TRAFFIC OPERATION ANALYSIS OF LAHORE-SIALKOT MOTORWAY INTERCHANGES THROUGH VISSIM

A CASE STUDY

UNDERGRADUATE FINAL YEAR PROJECT

Project submitted in partial fulfillment of the requirements for the degree of

BE Civil Engineering

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Dedication

Special dedication to

Our loving parents,

Our supervisor,

Our Instructors,

Our beloved friends,

And all those, who helped us reach this mark.

For all support, encouragement and believe in us. Thank you so much.

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Executive Summary

Civil engineering projects are designed to facilitate the people either they are building projects or the non-building projects. Buildings are designed to accommodate the people and roads are designed to carry sufficient traffic throughout their design life. There are several road projects undergoing in Pakistan. Lahore-Sialkot motorway is one of those projects connecting Lahore and Sialkot. It is always very important to check the adequacy of design. In case of roads, it is important to simulate the traffic to have a fair idea about the future situation on the road. Simulation can be termed as a prediction of future behavior of the roads before it actually happens.

To predict that behavior VISSIM was used as a simulation tool through which all the interchanges were simulated using the traffic for three different years i.e. 2017, 2027 and 2037. Traffic study report was the source of this traffic. Traffic for 2017 was given in the study report while the traffic for 2027 and 2037 was predicted using different growth factors. This traffic was used as an input for VISSIM and then LOS, Stop Delay, Queue Length, maximum Queue Length and vehicles delays were estimated.

Design of all the interchanges was provided in AutoCAD files. Those files were exported to VISSIM where exact replications of those interchanges were generated. On those interchanges the actual and predicted traffic was run. This process predicts the future situation on these interchanges. The output of these simulations was used to suggest the remedial measures to counter the drop of LOS with the passage of time. Most of the interchanges had a reliable LOS after running the simulations except at the Toll plazas where a delay of 5 or 10 seconds was given to the vehicles.

Remedial measures include the removal of a U-turn at Sambrial interchange to give a smooth flow of traffic and shifting the turning traffic to the next existing round-about. Moreover, Roundabouts at all the interchanges at the junction of local roads and ramps can also improve the level of service reducing the delays and queue lengths.

Chapter 1: Introduction

1.1 Background

The Lahore Sialkot motorway (LSM) is an undergoing project in Pakistan, linking two big cities i.e. Lahore and Sialkot through Sambrial. The motorway is 89 km long having four lanes, seven interchanges, eight flyovers, forty bridges and seventy underpasses. Three industrial zones and two universities would also be built along the project. It will be connected with M2 and N5 through Lahore link road near Kala Shah Kaku. The route will run parallel to GT road, passing east of Daska, east of Sambrial and end in Gujrat. The details of seven interchanges are as follow:

Table 1.1 Details of all the interchanges of LSM

Interchange Name	East Bound	West Bound	North Bound	South Bound	Running Distance (RD)
Sambrial	Wazirabad	Sialkot	Sambrial	Lahore	91+400
Daska-Sialkot	Daska	Sialkot	Sambrial	Lahore	78+000
Daska-Pasrur	Daska	Pasrur	Sialkot	Lahore	73+660
Pasrur-Gujranwala	Gujrawala	Pasrur	Sialkot	Lahore	59+760
Narowal	Kotli	Wahndo	Sialkot	Lahore	43+035
Muridke-Narowal	Muridke	Narowal	Sialkot	Lahore	22+100
KSK	Sharaqpur	Harbanspura	Sialkot	Lahore	Start of LSM

Kala Shah Kaku is the interchange which marks the start of LSM while Sambrial is the interchange which is the end of LSM near Sialkot at the RD of 91+400.

1.2 Simulation

Simulation modeling provides better solutions by giving clear insights into complex systems. Computer simulation is used when conducting experiments on a real system is impossible or impractical. Simulation can be done at corridor level to analyze delay time, tool revenue, queue length and congestion. Traffic Simulation is used for studying models which are difficult to solve through analytical or numerical technique, for experimental studies, studying detailed relations

and can easily produce future scenario visually in high quality result. Traffic simulation is the mathematical modeling of transportation systems (e.g., freeway junctions, roundabouts, downtown grid systems, signal control etc.) through the application of computer software to better help plan, design and operate transportation system. Software used for simulation of Lahore Sialkot Motorway is VISSIM.

VISSIM is microscopic multi-modal traffic flow simulation software. Microscopic simulation considers each individual entity thus considering all factors of an entity, like efficiently analyzing traffic flow through intersection. Micro simulation is often used to evaluate the proposed interventions prior to their construction in reality, its multi-modality allowed it to simulate more than one type of traffic like cars, trucks cycles etc.

Traffic for the simulation was provided in the study report. Traffic volume of 2017, 2027 and 2037 was given. As the design life of Lahore Sialkot Motorway is 30 years so simulation was done at three different times. Firstly the interchanges were simulated with the anticipated traffic of 2017 and level of service was determined. Similarly it was done for 2027 and 2037 and serviceability was evaluated.

Level of service (LOS) is a qualitative measure used to relate the quality of traffic service. LOS is used to analyze highways by categorizing traffic flow and assigning quality levels of traffic based on performance measure like speed, density, etc. Traffic coming on all the different interchanges was determined by using different methods and then it was converted into the future traffic using different growth factors. Now, this traffic can help us determine the level of service at the end of design period. Level of service varies from A to F with A being the most suitable condition and F being the worst and forced conditions of traffic flow. Delay time for traffic increases gradually from level A to F. So VISSIM will be used to check the LOS at the end of design period and if LOS does not meet the specified criteria then remedial measures will be suggested to bring the LOS up to the mark.

1.3 Aims & Objectives

The project will be completed by keeping following objectives in mind

1) Attain full command over the use of VISSIM software, different features like adding controls, general settings, data input, building network, links and connectors, running simulation and generating output etc.
2) Traffic volume from study report will be added to the VISSIM and simulation will be run for the six interchanges of Lahore Sialkot Motorway. Simulation will be run in three different phases equal to design period.
3) Determine whether the interchanges will be sufficient enough to accommodate the anticipated traffic and allow a smooth flow of traffic through them at the end of design period.

4) Evaluation of Level of Service at the end of design period. Level of service will indicate the serviceability, it ranges from A that is traffic flow is smooth and road is easily accommodating the design traffic to F which is the worst condition on the road.
5) Once Level of Service has been found and it is in the worst range then remedial or alternative measures will be suggested so that any shortcoming in the design will be cater and to make the project adequate.

1.4 Problem Statement

Construction of road network is very time consuming and very costly task, so, before the construction of highways or motorways it is necessary to check whether it will accommodate anticipated traffic or not. Traffic simulation is a technique with the help of which we can do it effectively and immediately thus saving cost and time. There are different software for this purpose. Software we used for the simulation of the traffic of Lahore Sialkot Motorway is VISSIM. It is microscopic, multi modal traffic flow simulation software. There are several outputs of this software like delay time, tool revenue, queue length, carbon emission from the vehicles cylinders. This software predicts the future scenario based on the results of simulations. The one important result of this simulation software is Level of service. LOS is a measure of the serviceability/traffic congestion on the road of the road. It varies from A (best) to F (worst). Due to its extensive use PTV VISSIM is used by transportation engineers around the globe for quantifying work zones impact on traffic delays.

So, in this project simulation of traffic of Lahore-Sialkot Motorway interchanges using VISSIM software to check the adequacy of designed interchanges under anticipated traffic at the end of design period will be done thus making it a project of traffic operation analysis at the specified motorway. After getting the results, remedial measures will also be suggested to counter for the drop of level of service with the passage of time.

1.4 Scope of the Study

The project will be covering a variety of the aspects including the understanding of study report as well as the use of the VISSIM software. The scope of the project with respect to these aspects is given below:

1) Study and analysis of traffic report for traffic calculation and Separation Traffic

Study report estimates the future traffic on the Lahore Sialkot Motorway for the year 2017 but design life of project is 30 years so for 2027 and 2037 the traffic is calculated through Geometric growth Method. Also for the separation of traffic for interchanges various factors and mathematical techniques will be used.

2) Understanding VISSIM, its features and tools

Simulation allows evaluating the future scenario prior to construction for the projects that are time consuming; VISSIM is used for simulation purpose. All the features and characteristics of

the VISSIM software will be learnt and practice to attain full command over the VISSIM, minimizing the chances of error.

3) Determining serviceability from Level of service

After running simulation, results will be generated leading to the level of service indicating the serviceability. LOS ranges from A (best) to F (worst). Remedial measures will also be suggested in case of any inadequacy.

Chapter 2: Literature Review

Literature review consists of two different parts:

1) Literature review of study report
2) Literature review of VISSIM

2.1 Literature review of study report

2.1.1 Introduction

Lahore Sialkot Motorway project is undertaken by National highway Authority with Frontier Works Organization (FWO) as Construction Company. The LSM is having four lanes, 89km long (Which was considered for the project) and having seven interchanges. Traffic study resulted in the traffic of the years 2017, 2027 and 2037. Traffic separation and composition is also the result of traffic study carried out. The proposed profile of LSM is given below:

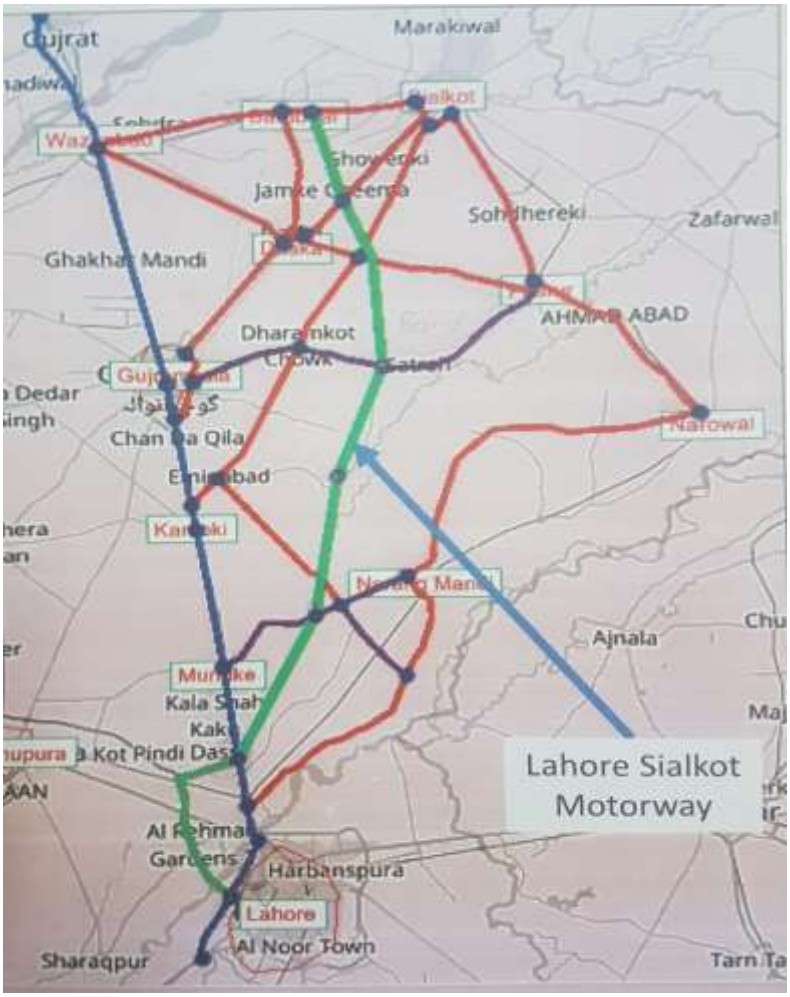

Fig. 2.1 Proposed LSM

2.1.2 Scope

The traffic report estimates the future traffic for the Lahore Sialkot Motorway by using different techniques and method. All the factors were incorporated affecting traffic growth. The output of this report that is (Traffic Volume) will be used as input for the design traffic of Lahore Sialkot Motorway.

2.1.3 Traffic Data Collection

Methods used for Estimating traffic data

Following methods were used to collect the data of traffic at different locations:

- Turning movement counts
- Directional counts

Equipment Used

The equipment used during the collection of data used are:

- Pneumatic tube
- Video Recording Unit

Fig. 2.2 Pneumatic Tube

Similarly, video recording unit is also shown here.

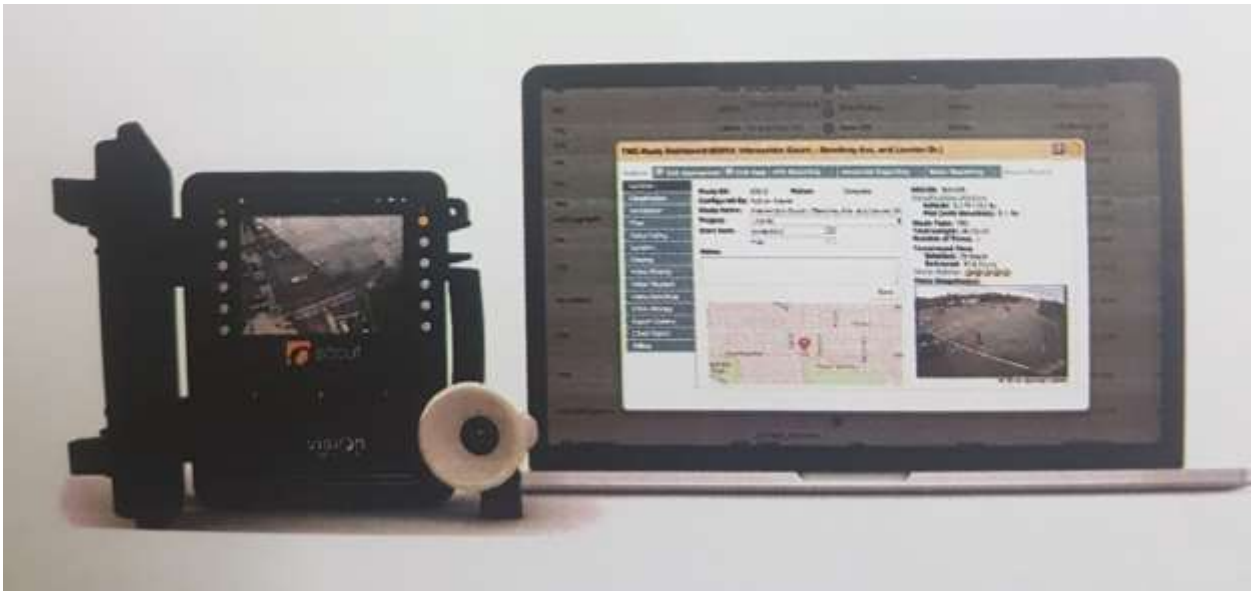

Fig. 2.3 Video Recording Unit

2.1.4 Data Collections and Schedule

Study area was defined based on influential areas of purposed LSM. Total 19 locations were identified on the roads within study areas. The counts were conducted for 7 days for both directions at 19 locations. The results of these counts are shown below.

2.1.5 Traffic Study Results

Location 1 (N-5 near Ferozewala)

- Traffic counts from KSK to Shahdara were 18,539 vehicles per day
- Traffic counts from Shahdara to KSK were 19,612 vehicles per day
- Average Volume 31,505 vehicles per day, These counts include 65% cars, 14% public transport and 21% trucks

Location 2 (Norowak-Muridke Road)

- Traffic counts from Muridke to Narang Mandi were 2.919 Vehicles per day
- Traffic counts from Narang Mandi to Muridke were 2,278 vehicles per day
- Average volume 4,725 vehicles per day
- These counts include 58% cars, 18% public transport and 24% trucks

Location 3 (Kala Khatie – Narang Mandi Road)

- Traffic counts from Kala Khatie to Narang Mandi were 3,488 vehicles per day
- Traffic counts from Narang Mandi to Kala Khatie were 2,796 vehicles per day
- Average Volume was 6,285 vehicles per day

- These counts include 58% cars, 24% public transport and 18% trucks

Location 4 (Chakkian Road)

- VCU was installed as road is under construction.
- Traffic counts from Kala Khatia to Narowal Road were 223 vehicles per day
- Traffic counts from Narowal to Kala Khatia were 217 vehicles per day
- Average Volume was 440 vehicles per day

Location 5 (Narowal Muridke Road)

- Traffic counts from Narang Mandi to Muridke were 427 vehicles per day
- Traffic counts from Muridke to Narang Mandi were 523 vehicles per day
- Average Volume was 949 vehicles per day

Location 6 (Gujranwala Road)

- Traffic counts were calculated using pneumatic tubes
- Traffic count towards Eminabad was 1,286
- Traffic counts towards Nanga Duuna was 1,166
- These counts include 78% cars, 7% public transport and 15% trucks

Location 7 (Gujranwala-Pasrur Road)

- Traffic counts were calculated using pneumatic tubes
- Traffic counts towards Pasrur (EB) were 1,973
- Traffic counts towards Gujranwala (WB) were 1,809
- These counts include 58% cars, 29% public transport and 13% trucks

Location 8 (Eminabad-Sialkot Road)

- Traffic counts were calculated using pneumatic tubes
- Traffic counts towards Sialkot (NB) were 2,310
- Traffic counts towards Eminabad (SB) were 2,424
- These counts include 64% cars, 18% public transport and 18% trucks

Location 9 (Gujraanwala-Pasrur Road)

- Traffic counts were calculated using pneumatic tubes
- Traffic counts towards Pasrur(EB) were 1,997
- Traffic counts towards Gujranwala(WB) were 2,138
- These counts include 57% cars, 24% public transport and 19% trucks

Location 10 (Pasrur Road)

- Traffic counts were calculated using pneumatic tubes

- Traffic counts towards Sialkot (NB) were 5,586
- Traffic counts towards Pasrur (SB) were 6,099
- These counts include 72% cars, 17% public transport and 11% trucks

Location 11 (Daska Road)

- Traffic counts were calculated using pneumatic tubes
- Traffic counts towards Pasrur (EB) were 1,564
- Traffic counts towards Daska (WB) were 1,935

Location 12 (Sambrial Road)

- Traffic counts were calculated using pneumatic tubes
- Traffic counts towards Sambrial (NB) were 2,075
- Traffic counts towards Daska (SB) were 2,019

Location 13 (Daska-Wazirabad Road)

- Traffic counts were calculated using pneumatic tubes
- Traffic counts towards Daska (EB) were 1,259
- Traffic counts towards Wazirabad (WB) were 1,389

Location 14 (Wazirabad-Sialkot Road)

- Traffic counts were calculated using pneumatic tubes
- Traffic counts towards Sambrial (EB) were 4,586
- Traffic counts towards Wazirabad (WB) were 4,407
- These counts include 71% cars, 15% public transport and 14% trucks

Location 15 (Sialkot-Daska Road)

- Traffic counts were calculated using pneumatic tubes
- Traffic counts from Daska to Sialkot were 7,979
- Traffic counts from Sialkot to Daska were 8,129
- These counts include 66% cars, 21% public transport and 13% trucks

Location 16 (Sialkot-Eminabad Road)

- Traffic counts from Mundeke to Sialkot are 3,776
- Traffic counts from Sialkot to Mundeke are 4,004
- These counts include 75% cars, 11% public transport and 14% trucks

Location 17(Ugoki Road)

- Traffic counts from Ugoki to Sialkot are 5,249
- Traffic counts from Sialkot to Ugoki are 5,705

- These counts include 69% cars, 20% public transport and 11% trucks

Location 18 (Gujranwala-Daska Road)

- Traffic counts were again calculated using pneumatic tubes
- Traffic counts from Gujranwala to Daska are 7,752
- Traffic counts from Daska to Gujranwala are 6,792
- These counts include 81% cars, 14% public transport and 5% trucks

Location 19 (KSK M-2 Toll Plaza)

- Traffic counts were calculated by using video recording equipment. This location has four directions of traffic
- Traffic counts from KSK to M-2 are 10,987
- Traffic counts from Shah Dra to M-2 are 1,194
- Traffic counts from M-2 to Shah Dra are 947
- Traffic counts from M-2 to KSK are 9,253
- These counts include 79% cars, 2% public transport and 19% trucks

2.1.6 Average Daily Traffic

Average daily traffic is the 24 hour average volume over a certain location for a time period less than a year. Highest ADT was observed near N-5 Ferozewala.

2.1.7 Estimation OF Traffic Growth

There are several factors on which traffic growth is dependent. Different indicators were reviewed for the estimation of growth factor for the travel demand forecasting which include rate of increase in

- No. of registered vehicles
- No. of vehicles on roads
- Agriculture & Industrial production
- Population
- GDP

2.1.7.1 Population Growth

Population growth in Pakistan is 1.98% and that of Punjab is 1.82%. As major portion of Lahore Sialkot motorway passes through Gujranwala so population growth there is 1.49%.This all data is for last five years. So now we have population growth factor for the last five years, we can add this in to our traffic count.

2.1.7.2 Growth of registered Vehicles

- **Pakistan**
  - The average rate of growth of cars for the last five years is 7.98%
  - The rate of growth of buses is 2.81%

- The rate of growth of trucks is 3.58%

- **Punjab**
  - The rate of growth of cars for last five years in Punjab is 8.37%
  - The rate for buses is 6.11%
  - The rate of growth of trucks is 5.08%
  - This rate is higher than the overall rate of growth in Pakistan

2.1.7.3 Growth of Vehicles on Roads of Pakistan

- The rate of growth of cars on roads for the last five years is 17.13%
- The rate for the growth of buses is 3.73%
- The rate for the growth of trucks is 4.75%

2.1.7.4 Growth in Agricultural and Industrial Sectors

- The growth rate of important crops is 3.7%
- The growth rate of overall agriculture is 2.83%
- Increase in growth rate of manufacturing is 4.11%
- The growth rate on GDP on price factor is 4.07%

We had all the factors for the last five years so we can add them in our last traffic count.

2.1.8 Origin-Destination (OD) Survey

O-D Surveys were conducted to ascertain the road user information and necessary data collection in the area. The O-D Surveys provide data regarding origin and destination of each vehicle. Survey was conducted on 20 different zones,

2.1.8.1 Survey Questionnaire

The basic purpose of survey is to have an idea/estimate of the traffic volume for the traffic count.

- O-D Info
- Trip Purpose
- Trip Frequency
- Willingness to pay toll for new LSM

O-D Info:

The destinations and origins of all the vehicles were asked in order to determine the need of the route to minimize the travel time.

Trip Purpose:

- Home (Coming or Going)
- Work
- Education (Coming or Going)

Trip Frequency:

- Daily
- Once a Week
- Two or Three Times a week
- Others (Once in a month/Rarely)

The percentage for daily trips varies from 37-76%

Willingness to Pay Toll:

During the O-D Survey, drivers were asked about the willingness to pay Toll for the proposed LSM. About 58-91% users agreed to pay the Toll.

2.1.9 Travel Time Study

Travel time study is used to determine the travel time and average speed of vehicles on the existing corridor. The Travel Time Surveys were carried out by the Consultant.

2.1.9.1 Methodology

Data was collected using a vehicle-mounted transmission sensor and a GPS receiver/laptop computer/GPS software combination.

This equipment is used to collect various types of traffic data and programmed for starting, ending and intermediate node points. The intersections and point of interests were as node points for the travel time runs.

The collected data was compiled using the computer software program PC-TRAVEL. To get accurate travel time data runs were performed during peak and off peak time periods

2.1.9.2 Estimation of Existing Time Travel

Travel Time is one of the measures of effectiveness (MOE) to evaluate the existing road network. This output of travel time study was also used as input for Travel Demand.

2.1.9.3 Travel Time for Sialkot-Gujranwala

Actual travel time taken by the vehicles to reach Gujranwala from Sialkot was 67 minutes whereas the Expected Travel Time for the same route is 52 mins. That means overall delay of 15 minutes was observed by the vehicle.

2.1.9.4 Travel Time for Gujrat-Sialkot

Actual travel time taken by the vehicle was 88 minutes whereas the Expected Travel Time for the same route is 73 minutes. That means overall delay of 15 minutes was observed by the vehicle.

2.1.10 Travel Demand Modeling

Travel forecasting phase of the transportation planning process is to perform a conditional prediction of travel demand on the transportation facility in future. This process consists of 4 steps

- Trip Generation
- Trip Distribution
- Modal Split
- Traffic Assignment

Trip Generation was estimated using factors such as employment, population, household size, origin and destination of each zone.

Trip Distribution was estimated based upon O-D data analysis.

Modal Split was estimated using the vehicle distribution estimated through traffic volume surveys.

Trip Assignment was done using equilibrium assignment method.

The complete network was coded in VISUM Software to perform travel demand modeling.

2.1.11 Coding in VISUM Software

It is a comprehensive, flexible software system for transportation planning and travel demand modeling.

Total 20 zones were coded in the model.

After coding of zones, the nodes and links were created within the study area. Following info was coded for each link in the model

- Link ID
- Link(Road) Name
- Free Flow Speed
- Travel Time
- Capacity
- Number of Lanes

The traffic for all the interchanges is shown in the following chapters.

2.2 Literature Review of VISSIM

VISSIM is microscopic multi-modal traffic flow simulation software. Microscopic simulation considers each individual entity thus considering all factors of an entity, like efficiently analyzing traffic flow through intersection. Micro simulation is often used to evaluate the proposed interventions prior to their construction in reality, its multi-modality allowed it to simulate more than one type of traffic like cars, trucks cycles etc.

A literature review has been conducted to determine the research efforts related to the calibration and validation of the highway models, freeways, roundabouts, intersections or interchange with PTV VISSIM. The review is divided into two major categories the first is general microsimulation modeling and second Multi-modality using PTV GROUP VISSIM software package. Both categories have been studied to determine where more research is required for both the simulation of interchange traffic and for specific VISSIM specifications.

2.2.1 General Traffic Simulation and Calibration

These processes present statistical functions for the validation of simulating the models of any place such as roads, highways etc. It consists of three stages, these are as follow:

1) Volume based calibration

2) Speed based calibration

3) Objective based calibration.

Any type of traffic simulation models can be run of VISSIM it gives accurate results for that we have to give modifications to Volume of traffic, Driver behavior, Route decision, Speed estimation and reduce speed areas for calibration of traffic simulation models.it can be a general guidelines for building model also, planning traffic simulation project, model calibration validation, and node analysis of results. It runs through a license and a student version, both has some limits.

The nine steps include:

1) Determination of traffic

2) Data collection

3) Identification of Peak hour

4) Route decision

5) Sign boards

6) Delay of vehicle at Toll plaza

7) Determination of parameter sets

8) Run preliminary simulations

9) Results of Node about LOS and delay.

The research is mainly focused on Motorway simulation and toll plaza delay operations to modify and simulate in VISSIM for freeway modeling.

A case study of the model Rashakai interchange and calibration was made for an interchange model using VISSIM software in order to practice and get its objectives and results in order to proceed for the motorway. Their research presents specific parameter details related to VISSIM. However, a standardized calibration and validation is not presented in their research.

2.2.2 Traffic Study

Traffic study is a major parameter of metropolitan areas concluding in various trials undertaken to low vehicle congestion. The first step in this whole process is the identification of the traffic from Lahore to Sialkot and its various features to direct us for the selection of suitable and requisite measures.

A lot of people travel every day from Lahore to Sialkot and vice versa and also the areas in between like Muridke to Narang Mandi, Kala Khatia to Narowal. A lot of time is wasted while travelling from GT road so motorway is being constructed so that at a speed of 120 km/h the time can be saved as well as increasing the cost of travelling of the society along with the increase in pollution. Numerous causes for which the project is under consideration include:

- Number of vehicles exceeding the design capacity at GT road.
- Low speed at GT road.
- Intersections at many places in between
- Traffic demand.
- Excessive pedestrian crossing.
- Increase in vehicle ownership causing limited use of mass transit system.

2.2.3 Intersection Delays

In the traffic system, urbanized road network performs main role in operations and application in Intersections, they are divided into two groups, on grade and without grade and they are basically on different levels of intersection control. It can be signalized; semi controlled or may be completely controlled. The factors that affect are delay, queue and LOS.

2.2.4 Capacity

Highway Capacity Manual says at any given time max hourly rate at which vehicles is required to traverse a point in a road. It may be assessed using saturation stream. Capacity may change by changing various roadway conditions like grades change or lane usage allocations, no. of lanes and lanes width.

2.2.5 Estimating Delay at Real-World

Delay is the time that is wasted by the passenger in vehicle due to queue. Delay includes queue time, clearance lost time and start up lost time.

Factors that affect delay are capacity and volume of vehicle in lane group, green time cycle length, delays may affect LOS.

2.2.6 LOS

LOS is abbreviated as Level of Service it characterizes the road service that how much it is capable of taking traffic It tell quality of traffic based on performance measure like density, acceleration speed etc. It is categorized as A, B, C, D, E, and F. If the delay is less than 10 seconds then LOS is A and if it is between 10-20 sec its LOS B, From 20-35 seconds its LOS C, 35-55 seconds is LOS D, 55 to 80 is LOS E greater than 80 sec is LOS F. Hence we get the LOS from this time. We have benefit in VISSIM that it tells the LOS itself by making a node where we want results A, B, C can be considered below that makes traffic congestion and mesh.

Table 2.1 Level of Service

LOS	Signalized Intersection	Un-signalized Intersection
A	≤10 sec	≤10 sec
B	10–20 sec	10–15 sec
C	20–35 sec	15–25 sec
D	35–55 sec	25–35 sec

E	55–80 sec	35–50 sec
F	>80 sec	>50 sec

2.2.7 Vehicle queuing

It is measure of effectiveness and behavior of traffic that also tells about the capacity of lanes, wait time and about the queue. When there is a lot of traffic and if signalized and green time is less than here the role of traffic engineer comes is to solve problem problems while optimizing the operation of the existing traffic system. The queue length is much more important and similar to that it has a unit of vehicle and characterizes as no. of vehicles its formula

Queue length = Vehicle per hour x Queue time

2.2.8 Conflict Areas

When 2 or more lanes merge, diverge or cross each other without any traffic signal so it becomes conflict area. VISSIM can give the priority to the traffic depending upon the preference specified by the user.

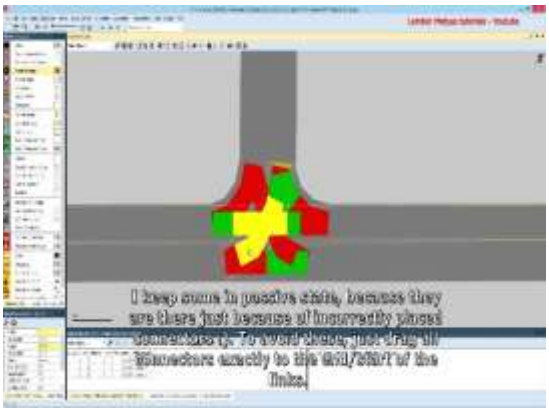

Fig. 2.4 Area of Conflict

2.2.9 Gap Acceptance

Gap acceptance is the least possible gap required to cease lane changing in a safe manner. Hence, its model can assist describe how a driver guess that he has to accept or reject. It may also be defined as a minor stream vehicle accepts accessible the available gap to maneuver.

2.2.10 Intersections

It is a point where two or more roads intersect It has many types in our interchange it is simple, the traffic coming from different areas conflict and go towards Toll plaza that creates Grade

separated intersections or interchanges that ensure the elimination of crossing conflicts that can occur at intersections with vertical separations in the road.

There are many types of intersection like 3,4,5,6,7-way approach, It can be T junction Y junction or may be signal controlled intersection, in our motorway design the toll plaza plays a role as interchange where the traffic has to move to its destination and it stops for a while hence they changes its routes by intersection.

Basically, the various turning ramps, various patterns of roadways are defined as interchanges. The design of an intersection is made to ensure:

- Economical traffic flow
- Direction of movement
- Right of way ROW
- Type of controls units
- Topography and operation on the crossing facilities that is the most important factor.

Chapter 3 Methodology

3.1 Introduction

This part of the research work explains the research methodology adopted during the study to achieve the stated objectives. Research methodology or method to conduct a study is considered as "a strategy, design or process lying behind the choice of and use of particular methods". Its purpose is to explain and justify the use of particular methods (Wellington, 2000).

Lahore-Sialkot Motorway contains 7 interchanges out of which 6 were simulated using VISSIM. Simulation of these interchanges included different steps:

- Drawing of Links and Connectors
- Assigning Traffic Routes
- Adding Traffic
- Adding Traffic Composition
- Running Simulation
- Getting Data Output

3.2 Data Collection

Data was collected using the following parameters

3.2.1 Traffic Volume Study

We utilized all the data provided in the traffic study report and used that data to give traffic inputs in the different interchanges and the traffic influencing those interchanges. Also, we used the AutoCAD file of each interchange provided to us to simulate the design of each interchange.

3.2.2 Geometric Condition

The on-site current geometric parameters which should be imperative for the investigation of Motorway Interchanges:

- Area type
- Number of lanes, N
- Average lane width, W (ft)
- Grade, G (%)
- Existence of exclusive LT or RT lanes

3.2.3 Signalization Conditions

A comprehensive data is required regarding signalization to perform such an investigation. This data embraces a phase layout demonstrating the phase plan, cycle length, green times, and change-and-clearance intervals.

The onsite prevailing signalization conditions parameters which should be imperative for the investigation of designated urban signalized intersection would be as under:

- Cycle length, C (s)
- Green time, G (s)
- Yellow-plus-all-red change-and-clearance interval
- (inter-green), Yellow (s)
- Actuated or pre timed operation

3.3 Determination of LOS

All the above parameters are put in VISSIM 10 software to determine the LOS of the intersections. The intersections are signalized having pre-timed cycle lengths. After putting in the data the results were generated which gave the LOS of existing conditions.

3.4 Proposed Design Alternatives

After the analysis of the LOS, time delay and Queue Length with the help VISSIM 10, it was concluded to suggest various design alternatives to improve the LOS. These alternatives consisted of short term and long term measures.

3.5 Peak Hour Factor

Peak Hour Factor is a number which takes into account the effect of Peak Hour Traffic. Its value ranges from 0.25 to 1. And it can be calculated as

PHF = (average flow rate)/ (4*Peak 15 minute flow rate)

The study report provided the data about the daily traffic but it didn't provide any data to calculate the Peak Hour Factor for the interchanges. So, in the absence of any data PHF can be taken as 0.94 as specified in Highway Capacity Manual for Freeways. So, the value of PHF has been taken as 0.94 and the traffic for peak hour was calculated. All the interchanges have been simulated for that peak hour traffic.

3.6 Data for individual interchanges

The dimensions of links and connectors, traffic and traffic routes for all the interchanges were different from one another depending upon the design of interchanges. Data about individual interchanges is given below:

3.6.1 Muridke-Narowal Interchange

Narowal-Muridke interchange is located at the start of the Lahore-Sialkot Motorway. This is the second interchange of the LSM but first interchange of our final year project. The layout of the interchange is shown here;

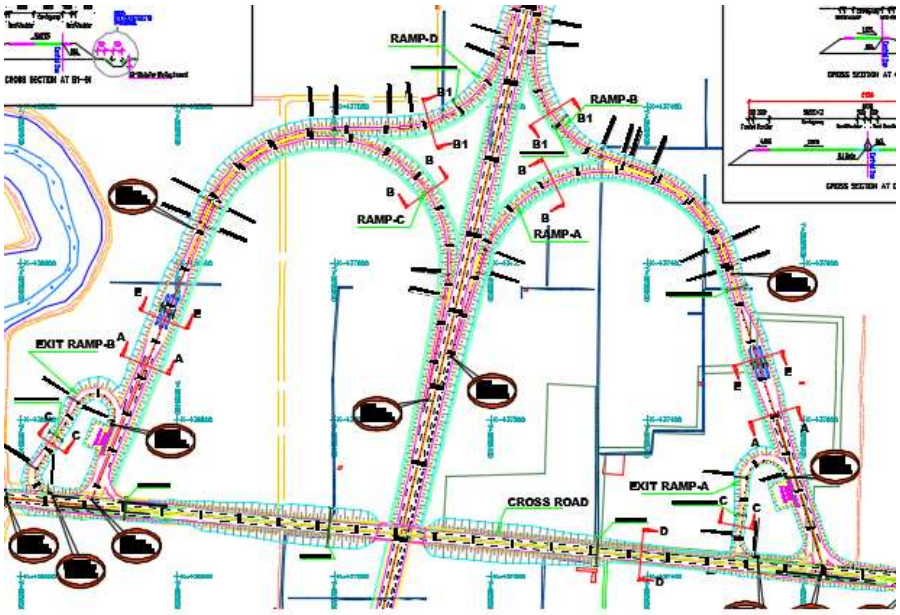

Fig. 3.1 Layout of Muridke-Narowal Interchange

This interchange is located to the north of Lahore and in between the cities of Narowal and Muridke. Muridke lies in the west of it while Narowal lies in the east of it. The city of Sialkot in situated at the far north of this interchange.

- The traffic moving between Narowal to Muridke does not need the motorway for their journey as through traffic moves freely on local road.
- The traffic coming to Narowal and Muridke from Sialkot will take an exit from Ramp-B and will turn at the junction of the ramp-crossroad towards their respective destinations.
- The traffic going to Sialkot from Muridke and Narowal will enter the motorway from the Ramp-D.
- The traffic coming from Lahore to Sialkot and from Sialkot to Lahore will not exit the motorway and will continue their journey on the LSM.
- The traffic coming to Narowal and Muridke from Lahore will take an exit from Ramp-C and will turn at the junction of the ramp-crossroad towards their respective destinations
- The traffic going from Muridke and Narowal to Lahore will enter the motorway from the Ramp-A.

The current traffic numbers and future traffic numbers are shown below:

Table 3.1 Traffic at Narowal-Muridke Interchange

	Narowal-Muridke Interchange (KM 22+100)			
Year / **Movements**	**Year 2017 (Vehicles/day)**	**2017 (Vehicles/hour)**	**2027 (Vehicles/hour)**	**2037 (Vehicles/hour)**
Narowal to Muridke	1772	79	105	140
Muridke to Narowal	1636	73	97	130
Sialkot to Narowal and Muridke	1572	70	93	124
Narowal and Muridke to Sialkot	1837	81	109	145
Lahore to Sialkot	10484	465	621	830
Sialkot to Lahore	12517	555	742	991
Lahore to Narowal and Muridke	1572	70	93	124
Narowal and Muridke to Lahore	1837	81	109	145

3.6.2 Narowal Interchange

Narowal interchange is the second interchange of our Lahore-Sialkot Motorway. Lahore is situated at the south and Sialkot at the north of this interchange. Kotli is situated at the north-eastern side while Wahndo is located on west side the Narowal interchange. The interchange may be considered critical because of its location and geometry. The layout of the interchange is shown on the next page.

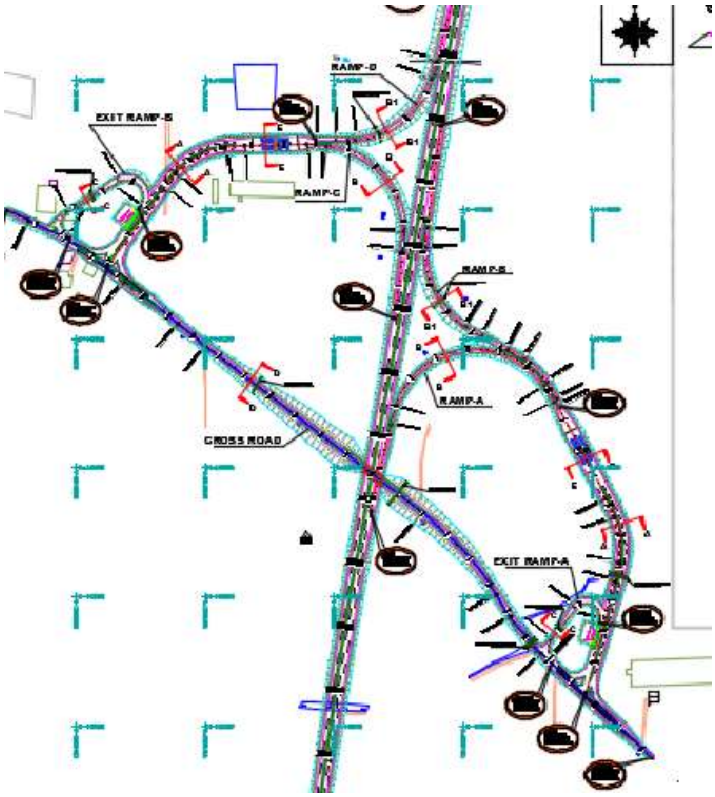

Fig. 3.2 Layout of Narowal Interchange

- The traffic coming from Kotli to Wahndo will take an exit from the Ramp-B and then turn towards left at the junction with the crossroad.
- The traffic going to Kotli from Wahndo will enter the motorway through the Ramp-D.
- The traffic coming from Lahore to Wahndo will take an exit from the Ramp-C while the traffic going to Kotli will not exit the motorway and will continue its journey towards Kotli.
- The traffic coming from Kotli to Lahore will already be on the motorway while the traffic going to Lahore from Wahndo will enter the motorway through Ramp-A
- The traffic coming from Sialkot
- The traffic going to Lahore from Sialkot will not exit the motorway.

The current traffic counts and future traffic counts are shown on the next page.

Table 3.2 Traffic at Narowal Interchange

	Narowal Interchange (KM 43+035)			
Year Movements	Year 2017 (Vehicles/day)	2017 (Vehicles/hour)	2027 (Vehicles/hour)	2037 (Vehicles/hour)
Kotli to Wahndo	4545	201	269	360
Wahndo to Kotli	4196	186	249	332
Lahore to Wahndo and Kotli	2858	127	169	226
Kotli and Wahndo to Lahore	1859	82	110	147
Sialkot to Wahndo and Kotli	2263	100	134	179
Kotli and Wahndo to Sialkot	1761	78	104	139
Lahore to Sialkot	9463	419	561	749
Sialkot to Lahore	11658	517	691	923

3.6.3 Gujranwala-Pasrur Interchange

Gujranwala-Pasrur interchange is the third interchange of Lahore Sialkot Motorway project. It is located at the far end of Lahore-Sialkot Motorway. Pasrur is located on the east side while Gujranwala is located on the west side of this interchange. The layout is as follows

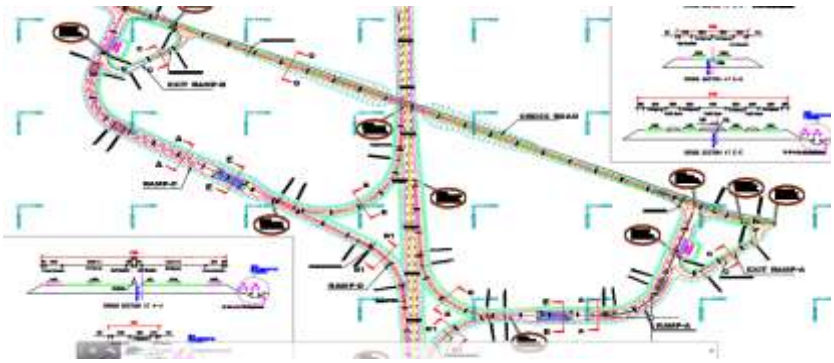

Fig. 3.3 Layout of Gujranwala-Pasrur Interchange

- The traffic going from Gujranwala to Pasrur do not need motorway for their journey and vice versa.
- The traffic coming from Lahore to Gujranwala and Pasrur will exit the motorway from the Ramp-D and at the junction of the Ramp with the local crossroad they will take a turn to their respective destinations.
- The traffic going to Lahore from Gujranwala and Pasrur will enter the motorway using the Ramp-B.
- The traffic going to Sialkot from Gujranwala and Pasrur will enter the motorway using the Ramp-C.
- The traffic coming from Sialkot to Gujranwala and Pasrur will exit the motorway from the Ramp-A and at the junction of the Ramp with the local crossroad they will take a turn to their respective destinations

The current traffic numbers and future traffic numbers are shown below

Table 3.3 Traffic at Gujranwala-Pasrur Interchange

	Gujranwala-Pasrur Interchange (KM 59+760)			
Year / **Movements**	**Year 2017 (Vehicles/day)**	**2017 (Vehicles/hour)**	**2027 (Vehicles/hour)**	**2037 (Vehicles/hour)**
Gujranwala to Pasrur	1973	87	117	156
Pasrur to Gujranwala	1809	80	107	143
Lahore to Gujranwala and Pasrur	4507	200	267	357
Pasrur and Gujranwala to Lahore	6936	307	411	549
Gujranwala and Pasrur to Sialkot	3869	171	229	306
Sialkot to Gujranwala and Pasrur	3672	163	218	291
Lahore to Sialkot	6717	298	398	532
Sialkot to Lahore	6985	310	414	553

3.6.4 Daska-Pasrur Interchange

Daska-Pasrur interchange is the fourth interchange of the Lahore-Sialkot Motorway. Pasrur is situated at the south side while Daska at the north side of this interchange. Also, Lahore lies in the western side and Sialkot at the eastern side of the Daska-Pasrur interchange. The layout is as follows

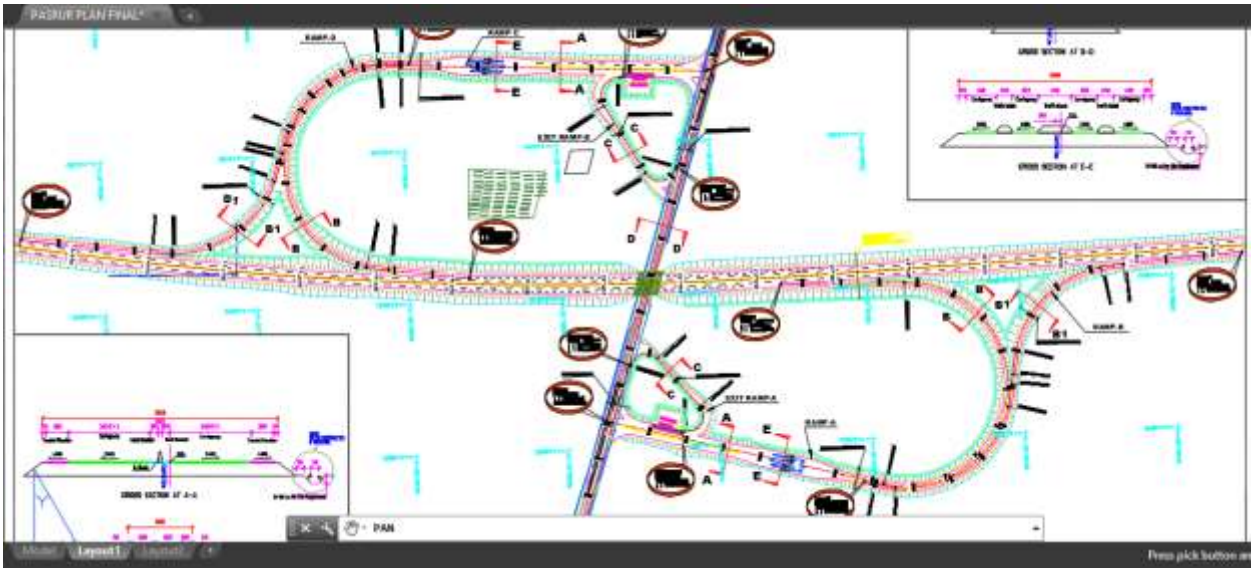

Fig. 3.4 Layout of Daska-Pasrur Interchange

- The traffic moving between Daska and Pasrur do not need the motorway for their movements.
- The traffic coming from Lahore to Daska and Pasrur will exit the motorway from the Ramp-D and at the junction of the Ramp with the local crossroad they will take a turn to their respective destinations.
- The traffic going to Lahore from Daska and Pasrur will enter the motorway using the Ramp-A.
- The traffic going to Sialkot from Daska and Pasrur will enter the motorway using the Ramp-C.
- The traffic coming from Sialkot to Daska and Pasrur will exit the motorway from the Ramp-B and at the junction of the Ramp with the local crossroad they will take a turn to their respective destinations.

The current traffic counts and future traffic counts are shown below

Table 3.4 Traffic at Daska-Pasrur Interchange

	Daska-Pasrur Interchange (KM 73+660)			
Year / **Movements**	**Year 2017 (Vehicles/day)**	**2017 (Vehicles/hour)**	**2027 (Vehicles/hour)**	**2037 (Vehicles/hour)**
Daska to Pasrur	1635	72	97	129
Pasrur to Daska	1509	67	89	119
Lahore to Daska and Pasrur	1363	60	81	108
Pasrur and Daska to Lahore	1093	48	65	87
Daska and Pasrur to Sialkot	599	27	35	47
Sialkot to Daska and Pasrur	89	4	5	7
Lahore to Sialkot	9223	409	547	730
Sialkot to Lahore	9563	424	567	757

3.6.5 Daska Interchange

Daska interchange is the second last interchange of the Lahore-Sialkot Motorway project. It lies in between the Sambrial interchange and the Daska-Pasrur interchange. . Pasrur is situated at the south western side while Daska at the north western side of this interchange. Also, Lahore lies in the western side and Sialkot at the eastern side of it. The layout is as

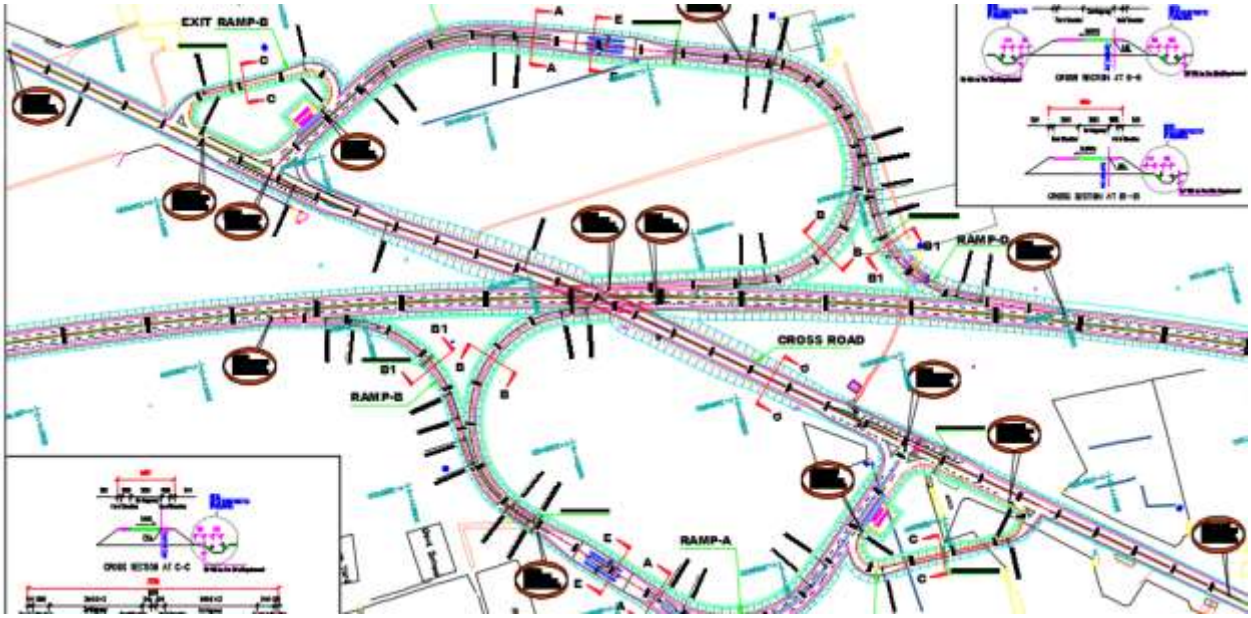

Fig. 3.5 Layout of Daska-Sialkot Interchange

- The traffic going to Sialkot from Daska will enter the motorway using the Ramp-D.
- The traffic coming from Sialkot to Daska will exit the motorway using the Ramp-A.
- The traffic coming from Lahore to Daska will exit the motorway from the Ramp-C and at the junction of the Ramp with the local crossroad they will take a turn left towards Daska
- The traffic going to Lahore from Daska will enter the motorway using the Ramp-B while the traffic going to Lahore will already be on motorway and will not exit the motorway.
- The traffic going to Sambrial from Daska and Sialkot will enter the motorway using the Ramp-A.
- The traffic going to Lahore from Sambrial is already on the motorway and will not exit the motorway and vice versa.

The current traffic counts and future traffic counts are shown below

Table 3.5 Traffic at Daska Interchange

3.6.6 Sambrial Interchange

	Daska Interchange (KM 78+000)			
Year / **Movements**	**Year 2017 (Vehicles/day)**	**2017 (Vehicles/hour)**	**2027 (Vehicles/hour)**	**2037 (Vehicles/hour)**
Daska to Sialkot	3359	149	199	266
Sialkot to Daska	3100	137	184	245
Lahore to Daska and Sialkot	2393	106	142	189
Sialkot and Daska to Lahore	2484	110	147	197
Daska and Sialkot to Sambrial	854	38	51	68
Sambrial to Daska and Sialkot	728	32	43	58
Lahore to Sambrial	7429	329	440	588
Sambrial to Lahore	7169	318	425	568

Sambrial interchange is located at the far end of the Lahore-Sialkot Motorway and is the last interchange of the LSM .This interchange lies between the cities of Sialkot and Wazirabad. Lahore is located in the south of these cities. On the east it joins with Sialkot while Wazirabad is situated on the western side of it. The layout is as

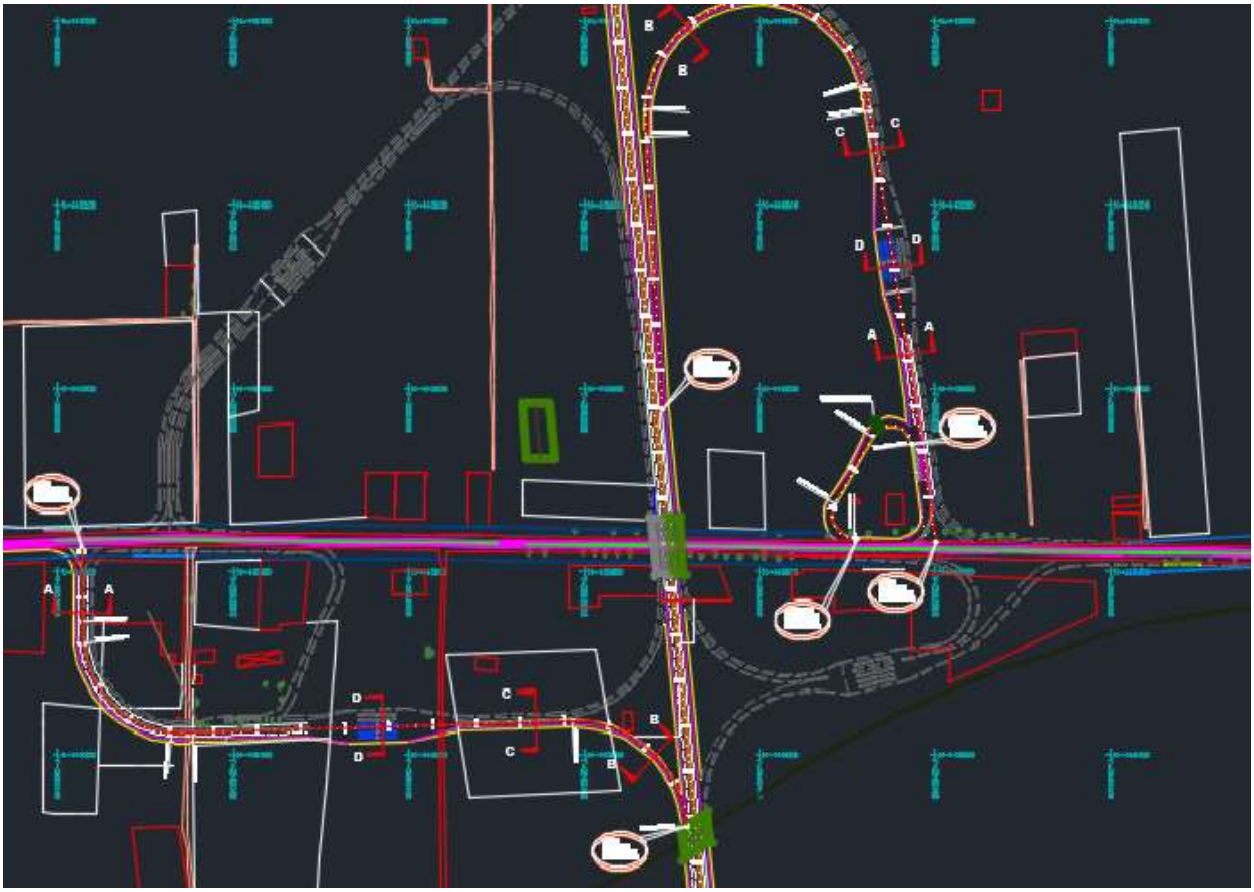

Fig. 3.6 Layout of Sambrial Interchange

- The traffic going to Lahore from Sialkot and Wazirabad will enter the motorway using the Ramp-B.
- The traffic coming from Lahore to Sialkot and Wazirabad will exit the motorway using the Ramp-B.
- The traffic moving between the cities of Sialkot and Wazirabad do not need motorway to reach their destinations.

The current traffic numbers and future traffic numbers are shown below

Table 3.6 Traffic at Sambrial Interchange

	Sambrial Interchange (KM 91+400)			
Year / **Movements**	**Year 2017 (Vehicles/day)**	**2017 (Vehicles/hour)**	**2027 (Vehicles/hour)**	**2037 (Vehicles/hour)**
Sialkot and Wazirabad to Lahore	7897	350	468	625
Lahore to Wazirabad and Sialkot	8283	367	491	656
Wazirabad to Sialkot	8413	373	499	666
Sialkot to Wazirabad	7766	344	460	615

3.7 Cross Sections

The cross-sections for motorway, toll plazas and ramps remain same with a slight change in Sambrial interchange. The cross-sections are shown here

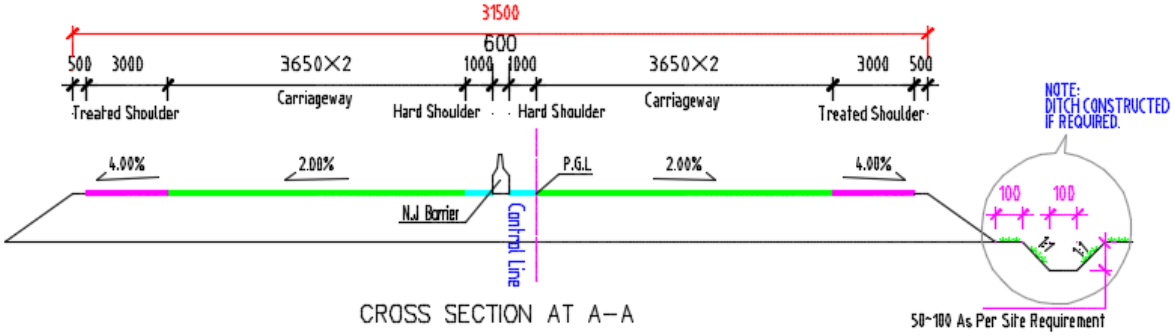

Fig. 3.7 Motorway Cross-Section

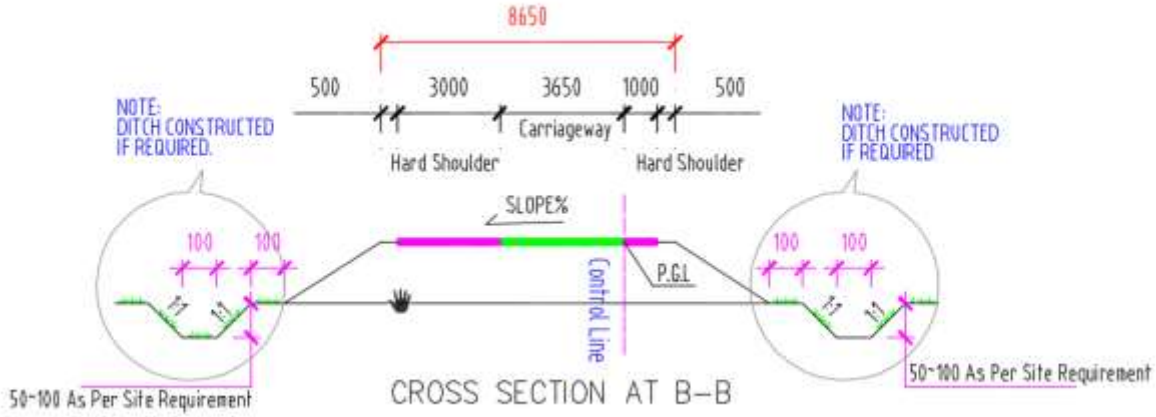

Fig. 3.8 Ramp Cross-Section

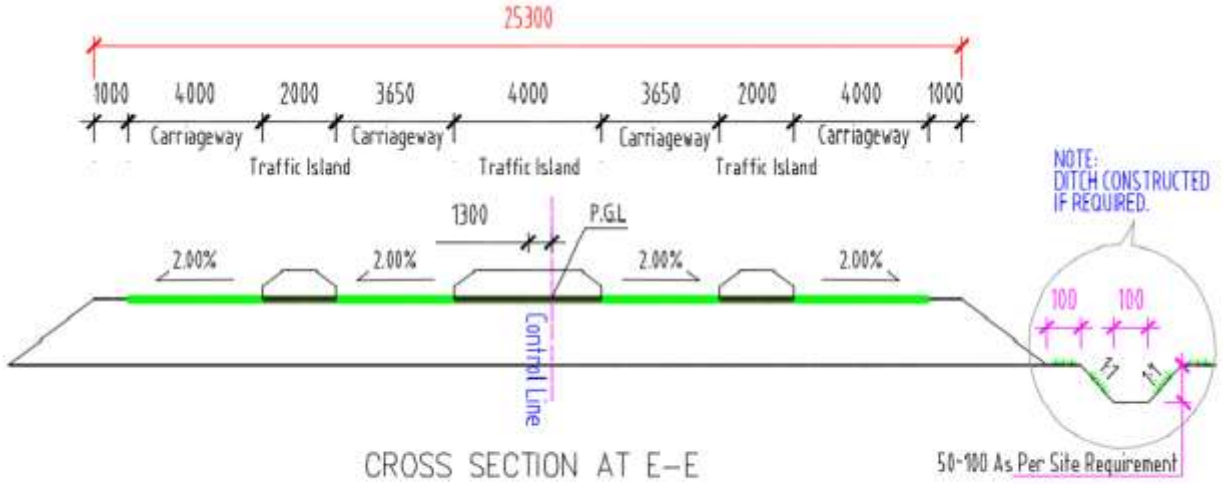

Fig. 3.9 Toll Booths Cross-Section

3.7 Speed of the Traffic

The simulation of interchanges involves the simulation of three different types of roads.

1) Motorway
2) Interchange Ramps
3) Local Roads

There are always different speeds for the traffic on these different roads. The speed used during the simulation is as follows:

Table 3.7 Speed of Traffic at interchanges

Type of Road	Type of Traffic	Speed(km/hour)
Motorway	LTV	120
	HTV	110
Ramps	LTV	60
	HTV	50
Local Roads	LTV	90
	HTV	80

3.8 Traffic Composition

Traffic composition is the percentage of different types of vehicles in any road. In any roads, mostly cars are in abundance while large buses are least abundant. VISSIM requires a specific composition of traffic to be inculcated in it which may generate results accordingly.

In VISSIM, three types of vehicles can be considered in traffic composition i.e.

1) Cars
2) Buses
3) Heavy Traffic

Cars and Wagons moving on the motorway have been considered in cars category. Large buses were given their percentage in the buses category while all trucks have been considered as Heavy Traffic. The composition according to this distribution is given below:

Table 3.8 Traffic Composition

Section	Cars (%)	Buses (%)	Truck Traffic (%)
Sambrial-Daska	75.96	6.25	17.79
Daska-Pasrur	77.73	6.15	16.12
Pasrur-Gujranwala	77	6.52	16.48
Gujranwala-Narowal	75.06	6.17	18.77
Narowal-Muridke	73.48	5.92	20.6
Muridke-KSK	73.62	5.84	20.54

3.9 Parameters Set in VISSIM

There are different parameters which are specified before running the simulation. Those parameters are explained here;

3.9.1 Simulation Speed

Simulation speed can be defined as number of real time seconds in one simulation second. It means that in one step of simulation, number of real time seconds passed.

For running the simulation, maximum speed was used which was

Simulation speed = 10 Real Time Second/ Simulation Second

3.9.2 Time Interval

Time interval can be defined as the number of simulation seconds for which the simulation was run for the purpose of obtaining the results.

During the simulation, the time interval was selected as 500-3000 simulation seconds. Initial 500 simulation seconds were provided for the purpose of initialization of the traffic flow.

By using these parameter i.e. PHF, Traffic speed and Traffic composition all the interchanges were drawn and then analyzed against the standard LOS. The results are shown in the next Chapter.

3.10 Screenshots

Here are some screenshots of the VISSIM files which include the toll plazas, motorway profile and other features.

Fig. 3.10 Motorway

Fig. 3.11 Toll Plaza

Fig. 3.12 Bridge

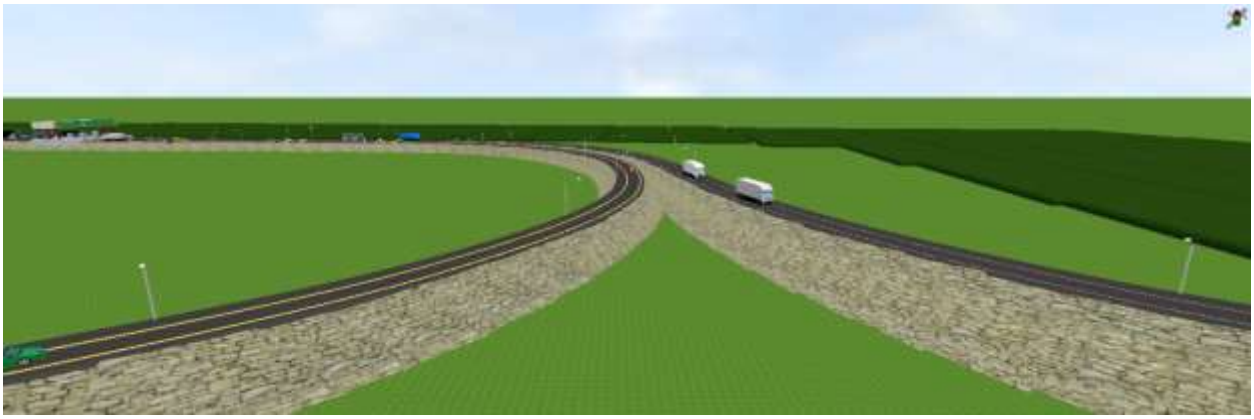

Fig. 3.13 Ramps

Fig. 3.14 Sign Boards

Chapter 4: Results

VISSIM is capable of providing a number of outputs about the traffic at any link or connector. These outcomes include

1) Queue Length
2) Maximum Queue Length
3) Vehicle Delay
4) Delay Time
5) Stop Delay
6) Person Delay
7) Level of Service
8) Fuel Consumption
9) Gases Emission

But since we are only concerned with the traffic operations on the roads, so, we will not consider the fuel consumption and gases emission because these things are more related to the environmental impact of traffic flow. Moreover, the numbers of persons in a single vehicle are not specified, so person delay can't be exactly determined. As a default value, it is considered that there is a single person in every vehicle, so person delay is same as vehicle delay.

The results are mainly dependent on the traffic counts provided at every interchange. Since, each interchange has been simulated for the three different traffics of 2017, 2027 and 2037, so, each interchange has three different results and LOS corresponding to the year for which it was simulated. A comparison of these three years can tell about the drop of LOS in these 20 years of design life of the motorway. Traffic for these years has been given in the above chapter of Methodology. The corresponding results for that traffic are given in this chapter. The results are interchange-wise starting from Sambrial to Muridke Interchange.

4.1 Important Terminologies:

Following are the terminologies used in VISSIM in data output.

TIMEINT	It is the simulation in simulation seconds time during which the output data was obtained
QLEN	The length of vehicle queue in terms of vehicles in the specified node at which data is being obtained
QLEN (MAX)	The maximum queue length generated at the specified node
VEHS (ALL)	The number of vehicles passing through the node in time interval
LOS (ALL)	Level of Service at the node
LOSVAL (ALL)	Level of Service in digital form

VEHDELAY (ALL) Delay of the vehicles in seconds caused at the node due to the congestion

STOPDELAY (ALL) The time during which a vehicle stopped completely in seconds

4.2 Muridke-Narowal Interchange:

The results showed that

- Level of Service for the year 2017 was C. In 2017, there was no queue length. Vehicular Delay observed was 15.39 seconds and Stop Delay was found to be 4.24 seconds.
- Level of Service for the year 2027 was C. Queue length again remained negligible while a vehicular delay of 16.5 seconds was observed. Moreover, Stop Delay was 4.53 seconds.
- Level of Service for the year 2037 was found to be D. The Queue length peaked at this point with 1.23 vehicles and Vehicular Delay was 25.31 seconds. And the Stop Delay was 7.05 seconds.
- The graph of Time against Level of Service, Vehicular Delay, Stop Delay and Queue Length is also added at the end.
- The interchange shows negligible drop in LOS over the design period of the interchange

The results are as follows:

Table 4.1 Results of Muridke-Narowal Interchange

Year	TIMEINT	QLEN	QLEN MAX	VEHS (ALL)	LOS (ALL)	LOSVAL (ALL)	VEHDELAY (ALL)	STOPDELAY (ALL)
2017	500-3000	0	0	105	LOS_C	3	15.39	4.24
2027	500-3000	0.08	17.29	149	LOS_C	3	16.5	4.53
2037	500-3000	1.23	34.82	266	LOS_D	4	25.31	7.05

The graph is as

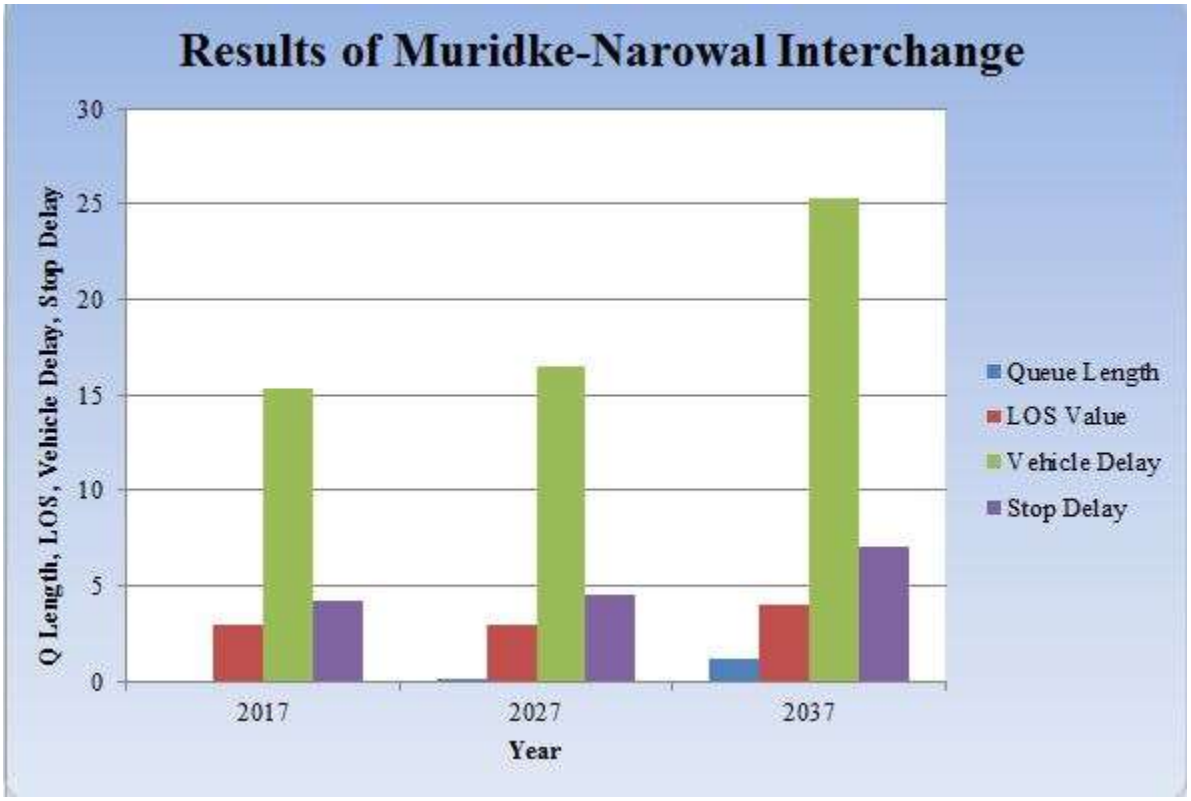

Fig. 4.1 Results of Muridke-Narowal Interchange

4.3 Narowal Interchange:

The results showed that

- Level of Service for the year 2017 was C. In 2017, there was negligible queue length. Vehicular Delay observed was 16.88 seconds and Stop Delay was found to be 5.1 seconds.
- Level of Service for the year 2027 was c. Queue length again remained negligible while a vehicular delay of 19.05 seconds was observed. Moreover, Stop Delay was 5.64 seconds.
- Level of Service for the year 2037 was found to be D. The Queue length peaked at this point with 1.52 vehicles and Vehicular Delay was 25.21 seconds. And the Stop Delay was 6.75 seconds.
- The graph of Time against Level of Service, Vehicular Delay, Stop Delay and Queue Length is also added at the end.
- The interchange shows negligible drop in LOS over the design period of the interchange

The results are as follows:

Table 4.2 Results of Narowal Interchange

Year	TIMEINT	QLEN	QLENMAX	VEHS (ALL)	LOS (ALL)	LOSVAL (ALL)	VEHDELAY (ALL)	STOPDELAY (ALL)
2017	500-3000	0.18	17.81	209	LOS_C	3	16.88	5.1
2027	500-3000	0.96	22.76	281	LOS_C	3	19.05	5.64
2037	500-3000	1.52	24.39	330	LOS_D	4	25.21	6.75

The graph is as

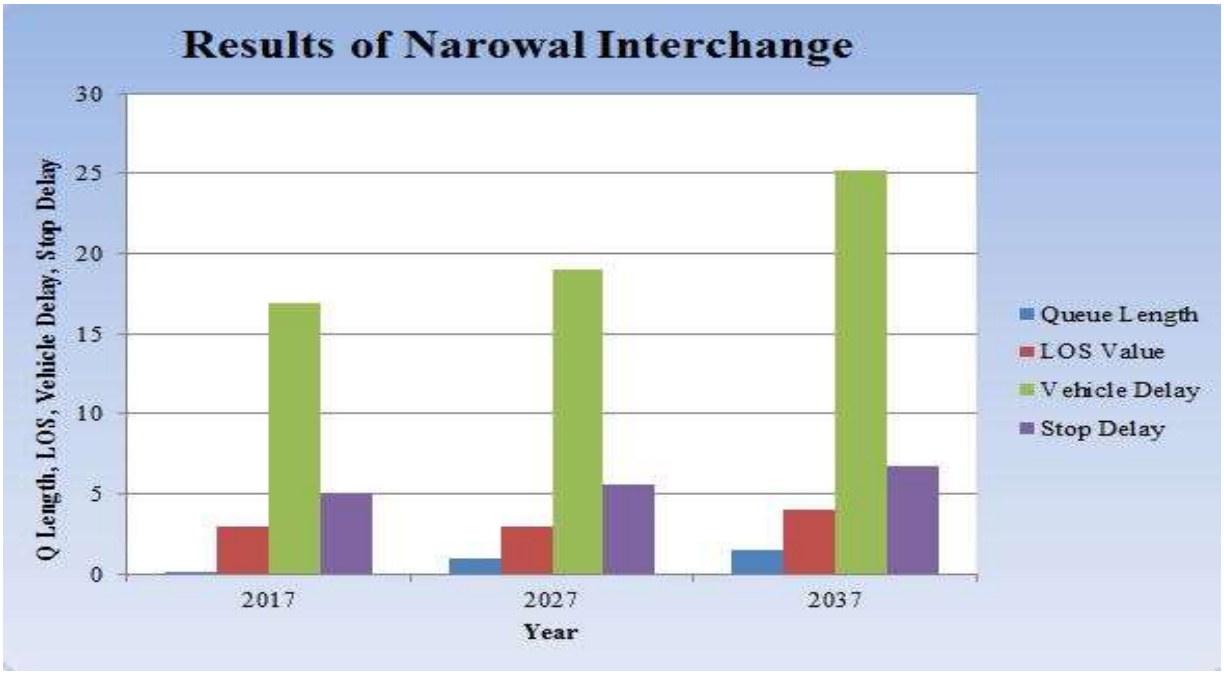

Fig. 4.2 Results of Narowal Interchange

4.4 Gujranwala-Pasrur Interchange:

The results showed that

- Level of Service for the year 2017 was C. In 2017, there was no queue length. Vehicular Delay observed was 18.72 seconds and Stop Delay was found to be 5.1 seconds.
- Level of Service for the year 2027 was D. A small queue length of 1.65 vehicles was found while a vehicular delay of 27.91 seconds was observed. Moreover, Stop Delay was 7.16 seconds.
- Level of Service for the year 2037 was found to be E. The Queue length peaked at this point with 10.48 vehicles and Vehicular Delay was 42.71 seconds. And the Stop Delay was 18.83 seconds.
- The graph of Time against Level of Service, Vehicular Delay, Stop Delay and Queue Length is also added at the end.

The results are as follows:

Table 4.3 Results of Gujranwala-Pasrur Interchange

Year	TIMEINT	QLEN	QLEN MAX	VEHS(ALL)	LOS(ALL)	LOS VAL(ALL)	VEH DELAY(ALL)	STOP DELAY(ALL)
2017	500-3000	0	0	117	LOS_C	3	18.72	5.1
2027	500-3000	1.65	57.45	172	LOS_D	4	27.91	7.16
2037	500-3000	10.48	77.3	126	LOS_E	5	42.71	18.83

The graph is also shown here

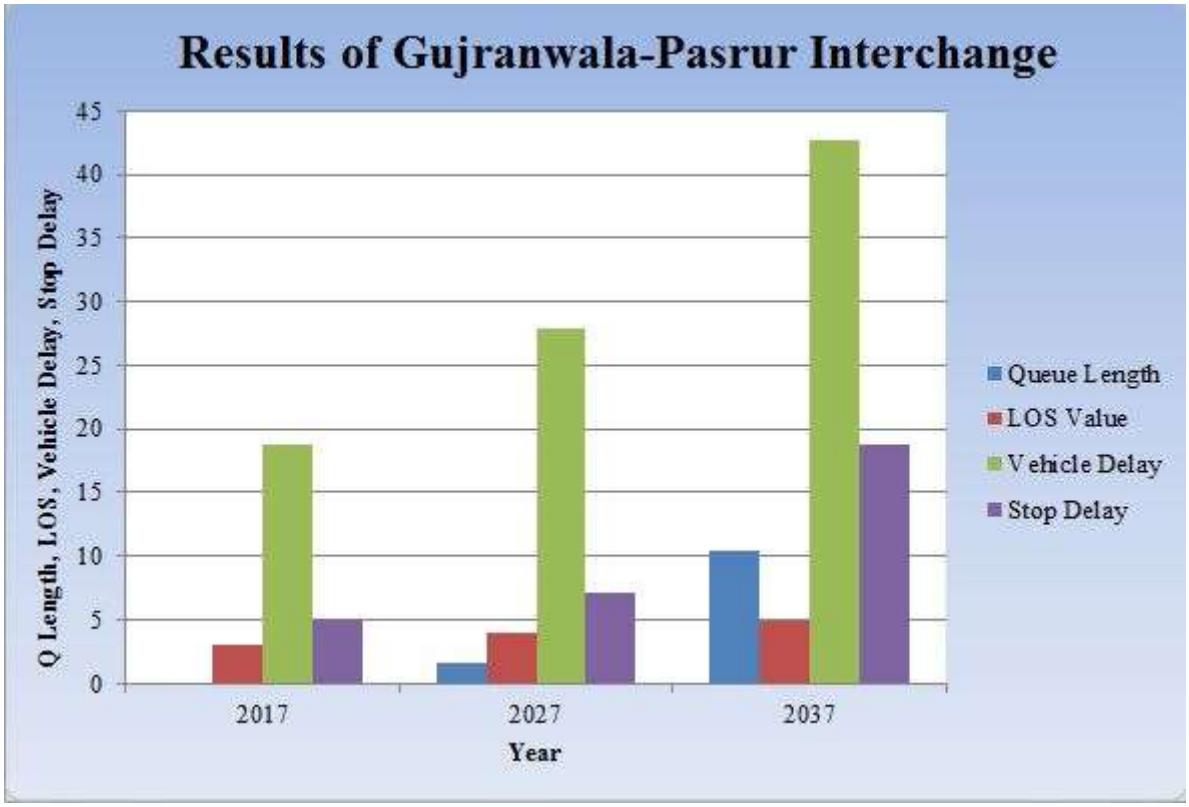

Fig. 4.3 Results of Gujranwala-Pasrur Interchange

4.5 Daska-Pasrur Interchange:

The results showed that

- Level of Service for the year 2017 was C. In 2017, there was no queue length. Vehicular Delay observed was 16.42 seconds and Stop Delay was found to be 8.29 seconds.
- Level of Service for the year 2027 was also C. Queue Length at this stage was also zero while a vehicular delay of 16.88 seconds was observed. Moreover, Stop Delay was 8.83 seconds.
- Level of Service for the year 2037 was found to be C again. The Queue length again remained zero and Vehicular Delay was 15.55 seconds. And the Stop Delay was 4.55 seconds.
- The graph of Time against Level of Service, Vehicular Delay, Stop Delay and Queue Length is also added at the end.

The results are as follows:

Table 4.4 Results of Daska-Pasrur Interchange

Year	TIMEINT	QLEN	QLEN MAX	VEHS (ALL)	LOS (ALL)	LOS VAL (ALL)	VEH DELAY (ALL)	STOP DELAY (ALL)
2017	500-3000	0	0	20	LOS-C	3	16.42	8.29
2027	500-3000	0	0	40	LOS-C	3	16.88	8.83
2037	500-3000	0	0	78	LOS-C	3	15.55	4.55

The graph is shown here

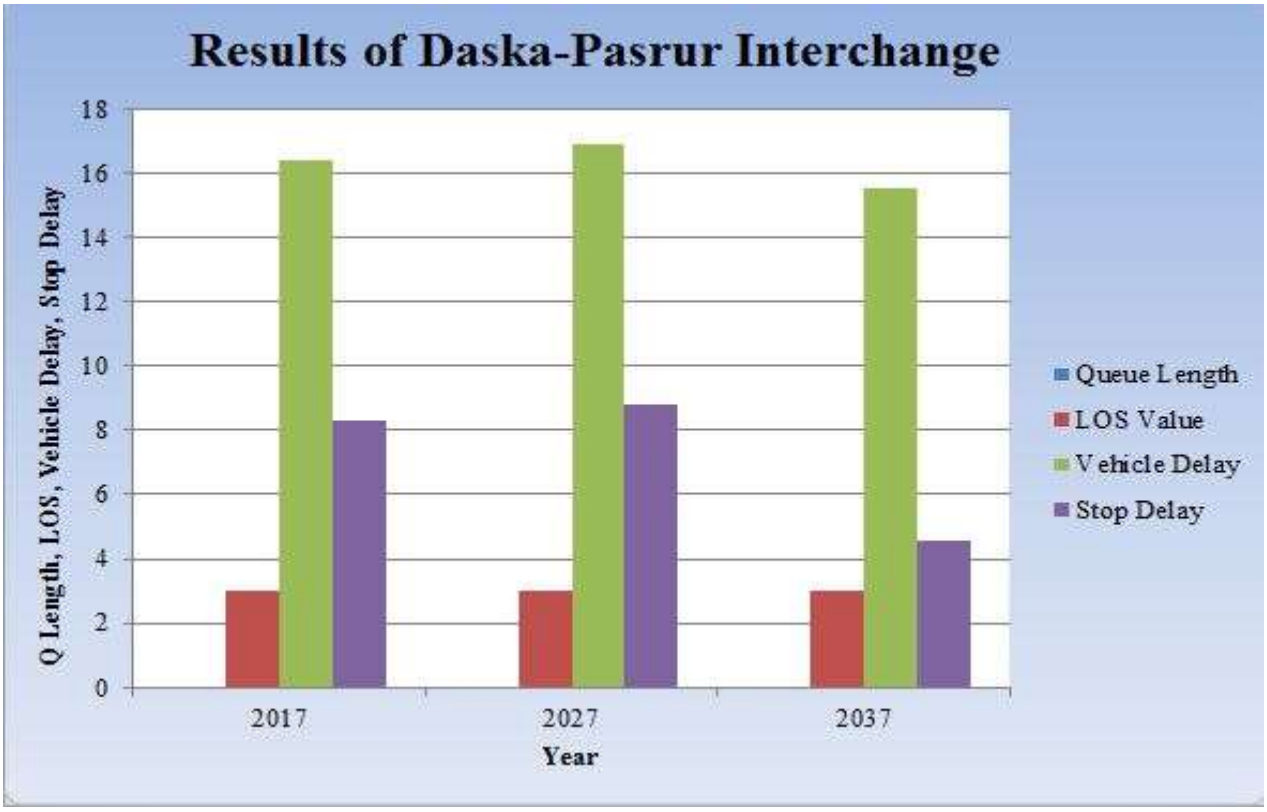

Fig. 4.4 Results of Daska-Pasrur Interchange

4.6 Daska-Sialkot Interchange:

The results showed that

- Level of Service for the year 2017 was C. In 2017, the Queue length was almost negligible. Vehicular Delay observed was 17.33 seconds and Stop Delay was found to be 6.49 seconds.
- Level of Service for the year 2027 was also C. Queue Length at this stage was 0.77 vehicles while a vehicular delay of 23.72 seconds was observed. Moreover, Stop Delay was 10.8 seconds.
- Level of Service for the year 2037 was found to be E. The Queue length increased to 11.75 vehicles and Vehicular Delay was 43.15 seconds. And the Stop Delay was 18.91 seconds.
- The results for the intersection of Local Road and Ramps were also determined. The results were satisfactory as LOS remains quite good.
- The graph of Time against Level of Service, Vehicular Delay, Stop Delay and Queue Length is also added at the end.

The results are as follows:

Table 4.5 Results of Daska-Sialkot Interchange

Year	TIMEINT	QLEN	QLEN MAX	VEHS (ALL)	LOS(ALL)	LOSVAL (ALL)	VEHDELAY (ALL)	STOPDELAY (ALL)
2017	500-3000	0.1	16.18	296	LOS_C	3	17.33	6.49
2027	500-3000	0.77	33.59	172	LOS_C	3	23.72	10.8
2037	500-3000	11.75	88.65	216	LOS_E	5	43.15	18.91

The graph is as

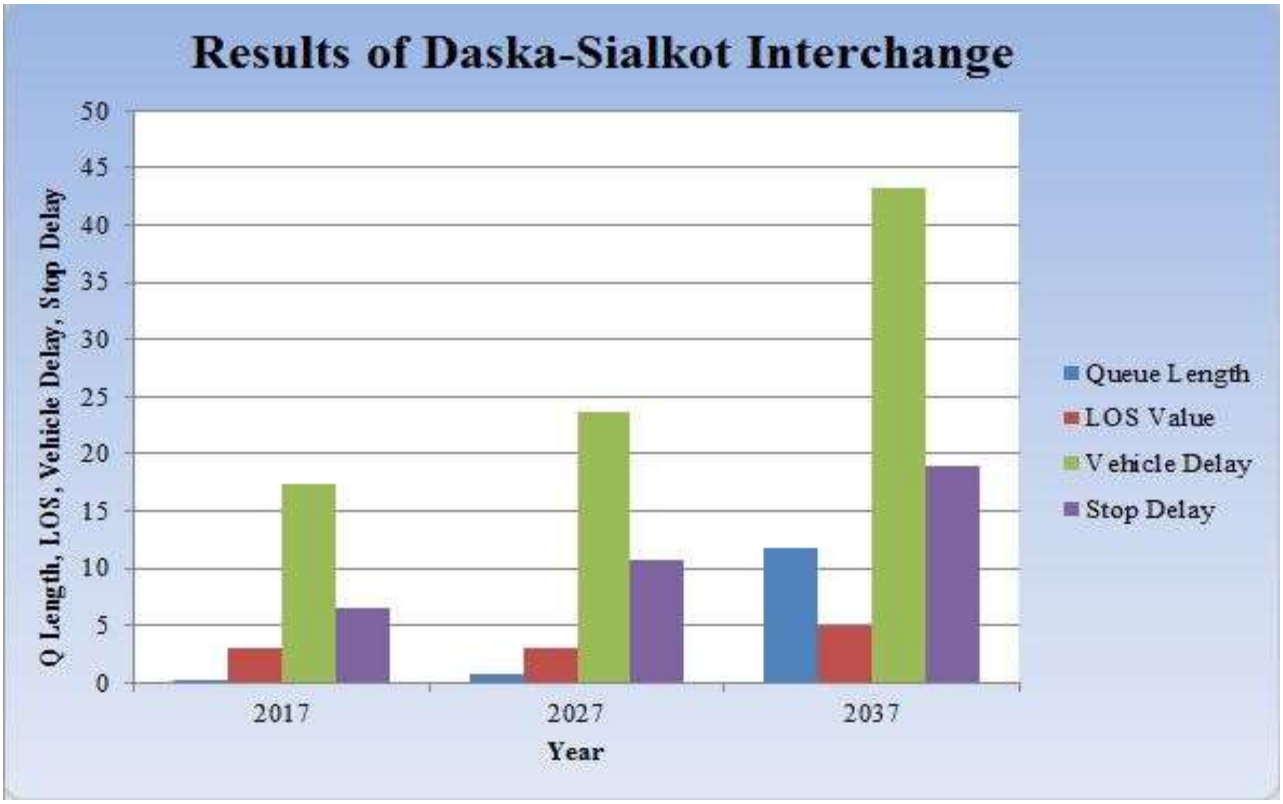

Fig. 4.5 Results of Daska-Sialkot Interchange

Daska-Sialkot is also considered critical because of its heavy traffic and fast traffic speed. So, it was recommended to check the LOS at the intersection of local roads and ramps. The results of this simulation are as

Table 4.6 Results of Daska-Sialkot Intersection

Year	TIMEINT	QLEN	QLENMAX	VEHS(ALL)	LOS(ALL)	LOSVAL(ALL)	VEHDELAY(ALL)	STOPDELAY(ALL)
2017	500-3000	0.325	11.24	111	LOS_A	1	5.32	0
2027	500-3000	2.92	16.92	146	LOS_B	2	15.91	1.09
2037	500-3000	11.74	23.75	257	LOS_C	3	25.64	3.24

The graph is as

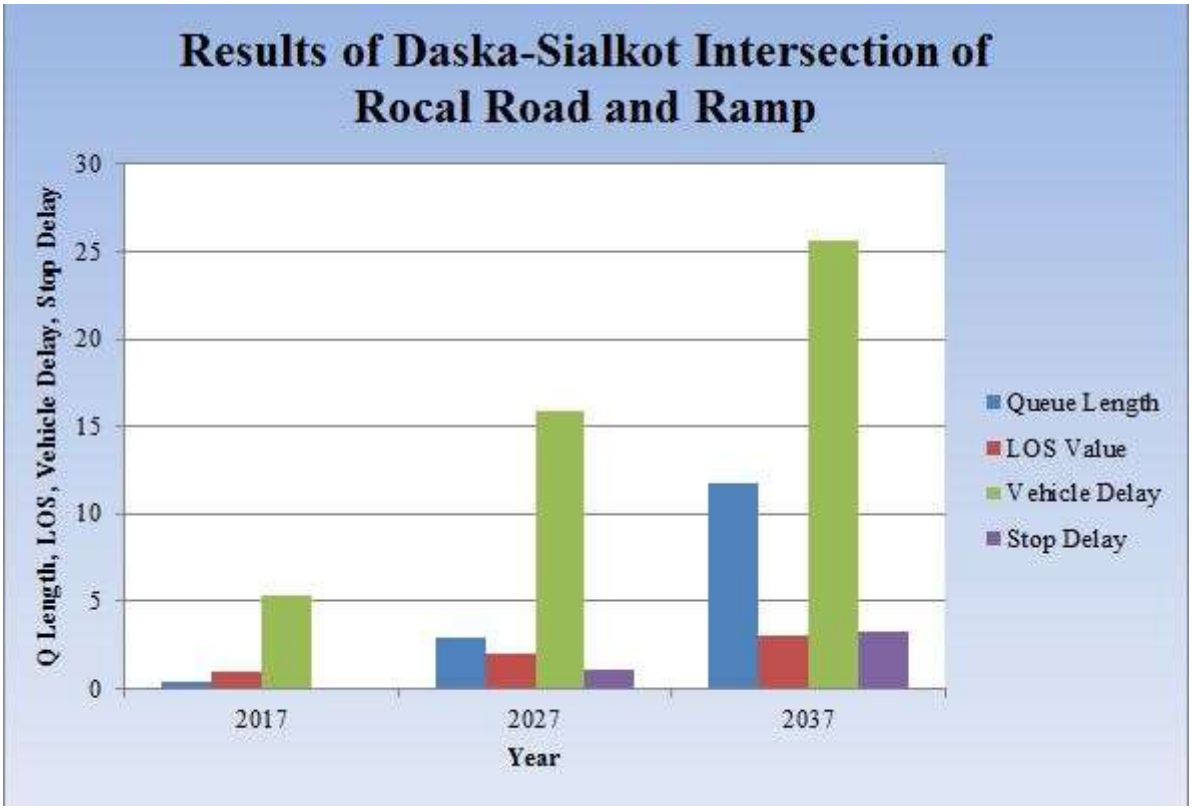

Fig. 4.6 Results of Daska-Sialkot Intersection

4.7 Sambrial Interchange:

Sambrial Interchange is an End of motorway at Sialkot. It has Wazirabad on one side and Sialkot on other side. The interchange is critical because it is located at the end of motorway so maximum of the traffic is passing through this interchange. The difference in the layout of the interchange is that it has 12 toll booths on each side. So, these booths are more than the demand for current traffic. So, we have simulated for 6 booths on each side. The results for all the three years are shown below.

- Level of Service for the year 2017 was C. This is because of the imposed delay at the interchange. In 2017, the Queue length was almost negligible. Vehicular Delay observed was 22.17 seconds and Stop Delay was found to be 9.95 seconds.
- Level of Service for the year 2027 was also C. Queue Length at this stage was also negligible while a vehicular delay of 22.46 seconds was observed. Moreover, Stop Delay was 9.88 seconds.
- Level of Service for the year 2037 was found to be D. The Queue length increased to 7.77 vehicles and Vehicular Delay was 27.96 seconds. And the Stop Delay was 13.06 seconds.
- There is a U-Turn near the intersection of local road and ramp which may affect the serviceability of the road. The results of this U-Turn are also shown below.
- The graph of Time against Level of Service, Vehicular Delay, Stop Delay and Queue Length is also added at the end.

The results are as follows:

Table 4.7 Results of Sambrial Interchange

Year	TIMEINT	QLEN	QLENMAX	VEHS (ALL)	LOS (ALL)	LOSVAL (ALL)	VEHDELAY(ALL)	STOPDELAY(ALL)
2017	500-3000	0.16533	17.1064	58	LOS_C	3	22.1127	9.95779
2027	500-3000	0.2899	23.0356	76	LOS_C	3	22.4649	9.88974
2037	500-3000	7.77947	44.6103	121	LOS_D	4	27.96	13.6011

The graph is as

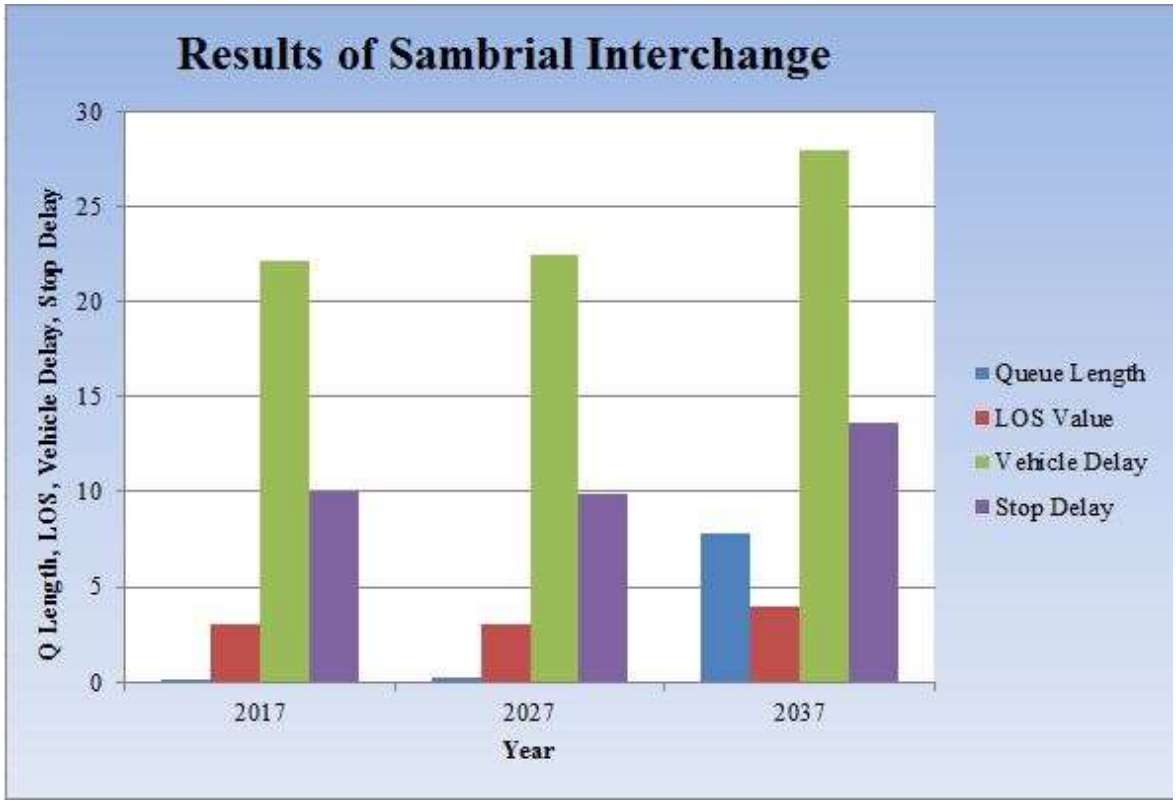

Fig. 4.7 Results of Sambrial Interchange

The results of the U-Turn are as

Table 4.8 Results of U-Turn at Sambrial Interchange

Year	TIMEINT	QLEN	QLENMAX	VEHS(ALL)	LOS(ALL)	LOSVAL(ALL)	VEHDELAY(ALL)	STOPDELAY(ALL)
2017	500-3000	0.05998	14.3835	139	LOS_A	1	0.0531	0
2027	500-3000	4.09877	18.4438	226	LOS_B	2	11.7369	2.9833
2037	500-3000	11.9273	67.3063	421	LOS_C	3	17.4359	4.05829

The graph for these results is as follows

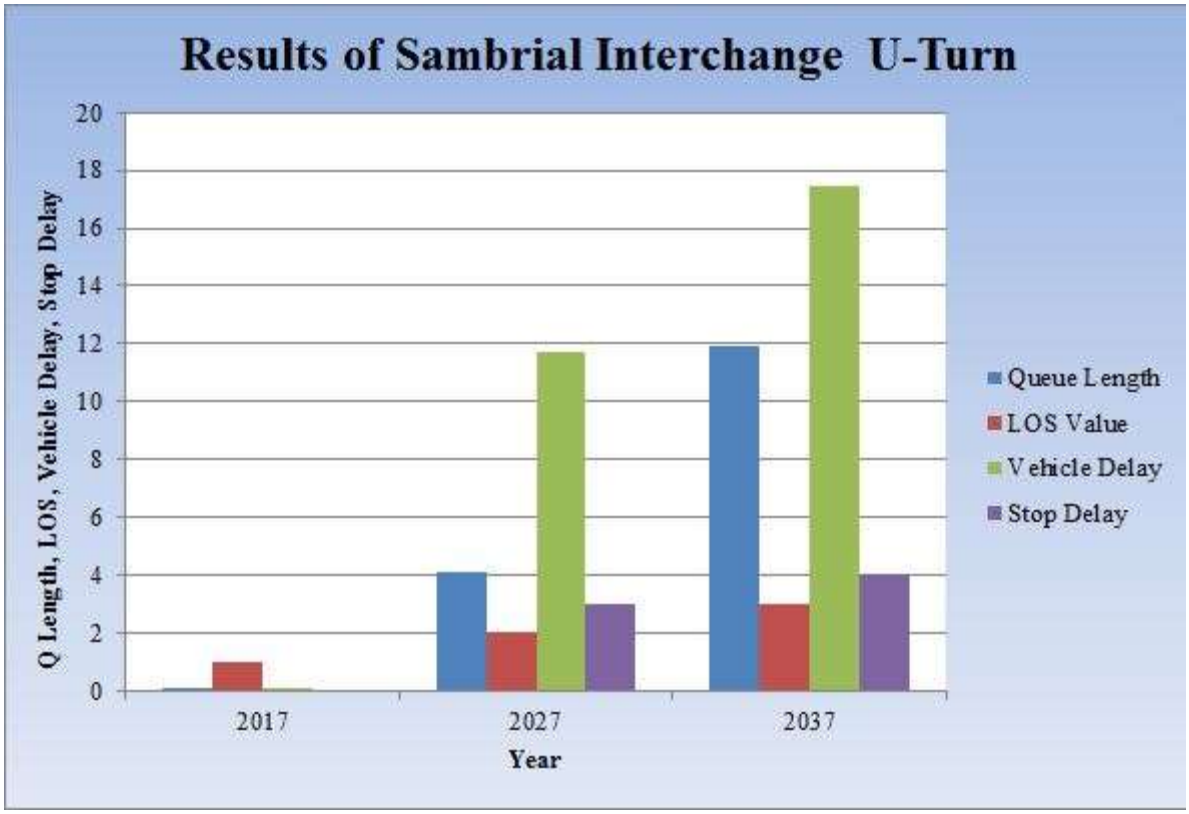

Fig. 4.8 Results of U-Turn at Sambrial Interchange

Chapter 5: Analysis and Conclusions

This chapter of the report will cover the findings of our project work. After the successful running of simulation, Level of Service and all other related factors that can affect the serviceability of the motorway have been determined. Now, these factors can help in analyzing the interchanges and then the suggestion of remedial measures.

5.1 Comparison of Results

A comparison of the results over a period of time can help in determining the pattern of drop in LOS. Here is a brief comparison of the results of all the interchanges.

5.1.1 Muridke-Narowal Interchange

Findings for this interchange are as:

- LOS of this interchange is also consistent for the design life of it. It drops to a minimum value of D with C being the value for the years 2027 and 2037.
- Vehicular Delay reaches at the maximum value of 25 seconds at the end of 2037 while for the first 2 stages it remains quite acceptable.
- Stop Delay is also quite low. A maximum stop delay of 7 seconds at the end of 2037 is appreciable.

5.1.2 Narowal Interchange

The conclusion from the simulation can be summarized as

- LOS remains consistent throughout the life of the interchange with a slight change in the year in 2037 where it drops from C to D.
- Queue Length remains negligible throughout the life of the interchange. It doesn't increase from 1 vehicle at the end of 2037 even.
- Vehicular Delay peaks at 25 seconds which is quite acceptable 20 years after the completion of the project.

5.1.3 Gujranwala-Pasrur Interchange

The results can give the idea that

- The serviceability of the interchange is reducing with the passage of time as LOS becomes C, D and E in the years 2017, 2027 and 2037 respectively.
- Similarly, queue length increases with the time. In 2017, it was negligible and at the end of 2037, it reached up to 10 vehicles.
- Vehicular Delay is showing a gradual increase as well as the Stop Delay.

5.1.4 Daska-Pasrur Interchange

The results can be compared

- The interchange shows most favorable results among all the interchanges.
- LOS remains C for all the three stages for which the interchange was simulated.
- There is no queue length at the interchange owing to the very small traffic counts at the interchange.
- Stop Delay is negligible as well as the vehicle delay.

5.1.5 Daska-Sialkot Interchange

The results are depicting that

- LOS remains C for the years 2017 and 2027.
- There is no drop of LOS in first ten years owing to the small change in traffic counts compared to the increase in last ten years. In the year 2037, LOS becomes E.
- Similarly, queue length remains negligible for the years 2017 and 2027. But in the year 2037, queue length becomes 11 vehicles.
- This shows that the conditions become worse in the last ten years of the design life of the interchange.

5.1.6 Sambrial Interchange

The conclusion of the simulation is given below

- Level of Service at this interchange is E for 2017. Very low serviceability is because of the high traffic counts at the interchange and the delay imposed on the vehicles which are paying the toll.
- LOS further worsens in year 2027 and 2037 when it touches the bottom line of F. At this point, the interchange is completely failing to accommodate the traffic.
- Queue Length is also a measure of serviceability. The queue length remains negligible in the year 2017 but in 2027 and 2037 it suddenly shoots to a value of 34 and 88 vehicles respectively.
- Sambrial interchange is the only interchange which is touching the least value of LOS i.e. F.

5.2 Conclusion

The above discussion shows that most of the interchanges are showing quite favorable results. Sambrial is the interchange showing a LOS F in the year 2037 while no other interchange is showing LOS less than E. It means all the interchanges can easily accommodate the specified traffic without any difficulty. Remedial measures should be taken for the improvement of LOS at Sambrial interchange.

Queue Length is another quality to check the serviceability of the road or motorway. Since, Queue Length id directly related to LOS, so the results are again coinciding with LOS. Sambrial

Interchange is showing maximum Queue length at the end of 2037 with a value of 88 vehicles in the Queue. Whereas Daska-Pasrur interchange shows minimum queue length with a value less than 1 vehicle in the queue.

Stop Delay and Vehicular Delay are the 2 parameters to describe the time loss during the travel. Sambrial interchange again shows the maximum value of both the parameters while Daska-Sialkot shows minimum value of these parameters.

In short, different interchanges are showing different behavior under different conditions. So, remedial measures can't be same for all the interchanges. Depending upon the need and the traffic conditions at the interchange, different measures should be suggested. The suggestions have been made in the next chapter.

Chapter 6: Recommendations

With the passage of time, the traffic count will increase. This increase in traffic will cause a drop in the Level of Service. If the drop in LOS is negligible and can be ignored then no remedies are required. But there are some cases where the remedial measures will be required after 10 or 15 years. This chapter will discuss those recommendations that can improve LOS after a period of time.

6.1 Recommendations for 2017

The results of 2017 show a very smooth flow of traffic on the freeway. LOS was found to be A on freeway. Though LOS dropped to C on the tool booths but this is because of the delay imposed on the vehicles for the purpose of paying the toll. Moreover, the traffic counts are so small at this time that they are not creating any problem at this stage.

So, from here, it can be concluded that **no intervention is required** for all the interchanges in the year 2017.

6.2 Recommendations for 2027

The results of the year 2027 are also satisfactory with a few exceptions. LOS is found to be C at all the interchanges except Gujranwala-Pasrur Interchange, where it dropped to D. Since, LOS is C in normal conditions due to the delay imposed; this LOS can be considered satisfactory. LOS at the freeway was found to be A, so, again this is not a problematic situation.

For the year 2027, no interventions are required except at the Gujranwala-Pasrur Interchange. The recommendation for this interchange is as follows;

6.2.1 Extra Toll Booth at Gujranwala-Pasrur Interchange

- To bring the LOS at Gujranwala-Pasrur Interchange at this stage, an extra toll booth can be added at the specified interchange. Since drop in LOS is observed at only the toll booths, so intervention is required only at the toll booth. To accommodate the traffic, an extra lane should be added on the ramp to take the traffic to the toll booth
- Freeway can easily accommodate the projected traffic. So, it does not require any intervention.

6.3 Recommendations for 2037

The maximum drop in LOS was observed for the year 2037. This is because of the increased demand of traffic and number of vehicles in the year. For all the interchanges, LOS dropped by some extent except Daska-Sialkot Interchange where it remained C for all the three stages of simulation. So, for Daska-Sialkot Interchange, no interventions are required. But for all other interchanges one of the following intervention can be chosen depending upon the extent of the problem, economic conditions and the traffic demand.

6.3.1 Extra Toll Booths

For maximum of the interchanges, the drop in LOS was found to be at the toll booths. Since, vehicles have to stop at the toll booths, so queues are formed at this place. To reduce the queue lengths and delay time, extra toll booths can be given. These booths can help in reducing the delay time and queue lengths and bringing the LOS up to the mark.

6.3.2 Removal of U-Turn on Sambrial Interchange

Sambrial Interchange has a U-Turn at the local road near the junction of the Ramp and the local road. This U-Turn can cause the problems for traffic. Delays are caused by un-signalized intersection at this point. If this U-Turn is removed and traffic is shifted to an existing Roundabout ahead of the U-Turn, the problem can be solved. There will be no queue near the junction of local road and ramp and the traffic flow will be smooth.

We have simulated the interchange without the U-Turn and found the results at the Roundabout ahead of the turn. The results showed a drop in LOS with the passage of time. Since, roundabout is a bit away from the Intersection, so it will be helpful in maintaining LOS at the intersection.

The results for the roundabout are as follows

Table 6.1 Results at Sambrial Interchange without U-Turn

Year	TIMEINT	QLEN	QLENMAX	VEHS(ALL)	LOS(ALL)	LOSVAL(ALL)	VEHDELAY(ALL)	STOPDELAY(ALL)
2017	500-3000	0	0	372	LOS_A	1	0.10844	0
2027	500-3000	5.34	16.733	612	LOS_B	2	10.2211	0.954
2037	500-3000	11.73	34.943	888	LOS_C	3	15.2459	1.223

And the graph will be as

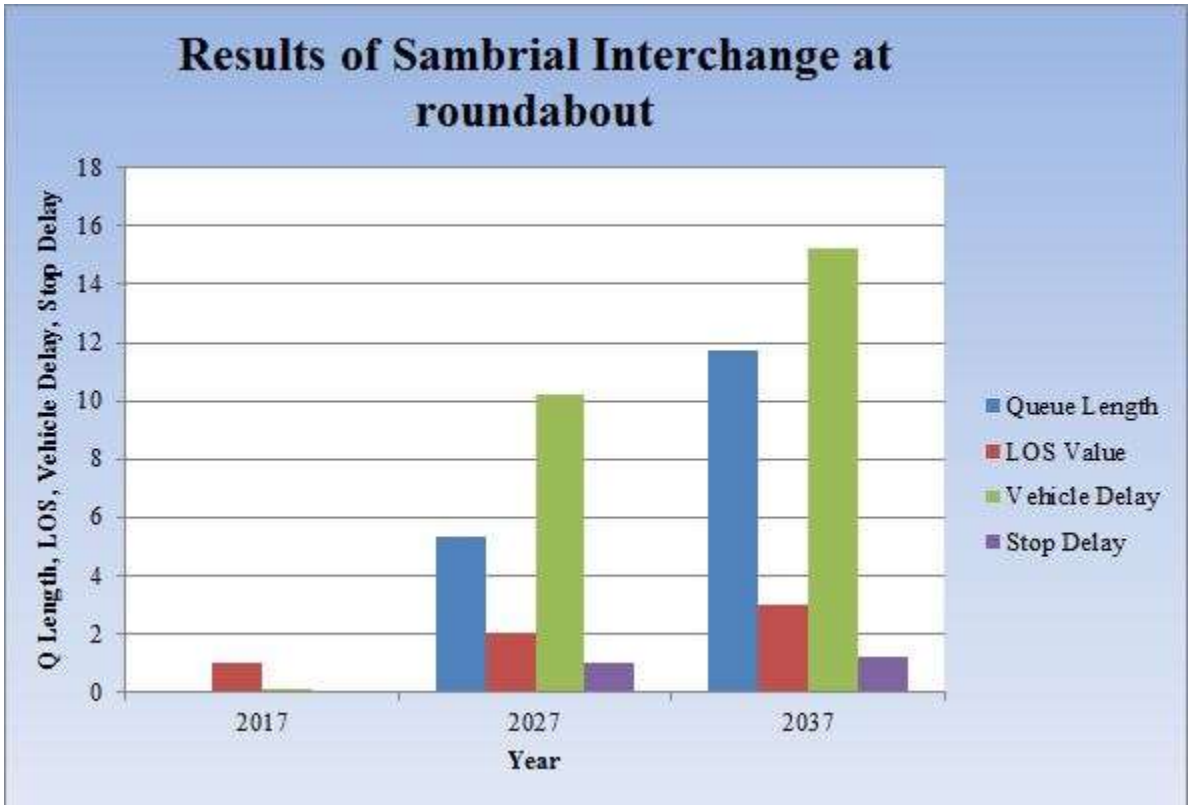

Fig. 6.1 Results at Sambrial Interchange without U-Turn

6.3.3 Extra Lane at the Ramps

Maximum drop in LOS was found on the ramps, so, interventions are also required at the ramps. It is clear that the ramps are unable to accommodate the projected traffic in the year 2037. So, adding an extra lane on the ramps may help in reducing the delay and queues formation.

6.3.4 Roundabout at the intersections

LOS can be restored to its original value by providing roundabouts at the intersection of local road and the ramps. Roundabouts will provide a way for the smooth flow of traffic for all the directions. So, the issue of drop of LOS can be resolved up to an extent.

6.4 Ending Notes

In general, all the interchanges are efficiently accommodating the traffic with minor drop of LOS with the passage of time. The remedial measures, if taken properly, can help in improving the LOS and can also make the interchanges capable of taking more traffic in future.

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