

Design of four Phase Traffic Signal using Webster Method -A Case Study

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ABSTRACT

The main aim of this investigations is to avoid conflicts at intersections and cross sections by proposing a safe and efficient design of four phase traffic signal at intersections where there are large number of crossings and right turns. The earlier practice of controlling the traffic by a traffic police using stop signs alternately at the cross roads so that one stream of traffic is allowed while the traffic flow from the other stream is stopped was quite effective. But now a days, due to the increase of traffic as well as pollution, a lot of difficulties are being faced by the traffic control authorities. In this aspect, the same problem is being faced at Sreenivas centre in Nandyal which is a four legged intersection. The heavy traffic flowing from bus-stand towards Atmakur and Srisailam causes a lot of conflicts in the traffic flow from Nunepally towards Gandhi Chowk and Byrmal Street. So in this direction to have a pleasant and safe travel, there should be an orderly movement of traffic which is possible through signal control. So there is a strong requirement of signal regulated traffic flow for the four legged intersection at Sreenivas Centre. This study proposed and designed the cycle length for the four phases traffic signal using Webster method.

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Introduction

A traffic light is a device that is designed to control the flow of traffic by using three colored lights. These lights are mainly green, yellow, and red. In 1860's London, the first traffic control device had arms that extended out to command drivers on how to react at an intersection. The first four way three color traffic light did not come until December 1920 in Detroit. A traffic light, traffic signal, or stop light is a signaling device positioned at a road intersection Pedestrian crossing, or other location in order To indicate when it is safe to drive, ride, or walk using a universal color code. In Malaysia, the Traffic light for vehicles commonly has three main lights, a red light that means stop, a green Light that mean go and yellow that means ready to stop. However for the pedestrians, there have only two lights, a red light and a green light that mean go and stop respectively. The traffic lights have given many benefits to all road users. Besides reducing the number of accidents, it made the traffic flow smoothly and possibly could save people time.

Site Selected For Design of Signal

Sreenivas centre is one of the busiest circles in the town of Nandyal. Roads from Srisailam and Atmakur cross the busiest street of Nandyal which is stretched from Nunepally towards Gandhi Chowk and Byrmal Street. The screen shot from Google map is shown in Fig1. As this cross section, there are merges and diverges in the crossing of these two roads and there will be no orderly movement of traffic. In this connection, there is possibility for the traffic jams as well as accidents to occur. So there is a very heavy requirement for regulation of traffic, as well as orderly movement. To achieve

this, there is a need of signalized cross-section. As it is a cross-section of two roads, there is a need of a four phase traffic signal.



Fig 1 Screen shot for Google map of selected site for design of signal

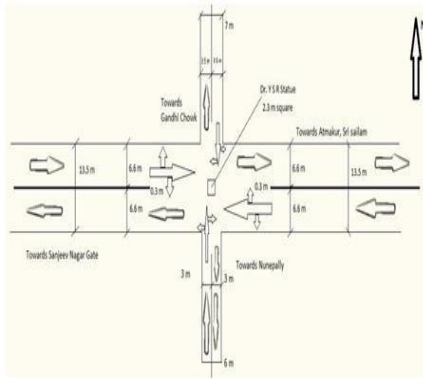


Fig 2 A layout of intersection at srinivas center Nandyal Methodology for the design of traffic (webster method)

The conflicts arising from movements of traffic in different directions is solved by time sharing of the principle. The advantages of traffic signal include an orderly movement of traffic, an increased capacity of the intersection and require only simple geometric design. However the disadvantages of the signalized intersection are it affects larger stop pedestrian delays, and the designer requires complex considerations. Although the overall delay may be lesser than a rotary for a high volume, a user is more concerned about the stopped delay.

Traffic counts

A survey is conducted for six days to obtain traffic hourly counts for all streams. There are 12 streams of flow of traffic at the two road intersection. The streams of the cross-section are as follows.

Streams

Streams of traffic flow at the cross section at Sreenivasa Centre presented in Table 1

Table 1: Streams of traffic flow at the cross section

S.No	From	Towards
1	Nunepally	Gandhi Chowk
		Atmakur Road
		Sanjeeva Nagar Gate
2	Atmakur Road	Sanjeeva Nagar Gate
		Nunepally
		Gandhi Chowk
3	Gandhi Chowk	Nunepally
		Atmakur Road
		Sanjeeva Nagar Gate
4	Sanjeeva Nagar Gate	Atmakur Road
		Gandhi Chowk
		Nunepally

Table 2: Schedule of the Survey

S.No	Date	Day	Session1	Session2	Session3	Session4
1	19/2/2015	Thursday	6AM-10AM	10AM-2PM	2PM-6PM	6PM-9PM
2	23/2/2015	Monday	6AM-10AM	10AM-2PM	2PM-6PM	6PM-9PM
3	24/2/2015	Tuesday	6AM-10AM	10AM-2PM	2PM-6PM	6PM-9PM
4	27/2/2015	Friday	6AM-10AM	10AM-2PM	2PM-6PM	6PM-9PM
5	28/2/2015	Saturday	6AM-10AM	10AM-2PM	2PM-6PM	6PM-9PM
6	1/3/2015	Sunday	6AM-10AM	10AM-2PM	2PM-6PM	6PM-9PM

For each phase, the maximum value is considered for calculation of cycle length. And for the calculation of cycle length for phase 1, phase 2 the value is taken half of the original value as it has a four lane width .So for phases 1, 2 the

values are taken as 223,314 for the calculation of cycle length. And for the phases 3,4 the value can be taken directly as it is a two lane road.

For the calculation of cycle length, saturation value, S is required, and it is taken as 1890 as the length of lane is 3.5 meters.

Normal flows, $q_1 = 223, q_2 = 314, q_3 = 432, q_4 = 361$

$Y_1 = 223/1890 = 0.117$

$Y_2 = 314/1890 = 0.166$

$Y_3 = 432/1890 = 0.22$

$Y_4 = 361/1890 = 0.191$

$Y = Y_1 + Y_2 + Y_3 + Y_4 = 0.117 + 0.166 + 0.22 + 0.191 = 0.694$

Cycle length according to Webster method is calculated using the formula

$C_o = (1.5 L + 5) / (1 - Y)$

where

$L = 2n + R = (2 * 4) + 12 = 20$ seconds.

Therefore, $C_o = ((1.5 * 20) + 5) / (1 - 0.694) = 115$ sec

Calculation of Green Time

Phase 1

$G_1 = (Y_1 / Y) / (C_o - L)$
 $= (0.117 / 0.694) (115 - 20)$
 $= 16$ Seconds.

Phase 2

$G_2 = (Y_2 / Y) / (C_o - L)$
 $= (0.166 / 0.694) (115 - 20)$
 $= 23$ Seconds.

Phase 3

$G_3 = (Y_3 / Y) / (C_o - L)$
 $= (0.22 / 0.694) (115 - 20)$
 $= 30$ Seconds.

Phase 4

$G_4 = (Y_4 / Y) / (C_o - L)$
 $= (0.191 / 0.694) (115 - 20)$
 $= 26$ Seconds.

Considering all pedestrian time = 12 seconds, Amber time = 2 seconds for each phase = 8 seconds for four phases.

Total Cycle length = 16+23+30+26+8+12 = **115 seconds.**

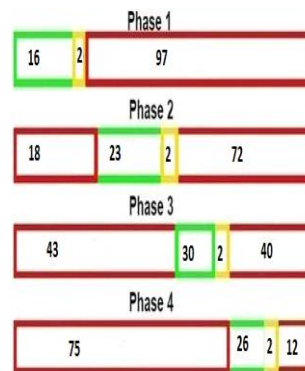


Fig 3 Signal Phase Diagram for Morning Session

Table 3: PCU Values from Nunepally towards Sanjeeva Nagar Gate

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	106	123	82	72	83	92
2	7AM-8AM	87	152	104	108	156	133
3	8AM-9AM	257	183	182	211	163	256
4	9AM-10AM	274	201	283	254	251	243
5	10AM-11AM	227	222	352	296	277	102
6	11AM-12PM	168	132	281	245	226	96
7	12-01PM	153	231	141	238	245	76
8	1PM-2PM	193	144	183	274	151	178
9	2PM-3PM	163	236	203	217	160	182
10	3PM-4PM	148	210	186	145	96	154
11	4PM-5PM	203	410	205	212	301	233
12	5PM-6PM	295	417	231	229	261	254
13	6PM-7PM	234	387	334	289	292	228
14	7PM-8PM	186	231	314	294	257	124
15	8PM-9PM	169	207	211	149	221	96

Table 4: PCU Values from Nunepally towards Gandhi Chowk

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	184	141	78	102	123	86
2	7AM-8AM	306	238	253	246	265	198
3	8AM-9AM	357	432	497	342	307	326
4	9AM-10AM	423	664	783	491	371	515
5	10AM-11AM	674	734	526	284	478	399
6	11AM-12PM	264	407	423	356	424	430
7	12-01PM	248	373	394	340	355	371
8	1PM-2PM	239	393	296	320	298	286
9	2PM-3PM	184	141	78	102	123	86
10	3PM-4PM	306	238	253	246	265	198
11	4PM-5PM	357	432	497	342	307	326
12	5PM-6PM	423	664	783	491	371	515
13	6PM-7PM	674	734	526	284	478	399
14	7PM-8PM	264	407	423	356	424	430
15	8PM-9PM	248	373	394	340	355	371

Table5: PCU Values from Nunepally towards Atmakur Road

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM						
2	7AM-8AM	193	132	96	114	186	77
3	8AM-9AM	210	146	154	123	221	154
4	9AM-10AM	301	273	368	265	315	220
5	10AM-11AM	327	384	354	350	388	265
6	11AM-12PM	368	367	398	374	429	312
7	12-01PM	246	313	292	283	372	497
8	1PM-2PM	306	310	327	297	236	233
9	2PM-3PM	269	355	298	269	254	227
10	3PM-4PM	238	263	268	255	249	248
11	4PM-5PM	189	402	284	246	286	256
12	5PM-6PM	287	279	291	342	312	378
13	6PM-7PM	251	534	267	309	363	352
14	7PM-8PM	270	366	396	299	384	326
15	8PM-9PM	304	414	290	340	283	353

Table 6 : PCU Values from Gandhi Chowk towards Atmakur Road

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	17	53	63	153	123	21
2	7AM-8AM	20	35	55	121	156	26
3	8AM-9AM	34	67	67	95	197	57
4	9AM-10AM	43	97	95	78	127	69
5	10AM-11AM	40	105	88	101	96	185
6	11AM-12PM	68	88	122	128	166	174
7	12-01PM	34	150	167	156	149	196
8	1PM-2PM	176	137	183	167	121	205
9	2PM-3PM	28	75	95	201	118	71
10	3PM-4PM	23	48	91	123	127	44
11	4PM-5PM	67	293	84	225	182	56
12	5PM-6PM	85	380	169	280	197	35
13	6PM-7PM	208	457	265	345	239	22
14	7PM-8PM	253	513	285	370	283	19
15	8PM-9PM	251	435	297	355	295	27

Table7: PCU Values from Atmakur Road towards Nunepally

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	244	178	118	83	259	215
2	7AM-8AM	406	339	373	113	455	416
3	8AM-9AM	1092	1256	1223	98	1489	1516
4	9AM-10AM	957	1049	1301	153	1296	1258
5	10AM-11AM	1131	791	725	125	959	986
6	11AM-12PM	550	756	477	89	464	676
7	12-01PM	697	973	423	97	472	788
8	1PM-2PM	564	992	554	106	481	536
9	2PM-3PM	722	599	408	73	422	512
10	3PM-4PM	853	994	714	119	411	533
11	4PM-5PM	652	462	396	215	412	401
12	5PM-6PM	679	438	481	275	392	493
13	6PM-7PM	753	511	943	198	577	502
14	7PM-8PM	477	454	853	308	499	338
15	8PM-9PM	590	441	411	178	271	262

Table8: PCU Values from Atmakur Road towards Gandhi Chowk

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	89	92	96	83	93	86
2	7AM-8AM	71	117	129	113	105	159
3	8AM-9AM	101	106	218	98	118	167
4	9AM-10AM	118	128	198	153	175	192
5	10AM-11AM	104	152	118	125	164	184
6	11AM-12PM	62	118	142	89	128	203
7	12-01PM	85	102	176	97	149	197
8	1PM-2PM	148	122	153	106	193	153
9	2PM-3PM	77	139	96	73	177	164
10	3PM-4PM	92	145	102	119	106	139
11	4PM-5PM	159	348	179	215	266	198
12	5PM-6PM	214	307	226	275	312	254
13	6PM-7PM	162	297	313	198	322	232
14	7PM-8PM	156	178	163	308	313	183
15	8PM-9PM	88	97	167	121	223	96

Table9: PCU Values from Gandhi Chowk towards Atmakur Road

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	17	53	63	153	123	21
2	7AM-8AM	20	35	55	121	156	26
3	8AM-9AM	34	67	67	95	197	57
4	9AM-10AM	43	97	95	78	127	69
5	10AM-11AM	40	105	88	101	96	185
6	11AM-12PM	68	88	122	128	166	174
7	12-01PM	34	150	167	156	149	196
8	1PM-2PM	176	137	183	167	121	205
9	2PM-3PM	28	75	95	201	118	71
10	3PM-4PM	23	48	91	123	127	44
11	4PM-5PM	67	293	84	225	182	56
12	5PM-6PM	85	380	169	280	197	35
13	6PM-7PM	208	457	265	345	239	22
14	7PM-8PM	253	513	285	370	283	19
15	8PM-9PM	251	435	297	355	295	27

Table10: PCU Values from Gandhi Chowk towards Nunepally

8.56	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	170	195	159	187	177	121
2	7AM-8AM	272	312	357	320	215	196
3	8AM-9AM	515	503	623	395	393	233
4	9AM-10AM	494	495	612	410	495	757
5	10AM-11AM	368	545	662	385	479	785
6	11AM-12PM	470	580	537	450	501	801
7	12-01PM	535	658	723	592	558	774
8	1PM-2PM	557	720	601	540	624	658
9	2PM-3PM	423	557	590	465	427	697
10	3PM-4PM	392	502	494	493	465	604
11	4PM-5PM	402	367	547	558	536	527
12	5PM-6PM	530	542	569	620	576	635
13	6PM-7PM	470	573	536	657	665	531
14	7PM-8PM	502	397	496	618	540	471
15	8PM-9PM	518	393	529	521	390	223

Table11: PCU Values from Gandhi Chowk towards Sanjeeva Nagar Gate

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	98	217	183	196	203	218
2	7AM-8AM	130	329	302	318	196	256
3	8AM-9AM	169	548	360	373	405	574
4	9AM-10AM	397	511	512	525	385	623
5	10AM-11AM	381	529	505	485	397	715
6	11AM-12PM	413	278	377	388	446	520
7	12-01PM	387	443	478	434	462	501
8	1PM-2PM	322	486	382	460	413	489
9	2PM-3PM	325	331	432	511	445	545
10	3PM-4PM	395	357	501	502	402	505
11	4PM-5PM	468	352	463	551	482	533
12	5PM-6PM	527	445	514	530	450	541
13	6PM-7PM	422	452	422	491	502	432
14	7PM-8PM	407	410	523	485	325	444
15	8PM-9PM	383	373	432	475	422	285

Table12: PCU Values from Sanjeeva Nagar Gate towards Nunepally

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	81	132	173	116	113	122
2	7AM-8AM	241	296	252	228	218	154
3	8AM-9AM	332	393	376	224	286	267
4	9AM-10AM	249	376	368	189	363	289
5	10AM-11AM	277	287	278	231	287	312
6	11AM-12PM	198	191	254	190	201	123
7	12-01PM	248	185	303	189	233	109
8	1PM-2PM	118	197	291	223	301	121
9	2PM-3PM	213	257	274	201	255	112
10	3PM-4PM	193	298	233	216	309	234
11	4PM-5PM	267	381	400	386	455	256
12	5PM-6PM	386	409	448	444	418	298
13	6PM-7PM	479	410	403	437	423	413
14	7PM-8PM	432	413	384	424	450	370
15	8PM-9PM	446	237	383	391	355	389

Table13: PCU Values from Sanjeeva Nagar Gate towards Gandhi Chowk

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	212	201	112	193	198	192
2	7AM-8AM	273	240	213	178	264	274
3	8AM-9AM	393	343	314	309	344	301
4	9AM-10AM	496	490	483	451	488	384
5	10AM-11AM	453	436	523	346	343	343
6	11AM-12PM	379	384	393	326	367	315
7	12-01PM	312	256	272	228	304	248
8	1PM-2PM	344	283	296	201	225	236
9	2PM-3PM	311	396	326	254	367	284
10	3PM-4PM	613	780	728	522	534	323
11	4PM-5PM	341	543	533	262	338	188
12	5PM-6PM	275	483	482	255	377	135
13	6PM-7PM	401	372	354	376	258	264
14	7PM-8PM	311	299	296	234	234	282
15	8PM-9PM	494	234	262	371	212	203

Table14: PCU Values from Sanjeeva Nagar Gate towards Atmakur Road

S.NO	DATE	19/2/2015	23/2/2015	24/2/2015	27/2/2015	28/2/2015	1/3/2015
1	6AM-7AM	211	184	124	204	234	133
2	7AM-8AM	533	287	233	427	387	294
3	8AM-9AM	562	376	398	561	553	574
4	9AM-10AM	511	497	554	372	463	587
5	10AM-11AM	1111	554	683	881	996	396
6	11AM-12PM	665	597	721	516	547	497
7	12-01PM	631	586	413	531	484	783
8	1PM-2PM	773	396	424	603	723	674
9	2PM-3PM	786	794	631	693	1005	774
10	3PM-4PM	993	960	979	914	997	486
11	4PM-5PM	1011	933	971	961	876	598
12	5PM-6PM	996	987	977	908	1013	786
13	6PM-7PM	955	1013	884	1016	1028	798
14	7PM-8PM	1047	974	815	974	976	976
15	8PM-9PM	1027	836	633	989	852	634

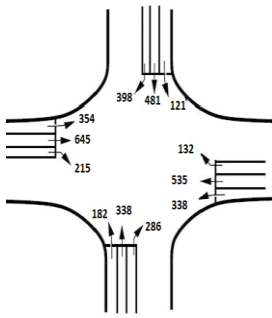


Fig4 PCU Values for Afternoon session from different streams

From the above PCU values, the maximum pcu value from each phase is considered for the calculation of cycle length. For each phase, the maximum value is considered for calculation of cycle length. And for the calculation of cycle length for phase 1, phase 2 the value is taken half of the original value as it has a four lane width .So for phases 1,2 the values are taken as 323,268 for the calculation of cycle length. And for the phases 3, 4, the value can be taken directly as it is a two lane road. For the calculation of cycle length, saturation value, S is required, and it is taken as 1890 as the length of lane is 3.5 meters.

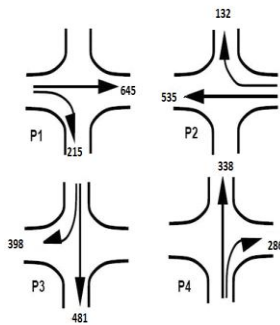


Fig 5 Peak values for Afternoon Session

For the calculation of cycle length, saturation value, S is required, and it is taken as 1890 as the length of lane is 3.5 meters.

Normal flows, $q_1 = 323, q_2 = 268, q_3 = 481, q_4 = 338$

$$Y_1 = 323/1890 = 0.17$$

$$Y_2 = 268/1890 = 0.14$$

$$Y_3 = 481/1890 = 0.25$$

$$Y_4 = 338/1890 = 0.17$$

$$Y = Y_1 + Y_2 + Y_3 + Y_4 = 0.17 + 0.14 + 0.25 + 0.17 = 0.73$$

Cycle length according to Webster method is calculated using the formula

$$C_o = (1.5 L + 5) / (1 - Y)$$

Where

$$L = 2n + R = (2 * 4) + 12 = 20 \text{ seconds.}$$

$$\text{Therefore } C_o = 1.5(20) + 5 / 1 - 0.73 = 130 \text{ seconds}$$

Calculation of Green Time

Phase 1

$$G_1 = (Y_1/Y) / (C_o - L) = (0.17/0.73)(130 - 20) = 26 \text{ Seconds.}$$

Phase 2

$$G_2 = (Y_2/Y) / (C_o - L) = (0.14/0.73)(130 - 20) = 21 \text{ Seconds.}$$

Phase 3

$$G_3 = (Y_3/Y) / (C_o - L) = (0.25/0.73)(130 - 20) = 37 \text{ Seconds.}$$

Phase 4

$$G_4 = (Y_4/Y)(C_o - L) = (0.17/0.73)(130 - 20) = 26 \text{ Seconds.}$$

Considering all pedestrian time = 12 seconds, Amber time = 2 seconds for each phase = 8 seconds for four phases.

$$\text{Total Cycle length} = 26 + 21 + 37 + 26 + 12 + 8 = 130 \text{ seconds.}$$



Fig 6 Signal Phase Diagram for Afternoon Session

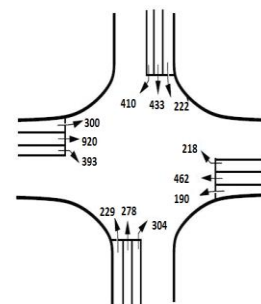


Fig 7 PCU Values for evening session from different streams

From the above PCU values, the maximum PCU value from each phase is considered for the calculation of cycle length. For each phase, the maximum value is considered for calculation of cycle length. And for the calculation of cycle length for phase 1, phase 2 the value is taken half of the original value as it has a four lane width .So for phases 1, 2 the values are taken as 460,231 for the calculation of cycle length. And for the phase 4, the values can be taken directly as it is a two lane road. For the calculation of cycle length, saturation value, S is required, and it is taken as 1890 as the length of lane is 3.5 meters.

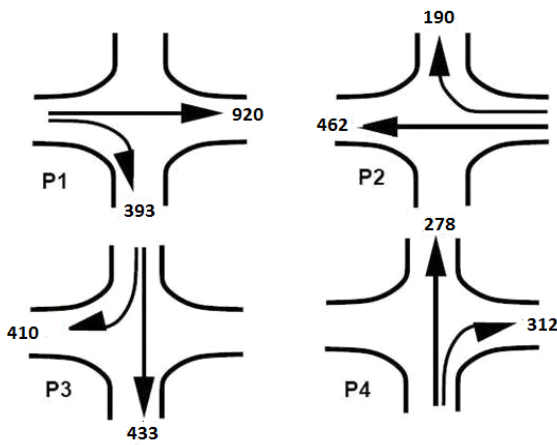


Fig 8 Peak Values for evening session

For the calculation of cycle length, saturation value, S is required, and it is taken as 1890 as the length of lane is 3.5 meters.

Normal flows, $q_1 = 460, q_2 = 231, q_3 = 433, q_4 = 312,$

$$Y_1 = 460/1890 = 0.24$$

$$Y_2 = 231/1890 = 0.12$$

$$Y_3 = 433/1890 = 0.22$$

$$Y_4 = 312/1890 = 0.16$$

$$Y = Y_1 + Y_2 + Y_3 + Y_4 = 0.24 + 0.12 + 0.22 + 0.16 = 0.74$$

Cycle length according to Webster method is calculated using the formula

$$C_o = (1.5 L + 5) / (1 - Y)$$

where

$$L = 2n + R = (2 * 4) + 12 = 20 \text{ seconds.}$$

$$\text{Therefore } C_o = 1.5(20) + 5 / 1 - 0.74 = 135 \text{ seconds}$$

$$\begin{aligned} G_3 &= (Y_3/Y) / (C_o - L) \\ &= (0.22/0.74)(135 - 20) \\ &= 35 \text{ Seconds.} \end{aligned}$$

Phase 4

$$\begin{aligned} G_4 &= (Y_4/Y) / (C_o - L) \\ &= (0.14/0.74)(135 - 20) \\ &= 22 \text{ Seconds} \end{aligned}$$

Considering all pedestrian time = 12 seconds, Amber time = 2 seconds for each phase = 8 seconds for four phases. Total Cycle length = 38+20+35+22+12+8 = 135 seconds.

Conclusion

Based on the calculations the PCU values obtained from the traffic survey, the signal cycle length for morning session is 115 seconds, for Afternoon session is 130 seconds and for evening session is 135 seconds. By providing signals, there will be reduction in the conflicts. Further, will be an orderly movement of traffic in the cross-section for the roads from Sanjeev Nagar Gate towards Atmakur, Srisailam and Nunepally towards Gandhi Chowk, Byrmal Street. As well, there is no necessary of traffic police to regulate the traffic at Sreenivas Centre.

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Fig 9 Signal Phase Diagram for Evening Session

Calculation of Green Time

Phase 1

$$\begin{aligned} G_1 &= (Y_1/Y) / (C_o - L) \\ &= (0.24/0.74)(135 - 20) \\ &= 38 \text{ Seconds.} \end{aligned}$$

Phase 2

$$\begin{aligned} G_2 &= (Y_2/Y) / (C_o - L) \\ &= 0.12/0.74(135 - 20) \\ &= 20 \text{ Seconds.} \end{aligned}$$

Phase 3