Design of Traffic Signal at Kundahallli Junction Bengaluru Karnataka

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ABSTRACT- About 16 people die and 58 are injured every hour in India due to road accidents – the death rate, in fact, is equivalent to wiping out about 40 percent of the population of a small nation like the Maldives in a year. The worst accident hotspots are near flyovers and junctions without signals. The increasing of traffic volume at the intersection has been on the rise which has resulted in many problems like road accidents, conflicts, and congestions.The objectives of traffic signals are First, they enable road users to safely navigate through an intersection. Secondly, they give priority to a particular direction or mode of travel at different times. Thirdly, they allow through large volumes of traffic with minimal delay. Traffic volume studies are to be made to determine the number, movement and classification of vehicles at the given location, which is done by the manual method. The vehicles are counted manually without using any device or sensor with respective vehicle categories like a passenger, commercial and agricultural etc. The Design of traffic signal is done according to the Indian Road congress (IRC 93) method of signal design by adopting maximum average Passenger count unit (PCU) on the intersection in each direction. The traffic signal is already provided at the intersection which is to be upgraded as the cycle length provided is more than the optimum cycle length.

KEY WORDS- Automated Signal, Intersection, PCU, IRC

1.0 INTRODUCTION

In earlier time traffic is controlled by traffic police manually by showing sign to the traffic in each direction but as the traffic volume is growing large and large it is not possible to handle the traffic by one traffic police so as to under come this problem traffic signals has been designed to control the traffic with accuracy and timely. The traffic signals has three lights orderly red, yellow, green, by which the can guide the traffic whether to move or stop. The first traffic signal was fixed in London in 1868 , which was a semaphore- arm type signal.

In this paper, we have taken kundalahalli junction, which is surrounded by 2 shopping malls, restaurants, corporate offices, etc. Moreover, there is a 3 bus stand due to which there is a heavy movement of people and traffic. Therefore at that place, Traffic Signal must be required which will reduce the chance of an accident, time of travel for the passengers, congestion, conflict, and bottleneck. These problems can be solved by providing an efficient traffic control at intersections and that can be achieved by a provision of automated volume based traffic signal system at intersections for continuous and efficient movement of vehicles through the intersections.

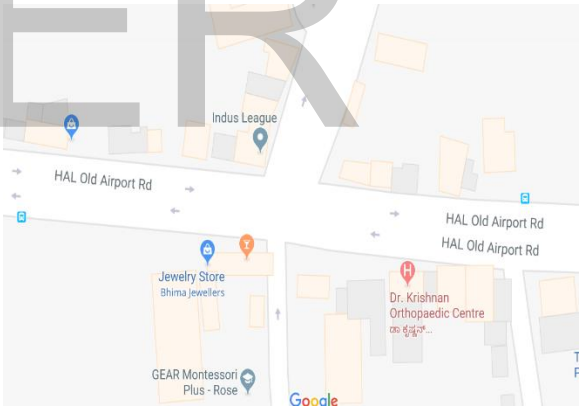

Fig 1.1 Goggle image of the kundalahalli gate signal

2.0 LITERATURE REVIEW

Ishant Sharma et al[2] (2015) proposed an automatic traffic signal at Madhya Marg, Chandigarh in which pre timed signals were designed by making use of Webster's method and I.R.C method of signal design. Webster's method gives the optimum cycle length whereas the I.R.C method gives minimum green time on basis of time taken by pedestrians to cross the approach lane. The count was taken by slow playback of video on laptop. In this paper, He has compared pre timed signal with automated signal in which automated signals were proven to be more efficient as these signals save the wasted time and increase the capacity.

Rubiyah yusuf et al[3] (1996) presented a combination of electromagnetic sensors and fuzzy logic technology in

which electromagnetic sensors where responsible for counting the number of cars and fuzzy logic technology was responsible for allotment green time to the traffic to clear off the intersection efficiently. This method was proven to be very effective in handling the traffic

Sachin Jat et al[4] (2015) designed a traffic signal at intersection of Vidisha, Madhya Pradesh. The traffic volume were collected manually without using any device or sensors with respective vehicle categories like passenger, commercial and agriculture. The design of traffic signal according to I.R.C method by adopting maximum P.C.U on the intersection in each direction.

Saleem Akhter et al[3](2015) presented a paper in which an attempt has been made whether to provide traffic signal or rotaries. Classified traffic volume data was collected for 12 minute duration. The classified volume was converted to a common unit called Passenger Car unit. The 12 minute data is then scaled to 1 hour to find the traffic volume in PCU/hr. The traffic capacity of rotary comes out to be 3017 PCU/hr which is greater than 3000 PCU/hr (maximum traffic volume a rotary can handle). Thus, traffic signal system should be introduced at the intersection with total cycle time of 140 seconds.

3.0 METHODOLOGY

3.1 COLLECTION OF DATA

In present study firstly, Traffic field studies are used to have the traffic volume at Kundanhalli Intersection which are used as input for the design of automatic traffic signals.Classified traffic volume (cars, two wheelers, buses, trucks) are collected for a period of 12 Hours (7:00-19:00) in order to have entire day data and to identify peak and non-peak hours. The data was collected for the interval of 15 minutes for 12 hours for 7 days. The 15 minutes data is then converted to 1 hour to find the traffic volume in PCU/hr.

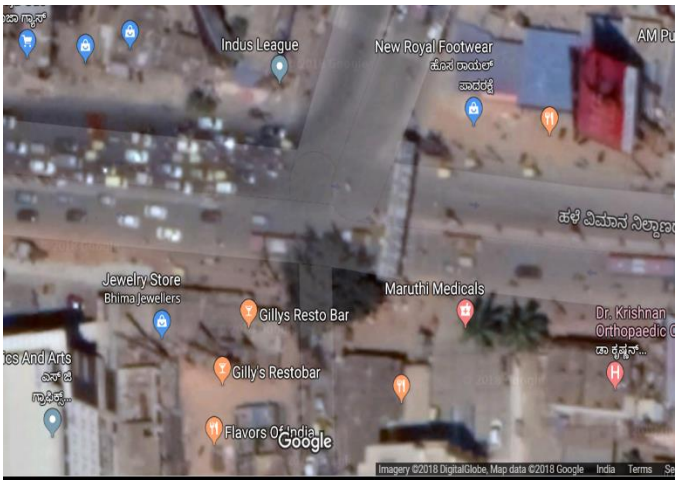

Fig 3.0 Satellite image of the kundalahalli gate signal.

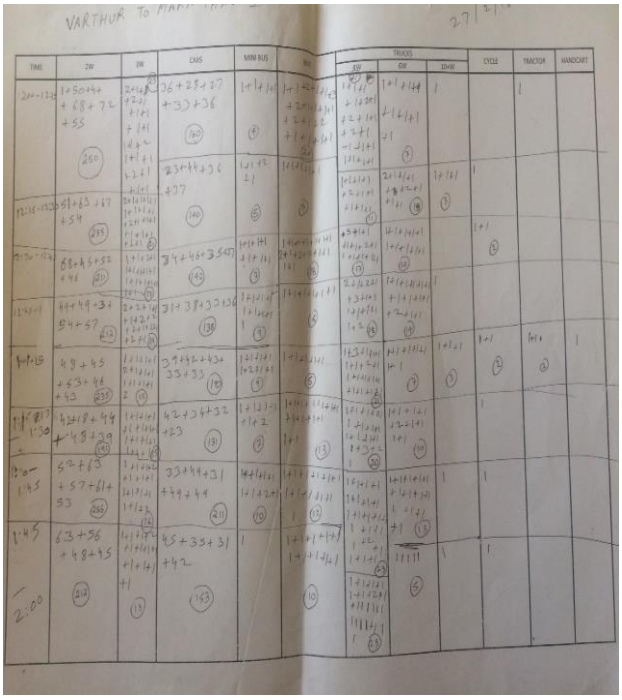

Fig 3.1 Sample Data Sheet of traffic count.

As there are 9 directions at our junction, we worked in two groups of 8 persons in each group for interval of 6hrs each.

Persons standing at Sai Baba Temple Road (Red mark) will take count of vehicles from (Whitefield - Marathahalli) Red lines in thejunction.

Persons standing at Marathahalli road (Green mark) will take count of vehicles from (Sai Baba Temple - Marathahalli and ITPL- Marathahalli) Green lines in junction.

Persons standing at ITPL road (Blue mark) will take count of vehicles from (Marathahalli -ITPL, Whitefield –ITPL and Sai Baba Temple-ITPL) Blue lines in junction.

Persons standing at Whitefield road (Purple mark) will take count of vehicles from (Marathahalli - Whitefield, ITPL-Whitefield and Sai Baba Temple-Whitefield) purple lines in junction.

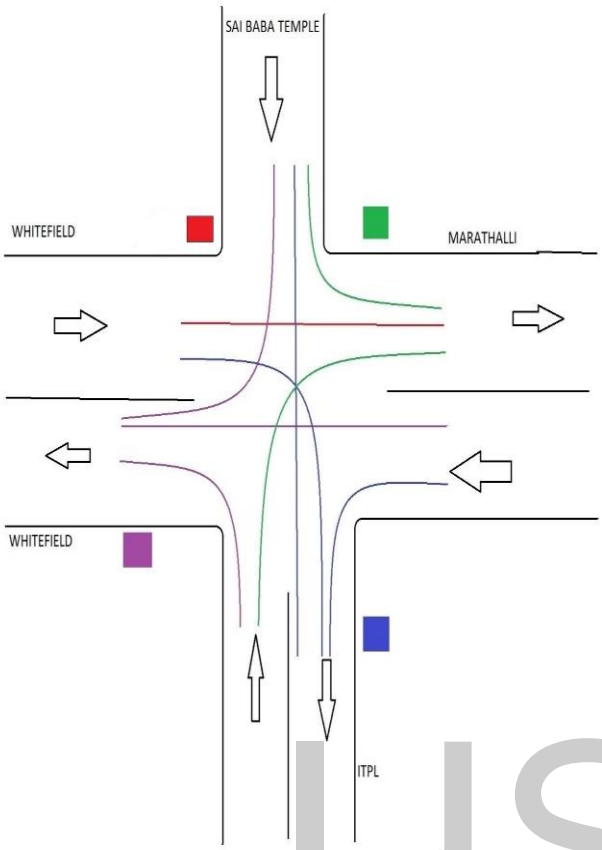

Fig 3.2 schematic diagram

DIRECTIONS	7 DAYS AVG. PEAK VALUE
WHITEFIELD to MARATHAHALLI	2280
WHITEFIELD to ITPL	200
SAI BABA TEMPLE to ITPL	298
MARATHAHALLI to ITPL	1353
ITPL to WHITEFIELD	276
SAI BABA TEMPLE to WHITEFIELD	388
MARATHAHALLI to WHITEFIELD	2229
ITPL to MARATHAHALLI	1896
SAI BABA TEMPLE to MARATHALLI	235

Table 3.1, 7 day average peak values

3.2 Conversion of Traffic Count

There are several types of vehicles (also called Classes) available on roads like cars, trucks, trailers, motorbikes. Their impact/interaction on traffic-flow is also varies due to variation in their sizes, shapes and speeds. It is very difficult to deal with such variety of vehicles from the design and engineering point of view. Therefore, a standard vehicle unit has been defined known as Passenger Car Unit, PCU. There are two set of PCU values according to IRC as

1. Urban roads. (I.R.C:106-1990, Guidelines for capacity of urban roads in plain areas Table-1, Page 10)
2. Non-urban roads (I.R.C: 64-1990 Guidelines for capacity of roads in rural areas Table-1, Page 10 TABLE-

Based on the type of road the PCU values are worked out. In this case we are using urban roads. After conversion of collected data into PCU/hr., the 7days average PCU/hr. value is obtained by taking average values of PCU/hr. for 12 hours i.e. (07:00-08:00 average in all 7 days and similarly for all 12 hours). The peak value obtained is used for design consideration as it satisfies for all the condition.

3.3 Weekly Variation of Traffic

The following graph shows the weekly variation in traffic: It can be observed from the graph, there is a rapid increase in traffic during morning hours then it starts decreasing during afternoon hours of the day and it again increases at evening hours for all 7 days. The volume of traffic is observed more on weekdays as compared to weekends.

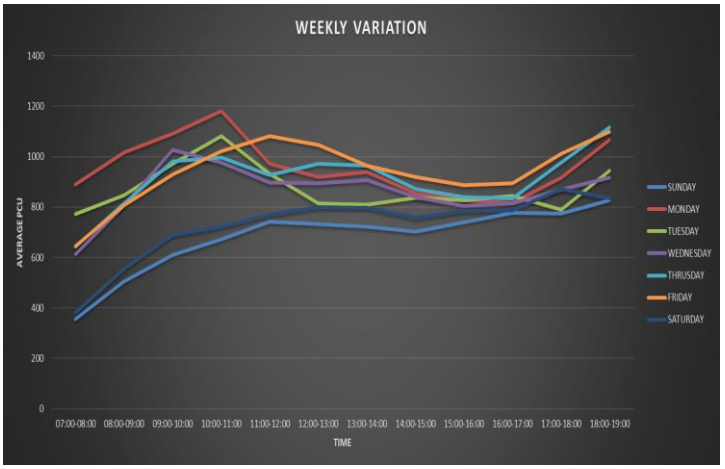

Fig. 3.3 weekly Variation of Traffic

3.4 PHASE DIAGRAM

The objective of phase design is to separate the conflicting movements in an intersection into various phases, so that movements in a phase should have no conflicts. If all the movements are to be separated with no conflicts, then a large number of phases are required. To illustrate various phase plan options, consider a four-legged intersection with through traffic having right and left turns.

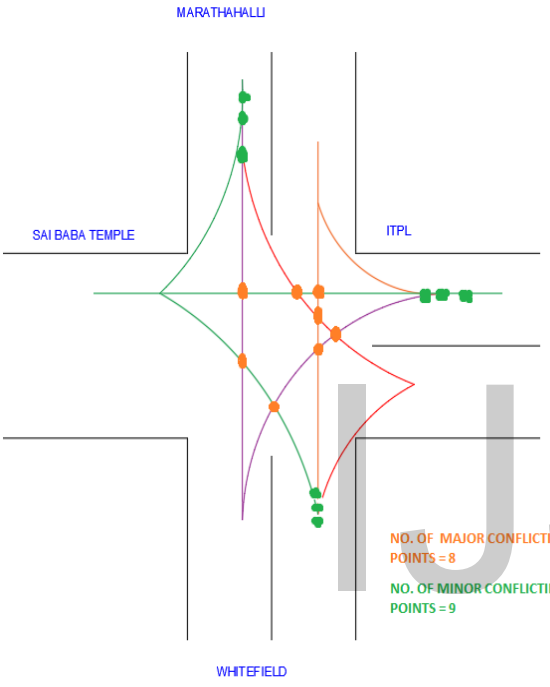

Fig 3.4 Number of Conflicting points at Intersection

Four phase signals are ideally suited in urban areas where the turning movements are comparable with through movements and when through traffic and turning traffic need to share same lane. Where, flow from each approach is put into a single phase avoiding all conflicts. This phase plan could be very inefficient when turning movements are relatively low. The non-conflicting right and left turn is grouped in respective phases. This type of phasing is very efficient when the intersection geometry permits to have at least one lane for each movement, and the through traffic volume is significantly high.

At Kundalahalli junction, at any time in a day there is a large volume of traffic moving in all 9 directions. The junction is having 3 major roads and 1minor roads. The four-phase system is ideally suited for this type of junction.The phase diagram of respective intersection is shown below.

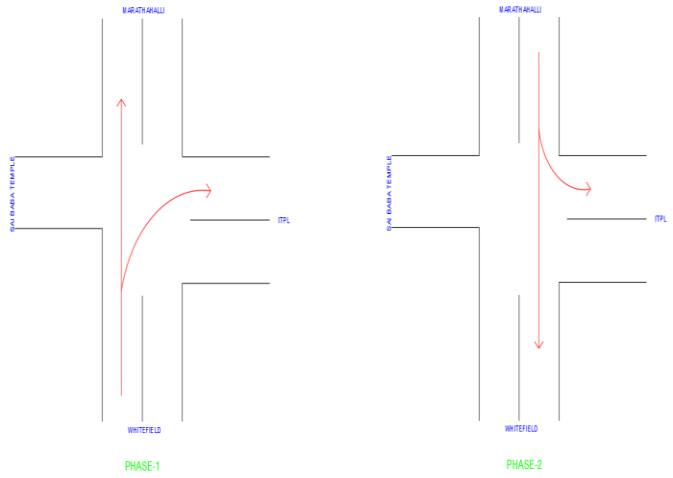

Fig 3.5 Phase Diagram

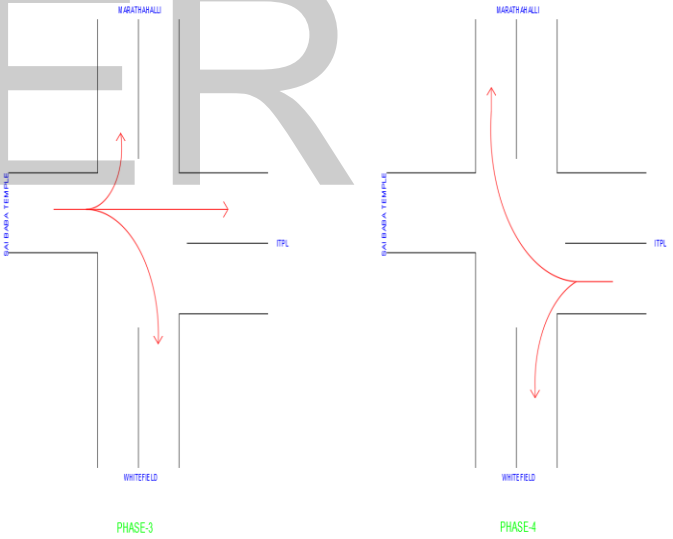

Fig 3.6 Phase Diagram

3.5 Weekly Average Composition of Vehicles at Intersection

The graph below shows the different composition of vehicles passing through the junction. It can be observed 2-wheelers are more as compared to other type of vehicles followed by cars and buses

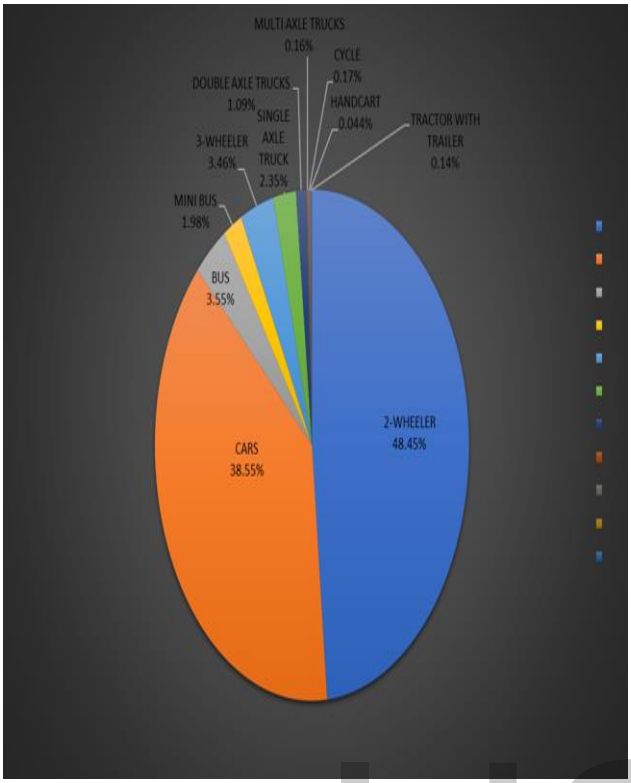

Fig. 3.7, 7 Day average composition of vehicles

4.0 Design of Traffic Signal

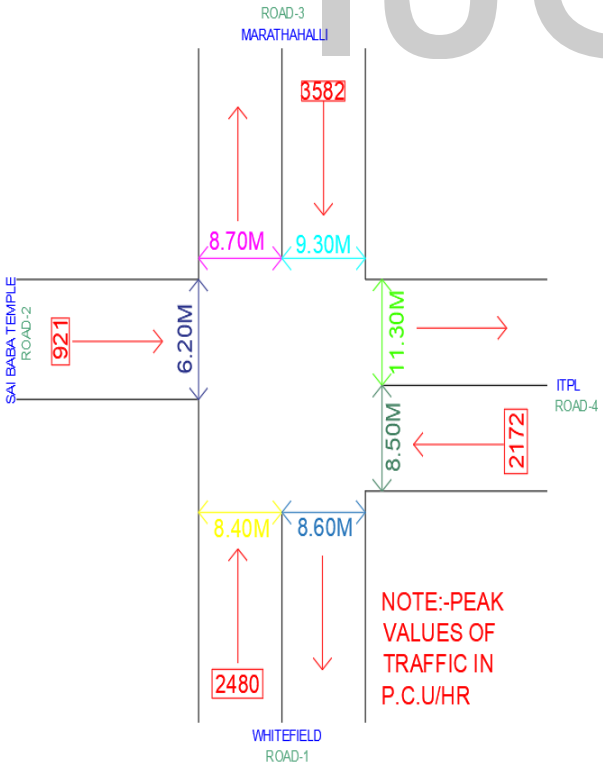

Fig 4.1 Kundalahalli jumction

SIGNAL DESIGN OF INTERSECTION :(Road 1 and Road 2)

Design traffic on road 1 = 2480/2=1240 PCU/hour/lane

Design traffic on road 2 = 921 PCU/hour/lane

Width of road 1 = 17m

Width of road 2 = 6.2m

No of lanes for road 1=2

No of lanes for road 2=1

1) Pedestrian green signal time for road 1

$$=\frac{17}{1.2}+7$$

= 22 sec.

Pedestrian green signal time for road 2

$$=\frac{6.2}{1.2}+7$$

= 13 sec.

2) Green signal time for vehicles on road 2,

G_2 = 22 sec

Green signal time for road 1,

$$G_1 = 22 \text{ X } \frac{1240}{921}$$

= 30sec

3) Adding 2.0 sec each to the clearance amber and 2.0 sec to the inter-green period for each phase Total cycle time required = (2+22+2) +(2+30+2)

= 60sec

Table-4.1 Calculated Signal timings for Whitefield and Sai Baba Road

Signal timing	Initial Amber	Green	Clearance Amber	Red	Cycle length
Whitefield Road	2	30	2	26	60
Sai Baba Temple Road	2	22	2	34	60

Similarly for road 3 and road 4

Table-4.2 Calculated Signal timings for Marathalli and ITPLRoad

Signal timing	Initial Amber	Green	Clearance Amber	Red	Cycle length
Marathalli Road	2	39	2	27	70
ITPL Temple Road	2	23	2	43	70

Check for Optimization of Signal Timing at Intersection by Webster's Formula

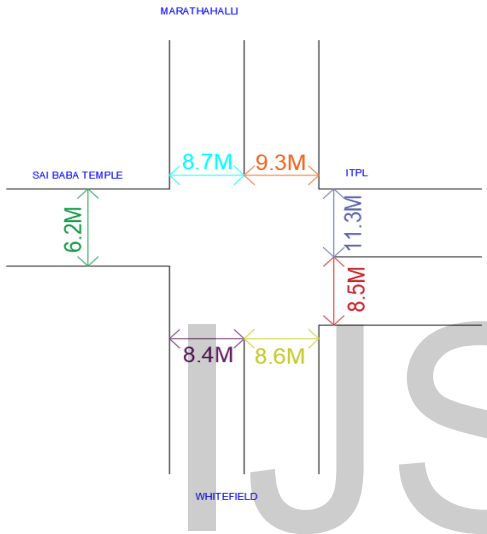

Fig 4.2 kundanhalli junction

The saturation flow values may be assumed from the below table for calculating the cycle length

Table-4.3 Saturation flow for Optimization of Signal Timing

SATURATION FLOW (PCU/HR)	ROAD WIDTH (IN METERS)
1850	3.0
1890	3.5
1950	4.0
2250	4.5
2550	5.0
2990	5.5

The above table is valid up to road width of 5.5m and width above 5.5m can be assumed as 525 per meter road width up to 18 meters.

$$C0 = (\mathbf{1.5}\boldsymbol{L}+\mathbf{5}) /(\mathbf{1}-\boldsymbol{y})$$

WHERE,

L= Lost time per cycle= (AMBER + inter green + time lost for Initial delay for two phases= (2+2+4)×2= 16 sec.

Y=Volume/saturation flow for critical approach in each phase

c0=optimum cycle length

The lost time is calculated from amber time, inter green time and Intial delay of 4 sec for first vehicle on each leg.

Lost time per cycle= (amber + inter green + time lost for Initial delay for two phases)= (2+2+4) ×2= 16sec.

Saturation flow for road 1 of width 8.4m= 525×8.4=4410 PCU/ hr

Saturation flow for road 2 of width 6.2m =525×6.2=3255 PCU/ hr

Saturation flow for road 3 of width 9.3m= 525×9.3=4882.5 PCU/ hr

Saturation flow for road 4 of width 8.50m= 525×8.50=4462 PCU/ hr

Y_1=1240/4410=0.28

Y_2= 921/3255= 0.28

Y_3=1791/4882.5=0.366

Y_4=1086/4462=0.243

$C_0 = (\mathbf{1.5}\boldsymbol{L}+\mathbf{5}) /(\mathbf{1}-\boldsymbol{y})$

(1.5*16+5)/ (1-0.28) =40 SECONDS

Table-4.4 Optimum Cycle Length for Intersection

	Q	S	Y=Q/S	Co(SECONDS)
ROAD 1	1240	4410	0.28	40
ROAD 2	921	3255	0.28	40
ROAD 3	1791	4882.5	0.366	46
ROAD 4	1086	4462	0.243	39

THEREFORE, the provided cycle length is safe as the optimum cycle length is less than provided.

Check for design of signal cycle timing on the basis of vehicular volume

It is assumed that the first vehicle on each approach lane will take six seconds reaction time to start after stop and subsequent other vehicles take 2 seconds.

CHECK FOR ROAD 1(Whitefield Road)

Number of vehicle per hour per lane=2480/2

1240 per lane

Number of vehicle per lane per cycle=1240/60

=20.67 (Say 21)

So,

= 1x6+20x2

= 46secs

Number of vehicles per lane per cycle (Whitefield to ITPL) =200/60= 3.34 vehicles (say=4)

So,

=1x6+3x2

= 12secs

As per IRC minimum green time should be limited to 16sec

Green time provided is 30secs which is not safe, so it should be increased to 46secs.

CHECK FOR ROAD 2 (Sia Baba Temple Road)

Number of vehicle per hour per lane=921

921 per lane

Number of vehicle per lane per cycle=921/60

=15.35 (Say 16)

So,

= 1x6+15x2

= 36secs

Similarly for Road 3 and Road 4.

REVISED GREEN TIME FOR TRAFFIC SIGNAL

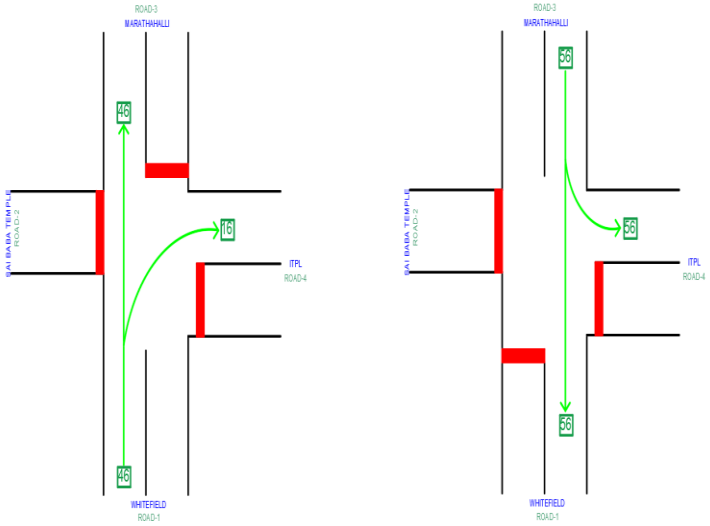

Fig 4.3 Revised Green Time for Whitefield And Marathalli Road

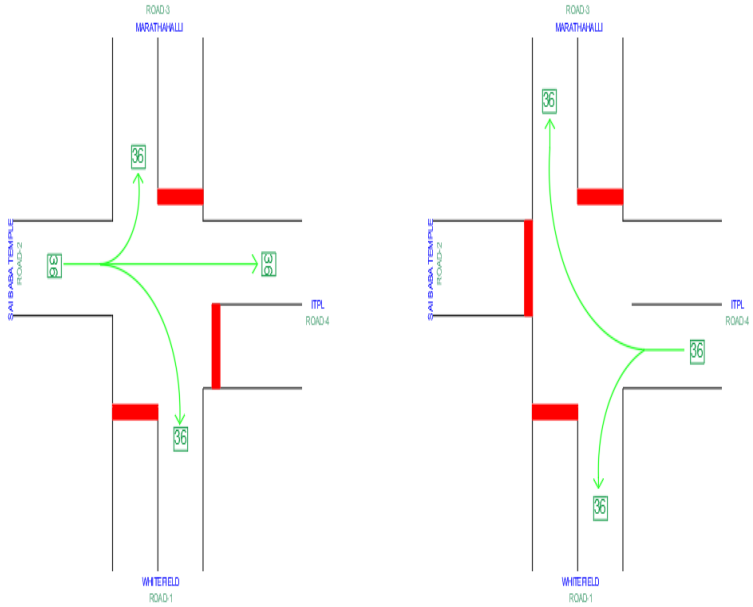

FIG 4.4 Revised Green Time for Sai Baba Temple And Itpl Road

In case of phase 1 when all roads are red except Whitefield to Marathahalli and Whitefield to ITPL. The green time for vehicles from Whitefield to ITPL is 16 seconds which means after 16 seconds the vehicles from Marathahalli to Whitefield will be stop. The green time from Marathahalli to Whitefield and Marathahalli to ITPL is 56 seconds, so Whitefield to Marathahalli can be given as green for vehicles. The green time for Marathahalli to Whitefield again increase from 46 to 56 seconds and total of 76 seconds.

5.0 Results

Based on the calculations done on the PCU values obtained from the traffic survey, the optimum Signal Cycle Length was found to be 148 seconds.

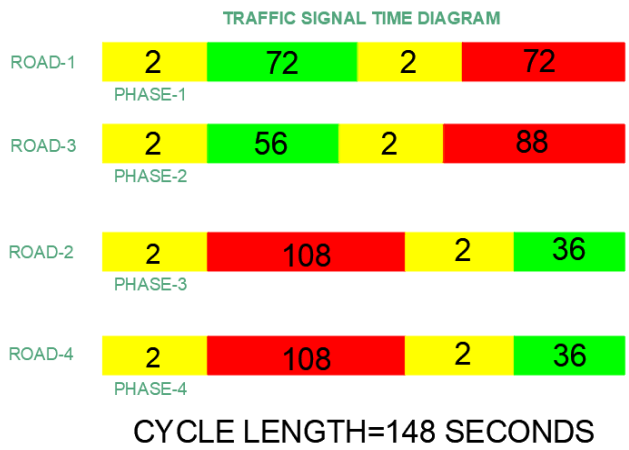

Fig 5.1 Cycle Length Diagram

6.0 Existing System

The existing system is a fixed time signal in which the cycle length are pre-determined and of fixed duration. This cycle length works for entire day for both peak and non-peak hours. The cycle length at the intersection is same for three major roads 189 seconds and for the minor road 259 seconds. The waiting time for the minor road is too large, there is a danger the good portion green time will be used by unsaturated flow of traffic which again leads to inefficiency. Therefore for each traffic flow volume there is a optimum cycle time which results in minimum delay to the vehicles. The traffic signal are operated manually when there is large volume of traffic at any part of day.

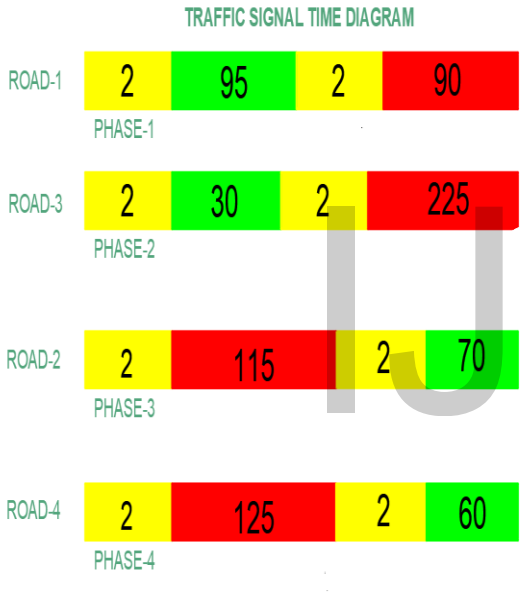

Fig 6.1 Existing Cycle Length at Intersection

7.0 DISCUSSION

- The traffic volume was collected from 07:00-19:00 and it was observed that the maximum number of vehicles passed through signal were from morning 09:00-11:00 and in evening 17:00-19:00, As these hours of the day during which traffic congestion on roads and crowding on public transport is at its highest. Normally, this happens twice every weekday—once in the morning and once in the evening, the times during which the most people commute
- Based on the conversion of traffic count to PCU it was observed that PCU obtained on Whitefield road is 2480, Itpl road is 2172, Marathalli road is 3582 and Sai Baba Temple road is 921.
- Based on the calculations done on the PCU values obtained from the traffic survey, the optimum Signal Cycle Length was found to be 148 seconds. The cycle length at the existing intersection is same for three major roads 189 seconds and for the minor road 259 seconds. The waiting time for the minor road is too large, there is a danger the good portion green time will be used by unsaturated flow of traffic which again leads to inefficiency.
- The timing of the signal provided at existing system is more than the optimum cycle length which causes delay to the vehicles. If the timing is causing extra delay to the vehicles than the driver will disobey the signal, resulting in cause of accident. Thus the signal timing should justify the movement of vehicles so that extra delay by the RED signal will not affect the total journey time. Main consideration in selecting the cycle length should be that least delay is caused due to the traffic passed through the intersection.

8.0 CONCLUSION

- The peak hours are identified as 09:00-11:00 in the morning and 17:00-19:00 in the evening.
- The P.C.U values was converted successfully and the maximum 7 days average peak values was found to be 3582.
- The Optimum cycle length was found to be 148 seconds for all the phases.
- The cycle length at intersection may be considered for upgradation.

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