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Traffic Congestion Control at Intersection of Chattogram City Using Channelization & Signaling System- A Case Study

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Abstract

Chattogram is the 2nd largest city of Bangladesh which faces frequent traffic congestion at intersection where different modes of vehicles come in contact to each other from different roads. This congestion degrades the economic development of Chattogram as well as for the whole country. There are many important intersections in Chattogram city. In this study, Kazir Dewri intersection has been chosen because it is one of the busiest intersection of Chattogram city which faces traffic congestion problem in recent years. First of all, geometric elements of existing rotary intersection are properly investigated to verify the comprising with the existing traffic volume. So traffic volume data is counted to check the capacity of the intersection as mini roundabout. In this study, causes of traffic jam of the intersection is properly observed and some remedial measures are proposed to solve this problem. Signaling and channelization are proposed for simultaneous operation to increase the efficiency of the intersection. The combination of signaling and channelization has greater significance that will offer the intersection traffic jam free along with other nearest intersection.

Keywords: *Intersection, Geometric elements, Traffic congestion, Channelization, Signaling system.*

1 Introduction

Without an appropriate transportation system it is quite impossible to achieve development of a country. There are so many traffic controlling system available in a road. Of them, Channelization & Signaling is mainly used to control the traffic flow in intersection. An intersection always requires a careful assessment of its design, which has to be consistent with its purposes. Due to the rapid industrial growth there are an increasing number of different types of vehicles. This is the reason why the issue is becoming worse. In this study, the existing geometric elements are firstly measured and compared with the standard one (IRC & AASHTO). It is needed to be done to find out if there is any fault in geometric elements. Traffic volume also needed to design of signal (Reddy, B.S. and Reddy, N.V.H., 2016) and channelization (Khanna, S.K & Justo, 2001). Existing drainage conditions also very important for intersection capacity because poor drainage condition will cause water logging problem which will interrupt to vehicle movement. Figure 1 and Figure 2 shows the present traffic conditions of Kazir Dewri intersection.

Figure 1. No traffic management & signalling

Figure 2. Parking of vehicles in the road way

From the above discussion, the following objectives are selected for the present study.

- To investigate the existing geometric elements of the intersection.
- To count the traffic volume at that intersection for verifying geometric elements & traffic capacity.
- To design an appropriate signaling system at that intersection.
- To propose channelization at the intersection.

2 Methodology

The successive processes are to be done in order to accomplish the necessary objectives, have shown in Figure 3.

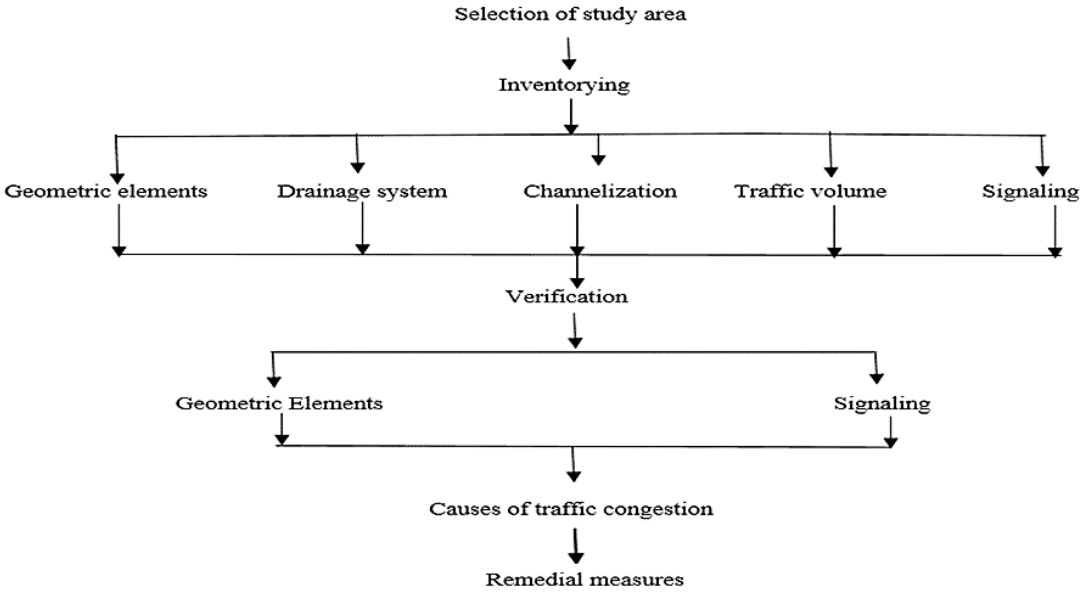

Figure 3. Workflow diagram

2.1 Selection of the study area

A preliminary survey has been conducted with the important intersections in Chattogram city (New Market, Oxygen, 2 No Gate, Anderkilla, Jamal Khan, Kazir Dewri etc.) and Kazir Dewri holds the most importance in Chattogram City. Recently, the construction of Elevated Expressway Project from Shah Amanat International Airport to Lalkhan Bazar is near to finish. So, it is expected that a huge traffic will be entering at Kazir Dewri intersection. After considering the importance of Kazir Dewri intersection, the area is selected.

2.2 Field Survey

The existing Geometric elements & Traffic volume at the intersection have been taken with care & attempted carefully to find out the problems by comparing with standard value that are affecting the congestion.

2.2.1 Footpath

The existing footpath dimensions of Kazir Dewri intersection are presented in Table 1.

Table 1. Width of Footpath

Approach Road	Direction	Width (m)	AASHTO Standard
IEB Road	Left	3.35	Min. 1.5m
	Right	3.58	
Chatteswari Road	Left	3.35	
	Right	1.68	
S S Khaled Road	Left	0.61	
	Right	4.27	
Jubilee Road	Left	5.18	
	Right	4.95	

2.2.2 Drainage facility

Drainage system of Kazir Dewri intersection has investigated and presented in Table 2.

Table 2. Existing dimensions of drainage condition

Road	Left side open drain width	Right side open drain width
IEB Road	1ft.	1ft.
S S Khaled Road	No open drain only covered drain	No open drain only covered drain
Chatteswari Road	No open drain only covered drain	No open drain only covered drain
Jubilee Road	1ft. 2 inch.	1ft. 6 inch.

2.2.3 Geometric elements of rotary intersection

Performance of a rotary intersection mostly depends on its geometric elements. The width of all carriageway are close to standard value 7m. Diameter of Rotary Island is 5.79m. Figure 3 shows all dimensions of geometric elements. Table 4 shows comparison between manual and digital surveyed data.

Table 3. Width of Carriageway

Approach Road	Direction	Width (m)	IRC Standard (2 lane)
IEB Road	Left	6.71	7m
	Right	6.71	
Chatteswari Road	Left	6.25	
	Right	5.59	
S S Khaled Road	Left	7.77	
	Right	7.77	
Jubilee Road	Left	6.10	
	Right	7.77	

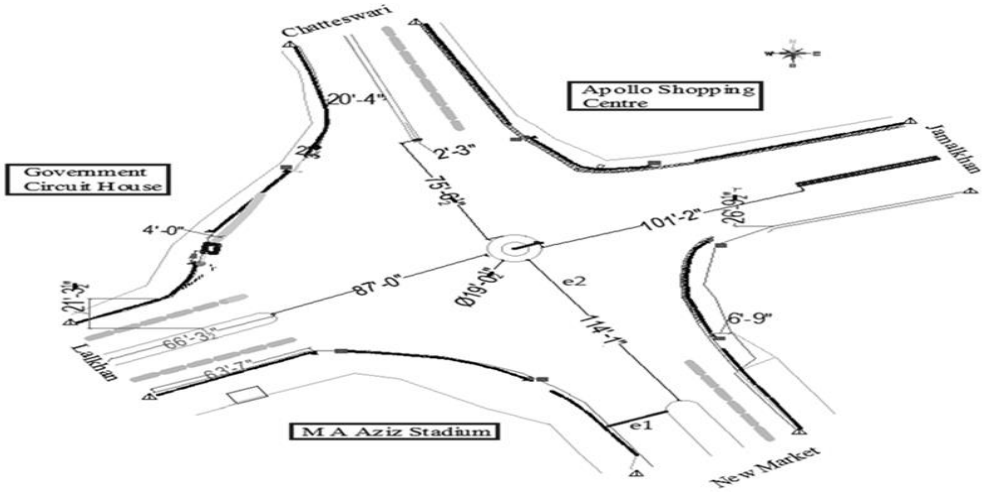

Figure 3. Existing geometric elements

Table 4. Comparison between Manual & Digital Survey Data

Geometric Elements			Footpath (m)	Carriageway (m)	Entry width (m)	Exit width (m)	Weaving Length (m)	Weaving Width (m)	Radius of Rotary Island (m)
Manually Measured	Chatteswari Road	L	3.35	6.25	6.28	22.26	25.46	17.77	5.79
		R	1.68	5.59					
	Jamalkhan Road	L	0.61	7.77	7.77	30.79	21.98	22.78	
		R	4.27	7.77					
	New Market Road	L	5.18	6.1	6.1	34.76	28.96	23.93	
		R	4.95	7.77					
	Lalkhan Road	L	3.35	6.71	6.7	26.52	45.27	20.11	
		R	3.58	6.71					
Digital Survey Data	Chatteswari Road	L	3.34	6.22	6.3	23.1	24.96	18.32	5.79
		R	1.70	5.58					
	Jamalkhan Road	L	0.59	7.82	7.57	28.71	22.71	22.56	
		R	4.31	7.82					
	New Market Road	L	5.16	6.12	6.15	34.87	28.04	22.89	
		R	5.01	7.82					
	Lalkhan Road	L	3.33	6.67	6.77	26.98	44.87	20.71	
		R	3.51	6.66					
Standard Dimensions According to AASHTO			min 2.4	14 (approx.)	7	7	min 30	10.5	-

2.3 Traffic volume

Traffic flow counts were undertaken at Kazir Dewri intersection for all directional traffic. The traffic was counted by high definition video camera. The peak hour data of traffic flow is converted to passenger car unit (PCU) and presented in the Figure 4.

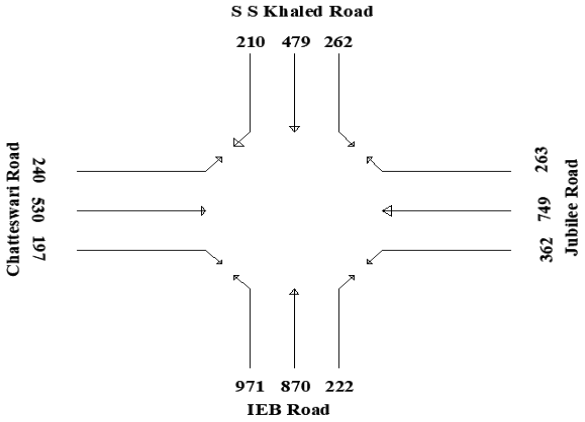

Figure 4. Traffic flow data of peak hour (PCU/hr.)

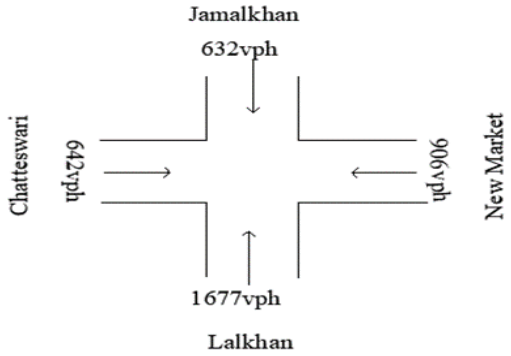

Figure 5. No. of vehicles in each road (vph)

2.4 Verification of rotary

- The minimum diameter of a rotary should be 22m (Kadyali & Lal, 2006). The existing diameter of the rotary is 5.8m which is very smaller than standard value. So, the existing intersection should be treated as mini roundabout. (Khanna, S.K & Justo, 2001)
- The ratio of $\frac{w}{l}$ should be 0.12-0.40 (Kadyali & Lal, 2006). But in this case, ratio is above 0.4.
- Radius at entry for a rotary at urban area should be in a range of 15-25 m (Kadyali & Lal, 2006) but here in Kazir Dewri intersection the entry width is very less than standard value for all approach road.
- A rotary requires more land and may not be feasible in this built up area of Kazir Dewri. So mini roundabout is preferable.

2.5 Mini roundabout

Diameter of central island of Kazir Dewri intersection is 5.79m is close to a mini roundabout diameter which is 8m. So the capacity of Kazir Dewri intersection is checked as mini roundabout here. (Khanna, S.K & Justo, 2001)

According to Blackmore equation, the capacity on the exit of mini roundabout is, $q=k\ (\sum w+a^{0.5})$……....eq^{n}1

Total entry of volume (q) for the mini roundabout at **IEB road** to **Chatteswari road** approach is calculated by using eq^{n}1 is given below.

$a=3962.7m^2$ & $k=70$(for 4 way junction), $\sum w = 13.41m$

And the practical capacity, $q=k\ (\sum w+a^{0.5}) = 70*(13.41+3962.7^{0.5}) = 5345.2 > 2063$ PCU/hr.

Similarly, for the mini roundabout at **S S Khaled road** to **Jubilee road** approach: q=5377.4>969 PCU/hr.

For the mini roundabout at **Chatteswari road** to **S S Khaled road** approach: q=5235.3>967 PCU/hr.

For the mini roundabout at **Jubilee road** to **IEB road** approach: q=5495>1374 PCU/hr.

From this above calculation it can be seen that the mini roundabout is quite satisfactory for the intersection.

3 Causes of traffic jam

Some important causes of traffic jam that are investigated are given below.

- ✓ Lack of signaling system
- ✓ Movement of pedestrian through the road
- ✓ Footpaths are occupied by the hawkers
- ✓ Improper drainage
- ✓ Traffic mismanagement
- ✓ Illegal parking of vehicles.

4 Remedial measures

Some remedial measures have been proposed to control traffic congestion problem.

a) Traffic rules should be strictly imposed. All drivers and road users should maintain those rules.
b) All hawkers should be rehabilitated another place to clear footpath for movement of pedestrians.

c) Channelization is proposed in article 4.1 should be done to avoid points of conflicts.
d) Signaling system is designed in article 4.2 should be adopted as early as possible.
e) Illegal parking of vehicles should be strictly prohibited.
f) If any violations of traffic rules are seen, legal punishments must be given by the authority instantly to discourage the violation of traffic rules.
g) Providing parking facilities but stoppage distance should be maintained.

4.1 Proposed Channelization

A Channelization is proposed for Kazir Dewri intersection. All fencing, islands used for channelization is shown in Figure 6. The minimum stopping distance of 25m between the Give-way line and the point of conflict with a vehicle from the left is provided. This is the dimension X=105.75 ft. in the Figure 6. The width between traffic islands and the roundabout shown as dimension Y=61.75 ft. in Figure 6 which is not less than the total lane width at the entry preceding it, i.e. dimension shown as Z=50.7 ft. in the same figure. So, Mini roundabout is more suitable. (Khanna, S.K & Justo, 2001)

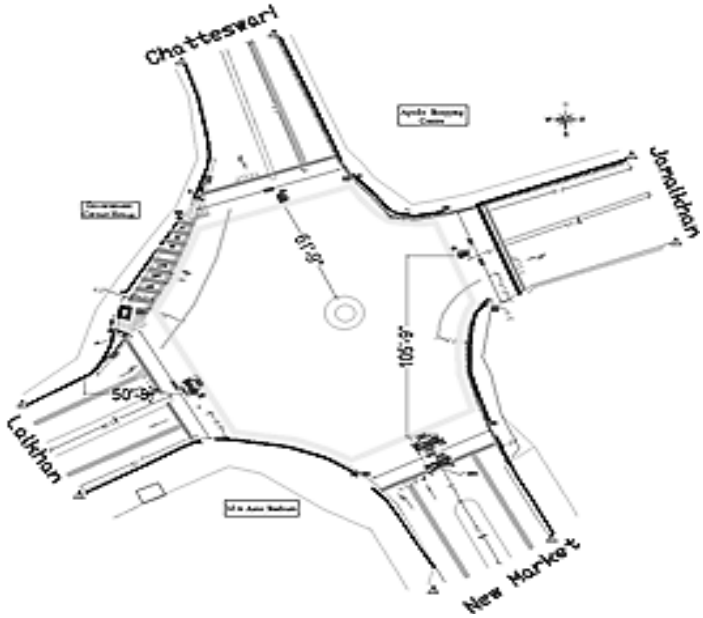

Figure 6. Dimension of proposed Channelization

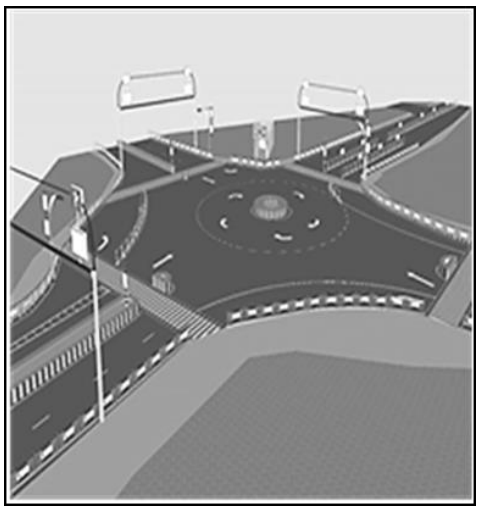

Figure 7. Proposed Channelization

4.2 Design of signal

A suitable signaling system is designed for Kazir Dewri intersection (Reddy, B.S. and Reddy,N.V.H.(2016). In Kazir Dewri intersection there exists 4 approach way all are 2 way roads. The design of simple two-phase Kazir Dewri intersection is given below: (Khanna, S.K & Justo, 2001)
For design of signal, truck factor 1.5 and right turn factor 1.6 are used.
N_1 & N_2 are PCE per lane in each direction.
Clearance interval (sec), $Y= t+\frac{v}{2a}+\frac{w+l}{v}$……eq^n 2
Where, t= Perception time (sec) =1 sec
v=Approach speed of clearing vehicle (ft. /sec)
a= Deceleration rate of clearing vehicle = 15ft. /sec
w=width of opposite lane (ft.)
l=length of vehicle =20ft.
Time for stop: $R= t_r+\frac{w}{v}$……..……. eq^n 3
Where, t_r= Pedestrian startup time = 5sec
w=Width of same street (ft.)
v= walking speed = 3.5 ft. /sec
Red time in one direction = (Green + Yellow) time of other direction
$R_1= G_2+Y_2$ …….eq^n 4 & $R_2=G_1+Y_1$..... eq^{n}5
$S_1=S_2=2.5$ sec
The no. of vehicles per hour in each road of Kazir Dewri intersection are presented in Figure 5 for designing of signal.
Main Street traffic volume =1677 vehicles/hr
Side Street traffic volume =906 vehicles/hr

Percent of truck at main street 2.5%
Percent of truck at side street 6.62%
Percent of right turn at main street 13%
Percent of right turn at side street 15%
Using truck factor 1.5 and right turn factor 1.
85thpercentile approach speed=36.7 ft./sec for all approach.

- **Critical Approach Volume**

Main Street: Volume= (0.13*1677)*1.6+ (0.025*1677)*1.5+ (1-0.13-0.025)*1677=1828.77 PCE
Side Street: Volume= (0.15*906)*1.6+ (0.066*906)*1.5+ (1-0.15-0.066)*906=1017.44 PCE
Parking is not allowed for each way.
PCE per lane, $N_1=\frac{1828.77}{2}$ =914.4
PCE per lane, $N_2=\frac{1017.44}{2}$ =508.72

- **Vehicle clearance interval (Y)**

Vehicle clearance interval (Main street), $Y_1=t+\frac{v}{2a}+\frac{w+l}{v}=1+\frac{36.7}{2*15}+\frac{57.6+20}{36.7}$ =4.3sec Assume, v=36.7 ft/sec
Vehicle clearance interval (Side street), $Y_2=1+\frac{36.7}{2*15}+\frac{52.5+20}{36.7}$ =4.2 sec.

- **Pedestrian Crossing**

Crossing the main street: Red time, $R_1=t_r+\frac{w}{v}=5+\frac{52.5}{3.5}$ =20sec here, pedestrian walking speed=3.5 ft/sec
Green time, $G_{2min}=R_1-Y_2$ =20-4.2=15.8sec.
Crossing Side Street: Red time, $R_2= t_r+\frac{w}{v}=5+\frac{57.6}{35}$ =21.4sec
Green time, $G_{1min}=R_2-Y_1$ =21.5-4.3=17.2sec
Approximate cycle length: Approximate cycle length, $C=R_1+R_2=G_2+Y_2+G_1+Y_1$ =41.5sec
Splitting the cycles: Main street green time $G_1=\frac{17.2*914.4}{508.72}$ =30.92 sec
Provided cycle length, $C_{provided}$=30.932+17.2+4.3+4.2 =56.62sec

Checking the timing:

Required green time (sec)		**Provided green time (sec)**
$\frac{914.4}{4*0.85}=268.94$	$\leq$	$\frac{15*60}{56.62}*30.92=491.5$
$\frac{508.72}{4*0.85}$=149.62	$\leq$	$\frac{15*60}{56.62}$*17.2=273.4

G_1=30.92sec Y_1=4.3sec R_1=20sec
G_2=15.8sec Y_2=4.2sec R_2=35.22sec

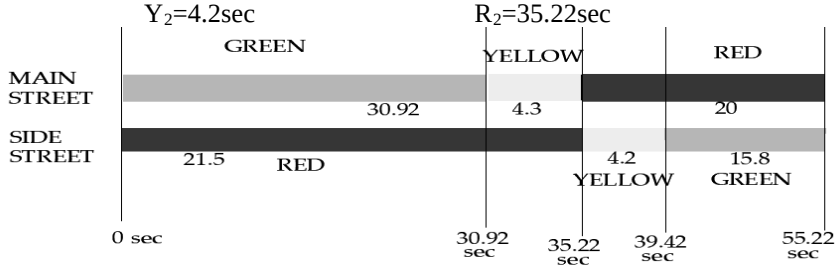

Figure 8. Signal timing

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