ANALYSIS AND IMPACT OF ROADWAYS CONDITIONS, TRAFFIC FEATURES AND MAN-MADE FEATURES ON ROADS SAFETY

Submitted in partial fulfillment

Of the requirements for the degree of

Master of technology

In

Civil engineering

With specialization in transportation engineering

By

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2016

DECLARATION

I, **Kushagra Pandey (registration no- 11003582)**, hereby declare that this thesis report entitled "**Analysis and impact of roadways conditions, traffic features and man-made feature on roads safety**" submitting in the partial fulfillment of the requirement for award of degree in Master of Civil engineering from the School of Civil Engineering, Lovely Professional University, NH-1, Phagwara is my own work. This matter embodied in the report hasn't submitted fully or partly to any universities nor any institutes for the awarding of any degree.

Date: Kushagra Pandey

Place:

CERTIFICATE

It is to ratify that this thesis report titled "**ANALYSIS AND IMPACT OF ROADWAYS CONDITIONS, TRAFFIC FEATURES AND MAN-MADE FEATURE ON ROADS SAFETY**" submitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara, sustained the works under my management for the award of degree. The report hasn't been offered to any other university or institution for the award of degree. This report has not been submitted to any universities or institutions for awarding of any degree or certificate.

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ABSTRACT

India is in developing phase and safety of the country on roads is in premature stage at this stage. Accidents increasing day by day leading a great loss of life, some having disablements, other as damage to property and health and degradation of environment resulting the situation in India to a tocsin stage.

Official records show that approx..1,42,000 persons were killed and approx. 4,80,000 injured in traffic accidents in India in 2014 (NCRB 2015). However, this is an under estimate of figures since many accidents are off the records also as all the accidents are not reported. This higher accident rate is due to inadequacy of highways and GT roads which cannot meet the traffic demands or some other reasons like vehicular defect, poor road geometry or road user behavior. These accidents deal a heavy blow to economy of country. Hence, road safety is a necessity for reduction in accidents.

Punjab is on the other hand is a state of country having 46% fatal accidents on state highways of total 6 2 0 0 0 km of road network. This state has to work upon safety of people as its records is also at alarming stage. NH-1 is the first national highway designed during construction stage and is also called Grand Trunk road in older Mughal period. NH-1 is a major connection between Amritsar to Delhi having a length of 456 km catering transportation of heavy goods, light goods and travelers passing Jalandhar Phagwara, Ludhiana, Kurukshetra, Panipat and Sonipat.

The selected stretch of road is a portion of NH-1 for studying and recording data related to the topic. Stretch covers a distance of 14.8 km between Jalandhar Bus Stand to Haveli, Village-Paragpur, NH-1, Jalandhar. Location is 98 km away from Amritsar. The lane of the road is not uniform. The accident data will be collected between this stretch analyzing black spots where traffic accidents often occurs. Data will be analyzed using Accident Frequency and Accident Severity Index method. Then further deficiencies if any will be dealt and suggested with further improvement.

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LIST OF ABBREVIATION

MORTH	Ministry of Road Transport and Highways
CAGR	Compounding Annual Growth Rate
ADT	Average Daily Traffic
AADT	Annual Average Daily Traffic
NH	National Highways
ITS	Intelligent Traffic System
LOS	Level of Service
FIR	First Information Report
PRADMS	Punjab Road Accidents Database Management Systems
AMS	Accident Management System
IPC	Indian Penal Code
PWD	Public Works Department
PCU	Passenger Car Unit

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CHAPTER 1

INTRODUCTION

1.1 General

Developing countries like India have serious issues when road accidents are concerned. It's a humanitarian havoc around globe. Approx. 3000 people face death daily around the globe.

Road safety on the other hand is a serious problem in India. Each year about 1.4 million people face death and about 40 million gets injured in India. If these facts will continue then as a result Traffic accident will stand 3rd among the leading contributors for Disease and Injury by 2022. (Torregrosa et al., 2012)

Fatality rates are high and rising. Fatality rate is the ratio of deaths per population in area. In this India, can earn a distinction as the fatality rates in our country is quite high as Road Safety is less practiced here. It is a major concern not only in India but also around globe.

Accidents are the reason of draining out the national economy also. As an estimate, World Bank says about $1 trillion i.e., about 4 % of the GDP (Gross Domestic Product) is lost through accidents.

Indian roads almost carry about 95% of passengers traffic and about 60% of freight resulting in increase of mortality rate per 10,000 vehicles to 15 compared with less than two for other developed countries due to heterogenous traffic on the lane. It almost includes all motorbikes, cars, buses, trucks, rickshaws, three-wheeler IPT's, bicycles, bullock carts etc.

Inadequate road safety, potholes or ruts formation on road, bad license system giving each and every person by paying some amount and also drunkards and underage driving can and should be blamed for these increased accident rates. As an estimate about 250 people are daily killed.

The concern of increasing motor vehicles on road should be also checked as it is of utmost importance because novice drivers who even don't understand basic motor skills are incapable to face a huge traffic but they drive recklessly. The increasing motor vehicles are because of these novice drivers aged 17-20 are provided with cars and bikes by the parents keeping road safety at stakes. It is a problem seen by developing countries where the economies are increasing and making cars affordable to people.

The situation in India is worsening as the road traffic injuries are increasing over past years. As shown in Figure 1.1,

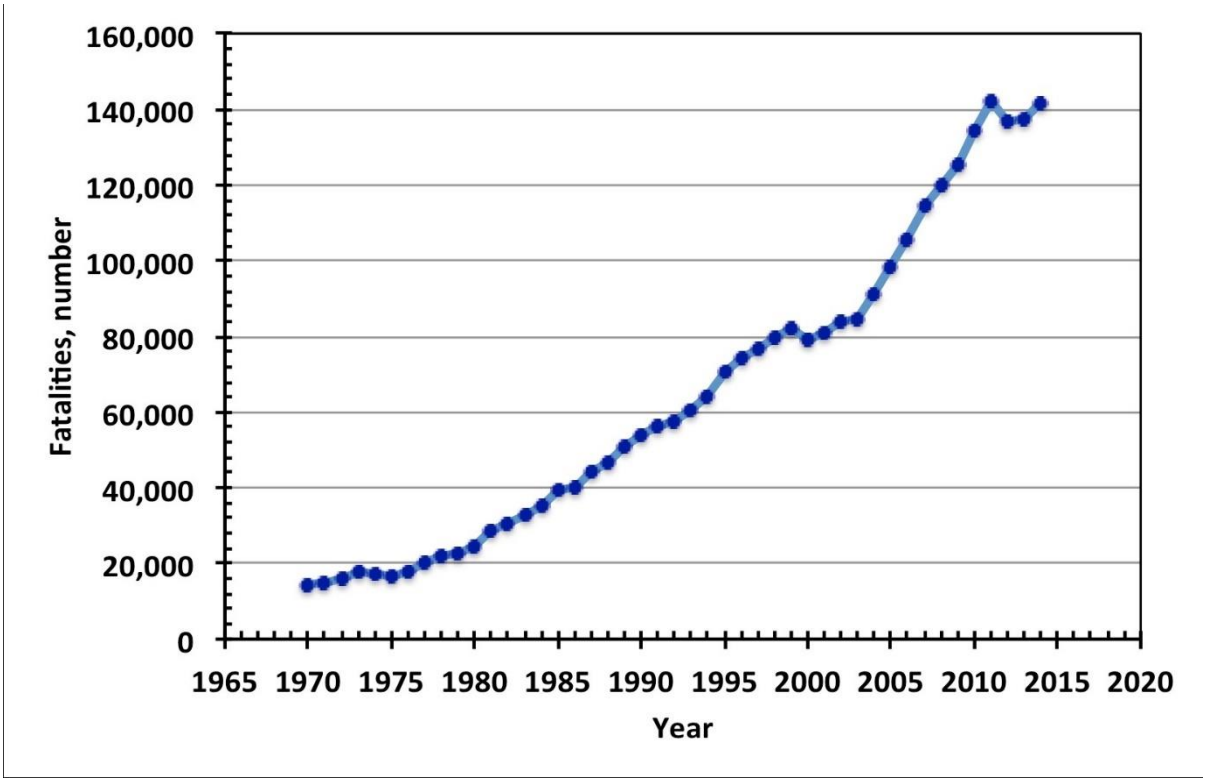


Figure 1.1 Traffic deaths from 1965-2020 estimate (Source: NCRB)

These data show the increment in the no. of fatalities over past years at a rate of about 7-8% a year.

Now, if these facts and figures are concerned then Road safety is a many sided and inter-sectoral issue. It includes expansion, management and development of roads, provision of safe vehicles, urban land use, child safety etc.

Causes of accidents are variable. There are different causes described in the statistics of road accidents in India in 2012

Table 1.1: Causes of accidents by road accidents report in India (2012)

Causes of accidents	**Percentage**
Accidents due to defects in vehicle	78%
Accidents due to driver fault	1.5%

Accident due to fault of pedestrian	1.3%
Accident due to bicyclists	2.4%
Accident due to weather condition	Less than 1%
Other accidental causes	15%

1.1.1 Causes of accidents

Since Indian roads have a heterogeneous traffic so road safety strategy of the driver should be prevention of fatal crash and death. Safe road geometrics can help ensuring vehicle speeds within human tolerance if any conflicting point exists.

Accidents happen due to various causes because of the followed factors as shown in Figure 1.2

a. Vehicles
b. Driver
c. Environment

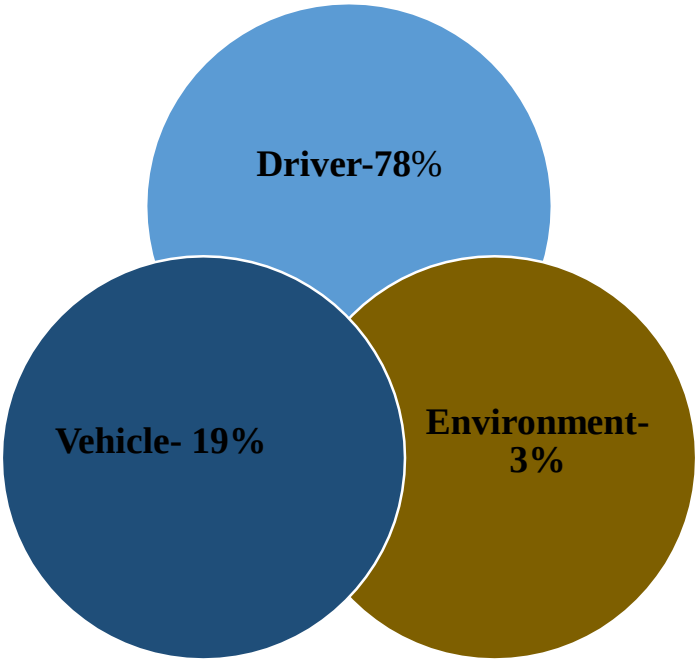


Figure 1.2: Causes of accidents

The details of various factors affecting and causing accidents are shown below in Table 1.2

Table 1.2: Various factors causing accidents

Vehicle related factors	
Overload	Tyre failure
Lights defects	Steering defects
Brake defects	Inappropriate wheel aligns
Driver related factors	
Unsafe speed	Distraction
Alcohol and drugs	Non-use of restraint
Fatigue	Sickness
Drowsing	Disregard to traffic controls
Inappropriate turning or passing	Cell phone use
Environment related factors	
Inappropriate traffic control	Water ponding
Fixed objects	Ruts and holes
Faulty shoulder	Garbage and debris
Road side hazards	Smog, fog or smoke
Vision obstructions	Glaring

1.1.2 Position of vehicles, types of accidents and its consequence

Accident inflicts indescribable and indisputable cost. Details are further explained in the Table 1.3 and Figure 1.3.

Table 1.3: Position of vehicles, types of accidents and its consequences

Position of vehicle	**Types of accident**
Vehicles from same direction	Rear end collision
Vehicles from opposite directions	Head on collision
Vehicles from adjacent direction	Angular collision and turning
While overtaking	While backing, or parking
Off-path roads	Run-off road

Off-path curves	Fixed objects like trees and poles
On-curve turning	Bikes and bicycles
Head on collision	Pedestrians crossing
Head on collision	Animal crossing road
Consequences	
Sprains (ankle/Joint twist)	On-Spot deaths
Vision/speech/hearing impairments	Loss of consciousness
Head or neck injury	Abrasion
Chest pain or respiratory impairment	Property losses
Amputation	Fracture

The figure is representing the directions of accidents below shown Figure 1.3

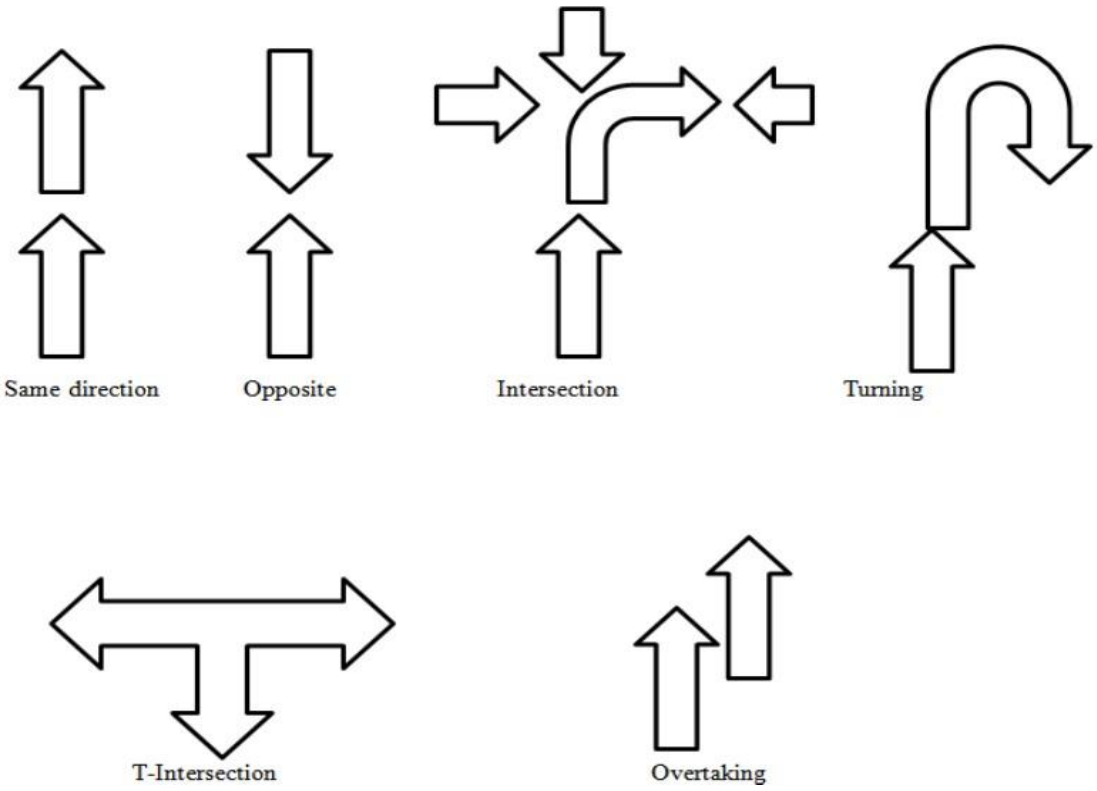


Figure 1.3: Crash positions of vehicle

1.1.3 Collision types and Accident Theory

Accidents are of different types:

a. Head on collision – Head to head collisions between both vehicles
b. Rear-end collision – Collisions between rear-end of 1st vehicle and head of 2nd vehicle.
c. Angular collision – Collision at an angle while turning.

Accident theories:

These theories are given to calculate the impact and energy absorbed by both vehicles are as follows:

a. **Poisson Impact Theory**: Poisson theory is based on restitution and compression. It separates the crash of vehicle in two phases:

i. Compression
ii. Restitution

Figure 1.4 presents 2 cars which are having initial speed v_1 and v_2 which collide and then have uniform speed u in the compression stage of both vehicles. After compression stage completes and deformation of the cars, a final speed of both car is obtained, u_1 and u_2 respectively.

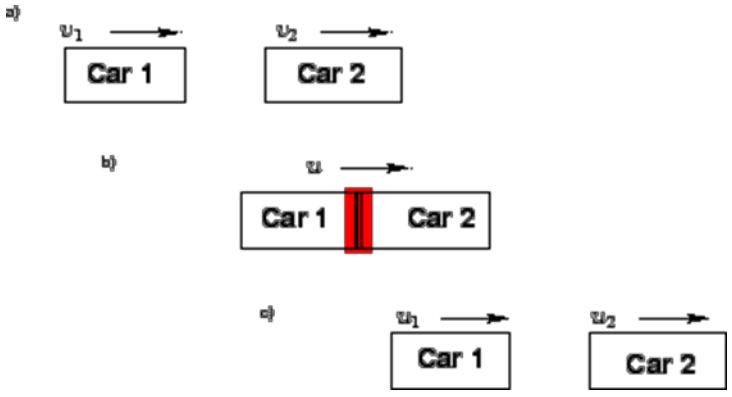


Figure 1.4 Representation of Poisson Impact at compression stage

Then according to Newton's second law of motion,

$$F = m*a$$

Where m are the masses of the car and a is the acceleration of both the cars after colliding. Then,

$$m_1 \frac{dv_1}{dt} = -F \quad \text{and} \quad m_2 \frac{dv_2}{dt} = F$$

Where, m_1 and m_2 is the mass of both cars and F is the contacting force while colliding. Now, according to Newton's 3rd law of motion, force provided by 1st car is equal to the force applied by 2nd car while collision. Hence, 1st car pushes the 2nd car with force F. The 2nd car will also exert force on the 1st car with same force index but in a divergent direction.

The force of action F and the reaction force $-F$ are shown in Figure 1.5 below

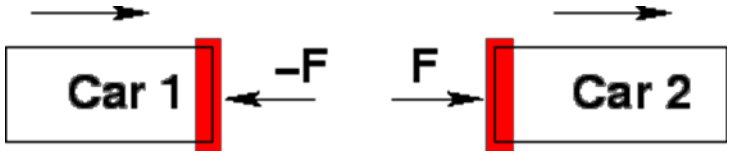


Figure 1.5: Representation of action and reaction force

Hence from this we will further calculate Compression impulse (P_c),

$$m_1(u - v_1) = -P_c \; m_2(u - v_2) = P_c$$ where

$$P_c \equiv \int_0^{\tau_c} F \, dt$$ where P_c is the compression impulse, and is τ_c the compression time in which both the cars after colliding will be join to one another compressing each other. Thus, final speed u after the collision will be calculated as:

$$u = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$$

then the compression impulse will be calculated as,

$$P_c = \frac{m_1 m_2}{m_1 + m_2}(v_1 - v_2)$$

Thus, in the restitution phase, an internal energy is released from the elastic part. Hence,

$$m_1(u_1 - u) = -P_r$$

$$m_2(u_2 - u) = P_r$$

Where $P_r \equiv \int_0^{\tau_r} F\ dt$ is the impulse of restitution and τ_r is the restitution time. Now, restitution impulse is equal to compression impulse as per the Poisson's hypothesis.

$P_r = e\ P_c$ now ***e*** is the restitution impulse given by,

$$e = \frac{u_2 - u_1}{v_1 - v_2}$$

The total impulse (***P***) then will be $P = P_c + P_r$ and is equal to,

$$P = (1+e)\frac{m_1 m_2}{m_1 + m_2}\Delta v$$

Thus, post collide or impacts velocities will be given by,

$$u_1 = u - e\frac{m_2}{m_1 + m_2}\Delta v = v_1 - \frac{(1+e)m_2}{m_1 + m_2}\Delta v$$

$$u_2 = u + e\frac{m_1}{m_1 + m_2}\Delta v = v_2 + \frac{(1+e)m_1}{m_1 + m_2}\Delta v$$

Where $\Delta v = v_1 - v_2$. Now since we were necessitating to find out the pre-impact speed from which safety on roads are planned. So, we need to find out v_1 and v_2 from u_1 and u_2.

b. **Energy theory**: This theory applies law of conservation of energy hence the inceptive speed of vehicles can be calculated if skid mark is considered after the accident. In this theory skid resistance is against work done due to reduction in kinetic energy. Hence, if vehicle ***W*** decelerates from speed V_1 to V_2, then kinetic energy loss would be equivalent to work against skid resistance. It is represented by

$W (V_1^2 - V_2^2)/2\ g = f.S.W$

where, ***f*** is the co-efficient of skid resistance and ***S*** is the distance of skid marks.

1.1.4 Haddon's Matrix:

This matrix focuses on factors relating the person's attribute, vehicular attributes and environment factors. The matrix was designed by William Haddon in 1970 to understand the relative importance of different factors and design problems. This matrix is shown in Table 1.4

Table 1.4: Haddon Matrix (Source: http://en.wikipedia.org/wiki/haddon_matrix)

Phases	**Factors related to Human**	**Factors related to vehicle and equipment**	**Factors related to Environment**
Pre-crash	Attitudes Police Enforcements Information Impairments	Breaking Speed management Lighting Road worthiness	Design of road and its layout Pedestrians facilities Speed limiting
While crash	Impairments Restraints usage	Crash-protective designing Other devices for safety purpose	Crash-protective designing along road side
Post-crash	Access to medics First-aid	Ease of access Fire risks	Congetion Rescuing facilities

1.2 Need and Objective of study

Road network expansion, motorization surging and increased population will and can cause increment in road accidents. Thus, CAGR has increased to 3.4%, 10% and 1.62% respectively in terms of number of accidents, registered motor vehicles and country population during 2001-2011. Similarly, road accidents and no. of people injured while road accident were about 6% and 2.5% respectively.

Less work has been carried out to analyze accidents on 4-lane roads in India. Some of the major objectives of this work are listed below:

i.) To study the variation in accidents rate (i.e., annual, monthly, daily and hourly) on selected stretch.

ii.) To study effects relating volume of traffic, traffic density and traffic capacity on the selected stretch.

iii.) To study road surface maintenance and shoulder maintenance on accident rate

iv.) To design a prediction model for accident (APM) based on AADT, road side features and the condition of road.

1.3 Outline of report

The documentation and records have been represented in the following manner.

Chapter 1 deals with existing accident outline at the national and state level. It incorporates significance of 4-lane roads, their safety and defines objectives.

Chapter 2 comprehend literature review.

Chapter 3 discusses the stretch selection for data computation and the methods adopted for collecting data.

Chapter 4 comprises of traffic properties of the stretch.

Chapter 5 deals with accident results and analysis of black spot

Chapter 6 comprises of conclusion and the recommendation of the report.

CHAPTER 2

LITERATURE REVIEW

Factors exhibits influence of driver behavioral issues and road safety on 4 lane highways. These are limited to,

A. Traffic factor which include traffic speed, traffic density, traffic volume, mixing of traffic and variations in the laning.
B. Humanitarian factors including inappropriate judgement due to influence of alcohol and drugs, uneducated and inexperienced drivers etc.
C. Deficiencies in vehicles including non-working and defective braking systems, inappropriate headlights, tyres etc.
D. Condition of roads including slipping, skidding surface, ruts etc.
E. Condition of weather like rainfall, smog, snow etc.
F. Several other causes including law enforcements, inappropriate display of road signs and signals, road side advertisements etc.

2.1 Characteristics of driver

2.1.1 Perception

Deery et. al., (1999) concluded that hazard perception among novice drivers are needed to be developed.

Sagberg Bjornskau et. al., (2006) concluded that young male drivers have extended time of reaction than normal reaction time by conducting video hazard perception tests.

2.1.2 Drugs and alcohol

Shivkumar, Krishnaraj et. al., (2012) Alcohol causes deteriorated driving even when having low levels increasing the probability of accidents. It is not digested instead absorbed in the blood stream. After drinking alcohol judging of driver impairs tending him to take more risks resulting in longer reaction time.

Boni et. al., (2010) conducted study on 600 patients and concluded crashes happened between 6pm to 6am while returning from bars and pubs and most of them were drugs dependants.

2.1.3 Age and gender

Chandraratna et. al., (2006) concluded after using Logistic method that younger drivers are involved in crash due to over-speeding and old drivers involved in crash due to non-speeding.

Aty, Hasan et. al., (2012) concluded that young driver having behavior issues suffer accident in Florida due to factors like aggressive violation or in-vehicle distractions.

2.1.4 Speed

Schagen, Aarts et. al., (2006) concluded that speed of vehicle is a beneficial factor in road safety management because speed increases the crash rate.

Lee et. al., (2006) concluded that speed limit when varies can reduce crash by 10% approx. he designed a crash prediction model relating crash potetial reduction and total time.

2.1.5 Fatigue

Driver's fatigue is also a main concern for long set out journey.

Houquani et. al., (2012) concluded fatigue is an important factor affecting traffic collision while studying hospitalized drivers and advised to not continue driving if feeling sleepy.

2.1.6 Mobile phones

Boiling, Tornros et. al., (2005) concluded by experimenting on 48 drivers that speed was decreased for users having hands free while driving performance was greatly reduced by using hand held. Also, reaction time was decreased by hand helds.

2.1.7 Use of restraints

Jamalludin et. al., (2013) concluded that seatbelt reduces crash severity.

Shreedharan et.al., (2010) concluded that non-use of crash helmets will suffer more head injuries among motorcyclists. He found approx. 70% motorcyclists were without helmet in Kerala.

2.2 Vehicular characteristics

Vehicle defectiveness are also a major factor in many accidents. They are caused by either due

to defective wheel alignment, failing of brakes, overloaded vehicles etc.

2.2.1 Brake Failures

Oduro et. al., (2012) concluded that approx. 80% of brake failure results in mishaps. Inappropriate braking efficiency is caused by uneven tyre pressure, inappropriate brakes adjustments, leaking of brake fluids or cracked brake drum.

2.2.2 Overloading

Osama et. al., (2012) concluded that overloaded vehicles can cause much damage and increase maintenance cost.

Chan et. al., (2008) concluded that overloaded trucks have a reduced braking ability and stability.

2.2.3 Tyre defects

Okorie, Osueke et. al., (2012) concluded that tyre defects due to overloading, under inflation etc. should be changed after every 6 years from manufacturer's date.

2.3 ENVIRONMENT CHARACTERSTICS

2.3.1 Elements of road

Shinar, Basat et. al., (2012) concluded that guard rails, shoulder width and geometry of road has a significant effect on safe speed.

2.3.2 Road side features

Somchainuek et. al. (2013) concluded that over speed of vehicles involves them more in road side crashes for about 32% of total road side crash were caused due to trees on sides of road.

2.3.3 Surface discontinuities

Forest et. al. (2009) designed relation linking surface discontinuities and accidental frequency. The accidents due to surface discontinuity is shown in Table 2.1

Table 2.1: Surface Discontinuities and Accident frequencies

Discontinuities	Accident Frequency	Discontinuities	Accident Frequency
Dropped	173	Dip	9
Water	143	Track	3
Hole	34	Patch	11
Edge	59	Ruts	4
Soft	71	Bump	9
Rock	19	Manhole	2
Rail	24	Bumps	2

2.3.3 Signals and Signs

Chen et. al. (2012) concluded that signals related countermeasures were designed for reduction in conflict were phase split, signal installation, pedestrian phases etc. reduces crashes. He designed a traffic safety model by regression method for New York.

2.3.4 Volume of traffic

Golob et al. (2004) concluded that implementation of ITS and enhancing education of the driver for safe speed will result in less lane-change crashes. He designed and analyzed relationship between flow of traffic and accidents.

Hisellius et. al. (2004) concluded that if the traffic flow is homogenous then accident rate decreases. He analyzed that trucks had a decrease in accidents and car accident rate was constant.

2.3.5 Fog and Smoke

Mohmed et. al. (2012) concluded that crashes due to obstruction in visibility can be caused due to smog in Florida (USA). He analyzed that smog obstructed crashes likely happen in night due to improper lighting. Head on collisions and rear end collisions were most prevalent.

CHAPTER 3

METHODOLOGY AND DATA COLLECTION

In this study, collection of data is from the accident studies which were collected from FIR lodged in the police stations and through a new type of information system called Punjab Road Accident Database Management System (PRADMS). The data was collected for 5 years (2010-2015) and was tried to be extracted from PRADMS more. Also, FIR records filed under IPC no. 279, 337, 338 and 304(A) were considered for data collection. Details of this will be further illustrated.

3.1 Selection of Stretch

Two lane and four lane roads from Jalandhar bus stand to Haveli, Village-Paragpur, NH-1, Phagwara on NH-1 was selected as the required stretch. Selected prone locations for higher probability of accidents are selected below and shown in Figure 3.1 below:

i. Jalandhar bus stand to PAP (Punjab Armed Police) Chowk
ii. PAP chowk to Rama mandi
iii. Rama mandi to Dakoha fatak
iv. Dakoha fatak to Haveli, Village-Paragpur, NH-1, Phagwara

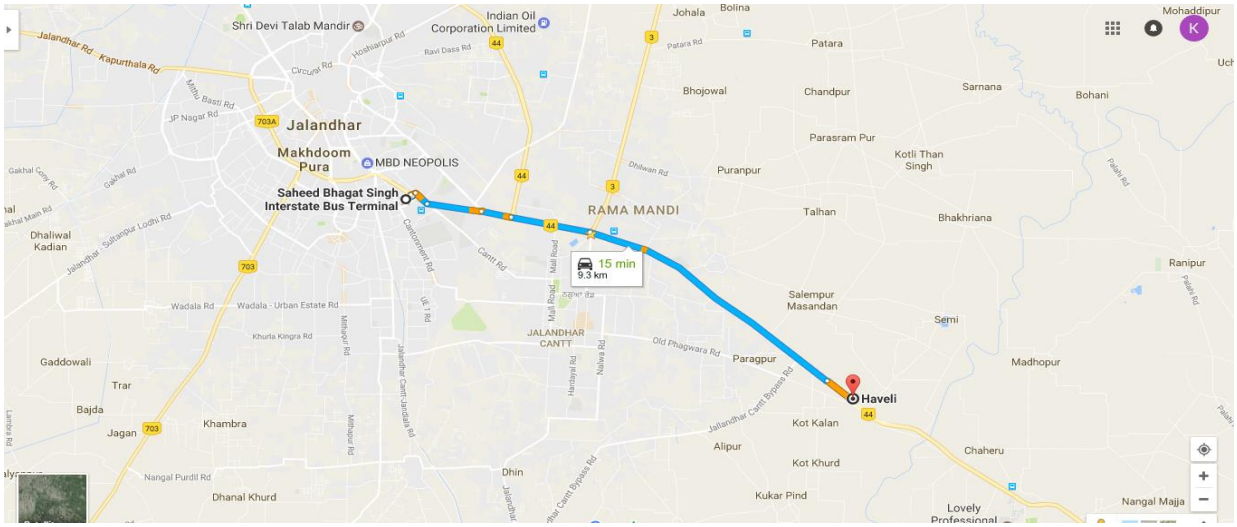


Figure 3.1: Selected stretch for study (Source: Google Maps)

A flow diagram for better understanding to further procedures is illustrated in Figure 3.2.

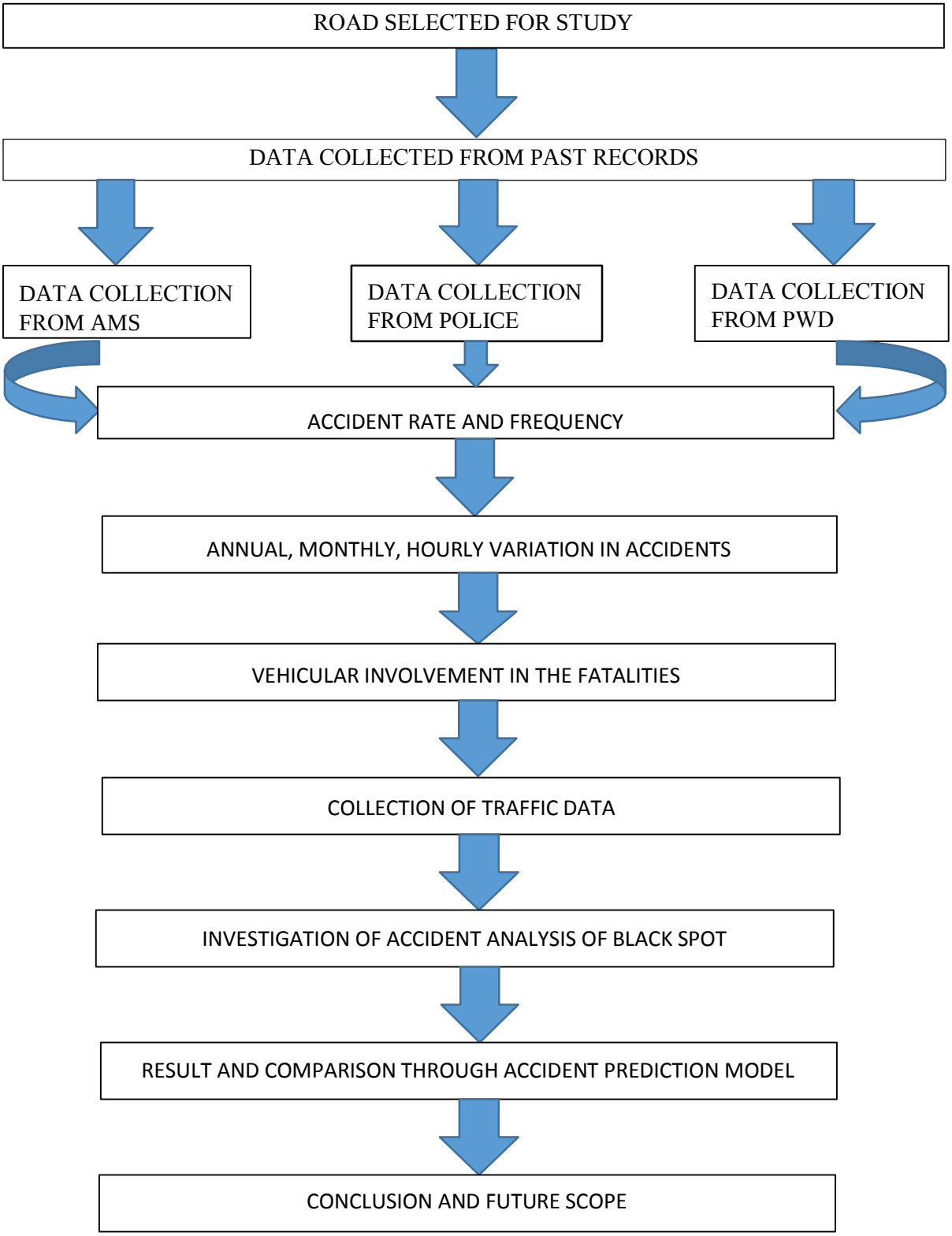


Figure 3.2: Stepwise Flow chart of the study

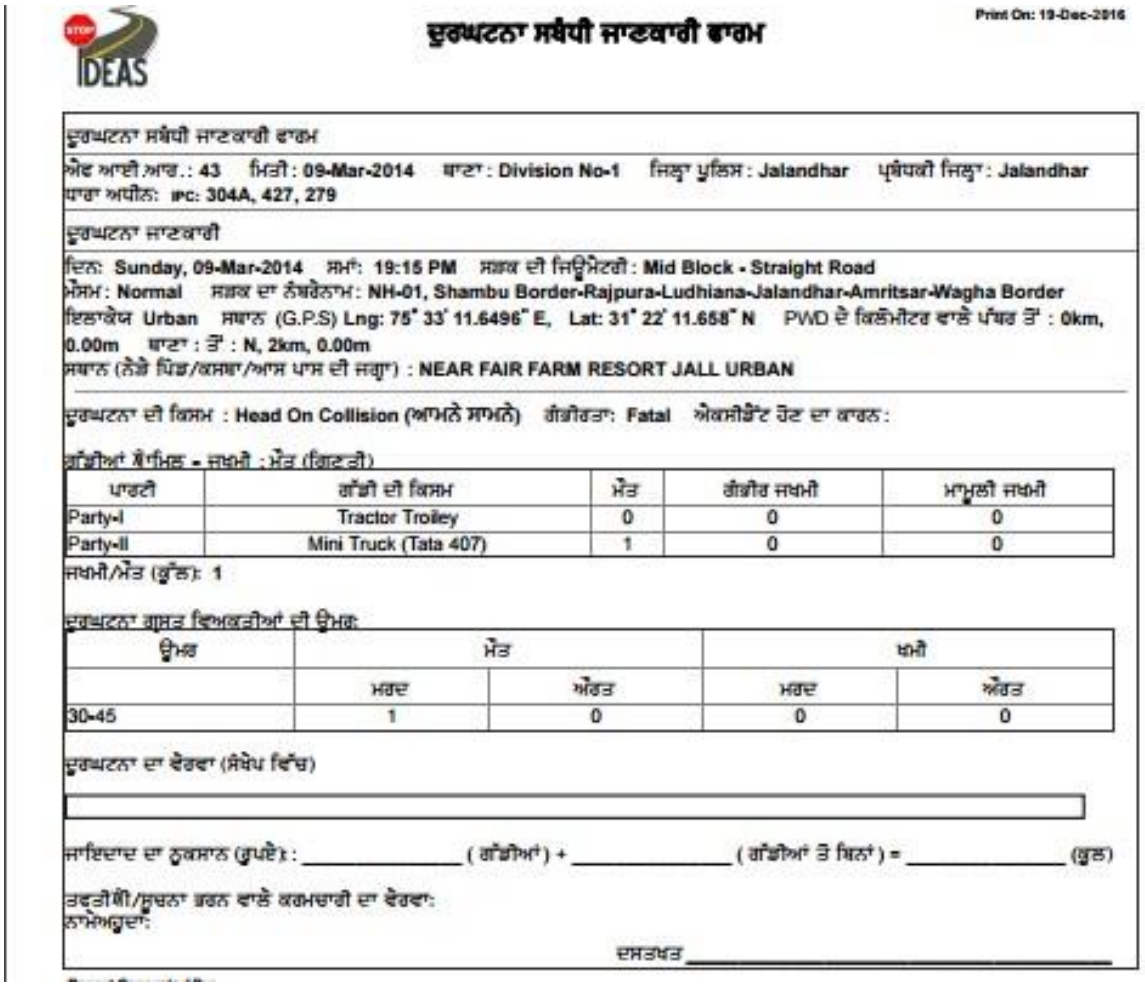
3.2 Data collection from FIR and PRADMS

The following data was collected from the PRADMS and displayed in Table 3.1.

Table 3.1: Name of Police Station and road section covered

Police stations	Road sections
Jalandhar bus stand	Km 0 to Km 2.1 on NH-1
PAP chowk, Jalandhar Bus stand	Km 2.1 to Km 5.6 on NH-1
Rama mandi	Km 5.6 to Km 7.7 on NH-1
Village-Paragpur, NH-1	Km 7.7 to Km 9.3 on NH-1

These police stations had records of past decade. The data was tried to be extracted of prior 5 years from the FIR filed under IPC no. 279, 337, 338, 304 (A). A sample copy of FIR is shown in Figure 3.3



ਦੁਰਘਟਨਾ ਸਬੰਧੀ ਜਾਣਕਾਰੀ ਫਾਰਮ

Print On: 19-Dec-2016

ਦੁਰਘਟਨਾ ਸਬੰਧੀ ਜਾਣਕਾਰੀ ਫਾਰਮ

ਐਫ ਆਈ ਆਰ.: 43 ਮਿਤੀ : 09-Mar-2014 ਥਾਣਾ : Division No-1 ਜਿਲ੍ਹਾ ਪੁਲਿਸ : Jalandhar ਪ੍ਰਬੰਧਕੀ ਜਿਲ੍ਹਾ : Jalandhar
ਧਾਰਾ ਅਧੀਨ: IPC: 304A, 427, 279

ਦੁਰਘਟਨਾ ਜਾਣਕਾਰੀ

ਦਿਨ: Sunday, 09-Mar-2014 ਸਮਾਂ: 19:15 PM ਸੜਕ ਦੀ ਜਿਉਮੈਟਰੀ : Mid Block - Straight Road
ਮੌਸਮ : Normal ਸੜਕ ਦਾ ਨੰਬਰਨਾਮ: NH-01, Shambu Border-Rajpura-Ludhiana-Jalandhar-Amritsar-Wagha Border
ਇਲਾਕੇਯ Urban ਸਥਾਨ (G.P.S) Lng: 75° 33' 11.6496" E, Lat: 31° 22' 11.658" N PWD ਦੇ ਕਿਲੋਮੀਟਰ ਵਾਲੇ ਪੱਥਰ ਤੋਂ : 0km, 0.00m ਥਾਣਾ : ਤੋਂ : N, 2km, 0.00m
ਸਥਾਨ (ਨੇੜੇ ਪਿੰਡ/ਕਸਬਾ/ਆਸ ਪਾਸ ਦੀ ਜਗ੍ਹਾ) : NEAR FAIR FARM RESORT JALL URBAN

ਦੁਰਘਟਨਾ ਦੀ ਕਿਸਮ : Head On Collision (ਆਮਨੇ ਸਾਮਨੇ) ਗੰਭੀਰਤਾ: Fatal ਐਕਸੀਡੈਂਟ ਹੋਣ ਦਾ ਕਾਰਨ :

ਗੱਡੀਆਂ ਬੰਪਮਿਲ - ਜਖਮੀ : ਮੌਤ (ਗਿਣਤੀ)

ਪਾਰਟੀ	ਗੱਡੀ ਦੀ ਕਿਸਮ	ਮੌਤ	ਗੰਭੀਰ ਜਖਮੀ	ਮਾਮੂਲੀ ਜਖਮੀ
Party-I	Tractor Trolley	0	0	0
Party-II	Mini Truck (Tata 407)	1	0	0

ਜਖਮੀ/ਮੌਤ (ਕੁੱਲ): 1

ਦੁਰਘਟਨਾ ਗ੍ਰਸਤ ਵਿਅਕਤੀਆਂ ਦੀ ਉਮਰ:

ਉਮਰ	ਮੌਤ		ਜਖਮੀ	
	ਮਰਦ	ਔਰਤ	ਮਰਦ	ਔਰਤ
30-45	1	0	0	0

ਦੁਰਘਟਨਾ ਦਾ ਵੇਰਵਾ (ਸੰਖੇਪ ਵਿੱਚ)

ਜਾਇਦਾਦ ਦਾ ਨੁਕਸਾਨ (ਰੁਪਏ): _____ (ਗੱਡੀਆਂ) + _____ (ਗੱਡੀਆਂ ਤੋ ਬਿਨਾਂ) = _____ (ਕੁਲ)

ਤਫਤੀਸ਼ੀ/ਸੂਚਨਾ ਭਰਨ ਵਾਲੇ ਕਰਮਚਾਰੀ ਦਾ ਵੇਰਵਾ:
ਨਾਮ/ਅਹੁਦਾ:

ਦਸਤਖਤ _____

Figure 3.3 Sample copy for FIR (Source: PRADMS)

Accidents during 2012-2016 on this stretch is shown in Table 3.2. Accidental data was poised yearly from PRADMS and accident records from police stations.

Table 3.2: Accident details between the stretch of road

Year	Fatal	Major injury	Minor injury
2012	0	3	12
2013	1	2	9
2014	0	2	6
2015	1	1	8
2016	2	1	7
Total injury	4	9	55

3.3 Collected Data of Central Public Works Department

PWD records were also collected for the details of the road section. A proforma used to record the details is shown in Table 3.3 for Jalandhar bus stand of different points. The first point is the road connecting to Jalandhar Bus Stand connecting Model town, Jalandhar and Choti Baradari, Jalandhar. The second point of manual collection of road width was road connecting Jalandhar Bus Stand and Police Lines, Jalandhar and PAP chowk. Third point of manual collection of road width is road connecting Jalandhar Bus Stand and Skylark Hotel, Namdev Chowk, Jalandhar.

Table 3.3 Data collection of road width of Location-1: Jalandhar Bus Stand
(Source: Manual Collection)

Carriage way width	7m	7.2m	7m
Formation width	14m	12m	12m
Width of land	32m	29m	31m
Footpath width	1.4m	none	1.3m

A typical cross section of Jalandhar bus stand can be seen in the Figure 3.4 below.

Figure 3.4: Jalandhar bus stand Road width (Source: Manual Study)

Manually data was collected from Location-2 at PAP chowk. This location is T-point connecting Jalandhar to Amritsar and Jalandhar to Ludhiana. Instrument used was a measuring tape. The first point is road connecting Jalandhar bus stand to PAP chowk. Second point is connecting Jalandhar bus stand to Amritsar via PAP chowk. Third point connects PAP chowk to Phagwara and Ludhiana.

Table 3.4 Data collection of road width at Location-2: PAP chowk (Source: Manual Collection)

Carriage way width	14.4m	17m	15m
Formation width	16m	20m	17m
Width of land	28m	26m	31m
Footpath width	1.6m	1.8m	1.5m

Another data was collected on Location-3 at Rama Mandi Chowk. This location is again an intersection joint connecting Jalandhar Cantonment to Ludhiana and Jalandhar Cantonment to Chandigarh Bypass. The first point connects Jalandhar City to Rama Mandi Chowk via Jalandhar Cantt. The second point connects Rama Mandi Chowk to Chandigarh Bypass connecting Adampur. The third point connects Rama Mandi Chowk to Ludhiana and Phagwara via Dakoha Fatak and Paragpur. The fourth point connects Rama Mandi Chowk to Jalandhar Cantt. The carriage way width at point S3 and S4 in increased due to presence of service roads on both sides.

Table 3.5 Data collection of road width at Location-3: Rama Mandi Chowk (Source: Manual Collection)

Carriage way width	17m	14.8m	21m	23m
Formation width	19m	16m	24m	25m
Width of land	24m	21m	36m	30m
Footpath width	1.2m	1.3m	None	None

A typical cross section of width while collecting the data of Rama Mandi chowk can be seen in Figure 3.6.

Figure 3.6: Cross section of Rama Mandi Chowk (Source: Manual Collection)

In addition to this, road fatalities in last decade (2001-2012) were collected from the past records. It is illustrated in Table 3.6

Table 3.6: Fatal accidents per year in last decade (2001-2012) (Source: Punjab Road Transport Corporation)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012
Fatal Accidents	2691	2637	2654	2581	2794	3059	3364	3332	3623	3423	3390

Fatalities in Punjab of prior decade (2001-2012) is been represented by a graph issued by Punjab Police as shown in Figure 3.7. Vertical values represent no. of accidents every year and horizontal values are the years the accidents happened.

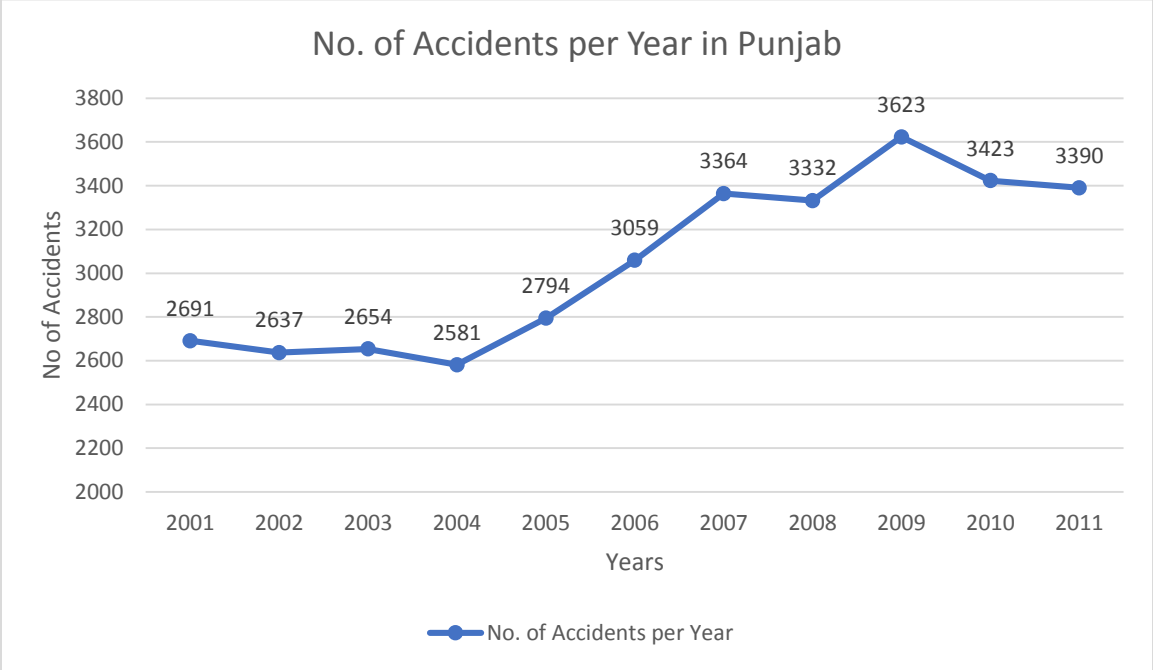


Figure 3.7: Road fatalities graph- Punjab (Source: PRADMS, Punjab Police)

Vehicular population recorded in 2009-2010 by a survey is shown in Table 3.7 below.

Table 3.7: Motor vehicle population in Punjab as per 2010 survey

Year	No. of Buses	No. of Cars	No. of Jeeps	No. of Taxi	No. of three-wheeler	No. of Two-wheeler	No. of trucks lorries	No. of tractors	Total no. of vehicles
2010	27146	486670	54798	13231	57879	3956279	149367	10181	5,254,068

3.4 Traffic properties

Traffic volume survey was carried out for the volume and peak hour traffic flow of vehicles moving across the selected point in both directions. The survey was done on a fair weather day in the generalized peak hours. The vehicular counts were tried to be converted in PCUs. Values as per IRC is shown in Table 4.5

Table 3.8 Standard PCU values as per IRC (Source: Traffic engineering, Dr. L.R. Kadiyali)

Vehicle type	**PCU value**
Cars/jeeps/vans	1.0
3-wheelers	1.0
2-wheelers	0.5
Buses	3.0
Trucks	3.0
LCV	1.5
Tractors	4.5
Cycles	0.5
Rickshaws	2.0
Mini-Bus	1.5

These values were further used for quantifying volume on the selected stretch. The volume count is shown in Table 4.6 below.

Table 3.9 Traffic intensity at the selected two points (Source: Manual collection: Total traffic:puda.gov.in)

LOCATION	Total traffic		Morning peak hours				Evening peak hours			
	Vehicles	PCU	Vehicle	% of total traffic	PCU	% of total PCU	Vehicle	% of total traffic	PCU	% of total traffic
PAP Chowk	57574	50478	5172	8.983	4717	9.344	6541	11.361	5273	10.446
Rama Mandi	61349	60143	4988	8.130	4790	7.929	7544	12.296	6894	11.462

This indicates that the surveyed road has average daily traffic volumes ranged from 55000-62000 clearly as a congested road due to heavy loads of traffic.

Rama Mandi chowk experiences high accommodation of vehicles in evening peak hours of 7544 vehicles as an average traffic volume. While, PAP chowk shows high volume in morning peak hours.

Peak hour duration is assorted because of horde of activities like office timing, school timing starts and end at specific times. Morning peak hour ranges from 8AM-1PM.whereas evening peak hour is between 6PM-8PM.

Traffic composition for the selected point PAP chowk and Rama Mandi is shown in Table 4.7

Table 3.10 Composition of selected point (Source: online source:puda.gov.in)

LOCATION		Fast moving passenger vehicle						Goods vehicles			Sum (No.s)	Sum (PCU's)
		Motor Vehicles			Buses		Total	Truck	LCV's	Total		
		Cars	2-wheel	Auto	Bus	Mini bus						
12 hrs vol. count	D1: PAP chowk to Rama Mandi	17062	11651	5964	255	291	35223	193	164	357	35580	30878
	D2: Rama Mandi to PAP chowk	17918	10706	4403	273	132	33432	201	222	423	33958	33223
	Both direction	34980	22357	10367	528	423	68655	394	386	780	69538	64101
	Composition	50.3	32.15	14.90	0.76	0.608	98.73	0.56	0.55	1.12	100.0	
Morning Peak (9:00 to 10:00)	Both direction	1418	1524	739	17	38	3736	12	48	60	3796	3135
	Composition	37.35	40.14	19.46	0.44	1.00	98.41	0.31	1.264	1.58	100.0	
Evening Peak (18:00 to 19:00)	Both direction	1845	2496	635	10	15	5001	19	45	64	5065	3870
	Composition	36.42	49.27	12.53	0.2	0.3	98.73	0.37	0.88	1.26	100.0	

3.5 Road-side features: Traffic data was collected from the distant two points having ADT and PCU per second was calculated. Rest data was collected manually by visiting the selected stretch. Table 4.8 shows the data of road side features.

Table 3.11 Road-side feature data

Location	ADT	Qmax (PCU/s)	Access roads	No. of Trees	No.of poles	Lighting conditions	Condition of Shoulder
PAP Chowk	57574	0.584	5	4	22	Good	Poor
Rama Mandi	61349	0.70	6	0	16	Average	Poor

From the above observation it can be concluded that the traffic condition exceeds as per the Indian Road Congress guidelines. Hence widening of lanes and construction of the stopped construction of the Flyover at PAP chowk should be administered. As well as Flyover construction stopped on the Rama Mandi location should also be started for better flow of traffic.

CHAPTER 4

DATA ANALYSIS AND DISCUSSIONS

4.1 Accidental Rate & Frequency

Accident rate is calculated as:

Accident rate = M/L

Where, M = Total no. of accidents

and L = Length of road

The accident rate for the selected stretch has been calculated and sum up in the Table 4.1 below. The accident rate represents selection of accident inclusion by the highway types. The data provides a means to compare relative safety of street system, different highway and traffic control.

Table 4.1: Accidental rate analysis from sum of accidents

Name of stretch	Length	Sum of accidents (2012-16)	Accident Rate
Jalandhar Bus stand-PAP Chowk (1)	2.1 km	13	6.19
PAP Chowk-Rama Mandi (2)	3.5 km	21	6.00
Rama Mandi-Dakoha Fatak (3)	1.1 km	6	5.45
Dakoha Fatak-Haveli, Village-Paragpur, NH-1 (4)	2.6 km	15	5.76

Table 4.2 reveals the number of accidents occurred between 2012-2016 and their frequency per stretch which will result in the total frequency of rate of accident.

Table 4.2: Frequency analysis from sum of accidents

Distance	No. of accidents (2012-16)	Frequency	Total Frequency
0-2.1 km	13	23.63	23.63
2.1-5.6 km	21	33.19	61.82
5.6-6.7 km	6	10.90	72.72
6.7-9.3 km	15	27.28	100
Total	113	100	

From above data table 4.1 and table 4.2, it can be observed that frequency and rate of accident is more for stretch 4 followed by stretch 2,1 and 3 respectively.

4.2 Yearly Variation of Accidents

Figure 4.1 provides information about the annual variations of accidents of the total stretch during year 2012-2016. It is observed that percentage increases every year of the accidents in the selected stretch. Reasons that can be seen are increasing no. of vehicles and vehicular movement, traffic condition and population increment.

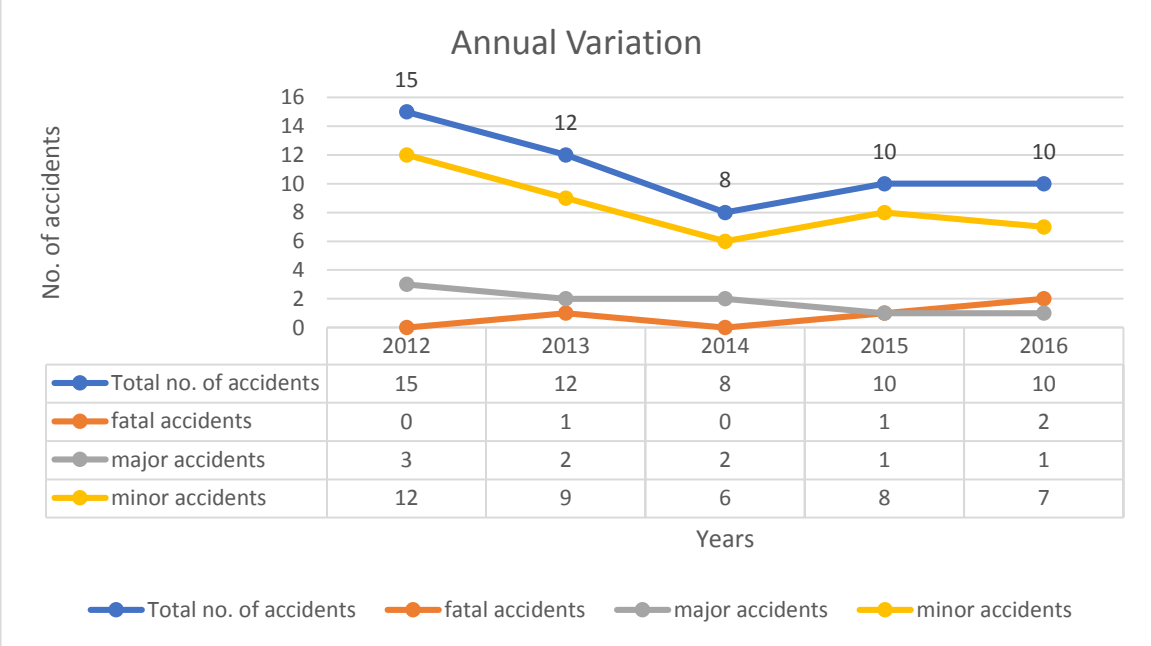


Figure 4.1: Annual Variation of the accidents in 2012-2016

Accident data per stretch yearly of all 4 stretches can be presented by the following Table 4.3

Table 4.3: Accident data per stretch annual variation (including fatal, major, minor accident)

Stretch No.	2012	2013	2014	2015	2016
1	3	4	1	2	1
2	5	3	4	2	4
3	2	3	1	1	1
4	5	2	2	5	3

Figure 4.2 reveals the graphical data of annual variation for each year for a particular stretch. Since it can be observed that maximum accidents were happened on between stretch 4 connecting Dakoha Fatak, Jalandhar and Haveli, Village-Paragpur, NH-1, Jalandhar. Followed by accident happened in Stretch 1,2 and 3 respectively.

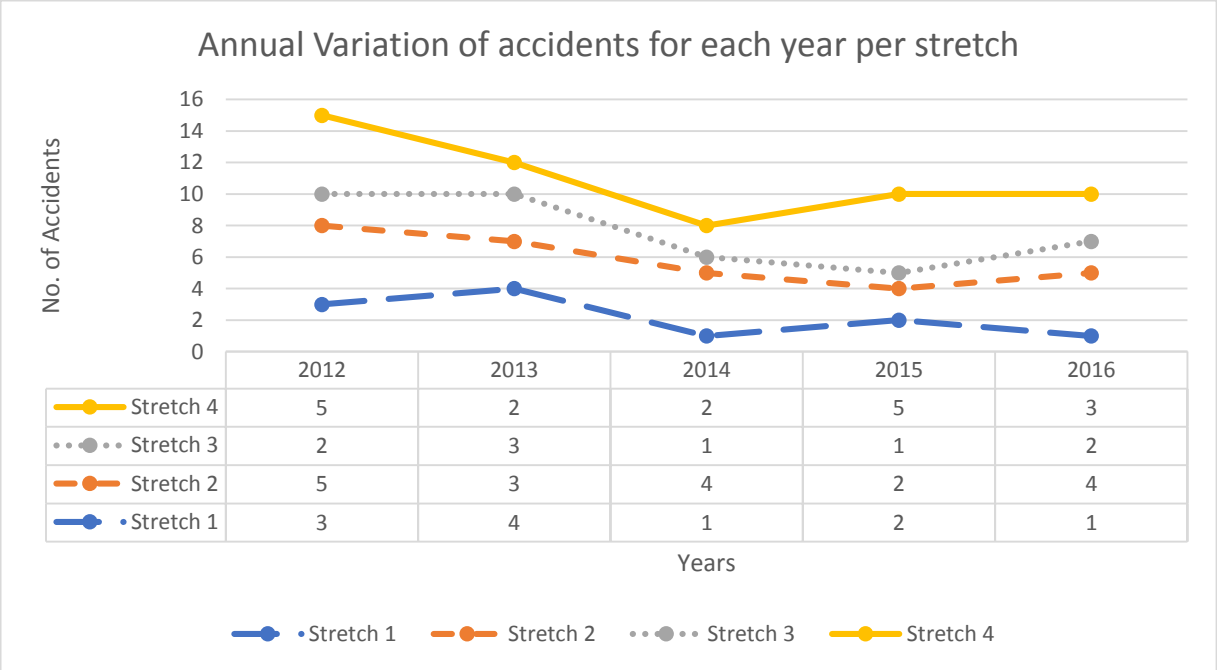


Figure 4.2: Annual variation of accidents per year per stretch

4.3 Monthly variation of accidents for selected stretch

In this section the monthly variation of different stretches respectively will be known. Peak month for occurrence of most no. of accidents is from April- July as the extreme summer season hits this time. Problems that could relate these are glare effect, fatigue, improper heat effects. Also, the most another set of accidents happens in the winter season (November-January) were

most accidents happened due to Fog conditions, lesser visibility, cold environment. Figure 4.3 will describe the monthly variation of all the stretches for the year 2015.

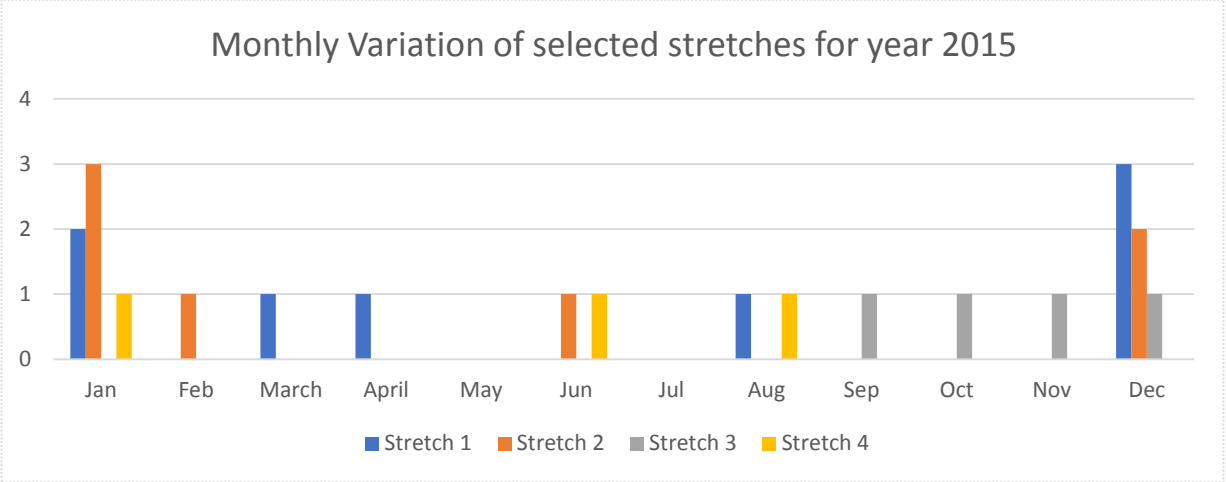


Figure 4.3: Monthly Variation of selected stretches for year 2015

4.4 Hourly variation of selected stretch

Increased no. of accidents occurs between 8am-12pm due to over traffic activity on the selected stretch. Also at the night especially 10pm-3am, more no. of accidents happens due to visual blocking or in-appropriate lighting, over-speeding, or dangerous passing. Sadly, none of the figures can show the data as minor accidents also happen in the course of time which are not recorded.

A rough idea although can be get through a following for the context year (2002-2012) from data collected through online sources can be visualized in Figure 4.4. Figure 4.4 shows hourly accident happened at the peak hours.

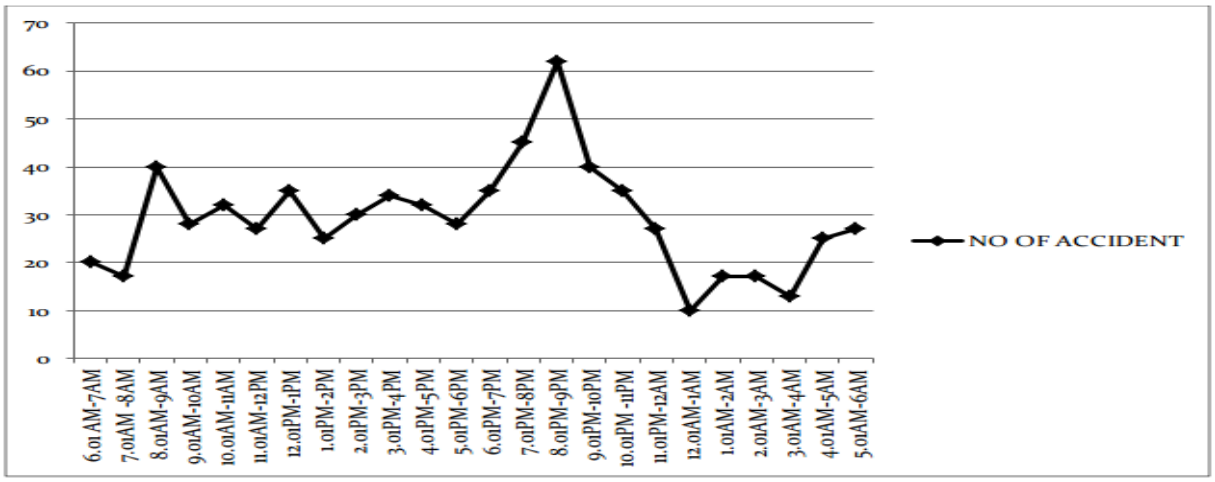


Figure 4.4: Accidents most likely time (2002-2012)

4.5 Involvement of vehicles in fatalities

Vehicle involvement are high as the results speak different shares for different vehicles. They indicate most no. of fatalities by cars and two wheelers as shown in Figure 4.5.

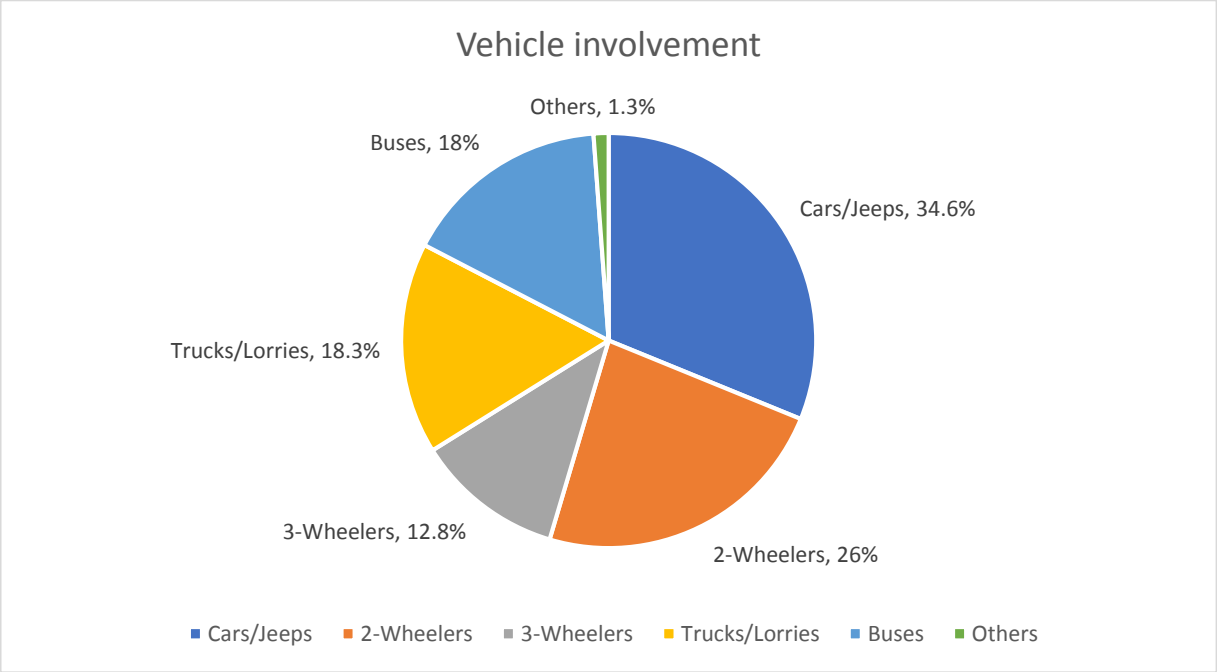


Figure 4.5: Vehicle involvement in accidents

4.6 Surface Properties

Skid number = $\sqrt{v^2/2gl}$ X 100

Here, v = vehicular velocity,

g = gravitational acceleration,

l = length of the skid.

Value for skid number was calculated by using Hyundai i20 car with kerb weight of 1066 kg with 4 persons are shown in Table 4.4. Generally, for asphaltic surface, skid number varies between 70 to 100. From the results obtained, it can be expected that surface friction lies within limit.

Table 4.4: Skid number value

Stretch No.	Skid length (m)	Speed (kmph)	Speed (mps)	Braking	Skid No.
1	9	40	11.111	Normal	84

2	7	40	11.111	Normal	95
3	7	50	13.888	Normal	118
4	12	50	13.888	Normal	91

4.7 Traffic Analysis

As per the data collected in section 3.4 traffic properties, it can be analyzed that total PCU's running on PAP chowk and Rama Mandi are higher while going towards the city. The percentage of total traffic in the morning peak hours in PAP chowk area is higher as 9.983% of total traffic passes during the peak hours.

The evening peak hours are higher of Rama Mandi having 12.296% of total percent of traffic. This can be represented in Figure 4.6 as follows:

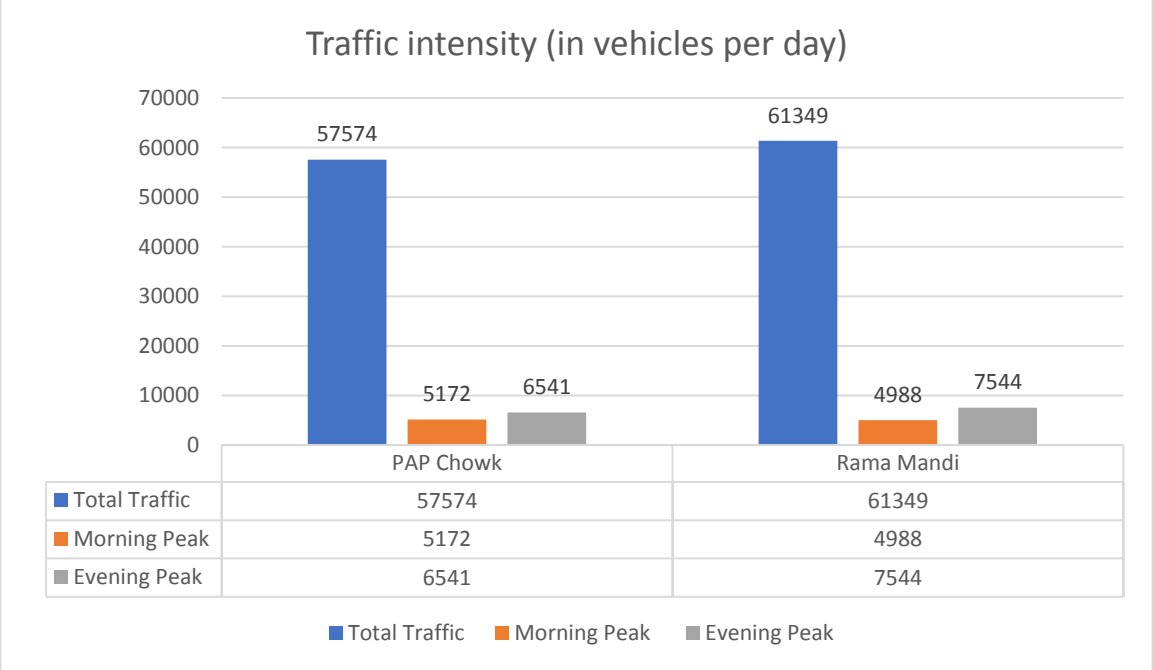


Figure 4.6: Traffic intensity in stretch (Refer Table 3.9)

This indicates traffic volume on daily average ranges from 55000-62000 suggesting this as a congested road.

Traffic composition on the selected stretch was done in both directions through Manual count in peak hours (refer Table 3.10). It can be clearly interpreted that the amount of Fast moving vehicle i.e., Cars and 2-wheelers have higher volume on the road which keeps on congesting PAP chowk.also, the busses and trucks have a considerable effect on the congestion of PAP chowk.

This can be interpreted as shown in Figure 4.7

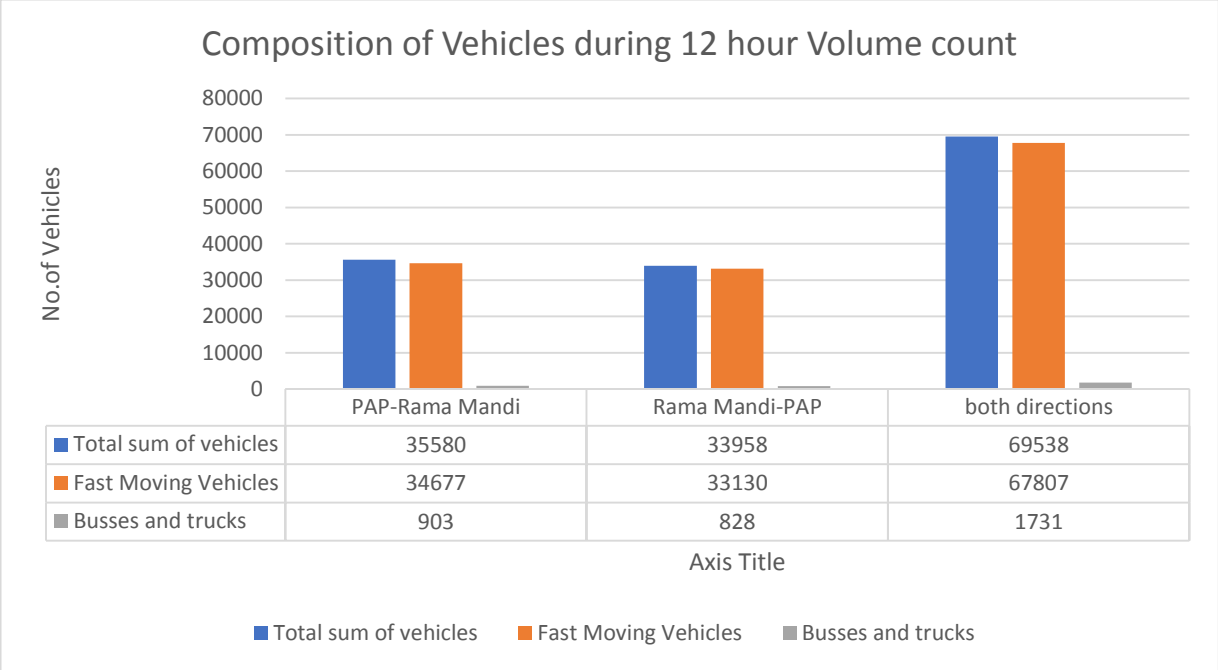


Figure 4.7: Composition of vehicle in 12-hour volume count bi-directional (Refer Table 3.10)

Clearly, it can be seen that the Fast moving vehicles have higher share of traffic volume. This includes Cars, jeeps, vans, 2-wheelers and autos. So, the lane widening should be a suggestion to overcome the huge traffic inflow. Also most of the time is unused and affects driving duration when there is a congestion problem. To overcome this, a channelized flow would be helpful on the stretch.

4.8 Interpretation of accidents

Accidents interpretation in tabular form has already been showcased in previous Chapter 3(Refer table 3.2) and Chapter 4 (Refer Table 4.1 and Table 4.2). The variations have also been shown and interpreted monthly, yearly and daily. The accident rate can be seen in Table 4.1. From this it can be interpreted that higher no.of accidents have happened between PAP chowk and Rama Mandi chowk. The reason mainly is higher no. of drunk driver cases. Among the Fatal accidents, mostly drink and drive cases were reported to police. Figure 4.8 shows the relation between Accident rate and frequency of the accident.

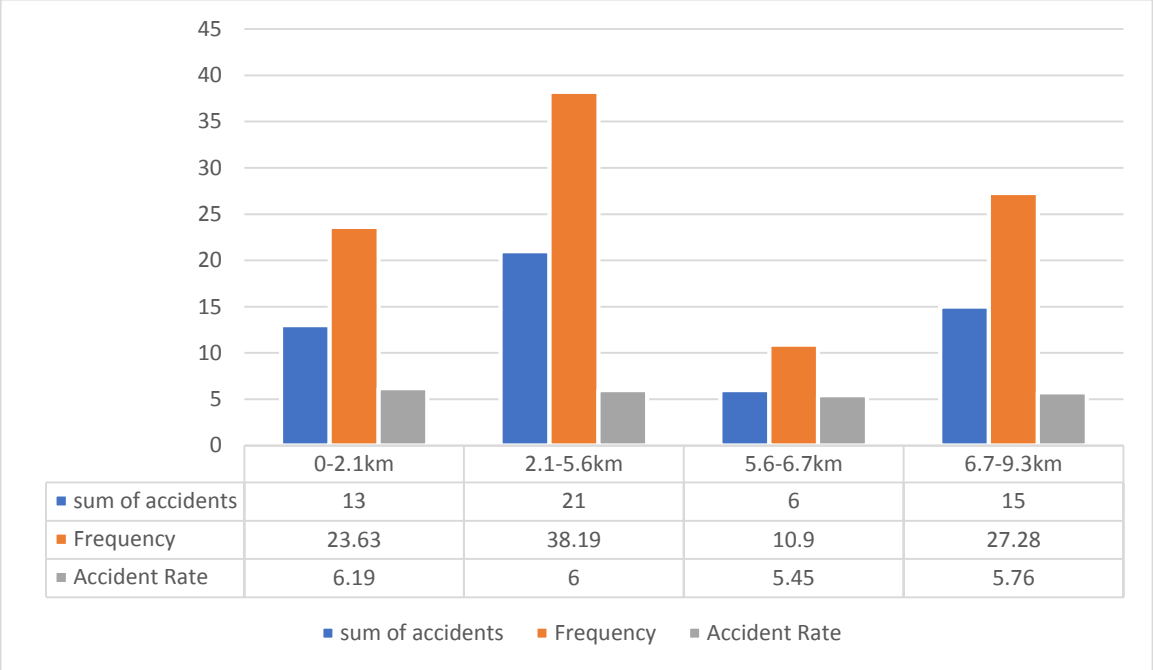


Figure 4.8: Relationship between sum of accidents, accident rate and accident frequency

The above graph with varies with lot of factors. Different road sections is the key of higher frequency. If frequency of accidents is higher then road accidents rate also rises.

CHAPTER-5

ANALYSIS OF ACCIDENTS

5.1 Different accidents recorded

Accident no. 1

Location: Rama Mandi, Dakoha

Date and time: 22 November, 2015 20:10PM

Vehicle included: Ford Figo (PB 08 A 1298) and Tata Bus

Fatalities/injuries: 2 dead and 2 severe injured

Description: On 22 November, 2015, a Ford Figo had a head-on collision with a Tata bus coming from the other lane. The car Ford Figo had 4 passengers who were returning from an event held in Haveli, Village-Paragpur, NH-1. Around 20:10PM when the car reached near Dakoha it went out of control due to over speeding. Car lost control and jumped the other side of road and rammed the bus coming from the other side.

2 person died at the spot while other 2 were in serious condition admitted to Johal hospital in Jalandhar. According to the police reports, crushed bottles of beer were found in the car. Drinking and over-speeding were the causes for the accident. The tyre and skid length was around 11 metres. The accident pictures have been shown in Figure 5.1

Figure 5.1: Accident Investigation 1 (Source: Punjab Police, Local News Paper- Punjab Kesari)

Accident no.2

Location: Haveli, Village-Paragpur, NH-1, Jalandhar

Accident type: Head-on collision, Angular collision

Date and time: December 14, 2016 2:30AM

Vehicles included: Tata Indica Xeta (PB 08 C 1868), Truck

Fatalities: 3 dead and 1 seriously injured

Description: On December 14, a Tata Indica car rammed a truck during night time around 2:30AM due to foggy conditions and over-speeding. The in-persons were all the students from Haveli, Village-Paragpur, NH-1 going to Phagwara railway station for dropping off one of the deceased. The skid marks recorded by police station, Phagwara was around 17 metres. The pictures of the accidents are shown in Figure 5.2

Figure 5.2: Accident investigation 2 (Source: Punjab Police, Local News Paper- Punjab Kesari)

Accident no. 3

Location: near PAP chowk, Jalandhar-Ludhiana Highway

Accident type: Side collision, Angular Collision

Date and time: July 11, 2016 059:40AM

Vehicles included: Government bus, Maruti Suzuki Swift (PB 46 S 4341)

Fatalities/Injuries: 2 dead, 1 serious injured

Description: A Maruti Swift car collided with Amritsar-bound government bus in the morning hours near PAP chowk where a newly married couple along with a relation person were travelling to Jalandhar from Amritsar. Due to heavy rain, road became slippery and the driver lost control on his car and rammed the bus in an angular position. 2 people were dead at the spot while other 1 was in serious condition admitted to PIMS but recovered. Following are the pictures taken by police and media at the time of accident in Figure 5.3

Figure 5.3: Accident investigation 3 (Source: Punjab Police, Local News Paper- Punjab Kesari)

5.2 Analysis and study of black spots

The inflicted points or spots were frequency of accidents are higher is called a black spot. These conflicting points should be removed for better traffic safety. The analysis of the black spot is shown in the Figure 5.4 and Table 5.1. There were no such black spots that can be analyzed but few accident conflicting points are existing still on the road.

Table 5.1: Analysis of Black spot

Conflicting Point	**Problems**	**Safety Enhancements**
PAP chowk	Unsignalized bypass road, Obstructed vision due to girders, self-created bus stand Refer Figure 5.4(a)	Flyover construction, Signalized flow, Clearance of girders, improvement of junction, Installation of speed breaker on the bypass road.

Rama Mandi chowk	Unsignalized T-point, Shops and School, Under construction site Refer Figure 5.4(b)	Signalized flow, Construction of conflicted flyover
Dakoha Fatak	Unsignalized flow, taxi stand, On-street parking, Vision obstructed due to trees on shoulders Refer Figure 5.4{c}	Junction improvement, signalized flow for oncoming traffic to Highway, Road Marking

A figure is provided to justify the problem. Figure 5.4(a),(b),(c) shows the conflicting points.

Figure 5.4(a): The marked conflicting point on PAP chowk

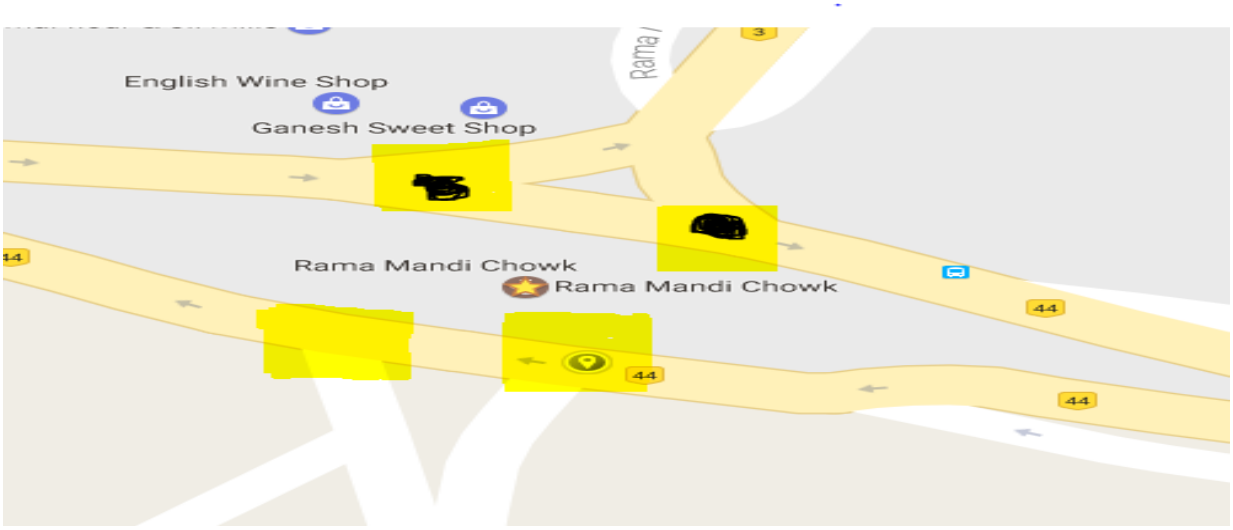


Figure 5.4(b): The marked conflicting point on Rama Mandi chowk

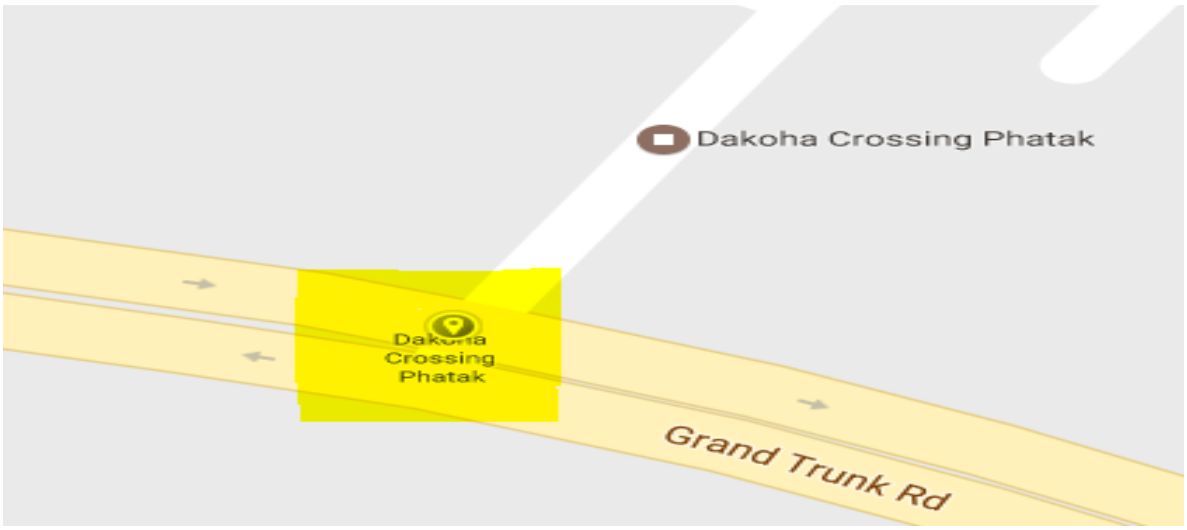


Figure 5.4(c): The marked conflicting point on Dakoha Fatak, Rama Mandi

From the above figures it can be seen that mostly the point is unsignalised starting from PAP chowk to Dakoha Fatak, Rama Mandi. These upon visual inspection were the conflicting points that can be a black spot if remedies are not provided.

CHAPTER-6

CONCLUSION AND RECOMMENDATION

6.1 Conclusions

1) The availed literature shows that accident analysis indicated about 77% of accidents due to driver's unawareness, drinking and driving etc.
2) Cars/Jeeps/Vans are the most accident causing on the stretch. It is estimated to be 35% followed by 2-wheelers of 26% and trucks (18%) and buses (18%).
3) Stretch-2 has highest numbers in accidents which is about 21% is the highest range. The accidents can be minimized by maintain the shoulder and starting the obstructed construction.
4) Stretch-4 has second highest share of 27.28% of total accident occurred. This rate can be minimized by signalized flow, starting the leftover construction of the flyover and providing speed-breakers on the oncoming traffic flow towards highway.
5) Stretch-1 stands 3rd highest of 23.63% of total accident. This rate can be reduced by providing speed limit on the junctions, installation of speed-breakers, removal of trees if any on the shoulder width.
6) Stretch-3 has lowest share as the accident is much lower due to less distance between the points but then also its rate is alarming. The proper measures that can be taken is the starting of the flyover construction on the Rama Mandi region. Signalised flow is of utmost importance here. Speed-breakers before the junction is important of the oncoming traffic on the highway area.
7) Proper lighting condition should be provided at the junctions as well as on the road.
8) Higher amount of traffic inflow towards the city should be maintained by widening of the road and signalizing the flow of traffic.
9) Proper enforcement measures should be under check and checking of drunk drivers and not allowing them to drive should be considered.
10) Along the whole stretch the Patrolling Police cars and the Ambulance services should be provided.
11) Old trees and poles on the shoulder of the road should be removed. Also, the shoulder should be maintained from time to time.
12) Starting the construction of flyovers at PAP chowk and Rama Mandi Chowk is of utmost importance which will lead to reduction in the congestion of the roads at PAP chowk.

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