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Traffic Impact Assessment of Mohakhali Flyover

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Level of Service,
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Abstract

This paper aims to delve into the inquisitive understanding regarding the impact of Mohakhali Flyover on roadway segments along the corridor and also adjacent to the flyover. Traffic flow and congestion degree have been estimated to justify evaluation of performance of the flyover. Level of Service (LOS) of individual segments as well as that of the overall facility have been evaluated according to the Highway Capacity Manual by Transport Research Board. This paper has evaluated the performance of segments during weekday day, which represents the worst traffic conditions. 15-minute classified traffic count along the corridor of Mohakhali Flyover revealed that one-third of traffic uses at-grade facilities. The average speed along entire facility was calculated to be 8.18 km/h, highlighting poor mobility conditions. In addition, free flow speeds, bus stoppage rates, parking manoeuvre rates and cycle times were measured to identify the Level of Service. LOS F was found at each segment and also at the total facility, suggesting very poor traffic conditions. Such findings have the potential to provide proper guidelines to the appropriate authority to adopt any policy to tackle the problem of prodigious traffic growth in Dhaka city.

1. Introduction

In line with Strategic Transport Plan, flyovers have been constructed around Dhaka city with aim of improving traffic conditions [1-3]. However, even though eight flyovers have been constructed until 2017, congestion degree has increased while the mobility decreased [4]. Existing flyovers were constructed in Dhaka considering only the localized impact of flyovers on its aligned roads, rather than conducting additional impact studies on adjacent areas to assess overall impact. As a result, overall traffic scenario in Dhaka city has not improved. To the best of author's knowledge, negligible study has been done in Bangladesh to assess mobility and congestion degree of flyovers in their adjacent areas, even though numerous studies abroad emphasize its importance [5-11]. It is of paramount importance that future flyovers be built considering a holistic Traffic Impact Analysis (TIA) of both the flyover corridor and adjacent areas, which is the key focus of this paper. This paper addresses the impact of Mohakhali Flyover along the corridor and on adjacent areas. The government undertook a number of remedial measures to address the public sufferings caused by intolerable

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traffic congestions in Dhaka city. As part of those measures, the first flyover in Bangladesh at Mohakhali was commissioned in October 4, 2004. The construction process of the flyover began in December 6, 2001. The 1.12 km flyover was built by Metallurgical Construction Limited, a Chinese firm, under the World Bank funded Dhaka Urban Transport Project. The Roads and Highways Department implemented the project. The construction cost was about BDT 116 crore. The four-lane flyover has one ramp going to the north towards the Airport Road is 147 meters and its length on the west, in front of Shaheen College is 177 meters [3]. Mohakhali flyover was constructed with aim of improving mobility and reducing congestion at grade. However, empirical observations suggest that it performs otherwise, mainly because of defective planning of flyover and its ramps. Such observations have been reflected in Traffic Impact Assessment (TIA) discussed in this study.

2. Literature review

Given the prevalence of flyovers in Dhaka city, surprisingly few studies have approached this subject methodically. Islam and Saha studied the impact of Mohakhali flyover as an urban element, but since then several other flyovers have been constructed, whose influence on Mohakhali flyover had not been projected yet [12]. Taleb and Majumder investigated how people in adjacent land of newly constructed flyovers are affected. They conclude that some businessmen and land-owners have experienced reduced incomes after construction of flyovers [3]. However, the questionnaire surveys were conducted on an inadequate sample number, which may not give accurate picture of people's opinions and represent the real scenario. Besides, the paper did not use any income analysis. Uddin made important discoveries regarding seismic loading on Khilgaon flyover [13]. Bureau of Research Testing and Consultation identified problems associated with Jatrabari-Gulistan Flyover and tried to offer rational solutions to those problems [14]. Hasnat, Hoque and Islam (2016) evaluated the economic, environmental and safety impact of six selected at-grade railway crossings beneath flyovers on Dhaka city, which calculated annual losses accumulating to 32.95 million USD [15]. However, the study did not fully represent the impact on influence area of any flyover. Anwari et al. assessed conditions of partially grade separated flyovers in Dhaka city without considering the variation during different times of the day [1]. Anwari et al. explored the reasons for poor traffic operation and rail-road conflict at Shaheed Ahsanullah Master Flyover [2]. However, the aforementioned literatures neither dealt comprehensively with traffic impact assessment of flyovers nor did they quantify the identified problems. This paper addresses the impact of Mohakhali flyover both along corridor and in the adjacent area.

3. Methodology and study area

Reconnaissance survey along flyover route identified and quantified existing roadway conditions as well as intersections under influence area of Mohakhali flyover. Video based 15-minute classified traffic counts conducted by cordon count method at the flyover during peak hour, identified from analysis of hourly traffic count over a period of 24 hours, was used to determine traffic flow. Queue length was measured using video based image processing technique. Travel time measured using intra-frame scene capture based on superimposed image at free-flow conditions was used to determine space mean free flow speeds. Travel speed at each segment was measured using floating car method. The period of measurement when data were collected for this study was weekday day, because that period was observed to have the worst traffic conditions. Collected data were analysed to identify level of service (LOS) and flow-capacity ratio. The study aims to reveal that a comprehensive wide-area TIA is more potent than a miniature corridor-based TIA. LOS was calculated as per guidelines of Highway Capacity Manual [16]. A total of 13 intersections and 14 road segments were identified along and adjacent to Mohakhali flyover i.e. within the project influence area, as shown in Figure 1.

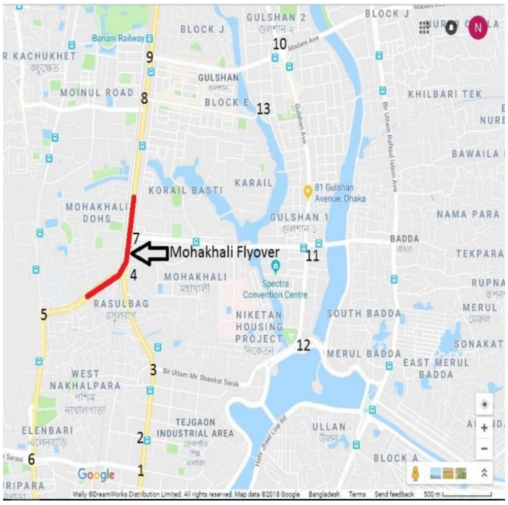

Figure 1. Location of the Study Area (Google Map View).

Because of limitations of the study, only the primary roads were considered, where greatest impact was observed. The impact of the flyover on the identified primary links have been studied. Primary data were collected in order to determine the level of service include roadway geometry, parking maneuver rate, bus stopping rate and intersection phase times. The intersections are labelled as per Figure 1. As per HCM (2010), the considered roadways were identified as urban street segments [16]. An urban street segment is defined as length of urban street from one boundary intersection to the next, including the upstream boundary intersection, but not the downstream boundary intersection. From Figure 1, the segments along the flyover corridor are: 1-2, 1-8, 1-12 and 12-11. The remaining segments are considered as segments adjacent to the flyover. All data have been taken in 2017.

4. Data collection and analysis

Collected data have been presented and analysed in the following subsections.

4.1. Assessment of traffic flow

15 minute classified traffic count was performed to assess the relative level of usage of road space under and over the flyover. Since vehicles of various sizes and weights pass through the study area, it was indispensable to expedient their impact using a common measuring unit. Hence, the vehicle counts were converted to passenger car units, using the following passenger car equivalent (PCE) factors prescribed by the Geometric Design Standards for Roads & Highways Department, Bangladesh: Rickshaw/Van: 2.00, Motorcycle: 0.75: Bicycle: 0.50, Car: 1.00, CNG: 0.75,Tempo: 0.75, Bus: 3.00, Utility: 1.00, Truck: 3.00, Bullock Carts: 4.00 [17]. Accordingly, traffic flow in terms of PCUs were obtained by multiplying vehicle count data with their corresponding PCE factors. The temporal flow variation is presented in Figure 2.

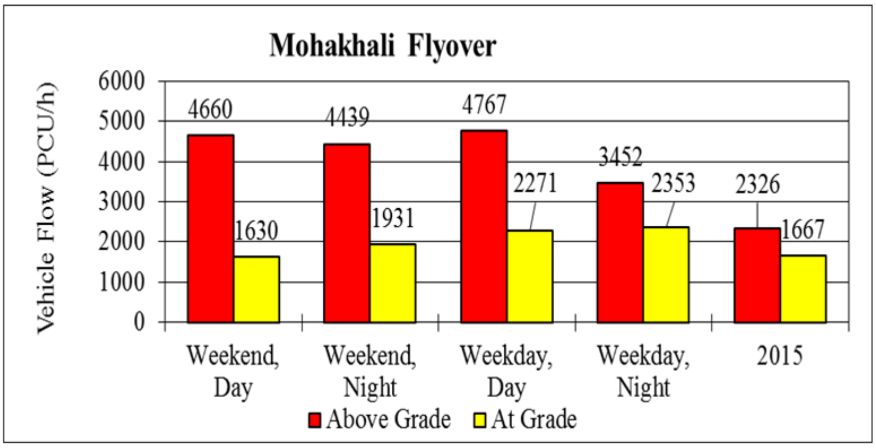

Figure 2. Traffic Flow along Corridor of Mohakhali Flyover

Figure 2 reveals that although a larger proportion of vehicles travelled above grade compared to at grade, traffic is still significant at grade. It is also evident that traffic flow was greatest during weekday day (4767 pcu/h) and least during weekday night (3452 pcu/h) (above grade). At grade flow was greatest during weekday night (2353 pcu/h) and least during weekend day (1630 pcu/h). Data are also compared with 2015 data taken by Anwari et al. [1]. Compared to 2015 weekday day period, flow has increased 104.98% at above-grade and 36.20% at at-grade respectively. So, flyover has been successful in diverting greater portion of traffic at above-grade.

4.2. Assessment of congestion degree

Queue length was taken at the most critical intersection (intersection 4) near the level crossing as shown in Figure 1.This refers to a high degree of congestion, as delineated in Figure 3. The longest queue length at grade was recorded at weekday day (373.7 m) while the shortest was recorded at weekday night (62.8 m). Compared to a study in 2015 by Anwari et al. [1], queue length in weekday, day has increased by 19.40% in 2017. The fact that queue length has developed at grade along the corridor of Mohakhali Flyover means that the flyover has failed to reduce congestion, even after having facilities to divert through traffic above grade. This comes despite the fact that a larger portion of traffic travelled above grade in 2017 compared to at-grade. In addition, measurement of above grade queue length shows that queues have developed at weekday, whereas there was no queue length in 2015. Since Mohakhali flyover has failed to reduce congestion in its target area, this warrants a thorough assessment of the impact of flyover along its corridor and in the adjacent area. As most of the previous studies identified weekday day traffic period as the most critical to analysis, the following part of this study will consider analysis pertaining to weekday day period.

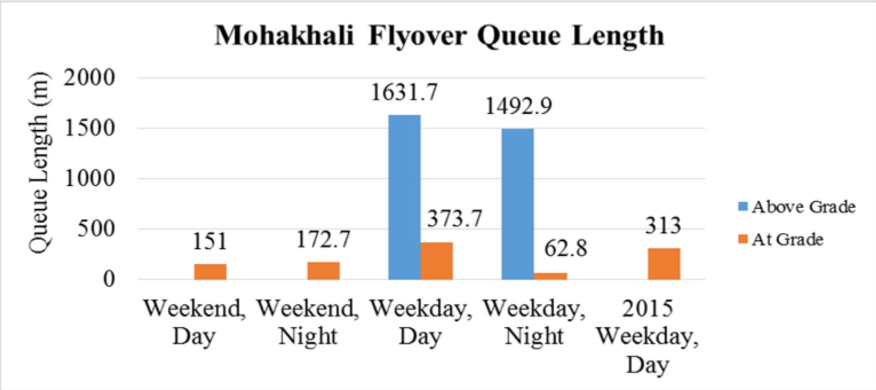

Figure 3. Queue Length Measured at Mohakhali Flyover

4.3. Assessment of travel speed

Floating car method was used to assess travel speed at each direction of each segment by recording the travel time (including motion time, segment delay and through vehicle delay) and dividing the segment length by the travel time. So this speed considers any stop-time delay. A permitted error of ± 1.0 miles/hour and 95% confidence interval was chosen to get speed difference (R) of 4 miles/hour between maximum and minimum value of travel times. As a result, a minimum of 10 test runs were required as per Manual of Transportation Engineering Studies [18]. Hence, 10 test runs over each segment was done during peak hour to determine the travel speed. Analysis of 15-minute traffic volume counts for a period of 24 hours on a weekday revealed that the highest traffic flow occurred in 5:15-5:30 pm slot. Hence, all subsequent data except free flow speed data were collected during this time period. The summary of the speed results is provided in Table 1:

Table 1. Travel Speed at Weekday Day along different segments adjacent to Mohakhali Flyover

Segment Label	**Segment Length (km)**	Average Speed (km/h)		
		Overall	First Direction	Opposite Direction
1-2	0.27	6.35	6.19	6.51
2-3	0.59	6.82	6.79	6.86
3-4	0.85	7.38	7.21	7.57
4-5	0.91	8.00	8.19	7.82
5-6	1.22	7.80	7.73	7.88
6-1	1.13	7.35	8.03	6.78
4-7	0.30	7.44	7.53	7.36
7-8	1.15	9.39	9.56	9.22
7-11	1.83	9.21	9.22	9.20
8-9	0.35	7.64	7.74	7.54

Segment Label	Segment Length (km)	Average Speed (km/h)		
		Overall	First Direction	Opposite Direction
8-13	1.22	8.74	8.83	8.65
9-10	1.38	8.14	7.95	8.34
10-11	1.66	9.64	9.72	9.57
11-12	0.85	7.15	7.46	6.86
Total Facility	13.71	8.18	8.27	8.10

4.4. Determination of free flow speed

HCM (2010) defines Free Flow Speed (FFS) as the average speed of the traffic stream when traffic volumes are sufficiently low that drivers are not influenced by the presence of other vehicles and when intersection traffic control is not present or is sufficiently distant as to have no effect on speed choice (Transportation Research Board, 2010). The average classified FFS at weekday, day is shown in Figure 4.

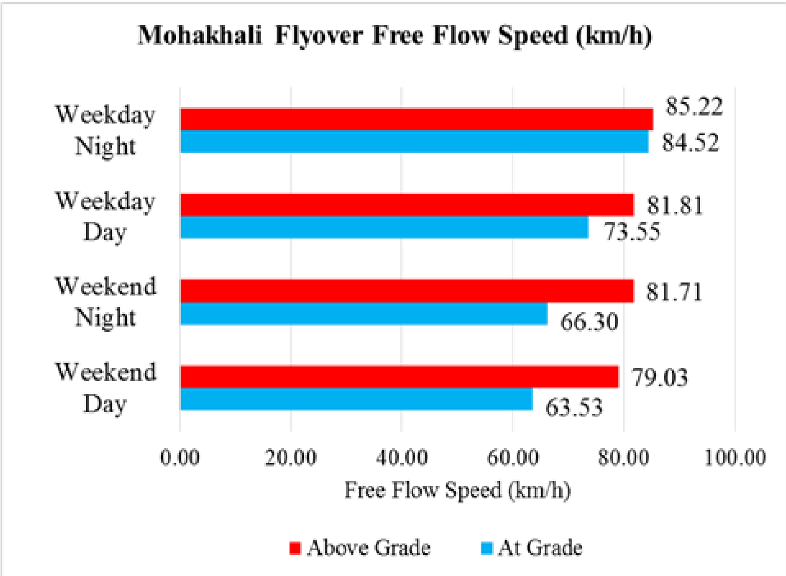

Figure 4. Free Flow Speed at Mohakhali Flyover in Various periods of Measurement

The classified FFS presented includes non-motorized vehicles (NMVs) such as rickshaws and bicycles. Rickshaw is a para-transit vehicle, the determination of whose LOS has not been fully covered in HCM (2010) [16]. In addition, bicycle only makes up a negligible portion of total traffic. Hence these two modes of traffic have been excluded from LOS evaluation.

4.5. Determination of saturation flow rate

A vital parameter to determine the LOS is the saturation flow rate, calculated using the following equation:

$$s = s_o\, f_w\, f_{HV}\, f_g\, f_p\, f_{bb}\, f_a\, f_{LU}\, f_{LT}\, f_{RT}\, f_{Lpb}\, f_{Rpb} \qquad (1)$$

Where, the parameters are listed as follows along with the values used in common for all analysed segments:

s = adjusted saturation flow rate (veh/h/ln),
s_o = base saturation flow rate (pc/h/ln) = 1900 pc/h/ln
f_w = adjustment factor for lane width
f_{HV} = adjustment factor for heavy vehicles in traffic stream
f_g = adjustment factor for approach grade = 1 (because of zero grade)
f_p = adjustment factor for existence of a parking lane and parking activity adjacent to lane group
f_{bb} = adjustment factor for blocking effect of local buses that stop within intersection area
f_a = adjustment factor for area type = 0.9
f_{LU} = adjustment factor for lane utilization = 1,
f_{LT} = adjustment factor for left-turn vehicle presence in a lane group = 1/1.18
f_{RT} = adjustment factor for right-turn vehicle presence in a lane group = 1/1.05
f_{Lpb} = pedestrian adjustment factor for left-turn groups = 1
f_{Rpb} = pedestrian-bicycle adjustment factor for right-turn groups = 1
Base saturation flow rate was taken as 1900 pc/h/ln as per HCM (2010) [16]. Adjustment factor for lane width was taken as 1.0 since all lanes had width in the range of 10 ft to 12.9 ft. All approach grades were assumed to be zero. Hence adjustment factor for approach grade was taken as 1.0. All lane group had shared lanes, hence adjustment factor for lane utilization was taken as 1.0. All turning movements were observed to be generally protected, hence pedestrian adjustment factors were taken as 1.0. The observed parking maneuver rates and bus stoppage rate for each directional segment is provided in Table 2.

Table 2. Observed Parking Maneuver Rate and Bus Stopping Rate at Each Segment

Segment	Direction	Parking Maneuver Rate, N_m (maneuvers/h)	Bus Stopping Rate, N_b (buses/h)	Segment	Direction	Parking Maneuver Rate, N_m (maneuvers/h)	Bus Stopping Rate, N_b (buses/h)
1-2	1-2	8	15	7-8	7-8	4	17
	2-1	15	15		8-7	3	11
2-3	2-3	11	11	7-11	7-11	7	19
	3-2	12	11		11-7	10	20
3-4	3-4	16	18	8-9	8-9	2	42
	4-3	11	19		9-8	3	47
4-5	4-5	5	8	8-13	8-13	11	0
	5-4	9	17		13-8	4	0
5-6	5-6	3	4	9-10	9-10	5	23
	6-5	3	6		10-9	6	32
6-1	6-1	2	0	10-11	10-11	7	19
	1-6	2	0		11-10	9	25
4-7	4-7	8	19	11-12	11-12	5	20
	7-4	5	18		12-11	5	10

The segment capacity was then calculated using

$$c = Nsg/C \quad (2)$$

where, c = capacity (veh/h)
N = number of lanes (ln)
s = saturation flow rate
g = effective green time (s)
C = cycle time.(s)

The Level of Service was calculated using the criteria provided in Table 3. Collected data were analyzed in Table 4 to determine Directional Segment Capacity. Table 4 shows that the directional capacity of segment direction 6-5 was highest (2181.33 pcu/h) while that of segment 1-6 was lowest (328.16 pcu/h). The average directional capacity of each segment was 1120.131 pcu/h, which is significantly lower than the base capacity.

Table 3. Determination of Level of Service

Travel Speed as a Percentage of Base Free-Flow Speed (%)	**LOS by Volume-to-Capacity Ratio**	
	<=1	>= 1
>85	A	F
>67-85	B	F
>50-67	C	F
>40-50	D	F
>30-40	E	F
<=30	F	F

Table 4. Determination of Directional Segment Capacity

Segment	**Direction**	**s_o (veh/h/ln)**	**fW**	**fHV**	**fg**	**fp**	**fbb**	**fA**	**fLU**	**fLT**	**fRT**	**fLph**	**fRph**	**s (veh/h/ln)**	**C (s)**	**G (s)**	**N (ln)**	**C (pcu/h)**
1-2	1-2	1900	1	0.94	1	0.95	0.97	0.9	1	0.85	0.95	1	1	1201	684	211	3	1112
	2-1	1900	1	0.95	1	0.94	0.97	0.9	1	0.85	0.95	1	1	1201	840	239	3	1025
2-3	2-3	1900	1	0.98	1	0.95	0.98	0.9	1	0.85	0.95	1	1	1253	500	205	3	1541
	3-2	1900	1	0.97	1	0.95	0.98	0.9	1	0.85	0.95	1	1	1238	684	225	3	1221
3-4	3-4	1900	1	0.99	1	0.94	0.96	0.9	1	0.85	0.95	1	1	1235	905	308	3	1261
	4-3	1900	1	0.99	1	0.95	0.96	0.9	1	0.85	0.95	1	1	1249	500	210	3	1574
4-5	4-5	1900	1	0.99	1	0.96	0.98	0.9	1	0.85	0.95	1	1	1293	425	180	3	1643
	5-4	1900	1	0.99	1	0.95	0.97	0.9	1	0.85	0.95	1	1	1261	905	237	3	990
5-6	5-6	1900	1	1.00	1	0.97	0.99	0.9	1	0.85	0.95	1	1	1330	920	284	4	1642
	6-5	1900	1	1.00	1	0.97	0.99	0.9	1	0.85	0.95	1	1	1324	425	175	4	2181
6-1	6-1	1900	1	0.98	1	0.95	1.00	0.9	1	0.85	0.95	1	1	1276	840	180	2	547
	1-6	1900	1	0.98	1	0.95	1.00	0.9	1	0.85	0.95	1	1	1279	920	118	2	328
4-7	4-7	1900	1	0.99	1	0.95	0.96	0.9	1	0.85	0.95	1	1	1249	450	135	3	1124
	7-4	1900	1	0.99	1	0.96	0.96	0.9	1	0.85	0.95	1	1	1266	905	345	3	1448
7-8	7-8	1900	1	0.98	1	0.96	0.97	0.9	1	0.85	0.95	1	1	1258	455	147	3	1219
	8-7	1900	1	0.98	1	0.96	0.98	0.9	1	0.85	0.95	1	1	1277	450	155	3	1319
7-11	7-11	1900	1	1.00	1	0.93	0.96	0.9	1	0.85	0.95	1	1	1238	600	135	2	557
	11-7	1900	1	1.00	1	0.93	0.96	0.9	1	0.85	0.95	1	1	1226	450	145	2	790
8-9	8-9	1900	1	0.99	1	0.96	0.92	0.9	1	0.85	0.95	1	1	1210	522	155	3	1078
	9-8	1900	1	0.99	1	0.96	0.91	0.9	1	0.85	0.95	1	1	1195	455	153	3	1206
8-13	8-13	1900	1	1.00	1	0.92	1.00	0.9	1	0.85	0.95	1	1	1273	339	110	2	826
	13-8	1900	1	1.00	1	0.94	1.00	0.9	1	0.85	0.95	1	1	1297	455	140	2	798
9-10	9-10	1900	1	1.00	1	0.96	0.95	0.9	1	0.85	0.95	1	1	1262	709	162	3	865
	10-9	1900	1	1.00	1	0.96	0.94	0.9	1	0.85	0.95	1	1	1236	522	127	3	902
10-11	10-11	1900	1	1.00	1	0.96	0.96	0.9	1	0.85	0.95	1	1	1268	600	155	3	983
	11-10	1900	1	1.00	1	0.95	0.95	0.9	1	0.85	0.95	1	1	1248	709	175	3	924
11-12	11-12	1900	1	1.00	1	0.96	0.96	0.9	1	0.85	0.95	1	1	1270	410	135	3	1254
	12-11	1900	1	1.00	1	0.96	0.98	0.9	1	0.85	0.95	1	1	1296	600	155	3	1005

4.6. Determination of level of service

LOS calculation is shown in Table 5. FFS used in calculation of LOS as presented in Table 5 only considers motorized vehicles.

Table 5. Level of Service Calculation

Segment	Direction	Travel Speed (km/h)	Free Flow Speed (km/h)	TS/FFS	Flow (pcu/h)	Capacity (pcu/h)	v/c	LOS
1-2	1-2	6.19	75.59	0.08	2009	1112	1.81	F
	2-1	6.51	75.59	0.09	1781	1025	1.74	F
2-3	2-3	6.79	75.59	0.09	2024	1541	1.31	F
	3-2	6.86	75.59	0.09	2039	1221	1.67	F
3-4	3-4	7.21	75.59	0.10	1796	1261	1.42	F
	4-3	7.57	75.59	0.10	1847	1574	1.17	F
4-5	4-5	8.19	75.59	0.11	2252	1643	1.37	F
	5-4	7.82	75.59	0.10	2245	990	2.27	F
5-6	5-6	7.73	75.59	0.10	2628	1642	1.60	F
	6-5	7.88	75.59	0.10	2495	2181	1.14	F
6-1	6-1	8.03	75.59	0.11	2009	547	3.67	F
	1-6	6.78	75.59	0.09	1884	328	5.74	F
4-7	4-7	7.53	75.59	0.10	1627	1124	1.45	F
	7-4	7.36	75.59	0.10	2031	1448	1.40	F
7-8	7-8	9.56	75.59	0.13	2112	1219	1.73	F
	8-7	9.22	75.59	0.12	2186	1319	1.66	F
7-11	7-11	9.22	75.59	0.12	1509	557	2.71	F
	11-7	9.20	75.59	0.12	1340	790	1.70	F
8-9	8-9	7.74	75.59	0.10	2282	1078	2.12	F
	9-8	7.54	75.59	0.10	2436	1206	2.02	F
8-13	8-13	8.83	75.59	0.12	1671	826	2.02	F
	13-8	8.65	75.59	0.11	1752	798	2.19	F
9-10	9-10	7.95	75.59	0.11	1553	865	1.80	F
	10-9	8.34	75.59	0.11	1479	902	1.64	F
10-11	10-11	9.72	75.59	0.13	2068	983	2.10	F
	11-10	9.57	75.59	0.13	1855	924	2.01	F
11-12	11-12	7.46	75.59	0.10	1781	1254	1.42	F
	12-11	6.86	75.59	0.09	1884	1005	1.88	F
Total Facility		8.18	75.59	0.11	1753	1095	1.60	F

Table 5 shows that irrespective of capacity, the LOS at all segments adjacent to Mohakhali Flyover is F during peak hour at weekday day, indicating the lowest level of service and that drivers are dissatisfied with the existing roadway conditions. It means that the flyover has not been effective in mitigating traffic crisis in Mohakhali. The flyover has failed to improve traffic conditions both along the flyover corridor and in the adjacent areas. Vehicles travelled slowest along segment 1-2 (travel speed of 6.19 km/h) while they travelled the fastest along segment 10-11 (travel speed of 9.72 km/h). The average speed along entire facility was calculated to be 8.18 km/h, which is only a little faster than the average walking speed (5 km/h) [19].

5. Conclusion

Analysis of LOS revealed that LOS is found to be F at all segments and also in the overall facility during peak hour of weekday day. It indicates that segments have poor driving conditions. Based on this investigation and the analysis in previous studies it can be concluded that neither through traffic nor local traffic has benefited much from Mohakhali flyover. Through traffic has suffered because the entry and exit ramps of the flyover have been directly constructed over primary roads. Such ramps should have been connected to local roads so that through traffic enjoys uninterrupted flow. Right now what is happening is that congestion has been shifted from Mohakhali level crossing into another intersection, namely the Kakoli Intersection (Intersection #9 in Figure 1). As a result, the performance of surrounding roadway segments continue to suffer. The study has also revealed the short-sightedness of transport authorities. The flyover was created with aims to increase mobility and reduce congestion. However, temporal analysis has disclosed that mobility has rather decreased while congestion has increased. It is recommended that to tackle prevailing chronic congestion problem of urban built up area, instead of constructing flyovers which merely shift traffic bottlenecks from one place to another, the rapid mass transit oriented measure should be undertaken, since it has the demand responsive sustainability potential.

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References

[1] Anwari N., Hoque M., Islam M.: Effectiveness of Flyovers Constructed over Railway Line, BUET-ANWAR ISPAT 1st Bangladesh Civil Engineering SUMMIT (2016).

[2] Anwari N., Hoque M., Islam M.: Investigating Conflicts between Rail-Road Traffic at Shaheed Ahsanullah Master Flyover.

[3] Taleb M. A., Majumder S.: Impact of Flyovers in Dhaka City of Bangladesh on the Affected People in the Adjacent Area. International Journal of Engineering and Technology, 4, 103 (2012).

[4] The World Bank, “A Modern Dhaka is Key to Bangladesh’s Upper-Middle Income Country Vision”, (2017), available online: http://www.worldbank.org/en/news/press-release/2017/07/19/modern-dhaka-key-bangladesh-upper-middle-income-country-vision, last visit: 14.06.2018.,

[5] Lang L., Machemehl R. B.: Congress Avenue Regional Arterial Study: Grade Separations, University of Texas, Center for Transportation Research (1995).

[6] Maitra B., Azmi M., Kumar N., Sarkar J.: Modeling traffic impact of flyover at an urban intersection under mixed traffic environment. (2004).

[7] Luophongsok P C. N. D. N.: Cost-Benefit Analysis of Sanpatong-. Hangdong (Phase 1) Bypass Project, Chiangmai. Journal of Management Science and Information Science, 6, (2011).

[8] Auttakorn S.: Assessment of traffic flow benefits of flyovers: A case study. Journal of Society for Transportation and Traffic Studies (JSTS), 4, 1-9 (2013).

[9] Salatoom N., Taneerananon P.: A study of the flyover-bridge intersection-improved junction. Engineering Journal, 19, 1-12 (2015).

[10] Salatoom N., Taneerananon P.: An Evaluation of Flyover-Improved Intersections: A Case Study of Airport Intersection. Journal of the Eastern Asia Society for Transportation Studies, 11, 2028-2040 (2015).

[11] Rahman M. L.: Modelling flyover induced travel demand in Dhaka, Bangladesh, Queensland University of Technology (2017).

[12] Islam F., Saha B.: Impact of flyover as an integrated element of urban transport system: A case study of Mohakhali flyover. An Unpublished Thesis Submitted to the DURP, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh, (2005).

[13] Uddin M.: Assessment of Khilgaon flyover under seismic load. An Unpublished Thesis, Submitted to the Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh, (2006).

[14] BRTC, "Dhaka City Corporation (DCC) Jatrabari-Gulistan Flyover Project: Rational Solution Approaches", Bureau of Research Testing & Consultation (BRTC), Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET), (2008).

[15] Hasnat M. M., Hoque M. S., Islam M. R.: Evaluation of Economic, Environmental and Safety Impact of At-Grade Railway Crossings on Urban City of Developing Country. Global Journal of Research In Engineering, (2016).

[16] Manual H. C.: HCM2010. Transportation Research Board, National Research Council, Washington, DC, (2010).

[17] Ministry of Communication, "Geometric Design Standards for Roads & Highways Department", Government of the People's Republic of Bangladesh Ministry of Communications Roads and Railways Division, (2000), Available online: http://www.rhd.gov.bd/Documents/ConvDocs/Road Geometric Design Manual.pdf, last visit: 14.06.2018.,

[18] Schroeder B. J., Cunningham C. M., Findley D. J., Hummer J. E., Foyle R. S.: Manual of transportation engineering studies (2010).

[19] Bohannon R. W.: Comfortable and maximum walking speed of adults aged 20—79 years: reference values and determinants. Age and ageing, 26, 15-19 (1997).