TRAFFIC IMPACT ASSESSMENT OF KHILGAON FLYOVER

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ABSTRACT

This paper aims to delve into the inquisitive understanding regarding the impact of Khilgaon 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. To the best of authors' knowledge, no study has been previously done at home to evaluate level of service of links in the influence area of flyovers. This paper has evaluated the performance of segments during weekday day, which represents the worst traffic conditions. 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 adopt any policy to tackle with the problem of prodigious traffic growth in Dhaka city.

Key Words: Traffic Impact Assessment, Level of Service, Performance of Flyovers. Congestion Level.

1.0 INTRODUCTION

In line with Strategic Transport Plan, flyovers have been constructed around Dhaka city with aim of improving traffic conditions [1], [2]. However, despite construction of eight flyovers, congestion degree increased while the mobility decreased [1]–[6]. 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 authors' 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 [7]–[13]. 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 Khilgaon Flyover on adjacent areas. The government undertook a number of remedial measures to address the public sufferings caused by intolerable traffic congestions in Dhaka city. As a part of the total initiatives to improve the traffic situation in Dhaka, the then government approved the Khilgaon Flyover project in the ECNEC meeting in 2000. Accordingly Local Government Engineering Division (LGED) constructed the flyover, which was opened for traffic from March 2005. However, the implementation was not done as per original plan or design because the subsequent government (2001-2006) dropped one of the important loops (Saidabad side) from the project. This has seriously constrained the objectives and expected benefits of the flyover as originally planned. This is illustrated in Figure 1. It is clearly evident that hazard in the form of conflict between pedestrian, vehicular and rail movement has not decreased, which essentially shows that neither rail nor road has benefited from construction of Khilgaon Flyover.

(a) 2003 (b) 2017

Fig 1: Comparison of Traffic Flow at Khilgaon Level Crossing Before and After Construction of Khilgaon Flyover.

Till now the large volume of traffic coming from Progoti Sarani and eastern part of the city (Mothertek, Kadamtali, Basabo, Shepaibag, Meradia, Goran) cannot use the existing flyover and they do not have any other uninterrupted access toward Motijheel commercial area and Rajarbag [14].

2.0 LITERATURE REVIEW

Given the prevalence of flyovers in Dhaka city, surprisingly few studies have approached this subject methodically. Anwari et al. (2016) assessed conditions of partially grade separated flyovers in Dhaka city without considering the variation during different times of the day [5]. Again, Anwari et al. (2016) explored the reasons for poor traffic operation and rail-road conflict at Shaheed Ahsanullah Master Flyover [6]. Later, Islam et al. (2018) evaluated the performance of Jatrabari-Gulistan Flyover incorporating temporal variation [3], [4]. But these studies did not incorporate traffic impact assessment of the studied flyover. Additionally, these studies lack evaluating the level of service of the studied flyovers. Anwari et al. assessed the impacts of Mohakhali Flyover on the adjacent roads along with the flyover corridor incorporating temporal variation [1], [2]. However, the aforementioned literatures neither dealt comprehensively with traffic impact assessment of Khilgaon flyover nor did they quantify the identified problems. This paper addresses the impact of Khilgaon flyover both along corridor and in the adjacent area.

3.0 METHODOLOGY AND STUDY AREA

Reconnaissance survey along the flyover alignment identified and quantified existing roadway conditions as well as intersections under influence area of each flyover approach ramp. The flyover and its influence area is shown in Google map based Figure 2. Video based 15 minute classified traffic counts conducted by cordon count method at each flyover approach ramp during peak hours, identified from hourly flow fluctuation 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 validated by radar gun spot-speed studies [15]. Operational speeds at each segment was measured using floating car method [16], [17].The period of measurement when data were collected was weekday day, because that period was observed to have the worst traffic conditions. Collected data were analyzed to identify level of service (LOS) and flow-capacity ratio, and compared spatio-temporally and with previous studies. LOS was calculated as per guidelines of Highway Capacity Manual [18].

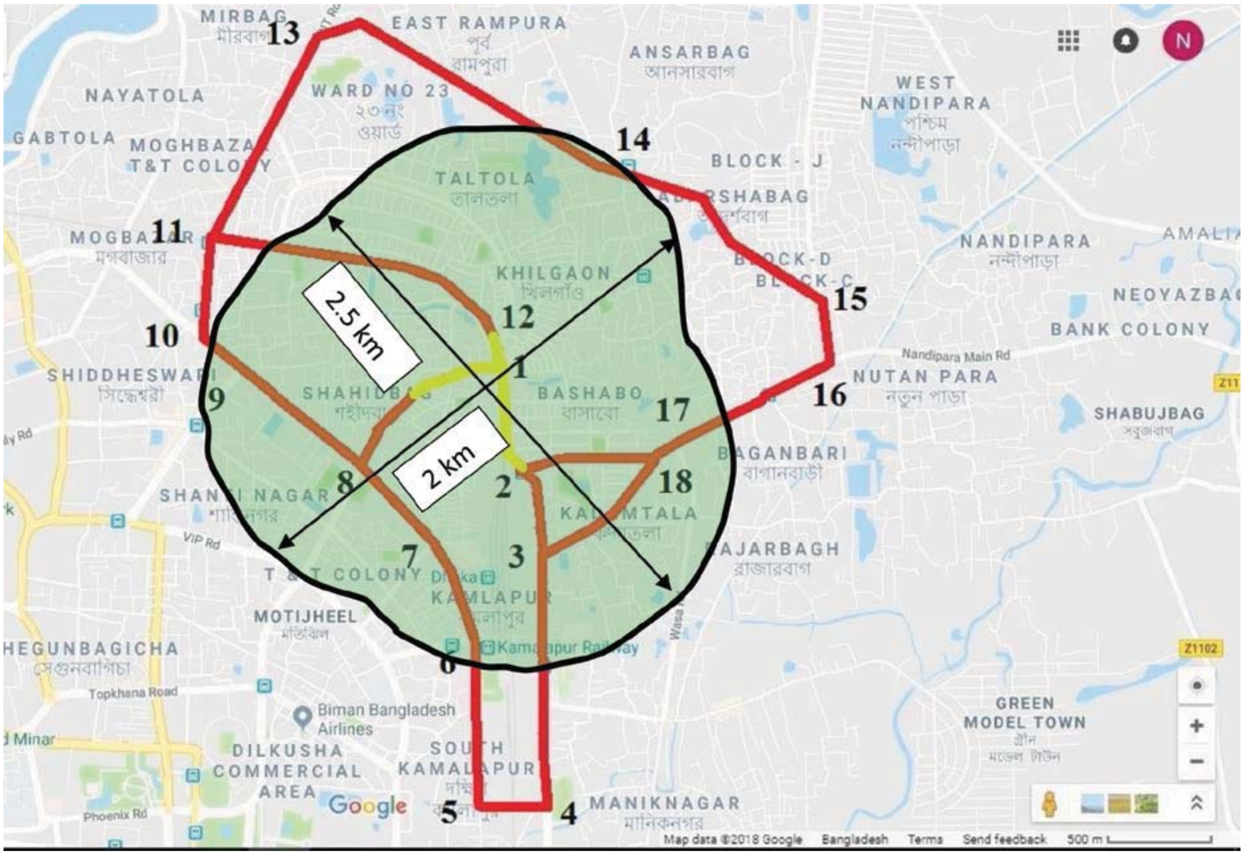

Fig 2: Google Map Image of Study Area

A total of 18 intersections and 21 road segments were identified adjacent to Khilgaon flyover i.e. within the project influence area. Due to limitations of the study, only the primary roads were considered. Secondary and lower-tier roads were ignored, because empirical observations revealed only low impact on these roads. The impact of the flyover on the identified primary links have been studied. Primary data 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 2.The yellow lines in Figure 2 indicate the route along the flyover corridor while the red lines indicate the route adjacent to the flyover. The intersections are marked from 1 to 18 along the selected study route. The numbered segments represent the travel time segment, namely, 1-2, 2-3, 3-4, 4-5, 5-6, 6-7, 7-8, 1-8, 8-9, 9-10, 10-11, 11-12, 11-13, 13-14, 14-15, 15-16, 16-17, 16-18, 17-2, 17-3 and 12-1. To measure travel time, floating car method was used where an observer inside the car noted down the travel time at predefined checkpoints along the road. The distance between checkpoints defining a particular road was found from Google Map and validated using GPS receiver on field. Cordon line used for traffic volume count is shown in Figure 3.

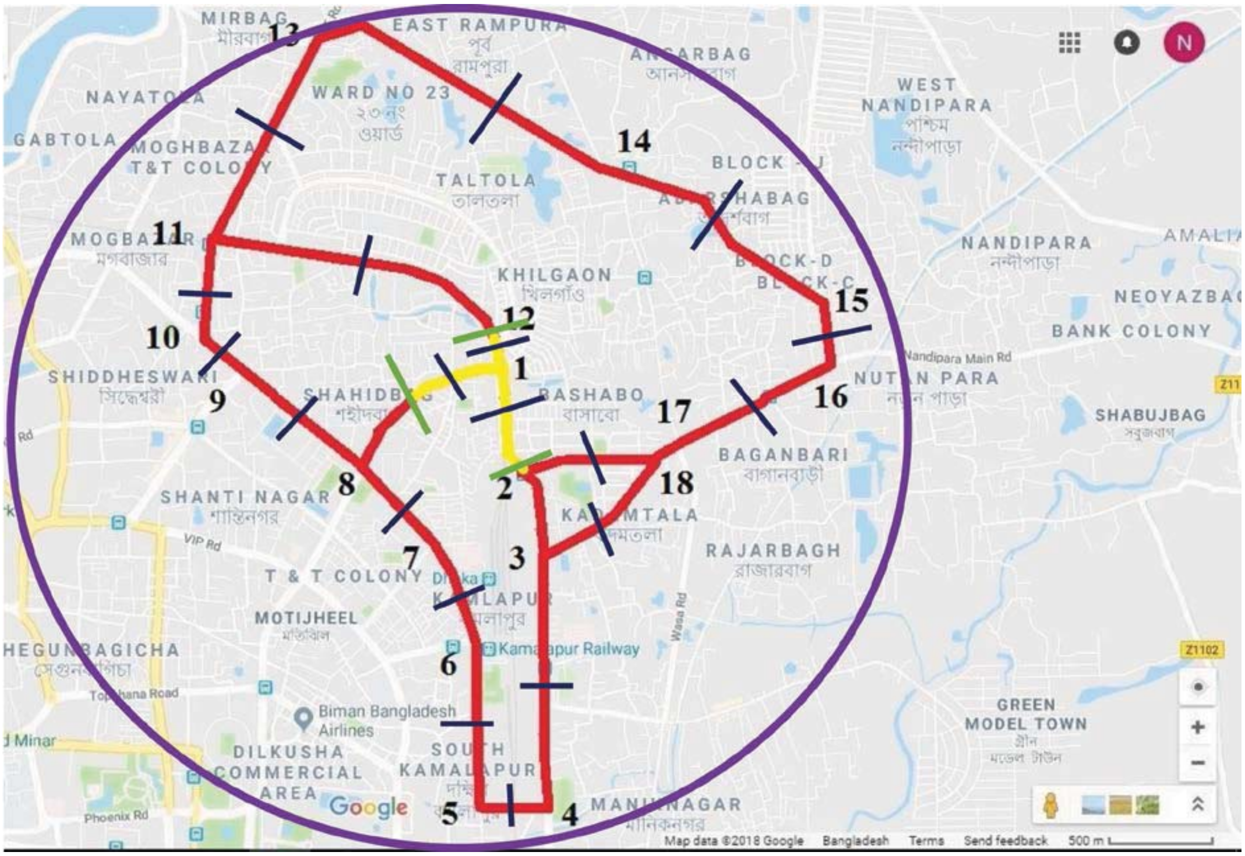

Fig 3: Google Map Image of Study Area along with Cordon Line

The purple circle in Figure 3 represents the cordon line. Cordon screens were used for traffic volume observation of individual road segments. Counts were taken where the cordon screens intersect the roads. Blue screen lines were used to count at-grade traffic vehicles, while green screen lines were used to count above-grade traffic vehicles.

An example of the traffic count is shown in Figure 4.

Fig 4: Satellite View of Segment 4-5/5-4 Showing Location of Cordon Screen

In Figure 4 the blue line represents the location of cordon screen for segment 4-5/5-4. Traffic volume was measured separately for the opposing directions. The flow coming from intersection 4 and going to intersection 5 was designated as traffic flow for segment direction 4-5, while the reverse flow was designated as traffic flow for segment direction 5-4. Traffic stream flow from access roads were observed to be negligible compared to the flow along the studied routes, therefore access roads were not considered separately. Video camera was set up at mid-block to observe at-grade flow while at the 3 down ramps to observe above-grade flow. Referring back to Figure 3, the traffic flow at only the up ramps of green screen lines were measured and aggregated to get above grade traffic flow.

As per HCM (2010) [18], the considered roadways were identified as urban street segments. 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 primary data were collected in 2017. In addition, traffic parameters are compared with a similar study performed by Anwari et al. [5] to assess temporal trends.

4.0 DATA COLLECTION AND ANALYSIS

4.1 Traffic Flow Assessment

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, as depicted in Table 1, 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 [19]. Accordingly, traffic flow in terms of PCUs were obtained multiplying vehicle count data by their corresponding PCE factors.

Table 1:15-Minute Classified Traffic Count at Khilgaon Flyover (PCUs)

Survey Time	Over/ Under	Rickshaw/ Van	Motorcycle	Bicycle	Car/ Jeep/ Microbus	CNG	Human Haulers	Bus	Utility	Truck	Total equivalent hourly flow (PCU)	Percentage of Total (%)	Ratio of Vehicles Passing over to those Under
Weekend, Day	Over	0	424	1	589	366	1	196	23	3	6634	43.69	0.78:1
	Under	1091	27	51	51	14	18	4	6	1	8551	56.31	
Weekend, Night	Over	0	289	0	857	438	0	190	35	0	7387	59.61	1.48:1
	Under	622	31	18	26	40	36	0	1	0	5006	40.39	
Weekday, Day	Over	0	329	0	1719	254	0	358	69	2	12163	53.24	1.14:1
	Under	1376	37	33	42	33	32	2	4	2	10683	46.76	
Weekday, Night	Over	0	215	0	2253	238	0	353	58	5	13707	63.08	1.71:1
	Under	1015	46	54	23	37	40	0	8	0	8023	36.92	

Table 1 and Figure 5 reveal that a larger proportion of vehicles travelled through at grade level as compared to above grade in weekend night, weekday day and weekday night, indicating that the flyover was evidently unsuccessful in mitigating congestion at at- grade level. It is also evident that traffic flow was greatest during weekday day and least during weekend night. Data are also compared with 2015 data taken by Anwari et al. [5]. Compared to 2015 weekday day period, flow has increased 1106% at above-grade and 58.14% at at-grade respectively, which essentially suggests that the flyover has been successful in diverting greater portion of traffic at above-grade level.

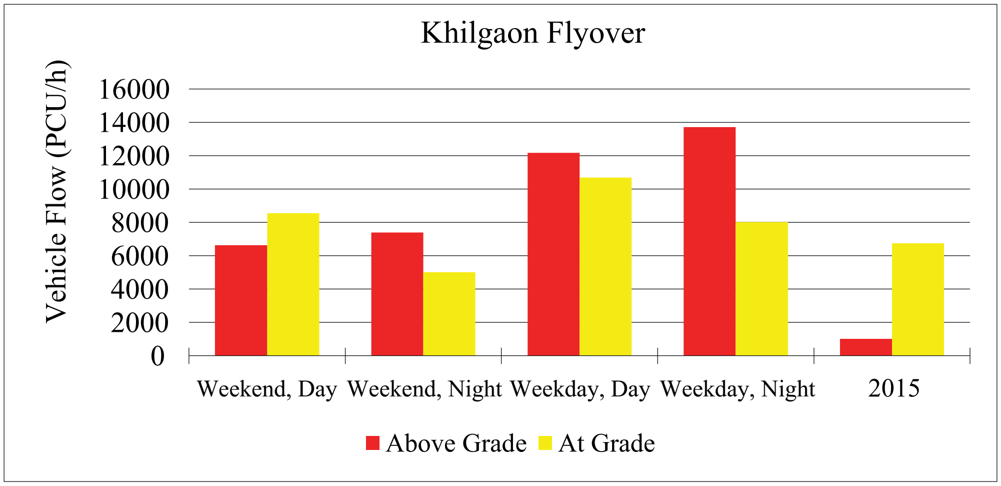

Fig 5: Traffic Flow along Khilgaon Flyover Alignment

4.2 Assessment of Congestion Degree

Queue length was taken at the most critical intersection (intersection 1) near the level crossing as shown in Figure 1.This refers to a high degree of congestion, as delineated in Figure 6. The longest queue length was recorded at weekday night (866.1 m) while the shortest was recorded at weekend day (202.1 m). Weekday day had experienced the second highest queue length (368 m). Data is also compared with queue length data taken by Anwari et al. [5] in 2015. Compared to 2015, queue length in weekday, day had nearly been doubled in 2017.

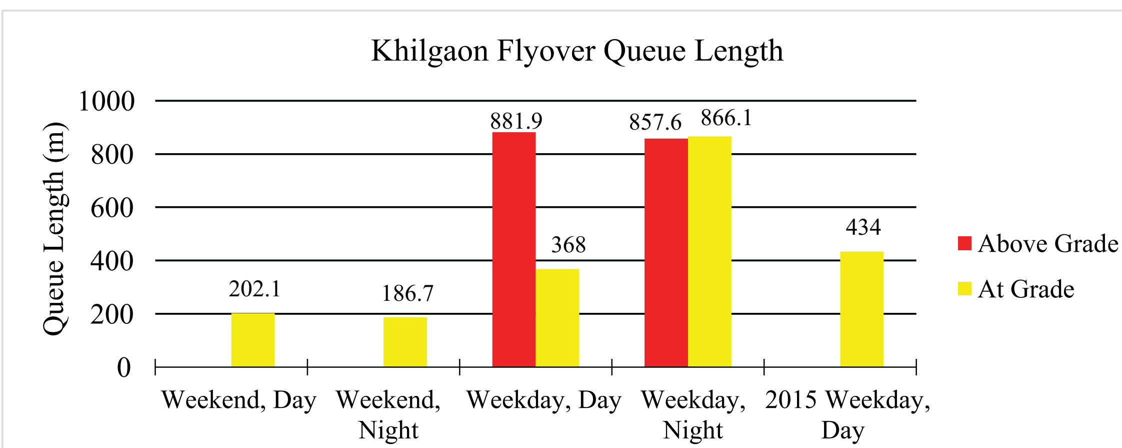

Fig 6: Queue Length Measured at Khilgaon Flyover

The fact that queue length has developed at grade along the corridor of Khilgaon 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 Khilgaon 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 analyzed, the following part of this study will consider analysis pertaining to weekday day period.

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 [20]. Hence, 10 test runs over each segment was done during peak hour to determine the operational 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 2. For example, the average speed in direction 1-2 was observed to be 7.08 km/h, while that in direction was observed to be 7.29 km/h, giving an overall speed of 7.17 km/h. Overall speed ranged from 3.76 km/h to 13.18 km/h, while total facility speed was found to be 8.77 km/h.

Table 2: Travel Speed at Weekday Day along different segments adjacent to Khilgaon Flyover

Segment Label	Segment Length (km)	Average Speed		
		Overall (km/h)	First Direction (km/h)	Opposite Direction (km/h)
1-2	0.52	7.17	7.06	7.29
2-3	0.41	6.46	6.53	6.39
3-4	1.25	13.18	13.11	13.26
4-5	0.32	7.52	7.65	7.39
5-6	0.81	12.52	12.36	12.69
6-7	0.49	6.63	6.64	6.61
7-8	0.52	6.56	6.55	6.57
8-9	0.74	7.12	6.99	7.26
9-10	0.28	4.03	3.94	4.11
10-11	0.47	6.60	6.54	6.65
11-12	1.52	13.18	13.20	13.16
12-1	0.14	7.95	7.61	8.32
1-8	0.89	7.74	7.61	7.88
11-13	1.09	11.98	12.14	11.83
13-14	1.69	10.41	10.25	10.57
14-15	1.17	8.74	8.57	8.91
15-16	0.30	4.98	4.93	5.03
16-17	0.84	10.18	10.07	10.29
17-18	0.13	3.76	3.89	3.64
18-2	0.64	8.45	8.35	8.55
18-3	0.74	9.09	9.19	8.99
Total Facility	14.97	8.77	8.71	8.83

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. The FFS was determined by measuring the distance travelled by a vehicle over a 90-100 ft length of segment in the mid-block part of segment and then dividing the distance travelled by time taken. The average classified FFS at weekday, day is shown in Figure 7.

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) [18]. In addition, bicycle only makes up a negligible portion of total traffic. Hence these two modes of traffic have been omitted during LOS evaluation. From Figure 7, the highest above-grade FFS occurred at weekend day (46.90 km/h) while lowest above-grade FFS occurred at weekday day (26.80 km/h). The highest at-grade FFS occurred at weekday day (16.07 km/h) while lowest at-grade FFS occurred at weekend day (12.24 km/h). It is seen that at-grade FFS is lower than above grade FFS by 60% on average.

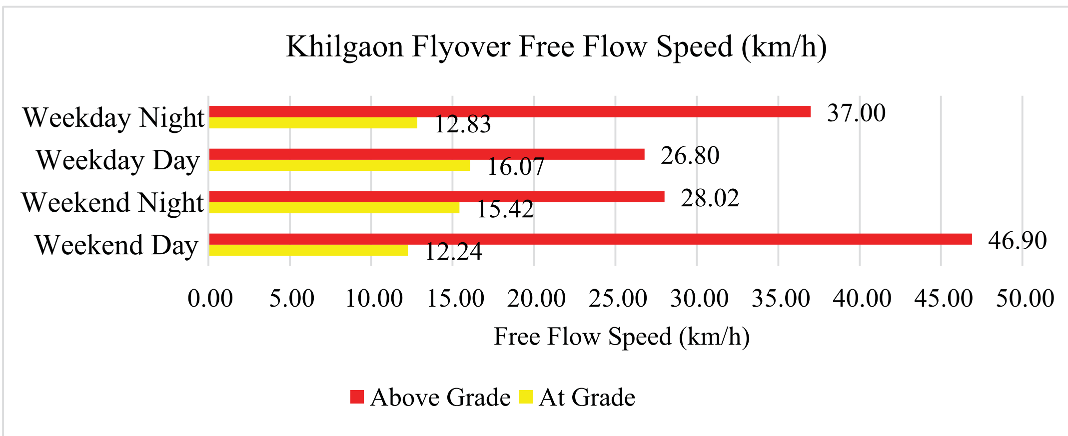

Fig 7: Free Flow Speed at Khilgaon Flyover in Various periods of Measurement

4.5 Determination of Saturation Flow Rate

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

$s = s_o f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$

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) [18]. 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 3.

Table 3: 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	12	15	12-1	12-1	5	6
	2-1	12	15		1-12	5	6
2-3	2-3	15	15	1-8	1-8	15	20
	3-2	15	15		8-1	15	20
3-4	3-4	13	18	11-13	11-13	12	21
	4-3	13	18		13-11	12	21
4-5	4-5	14	15	13-14	13-14	4	0
	5-4	14	15		14-13	4	0
5-6	5-6	12	11	14-15	14-15	8	0
	6-5	12	11		15-14	8	0
6-7	6-7	17	15	15-16	15-16	5	0
	7-6	17	15		16-15	5	0
7-8	7-8	18	11	16-17	16-17	6	0
	8-7	18	11		17-16	6	0
8-9	8-9	20	7	17-18	17-18	6	0
	9-8	20	7		18-17	6	0
9-10	9-10	10	15	18-2	18-2	5	0
	10-9	10	15		2-18	5	0
10-11	10-11	12	15	18-3	18-3	8	0
	11-10	12	15		3-18	8	0
11-12	11-12	25	15				
	12-11	25	15				

The segment capacity was then calculated using

$$c = Nsg/C$$

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 4:

Table 4: 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

Collected data were analyzed in Table 5 to determine Directional Segment Capacity:

Table 5: 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	g	N	c
															(s)	(s)	(ln)	(pcu/h)
1-2	1-2	1900	1	0.998	1	0.92	0.97	0.9	1	0.847	0.952	1	1	1229.10	236	75	3	1171.81
	2-1	1900	1	0.998	1	0.92	0.97	0.9	1	0.847	0.952	1	1	1229.10	200	35	3	645.28
2-3	2-3	1900	1	0.998	1	0.91	0.97	0.9	1	0.847	0.952	1	1	1219.08	211	78	3	1351.97
	3-2	1900	1	0.998	1	0.91	0.97	0.9	1	0.847	0.952	1	1	1219.08	236	75	3	1162.26
3-4	3-4	1900	1	0.998	1	0.92	0.98	0.9	1	0.847	0.952	1	1	1233.34	280	85	3	1123.22
	4-3	1900	1	0.998	1	0.92	0.98	0.9	1	0.847	0.952	1	1	1233.34	211	55	3	964.46
4-5	4-5	1900	1	0.998	1	0.92	0.97	0.9	1	0.847	0.952	1	1	1222.42	183	83	2	1108.86
	5-4	1900	1	0.998	1	0.92	0.97	0.9	1	0.847	0.952	1	1	1222.42	280	70	2	611.21
5-6	5-6	1900	1	0.998	1	0.92	0.98	0.9	1	0.847	0.952	1	1	1239.24	170	55	2	801.86
	6-5	1900	1	0.998	1	0.92	0.98	0.9	1	0.847	0.952	1	1	1239.24	183	35	2	474.03
6-7	6-7	1900	1	0.998	1	0.91	0.97	0.9	1	0.847	0.952	1	1	1212.40	255	75	2	713.18
	7-6	1900	1	0.998	1	0.91	0.97	0.9	1	0.847	0.952	1	1	1212.40	170	65	2	927.13
7-8	7-8	1900	1	0.998	1	0.91	0.98	0.9	1	0.847	0.952	1	1	1219.03	286	80	2	681.98
	8-7	1900	1	0.998	1	0.91	0.98	0.9	1	0.847	0.952	1	1	1219.03	255	65	2	621.47
8-9	8-9	1900	1	0.998	1	0.90	0.99	0.9	1	0.847	0.952	1	1	1222.21	283	80	2	691.00
	9-8	1900	1	0.998	1	0.90	0.99	0.9	1	0.847	0.952	1	1	1222.21	286	55	2	470.08
9-10	9-10	1900	1	0.998	1	0.93	0.97	0.9	1	0.847	0.952	1	1	1235.78	207	45	2	537.30
	10-9	1900	1	0.998	1	0.93	0.97	0.9	1	0.847	0.952	1	1	1235.78	283	73	2	637.54
10-11	10-11	1900	1	0.998	1	0.92	0.97	0.9	1	0.847	0.952	1	1	1229.10	184	46	3	921.83
	11-10	1900	1	0.998	1	0.92	0.97	0.9	1	0.847	0.952	1	1	1229.10	207	45	3	801.59
11-12	11-12	1900	1	0.998	1	0.89	0.97	0.9	1	0.847	0.952	1	1	1185.68	222	69	3	1105.57
	12-11	1900	1	0.998	1	0.89	0.97	0.9	1	0.847	0.952	1	1	1185.68	184	55	3	1063.25
12-1	12-1	1900	1	0.998	1	0.94	0.99	0.9	1	0.847	0.952	1	1	1275.72	200	55	3	1052.47
	1-12	1900	1	0.998	1	0.94	0.99	0.9	1	0.847	0.952	1	1	1275.72	222	77	3	1327.44
1-8	1-8	1900	1	0.998	1	0.91	0.96	0.9	1	0.847	0.952	1	1	1206.51	286	71	2	599.04
	8-1	1900	1	0.998	1	0.91	0.96	0.9	1	0.847	0.952	1	1	1206.51	200	55	2	663.58
11-13	11-13	1900	1	0.998	1	0.92	0.96	0.9	1	0.847	0.952	1	1	1213.90	150	45	3	1092.51
	13-11	1900	1	0.998	1	0.92	0.96	0.9	1	0.847	0.952	1	1	1213.90	184	68	3	1345.84
13-14	13-14	1900	1	0.998	1	0.94	1.00	0.9	1	0.847	0.952	1	1	1294.66	180	55	1	395.59
	14-13	1900	1	0.998	1	0.94	1.00	0.9	1	0.847	0.952	1	1	1294.66	150	25	1	215.78
14-15	14-15	1900	1	0.998	1	0.93	1.00	0.9	1	0.847	0.952	1	1	1280.89	160	45	1	360.25
	15-14	1900	1	0.998	1	0.93	1.00	0.9	1	0.847	0.952	1	1	1280.89	180	55	1	391.38
15-16	15-16	1900	1	0.998	1	0.94	1.00	0.9	1	0.847	0.952	1	1	1291.22	203	65	1	413.44
	16-15	1900	1	0.998	1	0.94	1.00	0.9	1	0.847	0.952	1	1	1291.22	160	45	1	363.15

16-17	16-17	1900	1	0.998	1	0.94	1.00	0.9	1	0.847	0.952	1	1	1287.77	229	55	1	309.29
	17-16	1900	1	0.998	1	0.94	1.00	0.9	1	0.847	0.952	1	1	1287.77	203	55	1	348.90
17-18	17-18	1900	1	0.998	1	0.94	1.00	0.9	1	0.847	0.952	1	1	1287.77	173	53	1	394.52
	18-17	1900	1	0.998	1	0.94	1.00	0.9	1	0.847	0.952	1	1	1287.77	229	60	1	337.41
18-2	18-2	1900	1	0.998	1	0.94	1.00	0.9	1	0.847	0.952	1	1	1291.22	236	71	1	388.46
	2-18	1900	1	0.998	1	0.94	1.00	0.9	1	0.847	0.952	1	1	1291.22	173	48	1	358.26
18-3	18-3	1900	1	0.998	1	0.93	1.00	0.9	1	0.847	0.952	1	1	1280.89	211	63	1	382.45
	3-18	1900	1	0.998	1	0.93	1.00	0.9	1	0.847	0.952	1	1	1280.89	173	57	1	422.03

Table 5 shows that the directional capacity of segment direction 2-3 was highest (1351.97 pcu/h) while that of segment 14-13 was lowest (215.78 pcu/h). The average directional capacity of each segment was 708.30 pcu/h, which is significantly lower than the base capacity.

LOS calculation is shown in Table 6. FFS used in calculation of LOS as presented in Table 6 only considers motorized vehicles.

Table 6: LOS Calculation

Segment	Direction	Travel Speed	Free Flow Speed	TS/FFS	Flow	Capacity	v/c	LOS
		(km/h)	(km/h)		(pcu/h)	(pcu/h)		
1-2	1-2	9.65	69.78	0.138	4887.04	1171.81	4.17	F
	2-1	10.30	69.78	0.148	4784.00	645.28	7.41	F
2-3	2-3	8.37	69.78	0.12	4231.08	1351.97	3.13	F
	3-2	7.93	69.78	0.114	4962.48	1162.26	4.27	F
3-4	3-4	17.06	69.78	0.244	4263.28	1123.22	3.8	F
	4-3	17.44	69.78	0.25	3790.40	964.46	3.93	F
4-5	4-5	9.50	69.78	0.136	3455.52	1108.86	3.12	F
	5-4	9.50	69.78	0.136	3595.36	611.21	5.88	F
5-6	5-6	15.49	69.78	0.222	2944.92	801.86	3.67	F
	6-5	15.69	69.78	0.225	3680.92	474.03	7.77	F
6-7	6-7	8.46	69.78	0.121	4496.96	713.18	6.31	F
	7-6	8.32	69.78	0.119	4253.16	927.13	4.59	F
7-8	7-8	8.41	69.78	0.12	4497.88	681.98	6.6	F
	8-7	8.20	69.78	0.118	3681.84	621.47	5.92	F
8-9	8-9	8.79	69.78	0.126	3725.08	691.00	5.39	F
	9-8	9.14	69.78	0.131	4686.48	470.08	9.97	F
9-10	9-10	4.78	69.78	0.068	4164.84	537.30	7.75	F
	10-9	5.21	69.78	0.075	3121.56	637.54	4.9	F
10-11	10-11	8.29	69.78	0.119	3166.64	921.83	3.44	F
	11-10	7.97	69.78	0.114	2496.88	801.59	3.11	F
11-12	11-12	16.09	69.78	0.231	3200.68	1105.57	2.9	F
	12-11	15.35	69.78	0.22	3139.96	1063.25	2.95	F

12-1	12-1	9.55	69.78	0.137	3595.36	1052.47	3.42	F
	1-12	9.30	69.78	0.133	3865.84	1327.44	2.91	F
1-8	1-8	10.11	69.78	0.145	5380.16	599.04	8.98	F
	8-1	10.04	69.78	0.144	5324.96	663.58	8.02	F
11-13	11-13	15.45	69.78	0.221	2806.00	1092.51	2.57	F
	13-11	15.27	69.78	0.219	3357.08	1345.84	2.49	F
13-14	13-14	11.50	69.78	0.165	1753.52	395.59	4.43	F
	14-13	11.05	69.78	0.158	1985.36	215.78	9.2	F
14-15	14-15	9.83	69.78	0.141	1870.36	360.25	5.19	F
	15-14	9.58	69.78	0.137	2171.20	391.38	5.55	F
15-16	15-16	6.13	69.78	0.088	2057.12	413.44	4.98	F
	16-15	6.19	69.78	0.089	1656.00	363.15	4.56	F
16-17	16-17	12.64	69.78	0.181	1659.68	309.29	5.37	F
	17-16	12.53	69.78	0.18	1710.28	348.90	4.9	F
17-18	17-18	4.03	69.78	0.058	978.88	394.52	2.48	F
	18-17	4.72	69.78	0.068	1062.60	337.41	3.15	F
18-2	18-2	11.16	69.78	0.16	1176.68	388.46	3.03	F
	2-18	10.54	69.78	0.151	1459.12	358.26	4.07	F
18-3	18-3	11.46	69.78	0.164	1527.20	382.45	3.99	F
	3-18	11.68	69.78	0.167	1100.32	422.03	2.61	F
Total Facility		**10.78**	**69.78**	**0.154**	**3136.30**	**708.30**	**4.43**	**F**

Table 6 shows that irrespective of capacity, the LOS at all segments adjacent to Khilgaon 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 Khilgaon. The flyover has failed to improve traffic conditions both along the flyover corridor and in the adjacent areas.

5.0 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 reveals that all 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 Khilgaon 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 Khilgaon level crossing into another intersection, namely the Malibagh Rail Gate Intersection (Intersection #11 in Figure 2). 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 built because of a political commitment to improve the safety situation around Khilgaon level crossing with aims to increase mobility, reduce congestion and improve safety for all road users. However, the flyover was constructed without proper feasibility study. That is why no engineering data such as traffic volume and delay were considered. The dearth of traffic data before construction of this flyover is a limitation of this study. So, the impact on surrounding roads before construction of this flyover could not be evaluated. Even though the principle objective was to improve safety situation, conflicting situations still remain. The degree of exposure has not been reduced rather it has increased because of rising volume of vehicular traffic, rail traffic and pedestrian movements. It is envisaged that the conflicting situation will be deteriorated further by the construction of on-going 3rd and 4th dual gauge rail tracks in Kamalapur-Tongi section [21]. Besides, temporal analysis has disclosed that overall mobility along the flyover intervention area has decreased due to high degree of congestion particularly at at-grade level. It essentially suggests that this partially grade separated flyover could not provide sustainable solution at the level crossing in terms of minimizing conflicting situation among vehicular, pedestrian and rail traffic. At the level crossing, full grade separation would be the better option to provide conflict free safer movements for both roadway and railways operation. It is also 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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