EFFECT OF NON-MOTORIZED TRANSPORT (NMT) ON ROAD SEGMENT FROM NOTUN RASTA TO B. N. SCHOOL AND COLLEGE, KHULNA

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ABSTRACT

On the zeitgeist of twenty-first century urbanization is a conspicuous consequence of intensifying urbanization. Being the third largest city as well as a major economic and industrial hub, transportation system of Khulna plays an indispensable role in the economy of Bangladesh. Effect of Non-motorized transport on the performance of urban transportation on a road segment of Khulna city is assessed in this study. A road segment Notun Rasta to BN School and College is taken as study area. The existing overall road traffic scenario is seen first, then performance parameters like traffic volume, speed etc. to know congestions and travel time, delay, travel cost etc. for traffic condition is perceived to see whether NMT has good influence or not. Travel pattern analysis (mode choice, trip length etc.), transport mode shares, volume study, speed study, level of service, traffic flow analysis, and congestion index analysis etc. are done to see the effect of NMT. Data is collected by reconnaissance survey, physical feature survey, user opinion survey, volume and speed survey. Low congestion rate, problems requiring traffic demand, traffic flows, problems due to merging and diverging were identified. The analysis of operational and physical features of NMT provides a diagram on the fixed facilities, control system and support system of the area. The result depicts that the congestion level is very low, easy bike is the most preferred vehicle in the area, in off peak and peak hour the spot speed was highest for motor bike that is a motorized vehicle. The NMT shows low spot speed in the area. Free flow with low volume and high speed for NMT is vivid. There are several recommendations for improving the condition. Such as on street and off street parking provision, round about road pattern, shoulder, separate bicycle lane etc. are to be addressed properly to amalgamate both privileges of motorized and non-motorized transport.

Keywords: *NMT, Urban transportation, Performance parameters, Travel pattern, Congestion.*

1. INTRODUCTION

Non-motorized transport is a cheap and handy way of transportation. However, around the world the aftermaths of modernization has not only made its use capricious (Wu & Lam, 2003; Zhang & Hu, 2004) but also has made the traffic flow heterogeneous (Hossain, Adhikary, Ibrahim, & Rezaur, 2005). Khulna one of the prominent industrial cities of Bangladesh (Hossain, Adhikary, Ibrahim, & Rezaur, 2005) with population density of 26287 per square km (KDA, 1999). In Khulna 13360 non-motorized vehicles are plying (Hossain, Adhikary, Ibrahim, & Rezaur, 2005) on the roads. Urban transportation system is quite complex having different modes of auto mobile dominated transports (James, 2006). Nevertheless, there are plethora of non-motorized transports such as bicycle, walking, cart etc. are widely used in Asian countries (Pendakur & Pardo, 2007). Non-motorized transport plays a vital role in Khulna city (Hossain, Adhikary, Ibrahim, & Rezaur, 2005) and it is assessed in this study. Travel pattern analysis, moving observer surveys in peak and off peak hour, level of service analysis etc. are scrutinized though dogged perseverance in this study.

Numerous studies had been conducted through the world regarding non-motorized transport in urban area. In a study in Delhi, non-motorized transport in Peri-urban areas are seen in a study. NMT is used only for utilitarian trips in Delhi where there is no assigned infrastructure for NMT (Arora, 2013). Bicycles area described as captive users in the city (Arora, 2013). Besides the peak hour for NMT is different from peak hour for MT (Arora, 2013) and forward collision warning system is a crying need (Mohan, Tsimhoni, & Flannagan, 2009) to ameliorate the situation as accidents occur frequently. In case of integrated land use and transportation system, NMT is included in a study by Waddel et. Al., 2002. They have implemented integrated land use and transport model that is potentially a sensitive model and the major public policy interests are addressed here that is getting more heed by the state (Waddell & Nourzad, 2002). Non-motorized transports are seen as a mode that hardly meet the fast needs of an area fully, nonetheless, walking and cycling has always prevailed to be acceptable solution for many accessibility problems (Litman, 2009). In Malaysia an investigation took place where NMT is seen to be sustainable transport. The use of NMT e.g. cycling and walking both reduces carbon emission and exhorts healthy lifestyle as well as a physical activity (Yazid, Ismail, & Atiq, 2011). Pedestrian flow characteristics in Khulna city is assessed in a study that found the free-flow speeds of were lower in Khulna than other Asian and Western countries (Nazir, Adhikary, Hossain, & Ali, 2012). They observed that the free-flow speed and densities are found proportional to each other (Nazir, Adhikary, Hossain, & Ali, 2012). Moreover the increase in road friction increases the jam density (Nazir, Adhikary, Hossain, & Ali, 2012).

2. METHODOLOGY

2.1 Study Area

Road segment from Notun Rasta More to B. N. School and College had been selected as study area as it not only connects Khulna city with other adjacent cities but also is one of the busiest road segments that connects easily with the city centre. Outer city Bypass road plays an important role in transportation of goods and passenger in Khulna district. The study area starts from Notun Rasta More and goes through Outer City Bypass road then takes a left turn to road no 23. The section is approximately 1.5 Km. With growing pollution and environmental degradation, cities are in dire need of transports that generates less amount of carbon and its derivatives. Therefore, non-motorized transport is a great option so, its effect is assessed on this important road segment.

2.2 Survey and Data Collection

To assess the effects of Non-Motorized Transport (NMT) on the performance of urban transportation in Khulna City, the field data was collected. 120 questionnaire surveys were conducted after stratified sampling. Among them 70 people were passer-by (including drivers, students and people who went to office regularly) and 25 people were the store keepers in the area. The rest were the residents of the

area who used the segment almost daily. The survey was conducted both during peak and off peak hours to get requires information. Based on the survey response income, mode choice etc. analysis had been done.

2.3 Traffic Performance Parameter Analysis

2.3.1 Volume Analysis

Manual Counting Method would be conducted to count volume of the traffic on two-week days at five different times (Three peak times & two off-peak times) in each day. Manual Counting Method was applied.

Average Daily Traffic (ADT): The volume during a given time period divided by the number of days in that time period and expressed in terms of vehicle per day (vpd).

$$ADT = \frac{\text{Volume of days } (> 1\text{days and} < 1\text{year})}{\text{Number of days}} \text{vpd}$$

(Source: Gurcharan Sing)

Normally 30 minutes are surveyed for volume analysis. After counting the vehicles, the data is converted into PCU (Passenger Car Unit). Passenger Car Unit (PCU) was calculated by using the following table-

Table 1: Vehicle Type

Vehicle Type	PCE	Vehicle Type	PCE
Bicycle	0.2	Passenger Car	1.0
Motorcycle	0.3	Truck/Mini Bus	2.0
Auto-Rickshaw/Tempo/Human Hauler	0.5	Large Bus	2.5
Rickshaw/Van	0.8	Pushcart	4.0

The PCU value that can be found after calculating is multiplied by two for converting PCU/hour. Then the total value is divided by two for converting the PCU/lane/hour.

2.3.2 Spot Speed Calculation

Spot speed could be used to design the geometry of road like horizontal and vertical curves, super elevation etc. Spot speed was calculated by this equation-

$$\text{Spot Speed} = \frac{\text{Distance}}{\text{Time taken by vehicle to pass the distance}} \text{Km/hr}$$

2.3.3 Moving Observe Method

Flow of the vehicles and mean journey time are calculated by the moving observed method. The total number of vehicle overtaken and overtaking is also found through this survey. Flow of the Vehicles

$$Q = \frac{X+Y}{Tg+Tw}$$

Where,
X = No of the vehicles with speed by the observer travelling
Y = No of the vehicles with speed which overtake the travelling when traveling with stream the number vehicle overtakes correspondence
Again,

$$\text{Mean Journey Time, } T = Tw - \frac{Y}{q}$$

$$\text{Mean Journey Speed} = \frac{Distance * 60}{Mean\ Journey\ Time}$$

$$\text{Running Speed} = \frac{Distance * 60}{Running\ Time}$$

2.3.4 Traffic Density

Traffic density is defined as the number of vehicles occupying a unit length of roadway. Analysts can easily obtain the relationship between traffic density and average distance headway from the following equation:

$$K = \frac{5280}{\bar{d}}$$

Where:
K=density (vehicles per lane-mile)
$\bar{d}$=average distance headway in a single lane (feet per vehicle)

2.3.5 Level of Service:

Volume to capacity ratio is calculated volume divided by design capacity 1400 PCU/lane/hour according to (DITS, 1994). Level of service was measured from the table of corresponding measure and corresponding level of service.

Table 2: Performance Measures and Corresponding Level of Service

	Level of Service	Speed (Kph)	Volume to Capacity Ratio
A	Free Flow, with low volumes & high speeds	>= 80	<= 0.6
B	Reasonably free flow, but speeds beginning to be restricted by traffic conditions.	>= 40	<= 0.7
C	Stable flow zone, but most drivers restricted in freedom to select their own speed	>= 30	<= 0.8
D	Approaching unstable flow, drivers have little freedom to maneuver	>=25	<= 0.9
E	Almost unstable flow, volumes reach near at the capacity of the highway	>=15	<=1
F	unstable flow may be short stoppages	<15	>1

2.4 Different traffic performance measurement Index

2.4.1 Congestion Index

It is computed by using the formula (C – C0) / C0 where C is the total travel time and C0 is the free flow time. Free flow travel time can be defined as the time taken to travel the distance when the traffic density is nearly zero.

$$\text{Congestion index} = \frac{(C - C0)}{C0}$$

If the value of (C – C0) / C0 is near zero it will indicate very low levels of congestion and if the value is greater than 1 than it means road is highly congested.

3. ILLUSTRATIONS

3.1 Travel Pattern Analysis

Travel pattern is influenced by some factors e.g. Trip length, Trip purpose, Mode choice, Travel time on NMT, Travel cost on NMT, Preferable vehicle, Frequency of Using Routes etc. Travel pattern is explained below:

3.1.1 Mode Choice Behaviour of the Respondents

The figure 1 represents the mode choice of the people in the study area. Mahindra, easy bike, private car and bus are available motorized vehicle in our site. As easy bike is mostly available in our site so 39 % people prefer easy bike, 23% prefer Mahindra. And 3% use motor bike. The percentage of using trips by private car is 19%, Non-motorized vehicle like Cycle, Rickshaw are attainable for general public 9%use Non-motorized vehicle. &7% for Rickshaw and 2% for cycle. About 2% make their trips on foot they prefer walking rather than using any mode for their trip. Most of the people prefer easy bike and Mahindra because the cost is lower rather than another available vehicle.

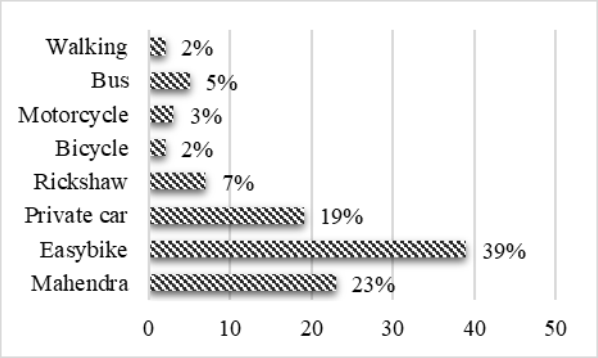

Figure 1: Mode Choice behavior of the respondents

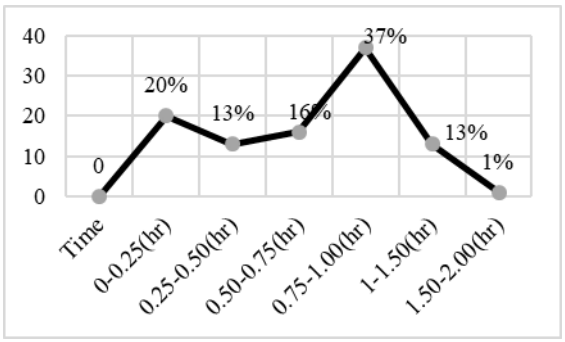

Figure 2: Travel time on NMT

3.1.2 Travel Time on NMT

The following figure 2 refers to the percentage of people's travel time period in NMT. From the figure we can easily see that, there is no percentage of people who do not travel in NMT. The most percentage of people travelling in NMT is 37 and the time duration is 45 minutes to 1 hour. About 20 percent of people's travel time in NMT is 15 minutes. . The best possible reason of the above chart, as the people who travel in that specific route are "Students" and "Drivers". Their travel time is normally high because they have to travel to their desired destination and according to the availability and lower travel cost of "Easy Bike", the percentage of using this particular transport mode is very high.

3.1.3 Travel cost on NMT

The table 3 shows the relation between people's income level and most preferable vehicle mode. From the table we can easily see that, the most percentage of people belong in the group of less than 5000-taka income's people which is 59 percent whose preferable vehicle mode is "Walking" and "Easy bike", some also like travel in "Mahindra" and "Bus". There is about 20 percent of people whose income is above 25000-taka and the preferable vehicle mode for that group is "Private Car" and also "Walking", "Mahindra". The percentage of people within the income group of 5001 to 10000 taka is about 13 percent and the transport mode are "Bus". They also interested in "Walking", "Mahindra", "Easy Bike", "Private Car", "Bus" The best possible reason could be, lower income people always try to travel within lower travel cost vehicles. Like other studies e.g. (Hassan, Sarkar, Uddin, & Rahman, 2016), from mideum income group most of the trips are generated in the study area.

Table 3: Income VS Preferable Vehicle

The table 4 provides us the relation of different occupation holding people's frequency of using that particular road. From the table we can see that, the most percentage of people using that road is 25 and they belong in the occupation group of "Drivers" and the frequency of using that particular road is "Several Times a Day".

Table 4: Occupation vs Frequency of Using Routes

Occupation	Frequency of Using This Route				
	Once A Day	Several Times in A Day	Once A Week	Various Time	Occasionally
Govt. Service	3	16	3	4	2
Private Service	9	2	4	0	7
Student	16	3	0	12	2
Driver	2	25	10	5	6
Housewife	2	3	2	2	1
Total	32	49	19	23	18

3.2 Performance Parameter Analysis

3.2.1 Spot Speed of the Study Area:

In weekdays at peak and off-peak hour different vehicles have different spot speed. Figure 3 shows the difference of spot speed in peak and off-peak hour for a specific vehicle. This study concentrates more on NMT so if NMT is seen first it is clear that spot speed of by-cycle is the most amongst all the NMT. But with peak and off-peak hour spot speed of rickshaw changes more. At peak hour spot speed is 10.82. At peak hour the speed is less because a large number of vehicle ply at peak hour with great speed specially motorized vehicles. So, at peak hour spot speed of rickshaw is reduced as a result of high competition with motorized vehicle. Spot speed of motorbike is the most at both peak (43.85km/hr.) and off peak (44.06km/hr.) hour.

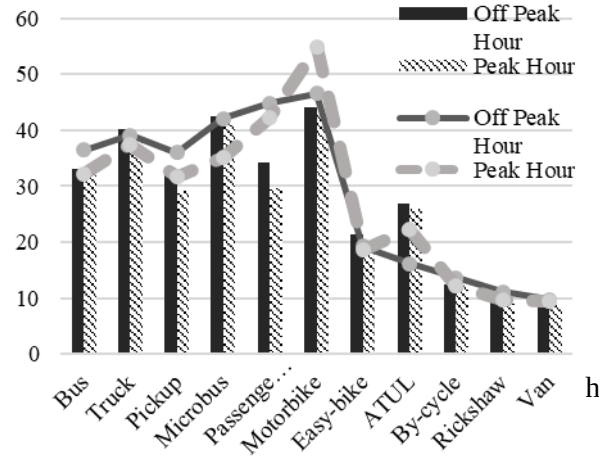

Figure 3: Spot speed of different vehicles on week days & weekend in both peak and off-peak hour in the Study Area.

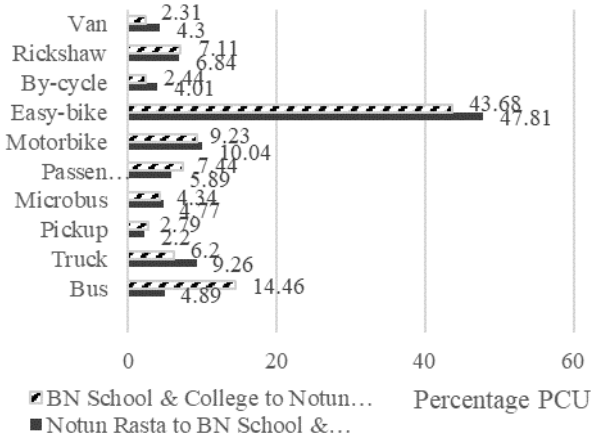

Figure 4: Volume of different vehicle for trip from Notun Rasta to B.N School and college and vice versa.

Income Level	Most Preferable Vehicle				
	Walking	Mahindra	Easy bike	Private Car	Bus
<5000	14	3	34	0	8
5001-10000	4	5	2	1	13
10001-15000	2	8	5	0	2
25000+	3	1	0	20	0
Total(percentage)	23	17	41	21	23

3.2.2 Vehicle Volume in the Study Area

For trip from Notun Rasta to B.N school and college and again reverse trip form B.N School and College to Notun Rasta for each vehicle type volume is shown in figure 4. For easy-bike volume is the most for both the trip. But from Notun Rasta to B.N school and college trip has more volume (47.81). Basically, this route has easy-bike as main transport mode. Students of this school and the patients and their relatives use these two trips. They prefer easy-bike because of availability and low cost. volume of van is lowest (2.31 and 4.3) in each the direction from B.N school to Notun Rasta and Notun Rasta to B.N School.

3.2.3 Fluctuations of Volume at Different Time in Two Direction (both weekdays and weekends):

For five separate time intervals at both the direction from B.N School and College to Notun Rasta and Notun Rasta to B.N School the fluctuation of volume is shown in figure 5 bellow:
From Notun Rasta to B.N School and College at 8:30 to 9:00 am the volume is the most. But for B.N School to Notun Rasta trip the volume is highest at 5:30 to 6:30 am. But the fluctuation is conspicuous at 8:30 am to 12:30 pm and 12:30 to 6:30 pm for both the direction. This is for week days in both directions that is for Notun Rasta to BN Scholl and college is 519.91 and for other trip is 503.82.

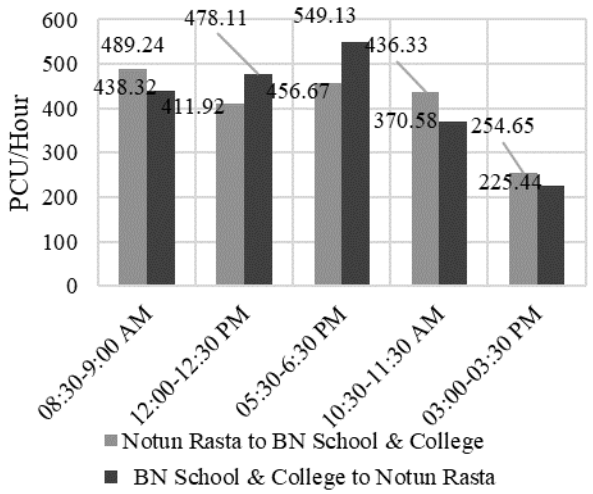

Figure 5: Fluctuations of Volume at Different Time in Two Direction (Week day)

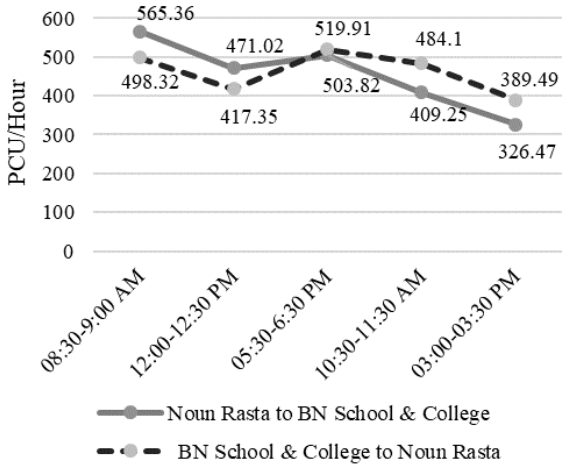

Figure 6: Fluctuations of Volume at Different Time in Two Direction (Weekend)

For weekend days the fluctuation is not so heavy as week days. Figure 6 shows at 5:30 to 6:30 from BN school to Notun Rasta the volume is maximum i.e. 549.13 and for the opposite direction the volume is maximum at 8:30 to 9:00 am and that is 489.24. So along with the trip direction the volume fluctuates with respect to time. For a specific time, interval, the graph shows that the values differ for volume.

3.2.4 Level of Service:

The value of level of service for this site tells the level is A; that means congestion is not seen here. Free and spontaneous flow exists in the two sections. Volume is low and the speed is high. For low volume NMT can be increased but for high speed of motorized transports the condition becomes risky.

Table 5: Level of Service

Intersection Pont	Time	Volume to Capacity Ratio	Range	Level of Service	
				Level	Service
Notun Rasta	Peak	.18	<= 0.6	A	Free flow, with low volumes and high speeds
	Off peak	.13	<= 0.6	A	
B N School and College	Peak	.17	<= 0.6	A	
	Off Peak	.16	<= 0.6	A	

3.2.5 Moving Observer Survey:

For the two directions the rate of flow is different, from Notun Rasta to BN School and college the flow is greater than the opposite direction. That means here interruption is less. Mean journey time and mean running time is less for this direction. This also implies that the flow towards this direction is better.

Table 6: Moving Observation

Section	Rate of Flow (PCU/Hour)	Mean Journey Time (min)	Mean Journey Speed(KPH)	Mean Running Time(min)	Mean Running Speed(KPH)
Notun Rasta to BN School & College	531.2	3.04	33.52	2.66	38.34
BN School & College to Notun Rasta	210	4.34	30.53	3.86	36.42

3.2.6 Moving Observer Survey from Notun Rasta to Gollamari more

Table 7: Moving Observation of Some Sections in Khulna City

Vehicles	North Bound		South Bound		Flow PCU/hr.
	Mean Journey Speed	Running Speed	Mean Journey Speed	Running Speed	
Notun Rasta-BN School and College	30.53 kmph	36.42 kmph	33.52 kmph	38.34 kmph	531.2
BN College- KPC	28.64 kmph	30.33 kmph	37.64 kmph	43.64 kmph	652.6
Khulna Public College-KMC	10.82 kmph	11.54 kmph	19.24 kmph	20.14 kmph	743.8
KMC- Sonadanga	11.34 kmph	11.79 kmph	9.66 kmph	11.34 kmph	651
Sonadanga-Gollamari	26.34 kmph	40 kmph	31.76 kmph	84.71 kmph	560
Notun Rasta to Gollamari more	21.53 kmph	26.01 kmph	26.36 kmph	39.63 kmph	628

The table 7 shows for all the links mean journey speed and running speed in case of inflow and outflow. In case of mean journey speed Notun Rasta to BN school and college shows the greatest value in case of north bound. But in south bound BN School to KPC has greatest mean journey speed. In case of running speed Sonadanga to Gollamari has the greatest running speed in south bound. This shows the difference in running and mean journey speed that leads to difference in mode choice. Flow of Notun Rasta to BN School and college is the least. So, less flow would encourage NMT s they have

lower speed. Whereas from Khulna Public College to KMC has greatest flow. It will discourage NMT as flow is basically of motorized vehicles for their low cost and high speed.

3.2.7 Occupancy of Different Vehicle of the Study Area

Figure 7 represents the occupancy data for different vehicles. Average occupancy of bus is seen to be the most. In the section of Notun Rasta-BN School and College, bus is not a prominent vehicle. But Easy-bike is the mostly used vehicle in this study area, so in the converted number of vehicle of occupancy is the most for easy-bike.

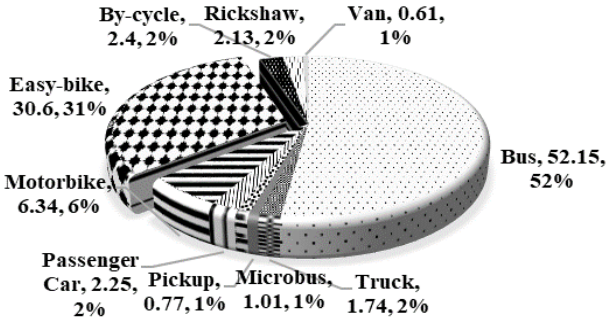

Figure 7: Occupancy of Different vehicle

Average occupancy of easy-bike is 2.2. As the converted value is the greatest, it proves people of this rout prefers easy-bike. Basic reason is its low cost and availability. A horizontal bar chart shows the average occupancy for different vehicles. This is simply the representation of the table above.

3.3 Congestion Index

3.3.1 Notun Rasta to BN School and College

Total Travel Time = 3 min 5 sec
Free Flow Travel Time = 2 min 42 sec
So, Congestion Index = 0.14

3.3.2 BN School & College to Notun Rasta

Total Travel Time = 3 min 20 sec
Free Flow Travel Time = 2 min 45 sec
So, Congestion Index = 0.21
So it is vivid that the congestion level is low in the study area.

4. CONCLUSIONS

Non-motorized vehicle is the salient mode by which individuals of every single monetary class can reach their destinations. It is averred that the satisfactory level is very low. Because most of the section of road has no footpath, median, signal and shoulder which create congestion in the road and also reason for accidents. Both side of the road land use is developing on the basis of commercial use. There is no formal parking and it creates congestion. Notun Rasta More is the most congested space of the study area. Congestion Index shows that the congestion level is low. From volume study the problems requiring traffic demand, traffic flows, problems due to merging and diverging were

identified. Different analysis methods are used in this report regarding volume study which can be used for further policy imposing or changing. Some recommendations are made bellow:

- ✓ There 152 sq. ft. on-street parking lots is available in Notun Rasta to BN School and College area that is used for illegal commercial activity resulting in illegal on-street parking. Congestion is the aftermath of such reduction in road width.
- ✓ There is no safe road crossing provision for the pedestrian in the study area. So, it is very dangerous for the pedestrian to cross the intersection point of the road like Notun Rasta more, BN School and College more etc. A foot over- bridge can certainly ensure safety requirement of those sections.
- ✓ Plethora of slow moving transports create immense congestion due to lack of proper management (Tasnim & Khan, 2018). A separate lane for non-motorized transport would be a lucrative measure to promote usage of NMT. However, with such narrow road it is not possible for the road section. If government acquires space, such initiative can be taken to increase usage of NMT.

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