Bangladesh University of Engineering and Technology, Dhaka

CE 6507

Assignment 2

ON ROUNDABOUT & TRAFFIC SIGNAL DESIGN and ALTERNATIVE

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Submitted to

Prof. Dr. Md. Moazzem Hossain
Professor, Department of Civil Engineering

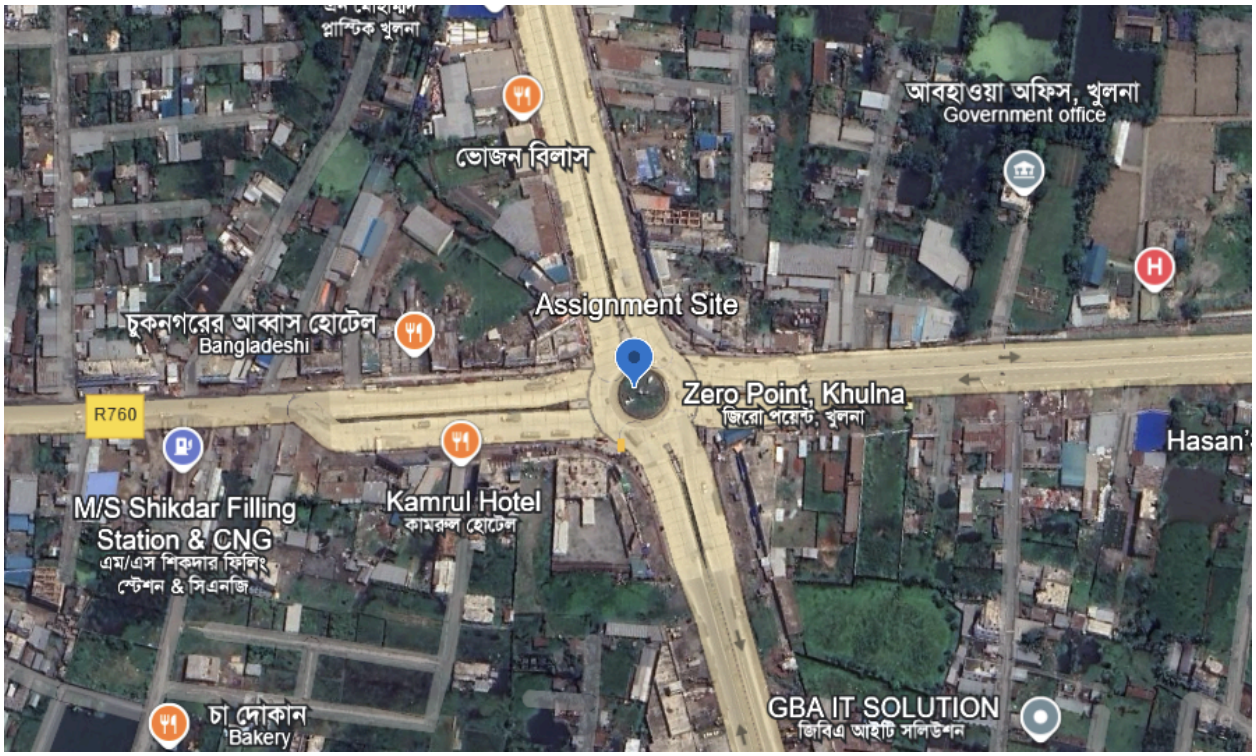
Submitted by

Arnob Protim Roy
ID : 0424042406
M.Sc Student
Department of Civil Engineering , BUET

Assignment 2

Ans No 1

Site selection : Khulna Zero Point



Up

239	N709-1	Fultala- (Int.with R760)	TS-N709-1	LRP004+970m ~ 5.000Km	280	1123	418	49	5	102	85	206	856	881	295	22	1	4005	318

Down

240	N709-3	Muhammed Nagar Chowraasta(Int.with Z7606)-Kudir Bottala(Int.with N7)	TS-N709-3L	LRP019+933m ~ 20.000Km	504	1682	656	273	353	426	202	643	1943	793	399	350	0	7475	749

Left

Road No : R760-Khulna-Chuknagar-Satkhira Road

458	R760-1	Khulna bus stand - Intersection with N709	TS-R760-1	LRP002+300m ~ 2.000Km	190	1374	333	142	180	180	62	279	2283	1709	218	47	0	6732	265

Right

459	R760-3	N709 Chuknagar (Int with R755)-Satkhira	TS-R760-3	LRP035+270m ~ 35.000Km	41	679	399	83	151	126	88	264	4612	3748	2257	47	0	10191	2304

It is quite interesting that the volume of traffic is larger in R760 than the others

Link Name			N709-1		N709-3		R760-1		R760-3	
Vehicle Type		PCU Factor	Count	Converted PCU	Count	Converted PCU	Count	Converted PCU	Count	Converted PCU
	Heavy	3	280	840	504	1512	190	570	41	123
Truck	Medium	1.5	1123	1684.5	1682	2523	1374	2061	679	1018.5
	Small	1.5	418	627	656	984	333	499.5	399	598.5
	Heavy	3	49	147	273	819	142	426	83	249
Bus	Medium	1.5	5	7.5	353	529.5	180	270	151	226.5
	Small	1.5	192	288	426	639	180	270	126	189
	Utility	1.5	85	127.5	292	438	62	93	88	132
	Car	1	206	206	643	643	279	279	264	264
	Auto-rikshaw	1.5	856	1284	1943	2914.5	2283	3424.5	4612	6918
	Motorcycle	0.75	881	660.75	793	594.75	1709	1281.75	3748	2811
	Bicycle	1	295	295	399	399	218	218	2257	2257
	Cycle-Rikshaw	2	22	44	350	700	47	94	47	94
	Cart	1	1	1	0	0	0	0	0	0
	Total Vehicle		4413		8314		6997		12495	
	Total AADT : PCU/day			6212.25		12695.75		9486.75		14880.5
	PCU/HOUR			259		529		395		620
	Vehicle/hour		183.875		346.4166667		291.5416667		520.625	

There is already a roundabout.
But first I will design assuming there is no existing roundabout then compare it with the current existing roundabout. First I observe the existing Leg conditions on four sides for determining approach half width. For simplicity I will take the roundabout symmetric.

Recommended Speed
50 km/h

Geometric Design of Roundabout

Direction	Up	Down	Left	Right
	N709-1	N709-3	R760-1	R760-3
Approach Lane Number (after analyzing road)	4	4	1	2
Approach Lane width (m), v	14.8	14.8	3.7	7.4
Average entry width(m) , e	18	18	18	18
Weaving Width(m) , w	12	12	12	12
Weaving Length(m), l	20	20	20	20
Radius of entry (m) , r	10	10	10	10
Proportion of weaving traffic (p)	0.7	0.7	0.7	0.7
Proportion of Heavy and medium traffic (For Simplicity Average) (h)	.22	.22	.08	.16

This geometric design match the specification range
(Note: this is in feet, for w, i converted and checked okay)

$20 < w < 60$ OK
$0.5 < e/w < 1.0$ OK
$0.4 < p < 1.0$ OK
$0 < h < 0.25$ OK

I have used this equation to calculate Q_{max}

$$Q_{max} = \frac{105w(1+e/w)(1-3w/4l)(1-p/3)}{(1+1.8h)} \quad \text{vph}$$

Now for all the leg this is applied , (Peak Factor is considered)

	up	down	left	right
	N709-1	N709-3	R760-1	R760-3
Qe (vph)	183.875	346.4166667	291.5416667	520.625
Qe (vph) = Considering Peak Hour Factor	198.585	374.13	314.865	562.275
Qe (pcu/hr)	259	529	395	620
v (m) = approach half-width	14.8	14.8	3.7	7.4
e (m) = Average entry width (e)	18	18	18	18
l (m) = the effective length of flare	20	20	20	20
r (m) = radius of entry	10	10	10	10
Proportion of weaving traffic (Let) (p)	0.7	0.7	0.7	0.7
Proportion of Heavy and medium traffic (h)	0.22	0.22	0.08	0.16
Avarage weaving width(m) ,w	20	20	20	20
Avarage weaving width(ft) ,w	65.6	65.6	65.6	65.6
Qmax	1796.833811	1796.833811	2192.63986	1947.5
Demand (vph)	198.585	374.13	314.865	562.275

It is seen this design Q_{max} is already more than enough than the demand.
Now operational analysis of designed roundabout to find average vehicular delay-

Operational Analysis
Now for average delay per vehicle,

Maycock developed a formula for average queuing delay in terms of the total capacity which is as follows:

$$D = \frac{Z_c \cdot \rho}{1.05Q(1.05-\rho)}$$

And Level of service is taken from this table,

EXHIBIT 17-2. LEVEL-OF-SERVICE CRITERIA FOR TWSC INTERSECTIONS

Level of Service	Average Control Delay (s/veh)
A	0–10
B	> 10–15
C	> 15–25
D	> 25–35
E	> 35–50
F	> 50

Zc	13,700.00	13,700.00	13,700.00	13,700.00
Row	0.11	0.21	0.14	0.29
Q (Vph)	1,796.83	1,796.83	2,192.64	1,947.50
D (sec/veh)	0.85	1.80	0.94	2.54
LOS	A	A	A	A

So my design is in acceptable condition in term of LOS.

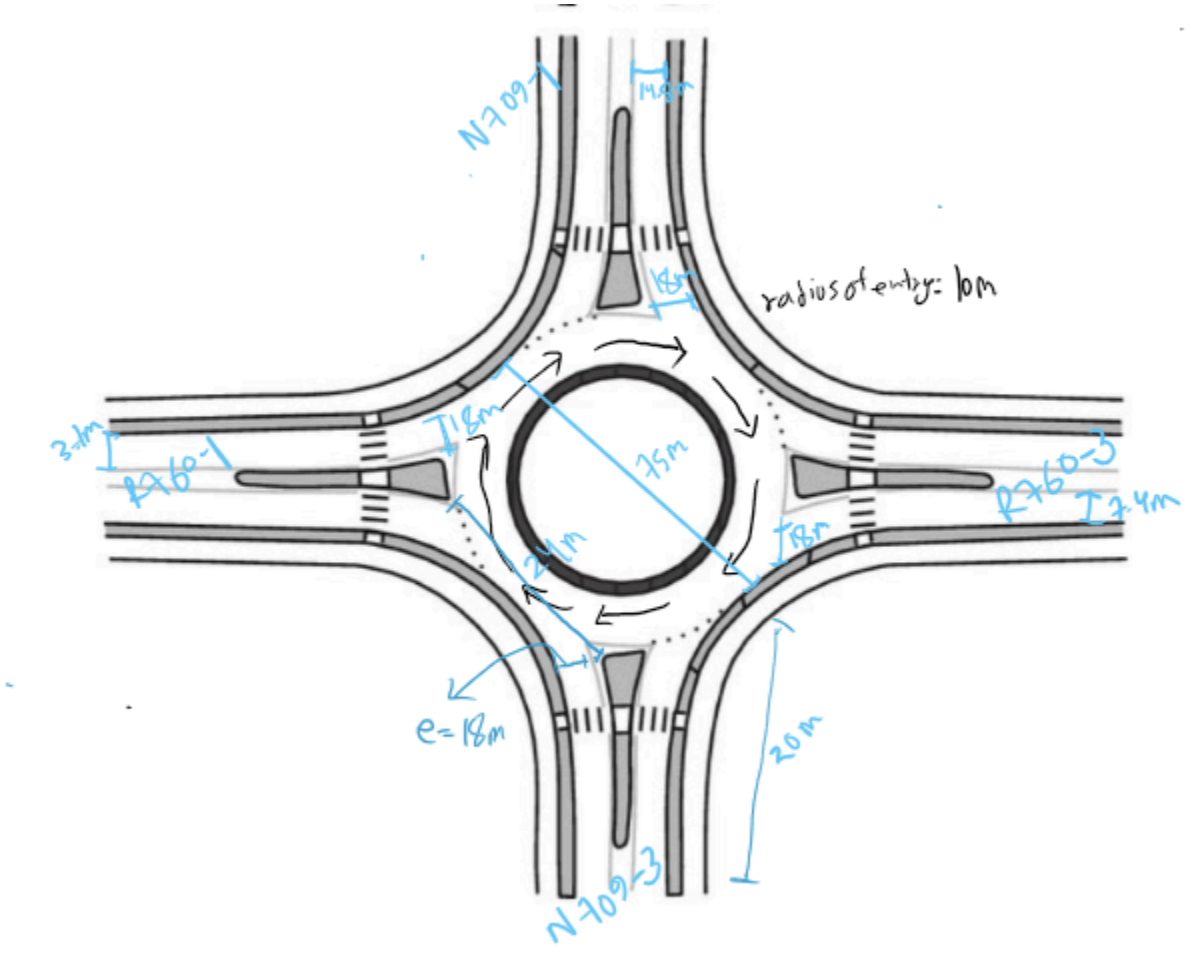
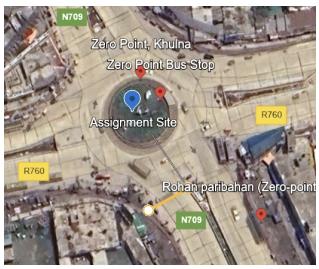


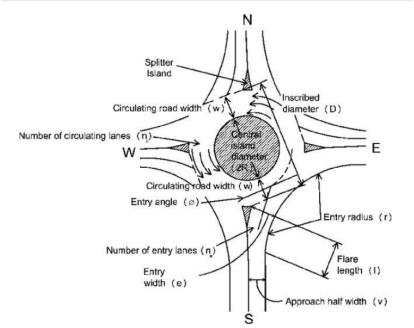
Figure: Diagram of the designed roundabout

Existing roundabout

Now similarly i am checking for the existing roundabout

Taking the measurement from google earth of the existing Roundabout





	up	down	left	right
	N709-1	N709-3	R760-1	R760-3
Qe (vph)	183.875	346.4166667	291.5416667	520.625
Qe (vph) = Considering Peak Factor	198.585	374.13	314.865	562.275
Qe (pcu/hr)	259	529	395	620
v (m) = approach half-width	5.87	9.45	5.07	11.2
e (m) = Average entry width (e)	18.36	18.36	18.36	18.36
l (m) = the effective length of flare	234	77.74	157	77.74
r (m) = radius of entry	45	60	50	35.77
Proportion of weaving traffic (Let) (p)	0.7	0.7	0.7	0.7
Proportion of Heavy and medium traffic (h)	0.16	0.16	0.16	0.16
Avarage weaving width(m) ,w	21.78	21.78	21.78	21.78
Avarage weaving width(ft) ,w	71.4384	71.4384	71.4384	71.4384
Qmax	7654.273442	6499.65685	7372.548315	6499.65685
Demand (vph)	198.585	374.13	314.865	562.275

Zc	13700.00	13700.00	13700.00	13700.00
Row	0.03	0.06	0.04	0.09
Q (Vph)	7654.27	6499.66	7372.55	6499.66
D (sec/veh)	0.04	0.12	0.08	0.18
LOS	A	A	A	A

It is seen that the Q_{max} is higher in the existing roundabout in my design.

Seeing the LOS, it can be concluded that the existing roundabout is better than my design.

Ans no 2

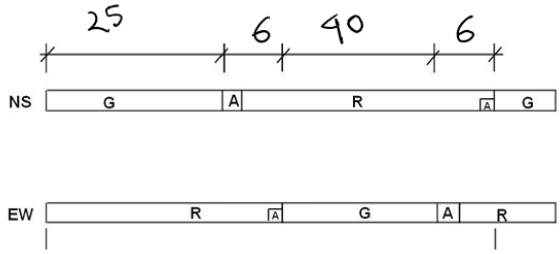
Signal design using webster method

	up	down	left	right
	N709-1	N709-3	R760-1	R760-3
demand (pcu/hr)	259	529	395	620
Demand * PF	279.72	571.32	426.6	669.6
Capacity	2100	2100	1000	1800
Y	0.1332	0.2720571429	0.4266	0.372
Y		0.2720571429	0.4266	
Sum(y) =	0.6986571429			
Amber (s)	3		NS/up-down	EW/left-right
Red-amber(s)	2	Intergreen (i) in sec	6	6
		Lost time (l) in sec	3	3
L =	12			

Where, Optimum cycle time, Co = [1.5 L + 5]/[1-Y]

L = all red + green-ends lost times

Optimum Cycle Length C0	76.32502133	
Cycle Length --->	77	
Total effective green time, Gte (C-L)=	65	
Yellow Time (s)	3	
	NS/up-down	EW/left-right
Effective green for g	25	40
Green + Amber period	28	43
Now,	GNS =	25
	intergreen NS =	6
	GEW=	40
	intergreen EW =	6
	Total=	**77**



Ans no 3

To calculate delay due to signal this formula is used ,

$$d = \frac{c(1-\lambda)^2}{2(1-\lambda x)} + \frac{x^2}{2q(1-x)} - 0.65\left(\frac{c}{q^2}\right)^{\frac{1}{3}} x^{(2+5\lambda)}$$

	up-down/ NS	left-right / EW
C	77	77
g	25	40
S	2100	1000
q	571.32	669.6
lamda	0.3246753247	0.5194805195
x	0.2720571429	0.6696
D (s/veh)	19.25965119	13.63111359
LOS	C	B

Ans no 4

After increasing 30% traffic in **Roundabout system**

	up	**down**	**left**	**right**
	N709-1	N709-3	R760-1	R760-3
Qe (vph) After Increasing 30%	239.0375	450.3416667	379.0041667	676.8125
Qe (vph) = Considering Peak Factor	258.1605	486.369	409.3245	730.9575
Qe (pcu/hr)	259	529	395	620
v (m) = approach half-width	14.8	14.8	3.7	7.4
e (m) = Average entry width (e)	18	18	18	18
l (m) = the effective length of flare	20	20	20	20
r (m) = radius of entry	10	10	10	10
Proportion of weaving traffic (Let) (p)	0.7	0.7	0.7	0.7
Proportion of Heavy and medium traffic (h)	0.22	0.22	0.08	0.16
Avarage weaving width(m) ,w	20	20	20	20
Avarage weaving width(ft) ,w	65.6	65.6	65.6	65.6
Qmax (vph)	1796.833811	1796.833811	2192.63986	1947.5
Demand (vph)	258.1605	486.369	409.3245	730.9575
Queing Delay in term of rounabout capacity				
Zc	13700	13700	13700	13700
Row	0.1436752238	0.2706811265	0.186681136	0.3753311938
Q (Vph)	1796.833811	1796.833811	2192.63986	1947.5
D (s/veh)	1.151122087	2.522122277	1.28674701	3.727158238
LOS	A	A	A	A

And for webster method , (After increasing 30% traffic)

	up	down	left	right
	N709-1	N709-3	R760-1	R760-3
demand (pcu/hr)	336.7	687.7	513.5	806
Demand * PF	363.636	742.716	554.58	870.48
Capacity	2100	2100	1000	1800
Y	0.17316	0.3536742857	0.55458	0.4836
Y		0.3536742857	0.55458	
Sum(y) =	0.9082542857			
Amber (s)	3		NS/up-down	EW/left-right
Red-amber(s)	2	Intergreen (i) in sec	6	6
		Lost time (l) in sec	3	3
L =	12			

Optimum Cycle Length C0	250.692909	
Cycle Length --->	252	
Total effective green time, Gte (C-L)=	240	
Yellow Time (s)	3	
	NS/up-down	EW/left-right
Effective green for g	93	147
Green + Amber period	96	150
Now,	GNS =	93
	intergreen NS =	6
	GEW=	147
	intergreen EW =	6
	Total=	**252**

	up-down/ NS	left-right / EW
C	252	252
g	93	147
S	2100	1000
q	742.716	870.48
lamda	0.369047619	0.5833333333
x	0.3536742857	0.87048
D (s/veh)	57.69065113	44.44150989
LOS	F	E

So If I make a comparison table

	Roundabout						Signal			
	My design Roundabout		My design Roundabout with 30% Increase of demand		Already Existing Roundabout		With Current Demand		With 30% Increase of demand	
Direction	NS	EW	NS	EW	NS	EW	NS	EW	NS	EW
Delay (Considering the dominating) s/veh	1.80	2.54	2.52	3.73	0.04	0.18	19.26	13.63	57.69	44.44
LOS	A	A	A	A	A	A	C	B	F	E
						Cycle Time (s)	77		252	

Ans no 5

For Current Demand

- My Design Roundabout performs well with delays of 1.80 s/veh (LOS A) for the NS direction and 2.54 s/veh (LOS B) for the EW direction, making it efficient for the current scenario.
- The existing roundabout outperforms the designed roundabout in both directions, showing extremely low delays and excellent LOS.

For 30% Increase of Demand

- The designed roundabout performs okay and gives LOS A.
- The traffic signal becomes inefficient under increased demand, with LOS F for NS and LOS E for EW.

So , If I choose the existing.design roundabout parameters for our design. it will be suitable for both cases. (It is noted that khulna zero point roundabout is very well performed and there is little delay in real life)

Recommendation: The **designed/existing roundabout is the optimal choice** for **both current and future demand scenarios**. Its excellent performance, negligible delays, and consistent LOS A demonstrate its ability to handle traffic effectively without requiring significant modifications. No need to shift. The traffic signal is not a viable option for this scenario due to its poor performance under increased demand, with long delays and low LOS.