speed (Km/hr.)	35.48
Mean Running Time(min)	7.86
Mean Running Speed (Km/hr.)	36.64

Micro bus	
Vehicle per minute, q	7
Mean Journey Time(min)	7.33
Mean Journey Speed (Km/hr.)	39.29
Mean Running Time(min)	7.07
Mean Running Speed (Km/hr.)	40.73

(Author, 2016)

The distance from Afil Gate and to Phultala was 4.8 km. Time required for travelling from Afil Gate to Phultala was 8.58 min including delay time of 0.26 min and from Phultala to Afil Gate, it was 8.05 min where delay time was 0.26 min. Journey speed of bus was calculated by moving observer method which was 35.48 km/hr. and running speed was 36.64 km/hr. which was obtained by deducting delay time from the total journey time. Again, journey speed of car was 39.29 km/hr. and running speed was 40.73 km/hr. from Phultala to Afil Gate.

It is observed from (Table 3) that bus required more journey time than car as bus had to stop frequently in different stoppages for boarding and lighting passenger. So they needed more time and had less journey speed. On the other hand, car required less journey time as delay time is lesser and speed is more than bus.

4.4 Flow analysis

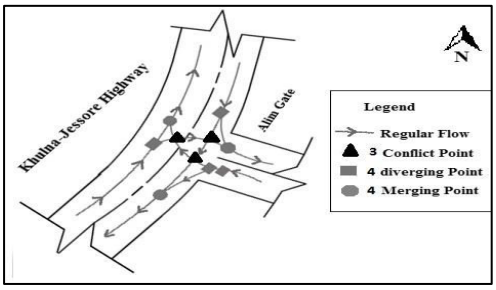

Figure 5: Intersections ofKhulna Jessore Highway and Alim Gate,*(Author, 2017)*

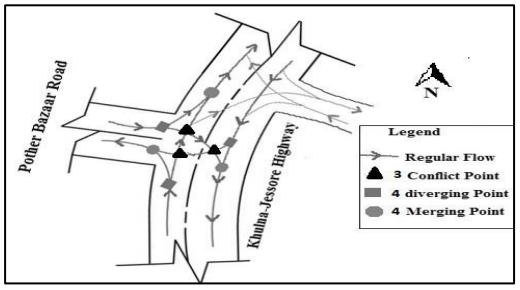

Figure 6: Intersections ofKhulna Jessore Highway and Pother Bazar, *(Author, 2017)*

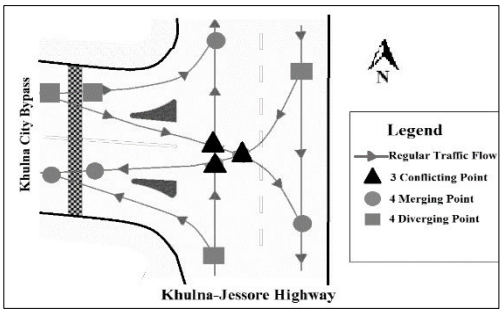

Figure 7: Intersections of Khulna-city Bypass and Khulna Jessore Highway, *(Author, 2017)*

From the (Figure 5, 6 &7) intersection nodes, it is noticed that our study area is not so risky as only three conflicting points in each node were found in the above three major intersections. But it seems a congestion prone area as all the intersections are “T shaped”. Due to having two secondary roads in the Pother Bazar, there arises some irregular flows and to restrict these flows formal parking is provided in this section.

Table 3: Duration of delay time and causes of delay within study area

Location	Delay time(min)	Delay cause
Afilgate bazaar Mor-Afilagte	0.05	Traffic congestion
Alimgate-Pother Bazaar	0.10	Speed breaker
Phultala Bazaar-Phultala Bus Stand	0.04	Traffic congestion
Afilgate-Alimgate	0.09	Traffic congestion

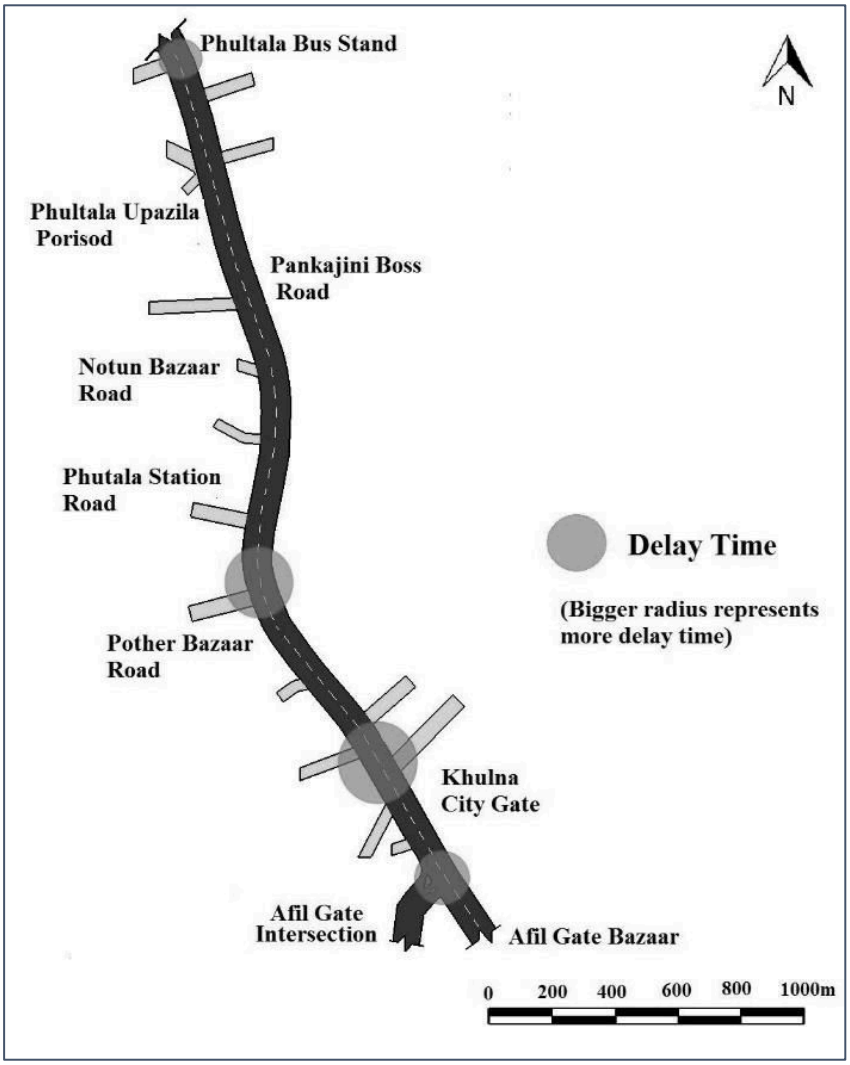

Figure 8: Ranking According to Delay Time(Field Survey, 2016)

In the direction from Phultala to Afil Gate,it is seen that volume of traffic are high in the pick hours. At 8.30-9.00, it is seen that traffic volume is very high as people from there come to Afil Gate as there remains Alim Gate jute mills and eastern jute mills where maximum of the people work. Again, at 5.00-5.30 maximum people return to home and people go to Khulna for shopping purpose

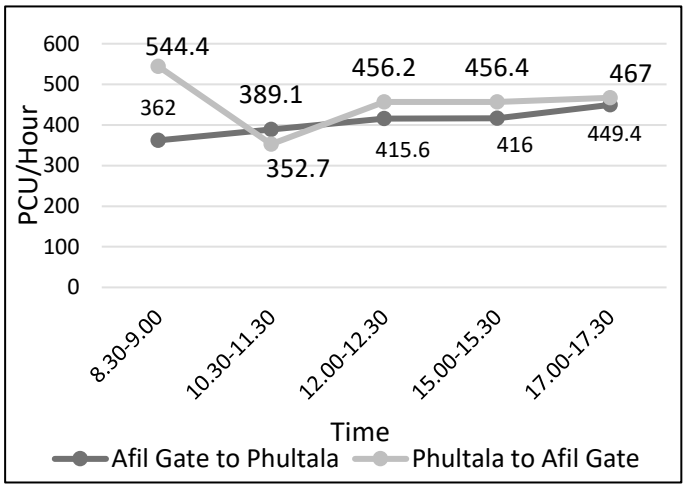

Figure 9: Flow Fluctuation (Field Survey, 2016)

4.5 Capacity & Level of Service

For calculating Level of Service (LOS) different types of measure were taken. Here, total volume(PCU/Hour) was calculatedand Capacity of a road section was taken as 1400 PCU per hour per lane(DITS, 1994).As there remains one lane in Phultala to Afil Gate roadway section so it was adopted.

Table 5: Volume to Capacity Ratio at Different Intersections

Intersection	Volume to Capacity Ratio									
	8.00 – 9.00		10.00 – 11.00		12.00 – 13.00		14.00 – 15.00		17.00 -18.00	
	To Fulbari Gate	To Jessore	To Fulbari Gate	To Jessore	To Fulbari Gate	To Jessore	To Fulbari Gate	To Jessore	To Fulbari Gate	To Jessore
Afil Gate	0.39	0.26	0.25	0.28	0.33	0.30	0.33	0.30	0.34	0.32
Pother Bazaar	0.35	0.23	0.27	0.27	0.31	0.28	0.33	0.31	0.37	0.34
Phultala	0.38	0.28	0.25	0.27	0.34	0.31	0.32	0.32	0.36	0.35

(Field Survey, 2016)

For Afil Gate Intersection**:**

- For peak hour:

Volume/Capacity value at 8.00-9.00 is = (0.39+0.26)/2 =0.325

Volume/Capacity value at 12.00-13.00 is= (0.33+0.30)/2 =0 .315

Volume/Capacity value at 17.00-18.00 is = (0.34+0.32)/2 =0.330

So Average Volume/Capacity value at peak hour is = (0.325+0.315+0.330)/3 = 0.32

- For Off peak hour:

Volume/Capacity value at 10.00-11.00 is= (0.25+0.28)/2= .265

Volume/Capacity value at 14.00-15.00 is= (0.33+0.30)/2= .315

So Average Volume/Capacity value at off- peak hour is= (0.265+0.315)/2 =0.24

Table 6: Level of Service (LOS) At Different Intersections (Volume/Capacity)

Road Intersection	Time	Lane	Volume/Capacity		Level of Service(LOS)	
					Level	Service
Afil Gate	Peak Hour	1	**0.32**	≤0.6	**A**	Allows free flow, with low volume and high speeds
	Off-Peak Hour	1	0.24	≤0.6	**A**	
Pother Bazaar	Peak Hour	1	0.31	≤0.6	**A**	
	Off-Peak Hour	1	0.29	≤0.6	**A**	
Phultala	Peak Hour	1	0.34	≤0.6	**A**	
	Off-Peak Hour	1	0.29	≤0.6	**A**	

(Field Survey, 2016)

In Level of Service (LOS) 'A', road provides the opportunity of free flow, with low volumes and high speed traffic and the traffic density is low with speeds controlled by driver's desired speed limits and physical road way conditions. Little or no restriction in maneuverability due to presence of other vehicles and drivers can maintain their desired speeds with little or no delay.

Table 7: Level of Service (LOS) at Different Intersections (Delay Time)

Road Intersection	Delay time (sec)		Level of Service(LOS)	
			Level	Service
Afil Gate	3	<=10	**A**	Allows free flow, with low volume and high speeds
Pother Bazaar	6	<=10	**A**	
Phultala	2.4	<=10	**A**	

(Field Survey, 2016)

Every intersection of the road section contains Level of Service (LOS) 'A' category which was gained from "Volume to Capacity Ratio" and "Delay Time". Again, overall speed of different vehicles couldn't be calculated but different vehicles were found moving at their own design speeds in average. So, it can be said that Phultala to Afil Gate road section has achieved level of service "A".

Some barrier such as slow and high speed vehicles move in the same road and same time in the same direction. Again, pedestrians crossing the road to and fro and boarding - alighting passengers every point of the road may cause the delay. As the highway road in the city area its need for every vehicles to moving in a limited speed range to avoid road accident.

4.6 Measurement Indices

According to Lindley, 1987 the volume capacity ratio of an intersection must be same or less than 0.77 for efficient run of the vehicle so that no congestion occur in that road. But if the value is greater than 0.77 it indicates that there exists congestion in the intersection.

$$\text{Lindley's index} = \frac{Volume}{Capacity}$$

Table 8: Volume in each intersection

Road Intersection	Time	Lane	Volume/Capacity
Afil Gate	Peak Hour	1	0.32
	Off-Peak Hour	1	0.24
Pother Bazaar	Peak Hour	1	0.31
	Off-Peak Hour	1	0.29
Phultala	Peak Hour	1	0.34
	Off-Peak Hour	1	0.29

(Field Survey, 2016)

So,it can be concluded from the analysis that road intersections of the study area is congestion free zone as all values of the vehicle to capacity ratio were less than the standard value 0.77 .Another measuring index is peak-hour factors (PHF) that states that typical peak-hour factors for freeways range between 0.80 and 0.95. Lower factors are more typical for rural freeways or off-peak conditions. Higher factors are typical of urban and suburban peak-hour conditions.

$$PHF = \frac{total\ volme\ during\ peak\ hour}{4 * v_{30}\ (peak\ rate\ of\ within\ the\ hour)}$$

Table 9: Flow rate in intersection at different time

Time	Volume		Rate of Flow	
	Afil Gate-Phultala	Phultala- Afil gate	Afil Gate-Phultala	Phultala- Afil gate
8.30-9.00 am	158	237	158*4=632	237*4=948
12.00-12.30 pm	182	196	728	784
5.30-6.00 pm	204	200	816	800
	V= 544	**V= 633**		

(Field Survey, 2016)

$$PHF_{(Afil\ Gate-Phultala)} = \frac{544}{816} = 0.67$$

From the standard of PHF value it can be easily said that the direction from Afil Gate to Phultala and vice versa have moderately steady flow at the peak hour.

$$PHF_{(Phultala-\ Afil\ Gate)} = \frac{633}{948} = 0.67$$

5. CONCLUSIONS

The analysis of roadway geometry and physical features gives an overview on the fixed facilities, control system and support system of the study area and which was not so satisfactory. The speed analysis identifies the operational cases of this transportation system. The results from the analysis has helped to identify the locations where improvement of operational features are required such as speed recording camera, rationale traffic facilities etc. According to that, various recommendations are proposed. The recommendations include establishment of signs and signals on various points, speed-breakers and other facilities for both the drivers and the pedestrians. This will help to improve the transportation system as well as to reduce the causes of accidents caused by vehicular movement for achieving a sustainable transportation system.

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