IMPROVEMENT OF TRAFFIC JUNCTION BY ANALYZING CAPACITY, ACCIDENTS AND APPROPRIATE INSTALLATION OF CONTROL DEVICES ON THE JUNCTION

(A Case Study on a Junction at 32-miles, Distt. Kangra, H.P.)

Submitted in partial fulfilment of the requirements

of the degree of

MASTER OF TECHNOLOGY

in

CIVIL ENGINEERING

by

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2017

DECLARATION

I, Karan Pathania (Reg. No. – 11506145), hereby declare that this thesis report entitled **"Improvement of Traffic Junction by analyzing Capacity, Accidents and appropriate installation of control devices on the junction (A Case Study on a Junction at 32-miles, Distt. Kangra, H.P.)"** submitted in partial fulfilment of the requirement for the award of degree of Master of Technology in Transportation Engineering to Lovely Professional University, Phagwara, Punjab (India) is my own work. The matter in this thesis is original and has not been submitted for any other degree.

Date: **Karan Pathania**

Place: Lovely Professional University, Phagwara

CERTIFICATE

This is to certify that the Dissertation entitled **"Improvement of Traffic Junction by analyzing Capacity, Accidents and appropriate installation of control devices on the junction (A Case Study on a Junction at 32-miles, Distt. Kangra, H.P.)"** submitted by **Karan Pathania** (Reg. No: 11506145) in partial fulfilment of the requirement for the award of degree of Master of Technology in Transportation Engineering to Lovely Professional University, Phagwara, Punjab (India) is record of candidate's own work carried out by him under my supervision. The matter embodied in this thesis is original and has not been submitted for award of any other degree.

Signature of Supervisor

Mr. Amit Kumar Yadav

Assistant Professor

ACKNOWLEDGEMENT

The success of this project required guidance of many people. I am fortunate to have the valuable information and proper guidance in the whole process of this project. I would like to thank those who co-operate me delightfully. I would like to express my profound gratitude towards my mentor Mr. Amit Kumar Yadav for his exemplary guidance, support and constant encouragement to carry out this project work successfully. His part in this project work was of keen importance which helped me to complete this project through various stages. I would also like to acknowledge my indebtedness to Almighty and to my parents for their constant encouragement and moral support.

Signature of Student
KARAN PATHANIA

ABSTRACT

Traffic system in India is having heterogeneous kind of nature which consists of various categories of vehicles such as buses, trucks, cars, two-wheelers, three-wheelers, tractors, light commercial vehicles, etc. differentiating from each other in dimensions as well as in their operations. So, it is essential to have a well-planned roadway system accordingly along with good traffic management. In the state of Himachal Pradesh, there are 17 NH roads that involve the total length of 2002 km. Out of this complete length, 795 km are still categorized as single-lane and about 295 km as intermediate-lane which can be considered as one of the most contributing factors for congestion on highways as well as on intersections because the day by day increase of vehicle population in the state couldn't meet its traffic management system and the requirement of desired roadways. The public transportation system, especially buses, could be seen vying in order to have the road space and also to contest with various other lighter as well as heavy vehicles such as cars, trucks, two wheelers, tractors, lighter commercial vehicles etc. Now it is even more essential to control the level of congestion and to maintain the traffic system of various places with the addition of infrastructure. The increment in traffic is one of the main concerns in Himachal Pradesh, especially in its Kangra district for being a bastion of various tourist destinations. It has been required to have the roadway system with higher capacity as well as serviceability provided in order to reduce the congestion problems at intersections. To evaluate the capacity of intersections plays a key role in the good management of traffic system in an area. At un-signalized intersections, the congestion problem arises because of improper management of traffic. In order to have the improvement of any traffic junction, it's required to have the existing parameters of traffic. In the present thesis, the various parameters of traffic at the proposed junction of "32 miles" in Kangra district have been collected. The condition of the traffic gets severe during peak hour flow of traffic, as the volume increases abruptly.

Keywords: Un-signalized, Traffic Volume, PCU, Capacity, Accident, Signal Design

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CHAPTER 1

INTRODUCTION

1.1 General

The development of the transport infrastructure in hilly region is greatly affected by the geography of the region. Himachal Pradesh, a state nestled in North India, has highest roads density amongst all hilly states in India. In this state, there are three airports as well as two narrow gauge railway tracks, but airways or railways couldn't serve transport needs of all people, especially in a hilly region where the climatic conditions are quite extreme. Thus, road network has always been remained the main transportation mode in Himachal Pradesh.

In Himachal Pradesh, the congestion on the roads is increasing day by day followed by the worst traffic control and its management which is creating problem especially in the district like Kangra which is the highest populated district of Himachal Pradesh bearing population more than 1.5 million as well as more than one lakh of registered vehicles excluding those which are coming from other states to visit various tourist places for being its one of the most picturesque valley of lower Himalaya region. All of these contributing factors cause rapid growth of traffic and further leads to increase in congestion on the roads, especially on national highways, as well as on the intersections day by day. Mostly people prefer private owned vehicles rather than public transport to visit tourist places to avoid stopping delays which also cause the roads and intersections to be full of congestion. So, it is required that the road capacity should be sufficient enough to promote safe and efficient journey of vehicles as well as of pedestrians on the roads.

1.2 Study Area

The area which has been selected for this case study is a Y-intersection, named as "32-miles" junction in Kangra district of Himachal Pradesh, India. This junction has been situated at the place where Mandi-Pathankot road (NH-154) intersects SH-23 [Fig 1.1]. This particular place consists of a three legged intersection, has been named as "32-miles" because of its total distance from Pathankot i.e. 32 miles (50 km). This junction having three legs connecting Pathankot, Mandi and Kangra [Fig 1.2], has been selected to determine volume of traffic to analyze traffic capacity. Apart from this, the case study also provides an in-depth analysis of the various accidents that have been occurred in the proposed junction and provides information of the various factors which have been contributed in the accidents such as non-

availability of appropriate control devices, carelessness of driver etc. The traffic flow at this junction varies in peak hours and non-peak hours. The traffic volume entering this junction mainly includes buses, trucks, cars, taxis and two-wheelers.

Fig. 1.1 Study Area of Junction, *Source: Primary Survey*

Fig. 1.2 Location on Google map, *Source: Google*

1.3 Terminology

1.3.1 Geometric Features

The intersections of two or more than two roads usually make the system of an 'at-grade' or 'grade-separated' interchange system. Since, intersection is a point where two or multiple paths are crossed by one another, so, that's why the opportunities of conflicts increase for those who cross it. The collisions at various intersections are quite common and many times, it results in serious injuries or even fatalities. The selected junction is situated at a place surrounding by mountainous region [Fig 1.3]. The roadway has un-even surface with various changes in alignments as well as in climatic conditions. Although, the population residing around junction is not so large but the arrival of users from various other places often makes this place crowded by pedestrians as well as vehicles. The geometry of the study area affects the study of traffic capacity in that particular area to a large extent. The widths of the roads, the approach leg width, condition of road surfaces are some of the directly influencing factors to the capacity of the area. The geometric features of a particular un-signalized intersection will also determine that with which speed the driver has to cross that intersection. The driver must have to check the conflict area and conflicting vehicles before crossing the intersection with desired speed. If the width of the road is less, like in hilly areas, the driver needs to limit the speed in order to avoid undesirable happening particularly if it's a rural area. Also in hilly areas, the geometric features play an important role at un-signalized intersections, because of change in alignments & un-even road surface and extreme climatic conditions affecting the road surfaces with increasing vehicular population day by day.

Fig. 1.3 Geometric Features, *Source: Primary Survey*

1.3.2 Traffic Capacity

The objective of the traffic capacity analysis is to evaluate the capacity that is available as well as the capacity that has used. Traffic capacity can be defined as the maximum number of vehicles, passengers which can be present on the roads under some given conditions. Capacity doesn't depend on the demand. It's only about the amount of vehicles as well as passengers that a particular road can bear or afford.

1.3.3 Level of Service

Level of Service is the qualitative measure that describes operational conditions in the traffic stream. The concept of Level of Service has been given by HCM in order to know about the facility that any road user can derive at various operating conditions as well as volume of traffic. When the road is having traffic volume equal to the capacity of that road at ideal conditions of traffic, then the conditions for operating traffic becomes poor, speed of the vehicles starts dropped down and the delays of vehicles starts rising up.

1.4 Road Accidents in India

Road Accidents is considered to be a major problem in India as well as in various other parts of the world. But in developing countries, it has been found that the fatality rates, i.e. accidental deaths as per 10,000 vehicles, are very high in comparison to some developed countries. In India, the road accidents are increasing at a very high rate. As per Ministry of Road Transport & Highways (MORTH), the number of road accidents in India has been increased by 2.5 percent.

According to MORTH reports, in the year 2014, the number of accidents occurred in India were 4,89,400, while it has been increased up to 5,01,423 in 2015. The reports also said that the number of persons killed in these accidents has also been increased from 1,39,671 in the year 2014 to 1,46,133 in 2015. As per reports, the fatality rate has been increased by 4.6%. The injuries that have been resulted because of these accidents have also been increased by 1.4 % from 4,93,474 in the year 2014 to 5,00,279 in the year 2015. The extremity rate of these accidents has measured according to total number of fatalities per 100 accidents has also been increased from 28.5 in 2014 to 29.1 in 2015.

According to MORTH, during the year 2015, the 53.8 per cent of total accidents have been occurred in rural areas. The percentage of accidental deaths as well as injuries due to accidents were also having more in rural areas of India which comprises of 61 per cent and

59.1 per cent respectively, as compared to the urban areas. The severity of highest accidental rate (roadways accidental deaths as per 100 accidental incidents) was reported in the state Mizoram (i.e. 102.9 %) which was then followed by Punjab (73.0 %) and, then Dadra and Nagar Haveli (60.9 %).

Fig. 1.4 Accident at proposed junction, *Source: Primary Survey*

In 2015, Kerala state has ranked the highest i.e. 29,096 in total number of people who were badly injured in India which was followed by the state of Karnataka i.e. 26,501 and the state of Maharashtra i.e. 23,363 at second and third positions respectively. People who were having minor injury in these roadway accidents were highest in the state of Tamil Nadu i.e. 70,321, which was followed respectively by the state of Madhya Pradesh i.e. 49,570, and the state Karnataka i.e. 30,470. Those who were having serious injuries and minor injuries in India in the year 2015 were 181471 and 318808 in numbers respectively.

1.5 Objectives

The study has been conducted in order to know about the various priorities for the improvement of the proposed junction. The various objectives for which the study has been conducted are as follows:-

1) To know about various conflicts in the major and minor traffic streams at the intersection of study area.

2) To analyze the capacity of un-signalized intersection.
3) To analyze fluctuations in flow as well as peak hour and non-peak hour flow.
4) To make sure of having a well - planned as well as co-ordinated management of traffic system at the proposed junction.
5) To do analysis of various accidents that has been occurred in the study area.
6) To analyze the various contributing factors of the accidents in the study area.
7) To analyze the need of installation of various appropriate control devices at the proposed study area.
8) To suggest suitable remedial measures for safe and efficient movement of vehicles.

1.6 Methodology

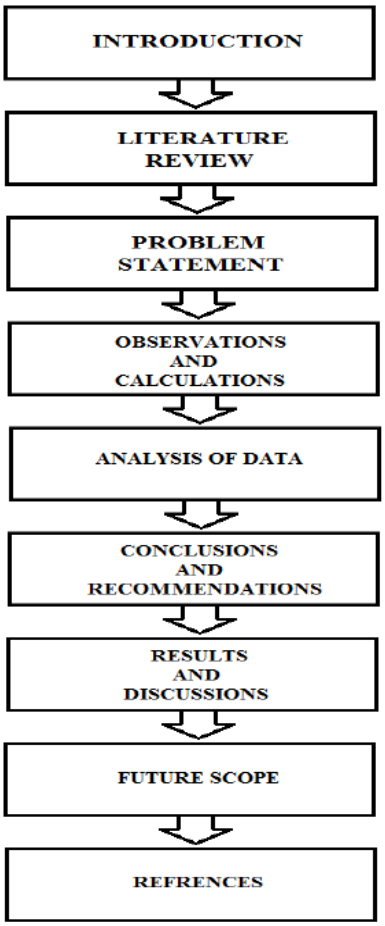


Fig. 1.5 Flow Chart of Methodology

CHAPTER 2

LITERATURE REVIEW

In order to understand the purpose and scope of this study, various previous studies, dealt with the same purpose and also relevant for this study, were reviewed. Those are mentioned as below:-

2.1 Estimation of traffic capacity at un-signalized junction at mixed conditions of traffic flow (2011)

Ramesh Surisetty and S. Siva Gowri Prasad [1]

American Journal of Engineering Research (AJER)

e - ISSN: 2320- 0847 p -ISSN: 2320-0936

Volume - 3, Issue - 11, pp – 213 - 221

www.ajer.org

The methodology has established for analysis of an un-signalized intersection where traffic condition depends on present traffic. Many attempts have made in order to develop the various approaches to analyze the un-signalized junctions under mixed traffic condition. Conflict technique is a recently used practical technique based on simplified concepts, considering interactions and also the impact between the traffic flow at intersections and using various mathematical models by calibrating the accuracy. This technique has been used in the present study to analyze capacity of un-signalized junction. The study area that has been selected to conduct surveys was Visakhapatnam, in order to measure various traffic parameters like traffic volume, traffic flow and traffic capacity using conflict method. By using this technique, approach wised capacities were obtained. Also, by using Highway Capacity Manual (2000), movement capacities has been evaluated and then, compared with those obtained from conflict technique.

The conclusions and recommendations that were obtained as a result of this study are as follows:-

a) The traffic data such as Capacity of vehicles, traffic flow and traffic volume can be taken as a result of field studies.

b) The capacity of a junction and the maximum traffic flow on stream can be evaluated based on measurement of flow.

c) The conflict technique approach that has been used in the study has found to be suitable for the calculation of capacity of un-signalized junctions under mix flow conditions, instead of using Highway Capacity Manual (2000), especially in India; it can act as a best alternative.

2.2 Traffic Capacity Analysis of Un-signalized Junctions under Mixed Traffic Conditions (2011)

Joewono Prasetijoa, Mehdi Hossein Poura and Seyed Mohammad Reza Ghadiria [2]

School of Civil Engineering, Universiti Sains Malaysia, Nibong Tebal, 14300, Malaysia

6th International Symposium for Highway Capacity and Quality of Service in Stockholm, Sweden June 28–July 1, 2011

Elsevier Ltd.

In a country like Indonesia, the composition of traffic on roads, behaviour of drivers and various road-side activities differ at a great extent than in various industrialized countries. Various cities of developing countries have heterogeneous flow that includes motorized vehicles as well un-motorized vehicles. The traffic rules and regulations such as "give-way" or disciplined movement on lanes is mostly ignored. This study is conducted at ten 3–legged un-signalized junctions in sub-urban city of Indonesia. The method adopted was based on interaction between the six conflicted streams and six conflicted points which are having average flow as well as speed. The empirical regression model was used to evaluate the interactions and all conflicted streams have considered together. The obtained results for capacity analysis were compared with the corresponding results of current Indonesian Highway Capacity Manual (IHCM).

After the capacity analysis has been done, various conclusions as well as recommendations were given at the end. The conclusions and recommendations that were obtained as a result of this study are as follows:-

a) The data that has been obtained from 3–legged junctions has been found to be valuable in order to analyze capacity of the un-signalized junctions in the developing countries like Indonesia.

b) In order to develop model, the measurements that have been done for speed and flow at 5 minutes intervals for one hour for each junction has been found to be appropriate for analysis.

c) A model has been developed with the help of relationship between the traffic speed and traffic flow of each junction. The results, thus obtained, have proved that capacity of junctions can be obtained based on relationship between traffic flow streams and their speed at various conflicted streams and points.

d) The obtained results were also compared with IHCM and the results showed approximately same values for capacity in speed range of 11 - 12 km/hour. Thus, this method can also be used for the analysis of capacity of un-signalized traffic junctions of Indonesia.

2.3 Measurement of urban traffic congestion (2012)

Amudapuram Mohan Rao, Kalaga Ramachandra Rao [3]

International Journal for Traffic and Transport Engineering, 2012, 2(4) : 286 –305

DOI: http://dx.doi.org/10.7708/ijtte.2012.2(4).01

The most of the metropolitan cities are having the problem of traffic congestion. To identify the traffic congestion is the first ever method to select some appropriate measures. Congestion affects the movement of pedestrians whether it is in reality or in perception. Congestion not only wastes energy and time but also results in environmental pollution. The factors, which effect the congestion, are broadly classified in two types. They are; (i) micro level factors (ii) macro level factors. The paper will give overview and will present some possible ways in order to identify metrics and measure them for congestion in urban areas. The systematic study has been carried out, based on various metrics like traffic volume, speed, level of service and travel time/delay. This review covers various different aspects such as definitions and criteria of measurement that is followed by various countries and organizations. Also, the strengths as well as weaknesses of all the measures have also been discussed.

After the measurements regarding congestion have done, various conclusions were made. The conclusions and recommendations that were obtained as a result of this study are as follows:-

a) The congestion in traffic can be easily expressed by travel time index in terms of both time and space.

b) The concept of travel time index can be easily understood by common people of locality.

c) Level of Service act as the representative for the analysis of traffic flow.

d) Congestion duration can be determined with the help of measurement of the reduction in travelling speed over a given time period.

2.4 Modelling on congestion of traffic in urban area roads by the use of Fuzzy Infrence System (2012)

Surendra R. Kukadapwar and Dr. D. K. Parbat [4]

American Journal of Engineering Research (AJER)

e - ISSN : 2320 - 0847 p - ISSN: 2320 – 0936

Volume - 4, Issue - 12, pp – 143 – 148

www.ajer.org

The problem of heavy congestion is one of the complex topics that is being faced by many metropolitan cities. Since, congestion is not the type of phenomenon that we can call well-defined, thus, its degree doesn't measured always. The real and actual or true conditions of traffic cannot be represented with the help of traditional kind of approaches and that's why the measurements regarding congestion gets deviated due to error in the measurements or the data variations and also for not being certain of the data. To counteract above mentioned problems, Fuzzy Infrence Approach has taken in account. In this approach, three parameters – rate of reduction of speed, the time when travelling with low velocity (< 5 km/h) is compared to the total travelling time and then the ratio of volume with capacity is combined in order to achieve the output in terms of congestion index. This model is signified by the consideration of actual time data regarding traffic flow on major roadway of Nagpur in India.

The conclusions and recommendations that were obtained as a result of this study are as follows:-

a) The proposed approach considers each small change in all the parameters and then their effect shows actual and true images of the conditions of traffic.

b) This model can be used with high accuracy and less margin of errors.

c) This model is very simple to apply and it follows absolute common logics.

d) This can be absolutely applied in order to represent conditions of traffic on the segments of roads, on a network of highways as well as on corridors.

e) The research includes future scope to include various other factors which cause congestion in road traffic like parking, road encroachments, condition of traffic etc.

2.5 Traffic Flow Characteristics for Heterogeneous Traffic On Urban Roads - A Case Study of Selected Stretch of Anand City (2014)

Dipak K. Thakor, Dr. L B Zala and Prof. A A Amin [5]

Journal of International Academic Research for Multi-disciplinary

ISSN : 2320 - 5083, Volume-2

www.jiarm.com

The roadway system must have proper and well – arranged data regarding all the parameters of traffic on the roads. In the present study, various parameters of traffic were assessed on the proposed urban roadway network. It was from Samarkha-chokdi to Anand new bus stand. The studies conducted were traffic-volume, spot speed and inventory studies and then the analysis is done. Capacity of the proposed road network as well as LOS was also calculated.

After this case study on traffic flow study has been done for the heterogeneous traffic conditions for the road of proposed urban area, various conclusions were made. The conclusions and recommendations that were obtained as a result of this study are as follows:-

a) It has been found that the traffic on proposed roadway network is very much heavy and also LOS doesn't fulfil the desirable requirements.

b) The vehicular speed is being affected as well as obstructed because of existing conditions of road surface. So, it needs improvement.

c) The roadway width is not as per requirements. So, widening of the proposed stretch needs to be done.

d) The overall stream of traffic system has mean speed of 25 km/h which is not sufficient. It shows reduction of LOS.

e) The 15^{th} percentiles speed has been found to be 19 km/h. It means the vehicles, whose speed is less than this, affects traffic.

2.6 Evaluation of capacity of a rotary in Kabul city, Afghanistan (2016)

Abdul Moqtadr Yousufzaii, Waseem Bhatt and Anup Bhaardwaj [6]

International Journal of Innovative Research and Advanced Studies (IJIRAS)

Volume – 3, Issue – September 10, 2016

ISSN : 2394 – 4404

www.ijiras.com

The traffic growth is one of the main concerns in almost every urban city in Afghanistan. Also, the increase in population in Kabul along-with the development of business as well as construction activities since past two decades has become the main issue for Traffic Dept. The department is interested and trying for the designing of road and also of Rotary Intersections in such a way to attain higher capacity as well as performance level so that to have the less congestion problem at intersections.

The evaluation of the capacity of the un-channelized intersections is important to manage the traffic. The capacity of road decreases in rotary intersections as compared to the straight roads, because the speed element decreases at rotary intersections, thus, having the formation of queue that not only pollute the atmosphere but also waste the time of travellers. At peak hours, in morning as well as in evening, the conditions become severe because of increasing of the volume and then reaching up to the double or sometimes even triple of the normal volume of the traffic.

Intersections are made for avoiding the queue, undesirable stoppage, accidents and also reducing the danger of crossing of vehicle from one lane to another and allow safe as well as smooth movement of vehicles. The various elements which affect capacity of a rotary have also been considered such as vehicle flow, climatic features and turning effect with the help of Poisson distribution. In this study, the focus is mainly on evaluating the capacity of rotary, by avoiding congestion, smooth movement of pedestrians and then to find the solutions for arising problems.

In this study, the capacity of rotary has been found to allow safe movement of vehicles and pedestrians. After this study of traffic capacity analysis of rotary is done, various conclusions were made. The conclusions and recommendations that were obtained as a result of this study are discussed as follows:-

a) The Rotary capacity have analysed and it has been found that North & West Legs have the Level of Capacity of D category having delay that could be resolved by having the signalization of rotary.

b) When this study has been done, the rotary was under the control of traffic police and many times, all traffic rules are not being followed by the users so by having the signalizations, the capacity and Level of Service of rotary and legs can be improved.

c) At the time of study, the peak hourly volume of traffic has been found to be as 10,555 passenger car units (PCU) so if the rotary could have been channelized, then it can further improve the capacity of the legs of the rotary.

d) The Level of Service of south and east legs was found to be as E & F respectively, that further affect capacity and LOS of the whole rotary. So, it has been mentioned in the conclusions to channelize this proposed rotary and also should have signalling design as per the entry volume of traffic to rotary from all the legs.

e) An extra lane around circle of the rotary inner circle has also been suggested in order to increase the capacity as per the assumption that it could increase the capacity by 10 per cent and reduce the delay time by 25 per cent.

2.7 Estimation of capacity at a four-lane divided Inter-urban Hilly Roadway with the help of video-graphy technique (2013)

Shrey Pahuja [7]

Transportation Planning Department,

School of Planning & Architecture, New Delhi

The highways in India have heterogeneous traffic because of various types of vehicles that varies in type and size with different characteristics. There are very less attempts in our country to examine the capacity of multi-lane roads especially when the condition of traffic is heterogeneous. If the capacity is to estimate on hilly areas, then a lot of factors are required to study. The geometric features of the road such as horizontal and vertical alignments, gradients are essential to study because they all affect the values of capacity.

Also, the estimation of capacity because of extreme weather is important because mostly researches are done at normal weather. The present study was done in order to analyze the

capacity of a four lane hilly roadway on the Himalayan Expressway, National Highway 5, which was priorly named National Highway-22. The data collection was done with the help of video-graphy and the data analysis was done to find out the different parameters regarding flow of traffic. The various models were used to find capacity. Also the reduction in capacity because of adversely conditions was estimated.

After the study has been done for the heterogeneous traffic conditions, various conclusions were made. The conclusions and recommendations that were obtained as a result of this study are as follows:-

a) The loss in capacity of 10 percent was observed from down grade towards up grade.

b) The loss in capacity of 15 per cent was also observed from straight road portion towards curved road portion.

c) The loss in capacity of 20 per cent was observed from normal conditioned weather to the adverse weather.

d) The estimation of the capacity was done for the straight road section which was coming out as 2,126 PCU/ hour/ direction.

e) The estimation of the capacity was done for the curve road section which was coming out as 1,809 PCU/ hour/ direction.

f) The value of capacity for combined straight and curve roadway section was 1,960 PCU/ hour/ direction.

2.8 Estimation of the capacity on un-signalized traffic junction at mixed flow conditions of traffic (2016)

Danish Zaffar Wani, Dr. M.S Mir [8]

International Journal of Advanced Research in Education & Technology (IJARET)

Volume - 3, Issue – 2, April – June, 2016

www.ijaret.com

In this study, the conflict technique has been used to calculate the capacity of an un-signalized T intersection. The various parameters regarding traffic were measured such as traffic flow, traffic volume. The capacity was estimated using Highway Capacity Manual

(HCM-2000). The conclusions and recommendations that were obtained as a result of this study are as follows: -

a) It has been concluded that the proposed area of study has shown mixed conditions of traffic.

b) After traffic count, it has been found that the peak hour's traffic in the morning is 984 and that has been found towards left side of junction area.

c) The approach that has been used is found to be suitable for calculation of capacity.

2.9 Procedure of Capacity Analysis for unsignalized intersection in Switzerland (1997)

Jian-an Tan and Franco Tufo [9]

CITEC Ingenieurs Conseils SA

Geneva, Switzerland

This paper presents the procedure to find out capacity of unsignalized junction including round-about and stop controlled intersection. In order to analyze the capacity of round-about and also to find out delays and queue formation on round-about, software has also been presented called Roundabout Operation Analysis Programming (ROAP).

Also, some important aspects for the improvement of intersection have been suggested in the paper.

The various conclusions were made after the study and recommendations and aspects that were discussed as a result of this study are as follows: -

a) It has been suggested that for the improvement of junction, it is essential that it should have less conflicting points and sufficient space for queue formation.

b) Traffic islands and pavement markings have been suggested to reduce conflict areas.

c) It has been said in the paper that the cross movements need to be minimized in order to reduce accidents. Also the roundabouts should be properly designed keeping in view the aspect of safety.

d) It has been suggested that the turning radii of the vehicles (especially heavy vehicles) should be considered in the design.

2.10 Signal Design for T-intersection using Webster's method in Nandyal town, District Kurnool of Andhra Pradesh (2016)

B. Sudarshan Reddy, N. Venkata Hussain Reddy [10]

International Research Journal of Engineering and Technology (IRJET)

Volume- 3, Issue- 4 April, 2016

www.irjet.net

In this study, the signal design of a T-intersection was done by using Webster's method. In this method, the total cycle length of signal has been determined which forms total least delay occurs at the signal. The PCU values of traffic volume were also determined by traffic survey of the study area. The cycle length for different times for a day is determined in the study. The various conclusions and recommendations that were made as a result of this study are as follows: -

- **a)** The signal cycle length for morning time is determined as 83 seconds, for afternoon, it has been determined as 145 seconds, while for evening session, it is 65 seconds.
- **b)** It has been concluded that by providing signals, it will be possible to reduce conflicts.
- **c)** The provision of signals has been concluded as very helpful for orderly movement of traffic and the necessity of traffic police for regulation of traffic will be eliminated.

CHAPTER 3

DATA COLLECTION

3.1 General

The traffic volume study plays an important role to help the engineers for designing un-signalized intersections, improvement of the traffic junctions, signal designing procedures and also for the designing of vehicular storage lane system. In this study, the aim is to do the improvement of Y-junction by analyzing its traffic volume count leads to capacity analysis Along with this, the study also aims at the analysis of various accidents that taken place at the spot so far since last certain period of time as well as the provision of various suitable measures to improve the junction keeping in view the type of area, its geometric features and the type of vehicular traffic in the area.

The data to be collected for the study is very essential to do the analysis of traffic as well as to understand the current condition and behaviour of traffic. The collection of the data regarding traffic volume count for this study has been done by manual method. It requires the record of traffic vehicular count on the recording sheets. The count was done to know about the various vehicles entering the proposed junction from all the three legs. The vehicular traffic included cars, buses, trucks; two-wheeler motorized vehicles, light commercial vehicles as well as tractors. The numbers of cars were found to be highest in number entering into the junction. The heavy multi-axle trucks' vehicular traffic has been found to be very less. The cyclists are almost negligible in the area because of hilly area. It has been found that people prefer both public as well as private transport to go to various places. The traffic count was done in order to know about the peak hours flow after converting the normal flow in Passenger Car Units (PCU's) [11].

3.2 Traffic Volume Counts

The aim to conduct traffic vehicular counting is determination of total number of roadway-vehicles, their movements as well as their classification based on type, size. With the help of this data, it is possible to know about the effect of large heavy vehicles on the overall traffic. Also, it is quite helpful to know how pedestrians' population affect the overall traffic. This data is also helpful for the improvement of any traffic junction. The method to be selected for study is determined by the period for which counting will be done. For a given study area, the

period of counting is the representative for the time of a day, days of a month or months of a particular year.

There are two types of methods which are used for conducting traffic count:

(1) Manual method

(2) Automatic method.

3.3 Manual Count Study

The study of manual traffic count is used in order to collect data for determining the classification of vehicle, travelling direction, volume. It consists of three main steps. These are as follows: -

1) Performing necessary preparations.
2) Selection of location.
3) Record Observations.

These steps can be further explained as follows: -

3.4 Performing Necessary Preparations

The preparation starts while reviewing the exact purpose of counting. This information helps to determine the procedure to follow on field, numbers of observers needed such as to do the study at any intersection with multiple lanes will require various number of observers.

3.5 Selection of Location

The location to be selected should be accessible for all the observers. The observers should stand at the place from where they will be having the clear vision of the on-going vehicular traffic. It is suggested that the observer should stand at a position which should be somewhat away at certain distance from the edge of road. If possible, the observers should be positioned at a place which is cleared of all obstructions. If two or more observers are present at site then all of them must have visualised contact with each other.

3.6 Record Observations

It is essential to organize the data record carefully as the traffic counts could have a number of data forms and various sheets. On each record sheet or tally sheet, it is required by the observer to mention the selected location, the date on which observation has been taken as

well as the time of recording observations. Along with this, the weather condition of the selected is also required to be mentioned on the record sheet.

Table 3.1 Traffic Volume in PCU, *Source: Primary Survey*

Traffic Count Hours	Total Volume in PCU			Total
	Mandi	Pathankot	Ranital	
08-09am	210.7	240	94.6	545.3
09-10am	**359.8**	**326.8**	**127.9**	**814.5**
10-11am	282	222	112.6	616.6
11-12am	267.4	286.2	84.8	638.4
12-01pm	292.9	238.3	89.6	620.8
01-02pm	254.3	249.9	86.4	590.6
02-03pm	218.1	251	79.9	549
03-04pm	231.3	234.6	86.3	552.2
04-05pm	265	234.5	100.7	600.2
05-06pm	214.4	224.6	76.4	515.4
06-07pm	312	215.2	47.7	574.9
07-08pm	210.5	228.3	28.7	467.5
Total volume	**3118.4**	**2951.4**	**1015.6**	**7085.4**

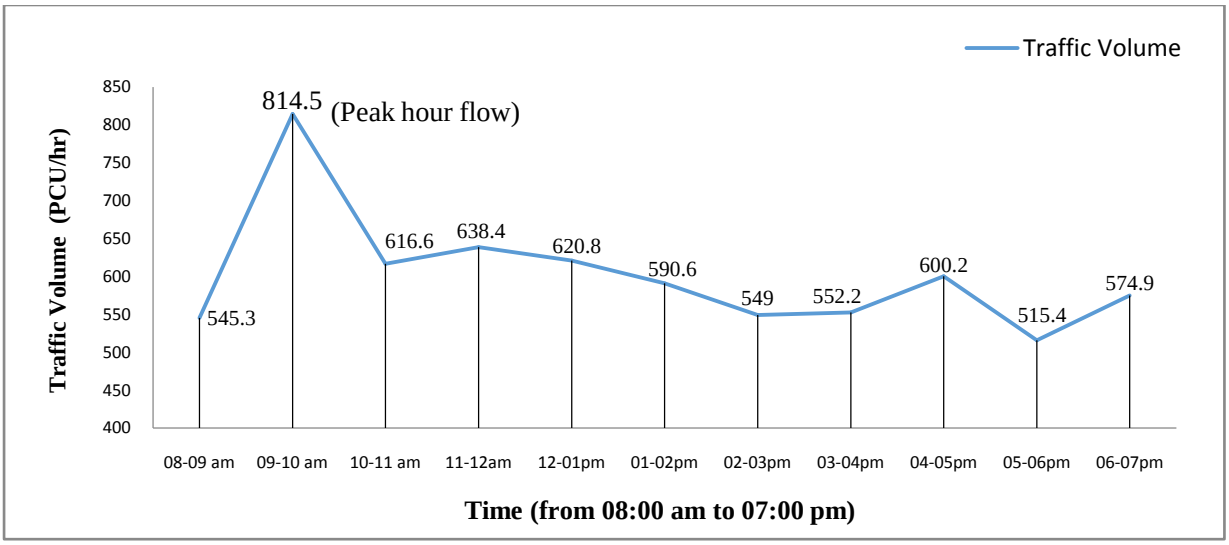


Fig. 3.1 Traffic Volume Chart, *Source: Primary Survey*

The manual method was used in this study in order to know the traffic volume count as well as to know about the peak hour of the day [Table 3.1]. Although the method has been proved to be time consuming, but it is also the suitable method of observing vehicular traffic and then prepare the record sheets. According to data collected at site, it has been found after its graphical representation that the maximum traffic flow at the proposed junction occurs in morning from 09:00 AM to 10:00 AM [Fig 3.1]. It has also been found that the flow was more on the road connecting Mandi to Pathankot. The involvement of pedestrians was also comparatively more in this time period.

3.7 Concept of Level of Service

The concept of Level of Service has been given by HCM in order to know about the facility that any road user can derive at various operating conditions as well as volume of traffic. When the road is having traffic volume equal to the capacity of that road at ideal conditions of traffic, then the conditions for operating traffic becomes poor, speed of the vehicles starts dropped down and the delays of vehicles starts rising up. Level of Service is the qualitative measure that describes operational conditions in the traffic stream. According to HCM, six levels of service have been defined describing various operating conditions as given below:

1) Level of Service (A): - This level denotes the free traffic flow at high speed and low volume on roads. The density of traffic is very low, so, it is possible for drivers to maintain the desired speed of vehicles with no possible delays.
2) Level of Service (B): - It denotes the level of stable traffic flow, but the condition of traffic starts restricting the speed of the vehicles to little extent. So, the drivers can maintain their desired speed to some reasonable amount.
3) Level of Service (C): - It also denotes the stable flow zone but the speeds of the vehicles are started to be controlled as a result of higher traffic volume. The freedom of the drivers to drive at their desired speed is restricted. However, a satisfactory speed can still be obtained relative to volume of traffic.
4) Level of Service (D): - This level of service denotes an unstable traffic flow, with some reasonable satisfactory operations of traffic flow. The speeds of the vehicles are affected by the fluctuations in traffic volume as well as restrictions in the flow of traffic. Drivers have less freedom to drive at desired speeds.

5) Level of Service (E): - This zone represents the operations of traffic at very low speeds, than in Level of Service D. At this stage, the volume of the traffic is approximately near to the capacity of the roadway.

6) Level of Service (F): - At this zone of Level of Service, the traffic volume is exactly below the capacity of the highway. Due to congestion, the speed of the vehicles gets reduced and delays start to be occurring for a short or long time periods. During the extreme conditions, both the traffic volume and the speed may even drop up to zero.

The curve in Fig. 3.2 shows the relationship between operations according to various levels of service and the volume/capacity ratio. This figure shows the various zones where the levels of service are found to occur.

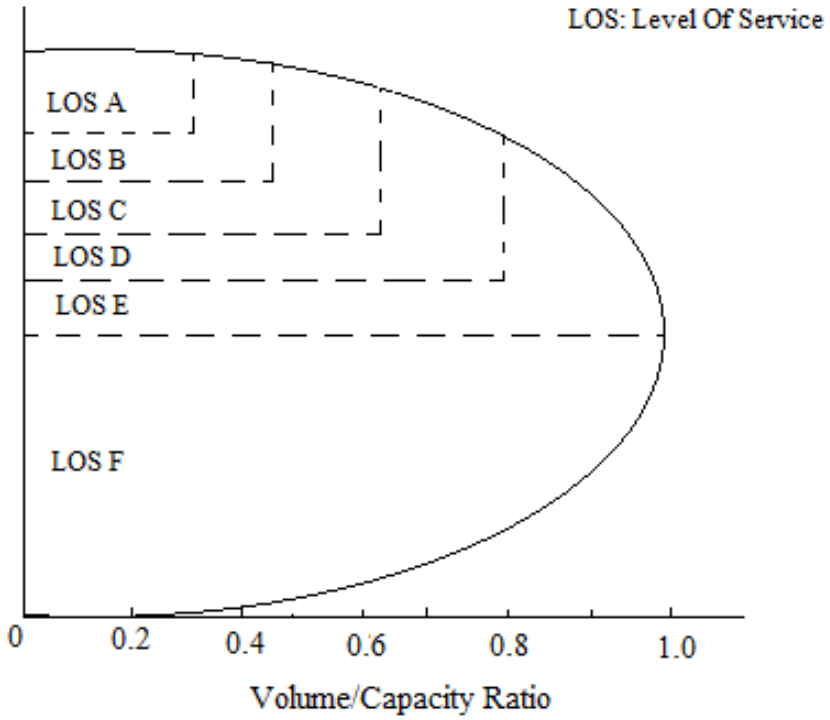


Fig. 3.2 Level of Service curve

3.8 Road Accidents

The road accidents on the roads as well as on the un-signalized intersections have always been an important cause of human misery as well as of economic loss. So, it is very important to know about the contributing factors of these accidents on various places and, thus, to have a proper solution of this problem in order to have a safe and efficient journey on the roads. The proper analysis of accident data is very helpful to know about the contributing factors as

well as required solutions of this problem. The engineers are concerned of the rules and regulations as well as the proper traffic management in order to have safer and efficient travel on roads.

3.9 Accident Data Collection

The collection of data regarding accidents of an area helps in identification of the main causes of accidents and, thus, to suggest proper solutions to reduce the risk of accidents in future. The various uses of accident data are as follows:

1) To use the data in the field of engineering.
2) To use the data for enforcing various rules and regulations.
3) To use the accident data in various policy issues.
4) To use the data from educational point of view.
5) To use the data for vehicular administrator.

3.9.1 Uses in Engineering

The accident data can have following uses in engineering: -

1) In the determination of shape, size of the traffic signs along with their adequacy.
2) In the determination of speed control requirements.
3) In the planning of control devices for safe and efficient journey of pedestrians.
4) In the planning and designing of lightning system for streets.
5) The planning of traffic along with proper safety in case of construction activities.
6) In the planning and improvement of horizontal and vertical alignments.
7) For the provision of adequate and proper sight distance.
8) In the determination as well as rectification in the super elevations and cambers.
9) In the planning and designing as well as re-designing of intersections.
10) In the determination of various deficiencies of pavements and means to improve them.

3.9.2 Uses for Enforcement

The various uses of accident data under this category are as follows: -

1) To control the behaviour of pedestrians.
2) To enable efficient operation of control device.
3) In enforcing the vehicular inspectional measures.

4) In enforcing cyclists inspectional measures.

3.9.3 Administrative and Policy Issues

The various use of accident data under administrative and the policy issues are as follows: -

1) To initiate and administrate traffic safety programs along with policy issues.
2) To evaluate the success regarding programs of traffic safety.
3) To determine accident cost.
4) To know about the necessity for the amendment of various suitable measures to enforce.

3.9.4 Educational Uses

The various educational uses of accident data are as follows: -

1) To plan and organize the various safety educational programs in schools.
2) To plan and organize driver's safety educational programs.

3.9.5 Uses for Motor Vehicle Administrator

The various uses for motor vehicular administrator are as follows: -

1) To review the procedure of licensing of drivers.
2) To review the procedure of licensing as well as registration of the vehicles.
3) To review the requirement of inspection of vehicles.

3.10 Requirement of Accident Data

The various requirements for an accident data are as follows: -

1) The accident data to be use should be accurate in terms of years and vehicles. It should not be misleading.
2) The data should be reported on the standard form so the uniform procedure is followed.
3) All the terms related to accidents should be accurately and properly defined.

3.11 Accident Record and Forecasting

In order to do analysis of accidents that have been occurred at the proposed junction, it was necessary to collect the previous accident record of the junction. Accident forecasting is helpful to have the future estimation of the rate of accidents in the present scenario in case the appropriate traffic planning and new enforcement rules are not being applied on the area. The

study area comes under police station, Jawali, Distt. Kangra, H.P. The accident record was, thus, obtained from the police station, Jawali from 2006 to 2016 which includes various bus accidents, car accidents, motorcycle accidents as well as tractor accidents as shown below in Table 3.2. This accident data also has various major injuries, minor injuries as well as fatal accidents (i.e. involving one or more deaths) that have taken place from 2006 to 2016. Multiple Linear Regression method is best suited for the analysis of these types of data in which the future estimation of accidents can be done according to the past records.

Table 3.2 Accident Data of Study Area (2006-2016), *Source: Primary Survey*

(collected from Police Station, Jawali, Distt. Kangra, H.P.)

Year	Number of years	Accident type/ Involvement of vehicle						
		Bus	Car	Motorcycle	Tractor	Minor Injuries	Major Injuries	Fatal
2006	1	0	2	2	0	5	2	1
2007	2	1	1	3	1	7	1	1
2008	3	2	2	1	0	12	3	0
2009	4	0	0	2	0	2	1	0
2010	5	2	3	1	0	3	1	2
2011	6	0	1	2	1	3	2	1
2012	7	0	2	1	1	2	1	0
2013	8	1	1	2	0	5	2	0
2014	9	2	3	1	1	11	2	2
2015	10	1	2	3	0	4	1	0
2016	11	1	3	0	1	14	5	3
Total		**10**	**20**	**18**	**5**	**68**	**21**	**10**

The graphical representation of different types of accidents which have taken place at site according to collected data along with their percentages is given in fig. 3.3: -

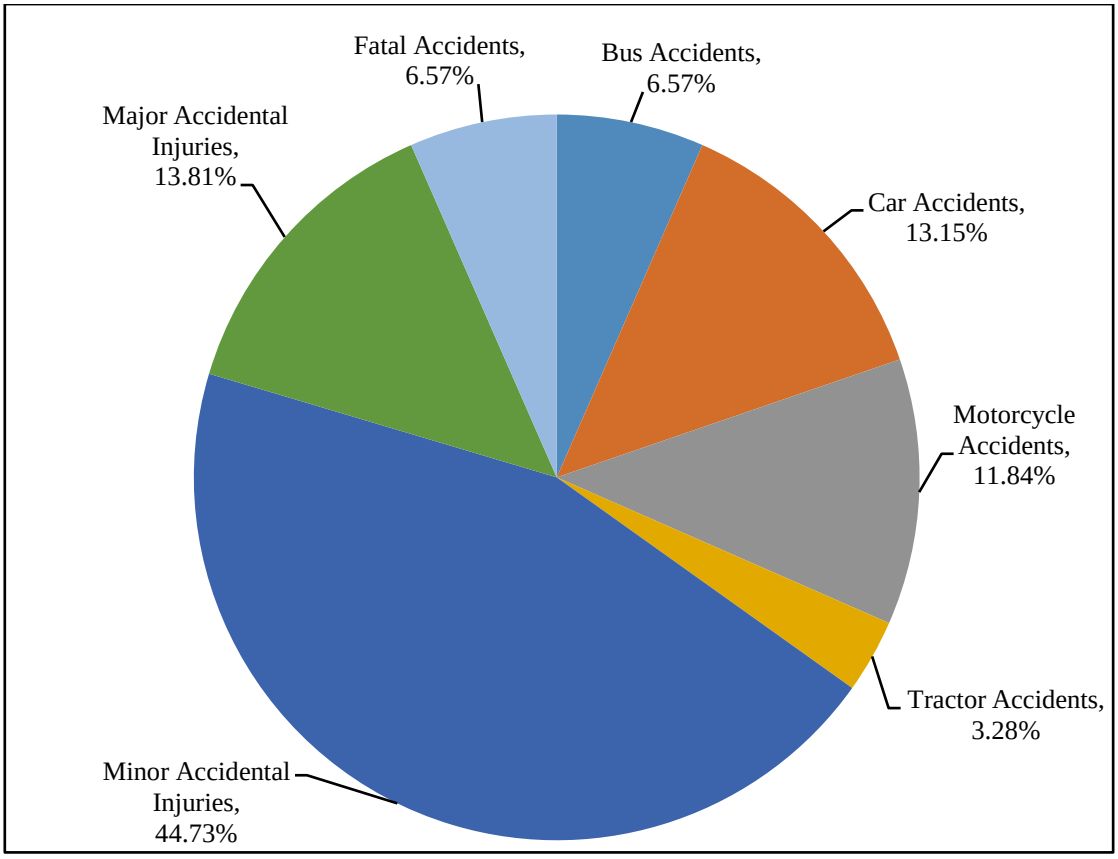


Fig 3.3 Graphical Representation of Accident data, *Source: Primary Survey*

(Collected from Police Station, Jawali, Distt. Kangra, H.P.)

CHAPTER 4

DATA ANALYSIS

4.1 General

The road accidents have always been an important cause of human misery as well as of economic loss. So, it is important to have proper analysis of accident data in order to know about the contributing factors of this problem. The engineers are concerned of the rules and regulations as well as the proper traffic management in order to have safer and efficient travel on roads.

4.2 Accident Data Analysis

The data that has been collected is analyzed with the help of Linear Regression Method. In Linear Regression, if the dependent variable is 'Y' and independent variable is 'X', then these two variables will have linear relationship. The general expression of the linear relationship between two variables 'X' and 'Y' in Linear Regression method is as follows: -

$$\mathbf{Y = a + b\,X} \qquad \textbf{… (4.1)}$$

$$b = \frac{\sum x_i\, y_i \; - n\, \bar{x}\, \bar{y}}{\sum x_{i2} - n\, \bar{x}^2} \qquad \text{… (4.2)}$$

$$a = \bar{y} - b\bar{x} \qquad \text{… (4.3)}$$

In the above equations;

Y = dependent variable

X = independent variable

x_i = number of years 1, 2, 3,….,11

y_i = number of different types of accidents involved

n = total number of years = 11

$\bar{x}$ = mean of n observed values of x_i

$\bar{y}$ = mean of n observed values of y_i

1) **In case of Bus Accidents: -**

Table 4.1 Bus Accident Data

Years	x_i	y_i	$x_i y_i$	x_i^2
2006	1	0	0	1
2007	2	1	2	4
2008	3	2	6	9
2009	4	0	0	16
2010	5	2	10	25
2011	6	0	0	36
2012	7	0	0	49
2013	8	1	8	64
2014	9	2	18	81
2015	10	1	10	100
2016	11	1	11	121
Total	**66**	**10**	**65**	**506**

Here,

n = number of years = 11

$\bar{x}$ = 66 / 11

$\bar{x}$ = 6

$\bar{y}$ = 10 / 11

$\bar{y}$ = 0.909

Using Equation 4.2,

$$b = \frac{\sum x_i y_i - n \bar{x} \bar{y}}{\sum x_i^2 - n \bar{x}^2}$$

b = [65 – (11 × 6 × 0.909)] / [506 – (11 × 6^2)]

b = 5.006 / 110

b = 0.045

Using Equation 4.3,

a = [0.909 – (0.045 × 6)]

a = 0.639

Using Equation 4.1,

Y = 0.639 + 0.045 X **…(4.4)**

2) In case of Car Accidents: -

Table 4.2 Car Accident Data

Years	x_i	y_i	$x_i y_i$	x_i^2
2006	1	2	2	1
2007	2	1	2	4
2008	3	2	6	9
2009	4	0	0	16
2010	5	3	15	25
2011	6	1	6	36
2012	7	2	14	49
2013	8	1	8	64
2014	9	3	27	81
2015	10	2	20	100
2016	11	3	33	121
Total	**66**	**20**	**133**	**506**

Here,

n = number of years = 11

$\bar{x}$ = 66 / 11

$\bar{x}$ = 6

$\bar{y}$ = 20 / 11

$\bar{y}$ = 1.818

Using Equation 4.2,

$$b = \frac{\sum x_i y_i - n \bar{x} \bar{y}}{\sum x_i^2 - n \bar{x}^2}$$

b = [133 – (11 × 6 × 1.818)] / [506 – (11 × 6^2)]

b = 13.012 / 110

b = 0.118

Using Equation 4.3,

a = [1.818 – (0.118 × 6)]

a = 1.110

Using Equation 4.1,

Y = 1.110 + 0.118 X **…(4.5)**

3) In case of Motorcycle Accidents: -

Table 4.3 Motorcycle Accident Data

Years	x_i	y_i	$x_i y_i$	x_i^2
2006	1	2	2	1
2007	2	3	6	4
2008	3	1	3	9
2009	4	2	8	16
2010	5	1	5	25
2011	6	2	12	36
2012	7	1	7	49
2013	8	2	16	64
2014	9	1	9	81
2015	10	3	30	100
2016	11	0	0	121
Total	**66**	**18**	**98**	**506**

Here,

n = number of years = 11

$\bar{x}$ = 66 / 11

$\bar{x}$ = 6

$\bar{y}$ = 18 / 11

$\bar{y}$ = 1.636

Using Equation 4.2,

$$b = \frac{\sum x_i y_i - n \bar{x} \bar{y}}{\sum x_i^2 - n \bar{x}^2}$$

b = [98 – (11 × 6 × 1.636)] / [506 – (11 × 6^2)]

b = - 9.976 / 110

b = - 0.090

Using Equation 4.3,

a = [1.636 – (- 0.090 × 6)]

a = 2.176

Using Equation 4.1,

Y = 2.176 - 0.090 X **…(4.6)**

4) In case of Tractor Accidents: -

Table 4.4 Tractor Accident Data

Years	x_i	y_i	$x_i y_i$	x_i^2
2006	1	0	0	1
2007	2	1	2	4
2008	3	0	0	9
2009	4	0	0	16
2010	5	0	0	25
2011	6	1	6	36
2012	7	1	7	49
2013	8	0	0	64
2014	9	1	9	81
2015	10	0	0	100
2016	11	1	11	121
Total	**66**	**5**	**35**	**506**

Here,

n = number of years = 11

$\bar{x}$ = 66 / 11

$\bar{x}$ = 6

$\bar{y}$ = 5 / 11

$\bar{y}$ = 0.454

Using Equation 4.2,

$$b = \frac{\sum x_i y_i - n \bar{x} \bar{y}}{\sum x_i^2 - n \bar{x}^2}$$

b = [35 – (11 × 6 × 0.454)] / [506 – (11 × 6^2)]

b = 5.036 / 110

b = 0.045

Using Equation 4.3,

a = [0.454 – (0.045× 6)]

a = 0.184

Using Equation 4.1,

Y = 0.184 + 0.045 X **…(4.7)**

5) In case of Minor Accidental Injuries: -

Table 4.5 Minor Accidental Injuries Data

Years	x_i	y_i	$x_i y_i$	x_i^2
2006	1	5	5	1
2007	2	7	14	4
2008	3	12	36	9
2009	4	2	8	16
2010	5	3	15	25

2011	6	3	18	36
2012	7	2	14	49
2013	8	5	40	64
2014	9	11	99	81
2015	10	4	40	100
2016	11	14	154	121
Total	**66**	**68**	**443**	**506**

Here,

n = number of years = 11

$\bar{x}$ = 66 / 11

$\bar{x}$ = 6

$\bar{y}$ = 68 / 11

$\bar{y}$ = 6.181

Using Equation 4.2,

$$b = \frac{\sum x_i y_i - n \bar{x} \bar{y}}{\sum x_i^2 - n \bar{x}^2}$$

b = [443 – (11 × 6 × 6.181)] / [506 – (11 × 6^2)]

b = 35.054 / 110

b = 0.318

Using Equation 4.3,

a = [6.181 – (0.318× 6)]

a = 4.273

Using Equation 4.1,

Y = 4.273 + 0.318 X **…(4.8)**

6) In case of Major Accidental Injuries: -

Table 4.6 Major Accidental Injuries Data

Years	x_i	y_i	$x_i y_i$	x_i^2
2006	1	2	2	1
2007	2	1	2	4
2008	3	3	9	9
2009	4	1	4	16
2010	5	1	5	25
2011	6	2	12	36
2012	7	1	7	49
2013	8	2	16	64
2014	9	2	18	81
2015	10	1	10	100
2016	11	5	55	121
Total	**66**	**21**	**140**	**506**

Here,

n = number of years = 11

$\bar{x}$ = 66 / 11

$\bar{x}$ = 6

$\bar{y}$ = 21 / 11

$\bar{y}$ = 1.909

Using Equation 4.2,

$$b = \frac{\sum x_i y_i - n \bar{x} \bar{y}}{\sum x_i^2 - n \bar{x}^2}$$

b = [140 – (11 × 6 × 1.909)] / [506 – (11 × 6^2)]

b = 14.006 / 110

b = 0.127

Using Equation 4.3,

a = [1.909 – (0.127× 6)]

a = 1.147

Using Equation 4.1,

Y = 1.147 + 0.127 X **…(4.9)**

7) In case of Fatal Accidents: -

Table 4.7 Fatal Accident Data

Years	x_i	y_i	$x_i y_i$	x_i^2
2006	1	1	1	1
2007	2	1	2	4
2008	3	0	0	9
2009	4	0	0	16
2010	5	2	10	25
2011	6	1	6	36
2012	7	0	0	49
2013	8	0	0	64
2014	9	2	18	81
2015	10	0	0	100
2016	11	3	33	121
Total	**66**	**10**	**70**	**506**

Here,

n = number of years = 11

$\bar{x}$ = 66 / 11

$\bar{x}$ = 6

$\bar{y}$ = 10 / 11

$\bar{y}$ = 0.909

Using Equation 4.2,

$$b = \frac{\sum x_i y_i - n \bar{x} \bar{y}}{\sum x_i^2 - n \bar{x}^2}$$

b = [70 – (11 × 6 × 0.909)] / [506 – (11 × 6^2)]

b = 10.006 / 110

b = 0.090

Using Equation 4.3,

a = [0.909 – (0.090× 6)]

a = 0.369

Using Equation 4.1,

Y = 0.369 + 0.090 X **…(4.10)**

By using this method for different type of accidents, the regression equations obtained are as follows: -

Table 4.8 Linear Regression Equations for all accidents

S.No.	Accident Type	Regression Equation
1	Bus Accidents	Y = 0.639 + 0.045 X
2	Car Accidents	Y = 1.110 + 0.118 X
3	Motorcycle Accidents	Y = 2.176 - 0.090 X
4	Tractor Accidents	Y = 0.184 + 0.045 X
5	Minor Accidental Injuries	Y = 4.273 + 0.318 X
6	Major Accidental Injuries	Y = 1.147 + 0.127 X
7	Fatal Accidents	Y = 0.369 + 0.090 X

The regressions equations for all types of accidents according to collected data, as shown above in table 4.8, are used for the future estimation of the accidents in normal case of present scenario. The accidents that may occur in case of current traffic system can be estimated by substituting desired year in the regression equations which are derived for various types of accidents involved.

After substituting the desired year (i.e. ‘X’) in the regression equation, the number of different type of accidents can be estimated which may occur in case of current traffic system as shown in table 4.9.

Table 4.9 Future Estimation of Accidents

Year	Accident type/ Involvement of vehicle						
	Bus	Car	Motorcycle	Tractor	Minor Injuries	Major Injuries	Fatal
2017	2	3	2	1	9	3	2
2018	2	3	2	1	9	3	2
2019	2	3	1	1	9	3	2
2020	2	3	1	1	10	4	2
2021	2	3	1	1	10	4	2
2022	2	4	1	1	10	4	2
2023	2	4	1	1	10	4	2
2024	2	4	1	2	11	4	3
2025	2	4	1	2	11	4	3
Total	**18**	**31**	**11**	**11**	**89**	**33**	**20**

With the help of the data obtained regarding accidents happened in previous 11 years as well as after analyzing with the help of Linear Regression method, it has been estimated that the number of accidents are expected to increase if the appropriate measures are not being taken to control the accidents at the study area. However, it has been estimated the percentage increase in the accidents is reasonable and can be reduced if proper steps are taken in order to arrive at required solution to reduce the accidents in future.

The graphical representation of the accidents which have been estimated to be occurred can be made in order to find percentage of the accidents involved. The various accidents along with the estimated percentage of all accidents have been shown in Fig. 4.1: -

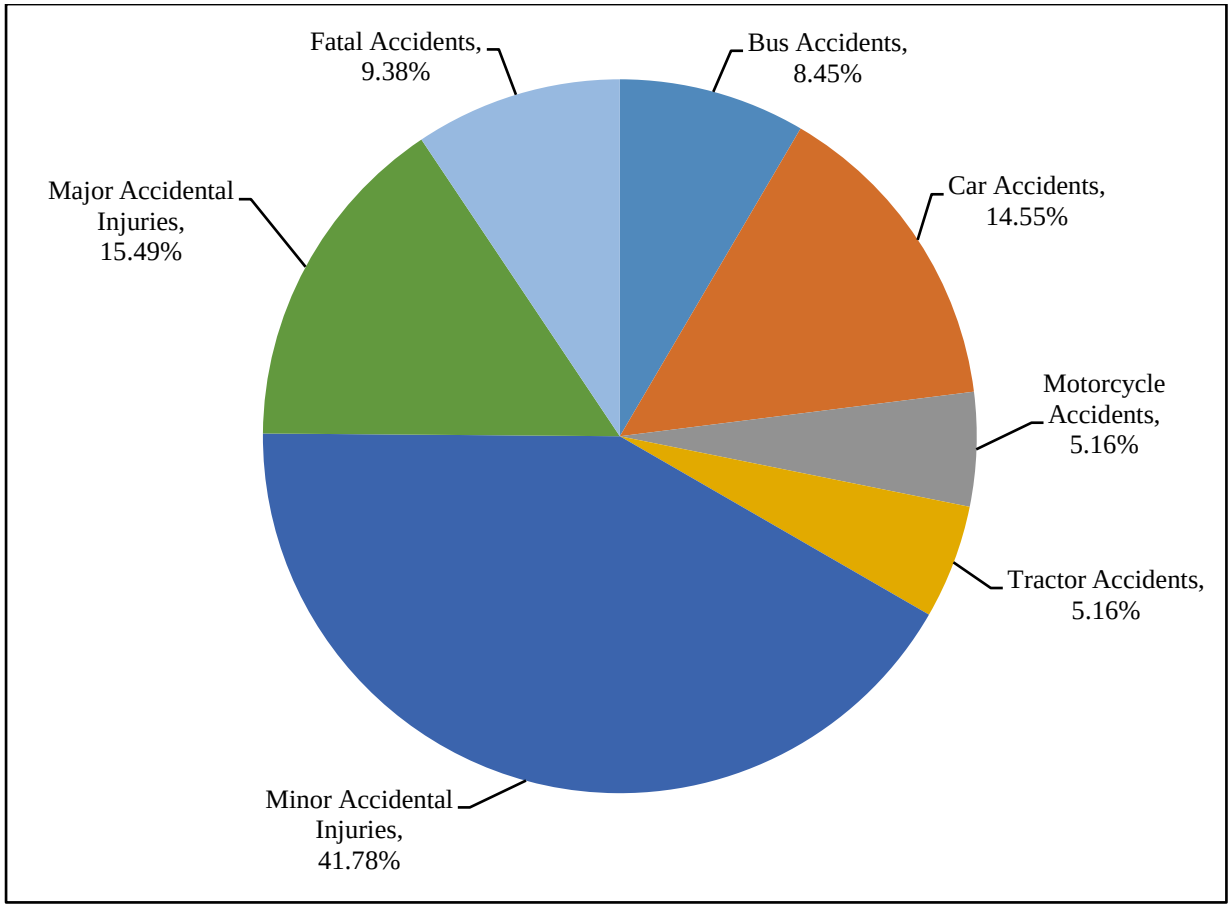


Fig. 4.1 Graphical Representation of Future Estimation of accidents

4.3 Traffic Capacity Analysis

The Highway Capacity Manual (HCM) gives a clear approach for determining capacity of the roads if the lane width as well as the number of lanes is known. Since, the traffic volume of the adjoining roads with the study area has already been found, thus, the level of serviceability can be determined for the study area. The roads connecting with each other at study area are two-lane national highways and the total width of the road is 6.75 metres approximately. According to HCM, the practical capacity for two lane roads for given lane width for all purpose street, when the capacity is restricted by waiting vehicles on junctions is given as 450 to 600 PCUs per hour for both directions of flow. So, the practical capacity for all the three roads is taken as 500 PCUs/hour, then

The level of service (LOS) can be calculated as follows;

$$LOS = v/c$$ where, v is peak hourly traffic volume

c is capacity

Thus,

For road I, i.e. road connecting to Mandi;

$$LOS = 359.8/500$$

$$= 0.71$$

For road II, i.e. road connecting to Pathankot;

$$LOS = 326.8/500$$

$$= 0.65$$

For road III, i.e. road connecting to Ranital;

$$LOS = 127.9/500$$

$$= 0.25$$

From the values obtained for Level of service of all three roads, it has been found that the operating conditions for all three roads are within less stable traffic flow zones. The traffic conditions on the highway connecting Mandi and Pathankot lies within Level of Service (D). It means the speeds of the vehicles on this highway are affected with the fluctuations in the volume of traffic and, thus, it further causes various restrictions to the flow of the traffic. These restrictions may lead to sudden drop in the operational speeds of the vehicles, if required. It has been found that, however, the serviceability approaches to unstable traffic flow on the highway at study area, but the operating conditions are tolerable for a shortest time period. However, for remained third leg of intersection the level of serviceability is under stable traffic zone.

4.4 Signal Design by Webster's Method

Webster's method is used for signal design. It is the rational approach of signal designing. In order to have proper traffic system on the study area, signal designing is necessary to be done. In this method, the total cycle length of the signal is determined. Cycle length is the time taken by a signal to complete one full rotation through all signal indications. Since, traffic vehicular count has already been done,

Thus, Normal flows from all three roads is given as

Normal peak hour flow from road towards Mandi (q_m) = 359.8 PCU/hr

Normal peak hour flow from road towards Pathankot (q_p) = 326.8 PCU/hr

Normal peak hour flow from road towards Ranital (q_r) = 127.9 PCU/hr

The method of measuring the saturation flow is described as follows: -

$$s = 525\ w \text{ PCU/hr}$$

where, s = saturation flow

w = width of road in metres

As the width of the approach roads is 6.75 metres;

Therefore, $s = 525 \times 6.75$

$s = 3543.75$ PCU/hr

Now,

$y_1 = 359.8/3543.75$

$= 0.101$

$y_2 = 326.8/3543.75$

$= 0.092$

$y_3 = 127.9/3543.75$

$= 0.036$

Therefore,

$Y = y_1 + y_2 + y_3$

$Y = 0.101 + 0.092 + 0.036$

$Y = 0.229$

According to Webster's method, optimum cycle length can be calculated as follows: -

$$C_0 = \frac{1.5\ L + 5}{1 - Y}$$

where,

$L = 2n + R$,

n = number of phases = 3

R = all-red time = 12 seconds

L = (2×3 + 12)

L = 18 seconds

Therefore,

$$C_0 = \frac{1.5 \times 18 + 5}{1 - 0.229}$$

C_0 = 42 seconds

The green time respectively for phase I, II and III can be calculated as follows: -

$G_1 = y_1/y\ [C_0 - L]$

= 0.101/0.229 [42 – 18]

= 10 seconds

$G_2 = y_2/y\ [C_0 - L]$

= 0.092/0.229 [42 – 18]

= 10 seconds

$G_3 = y_3/y\ [C_0 - L]$

= 0.036/0.229 [42 – 18]

= 4 seconds

Now, consider amber time of 2 seconds for each phase. Therefore, for three phases amber time will be of 6 seconds.

Also, consider all-red time of 12 seconds.

Thus,

Total Cycle Length = $G_1 + G_2 + G_3 + A_1 + A_2 + A_3$ + all-red time

= 10 + 10 + 4 + 2 + 2 + 2 + 12

= 42 seconds.

The signal phase diagram has been shown below in Fig. 4.2: -

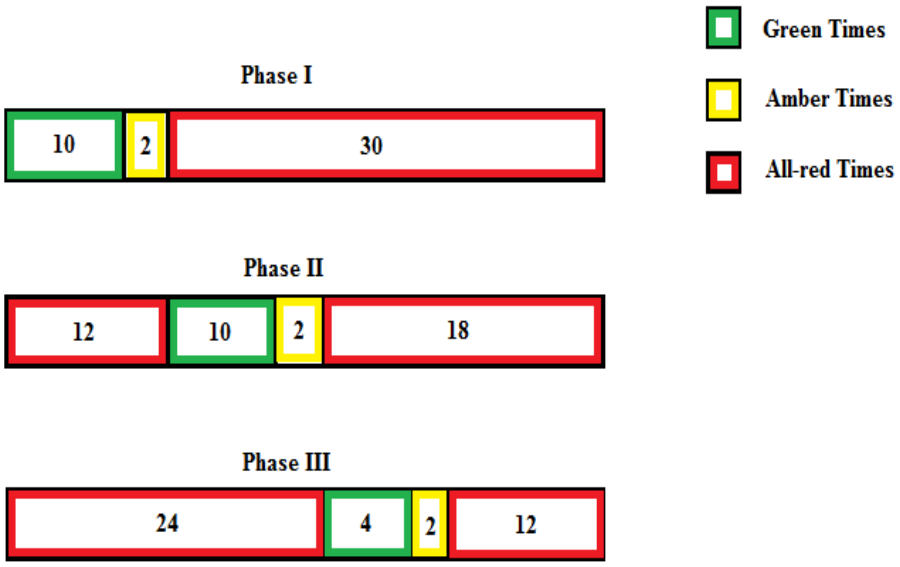


Fig. 4.2 Signal Phase Diagram

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 General

The present chapter deals with the results and various solutions that have been derived as a result of the collected data related to study area as well the analysis of the same data. It also deals with the discussions that have came across based on the derived results. The data that has been collected in this research work includes vehicle traffic counting in order to find the traffic volume and thus, the peak hour volume, at the intersection of the study area. The collected data also includes the collection of accident data of the study area for the previous years from 2006 to 2016. The analysis of the accident data was quite helpful for the future estimation of the accidents that may be expected to occur at site in case of the absence of various control measures. At present, no control measures are present at site despite the fact of being an area, intersecting national highway with a state highway. The various results have derived after the analysis of traffic data that have been collected after the primary survey of study area. Also, the results have been derived regarding accident data analysis.

5.2 Traffic Data

The traffic volume data was collected about the study area by doing traffic count at the study area. The various vehicles arriving at the junction from all three sides were observed and counted which includes buses, trucks, tractors, two-wheelers, etc. After counting of vehicular traffic, the peak hour volume was found out about the study area. The study about the traffic volume was also proved to be helpful to know about the level of serviceability according to the standard values of capacities given in the Highway Capacity Manual (HCM). The various results related to traffic data survey are as follows: -

1) The traffic survey of the study area shows that the maximum traffic occurs in between 9:00 AM to 10:00 AM which includes heavy vehicles, light vehicles as well as two-wheelers.
2) The analysis of traffic data is done in order to find the level of serviceability during the peak hours and the study shows that the national highway connecting Mandi to Pathankot (NH-154) approaches an unstable traffic flow during peak hours.
3) The Level of Service of this highway (NH-154) lies under category ‘D’ that approaches to unstable traffic flow.

4) The fluctuations in the traffic volume have already been observed at site during survey and it has also been derived after analysis that the operating conditions on the road leads to restrictions in the flow.
5) The road approaching to Ranital (SH-23) has been proved to have free flow of traffic during peak hours. The analytical studies also prove it as the level of serviceability of this road lies under category 'A'. The traffic density is quite less on this road with very little restrictions among vehicles as compared to that occur on adjoining national highway.
6) The traffic flow restrictions have been observed to be the leading cause of congestion and delay on the junction.
7) The absence of control devices such as signals, signs on the junction is also one of the main reasons of having congestion of vehicles.

5.3 Accident Data

The present study also deals with the collection of the accident data of the study area for the past few years from 2006 to 2016. The data was collected from the City Police Station, Jawali, Distt. Kangra, Himachal Pradesh which includes various bus accidents, car accidents, motorcycle accidents, tractor accidents along with major accidental injuries, minor accidental injuries as well as a wide range of fatal accidents. The accident data that has been collected was analyzed in order to have the future estimation of the accidents which may be occurred if the proper steps are not taken for the improvement of the junction. The various results and discussions obtained after analysis of accident data are as follows: -

1) The study of the accident data has revealed that the number of accidents happened in the year 2016 has enlisted the study area among the black spot areas, since the site has been witnessed of three fatal accidents which are registered officially.
2) It has been proved from past records of accident data that the accidents involving light vehicles are comparatively more that have been resulted in more major accidental injuries.
3) The data obtained from police station clearly shows that the year 2016 has been proved to be the most drastic year among past 11 years, in terms of accidents at study area involving major accidents, minor accidental injuries and most importantly the fatal accidents.

4) The future estimation of the accidents for next 9 years shows that the fatal accidents may be collectively increased up to 4% if proper steps are not taken at site to reduce them.
5) The accidents involving major accidental injuries are expected to increase if appropriate measures are not being applied.
6) It should be noted that the area has been situated at a place where a national highway intersects with a state highway. Also, in certain cases, this national highway is the only way accessible to various places of interests situated in the state. The vehicular population is also increasing day by day. So, it is a matter of concern to take suitable steps and apply appropriate control measures at the study area.

The Fig. 5.1 shows the comparative results of various accidents which have already happened at site with the future estimation for the accidents.

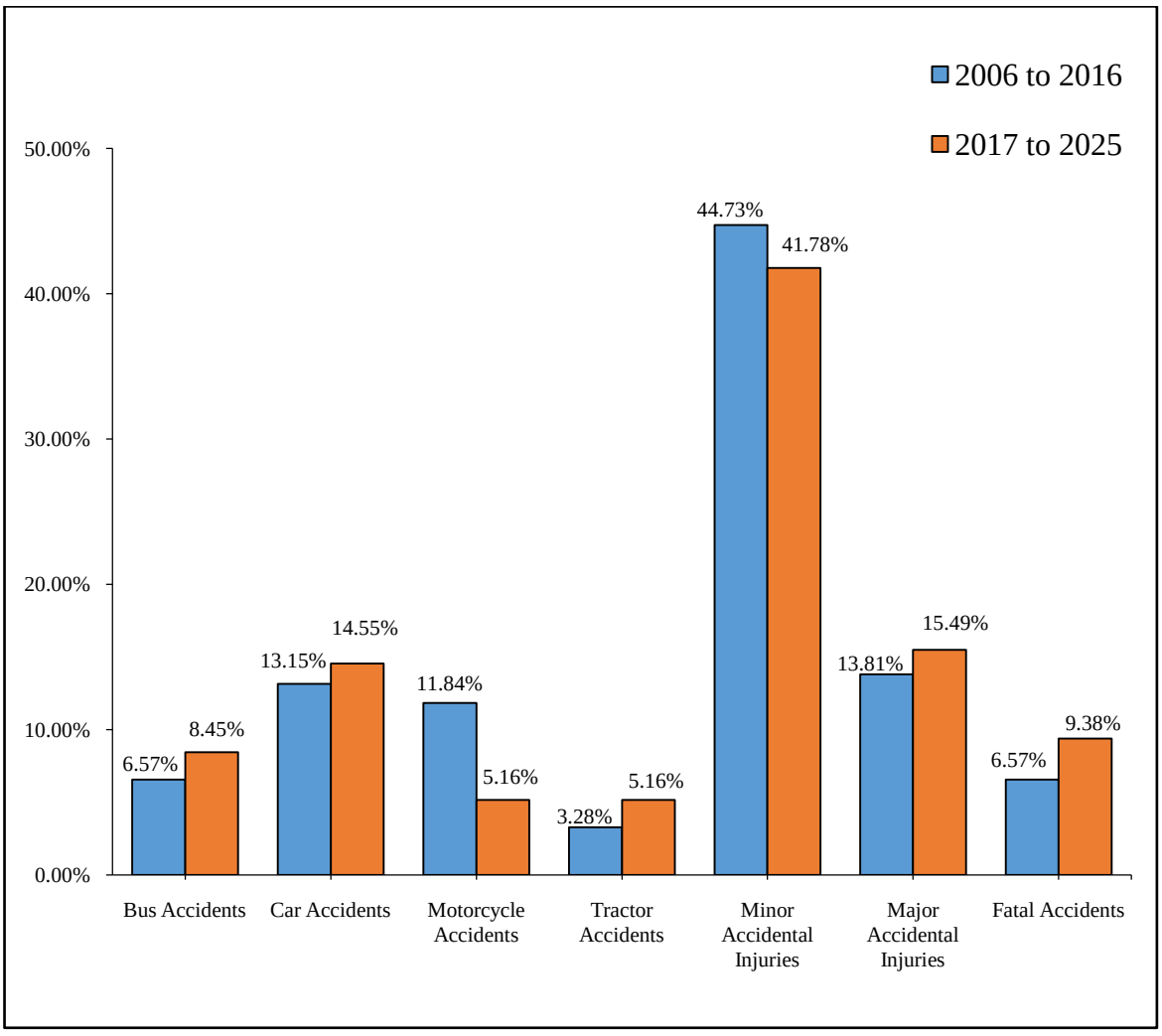


Fig. 5.1 Comparative Results of accident data

5.4 Signal Design

The present also dealt with signal designing at the study area as there are no signal facilities in the present scenario. The following results have been obtained after signal designing by using Webster's method: -

1) The saturation flow of the approach has been come out to be 3543.75 PCU/hour.
2) The optimum cycle length of the signal has been come out to be 42 seconds.
3) The all-red time has been considered as 12 seconds which includes combined red time as well as the flashing amber time of 2 seconds.

CHAPTER 6

CONCLUSIONS & RECOMMENDATIONS

6.1 General

The present study dealt with various analytical results related to traffic and accident data. It also dealt with signal designing. On the basis of data analysis as well as design of control devices, various conclusions and recommendations that have been made. These can be explained as follows.

6.2 Conclusions

The various conclusions that have been made as a result of this study are explained as follows: -

1) The traffic volume at intersection was calculated and it has been concluded that the volume exceeds the practical capacity. The Level of Service of national highway has been found under category 'D' and that of state highway under category 'A'.
2) It has been observed that the traffic system at site is not followed by proper rules and regulations because of non-availability of signs and signals.
3) It has also been observed that the capacity is generally restricted by the presence of the waiting vehicles at the junction which is affecting the overall traffic system.
4) The regulatory measures regarding restriction in the speed of the vehicles are required to be applied at the junction because over speeding vehicular activities can be noticed on the junction.
5) At the junction, it has been observed that the turning traffic creates problem and not only obstructs the general flow of traffic, but also results in the loss of the capacity of the junction. Due to unavailability of the controlling measures at the junction, turning traffic block-up the traffic flow. The proper signs and markings will be helpful in order to deal with undesirable turning movements.
6) The channelizing is required to be done in order to improve the level of serviceability and the signal designing should be done based on the traffic volume enters during peak hours.
7) At site, there are no speed limits enforced on the intersection for the vehicles which has been a primary cause of the accidents.
8) The drunk and drive is also one of the reason of accidents at site.

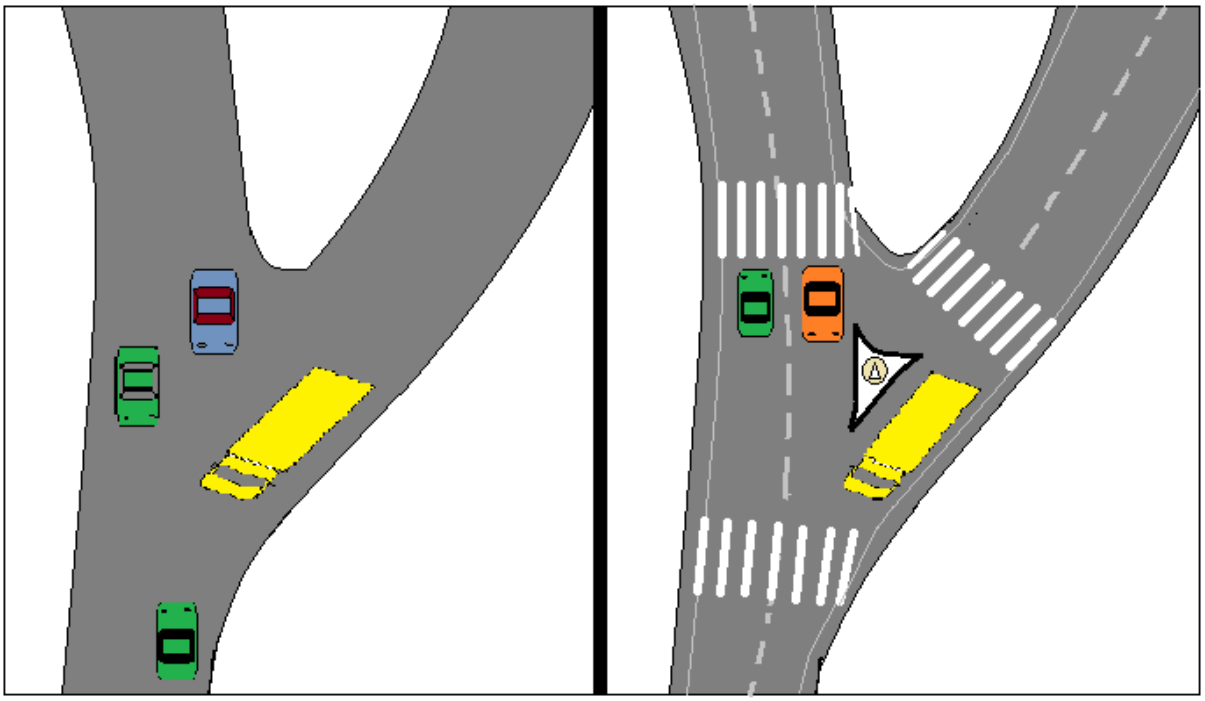
9) The inexperience among the drivers of younger age group has also been observed as one of the main reasons of accidents at site.
10) The separate lanes are required to be provided at the site for waiting vehicles, as it has been observed that waiting vehicles are affecting the capacity of junction.

6.3 Recommendations

On the basis of above mentioned conclusions, various recommendations can be made which have been described as follows: -

1) It is to be recommended to have the provision of signal devices at the study area as soon as possible.
2) The proper and strict enforcement is recommendable at the study area in order to have safe and efficient traffic flow.
3) It is recommended to have separate lanes for the waiting vehicles which, otherwise, restrict the capacity of the junction.
4) The proper signs and markings are recommended at site because it will be helpful in order to deal with undesirable turning movements of the vehicles.
5) It is recommended after the study to enforce speed limits for the vehicles at the study area to reduce accidents.
6) The consumption of drugs and alcohol are required to be decreased and proper enforcement should be there to reduce drunk and drive cases.
7) The proper enforcement for checking the licensing of the drivers is highly recommendable at site and inexperienced under-aged drivers are required to be prohibited strictly.
8) It is recommended on the site to have STOP and GIVE WAY signs and these should be appropriately visible to the road users.
9) It is recommended to provide pavement edge lines on the site in order to indicate the edges of the carriageways having no curbs. It will give guidance to the drivers about the limits up to which they can safely drive.
10) The transverse markings are also recommended to be applied as the study area approaches to a three-legged intersection.
11) The pedestrian crossings are also recommendable and are necessary to be applied on the site in order to reduce the conflicts between pedestrians and vehicular movements.

The Fig. 6.1 shows the present situation of the junction without any improvements and the future scenario which could be possible only after applying various requirements such as control devices, signs, signals and various road markings.



a) Present scenario at the junction **b)** Junction after improvements

Fig. 6.1 Scenarios of the Junction **(a)** Before Improvements **(b)** After Improvements

REFERENCES

1) RAMESH SURISETTY and S. SIVA GOWRI PRASAD (2011) -*"Estimation of Capacity at Un-Signalized Intersections under Mixed Traffic Flow Conditions" Volume-3, (2011).*

2) JOEWONO PRASETIJOA, MEHDI HOSSEIN POURA and SEYED MOHAMMAD REZA GHADIRIA (2011) - *"Capacity of Unsignalized Intersections under Mixed Traffic Conditions" 6th International Symposium for Highway Capacity and Quality of Service in Stockholm, Sweden June 28–July 1, (2011).*

3) AMUDAPURAM MOHAN RAO and KALAGA RAMACHANDRA RAO (2012) - *"Measuring Urban Traffic Congestion – A Review" International Journal for Traffic and Transport Engineering, (2012).*

4) SURENDRA R. KUKADAPWAR and DR. D. K. PARBAT (2012) - *"Modelling of traffic congestion on urban road network using fuzzy inference system" Volume- 4, (2012).*

5) DIPAK K. THAKOR, DR. L B ZALA and PROF. A A AMIN (2014) - *"Traffic Flow Characteristics For Heterogeneous Traffic On Urban Road-A Case Study Of Selected Stretch Of Anand City" Volume-2, (2014).*

6) ABDUL MOQTADR YOUSUFZAII, WASEEM BHATT and ANUP BHAARDWAJ (2016) - *"Capacity Evaluation Of Rotary Intersection In Kabul Afghanistan" Volume-3, (2016).*

7) SHREY PAHUJA (2013) - *"Capacity Estimation of 4-lane divided Inter Urban Hill Road Using Videography Technique" Submission Number:223, (2013).*

8) DANISH ZAFFAR WANI and DR. MS MIR (2016) – *"Estimation of the capacity on un-signalized traffic junction at mixed flow conditions of traffic" Volume - 3, (2016).*

9) JIAN-AN TAN and FRANCO TUFO (1997) – *"Procedure of Capacity Analysis for unsignalized intersection in Switzerland" CITEC Ingenieurs Conseils SA (1997).*

10) B. SUDARSHAN REDDY and N. VENKATA HUSSAIN REDDY (2016) – *"Signal Design for T-intersection using Webster's method in Nandyal town, District Kurnool of Andhra Pradesh" Volume-3, (2016).*

11) KADIYALI L.R. (2013) - "*Traffic Engineering and Transportation Planning", Khanna Publishers, New Delhi*.