Paper ID: CE 0277

Traffic Congestion in Dhaka City - A Case Study in Mirpur 1 to Mirpur 10

N. J. Shila[1], U. T. Toma[2], J. Podder[3], M. M. Rahman[4]

[1]Department of Civil Engineering, EUB, Dhaka, Bangladesh (nasrinshila88@gmail.com)
[2]Department of Civil Engineering, EUB, Dhaka, Bangladesh (ummetoma2017@gmail.com)
[3]Department of Civil Engineering, EUB, Dhaka, Bangladesh (jpodder8@gmail.com)
[4]Department of Civil Engineering, EUB, Dhaka, Bangladesh (moshiur.rah12@gmail.com)

Abstract

Traffic congestion in Dhaka is an issue for wasting valuable time. Level of congestion must be known to solve the problem. This paper investigates the fluctuations in passenger car equivalent (PCE) in selected road segments. The impact of various modes of transportation are measured by fluctuations in passenger car equivalent (PCE) values. To carry out the study, Mirpur-1 to Mirpur -10 road was chosen as the designated route which was divided in three segments. For estimating PCU, spot speeds of various vehicles were calculated. The manual method of volume survey was implemented to calibrate traffic volume at the selected segments of the Mirpur-1 to Mirpur-10 route. Two congestion indices, Capacity Adequacy Index (CAI) and Lindley's Congestion Index (LCI) were used to measure the traffic congestion levels. The segment from Mirpur-2 to Mirpur 10 were found most congested route with Lindley's Congestion Index (LCI) value of 1.47. In terms of volume by capacity (V/C) ratios, the study area showed level of service (LOS) F and E in segments. Congestion is generally found due to the lack of a control scheme, poor physical status of vehicles, and road infrastructure.

Keywords: *Traffic congestion; Volume survey; Level of service (LOS); Passenger Car Equivalent (PCE); Lindley's Congestion Index (LCI).*

1 Introduction

Dhaka the capital city of Bangladesh, is notorious for its severe traffic congestion. The city's roads are often congested with vehicles, making it difficult for people to move around quickly and efficiently. There can be several reasons for traffic congestion including high volume of vehicles, narrow roads, inadequate infrastructure, lack of traffic management systems. The high number of rickshaws, which are slow-moving vehicles, also contribute to traffic congestion. Traffic congestion refers to the situation where vehicles on the road are moving slower than their usual speed due to excessive traffic volume. It can cause delays and result in increased fuel consumption. Bangladesh's traffic congestion is at an all-time high, just like in the rest of the developing world (Shamsher and Abdullah, 2015). People in Dhaka City spend 2.35 hours in traffic on average, of which 1.30 hours are attributed to gridlock. People who remain in the traffic bottleneck lose 55% of their travel time (Barnamala, 2015). To address the congestion, the government is taking steps such as developing new roads and expanding those that are present, improving public transportation, implementing traffic management systems, and implementing policies aimed at reducing the number of vehicles on the road. The 'degree of congestion' is a crucial factor in describing how a traffic stream is doing. One of the widely used measurement is to describe the LOS of an urban road segment as the degree of congestion (Pandey and Biswas, 2022). Level of service (LOS) is a quality measure that describes operating circumstances within a traffic stream. Different researchers rated the traffic congestion in different ways along with LOS. Many indices have been used in different researches such as Capacity Adequacy Index (CAI), Lindley's Congestion Index (LCI), Speed Performance Index (SPI), Active Road performance Index (ARPI) and Road Segment Congestion Index (RSCI) (Noor et al., 2021; Tasnim and Khan, 2018). These indices are often measured by the help of determining different traffic volumes, where it is important to generalize the heterogenous traffic by converting into passenger car equivalents (PCE). The present study is undertaken to investigate the fluctuations in PCE due to vehicle lane and width oscillations. And also to investigate the impact of traffic congestion on various modes of transportation by using two congestion indices of Capacity Adequacy Index (CAI) and Lindley's congestion Index (LCI) and the level of service (LOS) on the Mirpur 1 to 10 area.

2 Materials and Methods

The whole data collecting took place from the 13th to the 16th of February. The steps of research are depicted in the flow chart below.

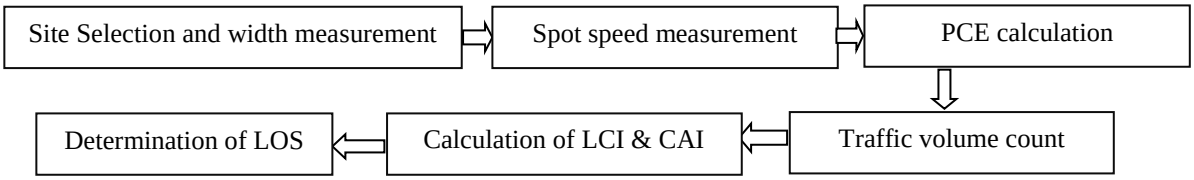

Figure 1 Flow chart of the methodology.

2.1 Site details

Located in Dhaka, Mirpur is one of the largest residential areas and is situated in the northwestern part of the city. In Mirpur, traffic can be both heavy and slow-moving. For the research, the road section was separated into three sections, beginning with Mirpur-1 (foot over bridge) to Sony Square Roundabout, Sony Square Roundabout to Mirpur-2(foot over bridge) and Mirpur-2(foot over bridge) to Mirpur-10 Roundabout.

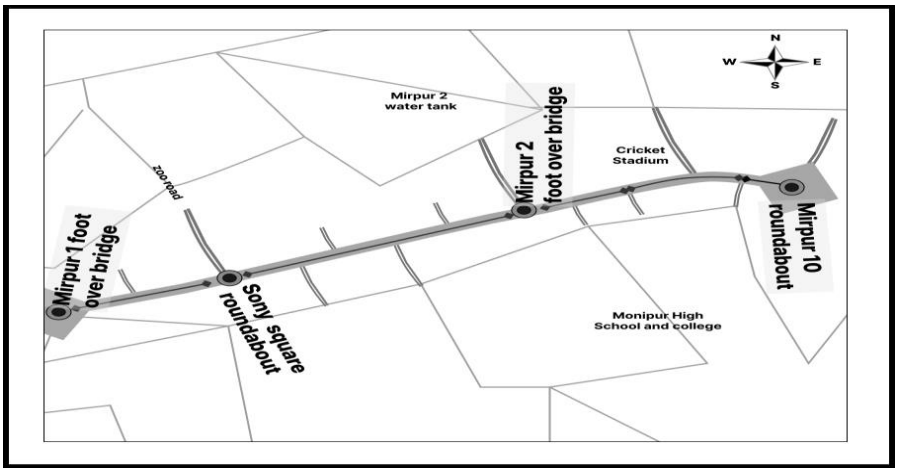

Figure 2 Study area.

2.2 Passenger Car Equivalent (PCE) calculation:

The large range of vehicles, as well as their varying sizes and speeds, cause a number of issues for traffic operations. Non-motorized traffic moves without regard for motorized traffic and small sized vehicles produce delays and create traffic congestion. That is why a proper analysis needs traffic stream contains only passenger cars (Chandra and Kumar, 2003). PCE values correlates the flows of passenger cars only and of mixed traffic streams that are equivalent in terms of the perception of the level of service (LOS) (Krammes and Crowley, 1986). Therefore, to understand the intensity of traffic congestion road geometry, along with size of vehicles should be expressed in terms of varying PCE values.

The passenger car unit is a means of representing several types of cars with varying features in a single equivalent unit. A single car is regarded as a single unit (Raj et al., 2019). To calculate the passenger car unit, spot speed data was collected of the selected vehicles. A 60-foot distance was calibrated by the measuring tape at the selected section. A stopwatch was used to calibrate the time when the selected vehicles passed the 60-foot distance. Distance was divided by time to determine the spot speed (km/hr) (Tasnim and Khan, 2018). To find out the PCU value, the given equation (1) was taken for each type of selected vehicle.

$$PCU=(\frac{Vc}{Vi})/(\frac{Ac}{Ai}) \quad (1)$$

Where, V_c = Spot speed of car, V_i = Spot speed of i type of vehicle, A_c = Standard Area of car and A_i = Standard Area of i type of vehicle. Standard area of each type of vehicles is shown in table 1. The standard areas of different vehicles in a tabular form have been presented following.

Table 1. Standard area for the chosen vehicles (Chandra and Kumar, 2003).

Vehicles name	Vehicles included	Length (m)	Width (m)	Area on ground (m^2)
Car	Car, jeep	3.72	1.44	5.39
Bus	Bus	10.1	2.43	24.74
LCV	Micro Bus, Pickup	6.1	2.1	12.81
Three-wheeler	CNG	3.2	1.4	4.48
Two-wheeler	Motor Bike	1.87	0.64	1.2
Van	Pedal van	2.7	0.95	2.56
Cycle	Bi-cycles	1.9	0.45	0.85
Rickshaw	Pedal rickshaw	2.7	0.95	2.56

2.3 Traffic Volume Count:

In the study indirect method has been used where manually all vehicles were counted with the help of video camera. Data was collected for 12 hours in West- East (W-E) and East-West (E-W) directions separately in three points from Mirpur 1(foot over bridge) to Mirpur 10 (roundabout). The abundantly found vehicles were bus, car, microbus, pickup, CNG, bi-cycle and van. Traffic volume is counted by converting all vehicles into passenger cars by using passenger car equivalents (PCE) calculated in the process.

2.4 Calculation of Lindley's Congestion Index (LCI) & Capacity Adequacy Index (CAI)

To investigate the rate congestion, two different indices were taken which were Capacity Adequacy Index (CAI) and Lindley's Congestion Index (LCI). The CAI provides an indication of how well the roadway system can handle the existing traffic demand during peak hours. A high CAI value indicates that there is sufficient capacity on the roadways to accommodate current and anticipated traffic volumes with minimal delays and congestion. On the other hand, the LCI provides a numerical value that represents the level of congestion on a road segment. A higher congestion index indicates a higher level of congestion while a lower index suggests less congestion.

$$\text{Capacity Adequacy Index (CAI)} = \frac{\text{Volume Capacity(Rated)}}{\text{Present design hour Volume}} * 100 \quad (2)$$

$$\text{Lindley's Congestion Index (LCI)} = \frac{\text{Peak Hour Volume}}{\text{Capacity}} \quad (3)$$

1400 per lane per hour was taken as capacity for both indexes (Guidelines for Capacity of Roads in Rural Areas, 1990). From equation (2), a CAI value greater than 100 reveals good traffic congestion, whereas a CAI value less than 100 indicates worse traffic congestion. Contrarily, for LCI values greater than 0.77 reveals worse traffic congestion, while LCI values less than 0.77 is mentioned as good traffic congestion (Tasnim and Khan, 2018).

2.5 Determination of Level of Service (LOS)

Level of Service (LOS) is typically measured on a scale of A to F, with A being the best and F being the worst. LOS is a qualitative measure of the effect of a number of factors, which include speed and travel time, traffic interruption, freedom to maneuver, safety, driving comfort and convenience, and operating cost (Krammes and Crowley, 1986). For the research LOS was calculated by Volume to Capacity ratio (V/C). V/C ratio being greater than 1 indicates a congested situation in roads where vehicles do not move (Kadiyali L, 2003). For calculation, 1400 per lane per hour was taken as capacity here as well.

3 Results and Discussion

From the study is has been seen that the geometrical features are rather same in the selected three sections as given in the following table.

Table 2 Geometrical elements in the study route.

Section	Carriage Way Width (m)	Lane Width (m)	Median (m)
Mirpur-1 to Sony Square	22.85	3.7	1.25
Sony Square to Mirpur-2 (Foot Over Bridge)	22.23	3.5	1.23
Mirpur-2 (Foot Over Bridge) to Mirpur-10	22.95	3.99	1.24

PCE value can determine the impact of vehicles in roads. Using equation (1) following PCE values have been found which are presented in table 3. The highest values of each vehicles are compared with conventional PCE values (Chowdhury, 2016) in figure 3. Bus PCE values were determined to be the highest in all road sections, which are significantly greater than the conventional PCE value of 3. PCE values of microbus, pickup, motorcycle, bi cycle reduces as we progress on the study route in W-E direction. Though PCE values of bus, rickshaw and van is least in Sony Square to Mirpur-2 route rather than Mirpur-2 to Mirpur-10 route. Even with less carriage way and lane widths as PCE values are calculated lower in the Sony Square to Mirpur-2 indicating a less congested section. Carriage way and lane width is less in Mirpur-1 to Sony Square route than Mirpur-2 to Mirpur-10 route but PCE values are greater in the first route. A high PCU number implies a threat to each lane's capacity. As PCE value increases, so does the volume in each lane, in contrast to the decreasing lane capacity, which can create further congestion (Tasnim and Khan, 2018). Mirpur-1 to Sony Square route implies chances of greater congestions for these reasons.

Table 3 Estimated PCE values for each type of vehicle.

Section	Bus	Micro Bus	Pick Up	CNG	Motor Bike	Rickshaw	Van	Bi Cycle
Mirpur-1(foot over bridge) to Sony Square Roundabout	**7**	**3.19**	**3.54**	0.88	**0.264**	**1.746**	**1.649**	**0.458**
Sony Square Roundabout to Mirpur-2 (foot over bridge)	4.83	2.81	2.92	**0.947**	0.217	0.692	0.696	0.348
Mirpur-2 (foot over bridge) to Mirpur-10 Roundabout	6.05	2.35	2.73	0.792	0.152	0.793	1.108	0.216

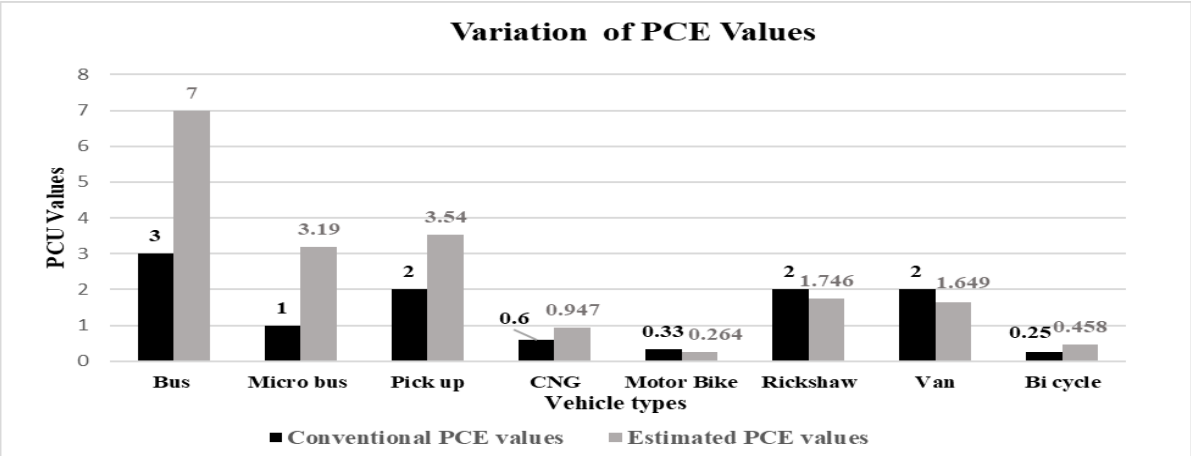

Figure 3 Comparison between Conventional and Estimated PCE Values.

The highest estimated values of PCE of bus, microbus, pickup, CNG, bi-cycle are respectively 2.33, 3.19, 1.77, 1.58, 1.83 times higher than the conventional PCE values. Higher values of PCU indicate higher carriage way usage which implements reasons for higher congestions. Motor cycles were found to have substantial speeds in the study area, which accounts for the lower PCE value. Same results have been acquired in terms of non-motorized vehicles like rickshaw and van.

Table 4 Capacity Adequacy Index (CAI) and Lindley's Congestion Index (LCI) at different Sections.

Section	Capacity Adequacy Index (CAI)		Lindley's Congestion Index (LCI)	
	West to East	East to West	West to East	East to West
Mirpur-1 to Sony Square	90.14	95.31	1.31	1.20
Sony Square to Mirpur-2 (Foot Over Bridge)	115.70	120.52	0.94	0.93
Mirpur-2 (Foot Over Bridge) to Mirpur-10 Roundabout	93.40	106.23	1.47	1.34

The segment from Mirpur-2 (foot over bridge) to Mirpur 10 (roundabout) were found most congested route in west to east direction with Lindley's Congestion Index (LCI) value being 1.47 which is greater than 0.77. In east west direction LCI value has been found 1.34 which also indicates that the specific segment in the road has a worse situation in terms of traffic congestion. Less traffic congestion has been found in the sony square to mirpur 2 area, as LCI values are less than the other two sections. LCI values being greater than 0.77 are also found in the Mirpur-1 to Sony Square region. The CAI values though represent that mirpur 1 to sony square is more congested as both values in E-W and W-E direction are less than 100. In case of the third segment, W-E direction has more congestion as CAI value is less than 100.

Table 5 The value of LOS at Different Sections

Time	8-9AM	9-10AM	10-11AM	11-12PM	12-1.00PM	1-2PM	2-3PM	3-4PM	4-5PM	5-6PM	6-7PM	7-8PM
Mirpur-1 to Sony Square												
V/C ratio (W-E)	0.71	0.71	0.64	0.90	0.89	0.79	0.8	0.84	1.31	1.24	1.04	1.28
LOS (W-E)	C	C	B	D	D	C	C	D	**F**	**F**	**F**	**F**
V/C ratio (E-W)	0.68	0.61	0.73	0.95	0.80	0.76	1.14	1.10	0.82	1.20	1.09	0.77
LOS (E-W)	B	B	C	E	C	C	**F**	**F**	D	**F**	**F**	C
Sony Square to Mirpur-2 (Foot Over Bridge)												
V/C ratio (W-E)	0.54	0.44	0.61	0.81	0.79	0.85	0.57	0.61	0.94	0.80	0.74	0.92
LOS (W-E)	A	A	B	D	C	D	A	B	E	C	C	E
V/C ratio (E-W)	0.45	0.48	0.46	0.78	0.82	0.93	0.84	0.81	0.76	0.8	0.79	0.55
LOS (E-W)	A	A	A	C	D	E	D	D	C	C	C	A
Mirpur-2 (Foot Over Bridge) to Mirpur-10 Roundabout												
V/C ratio (W-E)	0.53	0.53	0.35	0.66	0.66	0.95	0.60	0.64	1.00	1.35	1.47	1.01
LOS (W-E)	A	A	A	B	B	E	A	B	E	**F**	**F**	**F**
V/C ratio (E-W)	0.53	0.48	0.37	0.70	0.61	1.01	0.90	0.85	0.66	1.34	0.85	0.60
LOS (E-W)	A	A	A	B	B	**F**	D	D	B	**F**	D	A

In the study area, the traffic flow is less in morning part of the day as LOS calculated from V/C ratios are ranked as A. On the contrary, a different situation is seen during evening. At Mirpur 1 to Sony square after 3 PM a sudden rush of traffic can be seen as people often flock here for recreational activities with flow of diverse vehicles. LOS has been found F in both W-E and E-W directions in terms of volume by capacity (V/C) ratios. The second segment in the study route can be imposed as a less congested section for having LOS ranking of E at evening. The next section also has LOS of F in some specific timings in both directions. Level of service (LOS) F represents jam or stop & go conditions with frequent breakdown of flow (Kadiyali, 2003).

4 Conclusion

The purpose of the study was to rate the level of congestion as it is important for further demand management on the roads. Mirpur-1 to Sony Square and Mirpur-2 to Mirpur-10 Roundabout has been determined as congested segments in the study area. From the research it was seen that Passenger Car Equivalent values varies in the three sections. Flow of bus is found to be greatly taking part in creation a traffic jam with higher PCE values ranging from 4 to 7. To rate intensity of congestion through the two indices LCI and CAI, it has been found that both indexes above stated sections indicate congestion being worse. LOS ranking F has been found for both segments when traffic volume has been studied, especially in peak hours. The reasons of congestion should be thoroughly studied. Around, Sony Square often different vehicles are parked intensively on road creating reduction of capacity and carriage way widths. Abundant presence of non-motorized vehicles also influences rate of congestion. To reduce the problem of traffic congestion, several measures should be taken, such as implementing traffic management strategies, enforcing traffic rules and regulations, and promoting the use of public transportation. Government and local authorities can implement various measures such as introducing congestion pricing and improve lane markings. Additionally, promoting alternative modes of transportation such as cycling and walking can also help to reduce traffic volume.

References

Barnamala, M.T. (2015). Traffic Jam Is Freezing Strong Economy and Healthy Environment: A Case Study of Dhaka City. IOSR Journal of Economics and Finance. 6 (1), 36–40. https://doi.org/10.9790/5933-06123640.

Chandra, S. and Kumar, U. (2003). Effect of Lane Width on Capacity under Mixed Traffic Conditions in India. Journal of Transportation Engineering. 129 (2), 155–160. https://doi.org/10.1061/(ASCE)0733-947X(2003)129:2(155).

Chowdhury, M.M.A. (2016). Performance Evaluation Parameters for Signalized Road Intersections Under Heterogeneous Traffic Condition. M.Sc. Thesis Book Report, Buet, Bangladesh. Available in: http://lib.buet.ac.bd:8080/xmlui/handle/123456789/4524 (accessed 29 July 2022).

Guidelines for Capacity of Roads in Rural Areas. (1990). New Delhi: The Indian Road congress.

Kadiyali, L. (2003). Traffic Engineering & Transport Planning. Delhi: Khanna Publication.

Krammes, R. A. and Crowley, K. W. (1986). Passenger Car Equivalents for Trucks on Level Freeway Segments. Transportation Research Record. 10–17.

Noor, M. A., Ashrafi, S., Fattah, M.A., Morshed, S.R. and Rahman, S. (2021). Assessment of Traffic Congestion Scenario at the CBD Areas in a Developing City: In the Context of Khulna City, Bangladesh. Transportation Research Interdisciplinary Perspectives. 11: 100435. https://doi.org/10.1016/j.trip.2021.100435.

Pandey, A. and Biswas, S. (2022). Assessment of Level of Service on Urban Roads: A Revisit to Past Studies. Advances in Transportation Studies. 57, 49–70. https://doi.org/10.53136/97912218000674.

Raj, P, Sivagnanasundaram, K., Asaithambi, G. and Shankar, A.U.R. (2019). Review of Methods for Estimation of Passenger Car Unit Values of Vehicles. Journal of Transportation Engineering, Part A: Systems. 145 (6), 04019019. https://doi.org/10.1061/jtepbs.0000234.

Shamsher, R. and Abdullah, M.N. (2015). Traffic Congestion in Bangladesh- Causes and Solutions: A Study of Chittagong Metropolitan City. Asian Business Review. 2 (1), 13-18. https://doi.org/10.18034/abr.v2i1.309.

Tasnim, S. and Khan, M.M.H. (2018). Impact of Physical Feature on Traffic Congestion : A Case Study of Khulna Jessore Highway, Khulna. International Conference on Civil Engineering for Sustainable Development. 1–10.

.