Road Traffic Accident and Safety Evaluation Case of Addis Ababa Bole Sub City

BY

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ROAD TRAFFIC ACCIDENTS AND SAFETY EVALUATION CASE OF ADDIS ABABA BOLE SUB CITY

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DECLARATION

I, the undersigned, declare that this thesis is my original work performed under the supervision of my research advisor Dr. Bikila Teklu and has not been presented as a thesis for a degree in any other university. All sources of materials used for this thesis have been duly acknowledged.

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Acronyms

AACRA:	Addis Ababa City Road Authority
AADT:	Annual Average Daily Traffic
ADT:	Average Daily Traffic
AABSC:	Addis Ababa Bole Sub City
AAP:	Addis Ababa Police
AATA:	Addis Ababa Transport Authority
AATP:	Addis Ababa Traffic Police
AU:	African Union
BAC:	Blood Alcohol Concentration
BSCTP:	Bole Sub City Traffic Police
BSCP:	Bole Sub City Police
CS:	Collector Straight
CSA:	Central Statistics Authority
DALY:	Disability Adjusted Life Years
ERA:	Ethiopian road Authority
FP:	Federal Police
GIS:	Geographical Information System
GPS:	Global Positioning System
PAS:	Principal Arterial Straight
RTASE:	Road Traffic Accident Safety Evaluation
SAS:	Sub Arterial Straight
UN:	United Nation
WHO:	World Health Organization

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ABSTRACT

The main aim of this research study is to analyze and evaluate the cause of road traffic accident in Addis Ababa Bole Sub City and to recommend safety measures at identified black spots to create a safer transport system in the sub city. Bole sub city, being the largest sub city in the city, enjoys the city's major road compositions as well as local and international gate ways with high standard roads. Unfortunately, it has recorded the worst accident and safety record in the city as well. The study uses GIS based black spot identification schemes that employs five distinct scientific principles namely: accident frequency, accident rate, empirical Bayesian, critical accident and accident prediction models. A total of 31 sections of road and 9 junctions were studied using primary and secondary data. Out of the methods, empirical Bayesian proved superiority so that much of the conclusion was based on this method.

Results indicate that road sections 29, 11, and 10 were highly prone to accidents with PI EB values of 57.24, 55.4 and 53.55 respectively. The worst junctions were Emperial roundabout, Bole Michael roundabout and Millennium Hall intersection with PI EB values of 257.46, 222.43 and 121.25 respectively. Values of PI EB indicate that these sections need urgent attention to diagnose, prioritize, evaluate and give low cost and effective solution to reduce road traffic accident and increase safety performance. Possible solutions are using traffic signs, user awareness campaigns, policy revisions, and permanent geometry and pavement modifications.

1. INTRODUCTION

1.1 Background

Addis Ababa is a capital city of the Federal Government of Ethiopia and the head office of African Union (AU) is also found in this city and more than 100 diplomatic embassies exist. The city lies at 9°1′48″N latitude and 38°44′24″E longitude. Geographically the city is located at the heart of the country, an altitude ranging from 2,100 meters at Akaki in the south to 3,000(9,800 ft) meters at Entoto Hill in the North.

The city has a total population of approximately 3.5 - 4.0 million according to CSA's projected estimate for 2006E.C based on the 2006E.C census report for Addis Ababa (C.S.A, 2006). In the inner area of the city, there is a concentration of government administrative institutions and commercial activities mixed with residences. The city is growing with five intercity road networks. Especially the south route along Addis Ababa to Adama Road corridor is experiencing high growth according to the Office of Addis Ababa transport bureau. The office also stressed that the city had experienced a horizontal growth in unorganized approach in recent years.

The Federal Government of Ethiopia represented by Addis Ababa City Roads Authority (AACRA) has given much emphasis for road sector development. Many road development projects connecting different parts of the city to mid towns have been Bole undertaken. Bole sub city road projects are some of them. Addis Ababa's main route of transportation corridor to local and international destinations via the main express way and Bole international airport are also located in this sub city. Additionally the expansion of transportation sector has very significant contribution to realize the objective of the National economic Development to Lead Industrialization Policy, which is considered to attain the sustainable socioeconomic development in the Addis Ababa city.

The need for people to move, utilize and mobilize resources, improve manufactured production and market condition, access to social facilities using land and other related activities require transport as mechanism. It is also well recognized that transport plays a critical role in strengthening market linkage, advancing social relations and facilitating economic development

because of the city growing from day to day. Because of the high growth of Addis Ababa traffic volume and population, the road traffic accidents occurring increased especially on Bole sub city major road as a result of several factors associated with the traffic system, namely: road users, road environment, and vehicles.

1.2Statement of the Problem

Our world is witnessing serious fatal and injury accidents in recent years. Road traffic accidents take the highest share of these accidents. The World Health Organization (WHO) puts the number of fatalities and injuries due to road traffic accidents at 1.2 million and 50 million respectively. This research evaluates and analyzes road traffic accident and safety concerns in case of Addis Ababa Bole sub city, as Addis Ababa is one of the cities where severe road traffic accident with small amount of vehicle density occur.

Local authorities and police officers of Bole sub city attest that the sub city has recorded the worst traffic accident as compared to the vehicle density. Bole Initial estimates for the main reason behind the concentration of major accidents are that the sub city hosts links to different main roads and the only international airport which is the gateway for Ethiopia. Bole some reports show that Addis Ababa has the largest number of road traffic accidents, fatalities and injuries. Not only the traffic accidents are concentrated in Addis Ababa city but the volume of motorized traffic is very high as compared to the other parts of the country.

The road traffic accident number for both fatal and injured people increased from time to time. Hence this research will find out the main cause of road traffic accident in Bole sub city and evaluate the safety condition.

1.3 Objective of the Study

1.3.1General

The main objective of this research is to assess Road Traffic Accidents and Safety in the Case of Addis Ababa Bole Sub City, there is no prior RTASE done in this sub city.

1.3.2Specific

Specifically, the study tries to attend the following objectives:

- To explore the nature and characteristics of accidents in Bole sub city.
- Make comparative analysis on the identification of major road accident among PAS, SAS and ring road found in Bole sub city.
- To identify locations with abnormally high number of road traffic accidents, (black spots).
- To investigate and evaluate possible cause of road accident on the black spots location.
- To propose integrated permanent engineering solution using traffic sign , make awareness in a society and change a geometry and pavement of the road at indentified black spot location

1.4. Importance of the Research

The researcher proposes to answer the following research problems on Road Traffic Accidents and Safety Evaluation Case of Addis Ababa City in Bole Sub City.

The study will add knowledge on understanding what risk factors contribute to the Occurrence of road traffic accidents and related injuries in a restricted risk area in Addis Ababa in Bole sub city. The data obtained in this study, can be used by the road safety authorities for planning and evaluating road safety measures. The recommendations given if considered are going to benefit the public at large on prevention of road accidents and increasing safety performance.

1.5. Limitations in preparing the research

Ignorance on the importance of data and information

- Be shortage of teamwork and unwillingness from the concerned bodies in collecting and Providing data (officials and officers)
- Knowledge gap by professionals who participate on the traffic accident issue and a scientific ways of measurement using on collecting, organizing and analyzing of data.
- Be shortage of data quality and quantity.
- Time limited to do the research

1.6. Scope and Organization of the thesis

The report is organized in five chapters that are linked to the issues in relation to the Study: the scope of the thesis location was limited on Road Traffic Accidents and Safety Evaluation Case of Addis Ababa City in Bole Sub City and it also includes information from various sources relating to the study.

Chapter one gives the background of the study, problem statement and states the most important objective of the study. On Chapter two literature review of road traffic accident and safety evaluation related to the study.

Chapter three gives the description of the methodology used in the study, data collection mechanism and way of study on road traffic accident aspects. Chapter four presents the findings on data analysis and discussion related road traffic accident and safety evaluation.

Finally chapter five contains the final discussion, conclusions and recommendations on road traffic accident and safety evaluation.

2. LITERATURE REVIEW

2.1 Introduction

In this part of the study, basic and important literatures are reviewed to provide background information and current state of RTASE's in Bole sub city. A comprehensive collection of applicable works to support this research will also be compiled.

"Road traffic injuries are major problem but neglected public health challenge that requires determined efforts for effective and sustainable prevention. Of all the systems with which people have to deal every day, road traffic systems are the most complex and the most dangerous. Worldwide, an estimated 1.2 million people are killed in road crashes each year and as many as 50 million are injured. Projections indicate that these amounts will increase by about 65% over the next 20 years unless there is new commitment to prevention. Nevertheless, the tragedy behind these amounts attracts less mass media attention than other, less frequent types of tragedy. The World report on road traffic injury prevention is major report being jointly issued by the World Health Organization" (WHO 2009).

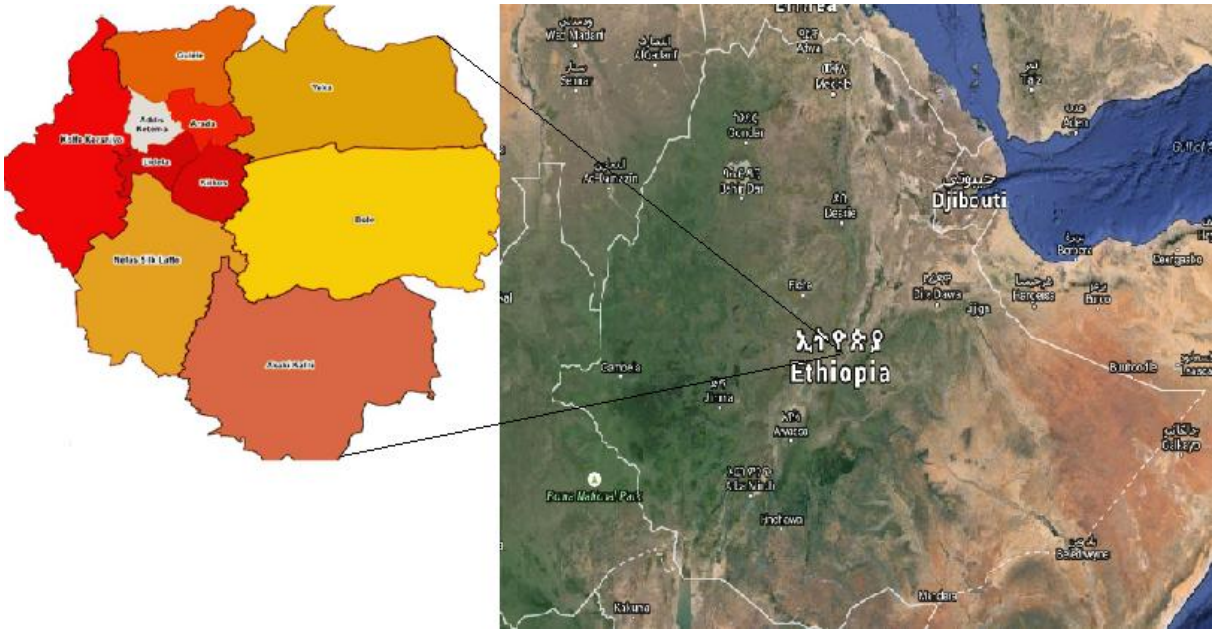


Figure: 1 Ethiopian and Addis Ababa map

Source: Google map and Addis Ababa administration office (2015)

2.2. International road traffic accident and safety

"To create greater levels of awareness, commitment and informed decision-making at all levels government, industry, international agencies and nongovernmental organizations so that strategies scientifically proven to be effective in preventing road injuries can be implemented. Any effective response to the global challenge of reducing road traffic casualties will require all these levels to mobilize great effort". (World health organization .WHO 2009)

.

Figure: 2 Road traffic accident prevention policies organs

Source: WHO global burden of diseases (World Health Organization, WHO 2009)

To contribute change in thinking about the nature of problem for road traffic in juries and what constitutes successful prevention. The perception that road traffic injury is the price to be paid to achieving mobility and economic development needs to be replaced by a more holistic idea that emphasizes prevention through action at all levels of the road traffic system.

" To help strengthen institutions and create effective partnerships deliver safer road traffic systems. Such partnerships should exist horizontally between different sectors of government and vertically between different levels of government, as well as between governments and

nongovernmental organizations. At the government level, this means establishing close collaboration between sectors, including public health, transport, finance, law enforcement and other sectors concerned.

This summary of the World report on road traffic injury prevention is primarily intended for people responsible for road safety policies and programmers at the national level and those most closely in touch with road safety problems and needs at the local level. The views expressed and the conclusions drawn are taken from the main report and on many studies to which that report refers". (World Health Organization, WHO 2009)

"The model as is shown below is used as a framework for understanding the multiple causes and prevention of traffic accidents that occur in developing cities. Available literature identifies traffic accidents in a place as been caused either by physical factors in the road system (environment), the vehicle or behavior factors, and how they interact with enforcement regulations in unique settings". (Modeling of traffic accident by Jorgensen and abane on 1999)

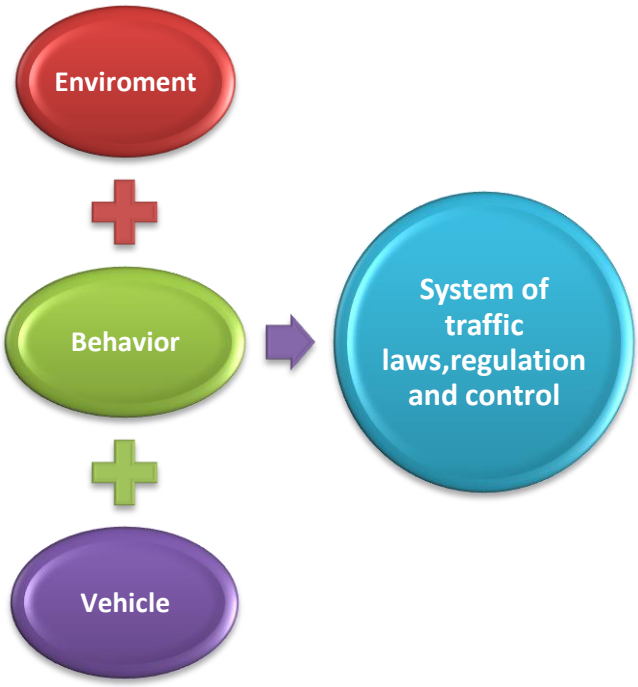


Figure: 3 A public health concern

Source: WHO global burden of diseases (World Health Organization, WHO 2009)

Every day around the world, more than 3000 people die from road traffic injury. Low-income and middle-income countries account for about 85% of the deaths and for 90% of the annual disability-adjusted life years lost because of road traffic injury. Projections show that, between 2000 and 2020, road traffic deaths will decline by about 30% in high-income countries but

increase substantially in low-income and middle-income countries. Without appropriate action, by 2020, road traffic injuries are predicted to be the third leading contributor to the global burden of disease and injury. (World Health Organization, WHO 2009)

Change in rank order of DALYs for the 10 leading causes of the global burden diseases			
Rank	**Disease of injury on 1990**	**Rank**	**Disease of injury on 2020**
1	Lower respiratory infection	1	Ischemic heart diseases
2	Diarrhoeal diseases	2	Unipoloar major depression
3	Perintal condition	3	Road traffic injuries
4	Unipoloar major depression	4	Cerebrovascular
5	Ischemic heart diseases	5	chronic obstructine pulumonar diseases
6	Cerebrovascular	6	Lower respiratory infection
7	Tuberculosis	7	Tuberculosis
8	Measles	8	war
9	Road traffic injuries	9	Diarrhoeal diseases
10	conhental abrornalites	10	HIV

Table: 1 Change in rank order of DALYs for the 10 leading causes of diseases.
Source: WHO global burden of diseases (World Health Organization, WHO 2009)

According to the world health organization, the first comprehensive analysis of road traffic crashes in Ethiopia using police-reported crash data. Road traffic crashes pose a significant burden in Ethiopia, as is the case for other developing countries. Currently, developing countries contribute to over 90% of the world's road traffic fatalities (WHO, 2009) and overall road injury disability-adjusted life year (DALYs) increased by 2.5% between 1990 and 2010, with pedestrian injury DALYs increasing by 12.9%, more than any other category (Murray, Lozano, Naghavi , & et al, 2012). This finding implies that a pedestrian injury on the road is a problem that has increased at a global level and is disproportionately attributable to developing countries. The social and economic impacts of road crashes in developing countries are not well understood. It is believed that the implications are immense and that road safety issues require more immediate attention of researchers, professionals, and politicians.

"Developing countries have embarked on achieving the United Nations Millennium Development Goals as a primary objective; however, the Goals do not explicitly include road safety. Despite the lack of a specific mention of road safety within economic targets, road crashes and economic productivity are linked because primary income earners within families are disproportionately represented among fatalities. At least one study has demonstrated that road crashes have a negative impact on the achievement of the Millennium Development Goals" (Ericson & Kim, 2011).

2.3. National Road traffic accident and safety

Ethiopia is one of those rising countries with low level of income accompanied by high rate of population growth and high number of traffic accident. As part of the developing world, Ethiopia is mostly an important country with low level of urbanization. The economic performance of different sectors of the national economy is not pleased. This low performance is due to a number of limitations such as low level of investment in different sectors of the national economy. On other hand there are less than 600,000 vehicles in Ethiopia but the traffic accident rate too much as compared to the volume of traffic. According to the Ethiopian federal police commission report the estimated five year traffic accident shown below on figure number 4.

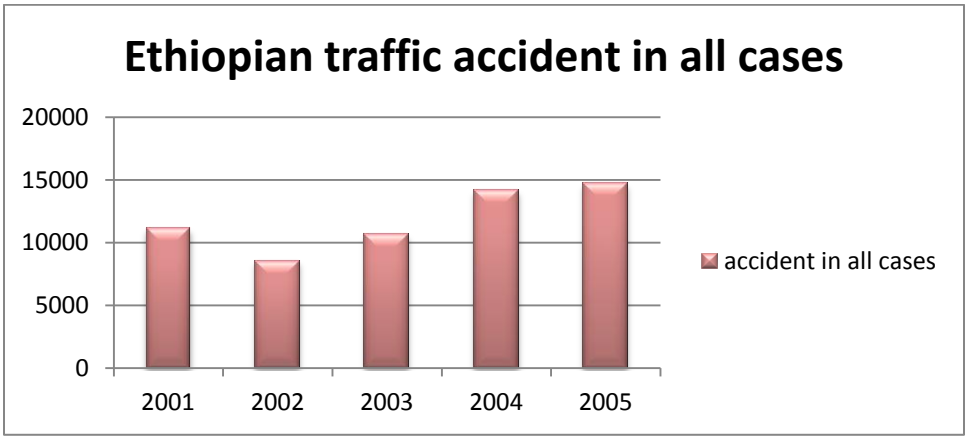


Figure: 4 Ethiopian traffic accidents in all cases

Source: Federal police commission annual report from (2001-2005)

This report shows that the traffic accident increased from time to time. As figure 4 indicated, accident number increased by more than 1000 within the past five years according to federal police report. Similarly the number of fatality increased tremendously as shown below on figure 5.

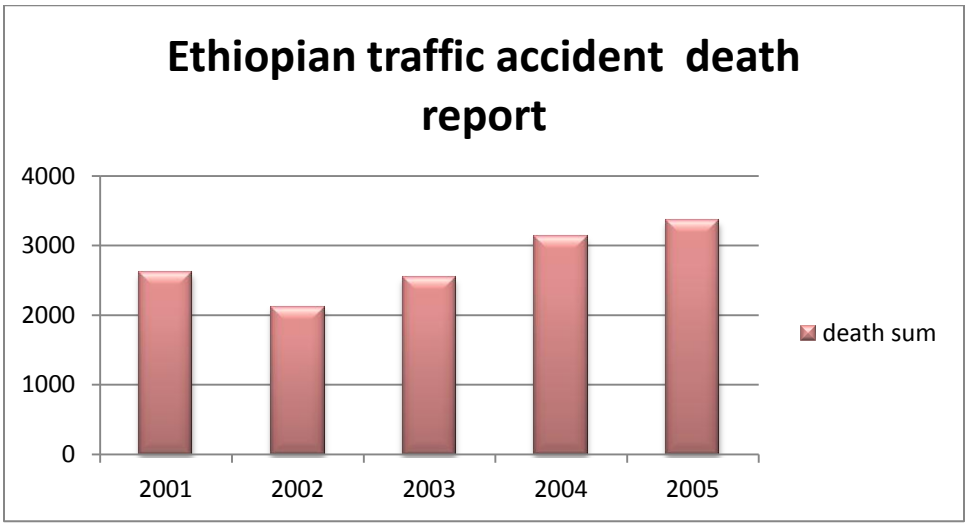


Figure: 5 Ethiopian traffic accident death reports

Source: Federal police commission annual report from (2001-2005)

Each governmental institution responsible for traffic safety fall within the transport ministry with other government departments such as police, justice, health, planning and education having some responsibility for key areas. Experience of several countries indicates that effective strategies for reducing traffic injury have a greater chance of being applied if there is a separate government agency with the power and budget to plan and implement its programmed.

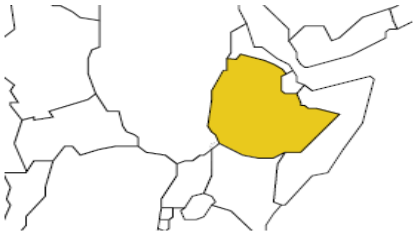
Informed and committed politicians are essential to achieving government commitment to road safety, since they authorize policies, programmers and budgets. They also play central roles in developing road safety legislation.

ETHIOPIA

Population: 83 099 190

Income group: Low

Gross national income per capita: $220



INSTITUTIONAL FRAMEWORK	
Lead agency	National Road Safety Committee
Funded in national budget	Yes
National road safety strategy	Yes
Measurable targets	Yes
Funded	Yes

DATA
Reported road traffic fatalities (2006) 2 517[d] (78% males, 22% females)
Reported non-fatal road traffic injuries (2007) 24 792[e]
Costing study available Yes (deaths and injuries)

[d] Police data, defined as died within 1 year of the crash.
[e] Police data adjusted by comparing with health data.

Table: 2. Ethiopian traffic accident institutional frame work

Source: From UN annual report and Federal police commission annual report from (2001-2005)

NATIONAL LEGISLATION	
Speed limits set nationally	**Yes**
Local authorities can set lower limits	**Yes**
Maximum limit urban roads	**60 km/h**
Enforcement[a]	0 1 **(2)** 3 4 5 6 7 8 9 10
Drink–driving law	**Yes**
BAC limit – general population	**None**[b]
BAC limit – young or novice drivers	**None**[b]
Random breath testing and/or police checkpoints	**No**
Road traffic deaths involving alcohol	**10%**[c]
Enforcement[a]	0 **(1)** 2 3 4 5 6 7 8 9 10
Motorcycle helmet law	**No (subnational)**
Applies to all riders	**n/a**
Helmet standards mandated	**n/a**
Helmet wearing rate	**60%**[c]
Enforcement[a]	**n/a**
Seat-belt law	**No (subnational)**
Applies to all occupants	**n/a**
Seat-belt wearing rate	**20%**[c]
Enforcement[a]	**n/a**
Child restraints law	**No**
Enforcement[a]	**n/a**

[a] Enforcement score represents consensus based on professional opinion of respondents, on a scale of 0 to 10 where 0 is not effective and 10 is highly effective.
[b] Drink–driving not defined by BAC limit.
[c] 2007, Consensus group estimate.

VEHICLE STANDARDS	
No car manufacturers	
ROAD SAFETY AUDITS	
Formal audits required for major new road construction projects	**No**
Regular audits of existing road infrastructure	**No**
PROMOTING ALTERNATIVE TRANSPORT	
National policies to promote walking or cycling	**No**
National policies to promote public transportation	**No**

Table 3. Ethiopian road traffic institutional frame work

Source: From UN annual report and Federal police commission annual report from (2001-2005)

According to the federal police commission report, pedestrians and passenger are the highly likely victims of fatality accidents as shown in figure 6 below. Most accidents occur because drivers do not give priority to pedestrians. Hence, major work needs to be done by concerned

Organizations to safeguard the safety of passengers and pedestrians and save lives.

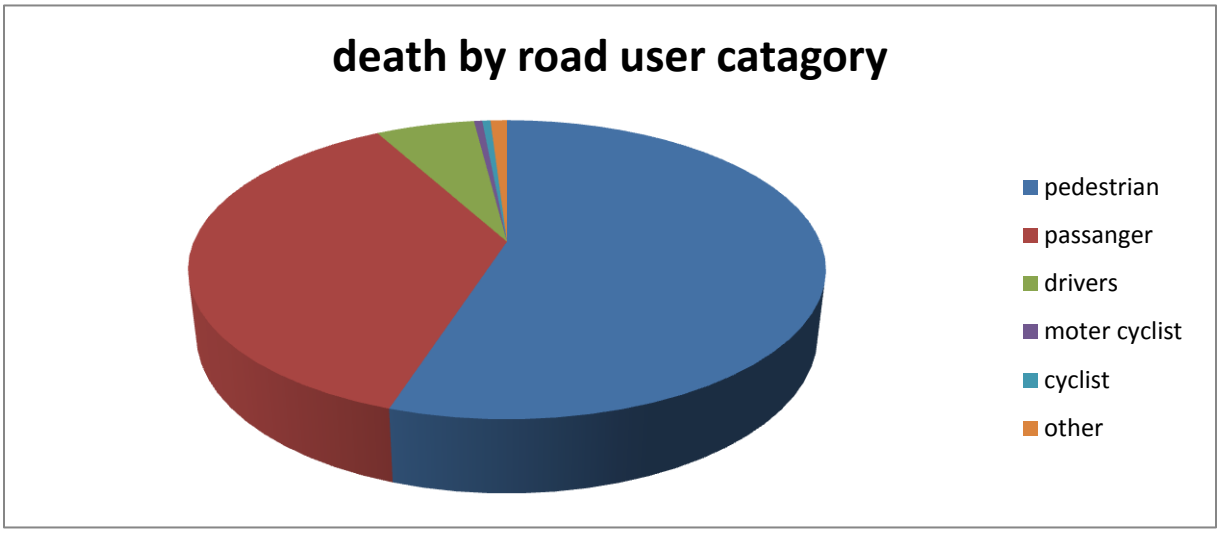


Figure 6. Traffic accident death by road user category

Source : Federal police commission annual report (2007)

In general, some study indicates that the main causes of the accidents at the black spot areas were unavailability of proper pedestrian facilities, pedestrian traffic volume, drivers' fatigue, lack of awareness of traffic rules and regulation and violation of speed limit in accordance to the pilot study by the National Road Safety Coordination Office. Besides, densities of accidents per kilometer were found to be a function of access points in towns. Narrow bridge, inadequate sight distance, insufficient illumination, road curvature, and faded road markings are usually the major causes of accidents.(Getu Segni,2007)

2.4. Current stakeholders for Addis Ababa road traffic accident and safety

Several organizations are the major stakeholders in working together to reduce the city's traffic accident and ensure safe and efficient movement of the city's citizens. These organizations need to come together to put different safety criteria and controlling mechanisms to create a safer transport system. Some of these organizations are:

- Addis Ababa transport office
- Addis Ababa police
- Addis Ababa city road authority

Bole sub city police

Figure 7. Traffic accident death by road user category

Source: Federal police commission annual report (2007)

2.4.1 Addis Ababa transport agency

From different governmental road and transport stakeholders Addis Ababa transport agency is one of them. The government of Addis Ababa city administration has decided to establish an independent institution authorized over all the Addis Ababa transport sectors. The AATA governmental institution established early separated Addis Ababa transport office from the previous Addis Ababa city road authority (AACRA) office and work independently to solve Addis Ababa transport issue. According to AATA, road traffic accident is one of the main issues of the city's transportation system and urgent steps need to be taken to solve this problem.

The bureau currently evaluates road project proposals based on road safety, geometrical conditions, and traffic volume; hence prioritizing proposals to suit the budget available. Additionally, the bureau conducts studies on selected road sections to identify black spot locations.

2.4.2Addis Ababa City Roads Authority

- Addis Ababa needs a large number of roads network with high standard, quality and safety conditions. AACRA is responsibile for the expansion of road transport system in Addis Ababa city, make every effort to attain 20% road coverage by 2020. Addis Ababa city road authority (AACRA) manages a total of 4148 km longroad With 7m width.

The main objective of the authority is

- The Authority shall, within its jurisdiction, have exclusive powers with regard to the administration and construction of road and other related activities.
- cover the demand of the Addis Ababa city road coverage according to the standards of a modern city.

Addis Ababa total road net work from 1990-2005.E.C	
Asphalt road	**2002 K.M**
Gravel road	**1419 K.M**
Coble stone road	**1596 K.M**
Number of bridge	**285 PCS**
Road covering percentage	**15.64%**

Table 4: Addis Ababa total road net work

Source: Addis Ababa city road authority (AACRA) ,(2015)

2.4.3 Addis Ababa police commission

On road traffic accident and road safety case, Police authorizations are responsible for law enforcement and the most important organization to satisfy the road safety. They are also responsible for collecting accident data. “This data must not only satisfy the requirement of police administration but also be reliable information for analysis for those who conduct further study on road safety .For instance, road engineer; transport planner, health and education

authority, road safety engineers and many organizations can participate directly or indirectly on road safety." (Oliver Michaud, 2004)

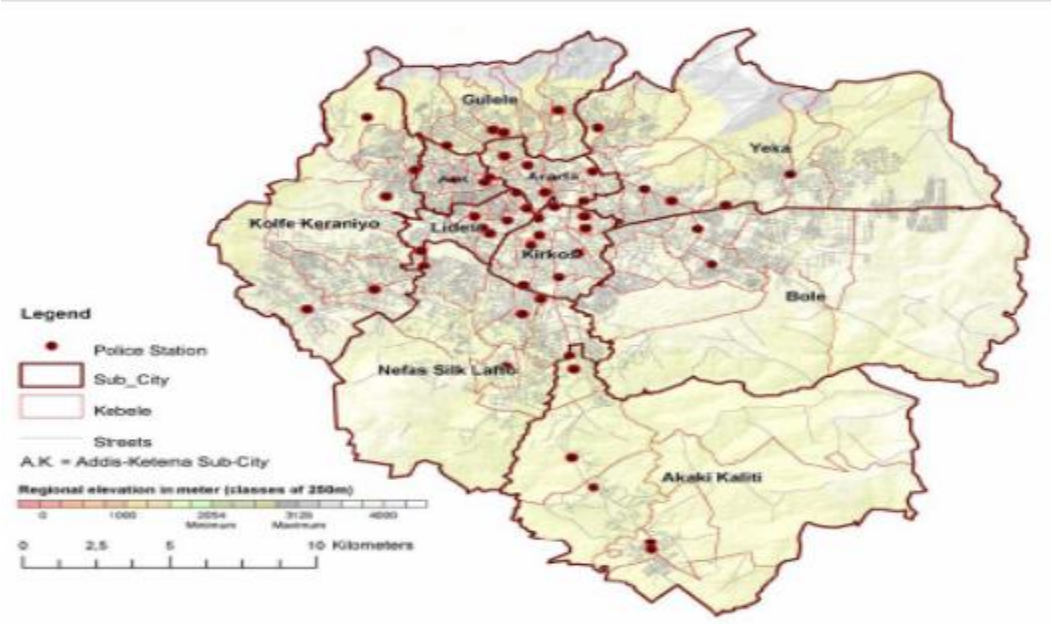


Figure 8: Number of police station in Addis Ababa

Source : CSA population and housing census report (2008)

2.4.4 Bole sub city traffic police

On Bole sub city road crashes were characterized using descriptive analysis to examine the relationships among factors and to identify possible causes and contributing factors. An analysis of time variation of crashes was carried out to identify the most crash prone hours of the day in order to propose enforcement measures to address the situation. Demographic factors of road users were characterized, as well as road environment factors, crashes by collision and vehicle types. The study sites are roads on Bole Sub City and a total of more than 75 kilometer in length were found for the study. Bole sub city roads carry high traffic and are high quality standard roads. In this sub city more than 400 people injured and 2829 property damaged were reported because of traffic accident in 2015.

2.5. Black spot criteria identification, analysis and treatment

The term black spot is said to derive from the method that was originally used to identify hazardous sites. "Accident is pinpointed on a map using colored to represent the severed of each of this site and black is also represented for accident having caused of fatal and property damage. On other hand black spot is universally defined hazardous location and high accident location the location which identified by black spot is highly profitable action of accident reduction and cost effectiveness." (Oliver Michaud, 2004)

The recent study conducted by the Addis Ababa Transport Authority (AATA) and Bole sub city Police (BSCP) found that, the maximum numbers of accident incident make bigger or black spots location. In this traditional identification of black spots, methodologies developed based on the total number of accidents occurred in that particular location. These criteria do not provide consideration to the road improvements and result in misleading of locations that are not truly hazardous from the road safety perspective.

2.6. Road user regulation, enforcement and safety education

2.6.1Setting road safety rules and securing compliance

Risk of injury from lack of rules and enforcement

Driving at excess or inappropriate speeds, while under the influence of alcohol, while sleepy or fatigued and without protective gear (such as seat-belts, child restraints and helmets) for all vehicle occupants are major contributors to road crashes, deaths and serious injuries. Laws alone are not enough to discourage these errors. Enforced compliance is the key. In the European Union, improving enforcement of current laws could reduce the number of road traffic deaths and serious injuries by an estimated 50%.

An extensive review of international experience with enforcement concluded as follows,

Creating a meaningful deterrent is critical.

Enforcement levels need to be high and maintained so the perceived risk of apprehension is high.

- Apprehension must be followed by swift administration of penalties.
- Automated enforcement such as cameras to catch speeders is most effective.
- Public education without enforcement has negligible effect but, combined with enforcement, increases compliance with laws.

Setting and enforcing speed limits

Risk posed by speed

"The higher the speed, the shorter the time a driver has to stop and avoid a crash. The higher the speed, the more severe the impact is when a crash occurs. The probability that a crash will result in injury is proportional to the square of the speed; for serious injury, proportional to the cube of the speed; and for fatal injury, proportional to the fourth power of the speed.

Vulnerable road users, outside motor vehicles, are at especially high risk of injury from speeding motor vehicles. The probability of a pedestrian dying as a result of a car crash increases exponentially as the speed of the car increases. Older pedestrians are more vulnerable than younger ones. The probability that a pedestrian aged 65 years or more will be killed by a car going 75 km/h is more than 60% versus 20% for a pedestrian younger than age 15 years." (World Health Organization, WHO 2009)

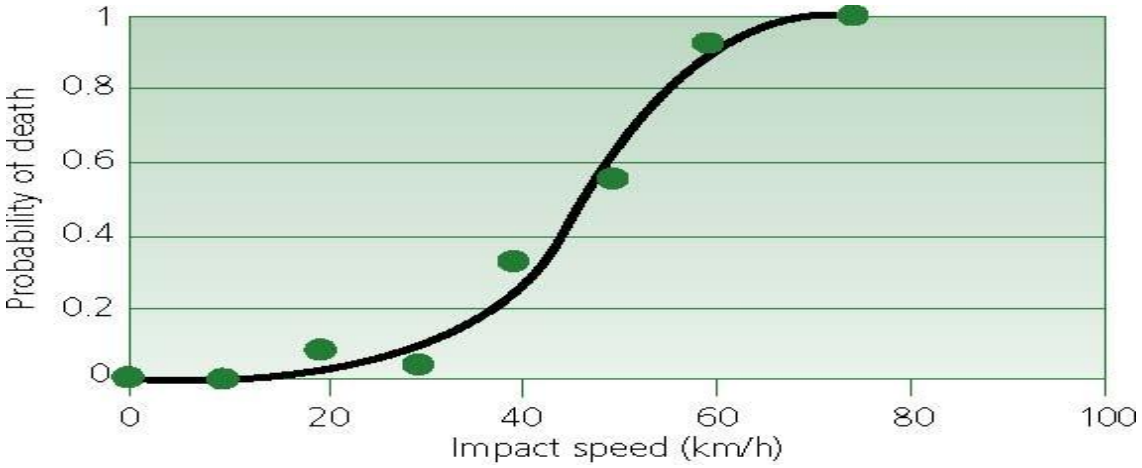


Figure 9: Impact speed and probability of death relation

Source: World Health Organization, (WHO 2009)

Speed limits

Speed limits that road users perceive as realistic and those that are self-enforcing have the greatest chance for achieving compliance. The layout of road networks and the design of roads, as discussed earlier, can make drivers uncomfortable with exceeding speed limits.

"Speed cameras or radar can catch drivers who are exceeding speed limits. A recent analysis of experience in several countries found that instruments that automatically catch drivers reduced road traffic deaths and serious injuries by 14%, whereas enforcement by police officers achieved a 6% reduction. Publicizing the presence of speed cameras or radar has been found to increase compliance with speed laws and to reduce the incidence of crash and injury substantially.

Nevertheless, an earlier study in Tasmania, Australia, found that the long-term placement of stationary police vehicles on each of three high-risk stretches of a rural road achieved an average 3.6 km/h reduction in speed and a 58% reduction in crashes resulting in death or serious injury.

Speed-limiting devices built into vehicles are also effective. Speed-limiting governors in heavy goods vehicles could reduce the incidence of road traffic injury by an estimated 2% . Requiring speed governors in buses, minibuses and trucks travelling on the rural roads of low-income and middle-income countries could contribute even more." (World Health Organization, WHO 2009)

Setting and enforcing alcohol limits

Risk posed by alcohol

Like speed, alcohol consumption increases the probability both that a crash will occur and that death or serious injury will result.

"Making comparisons is difficult because legal BAC limits and enforcement vary so much from country to country. Nevertheless, several studies indicate the extent of driving while under the influence of alcohol. A review of surveys done in European Union countries found that 1–3% of drivers were under the influenced depending on the country. Surveys in Croatia found that over 4% of drivers were intoxicated. A study in Ghana found that the BAC of more than 7% of drivers exceeded 0.08 g/dl.

A survey of studies in low-income and middle-income countries found that blood alcohol was present in 33–69% of fatally injured drivers and in 8–29% of drivers involved in crashes but not fatally injured . Studies in South Africa found that alcohol was a factor in 47% of driver deaths and 27% of crashes in which drivers were not killed; excess alcohol was present in 52% of the people with trauma involved in road crashes .In New Delhi, India, a study found that one third of motorized two-wheeler riders taken to hospital admitted to riding under the influence of alcohol.

Pedestrians, too, put themselves at greater risk of road traffic injury when they consume too much alcohol. A survey of studies in Australia found that the BAC of 20–30% of pedestrians dying in road crashes exceeded 0.15 g/dl. A study in South Africa found that alcohol was involved in more than 61% of pedestrian fatalities. A recent study in the United Kingdom concluded that 48% of pedestrians killed in road traffic collisions had been drinking." (World Health Organization, WHO 2009)

Blood alcohol concentration limits

In 1964, the Grand Rapids study showed how the crash risk increased with the amount of alcohol ,Many European countries and many states in the United States set a BAC limit of 0.02 g/dl for young drivers (generally under 21 years in the United States) and for all riders of motorized two-wheelers. Some set the lower limit for all newly licensed drivers. A review of published studies found that limits of between 0 and 0.02 g/dl can reduce the rate of crashes for young or novice drivers by 4–24%.

Enforcing blood alcohol concentration limits and publicizing enforcement

Research has shown that the perceived risk of being caught is considerably more effective than the severity of the penalty in discouraging driving while under the influence of alcohol. Nevertheless, both the perception of the risk of being caught and the actual likelihood are low in most countries.

"Breath-testing devices that provide objective evidence of BAC are the most effective enforcement tool. Although they are used in most high-income countries, they are not used in most low-income and middle-income countries. In any case, the deterrent effect of breath testing depends on the laws governing their use. Police powers vary among jurisdictions. Some allow the police to stop only obviously impaired drivers. Some allow roadblocks or sobriety checkpoints and testing only of those suspected of impairment. Others allow stopping drivers at random and testing everyone stopped.

Enforcement is most effective at reducing the frequency of driving with BAC exceeding legal limits if it is accompanied by mass media campaigns that increase public perception of the risk of being caught, reduce public acceptance of drinking and driving and increase public acceptance of enforcement. In general, harsh penalties such as imprisonment, despite being tried in several high-income countries, have not been found to deter people from driving after drinking. More effective is swift and certain punishment such as disqualification from driving after failing a breath test or refusing to submit to a test .There is also evidence that requiring high-risk offenders (those with BAC exceeding 0.15 g/dl) to take driver rehabilitation courses can reduce the rate of repeat offences ."(World Health Organization, WHO 2009)

Medicinal and recreational drugs

"The effects of drugs on driving performance and crash involvement are much less well understood than those of alcohol, largely because so many different drugs are used in varying doses and combinations, all with differing effects on different individuals. Drivers with medical

conditions, for example, may drive more safely when taking certain medicinal drugs than when not taking them. There is no strong evidence that the use of medicinal drugs and driving constitutes a significant road crash risk.

However, there is evidence for the increasing use among drivers of many psychoactive drugs, both medicinal and recreational, often in conjunction with alcohol. Research on this subject is urgently needed. Meanwhile, recent studies in France and the United Kingdom have found reduced driver capability when cannabis and alcohol are used in combination and a higher prevalence of the combination in drivers involved in road crashes than in other drivers". (World Health Organization, WHO 2009)

Requiring seat-belts and child restraints

Seat-belts

"Mandatory seat-belt use has been one of the greatest success stories of road injury prevention and has saved many lives. Seat-belts were introduced as optional features in new cars in the 1960s. They soon proved so successful at reducing the incidence of fatal and serious injury that, in 1971, the state of Victoria, Australia, led the way in passing laws to require their presence and use in all cars. By the end of that year, the rate of occupant deaths in car crashes had declined by 18% . Other countries followed suit and have since found that improved enforcement and compliance can achieve even better results.

Rates of seat-belt use vary from country to country, depending on the existence and enforcement of laws. A survey in Kenya found that only 1% of car occupants injured in crashes were wearing seat-belts. A recent study in Argentina found that 26% of drivers and front-seat passengers used seat-belts in Buenos Aires and 58% on national highways." (World Health Organization, WHO 2009)

Child restraints

Child restraints work in the same way as seat-belts. A study in the United States found that child restraints reduce the death rates in car crashes by 71% among infants and by 54% among young children.

"Various models are appropriate for children of different ages. For infants aged 0–15 months weighing up to 13 kg, forward-facing child restraints reduce all injuries by 34% and severe injuries by 60%, but rear-facing child restraints reduce all injuries by 76% and severe injuries by 90% . Rear-facing restraints optimally distribute any force of impact over infants' backs and

heads. As discussed previously, placing such seats in front of air bags is dangerous unless the air bag mechanism can automatically detect such a seat and switch it off. Children aged 9–18 months weighing 9–18 kg, forward-facing child restraints are appropriate. For older children, up to age 11 years, booster cushions of appropriate thickness can be used in conjunction with regular seat-belts" (World Health Organization, WHO 2009).

Requiring helmets on two-wheelers

Head injuries are the main cause of death among the riders of all two-wheelers. Helmets protect very effectively against such injuries.

Motorized two-wheelers

"Among moped and motorcycle riders, head injuries account for about 75% of deaths in Europe and 55–88% in Malaysia . One study found that riders without helmets were three times more likely to sustain head injuries than those with helmets. Another found that helmets reduced fatal and serious head injuries by 20–45%.

Bicycles

Wearing helmets among child cyclists involved in crashes reduced their incidence of head injury by 63% and of loss of consciousness by 86% . Although Australia, New Zealand, Sweden, the United States and several other countries have laws requiring that cyclists wear helmets, the worldwide proportion of bicycle helmet use is low. A concern is that requiring helmets could discourage people from participating in healthy cycling, even though there is abundant evidence that bicycle helmets prevent thousands of deaths and serious injuries every year.

Banning drivers from using hand-held mobile phones

Over the past 20 years, hand-held mobile telephones have emerged as a road safety problem. In the United States, for example, the number of such phones increased from 500 000 in 1985 to more than 120 million in 2002. Research has shown that the reaction time of drivers increases by 0.5 to 1.5 seconds when they are talking on handheld phones, and drivers have difficulty maintaining the correct positions in their lanes, maintaining appropriate speeds and judging and accepting safe gaps in traffic. Some evidence indicates that drivers who use hand-held phones face a risk of crash four times higher than risk faced by other drivers, imperiling themselves and other road users." (World Health Organization, WHO 2009)

Educating and informing the public

"In isolation, public education and information campaigns do not deliver tangible, sustained reductions in road traffic deaths and serious injuries. For this reason, early efforts at public education and information have left many people feeling. As mentioned previously, however, public education and information campaigns have proven to be highly effective when they accompany laws and law enforcement.

Public education and information can clearly improve knowledge about the rules of the road and increase compliance. They can tell people which vehicles are safer and thereby influence their purchases. They can also create a climate of concern about road safety and increase public acceptance of effective interventions." (World Health Organization, WHO 2009)

2.6.2. Standard road ways and modern vehicle technology on safety condition

Providing visible, crashworthy, smart vehicles

Risk of injury from poor vehicle design and maintenance

"Vehicle design can have considerable influence on crash injuries. Its contribution to crashes, through vehicle defects is generally between 3% and 5%. A recent European Commission report stated that, if all cars in the European Union were designed to be equal in standard to the best car available in each class, an estimated 50% of all fatal and disabling injuries could be prevented. Meanwhile, many low-income and middle-income countries do not set and enforce standards as high as the ones in the European Union.

From a car occupant's perspective, a major problem is the mismatch in size and weight between the vehicles involved in a crash. The rates of death and serious injury are many times higher in car to truck collisions than in car to car collisions. Other problems are: failure of the passenger compartment to provide a protective shell; lack of features to stop occupants from being ejected from the car; and lack of other safety features, such as high-mounted stop lamps in the rear.

In low-income and middle-income countries, buses, minibuses and trucks including open-backed trucks for transporting passengers are frequently involved in crashes and often do not meet the standards of crashworthiness demanded in high-income countries. Typically, their passengers are not provided with seat-belts and, in the case of open backed trucks, they are thrown from vehicles. Other problems include lack of emergency exits, glass-breakers and fire extinguishers on public transport vehicles". (World Health Organization, WHO 2009)

Improving the visibility of vehicles and vulnerable road users

"Seeing and being seen are fundamental prerequisites for the safety of all road users. Inadequate visibility plays a key role in three kinds of crash ,at night, motor vehicles running into the rears or sides of slowly moving or stationary motor vehicles, bicycles or pedestrians located ahead on the roadway; during the day, angled or head-on collisions; and at all times, rear end collisions in fog.

Colorful clothing, accessories and vehicle parts can make pedestrians, riders and non-motorized vehicles more visible. Reflector vests are often used in high-income countries, but their cost and unsuitability for hot weather may make them impractical for many low-income and middle-income countries. Alternatives include bright yellow or orange clothing or accessories. Similar colures on non-motorized vehicles (such as on bicycle frames or the wheels and rear ends of rickshaws) can make them more visible". (World Health Organization, WHO 2009)

Improving the crashworthiness of motor vehicles

'A recent study in the United Kingdom concluded that a combination of improving vehicles, roads, laws and law enforcement could reduce the number of fatal or serious road traffic crashes by 33%. Improving vehicles alone would yield the best results: a 15.4% reduction. A recent New Zealand study came to a similar conclusion.

High-income countries tend to share the results of such studies through such forums as the International Technical Conferences on the Enhanced Safety of Vehicles . Although their national and regional authorities (such as the European Union) set and enforce standards, they are moving towards common standards, both to ensure safety and to facilitate free trade. Many low-income and middle-income countries do not adopt the same high standards, however, with the result that their new vehicles do not incorporate the latest advances in engineering.

In addition, high proportions of the motor vehicles in low-income and middle-income countries are obsolete or deteriorated to the point at which they would not be tolerated in high-income countries. A recent study found that occupants in cars manufactured before 1984 have about three times the risk of crash injury of occupants of recently manufactured cars". (World Health Organization, WHO 2009)

Protecting pedestrians and cyclists with improved vehicle fronts

"In collisions with cars, the most frequent causes of pedestrian injury are impact between: the pedestrian's head and the car bonnet or windscreen frame; a pedestrian's pelvis or abdomen and the bonnet edge; a child pedestrian's abdomen or chest and the bonnet edge; and the legs and the

car bumper . Lower-limb trauma is the most common type of pedestrian injury, and head trauma is the most common cause of death. Tests show that, in general, new cars do not protect pedestrians and no country requires the fronts of motor vehicles to have crashworthy design to minimize injury to pedestrians". (World Health Organization, WHO 2009)

Protecting motor vehicle occupants

To protect occupants, a motor vehicle should be designed so the passenger compartment maintains its integrity (does not collapse) in a crash and has no elements that could cause injury. There should be restraints so that occupants do not eject from the vehicle or tumble about inside it, injuring themselves and other occupants. In addition, vehicles should be designed to minimize the impact in crashes with other vehicles of different mass, as in collisions between sports utility vehicles and smaller cars, between cars and motorcycles and so on. (World Health Organization, WHO 2009)

The vast majority of car crashes in high-income countries are offset frontal crashes (frontal impact with partial front-end overlap) . High-income countries therefore generally require that new models be tested to ensure that passenger compartments maintain their integrity and that occupant restraints are effective in such crashes.

"Air bags have been estimated to reduce driver and front passenger deaths by 8–14% in all types of crashes and by 22–29% in frontal crashes .The combination of seat-belts plus air bags has reduced driver and front passenger deaths by an estimated 68% . In the United States, many children have been fatally or severely injured while seated in rear-facing child safety seats when there were also air bags. Concern about this hazard has caused some European countries to require warning labels in cars and automatic sensors to detect the presence of child restraints and automatically disable the airbag". (World Health Organization, WHO 2009)

Vehicle Technology and Designing smart vehicles

New technologies are opening new opportunities for road safety. Some of the more promising recent developments are:

"Smart, audible seat-belt reminders that detect whether or not belts are in use in each occupied seat and emit increasingly aggressive warning signals until belts are fastened. In Sweden, for example, 35% of all new cars sold are equipped with these. Although Sweden already has high

rates of seat-belt use, these reminders could boost the rate to an estimated 97% and contribute to a 20% reduction in deaths among car occupants.

Intelligent speed adaptation is a system by which the vehicle determines the speed limit for a road. Current versions use a digital road map onto which speed limits have been coded. Intervention levels can be set to advisory (informing the driver of limits and violations), voluntary (the system is linked to the controls but the driver can enable or disable the link) or mandatory (the driver cannot override the system's control). The system could reduce fatal crashes by an estimated 18–25% at the advisory level, 19–32% at the voluntary level and 37–59% at the mandatory level. Experimental trials in Sweden indicate high driver acceptance of such a system in urban areas". (World Health Organization, WHO 2009)

2.7 Road traffic calming in road safety

"Two kinds of problem in relation to traffic speed are recognized by road safety engineers: excess speed, which is speed in excess of the legal limit, and inappropriate speed, which is speed which is deemed too high relative to the operating conditions. Both these problems are encountered on national roads at the interface between rural and urban sections, and within the urban areas themselves". (Crowley and MacDermott, 1996).

Traffic calming is a way of reducing vehicle speeds by self-enforcing traffic engineering methods and is commonly applied in urban and residential road safety management and in the road safety management of through routes in towns and villages. The transition zone between a high speed and a low speed road presents a difficult safety management problem. These transition zones usually occur on the approaches to towns and villages.

"New research by the Danish Road Directorate shows that the risk of being killed is approximately 95% at 70 Km/h and approximately 40% at 50 Km/h. The concepts of speed management and traffic calming were developed in response to the problem of high speed relative to the environment in road safety.

In the Republic of Ireland, traffic calming schemes have been in place on the approaches to some of the towns and villages on the National Route network since 1993 and the overall general public reaction has been positive". (O'Connor, 1999). "As a natural consequence, local authorities were faced with an increased demand for further traffic calming schemes in view of their cost effectiveness, given the limited resources available.

The safety benefits of lowered travel speeds include:

- Greater time to recognize hazards
- Reduced distance travelled while reacting to hazards
- Reduced stopping distance of the vehicle after braking
- Increased ability of other road users to judge vehicle speed and time before collision
- Greater opportunity for other road users to avoid a collision
- Less likelihood for a driver to lose vehicle control."(World Health Organization, WHO 2010)

Types of Traffic Calming Measures

Seven types of traffic calming measures are commonly used on Addis Ababa roads.

They are:

- Road Humps
- Rumble Strips
- Jiggle Bars
- Raised Islands / Centre Islands
- Narrowing the road
- Town Gates
- Pre-warning

3. RESEARCH METHODOLOGY

3.1Introduction

Road Traffic accidents are the major cause of death and injuries worldwide. The location in a road where the traffic accidents often occur is called a black spot. In these black spots, accidents are not a random event, but common due to varying factors. Expansion of road network, motorization and urbanization in the country has been accompanied by a rise in road accidents leading to road traffic injuries and fatalities as a major public health concern. Today road traffic injuries are one of the leading causes of deaths, disabilities and hospitalizations with severe socioeconomic costs across the world. In Ethiopia around 3,362 persons died and 11,358 persons injured and in Addis Ababa around 367 persons died and 2599 persons injured due to traffic accident the year 2012/2013 according to federal police report. These statistics indicate that accidents prove to be a socio-economic burden on the society. To undertake this situation effectively, it is important to identify, analyze and treat road accident on black spots as one of the most effective approaches to road accident prevention.

GPS and GIS integrate hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. The capability of GPS and GIS to link attributes data with spatial data facilitates prioritization of accident occurrence on roads and the results can be displayed graphically which can be used for planning and decision making. Accident prone locations can be identified using GPS and GIS by analyzing spatial characteristics about identified locations, and also able to figure out the underlying factors causing accidents. Then reasonable actions can be taken to improve safety in the accident-prone locations. In many developed countries, GPS and GIS have been widely used for analyzing the accident lying on black spots location.

A brief review of the various studies on black spot identification is given as follows. There are five different methods used in this study to identify black spots, i.e.

i) Accident frequency method

ii) Accident rate method

iii) Empirical Bayesian method.

iv) Critical accident rate

v) Accident prediction model.

3.2Site Selection and Sampling Procedures

The following detailed methodology has been adopted for obtaining the various aspects of the present study. The steps involved in the study are explained in the following sections.

The study site is located in Bole Sub City. The Sub city covers a total of 122.08 km^2 making it the largest sub city in Addis Ababa. Bole Population density of Bole is 2816.64 person/km^2 with a total population of 343,856. (Socio-Economic profile of Addis Ababa city, 2013).

Figure: 10 Addis Ababa Bole sub city road network maps

Source: Google map web site (2016)

3.2.1Area Sampling

The criteria for selection of the sample areas were the magnitude of vehicle traffic accidents in Addis Ababa on Bole sub city main road. It is selected since there is large amount of traffic volume due to the presence of Addis Ababa Bole international air port and air port cargo terminal. Bole Reports also suggest that the largest traffic accident locations in Addis Ababa are in this sub city.

3.2.2Sample Size

GIS was used to locate the accident spot based on the frequency of vehicle traffic accident statistics collected from records of Bole sub city traffic police (BSCTP) for the past 3 year period from 2005 to 2007 EC, 31 individual road section and 9 intersection for main roads of SAS, PAS and CS types of road on Bole sub city were arranged in rank order.

Based on the data available from various sources such as Addis Ababa Transport office, Bole sub city police office, Addis Ababa city road authority, vehicle drivers and researcher, Bole sub city vehicle population is dominated by 4WD and small car constituting about 80% of the total population especially on road project package 24. Package 24 road sample section stretches 15.5 km long divided in to thirty one500m long sections and 9 individual intersections and roundabouts.

Bole sub city Drivers, pedestrians and police officers were consulted during the data collection process. Random selection procedure was used to gather information about driving behavior, crossing behavior and traffic regulation enforcement. Questionnaires for drivers, pedestrian and police officer were distributed by a sample size taken from survey software with 95% confidence interval and 10% confidence level. (www.surveysystem.com/sscal)

3.3 Study approach

Descriptive Research

On this research, the study is descriptive research type and the goal of descriptive research is to describe some aspect of a phenomenon, i.e., the status of a given phenomenon. It can help understand a topic and lead to causal analysis. Descriptive research, therefore, involves a variety of research methods to achieve its goal. The methods that come under descriptive research are:

- Surveys
- Correlation studies
- Observation studies
- Case studies

Case studies

Lay emphasis on detailed background analysis of a limited number of events or conditions and their relationships. They are largely descriptive examinations, usually of a small number of sites

(small towns or sub city, section of road, institution). Case studies can provide very attractive, rich explorations of a project or application as it develops in a real-world setting.

3.4 Traffic data

Traffic studies were required to determine current and future traffic volume AADT expected to use the different road section of the road project, On other hand the purpose of traffic study on this research is important predict accident rate and identify the black spot location in different road section, There are three different type of traffic study,

- Normal traffic
- Diverted traffic
- Generated traffic

In our case ,to know the present traffic date ,use a generated traffic calculation method and for the determination of the generated traffic ,we have to now a better understanding on socio economical actives , population growth and trend of vehicle growth in Addis Ababa to be considered.

3.5. Accident reporting

The police officers are collecting traffic accident, since the first person for witness to the accident condition and accident sight. It is essential that police force recognize and assume their responsibility with respect to accident data. The report has three aims. To create greater levels of awareness, commitment and informed decision-making at all levels government, educational institution, industry, international agencies and nongovernmental organizations, so that strategies scientifically proven to be effective in preventing road injuries can be implemented. Any effective response to the global challenge of reducing road traffic casualties will require all these levels to mobilize great effort.

To help strengthen government, institutions and to create effective partnerships to deliver safer road traffic reporting systems can be created.

To improve the quality of accident reporting it is important to make communication between different stakeholders by

- Holding informal meeting and communication forum
- Publishing newsletter with articles on common title

- Provide complete feedback to the information providers
- Setting up a reward system to recognize proper completion of report forms

3.6 Accident data collection

3.6.1Data Collection procedure and source of data

In order to achieve the objectives of the study, both primary and secondary data were used. The primary data were obtained from three different questionnaires that were distributed to all vehicle drivers and pedestrians who were around and willing to complete the questionnaires and interview. Information was also gathered from officials in the Addis Ababa Transport Office transport engineers, the Addis Ababa Traffic Police officer, Bole sub city Traffic Police officers and traffic police statistical officer, pedestrians and vehicle drivers, and the Traffic Police men that were on duty and finally traffic volume count on site.

The secondary data were collected from, Ethiopian Road Authority (ERA), and, Addis Ababa City Road Authority (AACRA), Addis Ababa Transport Authority (AATA), Addis Ababa Traffic Police (AATP), Bole sub city Traffic Police (BSCTP), and the Central Statistical Authority (CSA), as well as other relevant published and unpublished information sources.

3.6.2Primary Data and Fields Work

3.6.2.1. Distribute Questioners for Drivers, Traffic Police and Pedestrian.

According to socio economic profile of Addis Ababa (2004E.C), the total population size of Bole sub city is 343,856. The required sample size with confidence level of 95% and confidence interval of 10% is calculated as 96 questionnaires.

3.6.2.2. Collected Data for Traffic Volume

Traffic Volume data was gathered for the identified study locations. Where previous AADT data was available from AACRA, that secondary data was used as the representative traffic volume on the section. If previous data was unavailable, direct traffic count was conducted on the locations. Instances of such direct counts are made at Bole Michael Round about.

3.6.3Secondary Data and Office Work

Three different questionnaires were prepared and distributed to vehicle drivers and pedestrians. These questionnaires were developed based on secondary data obtained from the Traffic Police records and other relevant literature. Different tables were developed to collect data from the archives of AACRA, CSA, AATA, FP, AAP and Bole sub city traffic police office (BSCTPO).

3.6.3.1 Traffic Accident Data

Some documentation shows that Bole sub City have a relatively good road network than other sub city but high number of traffic accident. The question is why? For this question the research tries to find out the cause and give the solution supported by the actual accident data collected from the Bole sub city documentation office.

The traffic accident casualty patterns in different routes (roads) of Addis Ababa are quite different. For example, among our sample routes section, Emperial round about, Bole Michael roundabout and Bole bridge roundabout at A.A Bole international air port, the casualties account for the vast majority of injuries based on three year data (2005 to 2007E.C).

Bole sub -City road network was sub divided into 31 road section and 9 main junction with a high traffic accident from the records of Bole sub city police documentation office. This condition leads to which road section and intersection has the major traffic accident problem and identified systematically the black spot locations.

3.7. Identification of Black Spot Location Using GPS and GIS

Using GIS map which is found from AACRA, this study try to locate all the traffic accident data counted from the office of Bole sub city accident record office taken all each individual files and put it to point out on Bole sub city major road GIS map and give section name to all major roads which is included on this research. This is to show as the different number of black spot location for further identification and final putting all black spot site locating using GPS coordination for further improvements.

3.8. System of Data Analysis

On this part, we see different methods of identification for road accident problems and ways of determining the black spot location. Additionally, we chose this reference because it is not done only for one country road safety condition but it is done with cooperation of different countries real road safety existing modeling condition jointly and this satisfied our country road safety condition especially it is better choice for case of Addis Ababa road safety requirements.

There are different methods for accident identification

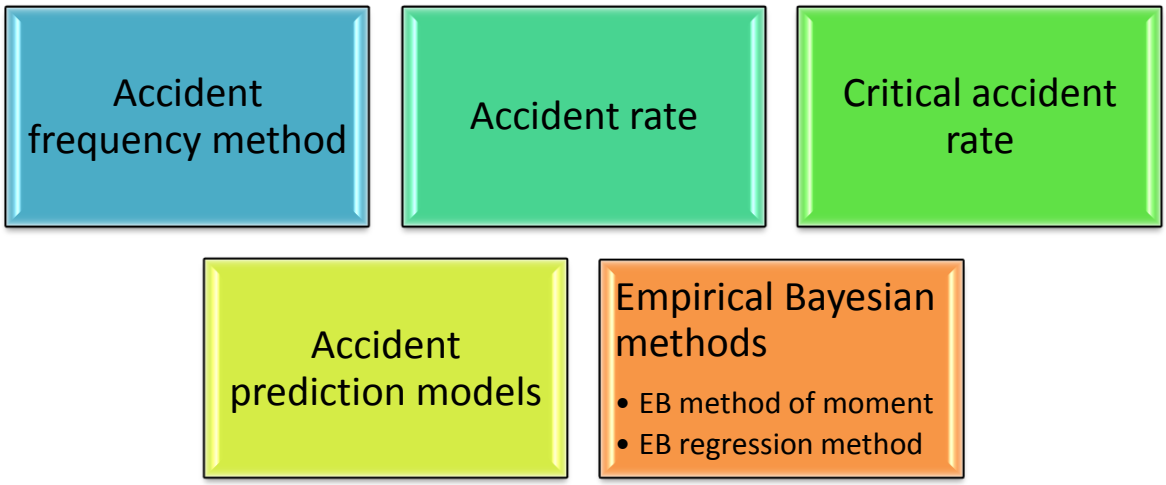


Figure: 11 Different forms of accident identification methods

Source: road safety manual by world road association Canada (2004)

Accident frequency method

Accident frequency is the simplest determination criteria, each accident is located at its point of occurrence on the road net work and the total number of accidents reported at each site is added up.

$$frp = \frac{\Sigma fj}{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.1)$$

$$Ir = 2xfrp \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.2)$$

Where

f_j=accident frequency at site j of a reference population

f_{rp}=average accident frequency

n=number of sites

Ir=minimum accident frequency that warrants a detailed safety analysis.

Accident rate

Accident rate is a ratio between a number of accidents and an exposure measure.

$$R_j = \frac{f_j x 10^6}{365.25 x P L_j Q} \text{ , for the accident rate of each site } \ldots\ldots\ldots \text{ (3.3)}$$

$$R_{rp} = \frac{\sum f_j x 10^6}{365.25 x P \sum L_j Q_W} \text{ , } \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (3.4)}$$

For the average accident rate for the reference population

$$Q_W = \frac{\sum (Q_j x L_j)}{\sum L_j} \text{ , } Q_j = AADT \text{ of site } j \ldots\ldots\ldots\ldots\ldots\ldots \text{ (3.5)}$$

$$\text{, } Ir = 2xRrp \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (3.6)}$$

Where

R_j=accident rate of site j(acc/Mveh-km)

R_{rp}= average accident rate (acc/Mveh-km)

f_j=accident frequency at site j

P=period of analysis (year)

L_j=section length of site j(km)

$\sum L_j$= total length of section j(km)

Q_j=average annual daily traffic of site j(AADT)

Q_w= weighted average annual daily traffic (AADT)

Ir=minimum accident frequency that warrants a detailed safety analysis

Critical accident rate

It comprise the accident rate at a site with the average accident rate calculation in a group of site having similar character and also comparing the accident rate and accident rate at each site .A detail safety analysis is justified when the accident rate is higher than the critical rate. we concluded the location is hazardous site.

$$R_{cj} = R_{rp} + K\sqrt{\frac{R_{rp\times 10^6}}{365.25\times PL_J\ \ Q_J}} + \frac{1+10^6}{730.5\times PL_J\ \ Q_J} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.7)}$$

Where

R_{cj}=critical accident rate at site j (acc/Mveh-km)

R_{rp}=average accident rate at similar sites (acc/Mveh-km)

K=statistical constant

1.036 for a level of confidence of 85%

1.282 for a level of confidence of 90%

1.645 for a level of confidence of 95%

2.326 for a level of confidence of 99%

P=period of analysis (year)

L_j=section length of site j (km)

Q_j=average annual daily traffic of site j (AADT)

Accident prediction models

$$PI_j = f_{j-}f_{rp} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.8)}$$

Where

PI_j=potential for improvement at site j

f_j=accident frequency at site j

f_{rp}=average accident frequency (reference population)

N=number of sites

S^2=variance of accident frequency

$accidents = a(traffic\ function)b$

Empirical Bayesian methods

The first has been computed based on the accident frequency reported at the site over a relatively short period of time or accident period.

EB method of moment

EB method of moment required calculating the populations mean accident frequency and its variance; those two statistics are then used to adjust the accident frequency at the site.

$f_{EBj} = f_j + \frac{f_{rp}}{S^2}(f_{rp} - f_{rp})$ ..... (3.9)

$frp = \frac{\sum fj}{n}$ ..... (3.10)

$s^2 = \frac{\sum(f_j - f_{rp})2}{n-1}$ ..... (3.11)

$PI_j = f_{EBj} - f_{pj}$ ..... (3.12)

, using to calculate potential improvement (PI) at each site.

Where

f_{EBj}=EB adjusted accident frequency at site j

f_j=accident frequency at site j

f_{rp}=average accident frequency (reference population)

n=number of sites

S^2=variance of accident frequency (reference population)

EB regression method

$f_{EBj} = w * f_{pj} + (1 - w) * f_j$ ..... (3.13)

$PI_j = f_{EBj} - f_{pj}$,..... (3.14)

Using to calculate potential improvement (PI) at each site.

Where

f_{pj}=prediction accident frequency at site j

w= weight of prediction accident frequency

3.9 Black spot detection and improvement process on the Research

On this research we try to give a better understanding for investigation of black spot location and improvement ways. Now the most commonly used steps of black spot improvement process are the following,

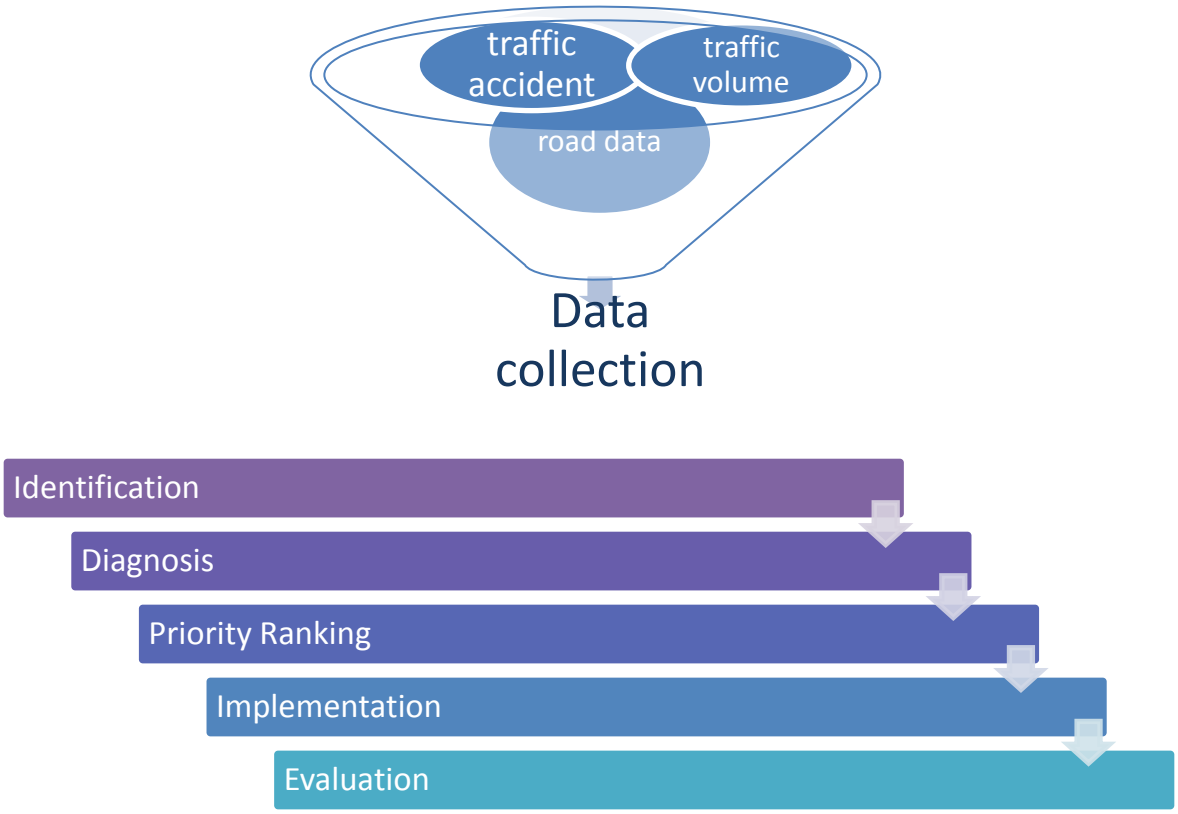


Figure: 12 Black spot identification systematic process and procedure

Source: Road safety manual by world road association Canada (2004)

4. DATA ANALYSIS AND DISCUSSION

4.1 Analysis of Road Traffic Accident in Bole sub city

This research shows briefly the review of the study of road traffic accident analysis done on the previous 3 years data from Bole sub city documentation office and 5 years of detail study on characteristics of traffic accident and analysis from Addis Ababa police. This detail investigation and diagnosis show the cause of accident and finds out the rank of the accident severity in Bole sub city to give a better evaluation and recommendation to minimize the road traffic accident.

A brief review of the various studies on black spot identification is given as follows .We start from data collected from different institutions and complies with a scientific way to make it easily understandable for anyone. The research conducts the following different methods to diagnose the black spot.

1) Accident frequency method;
2) Accident rate method
3) Critical accident rate
4) Accident prediction model.
5) Empirical Bayesian method.

4.1.1 Distribution of road accidents by day and year

The following chart shows detail road traffic accident data distribution for daily amount of traffic accident that occurred in the past 5 years in each day. According to this chart, there are a large number of accidents occurring on Saturday through out a year. This needs further study to identify the reason behind the accidents on Saturday.

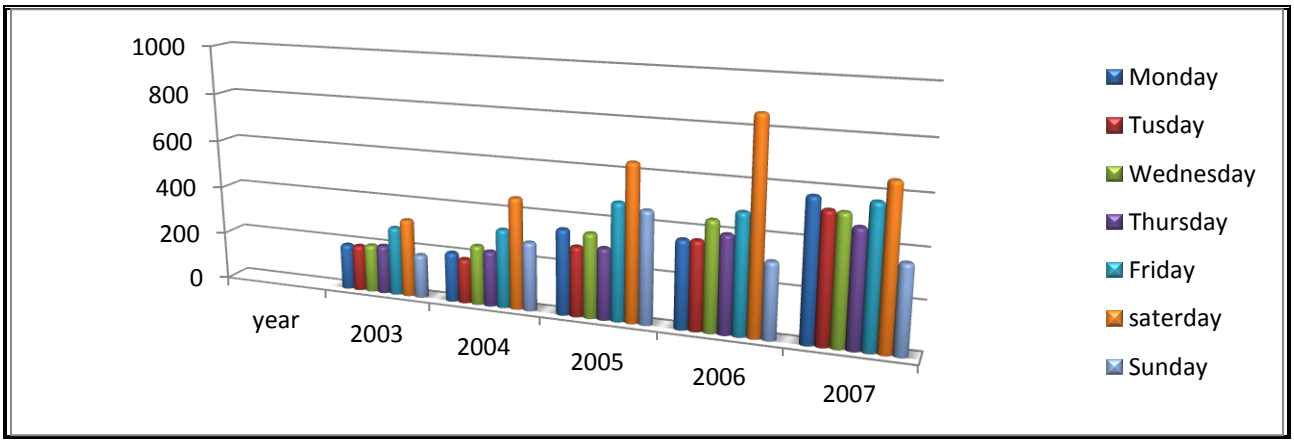


Figure: 13 Distribution of road accidents by day and year

Source: Addis Ababa Transport Authority, AATA (2016)

4.1.2 Distribution of fatal road traffic accidents by location and month

The following table shows that there are a high number of fatal traffic accidents on month of October. Data shows that the fatal locations are concentrated on Rwanda, Empirial, Yerer and Gerji . These locations recorded more than 3 times the fatal traffic accident recorded within 8 months.

	Distribution of fatal traffic accident in bole sub city by location for 2015/2014								
Month	**July**	**Augest**	**September**	**October**	**November**	**December**	**January**	**February**	**TOTAL**
location	ruwanda	goro bridge	goro bridge	gergi mebrat	emperial intersection	yerer	gerji	alemayew building	0
	hayat	frend ship		ruwanda	hayat	emperial intersection	bulbula	hayat hospital	0
	ruwanda	yerer		bulbula bridge	semit	arabsa	adwa bridge	gerji	0
	hayat	yerer		bole custem	bole brase	yerer gulit		goro	0
	ruwanda	semit		salitemhret church		yerer ber			0
	yerer			ruwanda		wasmar hotel			0
	amen hotel			bulbula bridge					0
				emperial intersection					0
				hayat					0
monthly total fatal	**7**	**5**	**1**	**9**	**4**	**6**	**3**	**4**	**39**

Table: 5 Distribution of fatal road traffic accidents by location and month

Source: Bole sub city police documentation office (2015)

4.1.3 Distribution of road accidents by intersection and round about

Table 6 below shows the accident distribution in different sections of a road segment. As the table indicates, there are a large number of accidents on junctions and roundabouts. Contrary to the junctions, straight sections of the road do not have large amounts of accident record. Therefore, much emphasis must be given at junctions and roundabouts to improve geometry of the road category.

	Distribution of taffic accident by road intersection and junction 2003-2007							
Day		intersection type						
Month	injory	no junction	Y shap junction	T shap junction	round about	intersection	x shap junction	TOTAL
								
2003	Serious	77	15	10	17	11	4	134
	minor	43	13	15	16	7	2	96
	property	808	139	134	160	58	38	1337
2004	Serious	158	2	6	6			172
	minor	74		2	4	2		82
	property	897	60	40	280	400		1677
2005	Serious	180	18	16	16	22	4	256
	minor	98	14	12	8	6	2	140
	property	1312	142	208	204	440	160	2466
2006	Serious	244			13			257
	minor	141			2			143
	property	2291			280	258		2829
2007	Serious	266			12	10		288
	minor	121			6	3		130
	property	2646			317	292	6	3261

Table: 6 Distribution of road accidents by road intersection

Source: Addis Ababa Transport Authority, AATA (2016)

4.1.4 Distribution of road accidents by age group

The following charts shows there is a higher number of accidents by younger people age group of 18-30 years, On this age group, most of young people participate in a society actively and due to this high activity and movement they will put their life in danger from all group of drivers, passengers and pedestrians younger people could be a cause of a traffic accident.

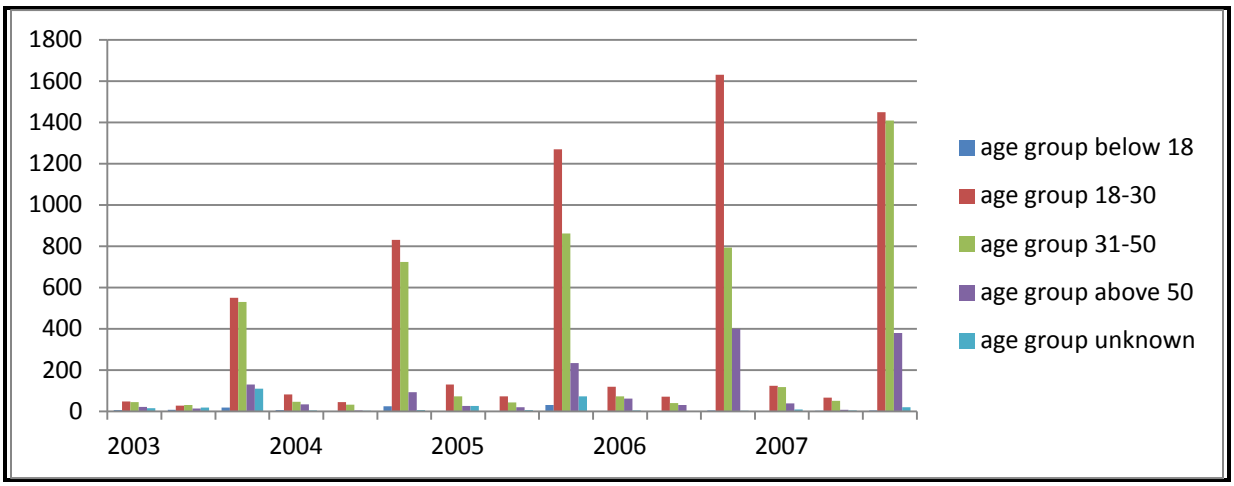


Figure: 14 Distribution of road accidents by age group

Source: Addis Ababa Transport Authority, AATA (2016)

4.1.5 Distribution of road accidents by gender

As chart below shows , most of a younger man can create a traffic accident and put their life and others in danger .To know why this situation happen, it need a further study but for this research, we take as an input for this thesis.

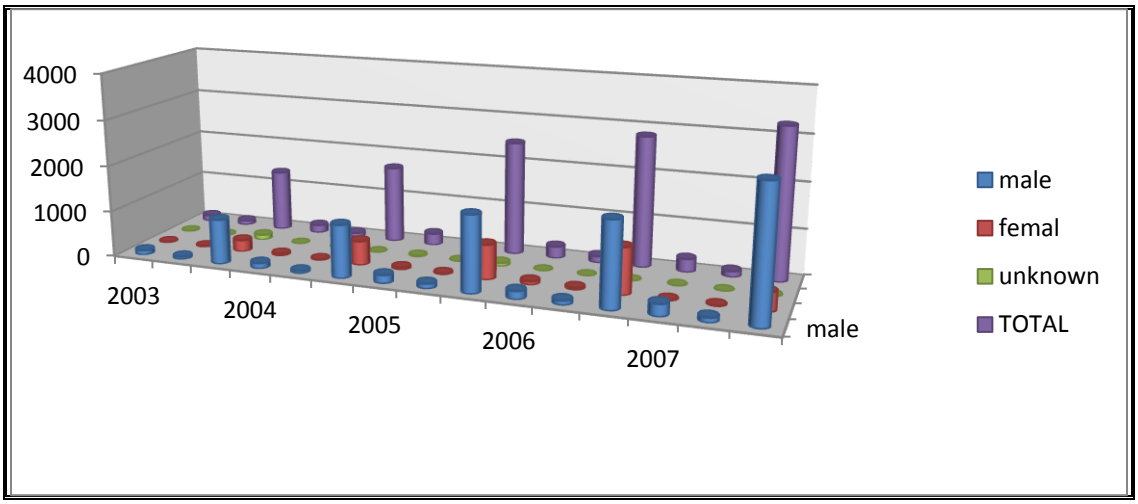


Figure: 15 Distribution of road accidents by gender

Source: Addis Ababa Transport Authority, AATA (2016)

4.1.6 Distribution of road accidents by hours

The next chart shows ,distribution of traffic accident with time difference throughout a day and the chart shows the most critical time for traffic accident is from morning 7:00 o'clock local time (0700) up to night 11:00 o'clock local time (2100) .

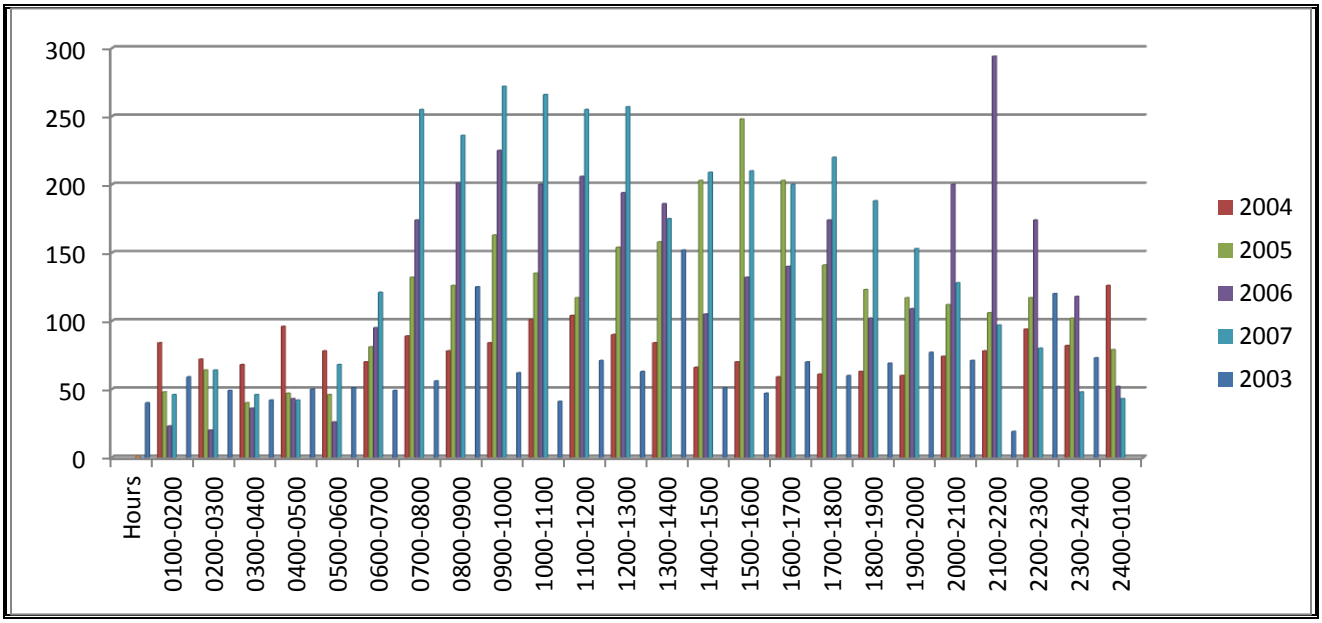


Figure: 16 Distribution of road accidents by hours

Source: Addis Ababa Transport Authority, AATA (2016)

4.1.7 Distribution of road accidents by accident location area

Analyzing the most potential different traffic accident location is important to assess its priority, to know the place and put black spot marking for this location. According to Bole sub city accident documentation office, the traffic accident allocation indicated most of the accidents happen at the market place and recreational centers. On other side there is a significant amount of traffic accident data that is not recorded properly and documented.

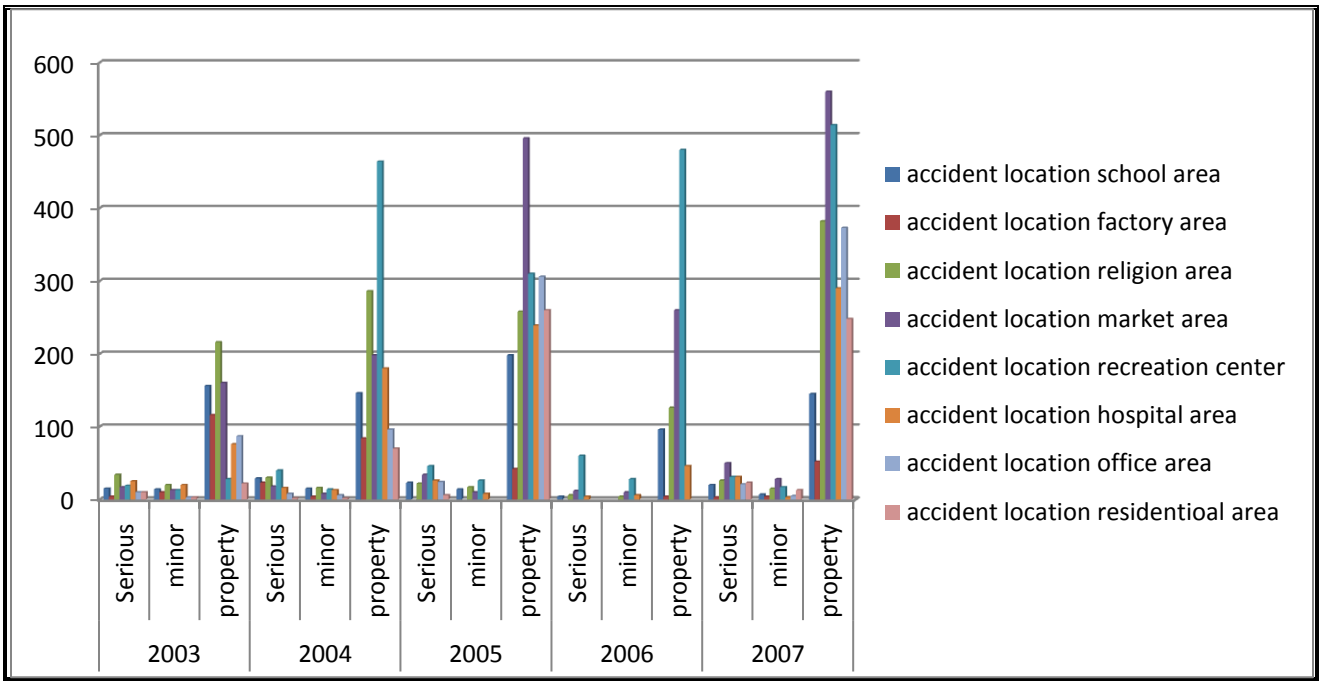


Figure: 17 Distribution of road accidents by accident location area

Source: Addis Ababa Transport Authority, AATA (2016)

4.1.8 Distribution of road accidents by illumination and weathering (lighting condition)

Previous researchers indicated that weather condition is a prime factor for the causation of accidents. As opposed to popular belief, most of the accidents in Bole sub city occurred during good weather conditions. Thus, it is decided that weather conditions are not the main reason behind the occurrence of accidents in Bole sub city. .

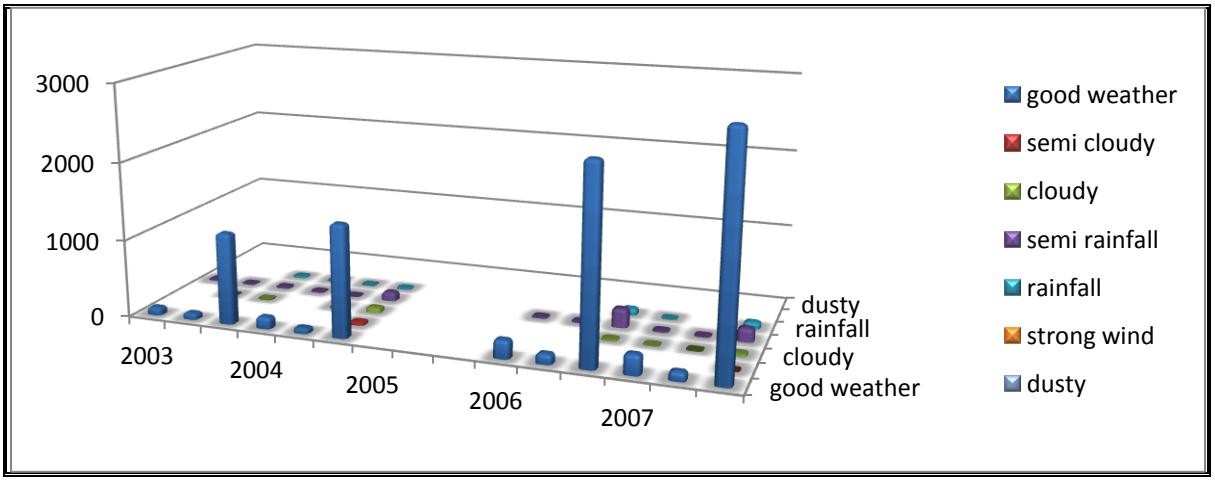


Figure: 18 Distribution of road accidents by weathering

Source: Addis Ababa Transport Authority, AATA (2016)

4.2 Analysis of interview, questioners and field observation results

A total of 96 questionnaires were distributed equally for drivers, pedestrian and traffic police. 89 questionnaires were returned back with complete answer for each question and the rest had gaps that were filled by interview, different drivers, pedestrian and police officers. On other hand to full fill the gap of population which is not returns the questioners form, the study conduct an interview for the pedestrian, police officer, driver to full fill this gap .

Questioners for drivers

item	Questionar for drivers	Strongly agree	agree	neutral	disagree	strongly disagree
1	Do you Agree the amount of traffic accidents in Bole sub city is greater compare to other sub cities in addis ababa	0	17	4	10	0
2	Do you Agree the pedestrian follow the traffic regulations like crossing road using on zebra crossing to protect from traffic accidents in Bole sub city	0	5	1	25	0
3	Do you Agree most of the traffic accidents occurs in Bole sub city is b/c of drivers do not given a priority to a pedestrian	0	2	2	22	5
4	Traffic safety education and training about traffic accidents is given for drivers and pedestrian is adequate in Bole sub city and also in addis ababa	0	7	14	9	1
5	Do you Agree most of the traffic accidents occurs in Bole sub city is at the same location and it must be putting a black spot location is necessary	1	18	4	5	3
6	Is there adequate number of traffic police ,traffic regulation, traffic sign and road environment available to reduce traffic accident in bole sub city	0	4	5	19	4
7	Are you comfortable driving and maintain with allowable speed using bole sub city road than other sub city road	2	21	3	5	0
8	Do you think available traffic rules and regulations can reduce traffic accidents	1	8	14	6	2

Table: 7 Drivers compiled questioner respond about RTASE

Source: Own calculated and collected questioner respond

Questioners for pedestrians

item	Questionar for pedistrain	Strongly agree	agree	neutral	disagree	strongly disagree
1	Do you Agree the amount of traffic accidents in Bole sub city is greater compare to other sub cities in addis ababa	0	20	5	2	1
2	Do you Agree you and other pedestrian follow the traffic regulations like crossing road using on zebra crossing to protect from traffic accidents in Bole sub city	1	18	4	3	2
3	Do you Agree most of the traffic accidents occurs in Bole sub city is b/c of drivers do not given a priority to a pedestrian	2	22	1	3	0
4	Traffic safety education and training about traffic accidents is given for drivers and pedestrian is adequate in Bole sub city and also in addis ababa	0	4	4	17	3
5	Do you Agree most of the road have comfortable pedestrian road pavement for normal person and disable person	0	3	0	21	4
6	Do you Agree most of the road have comfortable and adequate pedestrian road crossing structures and zebra crossing for normal person and disable person	0	5	1	19	3
7	Is there adequate number of traffic police ,traffic regulation, traffic sign and road environment available to reduce traffic accident in bole sub city	0	5	9	13	1
8	Are you comfortable waking and crossing zebra without any problems using bole sub city pedestrian road pavement than other sub city pedestrian road pavement	0	0	4	20	4
9	Do you think available traffic rules and regulations can reduce traffic accidents	1	4	7	15	1

Table: 8 Pedestrian compiled questioners respond about RTASE

Source: Own calculated and collected questioner respond

Questioners for police officers

item	Questionar for traffic poilce	Strongly agree	agree	neutral	disagree	strongly disagree
1	Do you Agree the magnitude of traffic accidents in Bole sub city is greater compare to other sub cities in addis ababa	8	17	2	3	0
2	Do you Agree most of the traffic accidents occurs in Bole sub city is b/c of drivers do not given a priority to a pedestrian	6	23	1	0	0
3	The most necessary traffic safety education and training about traffic accidents is given for drivers and pedestrian is adequate in Bole sub city and also in addis ababa	5	21	0	3	1
4	Do you Agree most of the traffic accidents occurs in Bole sub city is at the same location and it must be putting a black spot location is necessary	2	24	1	3	0
5	Is that adequate using menilik hospital to send verify dead bodies of persons who die at the site of accidents	2	7	5	16	0
6	Do you think the available traffic rules and regulations can reduce accidents	8	20	1	1	0

Table: 9 Police compiled questioners respond about RTASE

Source: Own calculated and collected questioner respond

4.3Identification and analysis of black spot evaluation on Bole sub city major road

To identify black spots by reference to a clearly defined population of roadway elements, it is obviously necessary to make a detailed division and classification of the entire road network into different roadway elements. The division and classification will vary from country to country and also from region to region. For instance, PAS, SAS, CS has been used for Addis Ababa road classification. This research study will cover detail black spot identification for three (3) years using counts from daily traffic accident record book and put mark using GIS map.

This research study covers several methods of road traffic accident and safety problem .This study mostly focused on identification of problems that are likely to be treatable through road

engineering .From this point of view, the first thing is to identify black spots location and take safety action with different safety measurement ways .

For identification of black spot are often located at nodes of the road network .i.e. at crossing points between two or more roads. There are several types of nodes that should be distinguished as they have different safety performance.

- Conventional intersection (Cross ,T ,X, Y)
  - Four-leg junctions
  - Three-leg junctions
  - Roundabouts
  - Access ramps
  - Straight sections of a specified length
  - Horizontal curves with different radius
  - Bridges
- Interchange

Traffic growth rate forecasting

To determine the forecasted annual average daily traffic (AADT) for design period of the previous years , the average Ethiopian traffic growth rate given by World Bank (7%) for small vehicle and 17% for truck by average is used.

$$\text{AADT}_{(2016)} = AADT_{(2011)} * (1 + i)^n$$

Where:

i - traffic growth rate for each vehicles

n - number of years the following years.

AADT – annual average daily traffic

Traffic volume growth rate forecasting table

	Forcasting for bole sub city road section AADT (2014-2023)								
LOCATION	**car**	**4 WD**	**S/BUS**	**L/BUS**	**S/TRUCK**	**M/TRUCK**	**H/TRUCK**	**T & T**	**TOTAL**
%	7	7	7	7	17	17	17	17	
FACTOR	1.07	1.07	1.07	1.07	1.17	1.17	1.17	1.17	
	car	**4 WD**	**S/BUS**	**L/BUS**	**S/TRUCK**	**M/TRUCK**	**H/TRUCK**	**T & T**	**TOTAL**
gergi korea hospital(2011)	20064	7880	2851	1205	580	376	190	298	33444
Forcast AADT(2016)	28141	11052	3999	1690	1272	824	417	653	48048
Yerer goro (2011)	8826	4291	2322	182	229	67	144	19	16080
Forcast AADT(2016)	12379	6018	3257	255	502	147	316	42	22916
royal GG hotel(2011)	17708	8719	1115	697	777	808	760	343	30927
Forcast AADT(2016)	24836	12229	1564	978	1704	1771	1666	752	45500
bole air port custum (2007)	5063	1989	719	304	146	95	48	75	8440
Forcast AADT(2016)	9309	3656	1323	559	601	390	197	309	16344
bole medihanalem (2006)	8778	3447	1247	527	254	164	83	130	14631
Forcast AADT(2016)	17267	6781	2454	1037	1220	791	400	627	30575
gurd shola (2006)	4800	1100	420	496	360	0	0	0	7176
Forcast AADT(2016)	9442	2164	826	976	1730	0	0	0	15139
CMC road (2006)	4816	886	454	0	414	286	0	0	6856
Forcast AADT(2016)	9474	1743	893	0	1990	1375	0	0	15475

Table: 10 AADT forecasting for different road section in Bole sub city

Source: AACRA documentation office from different consultant project (2006)

Traffic volume growth rate forecasting for Emperial junction and actual counted traffic volume for Bole Michael junction table

	Bole Sub City Road Junction AADT (2012-2016)								
	FORCASTING EMPERIAL JUNCTION				COUNTED ON SITE BOLE MICHAEL JUNCTION				
LOCATION	from megenagia	from bole roundabout	from 22 road	from roba bakery	from bole roundabout	from saris abo church	from rwand embasy	from bulbula	
%	7	7	7	7	17	17	17	17	
FACTOR	1.07	1.07	1.07	1.07	1.17	1.17	1.17	1.17	
AADT (2012)	42456	45743	10125	32867					
Forcast AADT(2016)	55651	59960	13272	43082	46504	45739	21503	20887	

Table: 11 AADT forecasting for different road section in Bole sub city

Source: AACRA documentation office from different consultant project (2006) and actual traffic count on Bole Michael site

4.3.1Analysis of black spot evaluation with accident frequency, accident rate and Critical accident rate methods.

First, we try to see traffic accident pattern, nature, priority and severity in detail using a scientific analysis and put remedial solution and recommendation for problems.

For further identification of black spot, the research use different methods such as 1) accident frequency method 2) accident rate 3) critical accident rate methods respectively.

On this type of traffic identification analysis, the amount of AADT is mandatory and it is priority to calculate all accident identification method. The second stage would be counting the accident frequency from secondary data source such as from police station documentation office. The data taken from Bole sub city police traffic accident documentation office for traffic accident data and AADT the data taken from Addis Ababa city road authority AACRA. For some location where AADT is not found traffic volume counts on actual site are taken.

	Bole sub city road section accident identification and diagnosis					
Section number	AADT	Accident frequency	individual accident rate(acc/ Mveh-km)	average accident rate(acc/ M veh-km)	It	critical rate
2	46504	15	0.59	0.97	1.94	1.194
3	46504	38	1.49	0.97	1.94	1.194
4	46504	8	0.31	0.97	1.94	1.194
6	59960	51	1.55	0.75	1.51	0.926
7	59960	8	0.24	0.75	1.51	0.926
9	55651	15	0.49	0.81	1.62	0.998
10	55651	58	1.90	0.81	1.62	0.998
11	55651	56	1.84	0.81	1.62	0.998
13	15139	22	2.65	2.99	5.97	3.669
14	15139	9	1.09	2.99	5.97	3.669
15	15139	7	0.84	2.99	5.97	3.669
16	15139	13	1.57	2.99	5.97	3.669
17	15139	18	2.17	2.99	5.97	3.669
19	15475	11	1.30	2.92	5.84	3.589
20	15475	11	1.30	2.92	5.84	3.589
21	15475	7	0.83	2.92	5.84	3.589
22	15475	17	2.01	2.92	5.84	3.589
23	15475	19	2.24	2.92	5.84	3.589
25	30575	23	1.37	1.48	2.96	1.817
27	43082	29	1.23	1.05	2.10	1.289
29	30575	60	3.58	1.48	2.96	1.817
30	30575	50	2.98	1.48	2.96	1.817
	TOTAL n=	545				

Table: 12 traffic accident diagnosis using accident rate method for road section

Source: Own calculated and road safety manual reference

Bole Sub city intersection accident identification and diagnosis						
Section number	Name of intersection	AADT	Accident frequency	individual accident rate(acc/M veh)	average accident rate(acc/M veh)	critical rate
1	bole michael round about	46504	254	4.98	22.78	23.49
5	bole bridge intersection	30575	85	2.54	34.65	35.72
8	emperial hotel round about	59960	296	4.51	17.67	18.22
12	megenagia bridge intersection	55651	126	2.07	19.04	19.63
18	sahlitemehire t church round about	15139	39	2.35	69.99	72.15
24	CMC roundabout	15475	33	1.95	68.47	70.58
26	bole medihanialem round about	30575	79	2.36	34.65	35.72
28	gerji mebrat intersection	48048	106	2.01	22.05	22.73
31	millinum hall intersection	30575	143	4.27	34.65	35.72
		TOTAL n=	1161			

Table: 13 traffic accident diagnosis using accident rate method for road intersection

Source: Own calculated and road safety manual reference

4.3.2Analysis of black spot evaluation with Accident prediction model

	Bole sub city road section accident identification and diagnosis						
Section number	AADT	Accident frequency	individual accident rate(acc/ Mveh-km)	average accident rate(acc/ M veh-km)	It	critical rate	Fp
2	46504	15	0.59	0.97	1.94	1.194	0.066
3	46504	38	1.49	0.97	1.94	1.194	0.133
4	46504	8	0.31	0.97	1.94	1.194	0.041
6	59960	51	1.55	0.75	1.51	0.926	0.167
7	59960	8	0.24	0.75	1.51	0.926	0.041
9	55651	15	0.49	0.81	1.62	0.998	0.066
10	55651	58	1.90	0.81	1.62	0.998	0.184
11	55651	56	1.84	0.81	1.62	0.998	0.179
13	15139	22	2.65	2.99	5.97	3.669	0.088
14	15139	9	1.09	2.99	5.97	3.669	0.045
15	15139	7	0.84	2.99	5.97	3.669	0.037
16	15139	13	1.57	2.99	5.97	3.669	0.059
17	15139	18	2.17	2.99	5.97	3.669	0.076
19	15475	11	1.30	2.92	5.84	3.589	0.052
20	15475	11	1.30	2.92	5.84	3.589	0.052
21	15475	7	0.83	2.92	5.84	3.589	0.037
22	15475	17	2.01	2.92	5.84	3.589	0.072
23	15475	19	2.24	2.92	5.84	3.589	0.079
25	30575	23	1.37	1.48	2.96	1.817	0.091
27	43082	29	1.23	1.05	2.10	1.289	0.109
29	30575	60	3.58	1.48	2.96	1.817	0.189
30	30575	50	2.98	1.48	2.96	1.817	0.164
	TOTAL n=	545					

Table: 14 traffic accident diagnosis using accident prediction model for road section

Source: Own calculated and road safety manual reference

Bole Sub city intersection accident identification and diagnosis							
Section number	Name of intersection	AADT	Accident frequency	individual accident rate(acc/M veh)	average accident rate(acc/M veh)	critical rate	Fp
1	bole michael round about	46504	254	4.98	22.78	23.49	29.62
5	bole bridge intersection	30575	85	2.54	34.65	35.72	21.54
8	emperial hotel round about	59960	296	4.51	17.67	18.22	35.93
12	megenagia bridge intersection	55651	126	2.07	19.04	19.63	33.95
18	sahlitemehire t church round about	15139	39	2.35	69.99	72.15	12.62
24	CMC roundabout	15475	33	1.95	68.47	70.58	12.84
26	bole medihanialem round about	30575	79	2.36	34.65	35.72	21.54
28	gerji mebrat intersection	48048	106	2.01	22.05	22.73	30.36
31	millinum hall intersection	30575	143	4.27	34.65	35.72	21.54
		TOTAL n=	1161				

Table: 15 traffic accident diagnosis using accident prediction model for road intersection

Source: Own calculated and road safety manual reference

4.3.3 Analysis of black spot evaluation with Empirical Bayesian methods

When conducting and analyzing road traffic accident in Addis Ababa Bole sub city, this diagnosis gives a better understanding about how to identify RTAs. The analysis process using different methodology, Such as accident frequency, accident rate, critical accident rate, accident prediction model and empirical Bayesian methods. Selecting an empirical Bayesian analysis for Addis Ababa Bole sub city because of this traffic accident analysis method, even if it is a little bit complex method the final output to full fill the other method equation 3.2, 3.6, 3.7 and 3.8. All this equation included and compiled the other equation in empirical Bayesian method. Finally the study concluded that this method means empirical Bayesian method was found to be the most suitable to identify and analyze black spots and give a better recommendation to create a safe traffic road.

	Bole sub city road section accident identification and diagnosis								
Section number	AADT	Accident frequency	individual accident rate(acc/ Mveh-km)	average accident rate(acc/ M veh-km)	It	critical rate	Fp	Feb	PI EB Methode
2	46504	15	0.59	0.97	1.94	1.194	0.066	15.71	15.65
3	46504	38	1.49	0.97	1.94	1.194	0.133	37.04	36.90
4	46504	8	0.31	0.97	1.94	1.194	0.041	9.22	9.18
6	59960	51	1.55	0.75	1.51	0.926	0.167	49.09	48.92
7	59960	8	0.24	0.75	1.51	0.926	0.041	9.22	9.18
9	55651	15	0.49	0.81	1.62	0.998	0.066	15.71	15.65
10	55651	58	1.90	0.81	1.62	0.998	0.184	55.58	55.40
11	55651	56	1.84	0.81	1.62	0.998	0.179	53.72	53.55
13	15139	22	2.65	2.99	5.97	3.669	0.088	22.20	22.11
14	15139	9	1.09	2.99	5.97	3.669	0.045	10.15	10.10
15	15139	7	0.84	2.99	5.97	3.669	0.037	8.29	8.26
16	15139	13	1.57	2.99	5.97	3.669	0.059	13.86	13.80
17	15139	18	2.17	2.99	5.97	3.669	0.076	18.49	18.42
19	15475	11	1.30	2.92	5.84	3.589	0.052	12.00	11.95
20	15475	11	1.30	2.92	5.84	3.589	0.052	12.00	11.95
21	15475	7	0.83	2.92	5.84	3.589	0.037	8.29	8.26
22	15475	17	2.01	2.92	5.84	3.589	0.072	17.57	17.49
23	15475	19	2.24	2.92	5.84	3.589	0.079	19.42	19.34
25	30575	23	1.37	1.48	2.96	1.817	0.091	23.13	23.04
27	43082	29	1.23	1.05	2.10	1.289	0.109	28.69	28.58
29	30575	60	3.58	1.48	2.96	1.817	0.189	57.43	57.24
30	30575	50	2.98	1.48	2.96	1.817	0.164	48.16	48.00
	TOTAL n=	545							

Table: 16 traffic accident diagnosis using empirical Bayesian method for road section

Source: own calculated and road safety manual reference

Bole Sub city intersection accident identification and diagnosis									
Section number	Name of intersection	AADT	Accident frequency	individual accident rate(acc/M veh)	average accident rate(acc/M veh)	critical rate	Fp	feb	PI EB Methode
1	bole michael round about	46504	254	4.98	22.78	23.49	29.62	252.05	222.43
5	bole bridge intersection	30575	85	2.54	34.65	35.72	21.54	85.69	64.15
8	emperial hotel round about	59960	296	4.51	17.67	18.22	35.93	293.39	257.46
12	megenagia bridge intersection	55651	126	2.07	19.04	19.63	33.95	126.05	92.10
18	sahlitemehire t church round about	15139	39	2.35	69.99	72.15	12.62	40.41	27.78
24	CMC roundabout	15475	33	1.95	68.47	70.58	12.84	34.50	21.67
26	bole medihanialem round about	30575	79	2.36	34.65	35.72	21.54	79.78	58.25
28	gerji mebrat intersection	48048	106	2.01	22.05	22.73	30.36	106.36	76.00
31	millinum hall intersection	30575	143	4.27	34.65	35.72	21.54	142.78	121.25
		TOTAL n=	1161						

Table: 17 traffic accident diagnosis using empirical Bayesian method for road intersection

Source: own calculated and road safety manual reference

4.3.4 Traffic accident priority ranking for Bole sub city road section

Traffic Accident priority ranking for bole sub city road section (PAS,SAS)			
Rank	Name of road section	Rank	Name of road section
1	Section -29	12	Section -22
2	Section -10	13	Section -9
3	Section -11	14	Section -2
4	Section -6	15	Section -16
5	Section -30	16	Section -19
6	Section -3	17	Section -20
7	Section -27	18	Section -14
8	Section -25	19	Section -4
9	Section -13	20	Section -7
10	Section -23	21	Section -15
11	Section -17	22	Section -21

Table: 18 traffic accident priority ranking for road section
Source: Own calculated

4.3.5 Traffic accident priority ranking for Bole sub city main road junction

One of the main processing on black spot identification is giving a traffic accident priority ranking for the most dangers road selecting to give attention for putting a black spot location.

Traffic Accident priority ranking for bole sub city main Junction					
Rank	Section	Name of road Junctio	Rank	Section	Name of road Junction
1	8	Emperial hotel round about	6	5	Bole bridge intersection
2	1	Bole michael round about	7	26	Bole medihanialem round about
3	31	Millinum hall intersection	8	18	Sahlitemehiret church round about
4	12	Megenagia bridge intersection	9	24	CMC roundabout
5	28	Gerji mebrat intersection			

Table: 19 traffic accident priority ranking for main junction

Source: Own calculated

4.4. Evaluation of black spot location (after black spot analysis)

Evaluation is the fourth step in the road traffic accident and safety evaluation before implementation steps. To incorporate findings is most important since it is where the traffic accident can actually impact on road safety.

4.4.1. Evaluation of black spot for Emperial round about

To assess this junction, there is some reason to increase the number of the road traffic accident for Emperial roundabout as compared to the other main junction. For this road intersection according to the previous analysis of road traffic accident, this junction shows the highest accident rate of 4.51 acc/M-vehicle and PI EB amount is 257.46. Because of this condition roundabout has the highest road traffic accident rates as compared to the other main intersection which is found in Bole sub city.

- The number of traffic volume is the highest one in Bole sub city and in Addis Ababa.
- Certain vehicle disturbed regular traffic flow pattern by crossing the roundabout illegally and there is no intelligent traffic controlling device except the traffic police.
- On junction geometry part, the diameter of round about circle is too small and also contrary to the traffic, Volume is over capacity of the existing round about. This results on long time delay and cause of traffic accident during peak hours.

Figure: 19 Emperial rounds about present time photo

Source: own taken picture from actual present condition (2016)

4.4.2. Evaluation of black spot for Bole Michel intersection

In evaluation of Bole Michael round about there is a number of factors that cause road traffic accident and black spot junction. Due to the result of previous analysis of main road junction Bole Michael road about shows on accident rate is 4.88 acc/M-vehicle and PI EB amount of 221.94 is the highest one compare to the other junction found in Bole sub city. Thus Bole Michael junction needs a permanent change of road geometry and pavement to reduce accident and the following point shows some evaluation about this junction.

- Similar On Michael junction ,the number of traffic volume that join the intersection from Bole roundabout and Saris Abo using ring road is to high
- On other side, most of a time the vehicle came from Bole roundabout with high speed they cannot control the vehicle when they approach the junction and traffic accident happens.
- The drivers do not give a priority to pedestrian until the drivers enforced by traffic police
- The pedestrian walk way is already damaged by car crash or construction work on walk way. Due to this condition the pedestrian walk way cannot give full service. This condition leads the pedestrian using the main road way to illegally cross and it is cause of road traffic accident.

Figure: 20 Bole Michael round about present time photo

Source: own taken picture from actual present condition (2016)

4.4.3 Evaluation of black spot for Millennium Hall intersection

For Millennium Hall road intersection construction was completed last year with new geometry and pavement design for high speed road, but the road traffic data is taken from Bole sub city police documentation office for the Past year before the new road opened. Even if there are also a large number of road traffic accidents happening now due to many reasons .The millennium hall intersection is not the highest PI EB value as compare as Bole Michael and Empreal intersection even if the accident frequency is 4.27 acc/M-vehicle and it is a significant amount of PI EB value is 121.25, this junction also needs to have a change with a low cost adjustment to achieve road safety standards.

- The drivers drive over the limited speed limit of 80km/hr and the traffic do not use any traffic speed controlling device. On other side, the drivers do not follow the instruction of traffic sign.
- The existing feeder road ,do not hold the existing new Bole –Meskel road traffic volume and this condition create a large traffic jam for main road to feeder road junction
- For the pedestrian on zebra crossing is too long for crossing four lane two way roads and this condition create difficulty to crossing this road.

Figure: 21 Millennium hall intersection present time photo

Source: Own taken picture from actual present condition (2016)

4.5. Principal arterial street (PAS) and Ring road (RR): Comparative analysis for identification of major road crash.

One of the main objective goals of this study is to give a comparative analysis for principal arterial street (PAS), sub arterial street (SAS) and ring road (RR) .As shown previous, Bole sub city road traffic accident data there is very small amount of data reported on SAS. There for, the study omitted SAS section from the study, and only consideration made on comparative analysis of road traffic accident between principal arterial street (PAS) and ring road (RR).

For Intersection

According to this research conduct for road traffic accident identification and analysis of the major traffic accident happened for road junction and intersection part. There is a high number of traffic accident is reported mainly on ring road section ,because for ring road the allowed speed limit is higher but the vehicle cannot meet this condition because on this road section there is a large number of traffic volume using this road section .

The pedestrian cannot cross the ring road intersection easily because the traffic signs for pedestrian crossing prioritization destroyed by car crash and road side construction.

Most of the ring road intersection is designed before 15 years traffic volume because this ring road cannot hold the existing traffic volume, this condition leads to cause of traffic accidents.

Bole Sub city intersction Compartive analysis on identification of major road crashes between Principal arterial street (PAS) and Ring road street (RR)				
			PI EB Method value	
section number	type of road	name of intersection	For Principal arterial street (PAS)	For ring road street (RR)
1	RR	bole michael round about	0.00	222.43
5	RR	bole bridge intersection	0.00	64.15
8	RR	emperial hotel round about	0.00	257.46
12	RR	megenagia bridge intersection	0.00	92.10
18	PAS	sahlitemehiret church round about	27.78	0.00
24	PAS	CMC roundabout	21.67	0.00
26	PAS	bole medihanialem round about	58.25	0.00
28	PAS	gerji mebrat intersection	76.00	0.00
31	PAS	millinum hall intersection	121.25	0.00

Table: 20 road intersection comparative analysis for traffic accident between PAS and SAS

Source: Own calculated

For Road Section

Similarly, for this road section there is also a high number of traffic accident reported on ring road section. This research identified one of the causes of traffic accident on Bole sub city road section; pedestrian bridge crossing is far from more than 500m from one to other pedestrian crossing. Thus pedestrians cross the road median illegally by jumping the concrete median.

On other hand, the ring roads have too old geometry and pavement condition to achieve present time traffic volume.

Bole Sub city road section Compartive analysis on identification of major road crashes between Principal arterial street (PAS) and Ring road street (RR)			
		PI EB Method value	
section number	type of road	For Principal arterial street (PAS)	For ring road street (RR)
2	RR	0.00	15.65
3	RR	0.00	36.90
4	RR	0.00	9.18
6	RR	0.00	48.92
7	RR	0.00	9.18
9	RR	0.00	15.65
10	RR	0.00	55.40
11	RR	0.00	53.55
13	PAS	22.11	0.00
14	PAS	10.10	0.00
15	PAS	8.26	0.00
16	PAS	13.80	0.00
17	PAS	18.42	0.00
19	PAS	11.95	0.00
20	PAS	11.95	0.00
21	PAS	8.26	0.00
22	PAS	17.49	0.00
23	PAS	19.34	0.00
25	PAS	23.04	0.00
27	PAS	28.58	0.00
29	PAS	57.24	0.00
30	PAS	48.00	0.00

Table: 21 road section comparative analysis for traffic accident between PAS and SAS

Source: Own calculated

4.6. Implementation of permanent geometry change, pavement change and putting traffic sign

Implementation is the last step in the road traffic accident and safety evaluation to integrate findings. Since it is where traffic accident can actually impact on road safety .on this research after identification, diagnosis and evaluation of black spot location the result of finding show remedial solution including putting a black spot signs to high road traffic accident location.

On implementation of permanent geometry change, according to previous data finding this research analysis of road junction capacity calculated. Before deciding geometry change the study calculated the amount of traffic volume. Due to this large amount of traffic volume, the studies decide to change the road geometry and select the exact type of grade separation junction to achieve more efficient and cost effective type of grade separation junction according to the following analysis cover this condition.

"The use of grade separation results in separation of traffic movements between the intersecting roads so that only merging and diverging movements remain. The extent to which individual traffic movements should be separated from each other depends mainly upon capacity requirements and traffic safety aspects; it also depends upon the extent to which important traffic movements should be given free flow conditions.

A study of the characteristics of various types of grade-separated junctions is necessary, and a number of alternative designs should be prepared. The final choice of scheme must satisfy capacity requirements, geometric standards, and operational needs, and represent an economical design. In some instances the choice of a particular design will be determined by the adoption of two-stage construction, e.g. constructing an at-grade junction first and providing grade separation later". (ERA manual)

4.6.1. Capacity

"Grade-separated junctions are generally designed using traffic volumes given in Daily High Volume (DHV) rather than Annual Average Daily Traffic (AADTs). A detailed traffic study and analysis can be made to determine these values. In the absence of such a study, it can be assumed that DHV, in an urban area, is 10% of AADT. It is also a good estimate of vehicles per hour. The capacity of each traffic lane, in DHV, is usually given as 1000 vehicles per hour". (ERA manual)

4.6.2 .Design Principles

"Special design principles apply to grade separated junctions and must be considered when Comparing the characteristics of alternative designs. The main principles and described below:

1. The high speeds normally met with on roads where grade separation is required and the low design speeds of ancillary roads make it necessary to pay particular attention to the transitions between high and low speed. This not only influences the use of long speed-change lanes and compound curves but also the choice of types of interchange which do not result in abrupt changes in vehicle speeds.
2. Weaving between lanes on the main roadway within the interchange is undesirable and can be avoided by arranging for diverging points to precede merging points.
3. On a road with a large number of grade-separated junctions, a consistent design speed is desirable for loops. This speed shall be not less than 65% of the speed of the adjoining major road.
4. As a general rule, left-turning movements that are grade separated should be made through a right-hand loop.
5. Unexpected prohibited traffic movements, especially where traffic is light, are difficult to enforce and cause danger. If possible the geometric layout should be designed to make prohibited movements difficult, e.g. on one-way loops entry contrary to the one way movement can be restricted by the use of suitably shaped traffic islands to supplement the traffic signs". (ERA manual)

4.6.3. Types of Junction

Grade separated junctions generally fail into four categories depending upon the number of roads involved and their relative importance. These categories are as follows:

- Three-way junctions;
- Junctions of major/minor roads;
- Junctions of two major roads; and
- Junctions of more than two major roads

4.6.3.1 Three way junctions (Layouts A and B)

"For some Y-junctions where grade separation of only one traffic stream is required, Layout A may be appropriate. The movements associated with the missing leg would have to be channeled to another location. This would only be appropriate of the traffic volumes on the missing leg were slight and were capable of being served by an at-grade junction elsewhere. Layout B shows a typical three-leg junction. It is appropriate for traffic where the major road is DS1 and the minor road is DS2- DS6. This configuration is appropriate for traffic volumes of up to 30,000 AADT on the four-lane major road (3,000 vehicles per hour). With a single loop lane, it is appropriate for loop traffic of 1,000 vehicles per hour. Higher loop traffic would require multiple loop lanes." (ERA manual)

4.6.3.2 Junctions of major / minor roads (Layouts C and D)

"Layouts C and D are the most simple for major/minor road junctions and both transfer the major traffic conflicts to the minor road. These configurations are appropriate for traffic volumes of up to 30,000 AADT on the four-lane major road (3,000 vehicles per hour), with traffic of up to 10,000 ADT on the minor road. They are appropriate for traffic where the major road is DS1 and the minor road is DS2- DS6. With a single loop lane, it is appropriate for loop traffic of 1,000 vehicles per hour. Higher loop traffic would require multiple loop lanes.

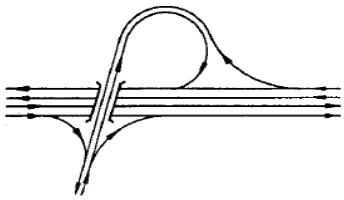
Layout C shows the 'half cloverleaf' type of junction, which has the advantage of being easily adapted to meet difficult site conditions. Layout D shows the normal 'diamond' junction, which requires the least land appropriation. The choice between these options is generally dependent on land requirements." (ERA manual)

4.6.3.3 Junctions of two major roads (Layouts E and F)

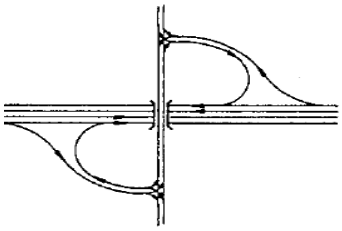
"Layouts E and F show the two basic junction layouts use where high traffic flows would make the use of simpler layouts unsatisfactory. They are appropriate for traffic volumes on both crossing roads of between 10,000 and 30,000 AADT (3,000 vehicles per hour).

Layout E shows a 'full cloverleaf' junction involving only one bridge but requiring a large land appropriation. Layout F shows a typical roundabout interchange involving two bridges. This layout would only be suitable if the secondary road containing the roundabout was a low design speed but carried a comparatively higher volume of traffic." (ERA manual)

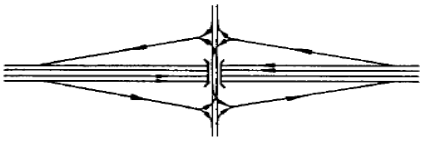
LAYOUT A



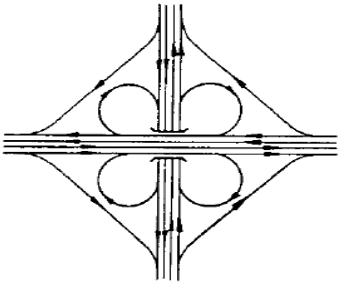
LAYOUT B



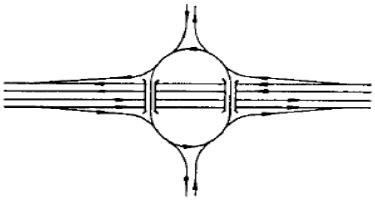
LAYOUT C



LAYOUT D

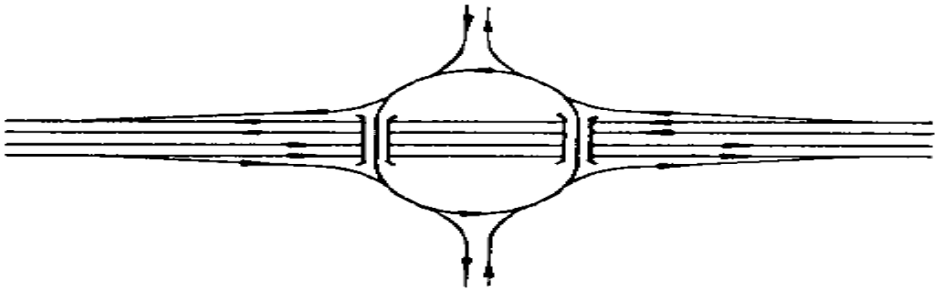


LAYOUT E



LAYOUT F

As per the above detail investigation of this research study decided referring to ERA and AACR manual our study area intersection traffic volume and geometric condition laid on the limit of layout F and chose this intersection type.



LAYOUT F

4.6.4. Implementation of permanent geometric and pavement change for Emperial round about

This study show that which road junction is a critical road traffic accident occur and on this junction there is largest traffic flow amount more than 59,960 AADT vehicles use this road section . Because of this study decide Emperial junction is one of the largest junction in Addis Ababa Bole sub city and need a permanent geometrical and pavement change to a small size of interchange and putting different traffic signs on it. The preliminary geometric design is shown on appendix B-3 in detail.

Figure: 22 Emperial hotel and totot hotel junction map

Source: Addis Ababa map from Google web site (2016)

4.6.5. Implementation of permanent geometric and pavement change for Bole Michael round about

The study observed that roundabout is too small to hold this large amount of traffic volume, According to actual site traffic counting, its AADT is more than 46,504. This amount is too large for small size Bole Michael round about, there for the study recommends to implement a permanent small size interchange constructed to minimize the right of way and construction cost. The preliminary geometric design is shown on appendix B-3.

Figure: 23 Bole Michael round about map

Source: Addis Ababa map from Google web site (2016)

4.6.6. Implementation of traffic sign for Millennium hall intersection

This road section was constructed one year ago and it is a new quality up to date standard geometry and pavement design built for high speed road. This study considered implementing a black spot for this intersection is not the only option, but also putting additional traffic sign like pedestrian priority traffic sign on zebra crossing, speed limit sign, etc. on other side widening the collector road as much as possible because collector road cannot hold the main road traffic volume with the present small size (7M-10M) and putting traffic sign for all appropriate location. Create awareness for drivers to give a priority for pedestrians and pedestrians to use only zebra crossing for main road.

Figure: 24 Bole millennium hall intersection maps

Source: Addis Ababa map from Google web site (2016)

4.6.7. Evaluation of black spot for section 29, 10, 11

Form the above black spot implementation criteria the following road section is high traffic accident, due to different reason some of them are the following

- The traffic sign are not on the proper places or destroyed by car crash
- The driver don't give priority for pedestrian
- The pedestrian using the main vehicle drive way b/c the pedestrian wake way either covered by construction material or excavated for some construction work.
- On ring road the pedestrian crossing and jumping guard rail across road median illegally inside the road because the pedestrian zebra crossing more than 500m far from one zebra crossing to next one.
- No black spot location and study before for this road section.
- The road marking is removed from road pavement and the drivers and pedestrian could use this road is difficult.

4.6.8. Implementation of traffic sign for section 29, 10, 11

From previous research study and analysis, this road section 29, 10, 11 would be the highest number of traffic accident occurred continually. Using different methodologies to know the priority of severity is found by calculating the AADT and frequency of traffic accident which is counted form Bole sub city police documentation office and finally have got this road section 29, 10, 11 is the highest accident rate and PI EB value .According to this research finding conclude that road section 29, 10, 11 is the black spot point or location.

Implementation of traffic sign and other road safety element for section 29

According to the study observation on this site most of the vehicle using to crossing an interchange with a high speed but this location is found in highly populated area because near to the road there a condominium residence found and park their vehicle at the corner of the road there for this road need not only a black spot sign but also putting no parking restriction sign and speed limit sign drive less than 50 km/hr.

Implementation of traffic sign and other road safety elements for section 10

The data collected on actual site condition observed form the location of section 10 is this section is found near to totot hotel interchange mainly used for high speed vehicles but it is not considering a pedestrian because pedestrian crossing is more than 400m far from one crossing to other one there for pedestrian illegal crossing ring road concrete median by jumping. There for the study decide not to putting a black spot sign but also constructing additional pedestrian crossing or remove out the ring road concrete median and constructing a pedestrian island every were it needs.

Implementation of traffic sign and other road safety elements for section 11

On this section the study found that the section is found at the middle of totot and megenagia junction and the drivers using this road most of them drive with a speed limit of 80 km/hr but for the present time this place change to the middle of city town and a large number of vehicle using this road there for driving with 80km/hr is to dangers on this present condition and the speed limit change to 50km/hr.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

A large number of minor, serious and fatal accidents were recorded in Addis Ababa Bole Sub City. Hence, road traffic accident and safety evaluations were undertaken to identify the most dangerous road section and junctions as part of the research.

Using different scientific methodology and analysis, the study has reached to the following conclusions.

- Bole Michael round about, Emperial round about and Millenium hall intersection are identified as the most hazardous junctions in the sub city
- Road sections 29, 10 and 11 are the most hazardous stretches of roads in the sub city.
- The Volume of traffics too much as compared to small size road geometry and pavement condition on present time.
- The awareness of drivers and pedestrian about road traffic rule and regulation is limited and road users do not give enough attention to safety issues.
- The drivers don't give a priority for a pedestrian in any road section even when pedestrians are rightfully using road crossings such as Zebra Crosses.
- The previous posted 80km/hr for ring road is unsafe for present traffic conditions in the middle of the city
- Alternate routes are absent in most of the road network especially at Bole Michael and Emperial Junctions. Peak hour traffic is not properly served at these junctions.
- There is no intelligent traffic controlling device and modern traffic controlling machines.

5.2. Recommendation

There are some recommendation are made, from the research study and analysis finding is the followings.

1. For Bole Michael and Emperial junction will change the existing round about geometric and pavement design to cost effective small size interchange junction as shows on pervious lay out F. According to ERA road junction capacity analysis manual and also considering the future traffic growth and diverted traffic must be considered.

2. For the previous identified a black spot location putting a black spot sign for all black spot location, and give awareness about black spot location and put an appropriate traffic sign for all road section.

3. Road traffic accident and safety education campaign should be given for all society including for pedestrian ,drivers and traffic police too, and give a gradual examination for drivers how made a frequently crossing laws of traffic rule and regulation.

4. If the drivers do not give a priority for pedestrian, the traffic police will put adequate amount of penalty how don't give a priority for a pedestrian.

5. Implementing the existing road traffic safety rule and regulation to satisfy the present road traffic safety condition. Including some of international standard recognized traffic rule and regulation .i.e. there must be putting some controlling way for drivers how take the above limit amount of drug and alcohol according to WHO standard.

6. Maintain all pedestrian and drive way road safety device and sign must be maintained properly with in short period of time.

7. For vehicle importers and producer must put and fixing modern safety device ,in some case most of the car would imported to Ethiopia was removed modern safety device from inside vehicle ,due to this condition the concerned authorized bodies should monitored the presence of this safety device before vehicle inter to the local market .

8. Fixing and implementing a modern intelligent traffic controlling device for all road section and road junction to facilitate modern transportation system and minimize road traffic accident in Addis Ababa Ethiopia.

Propose for future study

On this research recommended for any future study depend on this thesis issues could focus not only on the analysis of road traffic accident identification ,evaluation, prioritizing and putting a black spot ,but also try to make a study implementing a model for the existing Addis Ababa road traffic accident condition identification and prediction methods .

On other side make a study for long time black spot identification study without collecting a data from third part means of accident recording .the researchers should counted accident record by themselves using a CCTV camera put for long time on the city main corridor and make a study for long time research to main potential cause of road traffic accident and recommend a remedial solution depend on the long time study findings.

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Appendix A-1:

Questionnaire form

QUESTIONNAIRE FORM FOR INDIVIDUAL VEHICLE DRIVER.

SECTION ONE Personal details

1. Age in years

(a) Below 18 ☐

(b) 18 – 30 ☐ (c) 30 – 40 ☐

(d) 40 – 50 ☐ (e) 50 above ☐

2. Sex: (1) Male. ☐ (2) Female ☐

3. Occupation: labor ☐

Civil servant ☐

Businessman/woman ☐

Others (specify) ☐

4. Residence: (1) Bole sub city ☐ (2) Outside Bole sub city ☐

5. Driving experience in years

(a) Below 1 ☐

(b) 1 – 5 ☐ (c) 5 – 10 ☐

(d) 10 – 20 ☐ (e) 20 above ☐

Q.1.Do you think traffic accidents are very important problem in Bole sub city?

(a) Yes ☐ (b) No ☐

Q.2. Do you agree the amount of traffic accidents in Bole sub city is greater compare to other sub cities in Addis Ababa?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.3. Do you agree the pedestrian follow the traffic regulations like crossing road using on zebra crossing to protect from traffic accidents in Bole sub city?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.4.Do you Agree most of the traffic accidents occurs in Bole sub city is b/c of drivers do not given a priority to a pedestrian?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.5. Do you Agree most necessary traffic safety education and training about traffic accidents is given for drivers and pedestrian is adequate in Bole sub city and also in Addis Ababa?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.6. Do you Agree most of the traffic accidents occurs in Bole sub city is at the same location and it must be putting a black spot location is necessary?

a) Strongly agree ☐ (b) agree☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.7.Is there any problems facing on traffic police working for reduction of the traffic accident has Occurred? (a) Yes ☐ (b) No ☐

If yes, what are the problems? ----------

Q.8.Is there adequate number of traffic police ,traffic regulation, traffic sign and road environment available to reduce traffic accident in Bole sub city ?

a) Strongly agree ☐ (b) agree☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.9.Are you comfortable driving and maintain with allowable speed using Bole sub city road than other sub city road.

a) Strongly agree ☐ (b) agree☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.10.Did you have any traffic accident problems happen in your previous driving experience?

.(a) Yes ☐ (b) No ☐

If yes, due to whose fault the accidents happen?

a) Driver ☐ (b) pedestrian ☐c) road factor ☐ d) traffic sign ☐

Q.11.Do you have any recommendations and opinions on strategies of reducing the traffic accident in Bole sub city. (a) Yes ☐ (b) No ☐

If yes, what are your recommendations? ----------

Q.12. Are there any problems on implementing traffic safety measures in Bole sub city?

(a) Yes ☐ (b) No ☐

If yes, what are the problems? ----------

Q.13. Who do you think how should be the most responsible for traffic accident?

a) Driver ☐ (b) pedestrian ☐ c) government ☐ d) traffic police ☐

Q.14. Do you think available traffic rules and regulations can reduce traffic accidents?

a) Strongly agree ☐ (b) agree☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.15. what factors do you think facilitate the occurrence of road traffic accident in Bole sub city?

In terms of Vehicles ☐

In terms of (environment) road net work ☐

In terms of Peoples behavior ☐

In terms of legislation and regulations ☐

QUESTIONNAIRE FORM FOR REVIEWING INDIVIDUAL PEDESTRIAN.

SECTION ONE Personal details

1. Age in years

(a) Below 18 ☐

(b) 18 – 30 ☐ (c) 30 – 40 ☐

(d) 40 – 50 ☐ (e) 50 above ☐

2. Sex: (1) Male. ☐ (2) Female ☐

3. Occupation: labor ☐

civil servant ☐

Businessman/woman ☐

Others (specify) ☐

4. Residence: (1) Bole sub city ☐ (2) Outside Bole sub city ☐

Q.1.Do you think traffic accidents are very important problem in Bole sub city?

(a) Yes ☐ (b) No ☐

Q.2. Do you agree the amount of traffic accidents in Bole sub city is greater compare to other sub cities in Addis Ababa?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.3. Do you Agree the you and other pedestrian follow the traffic regulations like crossing road using on zebra crossing to protect from traffic accidents in Bole sub city ?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.4.Do you Agree most of the traffic accidents occurs in Bole sub city is b/c of drivers do not given a priority to a pedestrian?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.5. Do you Agree most necessary traffic safety education and training about traffic accidents is given for drivers and pedestrian is adequate in Bole sub city and also in Addis Ababa ?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.6. Do you agree most of the road have comfortable pedestrian road pavement for normal person and disable person?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.7. Do you Agree most of the road have comfortable and adequate pedestrian road crossing structures and zebra crossing for normal person and disable person ?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.8.Is there adequate number of traffic police ,traffic regulation, traffic sign and road environment available to reduce traffic accident in Bole sub city ?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.9.Are you comfortable waking and crossing zebra without any problems using Bole sub city pedestrian road pavement than other sub city pedestrian road pavement .

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.10.Did you have any traffic accident problems happen in your previous life experience ?

.(a) Yes ☐ (b) No ☐

If yes, due to whose fault the accident happen?

a) driver ☐ (b) pedestrian ☐ c) road factor ☐ d) traffic sign ☐

Q.11.Do you have any recommendations and opinions on strategies of reducing the traffic accident in Bole sub city. (a) Yes ☐ (b) No ☐

If yes, what are your recommendations? ----------

Q.12. Are there any problems on implementing traffic safety measures in Bole sub city?

(a) Yes ☐ (b) No ☐

If yes, What are the problems? ----------

Q.13. Who do you think how should be the most responsible for traffic accident?

a) driver ☐ (b) pedestrian ☐ c) government ☐ d) traffic police ☐

Q.14. Do you think available traffic rules and regulations can reduce traffic accidents?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.15. what factors do you think facilitate the occurrence of road traffic accident in Bole sub city?

In terms of Vehicles ☐

In terms of (environment) road net work ☐

In terms of Peoples behavior ☐

In terms of legislation and regulations ☐

QUESTIONNAIRE FORM FOR TRAFFIC POLICE OFFICERS

SECTION ONE Personal details Date----------

Rank----------

1. Age in years

(a) Below 18 ☐

(b) 18 – 30 ☐ (c) 30 – 40 ☐

(d) 40 – 50 ☐ (e) 50 above ☐

2. Sex: (1) Male. ☐ (2) Female ☐

3. Residence: (1) Bole sub city☐ (2) Outside Bole sub city ☐

4.Working experience in years

(a) Below 1 ☐

(b) 1 – 5 ☐ (c) 5 – 10 ☐

(d) 10 – 20 ☐ (e) 20 above ☐

Q.1.Do you think traffic accidents are very important problem in Bole sub city?

(a) Yes ☐ (b) No ☐

Q.2. Do you Agree the magnitude of traffic accidents in Bole sub city is greater compare to other sub cities in Addis Ababa ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.3.How do you normally get information after the motor accident has occurred?

a) from driver ☐ (b) pedestrian ☐ c) eye witness ☐ d) condition of vehicles ☐

Q.4.Do you Agree most of the traffic accidents occurs in Bole sub city is b/c of drivers do not given a priority to a pedestrian ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.5. The most necessary traffic safety education and training about traffic accidents is given for drivers and pedestrian is adequate in Bole sub city and also in Addis Ababa ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.6. Do you Agree most of the traffic accidents occurs in Bole sub city is at the same location and it must be putting a black spot location is necessary ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.7.Is there any problems in getting immediate information after the traffic accident has Occurred? (a) Yes ☐ (b) No ☐

If yes ,What are the problems? ----------

Q.8.How do you transport injured people from the site of accident to hospital?

(a) By police vehicle. ☐ (b) By ambulance ☐

.(c) By requesting other motorists to help. ☐ (d) Accident victims hire vehicles themselves. ☐

(e) Others (specify) ----------

Q.9.Is that adequate using menilik hospital to send verify dead bodies of persons who die at the site of accidents?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.10.Is there any problem of getting accurate report/information on traffic accidents Occurring in Bole sub city .(a) Yes (b) No

If yes ,What are the problems? ----------

Q.11.Do you face any problem in preservation of traffic accident reports in your office?

.(a) Yes (b) No

If yes ,What are the problems? ----------

Q.12.Do you have any recommendations and opinions on strategies of reducing the traffic accident in Bole sub city. (a) Yes (b) No

If yes, What are your recommendations? ----------

Q.13. Are there any problems on implementing traffic safety measures in Bole sub city?

(a) Yes (b) No

If yes, What are the problems? ----------

Q.14. Who do you think how should be the most responsible for traffic accident?

a) driver ☐ (b) pedestrian ☐ c) government ☐ d) traffic police ☐

Q.15. Do you think the available traffic rules and regulations can reduce accidents?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.16. what factors do you think facilitate the occurrence of road traffic accident in Bole sub city?

In terms of Vehicles ☐

In terms of (environment) road net work ☐

In terms of Peoples behavior ☐

In terms of legislation and regulations ☐

INTERVIEW FOR INDIVIDUAL VEHICLE DRIVER.

Q.1.Do you think traffic accidents are very important problem in Bole sub city?

(a) Yes ☐ (b) No ☐

Q.2. Do you Agree the amount of traffic accidents in Bole sub city is greater compare to other sub cities in Addis Ababa ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.3. Do you Agree the pedestrian follow the traffic regulations like crossing road using on zebra crossing to protect from traffic accidents in Bole sub city ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.4.Do you Agree most of the traffic accidents occurs in Bole sub city is b/c of drivers do not given a priority to a pedestrian ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.5. Do you Agree most necessary traffic safety education and training about traffic accidents is given for drivers and pedestrian is adequate in Bole sub city and also in Addis Ababa ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.6. Do you Agree most of the traffic accidents occurs in Bole sub city is at the same location and it must be putting a black spot location is necessary ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.7.Is there any problems facing on traffic police working for reduction of the traffic accident has Occurred? (a) Yes ☐ (b) No ☐

If yes ,What are the problems? ----------

Q.8.Is there adequate number of traffic police ,traffic regulation, traffic sign and road environment available to reduce traffic accident in Bole sub city ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.9.Are you comfortable driving and maintain with allowable speed using Bole sub city road than other sub city road .

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.10.Did you have any traffic accident problems happen in your previous driving experience ?

.(a) Yes ☐ (b) No ☐

If yes ,due to whose fault the accident happen?

a) driver ☐ (b) pedestrian ☐ c) road factor ☐ d) traffic sign ☐

Q.11.Do you have any recommendations and opinions on strategies of reducing the traffic accident in Bole sub city. (a) Yes ☐ (b) No ☐

If yes, What are your recommendations? ----------

Q.12. Are there any problems on implementing traffic safety measures in Bole sub city?

(a) Yes ☐ (b) No ☐

If yes, What are the problems? ----------

Q.13. Who do you think how should be the most responsible for traffic accident?

a) driver ☐ (b) pedestrian ☐ c) government ☐ d) traffic police ☐

INTERVIEW FOR INDIVIDUAL PEDESTRIAN.

Q.1.Do you think traffic accidents are very important problem in Bole sub city?

(a) Yes ☐ (b) No ☐

Q.2. Do you Agree the amount of traffic accidents in Bole sub city is greater compare to other sub cities in addis ababa ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.3. Do you Agree the you and other pedestrian follow the traffic regulations like crossing road using on zebra crossing to protect from traffic accidents in Bole sub city ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.4.Do you Agree most of the traffic accidents occurs in Bole sub city is b/c of drivers do not given a priority to a pedestrian?

a) Strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.5. Do you Agree most necessary traffic safety education and training about traffic accidents is given for drivers and pedestrian is adequate in Bole sub city and also in addis ababa ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.6. Do you Agree most of the road have comfortable pedestrian road pavement for normal person and disable person ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.7. Do you Agree most of the road have comfortable and adequate pedestrian road crossing structures and zebra crossing for normal person and disable person ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.8.Is there adequate number of traffic police ,traffic regulation, traffic sign and road environment available to reduce traffic accident in Bole sub city ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.9.Are you comfortable waking and crossing zebra without any problems using Bole sub city pedestrian road pavement than other sub city pedestrian road pavement .

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.10.Did you have any traffic accident problems happen in your previous life experience ?

.(a) Yes ☐ (b) No ☐

If yes ,due to whose fault the accident happen?

a) driver ☐ (b) pedestrian ☐ c) road factor ☐ d) traffic sign ☐

Q.11.Do you have any recommendations and opinions on strategies of reducing the traffic accident in Bole sub city. (a) Yes ☐ (b) No ☐

If yes, What are your recommendations? ----------

Q.12. Are there any problems on implementing traffic safety measures in Bole sub city?

(a) Yes ☐ (b) No ☐

If yes, What are the problems? ----------

Q.13. Who do you think how should be the most responsible for traffic accident?

a) driver ☐ (b) pedestrian ☐ c) government ☐ d) traffic police ☐

INTERVIEW FOR TRAFFIC POLICE AND TRANSPORT OFFICERS

Q.1.Do you think traffic accidents are very important problem in Bole sub city?

(a) Yes ☐ (b) No ☐

Q.2. Do you Agree the magnitude of traffic accidents in Bole sub city is greater compare to other sub cities in addis ababa ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.3.How do you normally get information after the motor accident has occurred?

a) from driver ☐ (b) pedestrian ☐ c) eye witness ☐ d) condition of vehicles ☐

Q.4.Do you Agree most of the traffic accidents occurs in Bole sub city is b/c of drivers do not given a priority to a pedestrian ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.5. The most necessary traffic safety education and training about traffic accidents is given for drivers and pedestrian is adequate in Bole sub city and also in addis ababa ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.6. Do you Agree most of the traffic accidents occurs in Bole sub city is at the same location and it must be putting a black spot location is necessary ?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.7.Is there any problems in getting immediate information after the traffic accident has Occurred? (a) Yes ☐ (b) No ☐

If yes ,What are the problems? ----------

Q.8.How do you transport injured people from the site of accident to hospital?

(a) By police vehicle. ☐ (b) By ambulance ☐

.(c) By requesting other motorists to help. ☐ (d) Accident victims hire vehicles themselves. ☐

(e) Others (specify) ----------

Q.9.Is that adequate using menilik hospital to send verify dead bodies of persons who die at the site of accidents?

a) strongly agree ☐ (b) agree ☐ c) neutral ☐ d) disagree ☐ e) strongly disagree ☐

Q.10.Is there any problem of getting accurate report/information on traffic accidents Occurring in Bole sub city .(a) Yes ☐ (b) No ☐

If yes ,What are the problems? ----------

Q.11.Do you face any problem in preservation of traffic accident reports in your office?

.(a) Yes ☐ (b) No ☐

If yes ,What are the problems? ----------

Q.12.Do you have any recommendations and opinions on strategies of reducing the traffic accident in Bole sub city. (a) Yes ☐ (b) No ☐

If yes, What are your recommendations? ----------

Q.13. Are there any problems on implementing traffic safety measures in Bole sub city?

(a) Yes ☐ (b) No ☐

If yes, What are the problems? ----------

Appendix A-2:

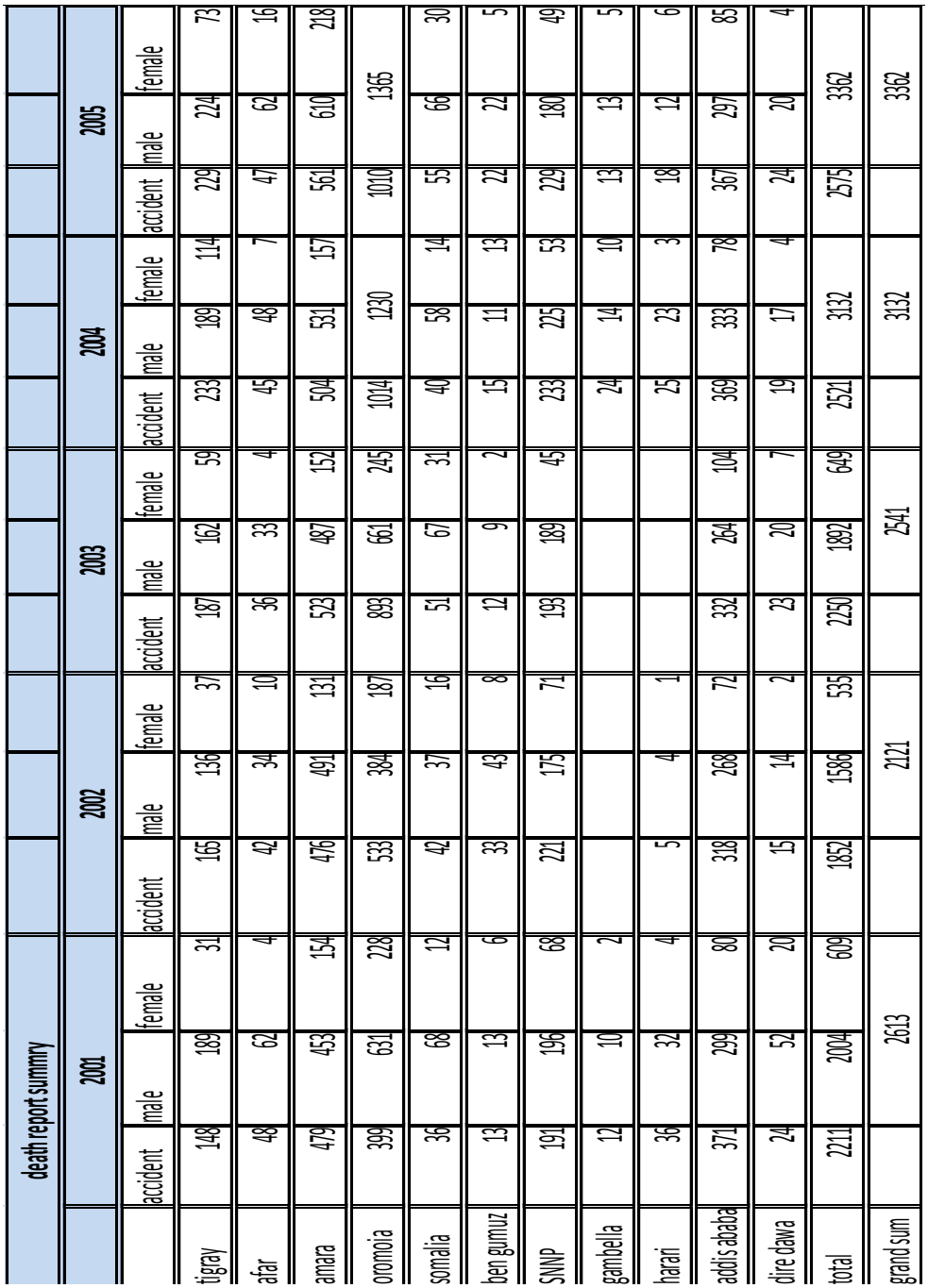
Police accident report data

	Bole sub city road section accident identification and diagnosis																						
Section number	AADT	Accident frequency	individual accident rate(acc/ Mveh-km)	average accident rate(acc/ M veh-km)	It	critical rate	Fp	Feb	PI EB Methode	frp	(fi-frp)2	S^2	Rank	Qw	QxL	C	C	sum L km	sum accident	P year	L km	C	85%
2	46504	15	0.59	0.97	1.94	1.194	0.066	15.71	15.65	24.77	95.51	339.99	14	24797.64	23252	1000000	365.25	11	545	3	0.5	730.5	1.036
3	46504	38	1.49	0.97	1.94	1.194	0.133	37.04	36.90	24.77	174.96	339.99	6	24797.64	23252	1000000	365.25	11	545	3	0.5	730.5	1.036
4	46504	8	0.31	0.97	1.94	1.194	0.041	9.22	9.18	24.77	281.32	339.99	19	24797.64	23252	1000000	365.25	11	545	3	0.5	730.5	1.036
6	59960	51	1.55	0.75	1.51	0.926	0.167	49.09	48.92	24.77	687.87	339.99	4	24797.64	29980	1000000	365.25	11	545	3	0.5	730.5	1.036
7	59960	8	0.24	0.75	1.51	0.926	0.041	9.22	9.18	24.77	281.32	339.99	20	24797.64	29980	1000000	365.25	11	545	3	0.5	730.5	1.036
9	55651	15	0.49	0.81	1.62	0.998	0.066	15.71	15.65	24.77	95.51	339.99	13	24797.64	27825.5	1000000	365.25	11	545	3	0.5	730.5	1.036
10	55651	58	1.90	0.81	1.62	0.998	0.184	55.58	55.40	24.77	1104.05	339.99	2	24797.64	27825.5	1000000	365.25	11	545	3	0.5	730.5	1.036
11	55651	56	1.84	0.81	1.62	0.998	0.179	53.72	53.55	24.77	975.14	339.99	3	24797.64	27825.5	1000000	365.25	11	545	3	0.5	730.5	1.036
13	15139	22	2.65	2.99	5.97	3.669	0.088	22.20	22.11	24.77	7.69	339.99	9	24797.64	7569.5	1000000	365.25	11	545	3	0.5	730.5	1.036
14	15139	9	1.09	2.99	5.97	3.669	0.045	10.15	10.10	24.77	248.78	339.99	18	24797.64	7569.5	1000000	365.25	11	545	3	0.5	730.5	1.036
15	15139	7	0.84	2.99	5.97	3.669	0.037	8.29	8.26	24.77	315.87	339.99	21	24797.64	7569.5	1000000	365.25	11	545	3	0.5	730.5	1.036
16	15139	13	1.57	2.99	5.97	3.669	0.059	13.86	13.80	24.77	138.60	339.99	15	24797.64	7569.5	1000000	365.25	11	545	3	0.5	730.5	1.036
17	15139	18	2.17	2.99	5.97	3.669	0.076	18.49	18.42	24.77	45.87	339.99	11	24797.64	7569.5	1000000	365.25	11	545	3	0.5	730.5	1.036
19	15475	11	1.30	2.92	5.84	3.589	0.052	12.00	11.95	24.77	189.69	339.99	16	24797.64	7737.5	1000000	365.25	11	545	3	0.5	730.5	1.036
20	15475	11	1.30	2.92	5.84	3.589	0.052	12.00	11.95	24.77	189.69	339.99	17	24797.64	7737.5	1000000	365.25	11	545	3	0.5	730.5	1.036
21	15475	7	0.83	2.92	5.84	3.589	0.037	8.29	8.26	24.77	315.87	339.99	22	24797.64	7737.5	1000000	365.25	11	545	3	0.5	730.5	1.036
22	15475	17	2.01	2.92	5.84	3.589	0.072	17.57	17.49	24.77	60.42	339.99	12	24797.64	7737.5	1000000	365.25	11	545	3	0.5	730.5	1.036
23	15475	19	2.24	2.92	5.84	3.589	0.079	19.42	19.34	24.77	33.32	339.99	10	24797.64	7737.5	1000000	365.25	11	545	3	0.5	730.5	1.036
25	30575	23	1.37	1.48	2.96	1.817	0.091	23.13	23.04	24.77	3.14	339.99	8	24797.64	15287.5	1000000	365.25	11	545	3	0.5	730.5	1.036
27	43082	29	1.23	1.05	2.10	1.289	0.109	28.69	28.58	24.77	17.87	339.99	7	24797.64	21541	1000000	365.25	11	545	3	0.5	730.5	1.036
29	30575	60	3.58	1.48	2.96	1.817	0.189	57.43	57.24	24.77	1240.96	339.99	1	24797.64	15287.5	1000000	365.25	11	545	3	0.5	730.5	1.036
30	30575	50	2.98	1.48	2.96	1.817	0.164	48.16	48.00	24.77	636.42	339.99	5	24797.64	15287.5	1000000	365.25	11	545	3	0.5	730.5	1.036
														24797.64		1000000	365.25	11	545	3	0.5	730.5	1.036
	TOTAL n=	545									7139.86				357131								

Bole sub city road traffic accident calculations done for priority ranking and analysis for road section

Bole Sub city intersection accident identification and diagnosis																									
Section number	Name of intersection	AADT	Accident frequency	individual accident rate(acc/M veh)	average accident rate(acc/M veh)	critical rate	Fp	feb	PI EB Methode	frp	(fi-frp)2	S^2			C	85%	C	C	SUM accident	P year					
1	bole michael round about	46504	254	4.98	22.78	23.49	29.62	252.05	222.43	129.00	15625.00	8250.00			730.5	1.036	1000000	365.25	1161	3					
5	bole bridge intersection	30575	85	2.54	34.65	35.72	21.54	85.69	64.15	129.00	1936.00	8250.00			730.5	1.036	1000000	365.25	1161	3					
8	emperial hotel round about	59960	296	4.51	17.67	18.22	35.93	293.39	257.46	129.00	27889.00	8250.00			730.5	1.036	1000000	365.25	1161	3					
12	megenagia bridge intersection	55651	126	2.07	19.04	19.63	33.95	126.05	92.10	129.00	9.00	8250.00			730.5	1.036	1000000	365.25	1161	3					
18	sahlitemehire t church round about	15139	39	2.35	69.99	72.15	12.62	40.41	27.78	129.00	8100.00	8250.00			730.5	1.036	1000000	365.25	1161	3					
24	CMC roundabout	15475	33	1.95	68.47	70.58	12.84	34.50	21.67	129.00	9216.00	8250.00			730.5	1.036	1000000	365.25	1161	3					
26	bole medhanialem round about	30575	79	2.36	34.65	35.72	21.54	79.78	58.25	129.00	2500.00	8250.00			730.5	1.036	1000000	365.25	1161	3					
28	gerji mebrat intersection	48048	106	2.01	22.05	22.73	30.36	106.36	76.00	129.00	529.00	8250.00			730.5	1.036	1000000	365.25	1161	3					
31	millinum hall intersection	30575	143	4.27	34.65	35.72	21.54	142.78	121.25	129.00	196.00	8250.00			730.5	1.036	1000000	365.25	1161	3					
			TOTAL n=	1161							66000.00				730.5	1.036	1000000	365.25	1161	3					

Bole sub city road traffic accident calculations done for priority ranking and analysis of different road junction



death report summry	2001			2002			2003			2004			2005		
	accident	male	female	accident	male	female	accident	male	female	accident	male	female	accident	male	female
tigray	148	189	31	165	136	37	187	162	59	233	189	114	229	224	73
afar	48	62	4	42	34	10	36	33	4	45	48	7	47	62	16
amara	479	453	154	476	491	131	523	487	152	504	531	157	561	610	218
oromoia	399	631	228	533	384	187	893	661	245	1014	1230		1010	1365	
somalia	36	68	12	42	37	16	51	67	31	40	58	14	55	66	30
ben gumuz	13	13	6	33	43	8	12	9	2	15	111	13	22	22	5
SNNP	191	196	68	221	175	71	193	189	45	233	225	53	229	180	49
gambella	12	10	2							24	14	10	13	13	5
harari	36	32	4	5	4	1				25	23	3	18	12	6
addis ababa	371	299	80	318	268	72	332	264	104	369	333	78	367	297	85
dire dawa	24	52	20	15	14	2	23	20	7	19	17	4	24	20	4
total	2211	2004	609	1852	1586	535	2250	1892	649	2521	3132		2575	3362	
grand sum		2613			2121			2541			3132			3362	

Ethiopian Federal police five years compiled different regional state road traffic accident fatality reports

Bole Sub city section GPS coordinates			
section number	type of road	Easting	Northing
2	RR	475792	992776
3	RR	476309	992978
4	RR	476769	993105
6	RR	477385	993877
7	RR	477567	994356
9	RR	478086	995221
10	RR	478350	995689
11	RR	478347	996066
13	PAS	478325	996822
14	PAS	478861	996925
15	PAS	479384	996832
16	PAS	479870	996793
17	PAS	480329	996723
19	PAS	481360	997072
20	PAS	481905	997040
21	PAS	482393	997015
22	PAS	482913	996990
23	PAS	483379	996967
25	PAS	476970	994073
27	PAS	477999	994877
29	PAS	478625	995434
30	PAS	478931	995220

Bole sub city selected road section GPS easting and northing coordinates

Bole Sub city intersction GPS coordinates				
section number	type of road	name of intersection	Easting	Northing
1	RR	bole michael round about	475154	992530
5	RR	bole bridge intersection	477106	993400
8	RR	emperial hotel round about	477919	994917
12	RR	megenagia bridge intersection	478145	996762
18	PAS	sahlitemehiret church round about	480863	996857
24	PAS	CMC roundabout	483638	996934
26	PAS	bole medihanialem round about	476495	994406
28	PAS	gerji mebrat intersection	478603	994401
31	PAS	millinum hall intersection	476581	993511
33	PAS	ruwanda intersection	475599	993788

Bole sub city selected road intersection GPS easting and northing coordinates

Distribution of traffic accident by hours for 2003-2007						
year	2003	2004	2005	2006	2007	TOTAL
Hours						
0100-0200	40	84	48	23	46	241
0200-0300	59	72	64	20	64	279
0300-0400	49	68	40	36	46	239
0400-0500	42	96	47	43	42	270
0500-0600	50	78	46	26	68	268
0600-0700	51	70	81	95	121	418
0700-0800	49	89	132	174	255	699
0800-0900	56	78	126	201	236	697
0900-1000	125	84	163	225	272	869
1000-1100	62	101	135	200	266	764
1100-1200	41	104	117	206	255	723
1200-1300	71	90	154	194	257	766
1300-1400	63	84	158	186	175	666
1400-1500	152	66	203	105	209	735
1500-1600	51	70	248	132	210	711
1600-1700	47	59	203	140	200	649
1700-1800	70	61	141	174	220	666
1800-1900	60	63	123	102	188	536
1900-2000	69	60	117	109	153	508
2000-2100	77	74	112	200	128	591
2100-2200	71	78	106	294	97	646
2200-2300	19	94	117	174	80	484
2300-2400	120	82	102	118	48	470
2400-0100	73	126	79	52	43	373
TOTAL	1567	1931	2862	3229	3679	

Bole sub city compiled sample five years road traffic accident data

	Distribution of traffic accident by age group 2003-2007						
		age group					
year	injory	below 18	18-30	31-50	above 50	unknown	TOTAL
2003	Serious	6	47	45	21	15	134
	minor	7	27	30	14	18	96
	property	18	550	529	130	110	1337
2004	Serious	6	82	46	34	4	172
	minor		44	32	4	2	82
	property	25	830	724	92	6	1677
2005	Serious	1	130	73	26	26	256
	minor		72	43	19	6	140
	property	30	1269	862	233	72	2466
2006	Serious		119	73	61	4	257
	minor		71	40	31	1	143
	property	4	1630	793	400	2	2829
2007	Serious		123	118	38	9	288
	minor	2	66	51	7	4	130
	property	5	1449	1408	379	20	3261

Bole sub city compiled sample five years road traffic accident data

	Distribution of traffic accident by day for 2003-2007							
Day	Monday	Tuesday	Wednesday	Thursday	Friday	saturday	Sunday	
year								TOTAL
2003	189	190	198	202	285	323	180	1567
2004	205	184	246	228	325	460	283	1931
2005	352	287	347	293	481	642	460	2862
2006	360	362	448	397	489	863	310	3229
2007	573	526	523	473	572	655	357	3679
TOTAL	1679	1549	1762	1593	2152	2943	1590	

Bole sub city compiled sample five years road traffic accident data

	Distribution of traffic accident by sex group 2003-2007				
year	injory	male	femal	unknown	TOTAL
2003	Serious	100	19	15	134
	minor	58	20	18	96
	property	974	253	110	1337
2004	Serious	122	46	4	172
	minor	56	24	2	82
	property	1147	524	6	1677
2005	Serious	181	49	26	256
	minor	108	26	6	140
	property	1644	750	72	2466
2006	Serious	177	76	4	257
	minor	97	45	1	143
	property	1826	1001	2	2829
2007	Serious	260	19	9	288
	minor	106	20	4	130
	property	2833	408	20	3261

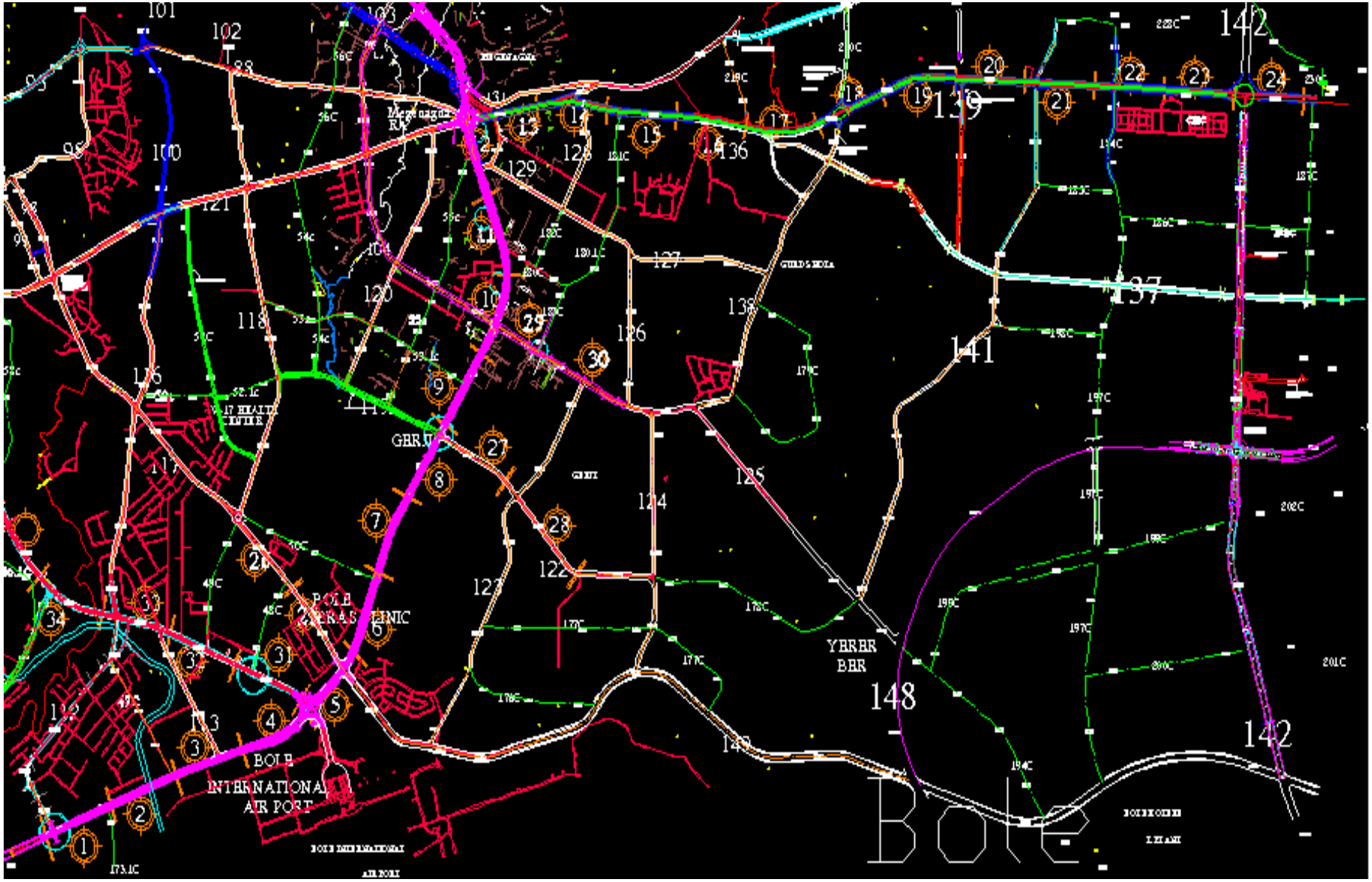
Bole sub city compiled sample five years road traffic accident data

	Distribution of traffic accident by accident location area 2003-2007										
		accident location									
Month	injory	school area	factory area	religion area	market area	recreation center	hospital area	office area	residentioal area	other area	total
2003	Serious	15	4	34	17	19	25	10	10		134
	minor	14	10	20	13	13	20	3	3		96
	property	156	116	216	160	28	76	87	22	476	1337
2004	Serious	29	23	30	18	40	16	8	2	6	172
	minor	15	4	16	8	14	13	6	2	4	82
	property	146	84	286	198	464	180	96	70	153	1677
2005	Serious	23		22	34	46	26	24	6	72	253
	minor	14		17	10	26	8			65	140
	property	198	42	258	496	310	239	306	260	357	2466
2006	Serious	4		6	12	60	4			171	257
	minor			4	10	28	6			95	143
	property	96	4	126	260	480	46			1817	2829
2007	Serious	20	3	26	50	31	31	21	23	83	288
	minor	7	4	15	28	17	3	5	13	38	130
	property	145	52	382	560	514	290	373	248	697	3261

Bole sub city compiled sample five years road traffic accident data

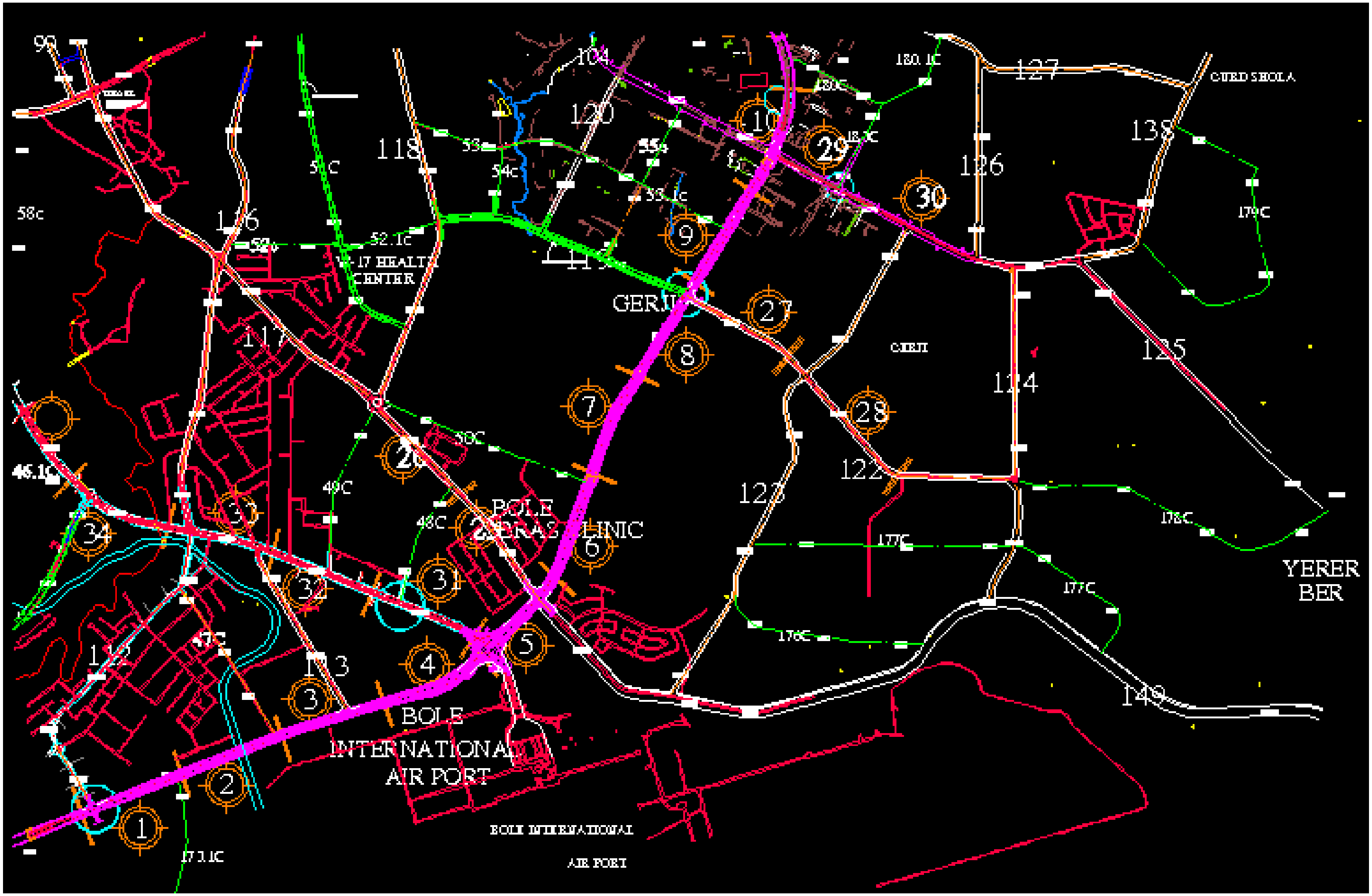
Appendix B-1:

Map of Addis Ababa road net work


BOLE
INTERNATIONAL
AIR PORT
YBRBR
BBR
Bole

Appendix B-2:

Map AABSC road net work and Black spot location


GERJI
BOLE INTERNATIONAL AIR PORT
YERER BER
CMED SHOLA
BOLE INTERNATIONAL
AIR PORT
HEALTH
CENTER


140
135
142
139
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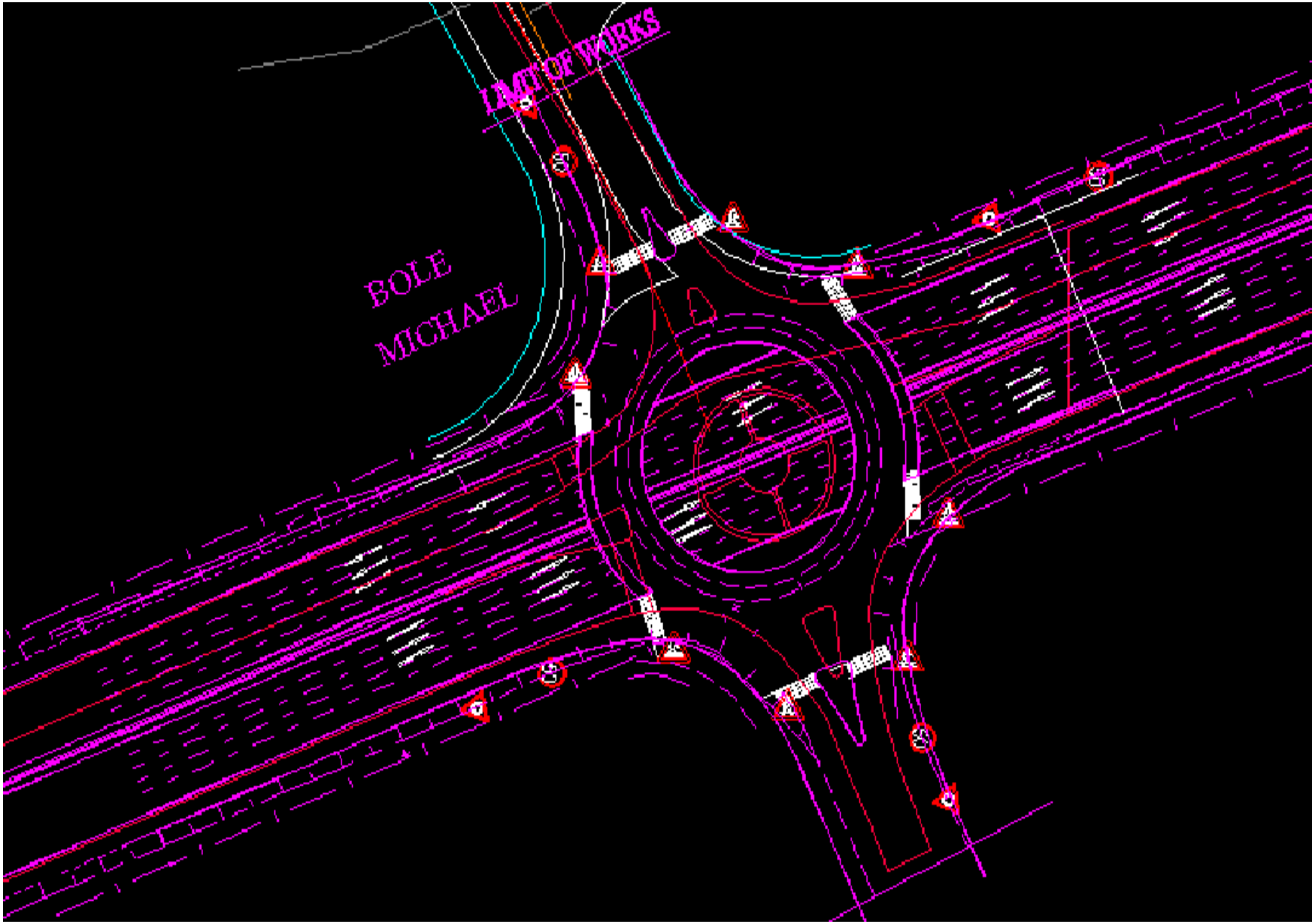
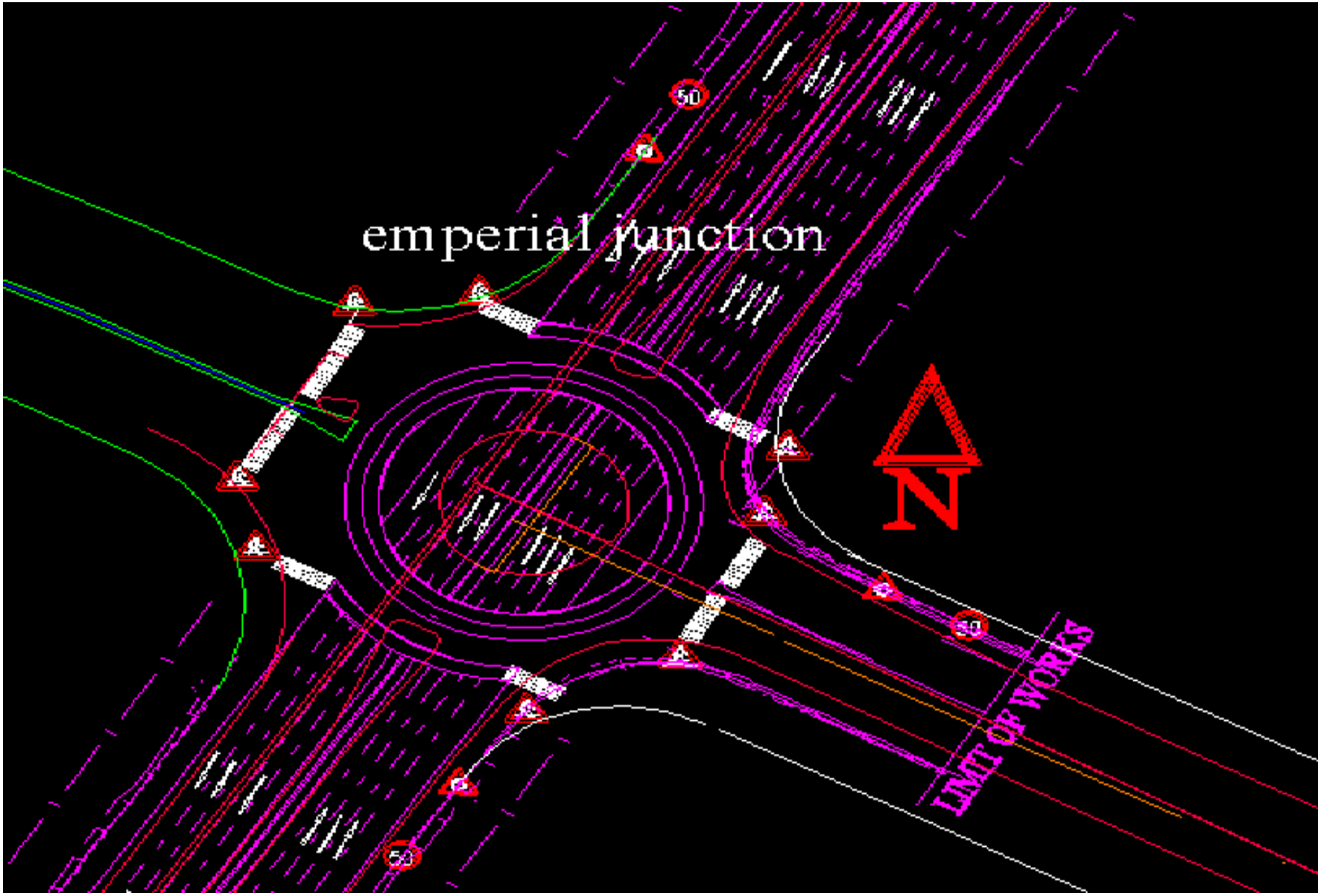
126
GERJI

Appendix B-3:

Design of Empireal and Bole Michael Junction


LIMIT OF WORKS
BOLE
MICHAEL


emperial junction
50
50
50
LIMIT OF WORKS
N