LAMAR UNIVERSITY

Transportation Engineering and Traffic Analysis
CVEN-5364

Group No: 01

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1)Name: Mostafizur Rahman Shawon
Id: L-20570457
2) Name: Minhajul Abedin Tajik
Id: L-20521113
3) Name: Tushon Dey Babu
Id: L-20585317
4) Name: Sonjoy Paul Avi
Id: L-20564404
5) Name: Partha Protim Roy
Id: L-20561710

Introduction:

We selected **Washington Boulevard** as the major street and three intersecting minor streets: **Park Street**, **Avenue A,** and **Avenue C.**

We've undertaken six tasks, beginning with the selection of our testbed. We ensured that our chosen intersections met specific criteria, with Washington Boulevard having at least two lanes and the minor streets providing suitable turning bays for efficient traffic flow.

In our workflow, we have taken 5-minute duration intervals and vehicle counts. Finally, calculated the vehicle per hour data for those three intersections. Those data are shown in below table-

During our onsite observations, conducted during daylight hours for safety reasons, we collected essential data, including photographs and measurements of intersection widths, which will inform our signal design.

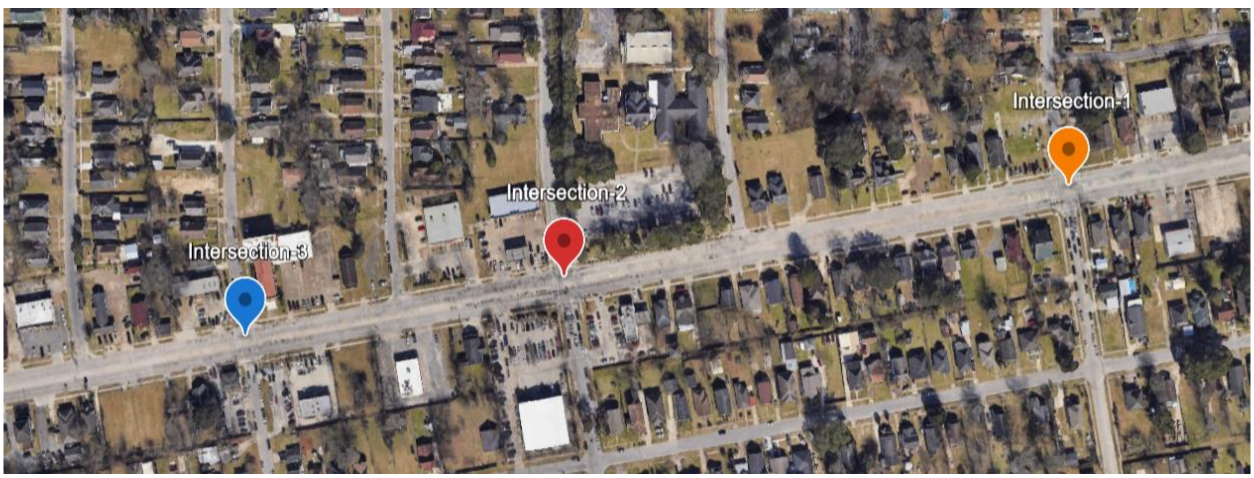
Data collection:

Table 1 Onsite Traffic 5-mimute Traffic Volume Observations

	Intersection I **Location: Park Street to Washington** **Volume (#veh/5-min)**					Intersection II Location: **Ave-A to Washington** **Volume (#veh/5-min)**			
	Major Road		Minor Road			Major Road		Minor Road	
	EB	WB	NB	SB		EB	WB	NB	SB
LT	1	0	7	3	LT	1	6	1	6
	1	2	5	4		3	7	2	4
Avg.	**1**	**1**	**6**	**3.5**	**Avg.**	**2**	**6.5**	**1.5**	**5**
TR	27	27	1	0	TR	27	34	4	3
	31	29	2	1		35	38	8	2
Avg.	**29**	**28**	**1.5**	**0.5**	**Avg.**	**31**	**36**	**6**	**2.5**
RT	2	0	3	3	RT	6	2	1	5
	1	1	4	2		9	2	1	7
Avg.	**1.5**	**0.5**	**3.5**	**2.5**	**Avg.**	**7.5**	**2**	**1**	**6**

	Intersection III Location: Ave-C to Washington			
	Volume (#veh/5-min)			
	Major Road		Minor Road	
	EB	WB	NB	SB
LT	0	2	2	3
	1	1	4	2
Avg.	**0.5**	**1.5**	**3**	**2.5**
TR	25	39	2	1
	24	42	3	0
Avg.	**24.5**	**40.5**	**2.5**	**0.5**
RT	2	0	1	1
	0	5	3	2
Avg.	**1**	**2.5**	**2**	**1.5**

Map:



Intersection- 01, 02 & 03

Figure01: Google Map preview

Subtask 2.3: Based on the average 5-min volumes calculated from Subtask 2.1, estimate the hourly traffic, and complete Table 2.

Table 2 Estimated Hourly Traffic Flow Rate based on 5-min Traffic volumes from Onsite Observations

	Intersection I			
	Flow Rate (#veh/hr)			
	Major Road		Minor Road	
	EB	WB	NB	SB
LT	12	12	72	42
TR	348	336	18	6
RT	18	6	42	30

	Intersection II			
	Flow Rate (#veh/hr)			
	Major Road		Minor Road	
	EB	WB	NB	SB
LT	24	78	18	60
TR	372	432	72	30
RT	90	24	12	72

	Intersection III (Optional)			
	Flow Rate (#veh/hr)			
	Major Road		Minor Road	
	EB	WB	NB	SB
LT	6	18	36	30
TR	294	486	30	6
RT	12	30	24	18

Note: LT – left turn, TR – through, RT – right turn

Intersection I
Location: Park Street to Washington

Intersection- II
Location: Ave-A to Washington

Intersection III

Location: Park Street to Washington

Task 3: Design the signal timing plan for the selected testbed.

Intersection-1

To design signals for the intersection, we adjusted our data since the provided information was insufficient for signal design calculations.

	Intersection I			
	Flow Rate (#veh/hr)			
	Major Road		Minor Road	
	EB	WB	NB	SB
LT	115	255	87	115
TR	988	880	25	30
RT	105	65	210	150

Table-04 : Flowrate for Intersection I

Name	Calculation	Decision
Westbound (WB) left turn	255*(988+105) = 278715	> 90000 for two opposing lane
Eastbound (EB) left turn	115* (880+65) = 108675	>90000 for two opposing lane
Southbound (WB) left turn	87*(30+150) =15660	<50000 for one opposing lane
Northbound (EB) left turn	115*(25+210) = 27025	<50000 for one opposing lane

Table 05 : Left lane calculation

Name		No. of vehicle	Decision
Major road	Westbound (WB) left turn	278715	Left turn phase Suggested
	Eastbound (EB) left turn	108675	Left turn phase Suggested
Minor road	Southbound (WB) left turn	15660	Not Required
	Northbound (EB) left turn	27025	Not Required

Table 06 : Phase determination

Upon calculation, it is evident that signals are required for vehicles making left turns on the Eastbound and Westbound lanes, as well as for through and right-turning vehicles. As minor road. As minor road has less traffic volume no dedicated signal is required for this intersection.

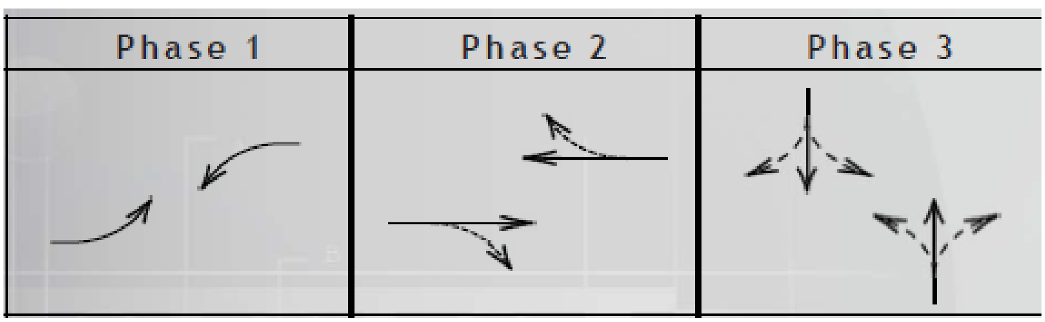


Figure 04 : Lane group determination

Phase 1 involves establishing specific signals for left turns on the Eastbound and Westbound lanes. Phase 2 entails signaling for vehicles proceeding straight and making right turns on the Eastbound-Westbound routes. Lastly, Phase 3 addresses the minor road, depicting a single signal for left turns, through traffic, and right turns.

Saturation flowrate for each phase:

Phase-1	Phase-2	Phase-3
EB L : 1750 veh/hr	EB T/R : 3400 veh/hr	SB L : 450 veh/hr
WB L : 1750 veh/hr	WB T/R : 3400 veh/hr	NB L : 475 veh/hr
		SB T/R : 1800 veh/hr
		NB T/R : 1800 veh/hr

Table 07 : Saturation flow rate

Calculation:

Phase-1	Phase-2	Phase-3
EB L= $\frac{115}{1750}$ = 0.065714 WB L= $\frac{255}{1750}$ = 0.145714	EB T/R= $\frac{988+105}{3400}$ = 0.321471 WB T/R= $\frac{255+880}{3400}$ = 0.333824	SB L= $\frac{115}{450}$ =0.255556 NB L= $\frac{87}{475}$ =0.183158 SB T/R= $\frac{30+150}{1800}$ =0.1 NB T/R= $\frac{25+210}{1800}$ =0.130556
Selected value(Max. value)		
0.145714	0.333824	0.255556

Table 08 : Calculation of v/c

Critical lane group:

$$Y_c = \sum_{i=1}^{n} \left(\frac{v}{s} \right)_{ci}$$

= 0.145714+ 0.333824+ 0.255556

= 0.73509337

Critical lost time :

Assuming 2 seconds of start-up lost time and 2 seconds of clearance lost time (1 second of yellow time plus 1 second of all-red time), for each critical lane group, gives a lost time of 4 s/phase. The total lost time for the cycle is then 12 seconds (3 phases × 4 s/phase).

So total critical lost time is 12 Seconds.

Calculate cycle length (Minimum) :

$$C_{\min} = \frac{L \times X_c}{X_c - \sum_{i=1}^{n} \left(\frac{v}{s} \right)_{ci}}$$

$C_{minimum}= \frac{12*0.9}{0.9-0.73509337}$ [Here, X_c is assumed to be 0.9 and L = 12 seconds]

= 65.49161 ≈ 70 seconds

Calculate cycle length (Optimum) :

$$C_{opt} = \frac{1.5 \times L + 5}{1.0 - \sum_{i=1}^{n} \left(\frac{v}{s} \right)_{ci}}$$

$C_{optimum} = \frac{(1.5*12)+5}{1-0.73509337}$

$= 86.82304 \approx 90$ Seconds

Rechecking X_c :

$$X_c = \frac{\sum_{i=1}^{n} \left(\frac{v}{s} \right)_i \times C}{C - L}$$

$X_c = \frac{0.73509337*70}{70-12} = 0.887182 \approx 0.9$ [which matches our assumed value]

Calculate effective green time :

EB and WB left-turn moven $g_i = \left(\frac{v}{s} \right)_{ci} \left(\frac{C}{X_i} \right)$

$$= \frac{70}{0.9} * 0.145714 = 11.333 \text{ seconds}$$

EB and WB through and right-turn movements, $g_2 = \frac{70}{0.9} * 0.33824 = 25.96405$ sec

NB and SB left-,through, and right-turn movements, $g_3 = \frac{70}{0.9} * 0.255556$ $= 19.87654$sec

Total cycle length , C= $g_1 + g_2 + g_3 + L$

$= 11.333 + 25.96405 + 19.87654 + 12$

$= 70$ seconds [Which is same as $C_{minimum}$]

good

Yellow time :

$$Y = t_r + \frac{V}{2a + 2gG}$$

$Y = 1 + \frac{(35*5280)/3600}{2*10} = 3.566667 \approx 4$ Seconds [$t_r = 1$, $a = 10$ ft/s^2 , v=35 mph , G=0]

All red :

$$AR = \frac{w+l}{V}$$

$=\frac{(12.5952+20)}{(35*5280)/3600}$ =0.634971 ≈ 1 second [w=12.5 ft , l= 20 ft , v = 35mph]

Determine green time :

$G= g - Y - AR + t_l$

$= 70-4-1+12 = 77$ seconds

Determine Red Time :

$R= C- g - t_l$

EB and WB left turn movements, $R_1 = 70- 11.333 - 12 = 46.50292 \approx 47$ seconds

EB and WB through and right turn movement, $R_2 = 70-26.33919-12 = 32.035 \approx 32.5$ seconds

NB and SB left, through and right turn movement , $R_3 = 70- 20.16373-12 = 38.146 \approx 38.5$ seconds

Final Result :

Intersection-1	Green	Red	Yellow	AR
EB and WB left-turn movements	11.3333	46.50292	3.566667	1
EB and WB through and right-turn movements	25.96405	32.03595		
NB and SB left-, through, and right-turn movements	19.87654	38.146		

Table 09 : Final calculation

Offset Calculation :

$$C_{prog} = \frac{d_o}{V} \times 2$$

$C_{prog} = \frac{1146}{(35*5280)/3600} * 2$ = 44.64935 seconds

Figure 05 : Two intersections on a one-way arterial are separated by 1146 ft.

Task 3: Design the signal timing plan for the selected testbed.

Intersection-1I

To design signals for the intersection, we adjusted our data since the provided information was insufficient for signal design calculations.

	Intersection II			
	Flow Rate (#veh/hr)			
	Major Road		Minor Road	
	EB	WB	NB	SB
LT	150	115	18	60
TR	775	550	72	30
RT	90	150	12	72

Table-04 : Flowrate for Intersection II

Name	Calculation	Decision
Westbound (WB) left turn	115*(775+90) = 99475	> 90000 for two opposing lane
Eastbound (EB) left turn	150* (550+150) =105000	>90000 for two opposing lane
Southbound (WB) left turn	18*(30+72) =1836	<50000 for one opposing lane
Northbound (EB) left turn	60*(72+12) = 5040	<50000 for one opposing lane

Table 05 : Left lane calculation

Name		**No. of vehicle**	**Decision**
Major road	Westbound (WB) left turn	99475	Left turn phase Suggested
	Eastbound (EB) left turn	105000	Left turn phase Suggested
Minor road	Southbound (WB) left turn	1836	Not Required
	Northbound (EB) left turn	5040	Not Required

Table 06 : Phase determination

Upon calculation, it is evident that signals are required for vehicles making left turns on the Eastbound and Westbound lanes, as well as for through and right-turning vehicles. As minor road. As minor road has less traffic volume no dedicated signal is required for this intersection.

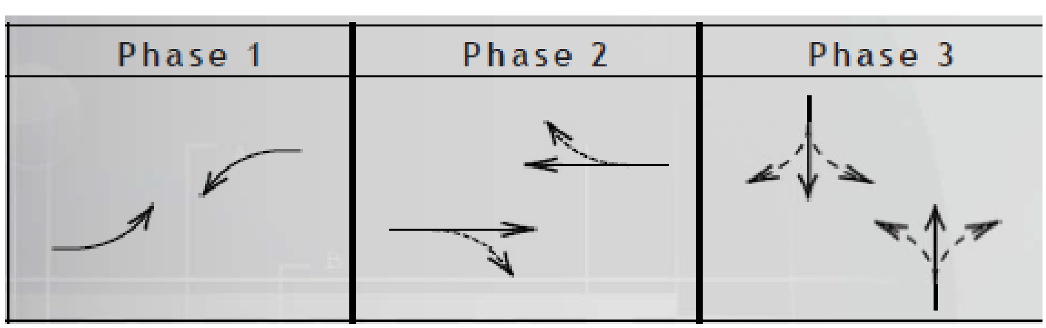


Figure 04 : Lane group determination

Phase 1 involves establishing specific signals for left turns on the Eastbound and Westbound lanes. Phase 2 entails signaling for vehicles proceeding straight and making right turns on the Eastbound-Westbound routes. Lastly, Phase 3 addresses the minor road, depicting a single signal for left turns, through traffic, and right turns.

Saturation flowrate for each phase:

Phase-1	Phase-2	Phase-3
EB L : 1750 veh/hr	EB T/R : 3400 veh/hr	SB L : 450 veh/hr
WB L : 1750 veh/hr	WB T/R : 3400 veh/hr	NB L : 475 veh/hr
		SB T/R : 1800 veh/hr
		NB T/R : 1800 veh/hr

Table 07 : Saturation flow rate

Calculation:

Phase-1	Phase-2	Phase-3
EB L= $\frac{150}{1750}$ = 0.085714 WB L= $\frac{115}{1750}$ = 0.065714	EB T/R= $\frac{775+90}{3400}$ =0.254412 WB T/R= $\frac{115+550}{3400}$ =0.195588	SB L= $\frac{60}{450}$ =0.13333 NB L= $\frac{18}{475}$ =0.037895 SB T/R= $\frac{30+72}{1800}$ =0.05667 NB T/R= $\frac{72+12}{1800}$ =0.046667
Selected value(Max. value)		
0.085714	0.254412	0.13333

Table 08 : Calculation of v/c

Critical lane group:

$$Y_c = \sum_{i=1}^{n} \left(\frac{v}{s} \right)_{ci}$$

= 0.085714+ 0.254412+ 0.13333

= 0.473479

Critical lost time :

Assuming 2 seconds of start-up lost time and 2 seconds of clearance lost time (1 second of yellow time plus 1 second of all-red time), for each critical lane group, gives a lost time of 4 s/phase. The total lost time for the cycle is then 12 seconds (3 phases × 4 s/phase).

So total critical lost time is 12 Seconds.

Calculate cycle length (Minimum) :

$$C_{\min} = \frac{L \times X_c}{X_c - \sum_{i=1}^{n}\left(\frac{v}{s}\right)_{ci}}$$

$C_{minimum} = \frac{12*0.9}{0.9-0.473459}$ [Here, X_c is assumed to be 0.9 and L = 12 seconds]

= 25.31998 ≈ 30 seconds

Calculate cycle length (Optimum) :

$$C_{opt} = \frac{1.5 \times L + 5}{1.0 - \sum_{i=1}^{n}\left(\frac{v}{s}\right)_{ci}}$$

$C_{optimum} = \frac{(1.5*12)+5}{1-0.473459}$

= 43.68134 ≈ 45 Seconds

Rechecking X_c :

$$X_c = \frac{\sum_{i=1}^{n}\left(\frac{v}{s}\right)_i \times C}{C - L}$$

$X_c = \frac{0.473459*30}{30-12}$ =0.889033 ≈ 0.9 [which matches our assumed value]

Calculate effective green time :

EB and WB left-turn moven $g_i = \left(\frac{v}{s}\right)_{ci}\left(\frac{C}{X_i}\right)$

$$= \frac{30}{0.9} * 0.085714 = 3.25869 \text{ seconds}$$

EB and WB through and right-turn movements, $g_2 = \frac{30}{0.9} * 0.254412 = 9.672238$ sec

NB and SB left-,through, and right-turn movements, $g_3 = \frac{30}{0.9} * 0.133 = 5.069073$sec

Total cycle length , C= $g_1 + g_2 + g_3 + L$

= 3.25869 +9.672238+5.069073+12

=30 seconds [Which is same as $C_{minimum}$]

Yellow time :

$$Y = t_r + \frac{V}{2a + 2gG}$$

$Y=1 + \frac{(35*5280)/3600}{2*10} = 3.566667 \approx 4$ Seconds [t_r= 1 , a = 10 ft/s^2 , v=35 mph , G=0]

All red :

$$AR = \frac{w + l}{V}$$

$=\frac{(12.5952+20)}{(35*5280)/3600} = 0.634971 \approx 1$ second [w=12.5 ft , l= 20 ft , v = 35mph]

Determine green time :

G= g – Y – AR+ t_l

= 30-4-1+12 = 37.433 seconds

rounded !

Determine Red Time :

R= C- g – t_l

EB and WB left turn movements, R_1 = 30- 3.25869 – 12 = 14.74131≈ 15 seconds

EB and WB through and right turn movement, R_2= 30-9.672238-12 = 8.32776 ≈ 8.5 seconds

NB and SB left, through and right turn movement , R_3 = 30- 5.069 -12 = 12.9303 ≈ 13 seconds

Final Result :

Intersection-II	Green	Red	Yellow	AR
EB and WB left-turn movements	3.25869	14.74131	3.566667	1
EB and WB through and right-turn movements	9.672238	8.327762		
NB and SB left-, through, and right-turn movements	5.069073	12.93093		

Table 09 : Final calculation

Offset Calculation :

$$C_{prog} = \frac{d_o}{V} \times 2$$

$C_{prog} = \frac{731}{(35*5280)/3600} * 2 = 28.48052$ seconds

Figure 05 : Two intersections on a one-way arterial are separated by 1146 ft.

Intersection-3

To design signals for the intersection, we adjusted our data since the provided information was insufficient for signal design calculations.

	Intersection 3			
	Flow Rate (#veh/hr)			
	Major Road		Minor Road	
	EB	WB	NB	SB
LT	118	180	36	30
TR	294	786	30	6
RT	312	30	24	18

Table-04 : Flowrate for Intersection 3

Name	Calculation	Decision
Westbound (WB) left turn	180*(294+312) = 109080	> 90000 for two opposing lane
Eastbound (EB) left turn	118* (786+30) = 962808	>90000 for two opposing lane
Southbound (SB) left turn	36*(6+18) =864	<50000 for one opposing lane
Northbound (EB) left turn	30*(30+24) = 1620	<50000 for one opposing lane

Table 05 : Left lane calculation

Name		**No. of vehicle**	**Decision**
Major road	Westbound (WB) left turn	109080	Left turn phase Suggested
	Eastbound (EB) left turn	962808	Left turn phase Suggested
Minor road	Southbound (WB) left turn	864	Not Required
	Northbound (EB) left turn	1620	Not Required

Table 06 : Phase determination

Upon calculation, it is evident that signals are required for vehicles making left turns on the Eastbound and Westbound lanes, as well as for through and right-turning vehicles. As minor road. As minor road has less traffic volume no dedicated signal is required for this intersection.

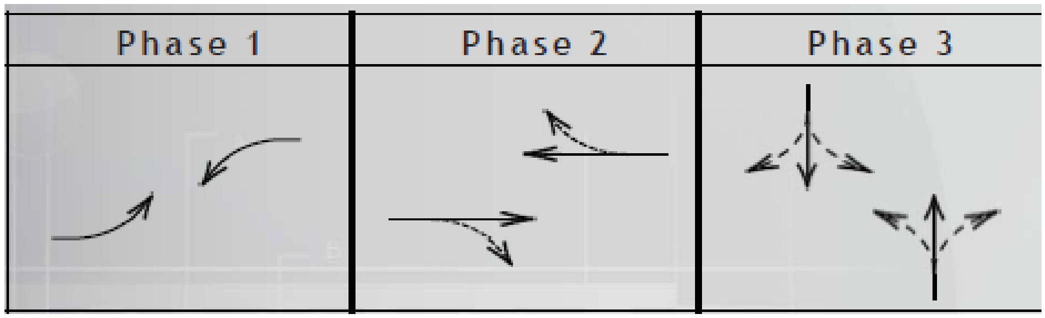


Figure 04 : Lane group determination

Phase 1 involves establishing specific signals for left turns on the Eastbound and Westbound lanes. Phase 2 entails signaling for vehicles proceeding straight and making right turns on the Eastbound-Westbound routes. Lastly, Phase 3 addresses the minor road, depicting a single signal for left turns, through traffic, and right turns.

Saturation flowrate for each phase:

Phase-1	Phase-2	Phase-3
EB L : 1750 veh/hr	EB T/R : 3400 veh/hr	SB L : 450 veh/hr
WB L : 1750 veh/hr	WB T/R : 3400 veh/hr	NB L : 475 veh/hr
		SB T/R : 1800 veh/hr
		NB T/R : 1800 veh/hr

Table 07 : Saturation flow rate

Calculation:

Phase-1	Phase-2	Phase-3
EB L= $\frac{118}{1750}$ = 0.06743 WB L= $\frac{180}{1750}$ = 0.10284	EB T/R= $\frac{294+312}{3400}$ = 0.17824 WB T/R= $\frac{180+786}{3400}$ = 0.28412	SB L= $\frac{30}{450}$ =0.06667 NB L= $\frac{36}{475}$ =0.17579 SB T/R= $\frac{6+18}{1800}$ =0.01333 NB T/R= $\frac{30+24}{1800}$ =0.03
Selected value(Max. value)		
0. 10284	0. 28412	0. 17579

Table 08 : Calculation of v/c

Critical lane group:

$$Y_c = \sum_{i=1}^{n} \left(\frac{v}{s} \right)_{ci}$$

= 0. 10284+ 0. 28412+ 0. 17579

= 0.46276

Critical lost time:

Assuming 2 seconds of start-up lost time and 2 seconds of clearance lost time (1 second of yellow time plus 1 second of all-red time), for each critical lane group, gives a lost time of 4 s/phase. The total lost time for the cycle is then 12 seconds (3 phases × 4 s/phase).

So total critical lost time is 12 Seconds.

Calculate cycle length (Minimum) :

$$C_{\min} = \frac{L \times X_c}{X_c - \sum_{i=1}^{n} \left(\frac{v}{s} \right)_{ci}}$$

$C_{minimum} = \frac{12*0.9}{0.9-0.46276}$ [Here, X_c is assumed to be 0.9 and L = 12 seconds]

= 24.7006 ≈ 25 seconds

Calculate cycle length (Optimum) :

$$C_{opt} = \frac{1.5 \times L + 5}{1.0 - \sum_{i=1}^{n} \left(\frac{v}{s} \right)_{ci}}$$

$C_{optimum} = \frac{(1.5*12)+5}{1-0.46276}$

= 42.8117 ≈ 43 Seconds

Rechecking X_c :

$$X_c = \frac{\sum_{i=1}^{n} \left(\frac{v}{s} \right)_i \times C}{C - L}$$

$X_c = \frac{0.46276*25}{25-12}$ =0.88993 ≈ 0.9 [which matches our assumed value]

Calculate effective green time :

EB and WB left-turn moven $g_i = \left(\frac{v}{s}\right)_{ci}\left(\frac{C}{X_i}\right)$

$$=\frac{25}{0.9} * 0.10284=2.857143 \text{ seconds}$$

EB and WB through and right-turn movements, $g_2 = \frac{25}{0.9} * 0.28412$= 7.89 sec

NB and SB left-,through, and right-turn movements, $g_3 = \frac{25}{0.9} * 0.17579$= 2.105263 sec

Total cycle length , C= $g_1 + g_2 + g_3 + L$

= 0.2857143 +7.89 +2.105263 +12

=24.85 seconds [Which is same as $C_{minimum}$]

Yellow time :

$$Y = t_r + \frac{V}{2a + 2gG}$$

Y=1 + $\frac{(35*5280)/3600}{2*10}$ = 3.566667 ≈4 Seconds [t_r= 1 , a = 10 ft/s^2 , v=35 mph , G=0]

All red :

$$AR = \frac{w+l}{V}$$

=$\frac{(12.5952+20)}{(35*5280)/3600}$ =0.634971 ≈ 1 second [w=12.5 ft , l= 20 ft , v = 35mph]

Determine green time :

G= g – Y – AR+ t_l

= 25-4-1+12 = 32 seconds

Determine Red Time :

$R = C - g - t_l$

EB and WB left turn movements, $R_1 = 25 - 2.857143 - 12 = 10.14286 \approx 11$ seconds

EB and WB through and right turn movement, $R_2 = 25 - 7.89 - 12 = 5.107 \approx 5.5$ seconds

NB and SB left, through and right turn movement , $R_3 = 25 - 2.105263 - 12 = 10.89 \approx 11$ seconds

Final Result :

Intersection-1	Green	Red	Yellow	AR
EB and WB left-turn movements	2.857143	12.71		
EB and WB through and right-turn movements	7.89	5.11	3.566667	1
NB and SB left-, through, and right-turn movements	2.105263	10.89		

Table 09 : Final calculation

Offset Calculation :

$$C_{prog} = \frac{d_o}{V} \times 2$$

$$C_{prog} = \frac{736}{(35*5280)/3600} * 2 = 28.6771 \text{ seconds}$$