PERFORMANCE EVALUATION AND CAPACITY ANALYSIS AT A SIGNALIZED INTERSECTION ON THE JUNCTION OF JINNAH AVENUE & FAISAL AVENUE USING VISSIM

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Report entitled

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DEDICATED
TO
OUR FAMILIES, TEACHERS AND COLLEAGUES

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Last but not the least we would like to thank our parents, who provided unlimited support to us morally and financially and had absolute faith in us.

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CBD	-	Central Business District
EB	-	East Bound
FLT	-	Left Turn Factor
FLU	-	Lane Utilization Factor
FRT	-	Right Turn Factor
HCM	-	Highway Capacity Manual
HCS	-	Highway Capacity Software
ICU	-	Intersection Capacity Utilization
LOS	-	Level of Service
NB	-	North Bound
RTOR	-	Right Turn on Red
SB	-	South Bound
TDC	-	Traffic Data Collector
TRB	-	Transportation Research Board
WB	-	West Bound

ABSTRACT

Due to urban sprawl and with growing traffic volumes the traffic congestion at main highway intersection has increased manifolds. The Jinnah/Faisal Avenue is one of the most important and heavily utilized intersections in capital city. To minimize the congestion and to facilitate the citizens at this intersection a flyover was constructed the underpass of which was opened in October 2008 whereas the main interchange was opened for traffic in March 2009.

After the inauguration of Centaurus, a seven-star hotel that is located near this junction, the traffic volume has again increased especially on the weekends, due to which the congestion and mobilization problem has resurfaced.

Today the residents of Islamabad especially commuters and those who visit Centaurus regularly face delay and disturbance due to increased traffic volumes.

We shall analyze the capacity and utilization of Jinnah/Faisal Avenue intersection keeping in view the volumes of traffic that have been increasing exponentially.

Chapter 1

INTRODUCTION

1.1 BACKGROUND

Signalized intersections are known as the most complex locations in urban networks. The operational conditions of signalized intersections profoundly affect the overall efficiency of the entire transportation network. As the operational quality of urban road network gradually deteriorates due to increase in traffic volume, a higher level of service is required and a well-planned, efficient and improved scheme is necessary to assure a well-defined urban transportation system.

The evaluation of performance of signalized intersections is one of the most important tasks in the management and improvement of urban traffic systems. Based on these assessment results, traffic authorities can isolate the strategies and plans to give rationale for taking improvement measures and allocation of funds. Researchers in the United States and Canada have suggested that both the capacity and level of service must be fully considered to evaluate the overall performance of signalized intersections.

Signal control is a frequently used remedy of capacity shortage in urban areas. An efficient method of predicting the capacity of signalized intersections is important for effective roadway design and traffic management. Signal control is the highest type of control possible at grade intersection. If the signal control plan is not designed properly, the signal control may become counterproductive. The problems which arise due to inadequate planning can be congestion, undue delays, fuel wastage, air pollution, reduced intersection capacity and tremendous inconvenience for the road user.

The purpose of this research is to study the factors associated with traffic congestion and delays on Jinnah/Faisal Avenue intersection. These factors include capacity analysis, v/c ratio, flow rate in saturated conditions, length of queues, and analysis of the currently employed optimizing strategies. Why they are rendered ineffective and how can they be improved for efficiency in traffic flow at intersections. VISSIM software will be used to compare the existing geometry at the signalized intersection with that after optimization. The software simulates a microscopic synchro/simtraffic environment which enables effective analysis.

1.2 RESEARCH OBJECTIVES

Analysis and Measurement of traffic data accurately on ground is an important factor for designing and operating traffic intersections. As a performance measure, data recording and analysis plays an important and critical role in evaluating intersection capacity utilization, its level of service (LOS) at intersections and its future demands. The main objectives of the project is to focus on the data recording and analysis for sorting out the reasons for the congestion at Faisal Avenue intersection and suggest alternate solutions which are feasible and economical to ensure a smooth and safe flow of traffic.

The objectives of this thesis are as follows:

1. To determine the current state and reasons for traffic congestion at Faisal Avenue Islamabad by field data recording
2. Recommend alternative solutions based on results obtained from analysis and recorded data for safe and smooth flow of traffic
3. To determine the capacity and v/c ratio of Faisal Avenue intersection before and after optimization with existing and improved geometry
4. To determine the efficiency of all approaches before and after optimization.
5. To improve management of access near the Faisal Avenue intersection
6. Reduce the frequency and severity of intersection conflicts by improving geometric designs
7. Improve sight distance at the intersection
8. Improve availability of gaps in traffic and assist drivers in judging the gap size
9. Reduce severity and frequency of intersection conflicts through geometric improvements
10. Provide possible solutions for the existing intersection and/or alternate solution for a revised or proposed plan to reduce the congestions on weekends.

1.3 SCOPE OF THE THESIS

In order to achieve the research objectives, a detailed outline for the execution of research was prepared in which the following assignments were carried out:

1. A review on the literature about the previous studies done on parameters including levels of service, ICU, volume/capacity ratios and saturation flow rates.
2. Vehicle count was done during evening peak hours at the at grade intersection of the Jinnah/Faisal Avenue. The traffic volume of a signalized intersection was observed during morning and evening peak periods.
3. The data for the flyover and underpass was also collected. However the utilization of the flyover and underpass did not have much impact on the congestion of the whole interchange. Therefore primary focus of the study was the at grade intersection.
4. Peak hour volumes and factors were determined after the data was collected and trend analysis was done.
5. Input parameters including lane width, grades, percentage of motorbikes and buses and signal cycle length including the green and red times were observed and measured. This also included the type of turning lanes, whether they were exclusive or U-turn etc.
6. PTV VISSIM was used to analyze the existing conditions of the intersection and optimize it to provide alternatives that reduce congestion and delay resulting in an improved level of service.

1.4 ORGANIZATION OF THE THESIS

The study is distributed into five chapters.

Chapter 1 introduces the various types of intersections, lays down the objectives of the research, outlines the scope of the thesis and highlights the importance of control delay and its effects on LOS and capacity analysis.

Chapter 2 includes a literature review on the results and drawn conclusions from previous studies on similar projects. Also it focuses on the various types of traffic flows.

Chapter 3 tells you about the site selected for study, the means used to collect the data, the collation of data and the methods used to calculate peak hour factors and volumes. It also explains why VISSIM was the best tool to use for this thesis.

Chapter 4 is essentially about the working of the software and how it was used to analyze and optimize the intersection. The procedures used to enter the data, the input parameters and brief discussion of the steps followed within the software are elaborated. The analysis results and comparison tables follow this.

Chapter 5 concludes and gives the way forward for the intersection. These conclusions and recommendations are strictly sketched from the outcomes of the study. The appendices at the end include the direct results and reports gathered from PTV VISSIM.

Chapter 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews the literature and theory of existing urban signalized intersections focusing on the at-grade urban signalized intersection which includes pre-timed, semi-actuated and fully actuated signals. The underlying causes of traffic congestion, supported by data from previous studies on homogeneous and heterogeneous traffic flow. Furthermore, the chapter introduces the tools and methods used for analysis in this study.

2.2 AT-GRADE URBAN SIGNALIZED INTERSECTIONS

An Intersection is a single point where two or more roads meet, a junction where different traffic streams compete with one another for a common space. Therefore, if left unsupervised there is likely to be a turmoil where the safety and efficiency of traffic flow will be compromised. It is critical therein, to use strategies that keep the traffic flow running while ensuring safety at the junction. The deployment of signals at intersection, is particularly advantageous in terms of reducing few types of crashes (angle crashes), allows the side-street vehicles to enter the traffic stream, possible improvements in space while reducing the incidence of delays. However, there are some disadvantages such as delays often caused by disturbance in traffic progression, leading to the use of routes that are not meant to accommodate for heavy traffic e.g. roads of residential areas and neighborhood. Moreover, junctions can increase the incidence of certain types of accidents (rear-end crashes).

An ‘At-grade urban signalized intersection’ the traffic flow is controlled by the periodical provision of access to certain streams that meet at the junction while restraining the entry of other stream’s traffic, for a limited time. Simply, the common space at the intersection is time-shared among the various traffic streams.

There are different types of time-sharing strategies for example:

2.2.1 Pre-Timed Signal

The timing -green light, cycle length etc. are fixed over specified time periods and do not respond to changes in traffic flow at the junction. Vehicle detection is not necessary for this operational technique.

Time-sharing accords with a pre-defined strategy which repeats at fixed intervals thus is termed as the Cycle length. During the cycle length a particular stream can utilize the intersection for a certain time that time is known as the Green time for that stream. Consequently, in that cycle length the streams that cannot use the intersection are referred to as the Red time. Furthermore, when the signal switches from a green to red, a yellow signal in between alerts the driver to be ready for the red signal. The sum of green, yellow and red times for a particular movement equals to the time for a single cycle length.

2.2.2 Semi-Actuated Signal

On these signals the timing (green light, cycle length etc.) partially, corresponds to the detection of vehicles via video or pavement embedded inductance loop detectors.

2.2.3 Fully-Actuated Signal

The timing (green light, cycle length etc.) on these signals is completely influenced by the volume of traffic present at the intersection. These are usually used where two major streets intersect and where there is a substantial variation in the volumes of traffic through-out the day.

2.3 TRAFFIC CONGESTION ON INTERSECTIONS

Traffic congestion becomes an inevitable consequence, over a period of time and is likely as a result of increased number of vehicles on road, which leads to increased usage and vehicular queuing. Similarly, signalized intersection become congested with traffic as the demand exceeds their capacity; vehicles tend to stop for long intervals, this is informally known as ‘Traffic jam’.

The causes of such traffic congestion are either recurring or non-recurring:

Recurring causes include inadequate capacity, uncontrolled demand, and poor management of space. While the non-recurring causes consist of accidents, working hours, weather and other occasional events, and emergencies.

2.4 URBAN SIGNALIZED INTERSECTION AND TRAFFIC FLOW

Mainly there are two types of traffic flows on urban signalized intersections – Heterogeneous and Homogeneous traffic flow.

2.4.1 Heterogeneous traffic flow

This is composed of a variety of vehicles these include cars (including jeeps and vans), buses, motorized two wheelers (MTW), light commercial vehicles, auto-rickshaws (three wheeled motorized vehicles) (LCV), bicycles and trucks which although share a common space but do not follow the road regimen and que order since there is no physical segregation.

Normally the smaller vehicles tend to accommodate into the spaces between the larger vehicles. Thus, there is diversity in the performance and operations of the vehicles in this traffic flow which makes it hard to study its characteristics using analytical models therefore, ‘Simulation tools’ are used for studying these varying Heterogeneous traffic flows. For example:

1. A simulation study determining the delays and queue lengths of uncontrolled T-intersections was done by Popat et al. (1989).
2. Simulation of an uncontrolled urban intersection with pedestrian crossings was conducted by Raghavachari et al. (1993).
3. Simulation of intersection flows to analyze the mixed traffic performed by Agarwal et al. (1994).
4. The influence of vehicular heterogeneity on urban signalized intersections was conducted by Arasan and Jagadeesh (1995). They proposed a probabilistic approach to estimate saturation flow and delay.
5. Various simulation models for uncontrolled signalized intersection including modeling conflicts of heterogeneous traffic at urban uncontrolled intersection were designed by Rao and Rengaraju (1998).

6. The discharge characteristics of vehicles and vehicle characteristics at urban signalized intersections were analyzed by Maini and Khan (2000).
7. Hossain (2001) estimated saturation flow at urban signalized intersections based on turning proportion, road width and percentage of heavy and non-motorized vehicles using a micro-simulation modeling approach.
8. The platoon dispersal pattern for heterogeneous traffic at an urban signalized intersection using a simulation model was done by Arasan and Kashani (2003).
9. A simulation model was created by Marwah et al. (2006) for signalized intersection to estimate queue length and delay.
10. Akgüngör, A. P. (2008a and 2008b) analyzed the delay parameter, which dependents on variable analysis period at urban signalized intersections

Yet, there still remains a necessity to further improve the traffic flow at urban signalized intersections, for effective traffic regulation and control, que formation, density, accumulation, and dissipation, strategies to effectively use the transport infrastructure etc.

2.4.2 Homogeneous traffic flow

On the contrary, this is a hypothetical simulation of traffic flow in which all vehicles move with the same speed independent of time and have the same space gaps. Thus, it can be studied via analytical models. Many studies have been already been conducted on Homogeneous traffic flow for example:

1. Modeling of que dissipation to control signal timing was studied by Lin and Cooke (1986).
2. Lin (1992) provided left-turn adjustment factors for shared permissive, left turn lane and also estimated the capacities.
3. Left turn adjustment factors for double left turn lanes in medium size cities was developed by Spring and Thomas (1999).
4. Dynamic and stochastic aspects of queue including queue length and queue delays at signalized intersections were studied by Zuylen and Taale (2001).
5. The study on platoon dispersion, and factors affecting it was carried by Clement et al. (2004)

6. The order and chaos in the dynamics of vehicle platoons were studied by Addison and Low (1996)
7. Laoufi et al. (2004) predicted the intersection queues with a dynamic balance model along with queue length, and queue dissipation.

2.5 ANALYZING AT-GRADE SIGNALIZED INTERSECTIONS

Various techniques are used to when analyzing signalized intersections, these include:

2.5.1 Delay analysis
2.5.2 HCM Level of service analysis
2.5.3 VISSIM analysis

2.5.1 Delay Analysis

At-Grade urban signalized intersections were developed in the early 20th century in England. With the introduction of these controls to manoeuver inconsistent streams of passenger traffic, researchers started to estimate delays due to these controls and also developing the ideal signal timings to minimize delay especially for pre-timed signals. Olszewski (1993) studied about the control delay, stopped delay, stops and their effect on signalized intersections. Mousa (2003) studied the simulation modeling and variability assessment of delays including uniform and incremental delay at signalized intersection. Kim and Benkohal (2005) compared control delays from CORSIM and highway capacity for oversaturated signalized intersections.

Webster’s equation is used for measuring most delay developed in 1958 assuming practical distributions like Poisson (random) arrivals with uniform discharge headways.

Akcelik, R. (1988) further developed the delay equation from the coordinate transformation technique to obtain a time-dependent equation that is applicable to signalized intersections. In USA delay, is defined by HCM 2000, is the additional travel time experienced by a driver or passenger. It includes the uniform delay, incremental delay and initial queue delay. The Highway Capacity Manual (HCM) delay equation is utilized in delay computations. The HCM 2000 propounds that delay is computed using the Equation 2.4

$$d = d_1 \times PF + d_2 + d_3 \tag{2.4}$$

$$d_1 = 0.5C(1 - g/C)^2 / 1 - [\min(1, X) \times g/C] \tag{2.5}$$

$$d_2 = 900T\left[(x-1) + \sqrt{(X-1)^2} + \sqrt{8klX/cT}\right] \tag{2.6}$$

Where,

d = control delay, sec/veh

d1 = uniform delay, sec/veh

d2 = incremental delay, sec/veh

d3 = initial queue delay

PF = delay adjustment factor for quality of progression

X = v/c ratio for each lane group

C = cycle length, sec

T = length of analysis period, hours

k = incremental delay factor, dependant on control settings

I = upstream filtering/metering adjustment factor

c = capacity of lane group, vph

g = effective green time for lane group, sec

2.5.2 HCM Level of Service (LOS)

Delay is one of the most important parameters to measure and define the level of service (LOS) for an at-grade urban signalized intersection. The average control delay is being estimated for each lane group and then combined for each approach and for the whole intersection. Level of service is directly related to the average control delay values.

How LOS is found is listed in Table

Table 2.2: Level of Services from Control Delay (2000 HCM)

Level of Service (LOS)	Control Delay / Vehicle (s/veh)
A	< 10
B	10-20
C	20-35
D	35-55
E	55-80
F	>80

2.5.3 VISSIM analysis

Different software tools are available to determine the performance and also optimization of signalized intersection. For the purpose of this project we will be using the PTV VISSIM software. PTV VISSIM is the ideal tool for state-of-art transportation planning and operations analysis. The software is designed to assist you in realistically simulating and balancing roadway capacity and traffic demand. Since the German and Pakistan traffic orientation is same, while doing analysis on VISSIM there will be no need to give the mirror values as inputs.

Chapter 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter is to discuss the methodology used for this research. The chapter contains a methodology for analyzing the capacity, delays and level of service (LOS) of at-grade urban signalized intersections. The analysis contains the existing traffic data on the intersection beneath the Jinnah flyover, including the amount and distribution of traffic movements and traffic composition as well as their geometric characteristics.

The methodology addresses the capacity, LOS, and other performance measures for lane groups and intersection approaches and the LOS for the intersection as a whole. Capacity is evaluated in terms of the ratio of demand flow rate to capacity (v/c ratio), whereas LOS is evaluated on the basis of control delay per vehicle (in seconds per vehicle). Control delay is the portion of the total delay attributed to traffic signal operation for signalized intersections. Control delay includes, queue move-up time, stopped delay, initial deceleration delay, and final acceleration delay.

The methodology for capacity analysis is based on known or projected signalization plans. The procedure used consists of the data collection that is turning movement counts, so as to get the peak hour volume counts which further give us the peak hour factor. This peak hour volume and peak hour factor is further being used along with the existing cycle length and existing green time to determine the existing overall delay, capacity of each movement and for whole signal along with LOS with the help of software VISSIM. Flow chart is illustrated in Figure 3.1

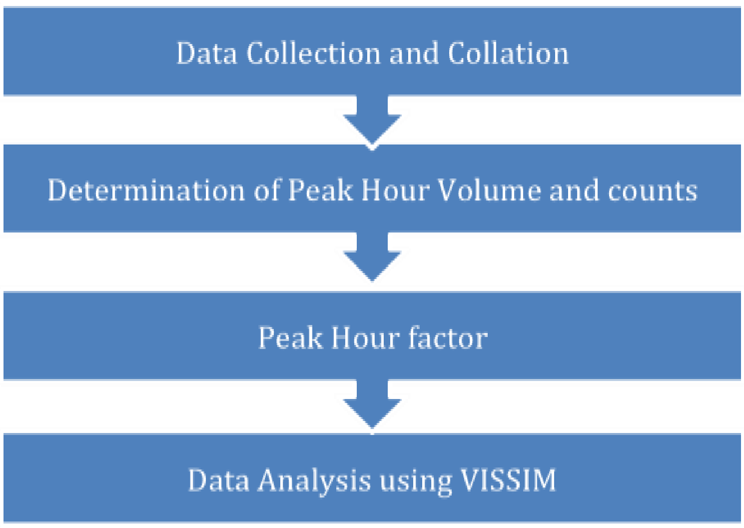


Figure 3.1

3.2 DATA COLLECTION AND COLLATION

The first step for the evaluation of signalized intersection is to collect the traffic data that is turning movement counts on the selected site i.e. Jinnah flyover intersection. Two options are available to collect the data signalized intersection. The options are:

3.2.1 Jamar Traffic Data Collector

3.2.2 Manual Data Collection

3.2.1 JAMAR Traffic Data Collector

Jamar data collectors are used since they are the most accurate and efficient devices for collecting traffic data. Moreover, its portability makes it easy to use. Jamar traffic data collector is shown in Figure 3.2.

Figure 3.2 Jamar Traffic Data Collector

3.2.2 Manual Data Collection

As the name indicates, manual data collection involves at least one man per road (preferably one per lane) with means to record their data as well as a stopwatch. This method is more hectic and time consuming and has plenty of room for error. However, if the manpower is more the error percentage can decrease remarkably and this method can prove to be even more accurate than using a traffic data counter. In some cases, especially when the number of lanes exceeds the maximum number of lanes that can be measured using the traffic data counter, manual data collection might be the only method that can be resorted to.

3.3 ON FIELD DATA COLLECTION AND TREND ANALYSIS

As per selected site, we collected the turning movement counts and through movement counts on evening peak hours from 6 to 9 pm on Friday and Saturday. The approximated peak hour factor for evening peak hours are provided in following tables. Peak hour factor is calculated as hourly volume divided by maximum rate of flow.

Date: 23 Feb 18
Day: Friday
Weather: Clear
Location: Jinnah/Faisal Ave Intersection
Observers: Maj Saim, Maj Hassan, Maj Umar, Capt Aun, Capt Aurangzeb

	North Bound (Aun)				**South Bound (Hassan)**				**East Bound (Saim)**			**West Bound (Aurangzeb)**			
Time	**L**	**T**	**R**	**U**	**L**	**T**	**R**	**U**	**L**	**T**	**R**	**L**	**T**	**R**	**Total**
1800 – 1815	101	73	176	144	29	125	47	38	152	47	229	109	36	67	1373
1815 – 1830	115	72	162	135	27	120	73	113	150	25	255	135	26	107	1515
1830 – 1845	109	81	173	132	27	122	67	130	151	34	236	109	41	86	1498
1845 – 1900	91	74	180	124	24	140	75	135	147	42	242	86	47	81	1488
1900 – 1915	83	66	191	130	41	168	82	163	134	28	254	91	40	71	1542
1915 – 1930	92	53	192	123	40	188	102	188	155	33	244	100	47	86	1643
1930 – 1945	90	66	189	118	23	190	103	182	150	40	221	84	47	99	1602
1945 – 2000	67	64	209	89	35	192	100	188	132	38	209	97	60	107	1587
2000 – 2015	87	70	211	97	37	200	94	200	138	43	217	100	45	51	1590
2015 – 2030	87	63	211	113	31	198	113	224	148	39	236	82	62	64	1671
2030 – 2045	82	60	192	72	39	181	99	209	142	29	253	63	39	51	1511
2045 – 2100	100	44	168	52	35	171	82	192	154	31	257	43	19	35	1383

TABLE 3.1

Peak Hour Factor: 0.9649

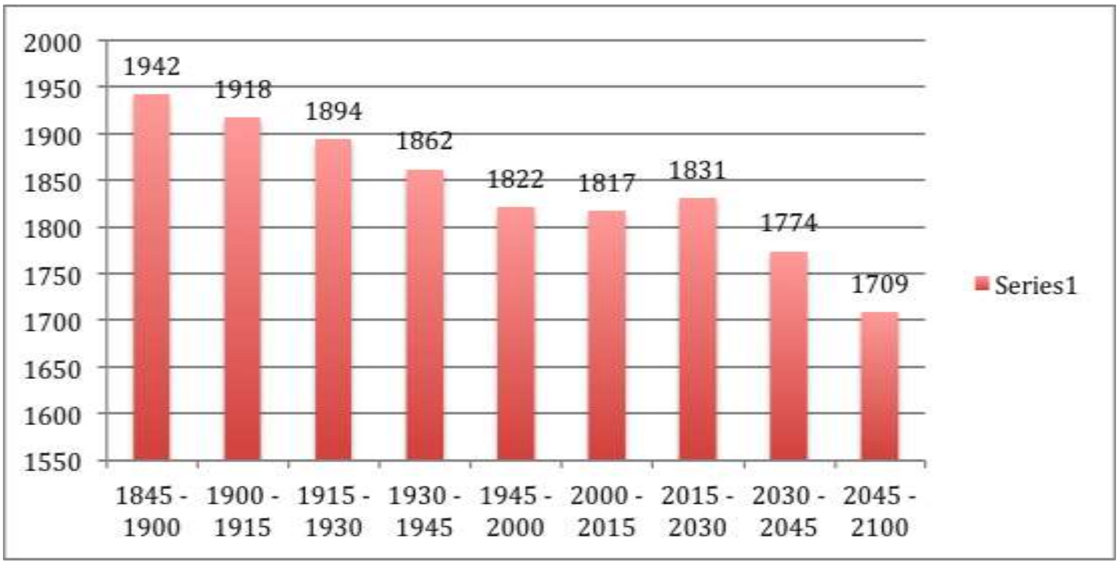


Figure 3.3 Peak Hour Volume for North Bound traffic (towards Faisal Mosque)

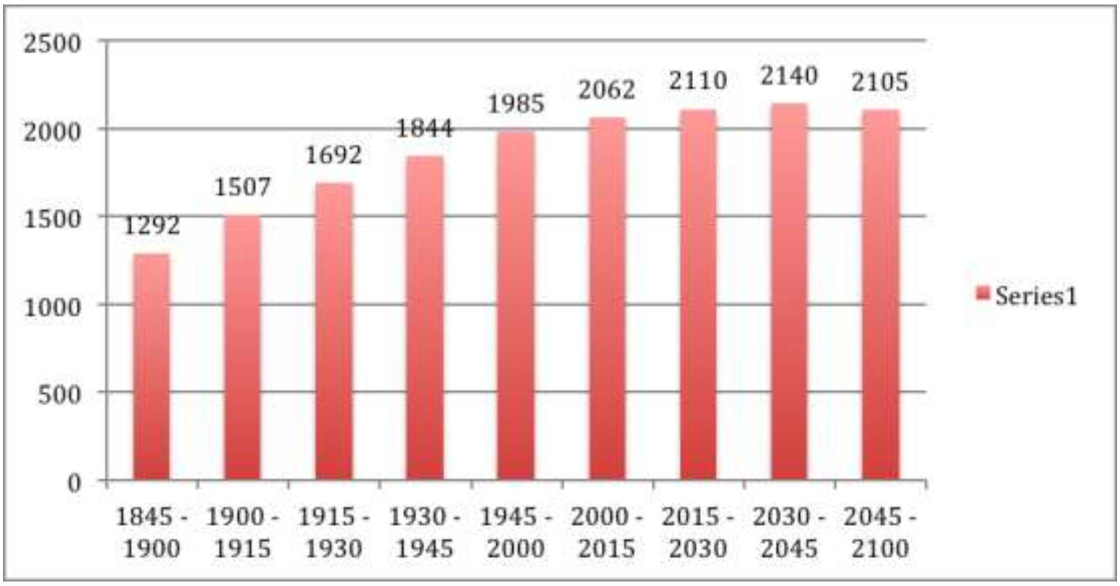


Figure 3.4 Peak Hour Volume for South Bound traffic

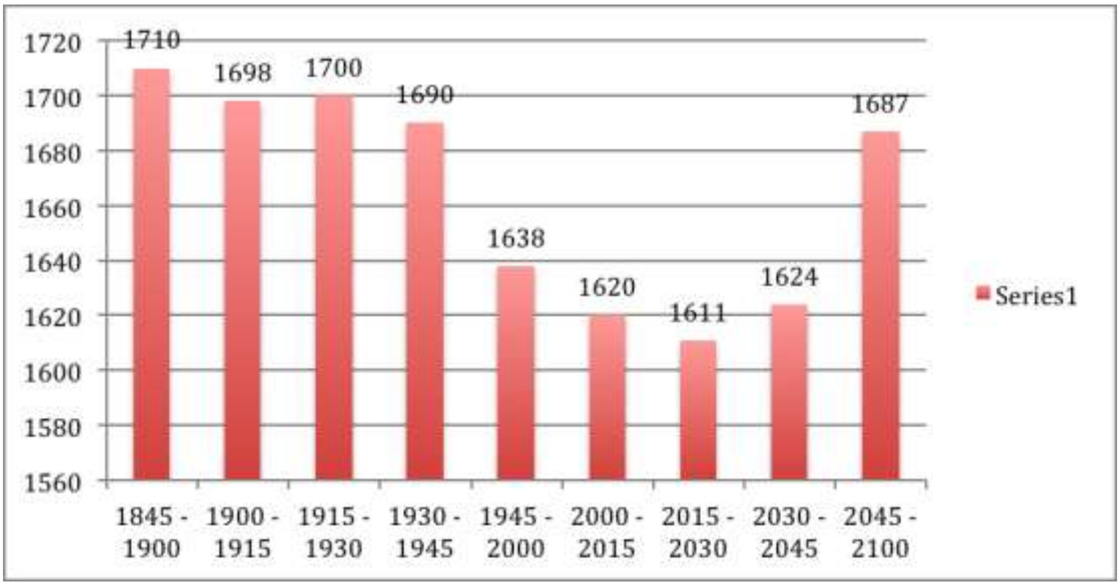


Figure 3.5 Peak Hour Volume for East Bound traffic

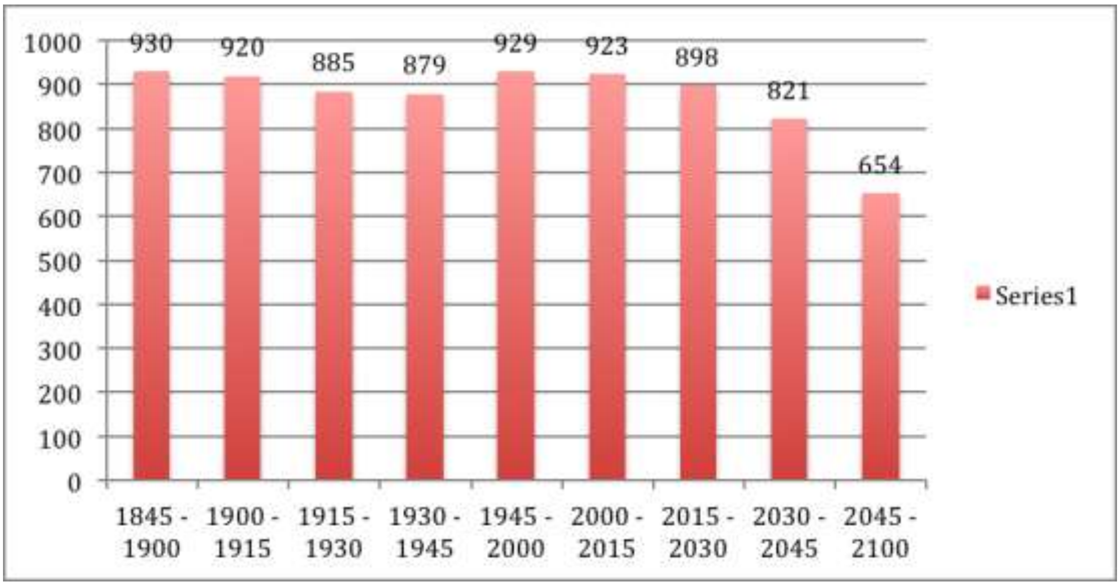


Figure 3.6 Peak Hour Volume for West Bound traffic

Date: 24 Feb 18
Day: Saturday
Weather: Clear
Location: Jinnah/Faisal Ave Intersection
Observers: Maj Saim, Maj Hassan, Maj Umar, Capt Aun, Capt Aurangzeb

Time	L	T	R	U	L	T	R	U	L	T	R	L	T	R	Total
1800 - 1815	156	56	250	157	35	131	53	141	185	65	262	125	45	88	1749
1815 - 1830	145	88	229	144	35	128	86	118	177	43	277	128	40	92	1730
1830 - 1845	170	45	246	140	36	136	75	137	178	32	264	115	42	69	1685
1845 - 1900	169	43	267	136	20	151	85	145	189	36	270	76	56	85	1728
1900 - 1915	130	54	270	152	48	180	97	162	145	30	268	115	60	54	1765
1915 - 1930	142	43	257	148	42	202	113	195	195	33	254	123	54	75	1876
1930 - 1945	119	71	235	153	40	200	127	200	186	47	269	98	62	69	1876
1945 - 2000	143	65	242	130	29	211	100	206	173	52	255	99	70	95	1870
2000 - 2015	129	54	220	143	37	212	101	212	152	41	248	120	65	90	1824
2015 - 2030	150	56	235	136	37	218	122	229	175	40	256	100	52	87	1893
2030 - 2045	137	35	210	121	35	188	122	215	162	37	249	86	48	74	1719
2045 - 2100	135	60	222	100	27	167	101	198	155	28	265	66	39	79	1642

Table 3.2

Peak Hour Factor: 0.9856

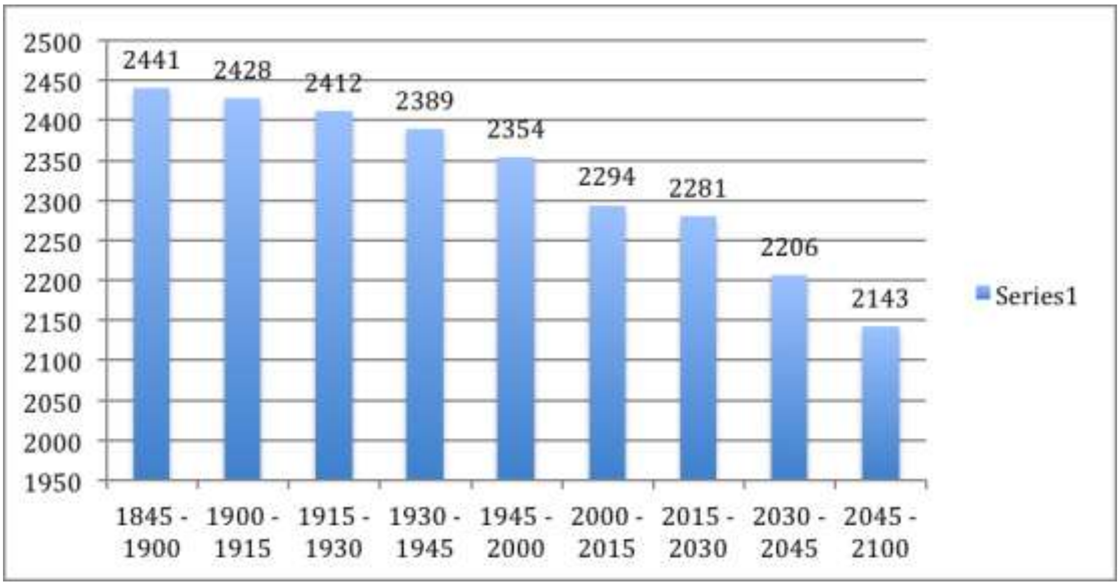


Figure 3.7 Peak Hour Volume for North Bound traffic

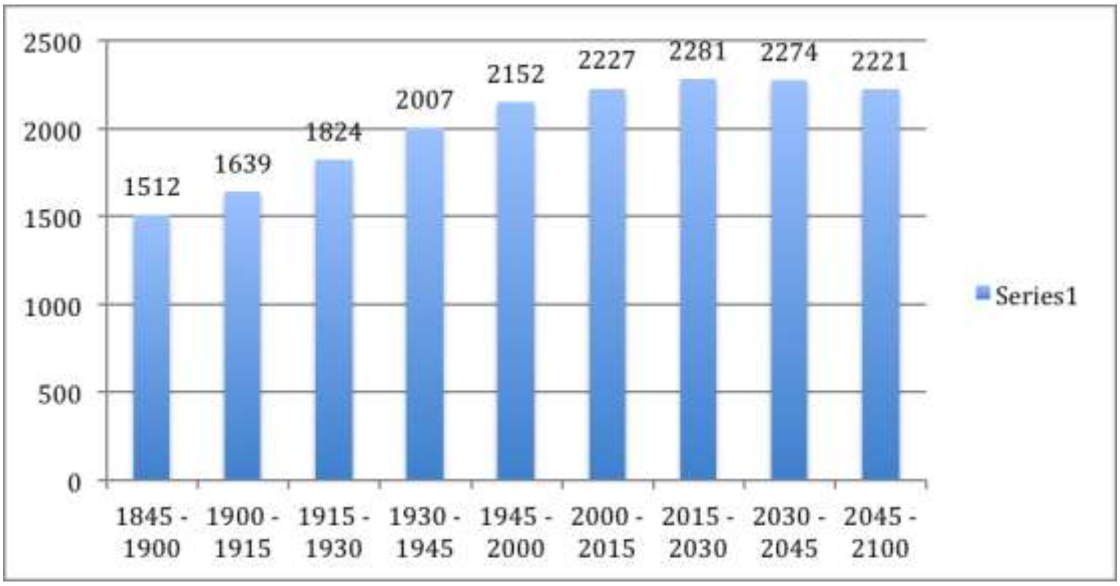


Figure 3.8 Peak Hour Volume for South Bound traffic

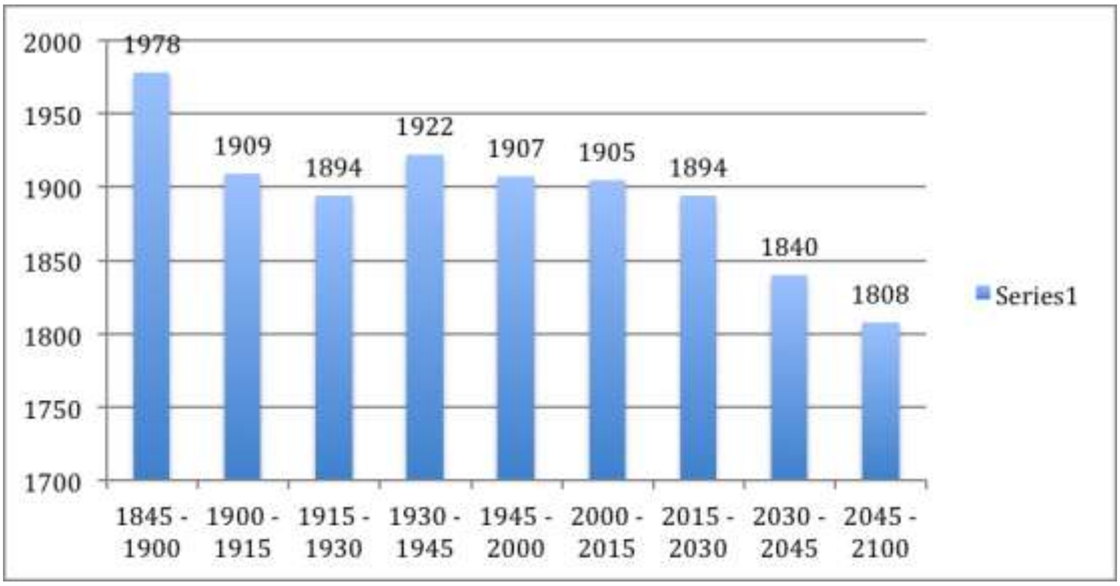


Figure 3.9 Peak Hour Volume for East Bound traffic

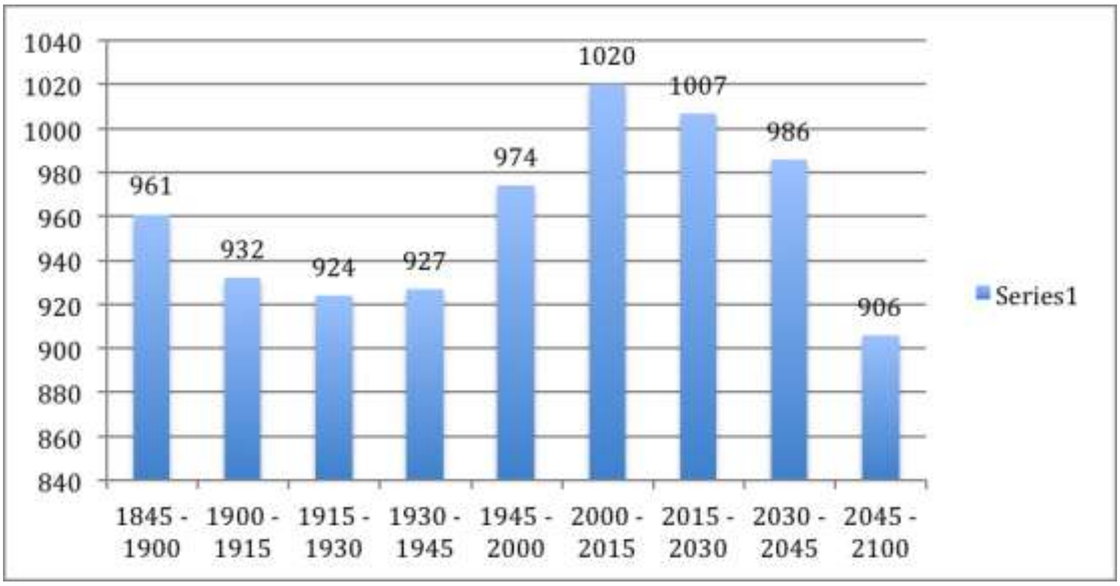


Figure 3.10 Peak Hour Volume for West Bound traffic

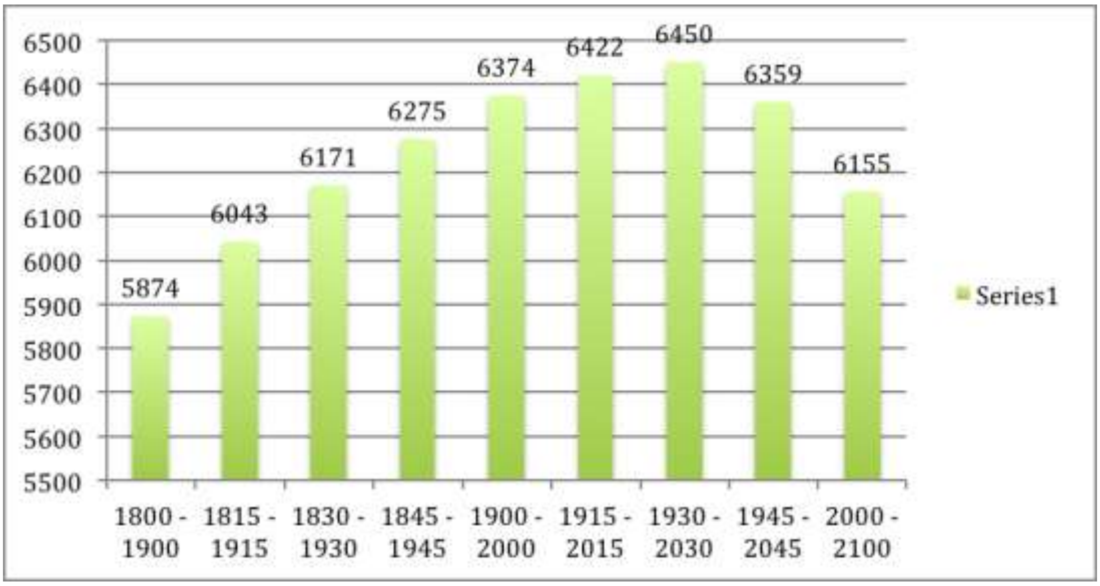


Figure 3.11 Total Peak Hour Volumes Friday

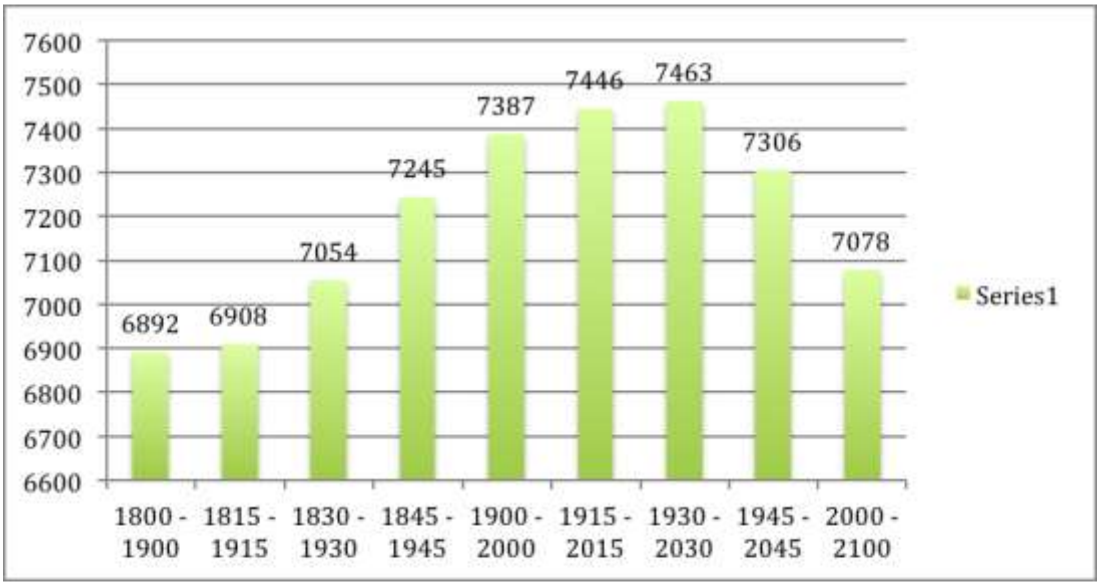


Figure 3.12 Total Peak Hour Volumes Saturday

3.3.1 Results and Conclusions

1. Peak Hour on Friday: 1930 – 2030 hrs
2. Peak Hour on Saturday: 1930 – 2030 hrs
3. Max Vehicle Count NB 1: 1942
4. Max Vehicle Count SB 1: 2140
5. Max Vehicle Count EB 1: 1710
6. Max Vehicle Count WB 1: 930
7. Max Vehicle Count NB 2: 2441
8. Max Vehicle Count SB 2: 2281
9. Max Vehicle Count EB 2: 1978
10. Max Vehicle Count WB 2: 1020
11. Therefore the most problematic approach is the South Bound approach

3.4 INPUT PARAMETERS

To conduct a valid operational analysis for signalized intersections in the urban commodities, the data obtained must be detailed, diverse and should fall into one of the three categories: Geometric, traffic and signalization.

3.4.1 Geometric Data

The geometric data provides a diagrammatic representation of relevant information. This includes the number and width of lanes, parking and approach grades, existence of exclusive Right turn and Left turn lanes along with capacity in lengths of such lanes.

3.4.2 Traffic Data

Traffic volumes in oversaturated situations, particularly at peak hours of the signalized intersection, are taken into account. The peak hour factor and volumes are collected in flow rate of vehicles per hour (v/h) furthermore, the number of turning movements are measured for a specified approach.

Another important factor kept in consideration while performing the analysis is the Vehicle type distribution, which is quantified as the percent of Heavy vehicles in each movement. The Heavy vehicles are characterized as the vehicles with more than four tires excluding the number of local busses since they are identified separately in all approaches, taking into account that the buses have to stop to pick-up and drop passengers on the intersection. Moreover, other factors such as pedestrian, bicycle and parking activities are eliminated.

3.4.3 Signalization Data

This data provides all the information regarding signalization, which is necessary to perform effective analysis of the urban signalized intersection. The information includes ‘Phase diagrams’ depicting a phase plan, cycle lengths, change and clearance intervals and the Green time.

3.5 ANALYSIS WITH VISSIM

Once the traffic data of the signalized intersection is obtained analysis with VISSM software is performed. As mentioned afore, the software simulates a microscopic environment to allow the analysis to be performed. The operations selected for evaluating the at-grade signalized intersection constitute: capacity and delay analysis, level of service (LOS), and ICU level of service.

Chapter 4

DATA ANALYSIS THROUGH VISSIM

4.1 INTRODUCTION

Traffic signals are one of the most effective tools of controlling traffic. The conflicts at intersections as well any other interfering movements are contained and controlled using traffic signals. In order to design a signalized intersection accurately, traffic considerations for all kinds of consumers have to be taken into deliberation. This is due to the fact that an intersection is used by all kinds of users. The commuter traffic may include cyclists, pedestrians, transit bus movements and many more. The volumes as well as speed of vehicles are the most significant parameters in this regard.

Control delay is the major factor in determining the Level of Service of an intersection. Control delay must be reproduced correctly when using microscopic traffic simulation to evaluate intersections. The following part demonstrates how VISSIM can be used for improving level of service of at grade intersection or interchange purpose. VISSIM is a microscopic, time step oriented, and behavior-based simulation tool for modelling urban and rural traffic. The traffic flow is simulated under various constraints of lane distribution, vehicle composition and signal control.

4.2 ANALYSIS

The analysis involved several steps that were chronologically performed on the VISSM software to attain a suitable design for the traffic intersection. These steps are as follows:

4.2.1 Layout Map

Figure-4.1

Jinnah Avenue and Faisal Avenue have an intersection with a flyover and an underpass. At grade intersection is having a signalized intersection. The signal timings in seconds are shown in the table:

BOUND	RED	YELLOW	GREEN
EAST	1:52	0:05	0:30
NORTH	1:30	0:05	0:45
WEST	2:05	0:05	0:18
SOUTH	1:52	0:05	0:30

Table-4.1

4.2.2 Add links

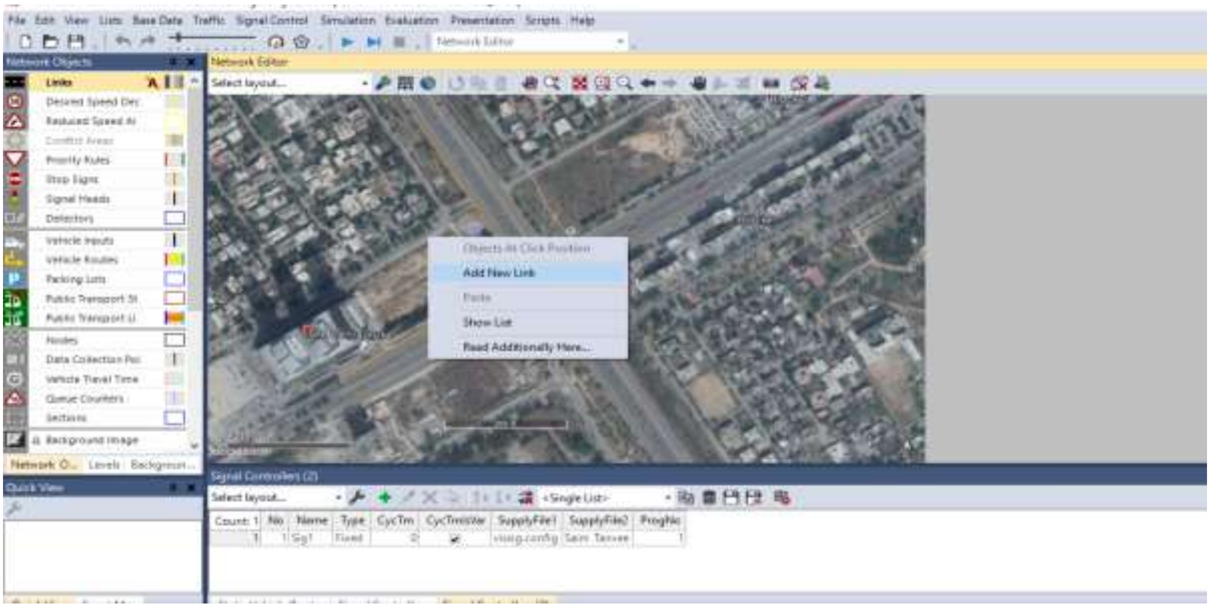


Figure-4.2

Links are added by adding new links. Links are the roads which are placed on the map shown in the software. By clicking ADD NEW LINK a window will open for adding attributes of the road or link to be placed for analysis. The input parameters for the link are

1. Number of lanes in the link
2. Length of the link required for the traffic analysis
3. Width of the lane

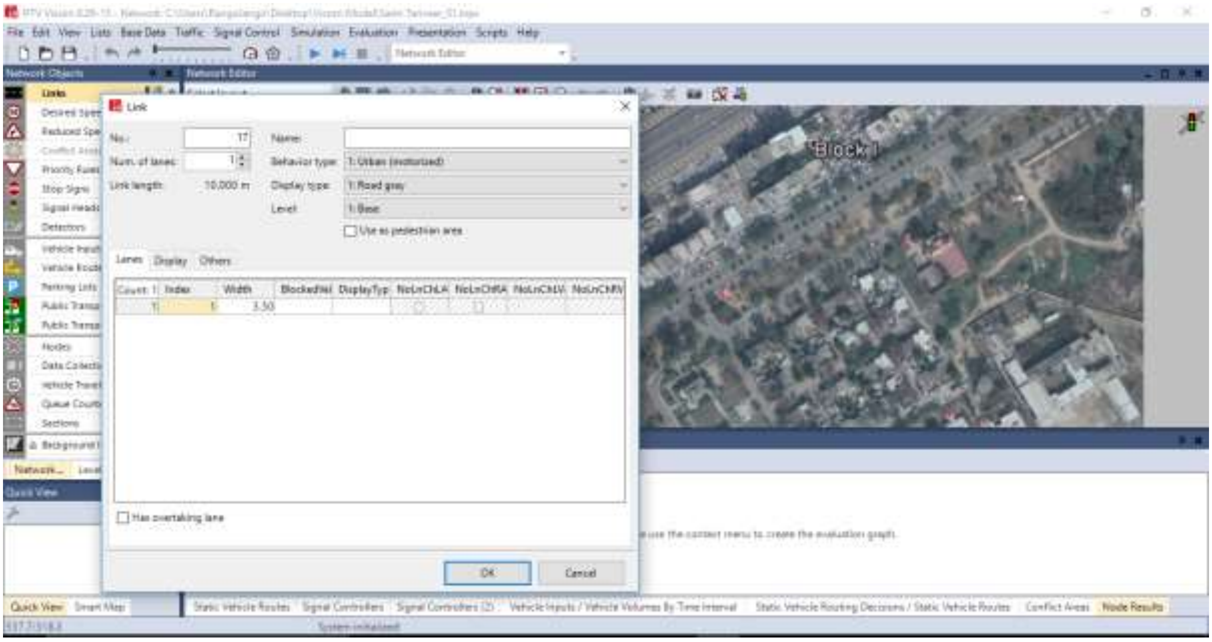


Figure-4.3

4.2.3 Adding connectors

Connectors are basically links and its parameters are same as of Links. They are links that connects already established two links.

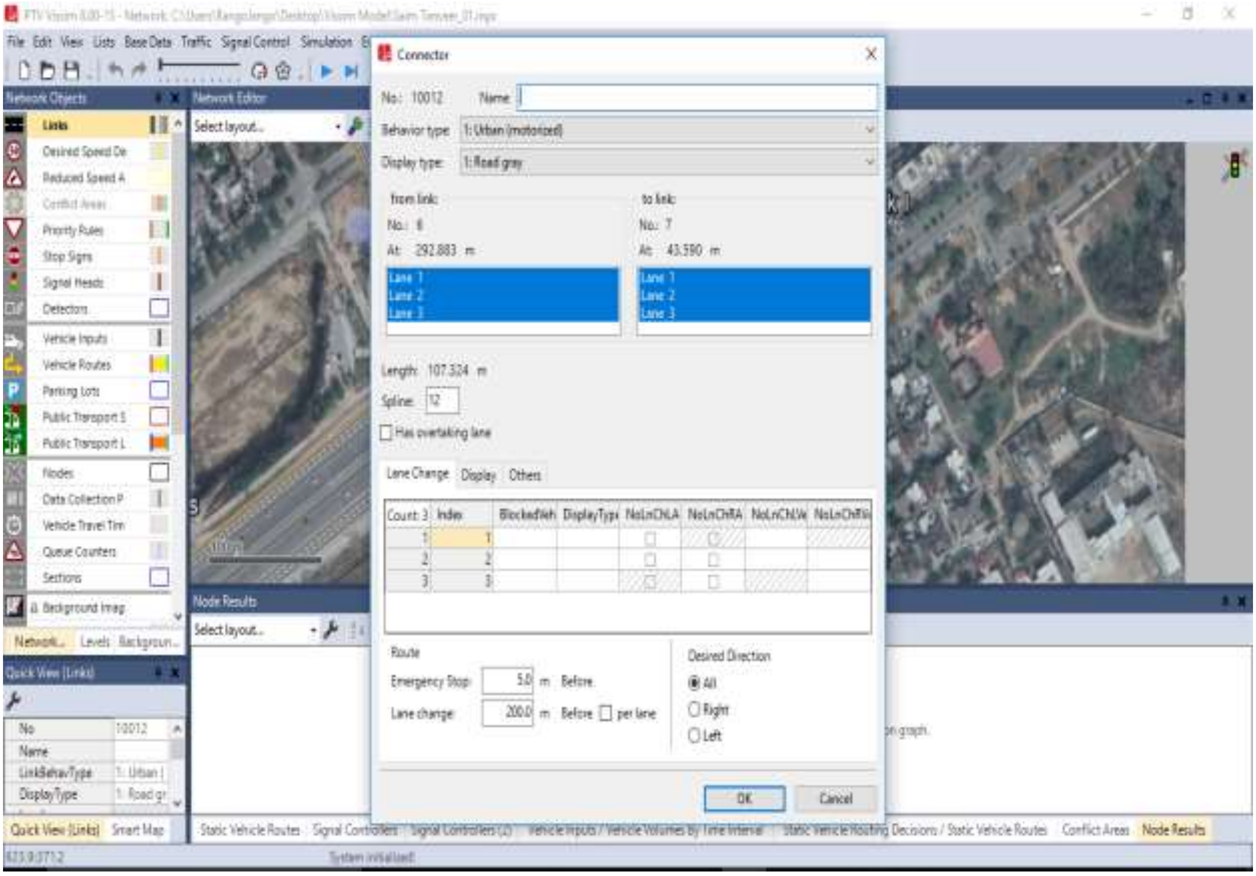


Figure-4.4

In order to give a circular or semi-circular connector we will increase the number of SPINE as shown in figure. We can change emergency stopping distance or can view suggested stopping distance from the ROUTE.

4.2.4 Adding vehicle inputs

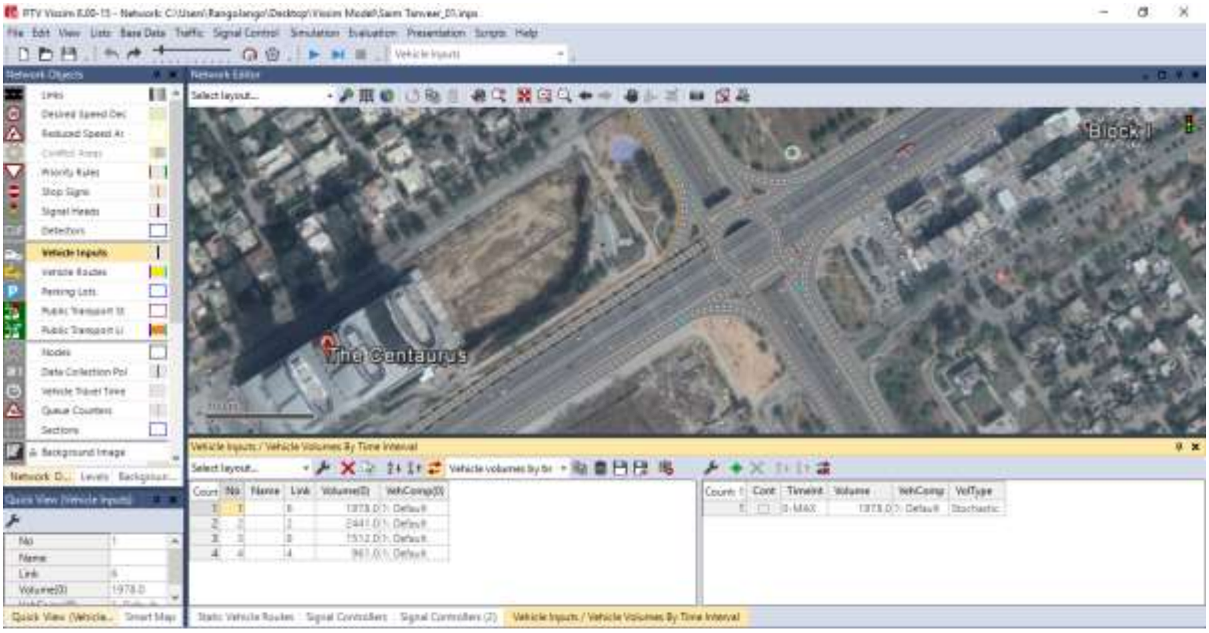


Figure-4.5

Vehicle inputs are given of the peak hour of all the incoming traffic towards the intersection during peak hour of each Link. Data can be collected by visual inspection, satellite aided software or traffic cameras. In above image we add this peak traffic volume in Volume column and this is the major parameter added in it.

The peak hour traffic volume added against each main LINK: -

EAST BOUND	1710
NORTH BOUND	1942
WEST BOUND	930
SOUTH BOUND	1292

Table-4.2

4.3 VEHICLE ROUTES

Now routes will be given for each Link where traffic of each link is dissipating i.e. through, left and right or U-turn as shown in the image

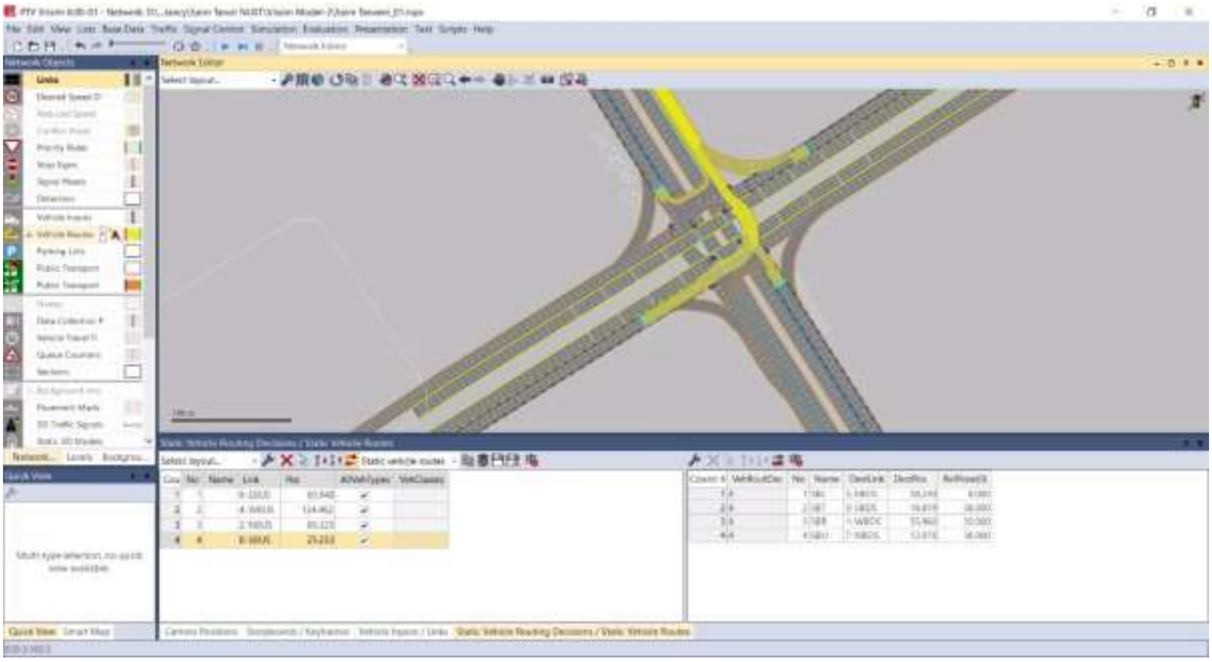
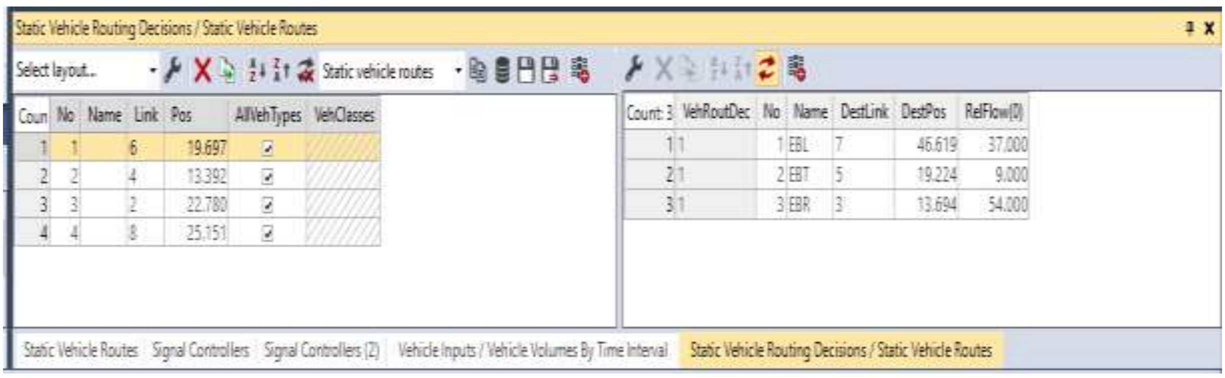


Figure-4.6

And then percentage of traffic moving from the link to routes is added and filled in column of RELFLOW.

4.3.1 East Bound traffic



Static Vehicle Routing Decisions / Static Vehicle Routes

Coun	No	Name	Link	Pos	AllVehTypes	VehClasses
1	1		6	19.697	☑	
2	2		4	13.392	☑	
3	3		2	22.780	☑	
4	4		8	25.151	☑	

Count: 3	VehRoutDec	No	Name	DestLink	DestPos	RelFlow(0)
1	1	1	EBL	7	46.619	37.000
2	1	2	EBT	5	19.224	9.000
3	1	3	EBR	3	13.694	54.000

Static Vehicle Routes | Signal Controllers | Signal Controllers (2) | Vehicle Inputs / Vehicle Volumes By Time Interval | Static Vehicle Routing Decisions / Static Vehicle Routes

Figure-4.7

4.3.2 West Bound traffic

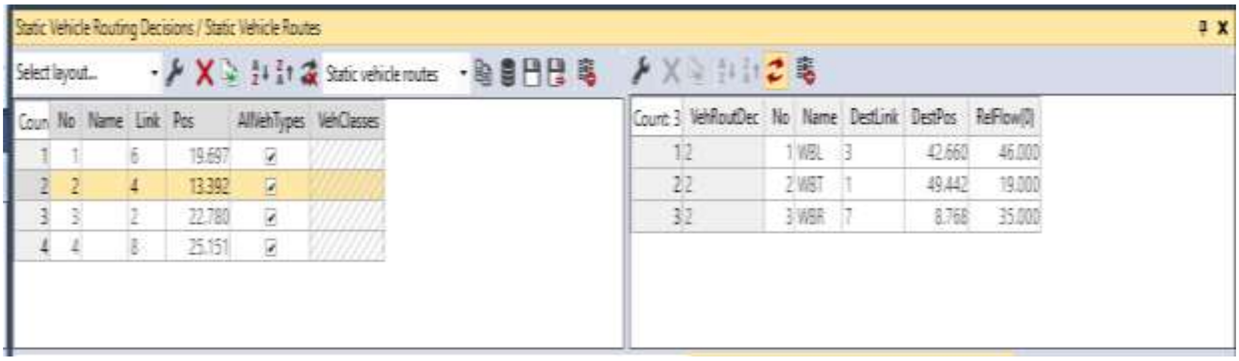


Figure-4.8

4.3.3 North Bound traffic

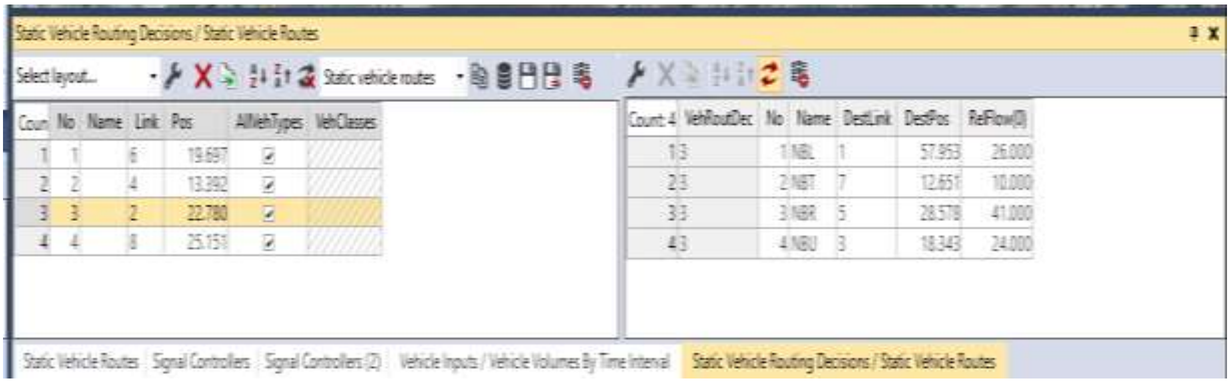


Figure-4.9

4.3.4 South Bound traffic

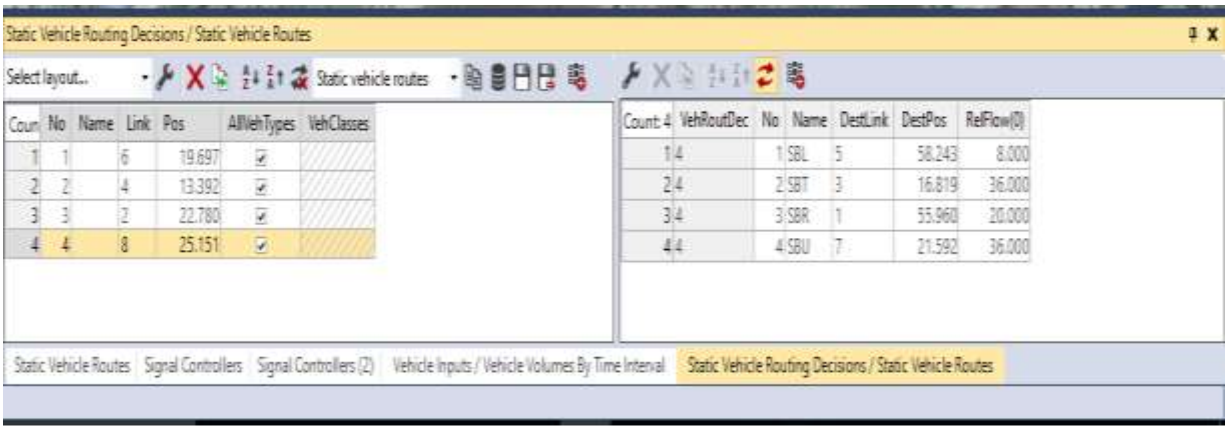


Figure-4.10

4.4 ADDING SIGNAL TIMINGS

Click SIGNAL CONTROL and then SIGNAL CONTROLLERS for adding signal timings

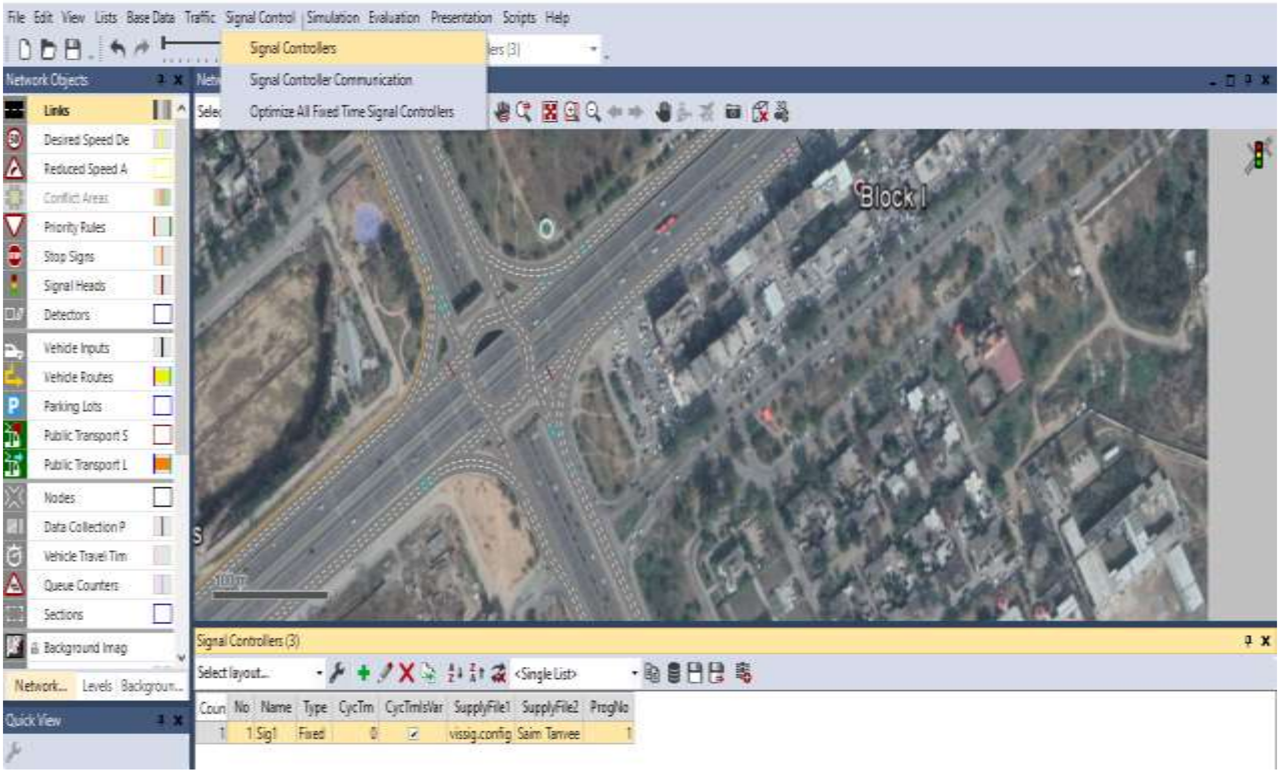


Figure-4.11

Then click EDIT SIGNAL CONTROL

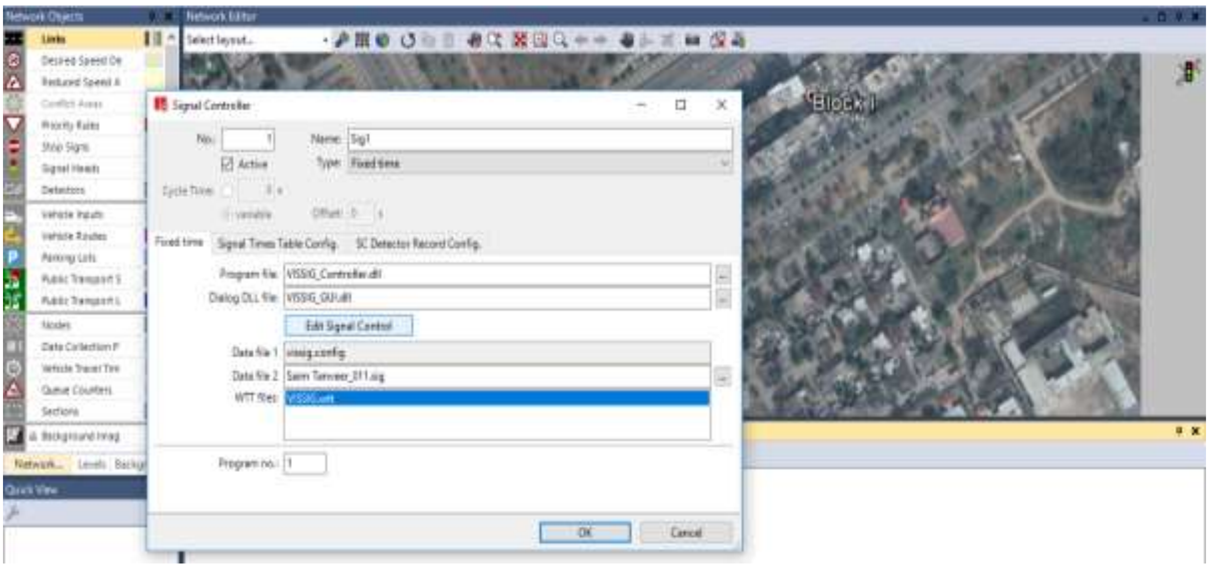


Figure-4.12

Add SIGNAL GROUP then adding the number of required signals

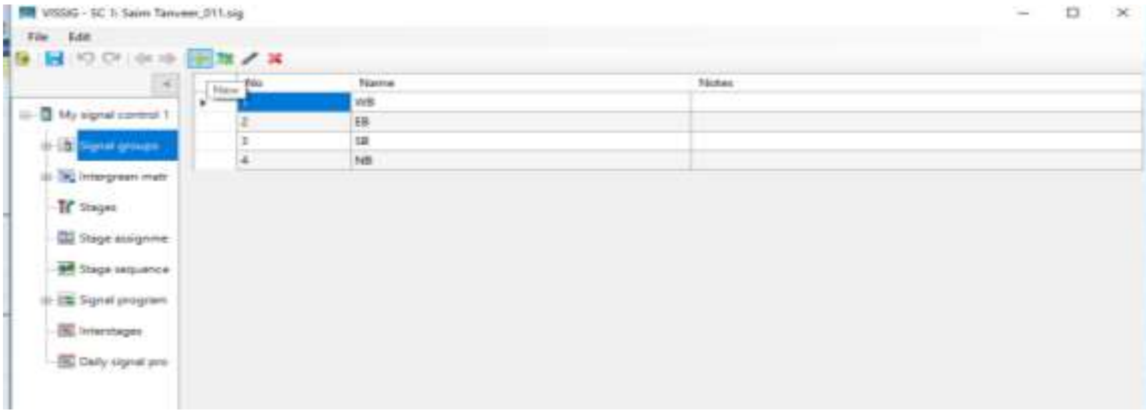


Figure-4.13

Now SIGNAL PROGRAM will be added and then creating a relation between "Signal groups" will be completed.

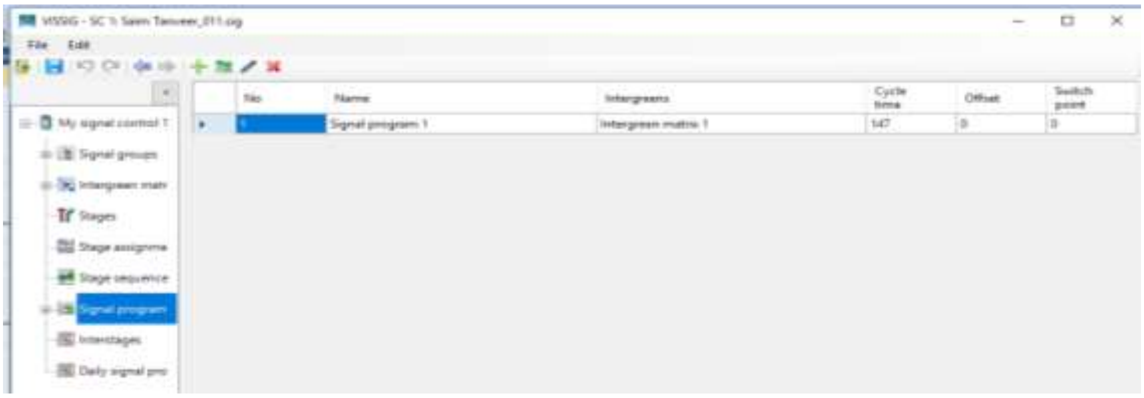


Figure-4.14

By double clicking the signal program signal timing adjustment window will open according to the required SIGNAL PROGRAM

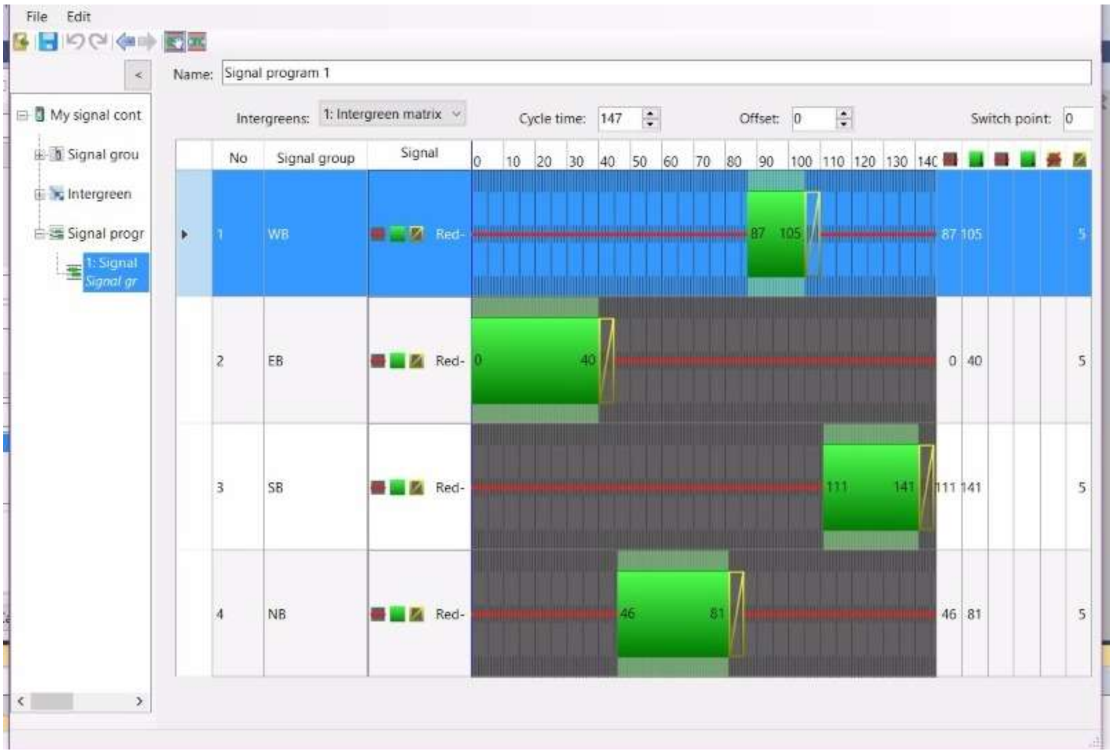


Figure-4.15

The input parameters are

1. East Bound green timings 0-40 secs
2. North Bound green timings 46-81 secs
3. West Bound green timings 87-105 secs
4. South Bound green timings 111-141 secs

Now here signal timings are adjusted according to the observed signal times in peak hour.

Now creating the connection of these signal timings with the model will be done by clicking option SIGNAL HEAD.A window will open of Signal Head and attributes of signals and its relation with required link is established. And it will be done for all links having signals.

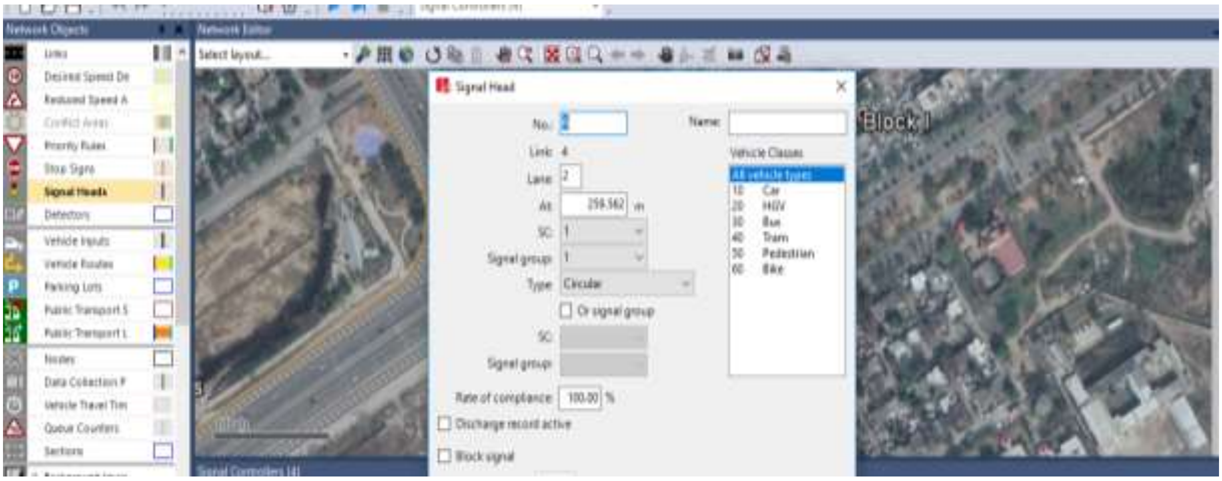


Figure-4.16

4.5 CONFLICT AREAS

Vissim also shows conflict areas in an intersection. It has four statuses which are added according to the data collected in peak time.

4.5.1 Undetermined

It shows that if there are two vehicles crossing single point but appearing from two different Links who so ever will come first will pass first and second vehicle will wait.

4.5.2 Passive

It is a conflict point where no decision can be made, accident may occur in passive conflict, the driver need to be vigilant on its own while passing such conflict point.

4.5.3 1 wait for 2

This shows points where one vehicle can pass another LINK after the wait of two vehicles who are moving on other LINKS. It normally happens on left turn when queue is large and traffic movement is slow.

4.5.4 2 wait for 1

This points where two vehicles can pass another LINK after the wait of one vehicle which is moving on other LINK. It normally happens on left turn when queue is large and traffic movement is slow

Figure-4.17

4.6 ADDING NODE

Node is used for selecting specific area of interest in the intersection. Certain configurations are adjusted after applying the node and then we can find Node Results. Node results have series of different attribute shown in VISSIM and concerned attribute is selected for the analysis purpose. In our case the main attribute which we require is VEHICLE DELAY for each bound i.e. North, South, East and West and the time shown against Vehicle Delay (Secs) will be checked in Highway Capacity Manual. Then the existing Level of Service will be found. Same procedure will be adopted for the adjusted parameters i.e. by increasing no of lanes in higher Level of Service LINK to decrease the existing Level of Service of the Link and both Level of Services are compared to find the solution.

Figure-4.18

Select NODE option and required area of interest is selected as shown in figure.

Now selecting NODE CONFIGRATION and apply required inputs. Here important parameters are: -

4.6.1 From time

It shows us that from which time the simulation should run and give results as selected from attribute. The time is added in seconds

4.6.2 To time

Time at which the simulation will end. Time entered is in seconds.

4.6.3 Interval

Interval means that after how much time the results selected from attributes are desired by the user. For example, FROM TIME - TO TIME is 3600 seconds and the interval is 900 seconds the attributes will show result in four parts 0-900 sec, 900-1800 secs, 1800 – 2700 secs and 2700 – 3600 secs.

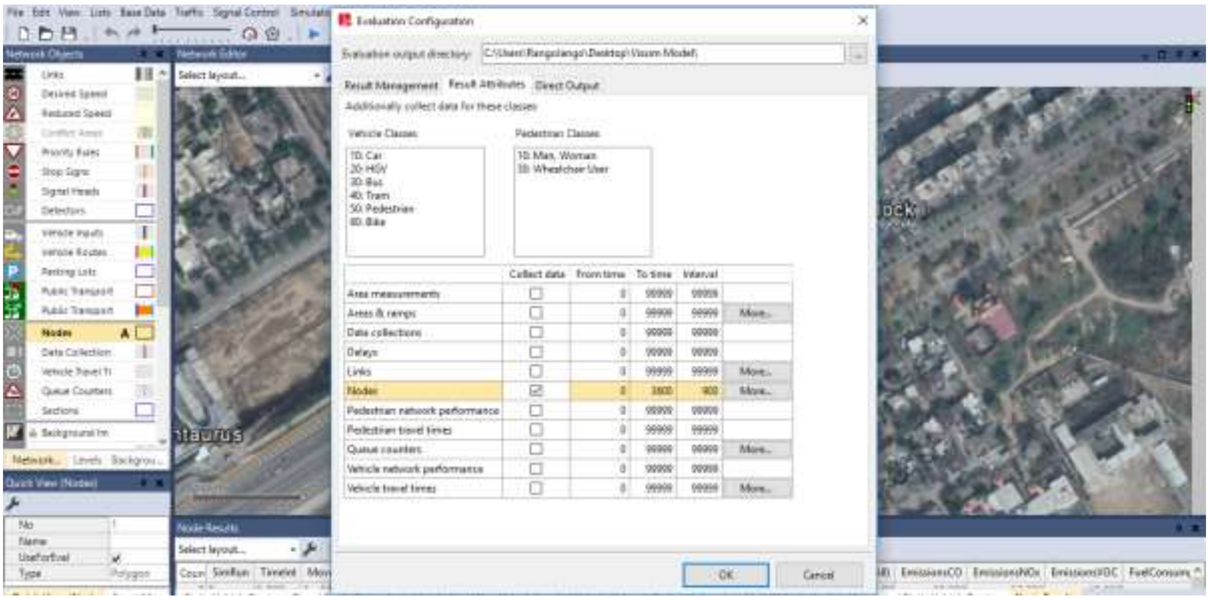


Figure-4.19

4.7 ATTRIBUTES

4.7.1 900 to 1800 seconds

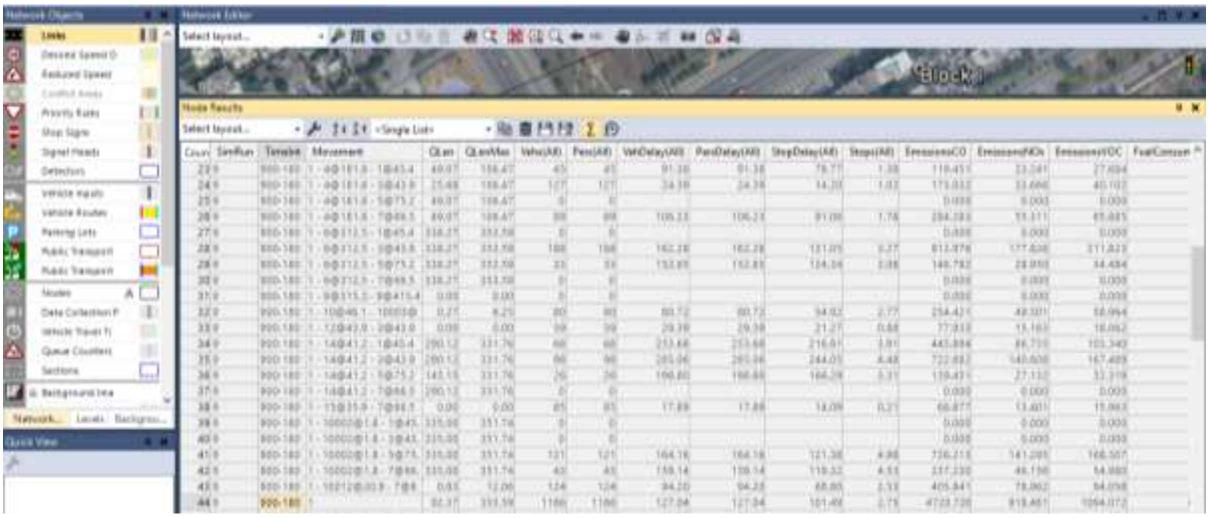


Figure-4.20

4.7.2 1800 to 2700 seconds

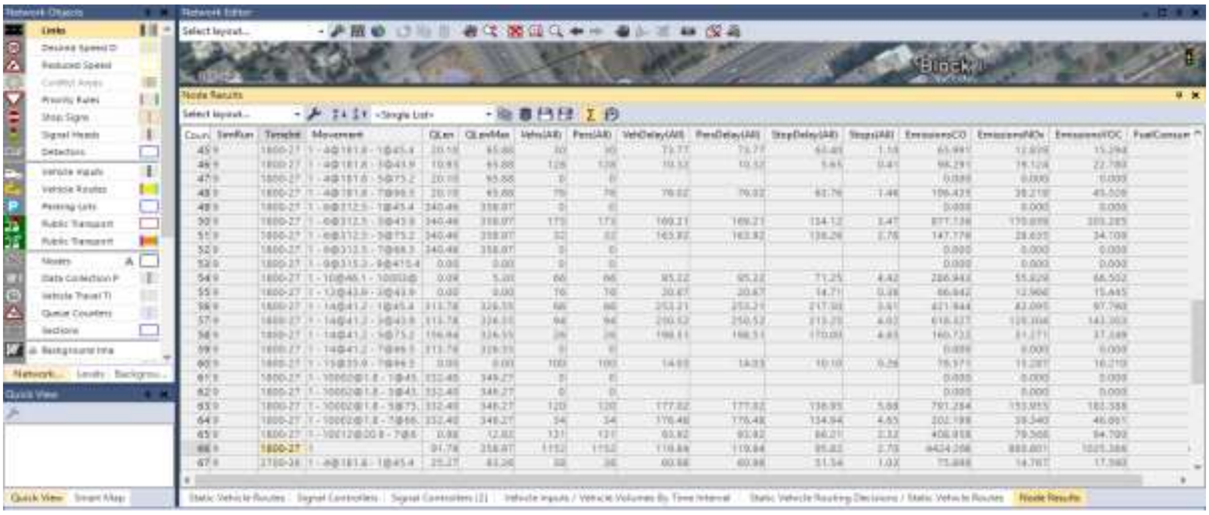


Figure-4.21

4.8 EXISTING DATA OF THE INTERSECTION

According to highway capacity manual the level of service for an intersection is compared with following table:

LOS	Control delay (Sec)
A	Less than or equal to 10
B	10 – 20
C	20 – 35
D	35 – 55
E	55 – 80
F	More than 80

Table-4.3

The existing level of service of the intersection is 43.62 sec/veh.

The table shows Level of Services of all bounds in the intersection and the data is collected from Vissim Nodal Analysis as shown in (Appendix A)

	To	VEH-DELAY(ALL)	LOS
WBUS	**WBDS**	60.08	**E**
WBUS	**SBDS**	9.9	**A**
WBUS	**NBDS**	61.85	**E**
EBUS	**SBDS**	95.29	**F**
EBUS	**EBDS**	88.7	**F**
EBUS	**NBDS**	48.31	**D**
NBUS	**WBDS**	2.96	**A**
NBUS	**SBDS**	3.6	**A**
NBUS	**EBDS**	43.4	**D**
NBUS	**NBDS**	40.9	**D**
SBUS	**WBDS**	56.99	**E**
SBUS	**SBDS**	53.78	**D**
SBUS	**EBDS**	2.2	**A**
SBUS	**NBDS**	3.14	**A**

Table-4.4

4.8 RESULTS AFTER OPTIMIZATION

In order to improve Level of Service two options are considered

- Changing green timings of cycle length
- Adding a lane in East bound upstream direction

By changing the green timings in cycle length the Level of Service of the intersection improves to C with average Vehicle Delay of 34.46 sec/veh.
The table shows the change in green timings (Appendix B)

Bound	Existing	New
East	30	40
North	45	35
West	18	18
South	30	30

After carrying out Nodal Analysis in Vissim following results were obtained with improved Level of Service (Appendix C).

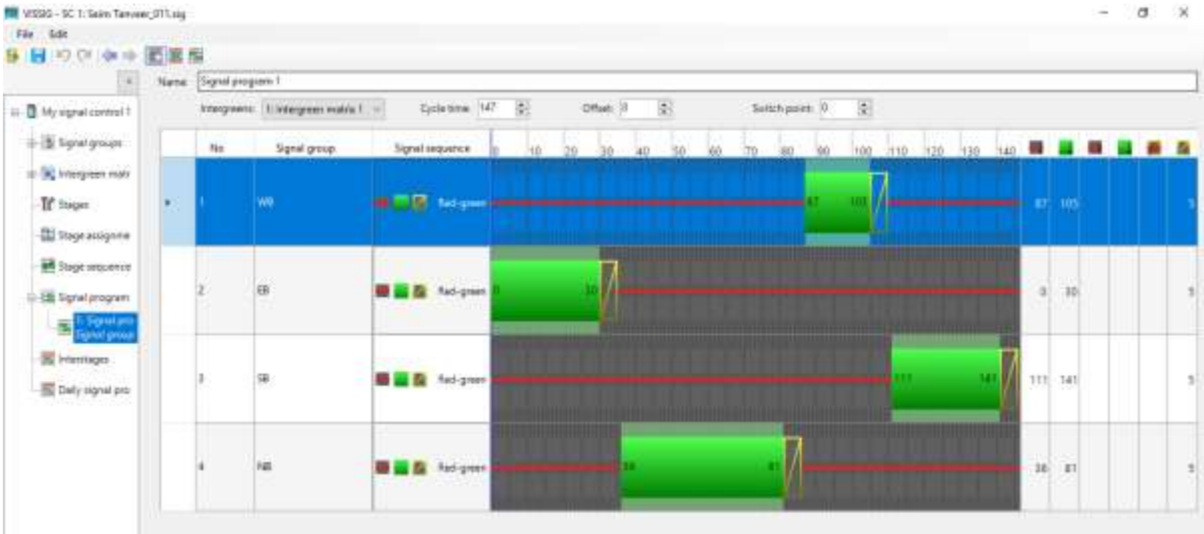


Figure-4.22

From	To	VEH-DELAY (ALL)	LOS (NEW)	Existing LOS
WBUS	**WBDS**	59.21	**E**	**E**
WBUS	**SBDS**	10.44	**B**	**A**
WBUS	**NBDS**	61.68	**E**	**E**
EBUS	**SBDS**	52.35	**D**	**F**
EBUS	**EBDS**	45.93	**D**	**F**
EBUS	**NBDS**	20.46	**B**	**D**
NBUS	**WBDS**	5.06	**A**	**A**
NBUS	**SBDS**	3.89	**A**	**A**
NBUS	**EBDS**	54.54	**C**	**D**
NBUS	**NBDS**	52.85	**C**	**D**
SBUS	**WBDS**	56.98	**D**	**E**
SBUS	**SBDS**	53.79	**C**	**D**
SBUS	**EBDS**	2.13	**A**	**A**
SBUS	**NBDS**	3.12	**A**	**A**

Table-4.5

The east bound Level of Service is F. Therefore, it is suggested to add a lane in east bound direction and Level of Service of Intersection improves to C with average Vehicle Delay of 32.31 sec/veh which is achieved after Nodal Analysis in Vissim (Appendix D).

From	To	VEH-DELAY(ALL)	LOS (NEW)	Existing LOS
WBUS	WBDS	60.15	E	E
WBUS	SBDS	6.89	A	A
WBUS	NBDS	62.38	E	E
EBUS	SBDS	57.41	E	F
EBUS	EBDS	54.77	D	F
EBUS	NBDS	4.62	A	D
NBUS	WBDS	2.45	A	A
NBUS	SBDS	3.37	A	A
NBUS	EBDS	43.12	C	D
NBUS	NBDS	40.42	C	D
SBUS	WBDS	56.97	E	E
SBUS	SBDS	53.74	D	D
SBUS	EBDS	2.96	A	A
SBUS	NBDS	3.17	A	A

Table-4.6

In order to improve Level of service without having a detrimental economic impact the most viable solution is changing the signal timings.

Comparison before and after optimization

Attributes	Before optimization	After optimization	
		Changing signal timings	Adding lane in East Bound Upstream
Cycle Length (Secs)	147	147	147
Control Type	Pre timed	Pre timed	Pre timed
Average Queue (m)	28.26	22.69	18.95
Avg Stop Delay (Secs)	31.94	22.66	25.1
v/c Ratio	0.3	0.3	0.3
Avg Veh Delay (sec/Veh)	43.62	34.46	32.31
LOS	D	C	C

Chapter 5

RECOMMENDATIONS AND CONCLUSIONS

5.1 GENERAL

The primary aim of this thesis was to suggest economic alternatives to a variety of everyday situations that cause congestion and delay on the Jinnah/Faisal Avenue intersection. Analyses done pre and post-optimization gave results that could be used to improve the Level of Service of the intersection. In the past it has been observed that similar studies resulted in solutions that mainly revolved around separation of grade altogether for any problematic intersection. Some plausible solutions that have been highlighted in this study are improving the geometric conditions by increasing the number of lanes on some, if not all, approaches, changing the cycle length, phases, and the timings of the signal itself. That leaves us with grade separation as the only other alternative left which, as emphasized earlier, is not an economic solution.

The modus operandi that was adopted in this study began with the basics. First off, urban signalized intersection, congestion and forms of traffic flows were explained. That was followed by a detailed review of the literature and then a brief introduction to the means used for collection of data as well as the software used for data analyses. A considerable reduction in the vehicle delay and the improvement of the current Level of Service was the core focus of the thesis.

5.2 CONCLUSIONS

Conclusions enlisted below are based on the research findings.

1. After a thorough analysis through VISSIM it was found that increasing the number of lanes has a positive impact. However, the LOS doesn’t improve as much as desired considering the cost of practically adding new lanes.
2. Improving the overall geometry of the intersection while reducing the delay, still did not improve the LOS significantly. Therefore increasing number of lanes is not a cost effective solution.
3. South bound traffic has the most contribution towards the failure of this intersection. The right turn movement on East Bound (from Centaurus) and the through movement from Faisal Mosque/Super/Jinnah Super both add on to the delay and congestion caused on the South Bound traffic.
4. By optimization of the intersection through VISSIM it is observed that control delays are reduced which in turn increase the capacity of the intersection and improve the v/c ratio.
5. While the optimization through VISSIM did improve the Levels of service on many approaches, it still did not profoundly improve the overall Level of Service of the complete intersection.
6. Intersection capacity utilization is only improved if number of lanes is increased.
7. The analysis also showed that the change of number of lanes and effect on signal timings were both mutually exclusive.

5.3 RECOMMENDATIONS

1. In the scope of this study, performance evaluation of the intersection's upstream and downstream traffic was carried out which included Level of service, control delay and capacity utilization analysis.
2. Since grade separation already exists at the site, it being an interchange with a flyover and an underpass, it was confirmed that grade separation had a negligible impact on the delays. Therefore out of lane increase and changing the signal timings, the latter proved to be the most cost effective solution.
3. Extreme delays in the eastbound and southbound approaches existed because of the current geometry of the intersection.
4. Proposed design for the interchange for future is shown in Figure 4.23. It will allow uninterrupted through movement on east and southbound and also ease the flow of traffic on north and westbound.

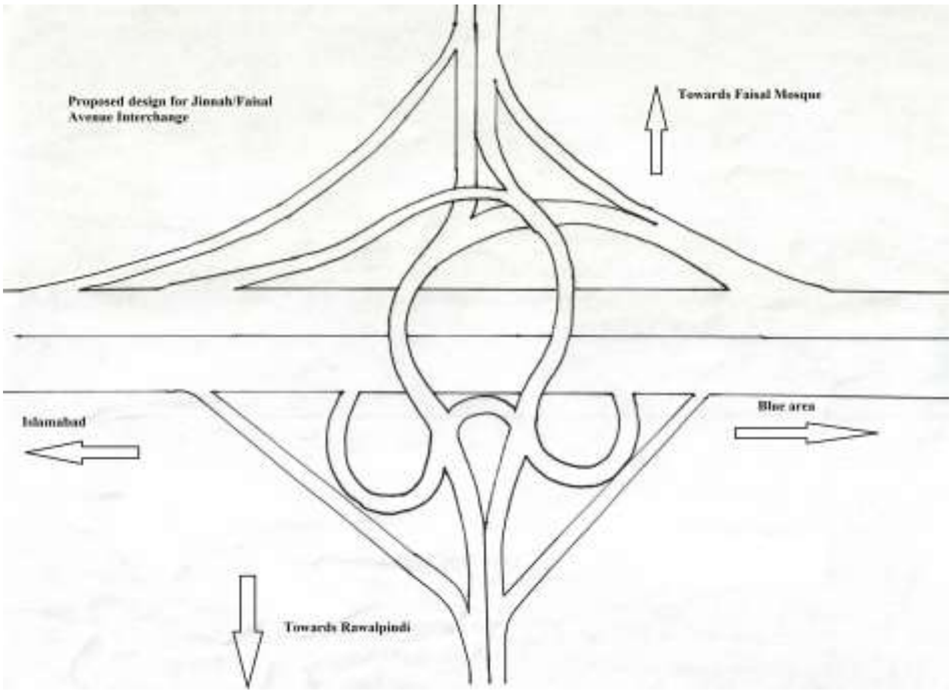


Figure-4.23

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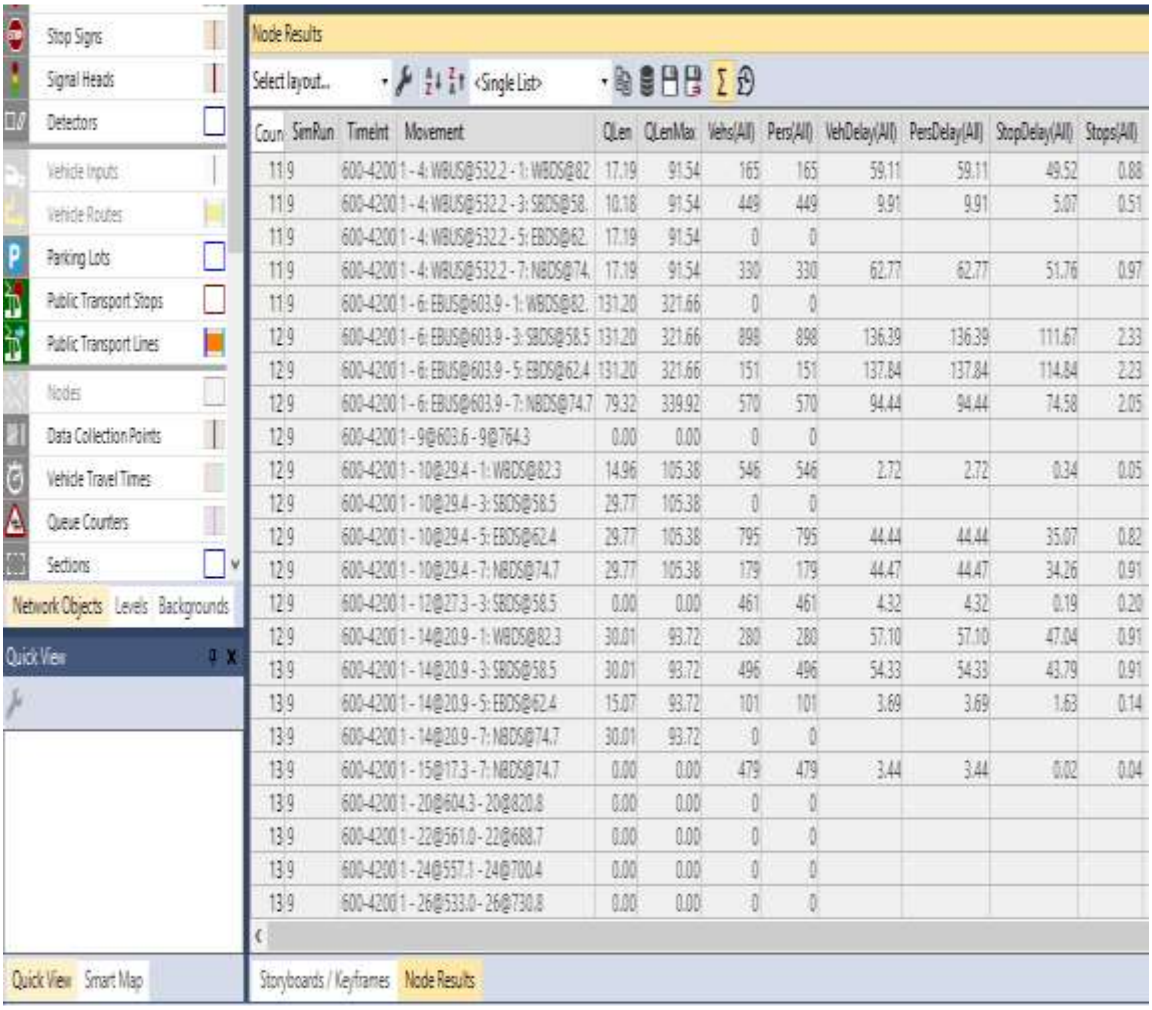
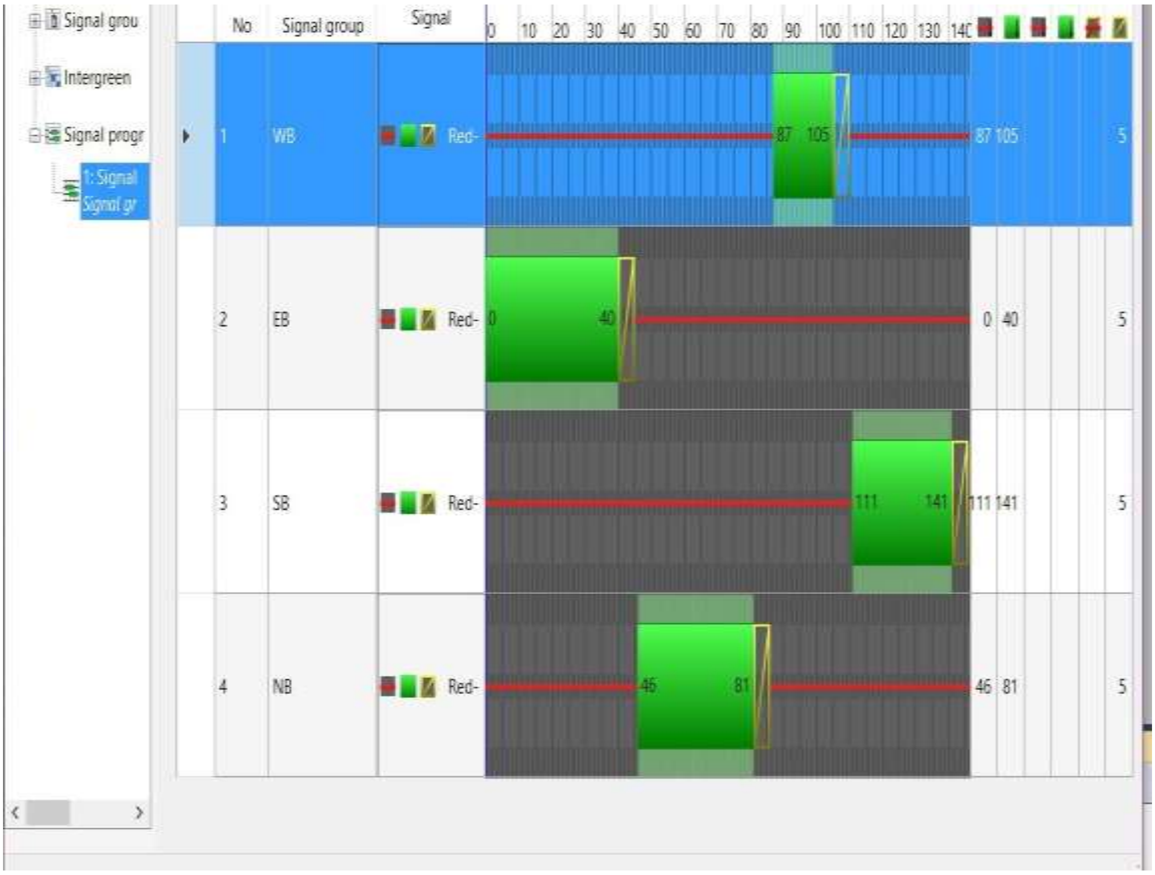
APPENDICES

APPENDIX A: VISSIM RESULTS BEFORE OPTIMIZATION

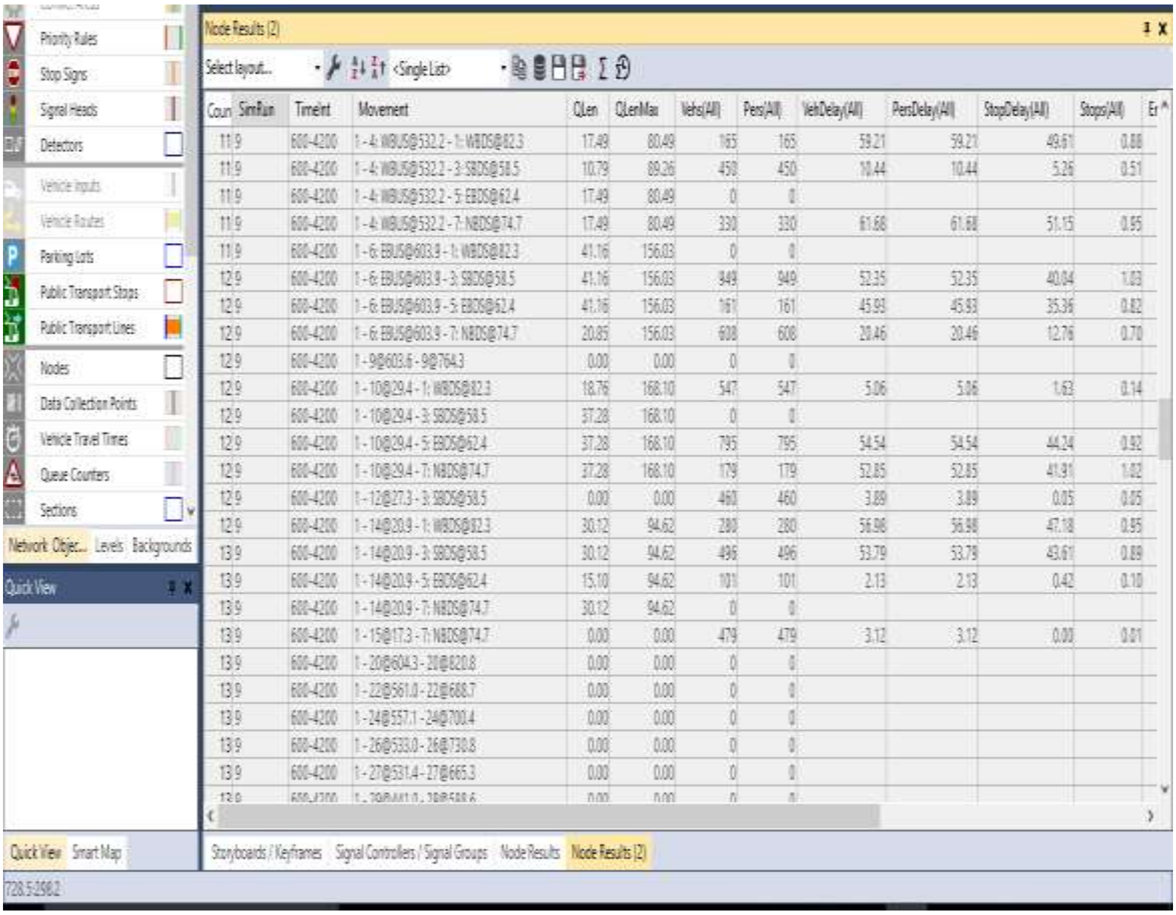


Coun	SimRun	TimeInt	Movement	QLen	QLenMax	Vehs(All)	Pers(All)	VehDelay(All)	PersDelay(All)	StopDelay(All)	Stops(All)
11	9	600-4200	1 - 4: WBUS@532.2 - 1: WBDS@82	17.19	91.54	165	165	59.11	59.11	49.52	0.88
11	9	600-4200	1 - 4: WBUS@532.2 - 3: SBDS@58.	10.18	91.54	449	449	9.91	9.91	5.07	0.51
11	9	600-4200	1 - 4: WBUS@532.2 - 5: EBDS@62.	17.19	91.54	0	0				
11	9	600-4200	1 - 4: WBUS@532.2 - 7: NBDS@74.	17.19	91.54	330	330	62.77	62.77	51.76	0.97
11	9	600-4200	1 - 6: EBUS@603.9 - 1: WBDS@82.	131.20	321.66	0	0				
12	9	600-4200	1 - 6: EBUS@603.9 - 3: SBDS@58.5	131.20	321.66	898	898	136.39	136.39	111.67	2.33
12	9	600-4200	1 - 6: EBUS@603.9 - 5: EBDS@62.4	131.20	321.66	151	151	137.84	137.84	114.84	2.23
12	9	600-4200	1 - 6: EBUS@603.9 - 7: NBDS@74.7	79.32	339.92	570	570	94.44	94.44	74.58	2.05
12	9	600-4200	1 - 9@603.6 - 9@764.3	0.00	0.00	0	0				
12	9	600-4200	1 - 10@29.4 - 1: WBDS@82.3	14.96	105.38	546	546	2.72	2.72	0.34	0.05
12	9	600-4200	1 - 10@29.4 - 3: SBDS@58.5	29.77	105.38	0	0				
12	9	600-4200	1 - 10@29.4 - 5: EBDS@62.4	29.77	105.38	795	795	44.44	44.44	35.07	0.82
12	9	600-4200	1 - 10@29.4 - 7: NBDS@74.7	29.77	105.38	179	179	44.47	44.47	34.26	0.91
12	9	600-4200	1 - 12@27.3 - 3: SBDS@58.5	0.00	0.00	461	461	4.32	4.32	0.19	0.20
12	9	600-4200	1 - 14@20.9 - 1: WBDS@82.3	30.01	93.72	280	280	57.10	57.10	47.04	0.91
13	9	600-4200	1 - 14@20.9 - 3: SBDS@58.5	30.01	93.72	496	496	54.33	54.33	43.79	0.91
13	9	600-4200	1 - 14@20.9 - 5: EBDS@62.4	15.07	93.72	101	101	3.69	3.69	1.63	0.14
13	9	600-4200	1 - 14@20.9 - 7: NBDS@74.7	30.01	93.72	0	0				
13	9	600-4200	1 - 15@17.3 - 7: NBDS@74.7	0.00	0.00	479	479	3.44	3.44	0.02	0.04
13	9	600-4200	1 - 20@604.3 - 20@820.8	0.00	0.00	0	0				
13	9	600-4200	1 - 22@561.0 - 22@688.7	0.00	0.00	0	0				
13	9	600-4200	1 - 24@557.1 - 24@700.4	0.00	0.00	0	0				
13	9	600-4200	1 - 26@533.0 - 26@730.8	0.00	0.00	0	0				

APPENDIX B: CHANGED TRAFFIC SIGNAL TIMINGS

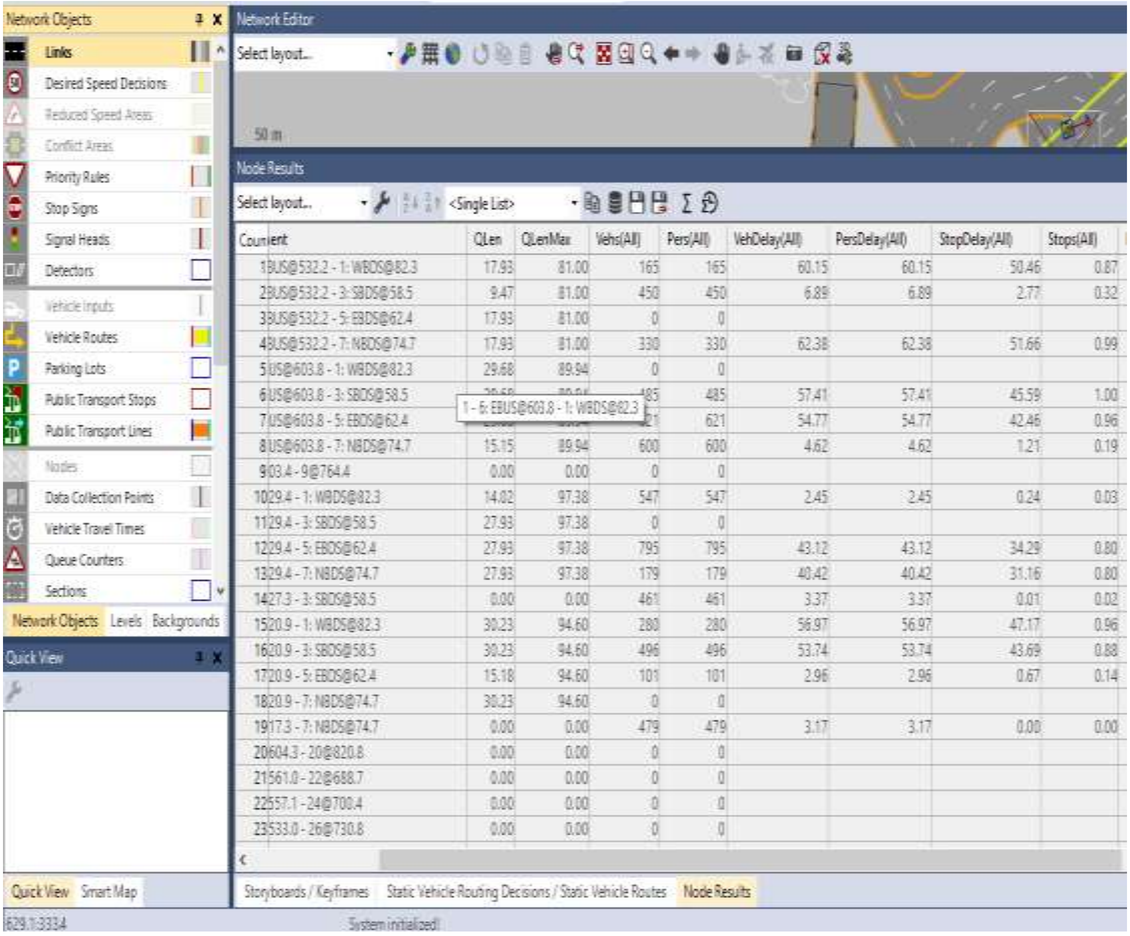


APPENDIX C: VISSIM RESULTS WITH IMPROVE TRAFFIC SIGNALS



Coun	SimRun	TimeInt	Movement	QLen	QLenMax	Vehs(All)	Pers(All)	VehDelay(All)	PersDelay(All)	StopDelay(All)	Stops(All)
11	9	600-4200	1 - 4: WBUS@532.2 - 1: WBDS@82.3	17.49	80.49	165	165	59.21	59.21	49.61	0.88
11	9	600-4200	1 - 4: WBUS@532.2 - 3: SBDS@58.5	10.79	89.26	450	450	10.44	10.44	5.26	0.51
11	9	600-4200	1 - 4: WBUS@532.2 - 5: EBDS@62.4	17.49	80.49	0	0				
11	9	600-4200	1 - 4: WBUS@532.2 - 7: NBDS@74.7	17.49	80.49	330	330	61.68	61.68	51.15	0.95
11	9	600-4200	1 - 6: EBUS@603.9 - 1: WBDS@82.3	41.16	156.03	0	0				
12	9	600-4200	1 - 6: EBUS@603.9 - 3: SBDS@58.5	41.16	156.03	949	949	52.35	52.35	40.04	1.03
12	9	600-4200	1 - 6: EBUS@603.9 - 5: EBDS@62.4	41.16	156.03	161	161	45.93	45.93	35.36	0.82
12	9	600-4200	1 - 6: EBUS@603.9 - 7: NBDS@74.7	20.85	156.03	608	608	20.46	20.46	12.76	0.70
12	9	600-4200	1 - 9@603.6 - 9@764.3	0.00	0.00	0	0				
12	9	600-4200	1 - 10@29.4 - 1: WBDS@82.3	18.76	168.10	547	547	5.06	5.06	1.63	0.14
12	9	600-4200	1 - 10@29.4 - 3: SBDS@58.5	37.28	168.10	0	0				
12	9	600-4200	1 - 10@29.4 - 5: EBDS@62.4	37.28	168.10	795	795	54.54	54.54	44.24	0.92
12	9	600-4200	1 - 10@29.4 - 7: NBDS@74.7	37.28	168.10	179	179	52.85	52.85	41.91	1.02
12	9	600-4200	1 - 12@27.3 - 3: SBDS@58.5	0.00	0.00	460	460	3.89	3.89	0.05	0.05
12	9	600-4200	1 - 14@20.9 - 1: WBDS@82.3	30.12	94.62	280	280	56.98	56.98	47.18	0.95
13	9	600-4200	1 - 14@20.9 - 3: SBDS@58.5	30.12	94.62	496	496	53.79	53.79	43.61	0.89
13	9	600-4200	1 - 14@20.9 - 5: EBDS@62.4	15.10	94.62	101	101	2.13	2.13	0.42	0.10
13	9	600-4200	1 - 14@20.9 - 7: NBDS@74.7	30.12	94.62	0	0				
13	9	600-4200	1 - 15@17.3 - 7: NBDS@74.7	0.00	0.00	479	479	3.12	3.12	0.00	0.01
13	9	600-4200	1 - 20@604.3 - 20@820.8	0.00	0.00	0	0				
13	9	600-4200	1 - 22@561.0 - 22@688.7	0.00	0.00	0	0				
13	9	600-4200	1 - 24@557.1 - 24@700.4	0.00	0.00	0	0				
13	9	600-4200	1 - 26@533.0 - 26@730.8	0.00	0.00	0	0				
13	9	600-4200	1 - 27@531.4 - 27@665.3	0.00	0.00	0	0				

APPENDIX D: VISSIM RESULTS AFTER ADDING LANE IN EAST BOUND APPROACH



Coun	ient	QLen	QLenMax	Vehs(All)	Pers(All)	VehDelay(All)	PersDelay(All)	StopDelay(All)	Stops(All)
1	BUS@532.2 - 1: WBDS@82.3	17.93	81.00	165	165	60.15	60.15	50.46	0.87
2	BUS@532.2 - 3: SBDS@58.5	9.47	81.00	450	450	6.89	6.89	2.77	0.32
3	BUS@532.2 - 5: EBDS@62.4	17.93	81.00	0	0				
4	BUS@532.2 - 7: NBDS@74.7	17.93	81.00	330	330	62.38	62.38	51.66	0.99
5	US@603.8 - 1: WBDS@82.3	29.68	89.94	0	0				
6	US@603.8 - 3: SBDS@58.5	[illegible]	[illegible]	485	485	57.41	57.41	45.59	1.00
7	US@603.8 - 5: EBDS@62.4	[illegible]	[illegible]	621	621	54.77	54.77	42.46	0.96
8	US@603.8 - 7: NBDS@74.7	15.15	89.94	600	600	4.62	4.62	1.21	0.19
9	03.4 - 9@764.4	0.00	0.00	0	0				
10	29.4 - 1: WBDS@82.3	14.02	97.38	547	547	2.45	2.45	0.24	0.03
11	29.4 - 3: SBDS@58.5	27.93	97.38	0	0				
12	29.4 - 5: EBDS@62.4	27.93	97.38	795	795	43.12	43.12	34.29	0.80
13	29.4 - 7: NBDS@74.7	27.93	97.38	179	179	40.42	40.42	31.16	0.80
14	27.3 - 3: SBDS@58.5	0.00	0.00	461	461	3.37	3.37	0.01	0.02
15	20.9 - 1: WBDS@82.3	30.23	94.60	280	280	56.97	56.97	47.17	0.96
16	20.9 - 3: SBDS@58.5	30.23	94.60	496	496	53.74	53.74	43.69	0.88
17	20.9 - 5: EBDS@62.4	15.18	94.60	101	101	2.96	2.96	0.67	0.14
18	20.9 - 7: NBDS@74.7	30.23	94.60	0	0				
19	17.3 - 7: NBDS@74.7	0.00	0.00	479	479	3.17	3.17	0.00	0.00
20	604.3 - 20@820.8	0.00	0.00	0	0				
21	561.0 - 22@688.7	0.00	0.00	0	0				
22	557.1 - 24@700.4	0.00	0.00	0	0				
23	533.0 - 26@730.8	0.00	0.00	0	0				