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Rail-road traffic interaction at Shaheed Ahsanullah Master Flyover

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Abstract

Among the six partially-grade separated flyovers constructed in Dhaka till July 2017, Shaheed Ahsanullah Master Flyover was found to be in the worst operating condition for at-grade traffic movements**.** A field investigation was conducted to identify and evaluate the at-grade traffic movement at Tongi Level Crossing under the flyover. The identified problems that exacerbate rail-road conflict include occupation of vehicular and pedestrian traffic on both sides of road, on-street parking, high elevation at level crossing, and excessive crossing time taken by trains. Detailed analyses of data and Computer Aided Drawing (CAD) are made to investigate the problems. At the level crossing near Tongi Railway Junction, which is one of the busiest railway stations in Dhaka City, trains are found to be crossing at slower than usual speed. Field observation revealed that average crossing time in Tongi Level Crossing is nearly double that of the other crossings using passenger trains. As compared to passenger trains, in general the freight trains take 30% longer time to cross this level crossing and thereby deteriorate the congestion level. This paper shed light on the traffic problems prevailing at Tongi Railway Crossing. Finally suitable recommendations are put forward to alleviate the associated problems.

Keywords: Level crossing, rail-road traffic movement, at grade traffic, flyover.

1. Introduction

The Government of Bangladesh has constructed eight flyovers in Dhaka city to negotiate with the omnipresent traffic congestions (Lamudi Bangladesh 2016). Eleven more are in the construction stage across the country and several projects are in planning stage as a part Vision 2021 (Planning Commission 2012). Detailed observations have revealed that of the 8 flyovers constructed in Dhaka city, 6 are partially grade separated from rail traffic and abject at-grade traffic conditions, of which Ahsanullah Master Flyover has the worst conditions. Railway operation is overseen by Bangladesh Railway, a principle transportation agency of the country, owned and managed by the Government of Bangladesh (Bangladesh Railway, 2017). Rail covers a length of 2,877.10 route kilometers including 2,541 rail-road crossings across the country. Unfortunately, eighty-five per cent of the railroad crossings are in a dangerous state as there is no lookout at 2,170 rail crossings. More than 2000 rail crossings have no traffic control devices. Lack of safety devices in level crossings have made them potential hotspots for accidents. Most victims of train accidents are pedestrians. On average, 12 people are killed in the accidents per month. (Prothom Alo 2017).

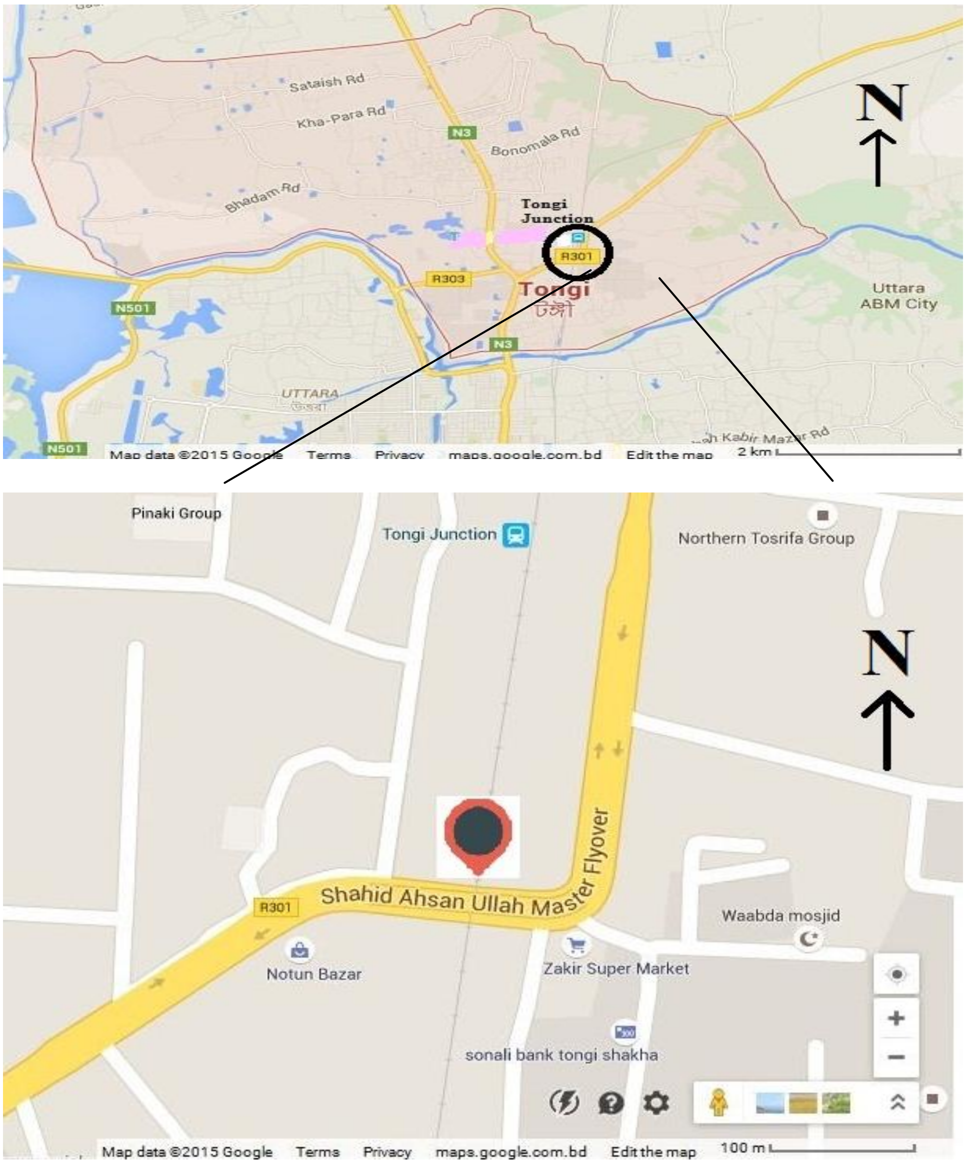

Fig. 1. Study area (Source: Google Map).

Considering the scenario described earlier, this paper highlights the key observations regarding at-grade traffic movement and conditions at Tongi Level Crossing, which is situated under Shaheed Ahsanullah Master Flyover. The objective of the field investigation is to identify and quantify the problems in Tongi Level Crossing. Besides, the study has tried to highlight the impotency of Shaheed Ahsanullah Master Flyover in alleviating those problems. Anwari *et al.* (2016) emphasized on Shaheed Ahsanullah Master Flyover because field observations revealed that the Tongi Level Crossing provides worst environment for traffic movement. Out of the five considered partially graded flyovers constructed before February 2016, the Shaheed Ahsanullah Master Flyover had been observed to have one of the lowest speeds both above grade and at-grade, indicating low mobility and capacity. Moreover, the ratio of above-grade to at-grade flow was measured to be very small. In addition, the flyover had a significant non-motorized vehicle (NMV) to total at-grade flow ratio, which hindered mobility (Anwari *et al.*, 2016).The authors of this paper studied an additional flyover called Moghbazar-Mouchak Flyover constructed after February 2016 and found that Ahsanullah Master Flyover still had the worst traffic conditions. These reasons have encouraged the authors to comprehensively investigate the problems in rail-road traffic movement at Shaheed Ahsanullah Master Flyover, highlighting problems unique to this flyover.

2. Literature review

Given the prevalence of flyovers in Dhaka city, surprisingly few studies have approached rail-road interaction methodically. Islam and Saha (2005) 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. Taleb and Majumder (2012) investigated how flyovers affected people in adjacent land. They conclude that some businessmen and landowners have experienced reduced incomes after construction of flyovers. However, the questionnaire surveys were conducted on an inadequate sample number, which may not give accurate picture of people's opinions. Besides, the paper did not use any income analysis. Uddin (2006) made important discoveries regarding seismic loading on Khilgaon flyover. Bureau of Research Testing and Consultation (BRTC, 2008) identified problems associated with Jatrabari-Gulistan Flyover and tried to offer rational solutions to those problems. Anwari *et al.* (2016) assessed conditions of partially grade separated flyovers in Dhaka city, but did not consider the variation during different times of the day. In a nutshell, none of the previous literature conducted comprehensive on-field investigations of rail-road interaction under flyovers. Hence, realizing the significance of study of rail-road interaction under flyovers this paper concentrates on Tongi Level Crossing rail-road interaction.

3. Study area

Tongi Level Crossing is located in Tongi, Dhaka on a bearing of 23°53'45.6"N 90°24'29.1"E. It is located 200 m away from Tongi Rail Junction. Shaheed Ahsanullah Master Flyover passes over this level crossing. Figure 1 shows the location of the flyover. Tongi level crossing is identified in the magnified figures. The route of flyover is marked with yellow line, while the railway line is marked black in Figure 1. The intersection of the two routes marks the location of the level crossing beneath the flyover. The flyover is 350 meters long and 7.5 meters wide. The link roads are 200 meters long. It has two ramps connecting to Tongi-Ghorashal Highway. There are two lanes in the flyover. The land on either side of the approach roads in mixed commercial and residential area. Most buildings are single-storied near the level crossing, but 5-storied buildings are also present. The construction of the flyover was started on March 26, 2006 and finished on April 7, 2015, at a cost of Tk 23.75 crore. It was inaugurated by Prime Minister Sheikh Hasina on April 11, 2015 (The Daily Star 2010). Non Motorised Vehicles (NMVs) are the most common type of vehicles moving at grade road. A sizeable number of private cars and CNGs are also pass through the level crossing. At above grade, private cars and trucks dominate the flyover user group. Local traffic travels at grade while through traffic travels above grade. The traffic composition and other characteristics were discussed in great detail in Anwari *et al.* (2016) for the observed data of 2015. This paper includes the traffic data taken in 2017 for Ahsanullah Master Flyover and compares with the data of 2015 for that flyover.

4. Methodology

A reconnaissance survey was first conducted to assess level crossing adjacent land use and surrounding conditions. Video based 15 minute classified traffic counts were made by Cordon count method for the following four periods: weekend-day, weekend-night, weekday-day and weekday-night. Data for day was collected during the morning peak hour from 9:00 am to 10:00 am. Data for night was collected during from 8:00 pm to 9:00 pm. Vehicles were then counted after analyzing video. Above grade, speed was measured using floating car survey under free-flow conditions, except for rickshaw, where the manual method was used. At the at-grade road, speed data was measured manually by using stopwatch to obtain travel time of randomly selected vehicles plying over a 100m roadway segment. For measuring queue length, video based image processing technique was used. Queue length was measured based on the vehicle road occupancy and was taken as the average length of waited vehicles in all lanes i.e. full width of the road. It was measured during the evening peak from 5:00 pm to 6:00 pm. The field survey works were undertaken between 19thMarch 2017 and 24thJuly 2017. Critical problems were identified and documented elaborately and photographs were taken for further observations.

Table 1
15 Minute Classified Traffic Count at Ahsanullah Master Flyover (PCUs)

Name of Flyover	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	32	0	60	21	73	7	17	12	841	23.83	0.31:1
	Under	311	3	6	12	7	45	0	31	7	2687	76.17	
Weekend, Night	Over	0	26	0	54	17	61	5	25	12	765	23.58	0.31:1
	Under	297	5	5	11	8	45	0	17	2	2475	76.42	
Weekday, Day	Over	0	36	0	60	29	141	14	57	39	1584	35.66	0.55:1
	Under	344	10	5	12	6	27	0	21	7	2858	64.34	
Weekday, Night	Over	0	12	0	22	13	87	8	22	19	769	44.33	0.80:1
	Under	70	15	10	23	59	16	0	15	4	966	55.67	

AutoCAD (Version 2007) was used to highlight several problems particularly the traffic circulation and their conflict with train movements. In addition, a questionnaire survey was conducted on drivers of various classes of vehicles parked on-street at at-grade level to understand their impact on traffic flow and the reasons behind parking on street. Drivers of 12 trucks, 9 CNGs, 6 pickups and 8 private cars were interviewed and taken as the sample size for this survey. Moreover, delay time (starting from the instance the level crossing gate is fully lowered to stop traffic movement to the instance the gate is raised to allow motor movement) of motor vehicles was measured at Tongi Level Crossing and after that it was compared with those measured in the Saidabad Level Crossing and the FDC level Crossing. In the definition of delay time, emphasis is given on the word “fully”, because the gate has been observed to be raised several times before it fully swings down, to allow for last minute scrambling of motor vehicles, especially rickshaws and motorcycles. Hence time was counted starting from when road traffic completely stopped moving. To assess the impact of level crossing on road traffic flow, observation was made for a total of 50 times (20 times at Tongi Level Crossing and Kawran Bazar/ FDC level crossing and 10 times at Saidabad Level Crossing). Flow interruption times were taken using stopwatch.

5. Analysis of observed traffic conditions

After gathering data both manually and using video, comprehensive analyses of the collected data have been made and the findings area presented in the following sections.

5.1 Assessment of Traffic Flow

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 requisite that their impact be judged using a common 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 Ministry of Communication (2011): 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 (Ministry of Communications, 2011). Accordingly traffic flow in terms of PCUs was obtained multiplying vehicle count data by their corresponding PCE factors.
The total flows across different times of the day are compared in the following charts.

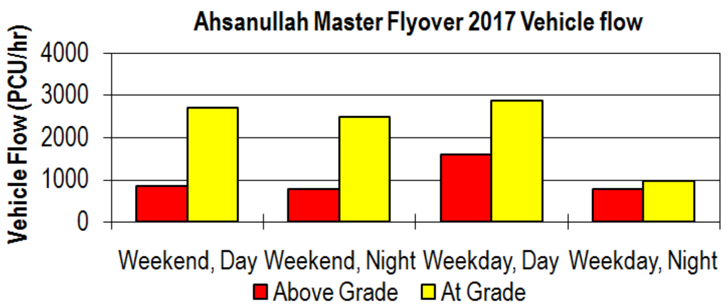

Fig. 2. Vehicle flow comparison for different grades at Ahsanullah Master Flyover for 2017.

A comparison with the data presented by Anwari *et al.* (2016) for the same flyover taken in 2015 is provided below.

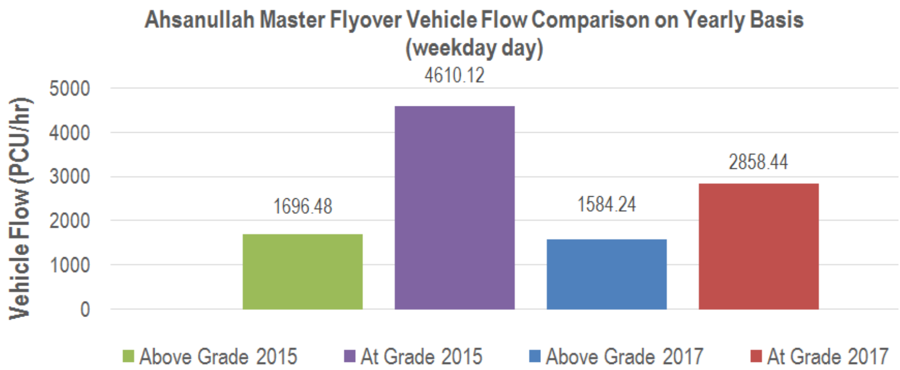

Fig. 3. Comparison on Yearly Basis of Ahsanullah Master Flyover Vehicle Flow (weekday day).

Table 1 and Figure 2 show that an overwhelming majority of vehicles continue to travel at grade, as clarified by thus degrading the rail-road traffic condition. The last column of the table showing relative usage by vehicles of road space over and under the flyover clarifies this proposition. The greatest disparity in flows between different grades is at weekend, night, with 76.42% vehicles travelling at grade and 23.58% vehicles travelling above grade. This variance decreases to a minimum of 55.67% and 44.33% respectively at weekday, night. Overall, the ratio of above-grade to at-grade flow is only 0.44:1. From Figure 2 it is seen that weekday, day showed the highest flow both at grade (2858 PCU/hr) and above grade (1584 PCU/hr). This is probably because of people travelling for work related purpose. Considering the combined situation, total day flow exceeded the night flow by 58% above grade and 61% at grade. On the other hand, total weekday flow exceeded weekend flow by 47% above grade while total weekend flow exceeded weekday flow by 35%.Comparing with 2015 data, the vehicle flow has decreased at both grades (from 1696 PCU/hr to 1584 PCU/hr above grade, and from 4610 PCU/hr to 2858 PCU/hr at grade) as shown in Figure 3. However, the at-grade to above grade flow ratio has slightly worsened from 0.38:1 to 0.31:1, indicating an increasing trend for vehicles to move at grade. Because the at-grade motor traffic make conflicts with the train movements at the level crossings at these sites, it can be essentially concluded that those three flyovers have failed in their objectives in segregating rail and road traffic and thereby unsuccessful in eliminating congestion as well as failed to improve safety issues. Rickshaw was the overwhelming major transport used at grade (84%) while human haulers were the most numerous above grade modes (25%). Table 2 shows the proportion of non-motorized vehicles (NMVs) travelling over and under flyover. NMVs refer to rickshaws/ vans and bicycles in this case.

Table 2
Proportion of NMVs Travelling Above Grade and At Grade at Ahsanullah Master Flyover

Time	Percentage of Rickshaws/ Vans		Percentage of Bicycles		Percentage of NMVs	
	Above grade	At grade	Above grade	At grade	Above grade	At grade
Weekend, Day	0.00	100.00	0.00	100.00	0.00	100.00
Weekend, Night	0.00	100.00	0.00	100.00	0.00	100.00
Weekday, Day	0.00	100.00	0.00	100.00	0.00	100.00
Weekday, Night	0.00	100.00	0.00	100.00	0.00	100.00

The total absence of NMVs travelling above grade can be attributed to the dimensions and grades of the approach ramps of flyovers that make it difficult for NMVs to get on the flyover. This means that a significant portion of traffic will always be forced to travel at-grade and come in conflict with rail, implying that there will always be conflict with rail at level crossings whether or not flyovers are present. Consequently, it can be concluded that it is never completely possible to eliminate conflicts at level crossings by continuing the design approaches adopted for flyover design in Bangladesh. Anwari *et al.* (2016) observed that nearly half of at-grade flow of all flyovers is attributed to NMVs. This implies that nearly 50% of existing vehicles will continue to come in conflict with rail. The authors emphasized on this problem in Ahsanullah Master Flyover as the largest number of vehicles passing underneath those flyovers is NMVs. Comparing with 2015 data it is found that 100% of NMVs continue to use at-grade road, strengthening the proposition that NMVs will not be the beneficiary of constructing new flyovers. In light of the above discussion, it can be concluded that the majority (69% on overall data) of the traffic travels at grade. Analyzing the yearly trend of data, it can also be inferred that majority of traffic will continue to travel (73% in 2015 and 64% in 2017 for weekday, day) at grade. Even though conversing with local people revealed that traffic congestion has eased compared to when there were no flyovers, it is evident that flow interruption and level of congestion will worsen with the ever growing size of motorized and non-motorized vehicle fleet along with high degree of pedestrian movement. Therefore, it is clear that it would not be able to make conflict free movements for both rail and road traffic in the studied flyovers, which is the prerequisite of controlling congestion and improving safety.

5.2 Assessment of operational speed

Speed of each type of vehicle was measured at each flyover to assess the mobility conditions of vehicles both at-grade and above grade. For a specific grade of a particular flyover, the speed of each class of vehicle was multiplied with the hourly PCUs of vehicle. This product was divided by the total hourly PCUs (Table 1) to obtain operating speed. The calculations were repeated for all grades (over and under flyover) and for all periods and presented in Figure 4. It is observed that the fastest average speed was in weekend night above grade (35.64 km/hr), while the slowest was in weekday, day at grade (11.08 km/hr).The combined average speed of Ahsanullah Master Flyover was 29.72 km/hr above grade and 12.70 km/hr at grade, implying a vehicle on average is 2.32 times slower in at-grade traffic. Comparing with 2015 data on Anwari *et al.* (2016) the discrepancy between at-grade and above grade average speed has decreased (3.39 times in 2015 as compared to 2.32 times in 2017). The combined average speed at day was 28.99 km/hr above grade and 12.80 km/hr at grade.

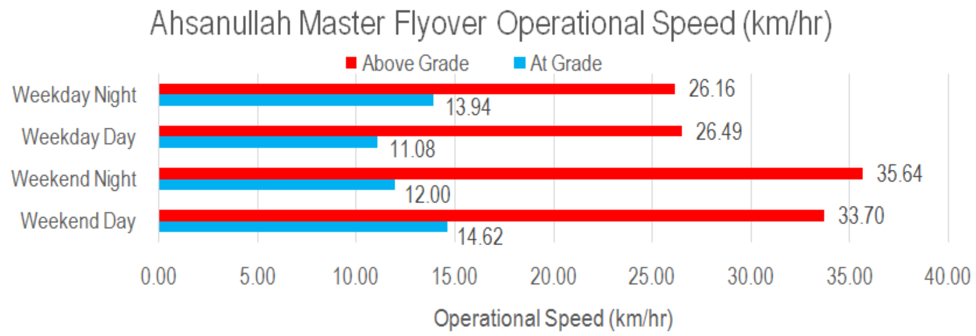

Fig. 4. Vehicle Operational Speed of Ahsanullah Master Flyover.

The combined average speed at night was 30.89 km/hr above grade and 12.54 km/hr at grade. So there is little variation in speed between day and night, meaning traffic speed is similar at both times. The combined average speed at weekday was 26.38 km/hr above grade and 11.80 km/hr at grade. The combined average speed at weekend was 34.62 km/hr above grade and 13.36 km/hr at grade. In this regard a weak relationship was observed between vehicle flow and average speed. Increase in vehicle flow reduced average speed and vice-versa.

6. Problems of at-grade traffic movement

Extensive observations and analyses of data have been effective in identifying several critical problems at and around Tongi Level Crossing.

6.1 Occupation of traffic on both sides of the road

During field observation, it is often seen that traffic coming from one direction ends up occupying both sides of the road, as shown in Figures 5 and 6. This occurs when the level crossing gate is lowered to obstruct vehicular flow. As the vehicles line up and wait for the train to pass, many of them move forward illegally to occupy the lanes intended for use of vehicles of opposite direction. The reason behind illegally occupying the lanes of opposite direction vehicle is to pass the rail crossing within the quickest period of time immediately after the train passes and barriers have been raised to allow vehicle movement. However, this type of queue formation significantly hampers traffic discharge when all the waiting vehicles start moving together. While discharging, the vehicles on the wrong side of the road eventually have to shift to the original lanes and the resultant traffic flow acts like a semi roundabout. Eventually this especial traffic circulation reduces the mobility and increase time of crossing. This bizarre traffic situation is portrayed in Figure 7 and Figure 8.

Fig. 5. Approach Road to Level Crossing (Towards Notun Bazar).

Fig. 7. Approach Road to Level Crossing (Towards Zakir Super Market).

Fig. 8. Vehicular Flow at Level Crossing.

Figure 8 shows how vehicles cross after the barrier in the original direction (circled orange) have been lowered. Figure 8 shows that vehicles from both directions are trying to pass the crossing using the same lanes. Figure 9 describes at-grade road traffic movement pattern. The green arrows indicate the path taken by vehicles coming from Notun Bazar approach, while blue arrows indicate vehicles coming from Zakir Super Market approach. The red lines represent the median of the road. As shown on Figure 10, vehicles coming from Notun Bazar approach occupy both sides of the road. When crossing the intersection, the vehicles on the wrong side of the road have to switch to the original side, as shown by the clockwise movement at intersection using green arrows. The similar is true for vehicles from the other approach. The two clockwise movements in the intersection decrease mobility at the intersection, and of the vehicles that started from the wrong side of the road on the pretext of reducing travel time experience otherwise.

Fig. 9. Vehicular Flow Exiting Level Crossing.

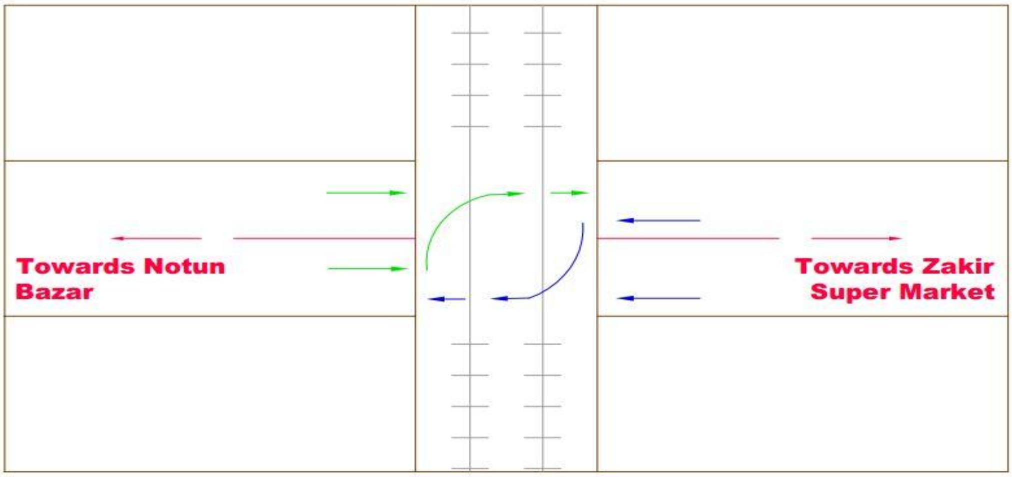

Fig. 10. Plan of Streets Showing At-grade Vehicle Movement at Tongi Level Crossing.

6.2 On-street parking

Vehicles have been observed to be parked illegally on the approach roads, as shown in Figure 10 and Figure11. It is alarming to observe that the parked trucks (circled yellow in Figure 6) at the beginning of the rail-road intersection. Subsequently, on-street parking reduces the effective road width and capacity, further reducing mobility, as can be seen in Figure11. Figure 11 shockingly demonstrates that the effective road width decreases by 7 feet, meaning only one-and-half lane, i.e. 70% of total road width is available to traffic. To analyze the extent of impact of parking on traffic flow and to understand the reasons for parking the vehicles, an open ended structured questionnaire survey was used. The sample size was mentioned in the methodology section. The questionnaire survey has revealed surprising results. The CNG drivers use the space as CNG stand, which was observed to have been occupied by 15 CNGs for 12 hours (8 am-8 pm). During that time some vehicles left the stand while others entered to fill the empty spots. Each vehicle may be kept there for as long as 24 hours if the driver doesn't get any customers. In addition, there is a stand for private vehicles which can be rented, which was observed to have been occupied by 8 cars.

Moreover, a pickup stand accommodating 10 pickups was present. Pickups can be privately rented to carry goods. The above three classes of vehicles had similar average parking times, meaning they affected traffic flow for 24 hours per day. The respondents stated that they usually did not face any restriction from authorities, except on certain days when the police evict them temporarily. However, the vehicles return to parking in the usual places as soon as the police leave.

Fig. 11. Illegally Parked Trucks (circled yellow) near Rail-Road Intersection.

Fig. 12. On-street parking at Approach Roads.

The surveyed truck had slightly differing characteristics as compared to those of other vehicle classes. On average, trucks parked for 12 hours closest to the intersection, as revealed in Figure 10. Basically these are commercials goods carrying trucks and park under the flyover for the purpose of loading and unloading goods. The surveyed trucks handled goods such as electronics, steel reinforcement bars, crockeries etc.

The respondents answered that they were forced to park on-street because their destination did not have adequate parking facilities. They usually do not face any objection even from the policemen. Thus these trucks directly affected the junction capacity.

6.3 High elevation at level crossing

The approach roads are at a lower elevation compared to the rail track (6 inch/ft), and the change in grade is abrupt in the level crossing. Hence, it is difficult for rickshaws to quickly get onto the level crossing, because they have to negotiate the steep grade. The problem becomes worse if a rickshaw is carrying heavy load. Depending on the amount of load being carried, it may take a rickshaw up to one minute just to get on the level crossing, after people have pushed it from behind. This is time loss for the rickshaw-puller and the passenger. This time loss might be prolonged if the rickshaw cannot cross before the level crossing gate is lowered.

6.4 Longer crossing time taken by trains

Tongi Station is just 200 meters away from the level crossing. This is a busy junction, where numerous trains stop or at least have to negotiate each other. So, trains travel at reduced speed as they approach the station and cross the level crossing. Thus they take more time and thereby increasing the level of congestion. To ascertain this problem, the time taken by train to traverse this crossing was measured and then compared with travel times obtained from other crossings, namely, from Saidabad level crossing and FDC level crossing. Crossing time for 10 freight trains and 10 passenger trains were measured as they passed the level crossing in Tongi. The times recorded are provided in the Table 3.

Table 3
Measured Crossing Times at Selected Level Crossings

Reading No.	Time taken (seconds)				
	Saidabad Level Crossing	FDC Level crossing		Tongi Level Crossing	
	Passenger Trains	Passenger Trains	Freight Trains	Passenger Trains	Freight Trains
1	230	242	421	423	571
2	248	238	447	419	549
3	221	283	432	469	595
4	274	254	457	461	601
5	287	246	472	495	594
6	244	237	417	443	588
7	262	229	434	427	554
8	254	268	436	404	574
9	261	251	452	412	620
10	249	263	453	456	568
Mean	253	251.1	442.1	440.9	581.3
Standard Deviation	19.488	16.401	17.117	27.46	20.99

Table 3 shows that the average crossing time in Tongi Level Crossing is nearly double that of the other crossings using passenger train. On the other hand, freight trains take 30% longer time to cross Tongi Level Crossing.

7. Conclusions and recommendations

Field investigations of traffic movement in Tongi Level Crossing have tried to highlight graphically the afflicting problems, including the peculiar clockwise motion at level crossing. The investigation has found trains to take longer than average time to cross junction because of presence of Tongi Rail Junction nearby. In addition, excessive side friction in the form of on-street parking has found to be increasing delay and queue length. Based on this investigation and the analysis in previous studies it can be concluded that though through traffic have benefited due to this flyover, but as a whole the local traffic are still suffering even after construction of the Shaheed Ahsanullah Master Flyover. The filed investigation prompted some remedies that are to be taken urgently in Shaheed Ahsanullah Master Flyover. Among them, on-street parking needs to be prohibited and police need to monitor the site round the clock. In addition to construction of self-enforcing physical measure like installation of extended divider with splitter nose, the gatemen need to be properly instructed not to let any vehicle pass through to go to the wrong traffic direction. Moreover, pedestrian foot-over bridges need to be constructed near the level crossing and pedestrians need to be encouraged to use the foot over-bridges. For smooth driving over the level crossing particularly by NMV users, the top surface of approach roads need to be adjusted with respect to the level crossing elevation.

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