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Improving Traffic Operations at Two Closely-Spaced Intersections on Begum Rokeya Avenue Near the Pallabi Metro Station in Dhaka City

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Abstract

This study attempts to improve traffic operations at two closely-spaced intersections on Begum Rokeya Avenue (BRA) --- a two-way multilane arterial roadway in Dhaka city that runs in the north-south direction between Mirpur DOHS and Bangladesh National Parliament. The intersections (i.e., BRA at Road # 8, and Mirpur Ceramic Road, respectively) are located on the north side of the Pallabi Metro Station and are managed by traffic police. There exist major operational flaws at both intersections as they accommodate nonstandard (unconventional) movements while poorly delineating lane groups and permitting inappropriate turns. The purpose of this study is to (1) identify and assess safety and operational issues at both intersections; (2) reconfigure/redevelop intersection layouts including lane groups and control plans (hereafter proposed scheme) for safer and improved operations. Traffic data including turning movements and classification counts are collected in the peak travel hours and roadway inventories and measurements are taken. Highway Capacity Manual methodology has been employed to measure control delay and level of service at intersections. It is found that the proposed scheme has the potential to improve traffic operations significantly. Furthermore, the proposed scheme qualitatively improves traffic safety at both intersections by eliminating a large number of existing potential (vehicle-vehicle and vehicle-pedestrian) conflict points.

Keywords: *Traffic Operations; Arterial Intersection; Begum Rokeya Avenue/Sharini; Pallabi Metro Station*.

1 Introduction

Intersections are critical elements on any roadway; and poorly operated and managed arterial intersections are the primary source of congestion as well as hot spots for traffic collisions in urban areas (Chowdhury, 2014a, 2014b). This study attempts to improve traffic operations at two closely-spaced (approximately 550 ft apart) un-signalized (traffic police controlled) intersections on Begum Rokeya Sharani/Avenue (BRA). BRA is a multilane (3 lanes in each direction) urban arterial that passes through greater Mirpur area and runs in the north-south direction between Mirpur DOHS (Mirpur Ceramic Road) and Bangladesh National Parliament (Bijoy Sharani). As shown in Fig. 1, the two studied intersections are located on the north side of Pallabi Metro Station (PMS). The first intersection (i.e., BRA at Road #8 also called Pallabi intersection) is located at the north end of Palllabi Metro station and the second one (i.e., BRA at Mirpur Ceramic Road also called MCR intersection), a T-intersection, is located further north of the first intersection. BRA can generally be characterized as non-lane based roadway permitting heterogeneous traffic. These intersections are poorly planned, designed, and operated. There exist major operational flaws at both intersections as they accommodate nonstandard (unconventional) movements while poorly delineating lane groups and permitting inappropriate turns. Currently, these two intersections are manually controlled (managed) by traffic police and they remain congested during the peak travel hours. To improve traffic flow on BRA as well as to provide multimodal ground access to PMS, safety and operational efficiency at both intersections need to be improved. The purpose of this study is to (1) identify and assess the safety and operational issues at both intersections; (2) reconfigure/redevelop intersection layouts including lane groups and control plans (hereafter proposed scheme) for safer and improved operations.

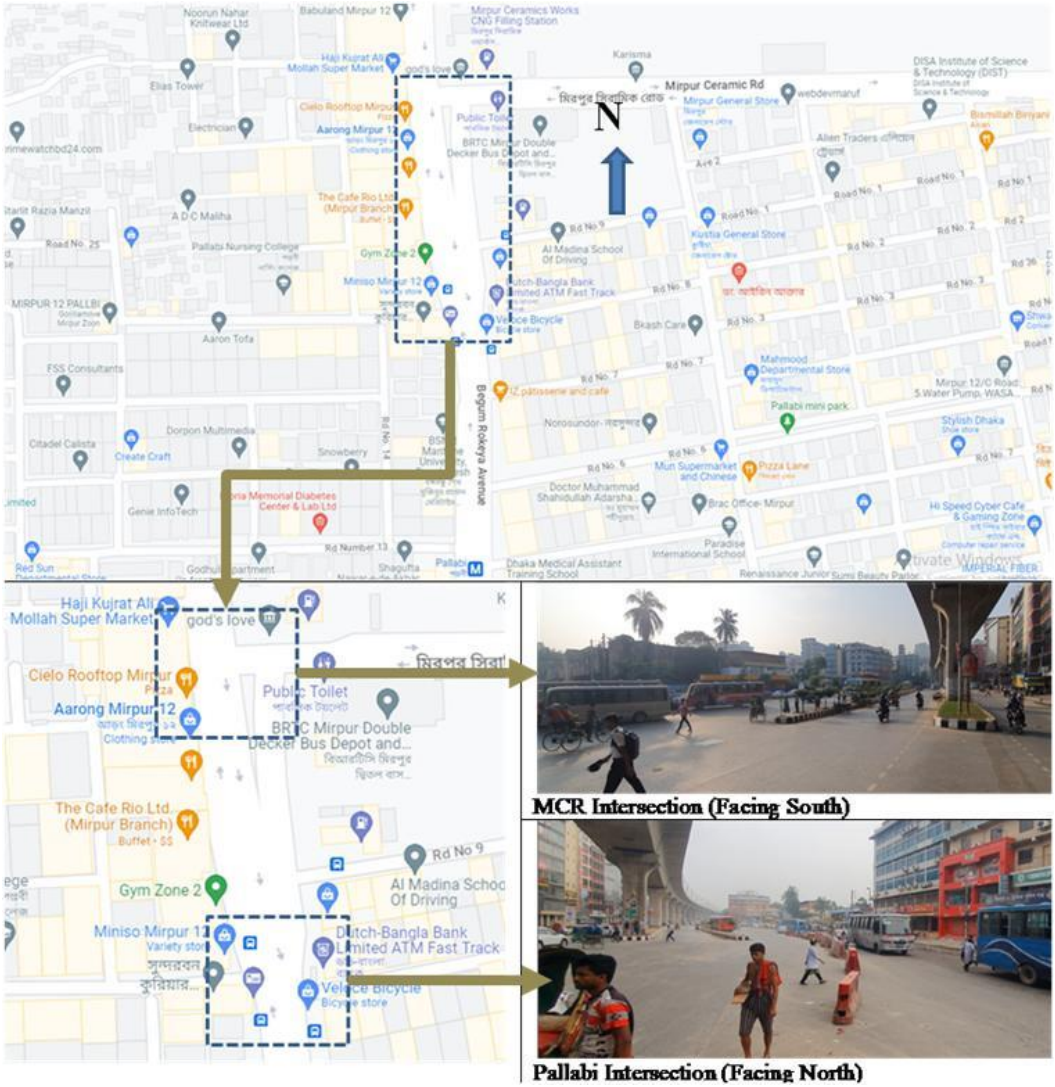


Figure 1. Study area (the Segment of BRA and its associated two closely spaced intersections).

2 Methodology

In order to achieve the aforementioned objectives, the methodology includes both qualitative and quantitative research approaches. Roadway and intersection inventories including measurements (i.e., geometric, lane width, and right of way details) are taken and layouts of both intersections including the segment of BRA between them are drawn in Fig. 2a.

Reconnaissance surveys including field observations are made; notes and images are taken as part of field visits; and safety and operational issues are identified qualitatively. Key issues that are identified include: (a) formal crosswalks are missing at both intersections and thus, pedestrians cross BRA haphazardly (indiscriminately) compromising their safety (Fig. 3.2b); (b) pavement/lane markings are poor/missing (Fig. 3.2b); (c) signs indicating permitted and prohibited turns are missing; (d) some vehicles are found to be moving in the wrong direction (Fig. 3.1a, 3.2a); and (e) vehicles and pedestrians are found to be disobeying traffic rules (3.1c, 3.2b) etc.

Video recording technique is applied to collect vehicular and pedestrian data (i.e., vehicular turning movements and classification counts; and pedestrian crossing counts). The data are collected simultaneously at both intersections in the AM (7:30 AM-8:30 AM) and PM (5 PM-6 PM) peak hours on three week days in November 2022. The video recorded data are post processed to develop 3-day average balanced network volumes (veh./h). However, to keep the manuscript at a manageable size as well as to ensure a conservative analysis, this study utilizes PM peak hour data for traffic operations analysis purpose. Based on the classification counts, the overall composition of traffic (i.e., distribution of vehicular modes in percentage) in the studied intersections is computed and shown in Fig. 4.1. The figure shows that car is the dominant mode in the traffic stream. However,

a large number of buses are observed on MCR and BRA as buses operate on them (both directions), while Rickshaws (Non-motorized vehicles) are found to be the dominant mode on crossing roads (i.e., side streets/local roads). Considering that there exists speed differential between the motorized and non-motorized vehicles, it has been decided to ban non-motorized vehicles (Rickshaws and Bicycles) on BRA under the proposed scheme (Fig. 2b). The balanced network volumes (excluding the non-motorized vehicles) are then converted to Equivalent Passenger Car Units (EPCU) (see Fig. 4.3) by utilizing the passenger car equivalent factors (RHD, 2000). The pedestrian crossing volumes (i.e., 1800 ped./h at the Pallabi intersection and 450 ped./h at the MCR intersection) on BRA are also shown in Fig. 4.3.

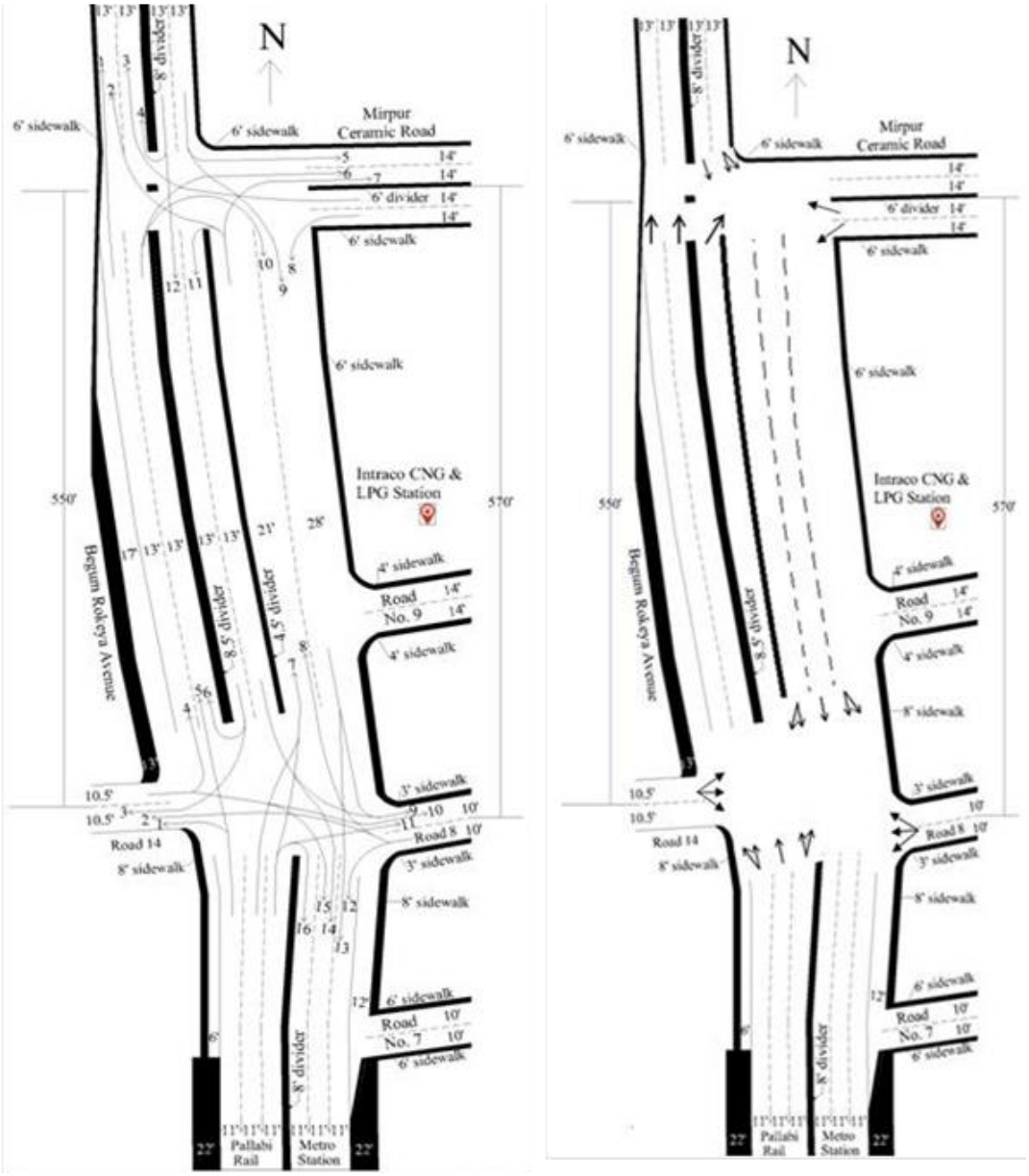


Figure 2a: BRA (layouts of the existing intersections showing all conflicting movements)

Figure 2b: BRA (layouts of the redeveloped intersections)

Figure 2. Study roadway segment and intersections (existing and proposed layouts).

Travel time surveys (including running and delay times) are conducted concurrently with the vehicular counts by utilizing a floating car technique (Ross et. al., 2011). Four survey routes are identified and ten travel time runs are performed on each route and average intersection approach specific delay times are calculated. Fig. 4.4 shows the control delays (i.e., the intersection induced delay time component of travel time) at selected intersection approaches and their corresponding Level of Service (LOS). LOS (varies between A and F) is a quality measures describing operational conditions of intersection approaches based on control delays (sec/veh).

The first five LOS (i.e., between A and E) describes under-saturated operations, while LOS F describes oversaturated (congested) operations (HCM 2010; Ross et.al., 2011).

Mirpur Ceremic Road Intersection **Pallabi Intersection**

3.1a. Facing south

3.2a. Facing South

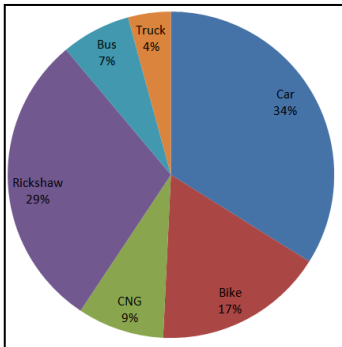
3.1b. facing south

3.2b. Facing North

3.1c. facing north

3.2c Facing North

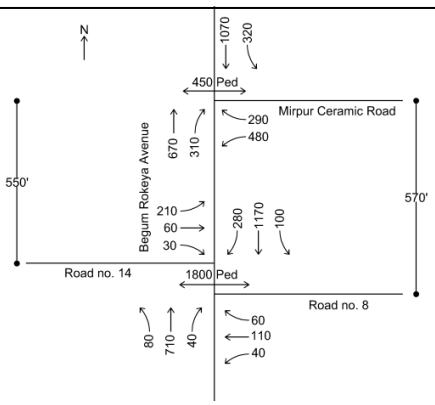
Figure 3. Existing operational and safety Issues as identified during the field visits.



4.1 Vehicular distribution

Vehicle Type	PCE Factors
CNG	0.75
Car	1
Bike	0.75
Truck	3
Mini-Truck	3
Bus	3
Mini-Bus	3
Human Hauler	0.75
NMVs	2

4.2 Passenger Car Equivalent Factors



4.3 Balanced Volumes (PCEU) excluding NMV

Intersection	Pallabi Intersection		Mirpur Ceramic Road Intersection		
Approach (movement)	NB (T)	SB (T)	WB (R)	NB (T)	SB (T)
Dealy (sec/veh)	91	178	124	55	140
LOS	F	F	F	D/E	F

4.4 Average Intersection Delay based on travel time survey

Figure 4. Vehicular distribution, vehicular volumes (PCEU) and existing intersection approach delays.

Finally, the proposed scheme (Fig. 2b) has been developed by reconfiguring/redeveloping intersection layouts including lane groups. Signal control plans are also developed for both intersections. At this planning level study, simple two-phase pre-timed signal with 90s cycle length is considered for both intersections. It is to note that the 90 seconds cycle length is appropriate for closely-spaced intersections on urban arterials (Chowdhury 2014a) and joint optimization of signal timing plans for coordinated operations is beyond the scope of this study. However, the green split for each signal phase is iteratively optimized using the Highway Capacity Software (HCS) (HCM 2010). Table-1 shows major inputs used in HCS as well as HCS generated outputs (i.e., v/c ratio, control delay and Level of Service (LOS) etc. for intersections and their associated approaches).

Table 1. HCS analysis (intersections with proposed improvements).

Intersection	**Pallabi (BRA@Road # 8)**												**Mirpur Ceremic Road (BRA@MCR)**					
Approach	**EB**			**WB**			**NB**			**SB**			**WB**		**NB**		**SB**	
Turning Movement	L	T	R	L	T	R	L	T	R	L	T	R	L	R	T	R	T	R
No. Lanes	0	1	0	0	1	0	0	3	0	0	3	0	1	1	2	1	2	
Lane Group		LTR			LTR		LT	T	TR	LT	T	TR	L	R	T	R	T	TR
Volume (PCEU/hr)	210	60	60	40	110	60	80	710	40	100	1170	280	480	290	670	310	1070	320
Signal Timing Plan	Two phase signal (SBR protected plus permitted)												Two phase signal (NBR permitted plus protected)					
Green (G), sec	27			27			28			53			22		55		41	
Tellow (Y), sec	3			3			3			3			3		3		3	
All Red (AR), sec	2			2			2			2			2		2		-	
V/C Ratio	0.62			0.5			0.66			0.88			0.8	0.66	0.29	0.75	0.93	
Dealy (sec/veh)	32.8			30.1			29.6			5.6			52.8	38.1	3.5	42.4	34.5	
LOS	C			C			C			A			D	D	A	D	C	
Intersection Delay	**17.1 (sec/veh)**												**29.9 (sec/veh)**					
Intersection LOS	**B**												**C**					

4 Analyses of Results and Discussion of Major Findings

As indicated before, both qualitative and quantitative approaches are taken into consideration in the comparison of safety and operational performance of existing and proposed schemes. As can be seen in Fig. 2a, under the existing scheme, north and southbound through movements are crisscrossed. This kind of operations is very unusual and non-standard as it creates confusion and major safety hazard as vehicles move through the intersections (TRB 2010; AASHTO 2011; Ross et.al., 2011). Consequently, it leads to inefficient and unsafe operations. Furthermore, the existing scheme (Fig. 2a) reveals that there exist a large number of potential conflict points at both intersections. As a surrogate or indirect safety measure, these conflict points (vehicle-vehicle and vehicle-pedestrian) makes existing intersections very unsafe. Contrary to the existing scheme, the proposed scheme not only reduces the potential conflict points (Fig. 2b) but also eliminates most of them as the intersections are signalized (Ross et. al., 2011.). A number of other improvements of the proposed scheme include: (a) designation of lane groups makes turns safer, efficient and more direct; and (b) placement of formal pedestrian crosswalks and protection of pedestrian crossing movements as part of signal controlled intersections would enhance pedestrian safety further. Furthermore, all safety and operational issues as identified in the methodology section (Fig. 3) are recommended to be corrected under the proposed scheme.

As shown in Fig. 4.4 and Table-1, comparing the control delays under the existing and proposed schemes it is found that the operational benefits of the proposed scheme in terms of delay time savings for northbound and southbound through traffic at Pallabi intersection are 61.4s (=91-29.6), and 172.4s (=178-5.6) sec/veh, respectively; and for northbound through, southbound through and westbound right turning traffic at MCR intersection are 51.5s (=55-3.5), 105.5 (=140-34.5), and 85.9 (=124-38.1) sec/veh, respectively. Table-1 further shows that the Pallabi and MCR intersections under the proposed scheme operate at LOS B and C, respectively meaning that the intersections would maintain very stable (uncongested) operations.

5 Conclusions and Recommendations

In this study, traffic operations at two closely-spaced (approximately 550 ft apart) intersections on BRA have been improved. Particularly the safety and operational performance of the existing scheme (intersections) are assessed; intersection layouts are redeveloped including lane groups and control plans (two-phase pre-timed signal) for safer and improved operations. The proposed scheme is assessed/ evaluated from the perspective of safety and operational benefits. A qualitative approach (i.e., reconnaissance surveys; field observations of safety issues including conflict studies) is used to assess the safety benefits and quantitative approach (i.e., travel time/delay survey and HCS generated control delay and LOS analysis) is used to measure the operational benefits of the intersections under the existing and proposed schemes. The conclusion is that the proposed

scheme has the potential to improve traffic safety and operations at both intersections. Although not studied explicitly, however, it is likely that the proposed scheme with safer and improved traffic operations on the studied segment of BRA would reduce overall travel time, fuel consumption, and vehicular emission.

At this planning level study, no attempt has been made to optimize coordinated signal timing plans. Thus, the future study should focus on optimizing time of the day based (AM, MD, PM etc) coordinated signal timing plan for field implementation purpose. Considering that the Metrorail will be fully operational soon, it requires improving traffic operations on BRA and pedestrian circulations around the Pallabi Metro-station through the studied intersections. Therefore, the future study should also focus on assessing the benefits of providing integrated grade separated pedestrian crossings at the Pallabi intersection on BRA while connecting the Pallabi Metro-station (Chowdhury et. al, 2020; Chowdhury and Sakib, 2021; Chowdhury et. al., 2023).

AUTHOR CONTRIBUTIONS

The first author (Md. Shoaib Chowdhury) has planned, conceived (scope, objective, & methodology), performed (developed and analyzed schemes) & prepared/written the manuscript. The coauthors have led the data collection effort (collected, and compiled) and prepared numerous tables/figures and images under the supervision/ direction of first author.

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