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Design of Traffic Signal using Webster Method

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ABSTRACT

Najafgarh is our area of concern for traffic jams. If Congestion in Najafgarh can be reduced it will ultimately reduce the travelling time to all nearby places.
Therefore, to reduce congestion we:

- Analyzed the whole Area
- Found out the main Causes for the Congestion
- Studied the Various Characteristics
- Put Up some Remedial Measures to Reduce congestion
- Designed Traffic signal using webster method

1: INTRODUCTION

1.1 NAJAFGARH

Najafgarh is a town in the South West Delhi district in the National Capital Territory of Delhi, India. It is one of the three subdivisions of the Southwest Delhi district.[2] Najafgarh is located at the outskirts of the southwestern part of Delhi near the Haryana border, a distance of 29 kilometres (18 miles) from the New Delhi City Center. It has a mixture of rural and urban populations from Delhi and Haryana. Due to the presence of a lot of freehold land, Najafgarh is one of the fastest developing tehsil (sub-district) in the southwest district of Delhi.

Najafgarh is primarily known for being an economic and transport hub in rural Delhi. Major markets located in Najafgarh include Main Market, Nawada Bazaar, Anaz Mandi (foodgrain market), Tura Mandi (fodder market) and Sabzi Mandi (vegetable market). Seven roads start at the Najafgarh Phirni (circular road) and go to: Inderlok , Chhawla , Khaira , Dhansa , Jharoda , Dichaon and Nangloi. The roads towards Chhawla, Dhansa and Jharoda further lead up to the cities of Gurgaon, Jhajjar and Bahadurgarh in Haryana.

Najafgarh-Bahadurgarh Road is an intersection in nazafgarh with one road leading to dhansa and other one leading to khera dabar. Because of increasing traffic and no traffic signal, there is often traffic jam at this intersection.

1.2 MOTIVATION

As we daily commute to college, we pass through Najafgarh-Bahadurgarh Road and many times we were stuck in traffic jam there. The jams at Najafgarh-Bahadurgarh Road were long and irritating. Sometimes, we were late to our exams due to this traffic. These jams, generally, use to increase our travelling time by 10 minutes. Therefore, we decided to study the traffic conditions there and find remedies for it.

Also, it was necessary to design a Traffic signal as there is no signal at intersection and the absence of signal is a major cause of chaos at intersection.

1.3 LITERATURE REVIEW

Traffic congestion in Indian cities is visibly on the rise. This has a detrimental effect on productivity, air pollution, fuel wastage, health, and quality of life. In the developed world, traffic congestion has long been recognized as an economic as well as a social impediment, and detailed studies on the economic aspects of congestion have been conducted. Such studies have been successful in sparking numerous policy deliberations and have generated interest in devising novel traffic management systems.

A brief overview of road congestion statistics in some developed economies is given below.

• Annual congestion cost in the United Kingdom (UK) will reach 33.4 billion US$ by 2030, rising by over 50% from the 2014 levels of 20.5 billion US$

• Annual cost of congestion in the United States (US) as of 2014, has been pegged at 124 billion US$; this is projected to increase to 186 billion US$ by 2030

• In Australia, annual congestion cost levels are expected to rise from Australian Dollars (AUD) 3.5 billion (2005) to AUD 7.8 billion (2020) for Sydney, and AUD 3.0 billion (2005) to AUD 6.1 billion (2020) for Melbourne.

Such extensive studies have not been conducted for Indian cities as yet. However, it is being recognised that as India develops, congestion in cities is going to increase sharply, with numerous negative implications.

The following statistics provide some insights into the congestion scenario in New Delhi:

• New Delhi’s vehicular population is projected to rise to 10 million by 2020, leading to a marked increase in congestion, which will severely impede economic activity

• In New Delhi, at least about 300,000 US$ worth of fuel was being wasted everyday, by vehicles idling at traffic signals as early as in 1998. This figure jumped to approximately 1.6 million US$ per day as of 2010.

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• New Delhi has been named the world's most polluted city among 1600 cities by the World Health Organisation (WHO), and vehicular emissions are a major contributor to this situation

Table 1.1 Marginal costs of congestion due to productivity losses

Mode of transport	2001 (INR/VKm)	2013 (INR/VKm)
Car	4.91	9.57
Bus	9.83	19.16
Two-wheeler	0.98	1.91

Table 1.2 Economic costs of accidents

Accident classification	Costs (in INR prices of 2013-2014)
Fatality	1745600
Major accident	311430
Minor accident	40917

Table 1.3 Total cost of congestion in New Delhi due to productivity losses

Mode	Cost(in million us dollar/year)
Car	869
Bus	6310
Two-wheeler	239
Total	7410

Table 1.4 Total cost of congestion in New Delhi

Mode	Total cost (in million us dollar/ year)
Car	911
Bus	6980
Two-wheeler	258
Accidents	64
Fuel wastage	699
Total	8912

1.4 OBJECTIVE

Our objective is to:-

- Analyze the whole area
- Find causes for traffic congestion
- Find remedies for the causes
- Study and record various parameters
- Design traffic signal for Najafgarh-Bahadurgarh Road

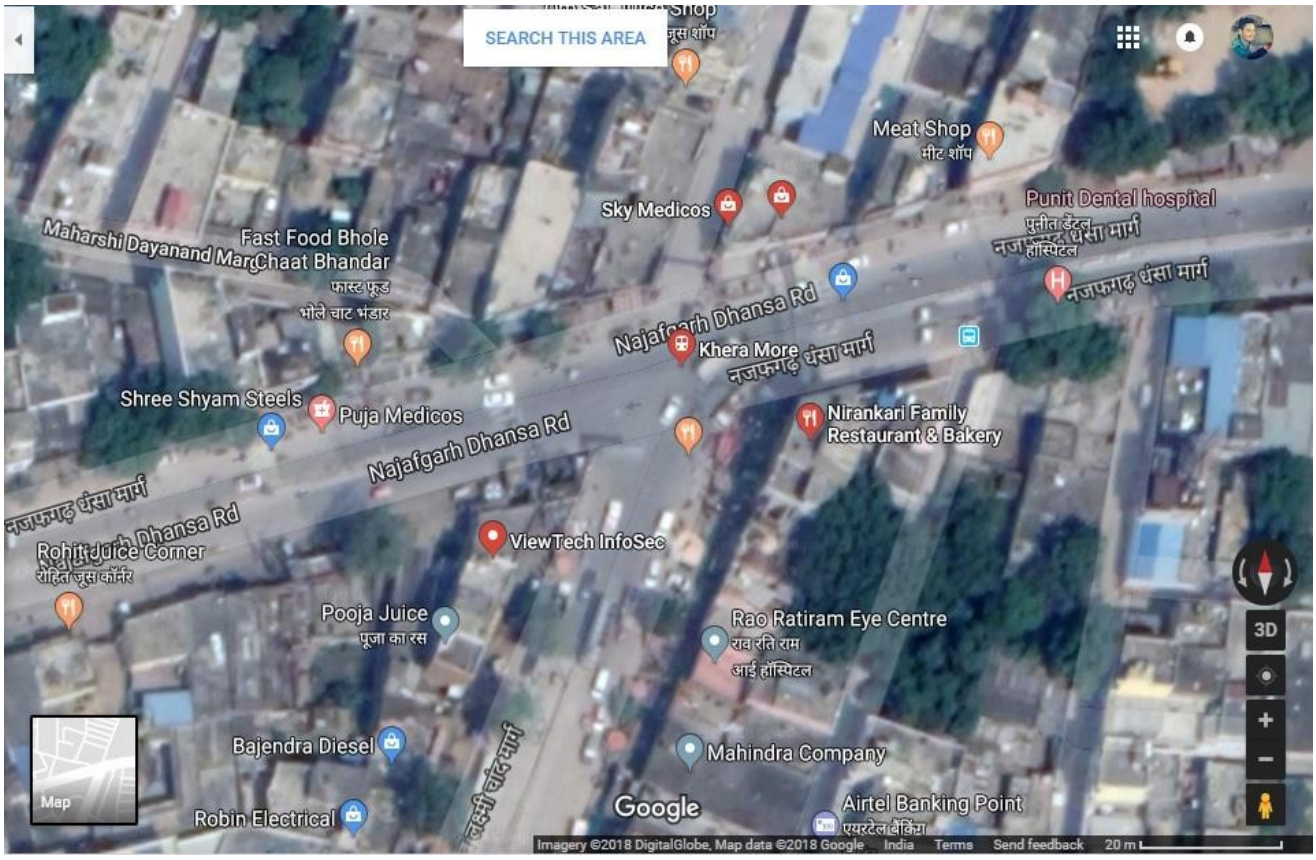

Figure 1.1 satellite image of Najafgarh-Bahadurgarh Road

CHAPTER 2: CAUSES OF TRAFFIC CONGESTION

2.1 PUZZLED POSITION OF BUS STOPS

At Najafgarh-Bahadurgarh Road, there is no dedicated and proper bus stop. Therefore, buses often stop at locations, blocking the traffic behind them. Buses stop just after crossing the intersection. Width of road at this section is less due to encroachment and stopping of bus further blocks the movement.

Figure 2.1

Figure 2.2

2.2 ENCROACHMENTS

The effective width, of already narrow road, is reduced by encroachments. There is a transformer just the corner of intersection which creates problem for trucks turning left from khera dabur side. Just after transformer, there is a juice stall. Also, the shop owners put their sign boards and stock outside the shops on road.

Figure 2.3

Figure 2.4

2.3 NO PROPER HALTING POINT FOR GRAMIN SEWA AND RTV

There is no dedicated halting point for gramin sewa and RTVs. Because of this they randomly stop anywhere to pic and drop passengers, without caring for traffic behind them. This sometimes leads to altercation between drivers and leading to Road jam.

Figure 2.5

Figure 2.6

2.4 UNTRAINED DRIVERS OF RTVS, GRAMIN SEWA AND E-RICKSHAWS

Most of the drivers of these vehicles are untrained. They overload their vehicles and drive recklessly. They stop at any location at their will leading to traffic jam.

2.5 NOT WORKING OF RED LIGHTS

There is no working red light at the intersection. When there are Road vehicles, traffic signal is needed to guide vehicles at intersection.

2.6 LONG RUSHES AND HECTIC CROWDS

The crowd is impatient. Everyone tries to go first at the expense of others. This leads to interlocking of vehicles at intersection.

Figure 2.7

Figure 2.8

Figure 2.9

3: REMEDIES

3.1 NEW POSITION FOR BUS STOP

Length of DTC low floor Bus : 12m

Length of cluster Bus : 11.2m

So taking the maximum of the above two lengths,

L = 12m

Assuming 2 Buses stop at the same time at the Bus stop,

Total length of Buses, L=12 x 2 = 24m

Taking average distance between two Buses equal to 1 m Total

minimum distance required after traffic signal would be, Leq =

12+1+12 = 25m

So, Bus stops should be placed at least a distance of 25 from traffic signals so as to accommodate 2 Buses at a time easily which is already a rare case.

Taking a factor of safety of 1.3

Length to be taken for bus stop, 25 x 1.3 = 32.5m

We will build bus stop after 80m from intersection

Figure 3.1 satellite image of proposed location of bus stop

Figure 3.2 proposed location of bus stop

Figure 3.3

3.2 SOLUTION FOR GRAMIN SEWA AND RTV

- Providing proper auto-stand for parking of Autos and gramin sewa.
- There should be a limit on number of vehicles that will be observed by the corresponding authority.
- Ensuring strict implementation of traffic rules by gramin sewa for moving at wrong sides and stopping at wrong locations.
- Providing unique identities to these rickshaws so that they can be identified easily if they break any rules.
- Provide proper training to drivers and make high standards in providing them licences.

4: DESIGN OF TRAFFIC SIGNAL USING WEBSTER METHOD

4.1 NEED FOR TRAFFIC SIGNALS

Traffic lights are signaling devices positioned at road intersections, pedestrian crossings, and other locations to control flows of traffic. Traffic lights alternate the right of way accorded to users by displaying lights of a standard colour (red, amber (yellow), and green) following a universal colour code. In the typical sequence of colour phases.

- The green light allows traffic to proceed in the direction denoted, if it is safe to do so and there is room on the other side of the intersection.
- The amber (yellow) light warns that the signal is about to change to red. Actions required by drivers on a yellow light vary, with some jurisdictions requiring drivers to stop if it is safe to do so, and others allowing drivers to go through the intersection if safe to do so.
- A flashing amber indication is a warning signal.
- The red signal prohibits any traffic from proceeding.
- A flashing red indication is treated as a stop sign.

4.2 PASSENGER CAR UNIT

The PCU may be considered as a measure of relative space requirement of a vehicle class compared to that of a passenger car under a specified set of roadway, traffic and other conditions. The PCU value of a particular vehicle class may be considered as the ratio of capacity of a roadway when there are passenger cars only to the capacity of the same roadway when there are vehicles of that class only.

4.3 FACTORS AFFECTING PASSENGER CAR UNIT(PCU)

a) Dimension of vehicle such as width and length.
b) Dynamic characteristic of vehicles- speed, acceleration and braking.
c) Transverse and longitudinal gaps or clearance between moving vehicle which depends upon speed, driver characteristics and vehicle class.
d) Roadway characteristic such as road geometrics including gradient and curves, access control, rural or urban road , presence of intersections and type of intersections.
e) Environmental and climatic conditions.

Table 4.1 PCU values recommended by IRC

SERIAL NO	VEHICLE TYPE	EQUIVALENT PCU FACTOR
1	BUS/TRUCK	2.2
2	TRACTOR TROLLY	4.0
3	GRAMIN SEWA/PICKUP VAN/CAR	1
4	2 WHEELER	0.5
5	E-RICKSHAW/AUTO RICKSHAW	1.5

4.4 TRAFFIC FLOW DATA

TABLE 4.2 DAYWISE PCU

Time/Day	30th March	31st March	1st April	2nd April	3rd April	4th April	5th April	Average
8-10	3210	3102	2694	3800	3985	4208	3856	3600
12-2	2108	1912	1632	2641	2800	2902	2986	2500
5-7	3250	2800	2298	3512	3409	3453	3408	3100

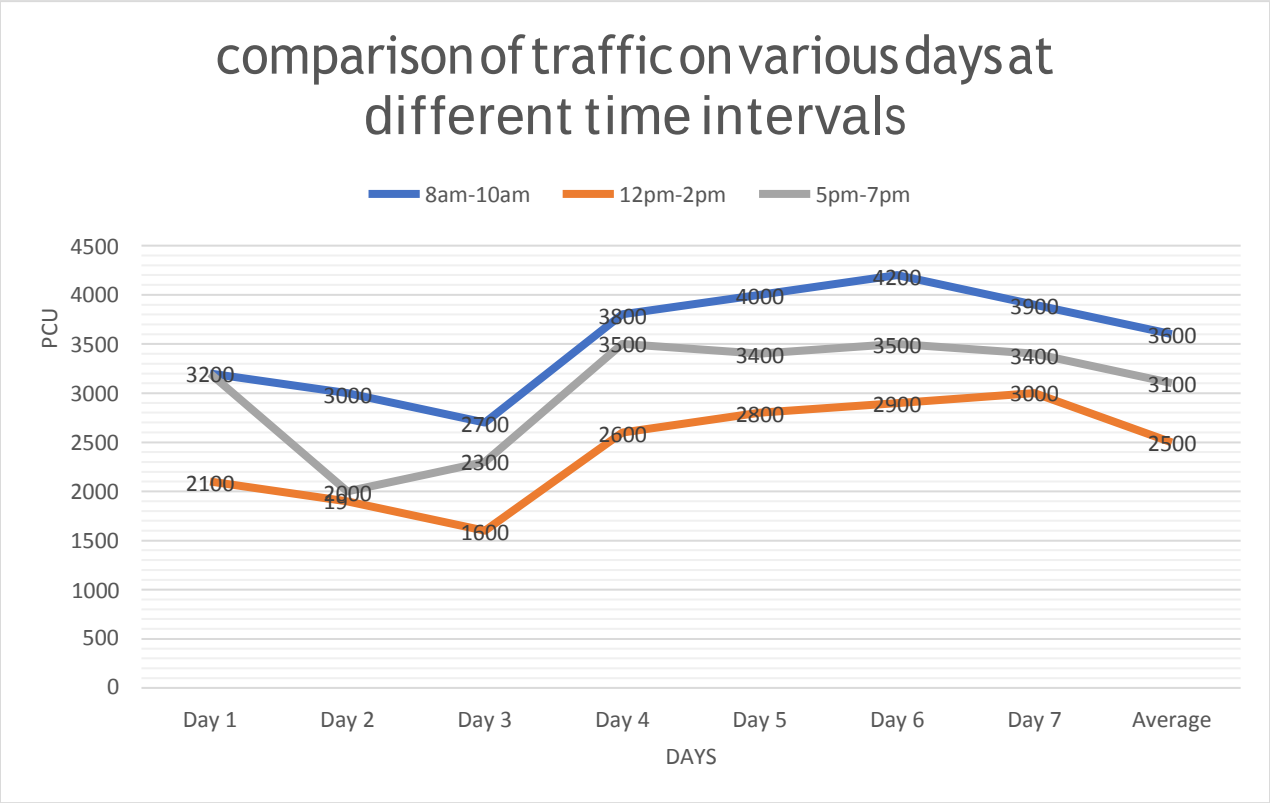

Figure 4.1

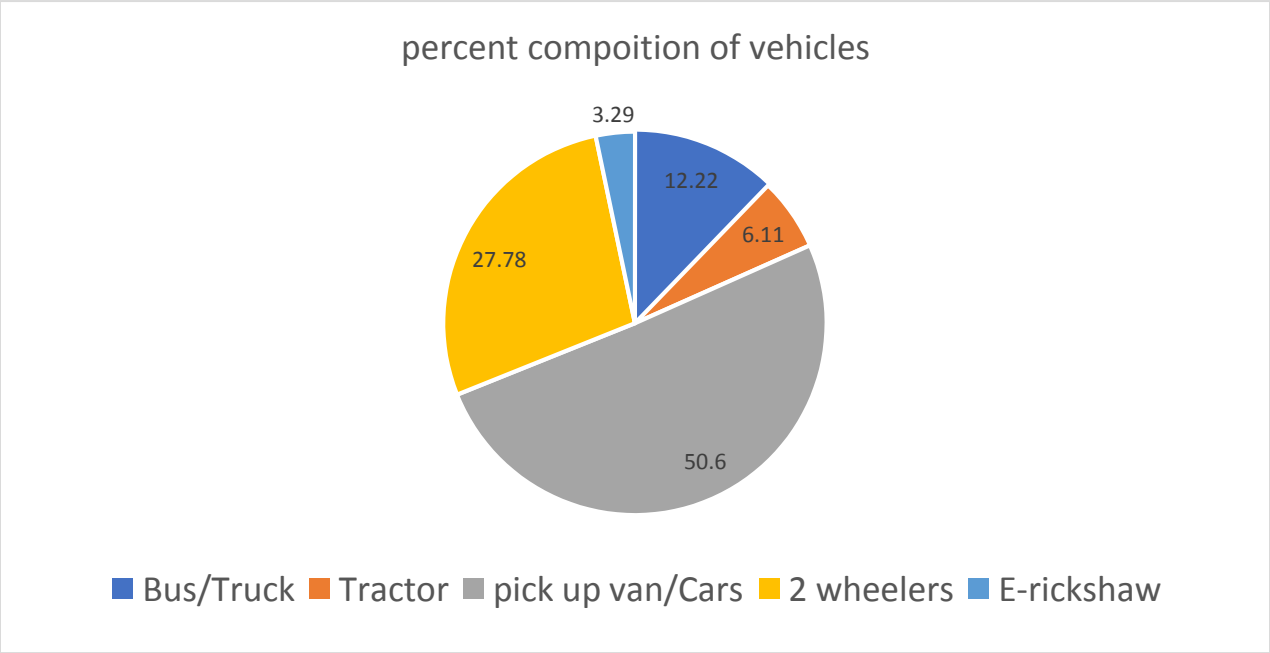

Figure 4.2

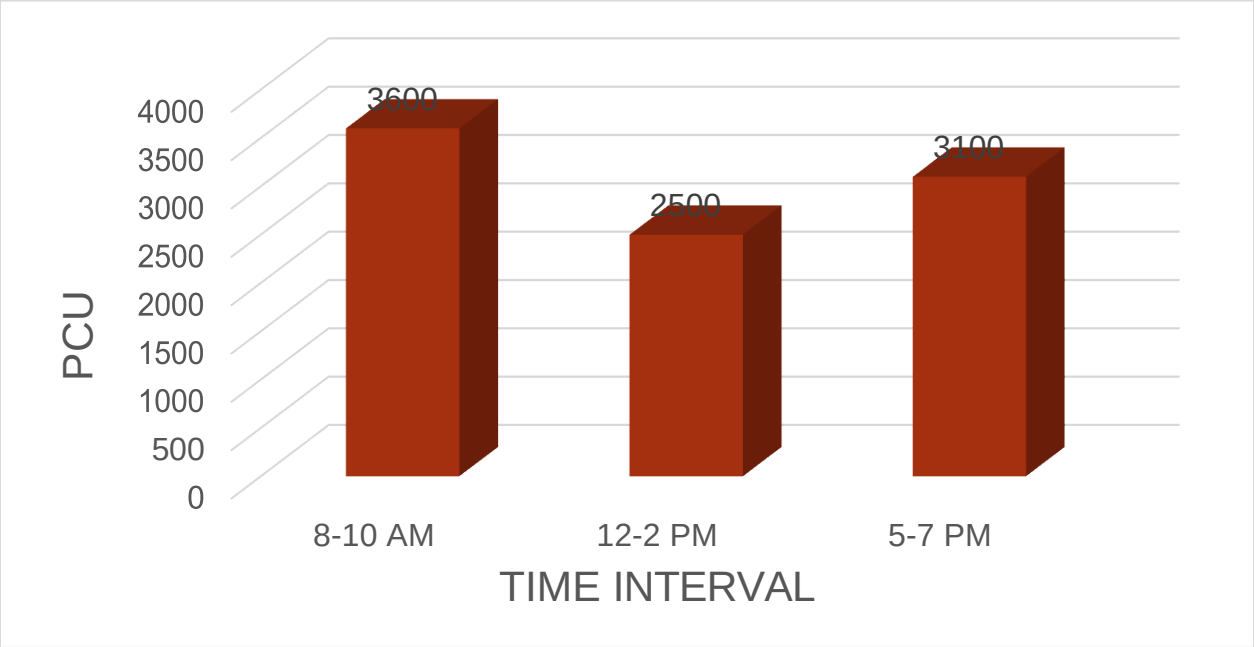

Figure 4.3

4.5 WEBSTER'S METHOD OF TRAFFIC SIGNAL DESIGN

It has been found from studies that the average delay and the overall delay to the vehicles at a signalized intersection vary with the signal cycle length. The average delay per vehicle is high when the cycle length is very less, as a sizable proportion of vehicles may not get cleared during the first cycle and may spill over to subsequent cycles. As signal cycle time is increased, the average delay per vehicle decrease up to a certain minimum value and there after the delay starts increasing, indicating that there is an **optimum signal cycle time** corresponding to least overall delay. The optimum cycle time depends upon geometric details of the intersection and the volume of traffic approaching the intersection from all the approach roads during the design hours.

Webster's method of traffic signal design is an analytical approach of determining the optimum signal cycle time, **Co** corresponding to minimum total delay to all vehicles at the approach road of intersection.
The field work consists of determining the following two sets of values on each approach road near the intersection: -

- The normal flow **q** on each approach during the design hour
- The saturation flow **S** per unit time

4.6 FORMULAE USED

☐ Optimum cycle length, $C_O = (1.5L+5) \div (1-Y)$

Where, L= total lost time per cycle

$L = n[t_{sl} + t_{cl} + \text{all red}]$

$Y = y1 + y2 + ... + yn$

$= (q1/s1) + (q2/s2) + ……. + (q_n/s_n)$

- ☐ Effective green interval $G_1 = Y_1(C_o - L)/Y$
- ☐ $Q_c = 1000V/S$

Where, q_c = capacity of single lane, vehicles per hour per lane

V= speed in KMPH

S= average Centre to Centre spacing of vehicles when they follow one behind the other as a queue or space headway, meter

S= 0.7v+ L, m L=Length of vehicle

4.7 CALCULATIONS

- q_1=380 PCU S_1= 2500 PCU
- q_2=860 PCU S_2= 2500 PCU
- q_3=340 PCU S_3= 2200 PCU
- q_4=230 PCU S_4= 2000 PCU

$Y = q1/S1 + q2/S2 + q3/S3 + q4/S4$

$= 380/2500 + 860/2500 + 340/2200 + 230/2000$

$= 0.765$

$C_o = (1.5 * 16 + 5)/ (1 - 0.765)$

$= 123.404 \sim 124$

GREEN TIME FOR DIFFERENT

PHASES PHASE 1

$G_1 = (124-16)*0.152/0.765 = 21.458 \sim 21$ s

PHASE 2

$G_2 = (124-16)*0.344/0.765 = 49.56 \sim 50$s

PHASE 3

$G_3 = (124- 16)*0.154/0.765 = 21.74 \sim 22$s

PHASE 4

G4= (124-16)*0.115/0.765 = 15.25 ~ 15s

: RESULTS AND CONCLUSIONS

5.1 PHASE 1

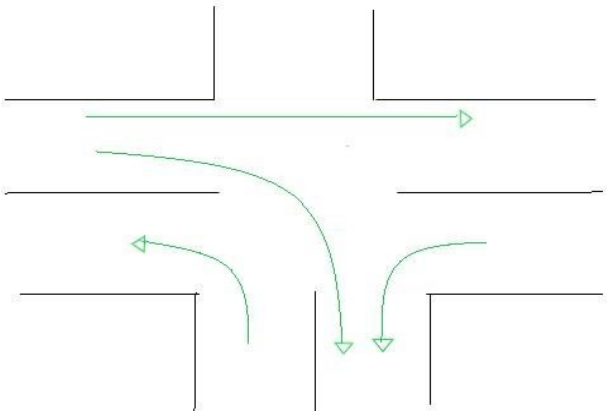

Figure 5.1

Normal flow = 380 PCU per hour per
lane Saturation flow = 2500 PCU
EFFECTIVE GREEN TIME G1 = 21 s

5.2 PHASE 2

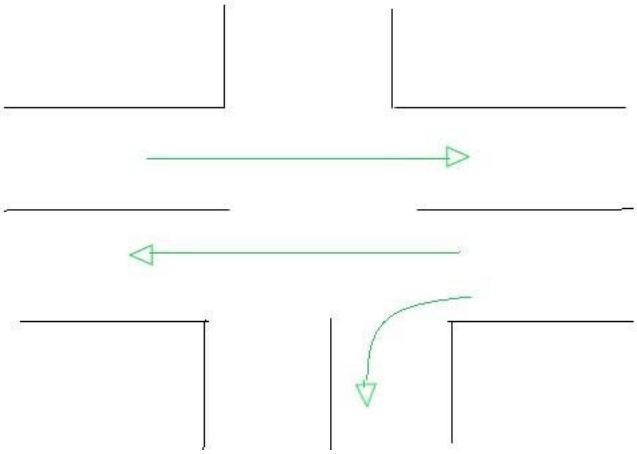

Figure 5.2

Normal flow = 860 PCU per hour per
lane Saturation flow = 2500 PCU

EFFECTIVE GREEN TIME G2= 50s

5.3 PHASE 3

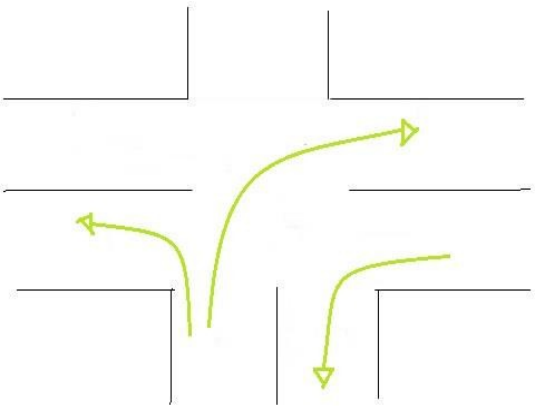

Figure 5.3

Normal flow = 340 PCU per hour per

lane Saturation flow = 2200 PCU

EFFECTIVE GREEN TIME G_3 = 22s

5.4 PHASE 4

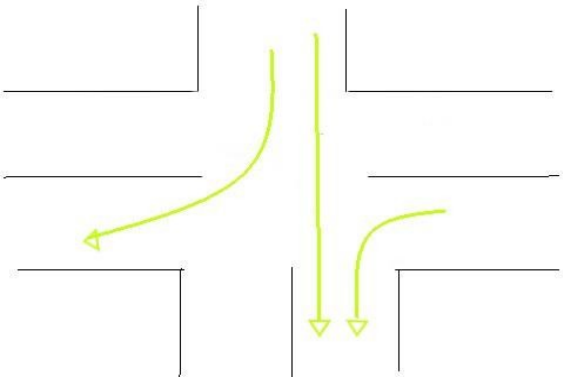

Figure 5.4

Normal flow = 230 PCU per hour per lane

Saturation flow = 2000 PCU per hour per lane

EFFECTIVE GREEN TIME G_4 = 15s

Table 5.1 Comparison of Existing and Required green time

PHASE	EXISTING GREEN TIME	DESIGNED GREEN TIME (s)
1	NOT WORKING	21
2	NOT WORKING	50
3	NOT WORKING	22
4	NOT WORKING	15

5.5 Conclusions

- A new bus stop is provided 80 meters ahead of the intersection. As our recommended distance from intersection was 32.5 meters, hence our provided distance is ok.
- A proper auto-stand for parking of Autos and gramin sewa should be provided.
- There should be a limit on number of vehicles that will be observed by the corresponding authority.
- Strict implementation of traffic rules by gramin sewa for moving at wrong sides and stopping at wrong locations.
- Providing unique identities to these rickshaws so that they can be identified easily if they break any rules.
- Provide proper training to drivers and make high standards in providing them licenses.
- Road from Najafgarh-Bahadurgarh Road to inner Najafgarh is made one way only.
- A 4-phase traffic signal is provided at the intersection with green time of each phase as follows.

Table 5.2 Green time for each phase

PHASE	**GREEN TIME**
1	**21**
2	**50**
3	**22**
4	**15**

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