



ADDIS ABABA UNIVERSITY  
SCHOOL OF GRADUATE STUDIES  
ADDIS ABABA INSTITUTE OF TECHNOLOGY  
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

**Assessment on Pedestrian Illegal Crossing and Safety  
on the Addis Ababa City Ring Road  
(The case of Winget-Torhayloch-Ayertena Road)**

**Wondwossen Getahun  
GSR3525/07**

*A Thesis Submitted to the Addis Ababa University School of Graduate Studies for the partial  
fulfilment of a Degree of Masters of Science in Civil Engineering  
(Road and Transport engineering)*

**Advisor: Dr. Bikila Teklu**

**Addis Ababa, Ethiopia  
August, 2018**

**Addis Ababa University**  
**Addis Ababa institute of technology**  
**School of Civil and Environmental Engineering**

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External Examiner \_\_\_\_\_ Signature \_\_\_\_\_ Date \_\_\_\_\_

Advisor \_\_\_\_\_ Signature \_\_\_\_\_ Date \_\_\_\_\_

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## **Acknowledgement**

I would like to express my genuine thanks to Almighty GOD and then deepest gratitude to my advisor Dr.Bikila Teklu, for his guidance support and supervision throughout this research work.

Special thanks go to all the staff in School of Civil and Environmental Engineering in AAU for their cooperation and assistance during my study.

Thanks to staff of Addis Ababa Police Commission and Kolfe- Keranio Police Commission for their assistance and provision of the documents relevant for this research.

Also thanks to all who participate in this study by scarifying their time to give the interview and for those who participate in the distribution and collection of questioner.

Finally, my special appreciations are to my family and friends, for their patience and continued support in the lengthy exercise of this thesis.

## Abstract

This research focuses on Addis Ababa Ring Road the road section of Winget-Torhayloch-Ayertena which have a length of 10 km and consist of eleven pedestrian overpass and seven zebra stripped crossing provided for pedestrian. The research attempts to assess pedestrian crossing behavior, to investigate magnitude of traffic accident resulted due pedestrian illegal crossing, to evaluate the performance of pedestrian overpass provided along the road section and to propose a mitigation measure to reduce the accident on the road section.

To meet these objectives detail review of literatures about the subject matter was conducted and relevant data about pedestrian behavior, pedestrian crossing facilities, pedestrian traffic and traffic accident data was collected and investigated through statistical analysis.

A traffic accident data of Addis Ababa City and Kolfe Keranio Sub city was collected from the respective Police Commission. Pedestrian traffic count was conducted on the selected pedestrian crossings to analyze performance of pedestrian crossings. Random survey was done for pedestrian to assess their crossing behavior and usage of crossing facilities. This data was collected through questioner and structured interviews. The researcher detected the contributing factor that directed pedestrians for illegal crossing through observation, interview and/or questioners. 300 pedestrians were randomly selected along the section of the ring road.

The research analysis shows that Illegal crossing is the major reason for traffic accident in ring road, 75% of the accident occurred on pedestrians and 52% of pedestrian accident resulted while the pedestrian cross the road. The major factor for pedestrian illegal crossing is pedestrian's improper road crossing behavior.

The analysis shows that service level of selected pedestrian overpass in the road section is below a LOS C. From the data the researcher identifies that the basic parameters that affect the performance of Pedestrian overpass were walkway width and location or spacing of overpass.

The researcher finally provides a possible counter measures to minimize the accident of pedestrians in the road section. This includes road safety education and promotional campaign for road users to change the attitude of road users toward illegal crossing behavior and enforcement of pedestrian will reduce the number of illegally crossing pedestrian.

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## **Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)**

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### **1. Introduction**

#### **1.1. Background**

Illegal crossing is the major factor of pedestrian crash. The Addis Ababa City Ring Road traverses through mostly densely populated areas, and has a central New Jersey barrier which makes it impossible for pedestrians to cross. As a consequence there is fencing to prevent pedestrians using the road and overpasses are provided, however pedestrians are often reluctant to use pedestrian overpasses. Instead, they jump over the fences and median barriers to cross the roadways. As a result, many pedestrians have been seriously injured or killed by fast moving vehicles.

Crossing behavior of pedestrians in Addis Ababa is rarely in compliance with the pedestrian regulations, though drivers contribute to this as they do not yield at pedestrian crossings. There are also infrastructure factors that contribute to illegal crossing behavior: there are relatively few legal crossing points, and center medians are sometimes difficult or impossible for pedestrians to negotiate. At other locations there are interactions between behavioral and infrastructure factors. For example, it is worth noting that, according to the Ethiopian traffic rules, drivers are not liable for such pedestrian injuries or fatalities because it is a fully access-controlled road.

The occurrence of traffic accidents is increasing as the exposure to this risk increases with rapid motorization (without appropriate regulation), rapid population growth, and increase in the road network coupled with poor attitude and safety culture of road users. To reduce the number of pedestrian traffic accident and the resulting loss, it is in need to assess pedestrian crossing behavior and evaluate LOS of pedestrian crossing facilities.

This research will evaluate the LOS of Stairways located in the road section of Winget-Torhayloch-Ayertena and also will assess pedestrian crossing behavior along the road section, which is part of the Addis Ababa City Ring Road.

#### **1.2. Statement of the problem**

Road traffic accidents cause a great loss of human and economic resources. This problem is increasing from year to year at an alarming rate accompanying the rapid increase of population and the number of vehicles.

Despite having very low road network density and vehicle ownership, Ethiopia has a relatively high accident record. According to WHO report (global status on road safety, 2015) traffic accidents in Ethiopia accounts for the death of 37.28 persons per 100,000 populations this is 2.77% of the total death in the country placing Ethiopia 12<sup>th</sup> in the world. As per IRIN Ethiopia report, annually at least 70 people die for every 10,000 vehicle accidents.

A research on Characteristics of Police-reported Road Traffic Crashes in Ethiopia over a Six Year Period, 2013 states that not less than half of the accident occurred on pedestrians. Considering a six-year police recorded traffic crash study in Ethiopia 48.55% of fatality and 53.16% of Injury occurred with vehicle-pedestrian collision. It has been also stated that 70% of

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traffic accident happened in city road and 77% of country's vehicle population found in Addis Ababa. This shows the importance of improvement of pedestrian facility in the city.

The occurrence of traffic accidents is increasing as the exposure to this risk increases with rapid motorization (without appropriate regulation), rapid population growth, and increase in the road network coupled with poor attitude and safety culture of road users.

Illegal crossing of pedestrian along the road is one of the causes for pedestrian crash. The Addis Ababa City Ring Road traverses through most densely populated areas, and has a central New Jersey barrier which makes it impossible for pedestrians to cross. As a result of this there is fencing to prevent pedestrians using the road and overpasses are provided. However, previous studies and researchers' field observation indicate that pedestrians are often reluctant to use pedestrian overpasses. Instead, they jump over the fences and median barriers to cross the roadways. As a result, many pedestrians have been seriously injured or killed by fast moving vehicles.

~~Despite many peculiarities in the road traffic environment, vehicle factors and traffic enforcement setting, no local study has attempted to investigate performance of crossing facility and pedestrian road crossing behavior.~~ Thus, this research has been conducted to over view pedestrian crossing behavior together with performance of pedestrian crossing facilities for the case of the selected road section of Addis Ababa ring road so as to come up with alternative solution for the case at hand.

### 1.3. Objective of study

~~The general objective of this research is performance evaluation of pedestrian crossing facilities and assessment of pedestrian accident to assess state of pedestrian crossing and safety on the selected road section of Addis Ababa City Ring Road.~~ The research has the following specific objectives:

- To evaluate the level of service of pedestrian stairways
- To investigate magnitude of traffic accident resulted from pedestrian illegal crossing
- To detect contributing factor that directed pedestrians for illegal crossing

### 1.4. Research questions

Keeping in view the research statement of the Problem, this study tries to answer the following questions for the section of Winget- Torhayloch- Ayertena road:

- What is the performance level of the Pedestrian stairways in this road?
- How much of the traffic accident in this section caused by illegal crossing of pedestrian?
- What are the contributing factors for pedestrian's illegal crossing in the ring road?
- What are the possible improvements to mitigate the problem initiating illegal crossing?

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### **2. Literature Review**

The Addis Ababa City ring road traverses through mostly densely populated areas, and has a central New Jersey barrier which makes it impossible for pedestrians to cross. As a consequence there is fencing to prevent pedestrians using the road and overpasses are provided, however pedestrians are often reluctant to use pedestrian overpasses (Ribbens 1996, p16). Instead, they jump over the fences and median barriers to cross the roadways. As a result, many pedestrians have been seriously injured or killed by fast moving vehicles.

#### **2.1. Road traffic accident**

Road traffic accident (RTA) is defined as a collision or incident involving at least one road vehicle in motion that can be on a public or private road to which the public have the right of access. Thus, RTA can be a collision among vehicles, between vehicles and pedestrians, between vehicles and animals, or between vehicles and geographical or architectural obstacles (Goswami A, Sonowal R, 2009).

Road traffic crashes are a leading cause of death globally, and the main cause of death among those aged 15–29 years by 2012 (WHO, 2015). RTA related fatalities disproportionately affect pedestrians rather than vehicle passengers. A report in 2008 states that over 1.2 million people die each year on the world's roads and between 20 and 50 million suffer non-fatal injuries (WHO, 2015). From this, over 90% of the world's fatalities on the roads occur in low-income and middle income countries, which have only 48% of the world's registered vehicles.

Currently, road traffic crashes in developed countries show a declining trend due to ongoing investment in safety programs and countermeasures. However, the literature on pedestrian crash risk in developing countries (DCs) is at an early stage as the implementation of road safety interventions has only begun recently and rapid motorization is taking place. Moreover, the focus of road safety interventions has generally been restricted to improving the safety of motorists rather than pedestrians.

The WHO report shows that 68 countries have seen a rise in the number of road traffic deaths since 2010, of which 84% are low- or middle-income countries. Seventy-nine countries have seen a decrease in the absolute number of deaths, of which 56% are low- and middle-income. However, low-income countries have fatality rates more than double those in high-income countries and there are a disproportionate number of deaths relative to these countries' level of motorization. 90% of road traffic deaths occur in low- and middle-income countries, yet these countries have just 54% of the world's vehicles (WHO, 2015). The African Region has the highest proportion of pedestrian and cyclist deaths at 43% of all road traffic deaths. Ethiopia has experienced high rates of road traffic accidents, as the road is the major means of transportation. From 2001/02-2004/5, the traffic accident death rate was in the range of 129 and 145 per ten thousand motor vehicles (Segni G, 2007). Furthermore, Ethiopia has a relatively high accident records despite having low road network density and vehicle ownership.

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### **2.1.1 Road traffic accident in Ethiopia**

Regarding literature on Ethiopia, in particular, there are a few papers related to motor vehicle crashes in Addis Ababa published by various authors. A past study revealed that 85% of total crashes in Addis Ababa involved pedestrians (Dessie & Larson, 1991). Despite the advances made in the city since that study, pedestrian crashes remain a problem.

Various studies done on road traffic accidents in Ethiopia have shown the escalation of the problem at the national level. Road traffic injury is high in Ethiopia, at least 70 people die for every 10,000 vehicle accidents annually (IRIN. Ethiopia, 2012). According to Road Transport Authority report, 1,800 people died and 7,000 injured in 2003 across the country (Road Transport Authority, 2013). In 2007/8, a total of 15,082 accidents occurred in the country. Of them the number of people killed was 2,161 while 7,140 experienced non-fatal injuries (United Nations, 2013). Road traffic deaths and injuries impose a huge economic burden on developing economies, amounting to 1-2% of GNP in most countries. Unless adequate measures are taken timely, the situation is expected to get worse (United Nations, 2013).

### **2.1.2 Road traffic accident in Addis Ababa**

Addis Ababa is the capital city of Ethiopia and is considered of diplomatic and political significance for the African continent (United Nations Economic Commission for Africa, 2013). The city consist a population of 3.3 million as per the 2015 census, with a yearly growth rate of 3.8%, hence the population of Addis Ababa in 2017 is estimated to be 6.6 million.

Recently, road traffic crashes, and particularly pedestrian crashes, have become a challenging problem within the city. Walking is the principal mode of transportation in Addis Ababa accounting for about 60% of daily trips, whereas pedestrian injuries account for about 85% of total injury crashes. Despite infrastructure and social advancements of the city, pedestrian crashes are a persistent problem.

Recently, road crashes have increased at an alarming rate throughout the country, as well as in Addis Ababa (Tulu, Washington, & King, 2013). Pedestrian injury crashes accounted for 85% of total injury crashes in the city (Addis Ababa Police Commission, 2012; Downing, et al., 2000). Currently, in Addis Ababa, at least one person dies and 8 persons are injured every day, on average (Federal Police Commission of Ethiopia, 2013).

## **2.2. Pedestrian Crashes**

Pedestrians constitute the most vulnerable part of road users worldwide. About 1.24 million road traffic deaths occur each year around the world which makes road traffic injuries the eighth leading cause of death globally. More than 270,000 pedestrians die annually in road traffic accidents, equaling 22% of all road deaths (World Health Organization, 2013).

Pedestrian fatalities in African countries account for more than 38% of total road traffic deaths (WHO, 2013b). In the case of Ethiopia, pedestrians account for 55% of fatal crashes per annum (Tulu et al. 2013, p2, WHO 2009, p99), although the comparative levels of exposure to risk are not known with certainty. In spite of these high numbers, policy makers in DCs have failed to

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remediate the growing scale of pedestrian crash risk, which is exacerbated by the rapid motorization in DCs. Given these trends it is worthwhile to scrutinize the problem of pedestrian crash risk in DCs by providing a comprehensive synthesis of the factors which expose pedestrians to crash risk.

Despite the frequency of pedestrian crashes and the importance of walking as a mode of transport, the road authority in Ethiopia often gives attention to the construction and maintenance of roadways but not to pedestrian facilities. Recently, newly upgraded roads have been provided with footpaths; however, there is a serious problem with maintenance of these 154 footpaths. In 2010, there was a total of 387 kilometers of pedestrian footpaths in Addis Ababa (Getachew, 2010), whereas the total length of 7m wide roadways is 3,324 kilometers (Bogale, 2012).

Walking is an important mode of transport. In urban areas a significant proportion of trips up to 1-2 Km in length are performed on foot. Moreover every journey necessarily starts and ends as a walk trip. Since pedestrians are more vulnerable to being involved in accidents, it is imperative that adequate consideration should be given to their safety through provision of facilities like guard rails, secured crossing areas, footpath and grade separations. (T. Subramani, 2012)

In terms of modal split, citizens use walking as the primary means of transportation (Tulu, Washington, King, et al., 2013) accounting for about 60% of the trips within the city. Apart from this, a high presence of motorized traffic in Addis Ababa may have implications for the pedestrian safety.

### **2.2.1 Pedestrian Crashes in Addis Ababa City Ring Road**

Crossing behavior of pedestrians in Addis Ababa City, Ethiopia is rarely in compliance with the pedestrian regulations, though drivers contribute to this as they do not yield at pedestrian crossings. There are also infrastructure factors that contribute to illegal crossing behavior: there are relatively few legal crossing points, and center medians are sometimes difficult or impossible for pedestrians to negotiate, and in recent years the traffic lights in Addis Ababa (which should halt traffic to allow a pedestrian phase) have been turned off because their unlinked fixed-phase operation contributes to greater congestion. At other locations there are interactions between behavioral and infrastructure factors. For example, It is worth noting that, according to the Ethiopian traffic rules, drivers are not liable for such pedestrian injuries or fatalities because it is a fully access-controlled road.

One implication is that significant emphasis should be given to engineering measures that separate pedestrians in space and time (Retting, et al., 2003). On the other hand, despite the availability of elevated pedestrian crossings on the fully access-controlled Addis Ababa ring road, illegal crossing is a major issue that increases the risk of fatal injuries. To address this problem, strict enforcement in the form of fines could be applied to pedestrians and supplemented by education campaigns and awareness programs.

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On average, about 56 per cent of the road traffic accident fatalities are pedestrians, 36 percent are passengers, and only 8 percent are drivers. The figure of pedestrian fatalities rises in built-up areas. For example in the city of Addis Ababa, pedestrian fatalities are about 90 per cent of the total road accident fatalities in the city. These figures are indicators of the poor safety behavior of road users and lack of pedestrian facilities and respect for them. (UNECA, 2009)

the major causes of traffic accidents are failure to give way for pedestrians, followed by over speeding and failure to give way for other vehicles in that order. However, the major causes of fatal accidents in their order of importance are failure to give way for pedestrians, over speeding, failure to respect right hand rule.

### **2.3. Pedestrian Illegal Crossing Behavior**

Council of ministers provides a regulation no 208/2011 for road transport traffic control. Under this regulation Article 56 sub-article 4 states that “*wherever pedestrian crossing have been provided and marked as such, no person may cross municipal road except within such marked crossing or crossing bridge*”. Article 59 of the regulation also states that “*where a fence is installed on the edge of any side walk, no pedestrians may stand, seat, lean over or move on the side of the fence nearest to the road.*” As per the regulation the penalty against pedestrian crossing the road without due care is ETB 40.00 birr.

Pedestrians are expected to follow traffic rules and cross on pedestrian designated facilities particularly in built up areas, and it is worth noting that there are fewer rules for pedestrians than for drivers (King, Soole, & Ghafourian, 2009). However, comprehensive road traffic legislation is in place for only 7% of the world’s population (WHO, 2013a).

Previous researches have made theoretical and methodological contribution to a practical understanding of pedestrian’s behavior and the interaction between the driver and the pedestrian at pedestrian crossings (Sun et al., 2011). Pedestrians arriving at the pedestrian crossing look for acceptable gaps between vehicles in the traffic stream. They either accept or reject such gaps. Rejection of prevailing gaps leads to longer waiting time at the curb side.

Illegal crossing behavior and absence of discipline in the road environment are relatively well investigated in some DCs which give an emphasis to these issues within other major topics to explain the high rates of pedestrian crashes (Cherry, Donlon, Yan, & Xiong, 2011; Damsere-Derry, et al., 2010; Ibrahim, Day, Hirshon, & El-Setouhy, 2011; Wang, Guo, Gao, & Bubb, 2011). A study in China found that 65.7% of pedestrians did not check the oncoming and departing vehicles when they crossed unmarked roadways (Zhuang & Wua, 2011) due to poor perception priority rules. A recent study in Chile has revealed that pedestrians have a positive attitude towards illegal midblock crossing (Diaz, 2002). In cities of DCs, illegal crossing can be governed by psychological attributes and complexity of road environment (Wickramasinghe, Priyankara, & Dissanayake, 2012).

Crossing behavior of pedestrians in Addis Ababa City, Ethiopia is rarely in compliance with the pedestrian regulations, though drivers contribute to this as they do not yield at

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pedestrian crossings. There are also infrastructure factors that contribute to illegal crossing behavior: there are relatively few legal crossing points, and center medians are sometimes difficult or impossible for pedestrians to negotiate, and in recent years the traffic lights in Addis Ababa (which should halt traffic to allow a pedestrian phase) have been turned off because their unlinked fixed-phase operation contributes to greater congestion. At other locations there are interactions between behavioral and infrastructure factors. For example, the Addis Ababa City Ring Road traverses through mostly densely populated areas, and has a central New Jersey barrier which makes it impossible for pedestrians to cross. As a consequence there is fencing to prevent pedestrians using the road and 86 pedestrian overpasses are provided to cross the road, however pedestrians are often reluctant to use pedestrian overpasses (Ribbens, 1996). Instead, they jump over the fences and median barriers to cross the roadways. As a result, many pedestrians have been seriously injured or killed by fast moving vehicles. It is worth noting that, according to the Ethiopian traffic rules, drivers are not liable for such pedestrian injuries or fatalities because it is a fully access-controlled road.

Although illegal behavior is widespread, there is little information about the relative contribution to this behavior of levels of knowledge about road rules, levels of enforcement of the rules, relative opportunities to cross legally (which is in turn influenced by amount of traffic, distribution of legal crossing points, and compliance of drivers with requirements to stop or give way at crossing points). Research with pedestrians and drivers about their knowledge, attitudes and practices would provide valuable insights.

Pedestrian crossing behavior is usually get influenced by various factors related to pedestrian characteristics, pedestrian movements, traffic conditions, road conditions and environmental surroundings. Rosenbloom et al. (2008) observed unsafe crossing behavior of children, like not stopping at the curb, not looking before crossing, attempting to cross when a vehicle is nearing and running across the road. Female pedestrians are observed accepting more gaps and less risk compared to male pedestrians. Oxley et al. (2005) have done experimental studies on the effect of age of a pedestrian in gap selection. They reported that, for all age groups, gap selection is primarily based on vehicle distance and speed.

### **2.4. Pedestrian crossing facilities**

The potential need for pedestrians to move across multilane facilities with lengthy distances between signalized intersections will be considered during design. For instance, near schools, parks, hospitals, public buildings, or shopping centers there may be high demand for pedestrians to cross a roadway between signalized intersections. A raised median, with curb cuts, is the preferred approach to provide a safer crossing for pedestrians. A pedestrian underpass or overpass may also be considered if it is economically feasible.

#### **2.4.1 General Requirements of Pedestrian Crossings**

##### **2.4.1**

General requirements of pedestrian crossings according to The Department of the Environment for Northern Ireland: (Local Transport Note 2/95)

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## **Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)**

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### **1. Proximity of Junctions**

Crossings should be located away from conflict points at uncontrolled junctions. This will give drivers an adequate opportunity to appreciate the existence of a crossing and to brake safely.

### **2. Visibility**

Pedestrians must be able to see and be seen by approaching traffic. Visibility should not be obscured or restricted by, for example, parked vehicles, trees or street furniture. If it is not possible to site the crossing elsewhere consideration must be given to either removing the obstacle or, if the carriageway is sufficiently wide, to building out the kerb-line to provide enhanced sightlines.

### **3. Crossing Width**

The minimum width (between the two rows of studs) for a Zebra, Pelican or Puffin pedestrian crossing is 2.4 meters. There are no regulations defining the width at a refuge island. However, 2 meters is considered a reasonable minimum to allow for two wheelchairs to pass each other. The use of wide crossings also may help prevent overcrowding of narrow footways.

### **4. Guard Railing**

Many accidents at pedestrian crossings occur on the approach to the crossing. The provision of guard railing at such positions should be considered. Guard railing may also provide useful guidance for blind and partially sighted pedestrians.

### **5. Crossing Approach Surfaces for Footways and Carriageways**

Crossings should be installed so that adjacent drainage collects surface water from the crossing area. Care should be taken to ensure that, even after remedial surface treatment, excess water does not collect at the crossing point. Dropped kerbs must always be provided across the crossing width.

### **6. Facilities for Disabled Pedestrians**

The needs of disabled pedestrians should be considered when designing the layout of crossings. If these are well provided then a better crossing will probably result for all users. Dropped kerbs provide easy access for wheelchair users and people with walking difficulties.

### **7. Lighting**

It should be remembered that pedestrian crossings are often used at night as well as during the day. It is necessary to ensure that the crossing can readily be seen against the background of other lights and signs.

### **8. Street Furniture**

Adequate clearance is required between the kerb edge and the closest part of any street furniture. A minimum of 0.5 meter is recommended but this should be increased in cases where the road camber or speed of vehicles necessitates.

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### **2.4.2 Types of Pedestrian Crossings.**

Pedestrian crossing can be broadly classified as:

1. Grade separated crossings,
2. At-grade crossings.

#### Grade separated crossings (Bridges or Pedestrian Overpass)

These are the crossings where the pedestrians are required to cross the carriageway at a level different from that of vehicular movement. It may be in the form of a pedestrian subway or a foot over bridge across the road.

On the approach to a bridge that has a raised sidewalk, provide a ramp that transitions to the sidewalk from the paved shoulder. A ramp that transitions from a paved shoulder to a sidewalk on a bridge is to have a slope of 5% maximum and be constructed of asphalt or cement concrete. In addition to aiding pedestrian access, the ramp also serves as a roadside safety feature to mitigate the raised blunt end of the concrete sidewalk. When considering a grade-separated pedestrian structure, determine whether the conditions that require the crossing are permanent. If there is likelihood that pedestrians will not use a grade separation, consider less-costly solutions. Locate the grade-separated crossing where pedestrians are most likely to cross the roadway. A crossing might not be used if the pedestrian is required to deviate significantly from a more direct route.

It is sometimes necessary to install fencing or other physical barriers to channel the pedestrians to the structure and reduce the possibility of undesired at-grade crossings. Elevated grade separations in cut sections, where pedestrians climb stairs or use long approach ramps, tend to be underused. Pedestrian bridges need adequate right of way to accommodate accessible ramp approaches leading up to and off of the structure. The bridge structure must comply with ADA requirements and meet the accessibility criteria for either a pedestrian circulation path (if the grade is 5% or less) or an access ramp (if the grade is greater than 5% but less than or equal to 8.3%), and must include a pedestrian access route. The height of the structure can affect the length of the pedestrian ramp approaches to the structure. When access ramps are not feasible, provide both elevators and stairways. Provide railings on pedestrian bridges. Protective screening is sometimes desirable to deter pedestrians from throwing objects from an overhead pedestrian structure. The minimum clear width for pedestrian bridges is 8 feet. Consider a clear width of 14 feet where a pedestrian bridge is enclosed or shared with bicyclists, or equestrians, or if maintenance or emergency vehicles will need to access. (WSDOT Design Manual M 22-01.10 Page 1510-37&38, July 2013)

#### At grade crossings (Zebra-Striped crossings)

At grade crossings the pedestrians cross the carriageway at the same level as that of vehicular movement. It is very common in cities and towns. It may be controlled and uncontrolled.

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Uncontrolled crossings are those where the pedestrian cross walk is marked by studs or paint line but not controlled by any system of signals or a zebra form of crossing.

### **2.5. Performance measure of pedestrian facilities**

The LOS concept was first developed by traffic engineers for vehicular capacity studies connected with street and highway design. It is a powerful quantitative tool for planning, designing, and assessing transportation facilities serving vehicular movement. It was therefore not surprising that engineer's arid planners adopted the LOS concept for designing pedestrian facilities also. Pedestrian capacity analysis is a relatively new area of study, beginning with Fruin's Pedestrian Planning and Design in 1971 (Fruin, J., 1971). In recent years the 1985 Highway Capacity Manual (HCM) has provided guidelines for designing walkways, crosswalks, and street corners using the LOS concept (Special Report 209, 1985).

#### **2.5.1 Highway Capacity Manual 2010**

The Highway Capacity Manual (HCM 2010) is widely used in the United States and throughout the world to determine the capacity and operating characteristics of various types of transportation facilities.

The following are important terms used for pedestrian facility capacity and LOS analysis:

- I. *Pedestrian speed* is the average pedestrian walking speed, generally expressed in units of feet per second.
- II. *Pedestrian flow* rate is the number of pedestrians passing a point per unit of time, expressed as pedestrians per 15 min or pedestrians per minute. Point refers to a line of sight across the width of a walkway perpendicular to the pedestrian path.
- III. *Pedestrian flow per unit of width* is the average flow of pedestrians per unit of effective walkway width, expressed as pedestrians per minute per foot (p/min/ft).
- IV. *Pedestrian density* is the average number of pedestrians per unit of area within a walkway or queuing area, expressed as pedestrians per square foot (p/ft<sup>2</sup>).
- V. *Pedestrian space* is the average area provided for each pedestrian in a walkway or queuing area, expressed in terms of square feet per pedestrian. This is the inverse of density, and is often a more practical unit for analyzing pedestrian facilities.
- VI. *Platoon* refers to a number of pedestrians walking together in a group, usually involuntarily, as a result of signal control and other factors.

#### **Principles of Pedestrian Flow**

The qualitative measures of pedestrian flow are similar to those used for vehicular flow, such as the freedom to choose desired speeds and to bypass others. Other measures related specifically to pedestrian flow include the ability to cross a pedestrian traffic stream, to walk in the reverse direction of a major pedestrian flow, to maneuver generally without conflicts and changes in walking speed, and the delay experienced by pedestrians at signalized and un-signalized intersections.

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**Uninterrupted-Flow Pedestrian Facilities**

Uninterrupted pedestrian facilities include both exclusive and shared pedestrian paths (both indoor and outdoor) designated for pedestrian use. These pedestrian facilities are unique because pedestrians do not experience any disruption except the interaction with other pedestrians and, on shared paths, with other non-motorized modes of transportation.

**Walkways and Sidewalks**

Walkway and sidewalk paths are separated from motor vehicle traffic and typically do not allow bicycles or users other than pedestrians. These facilities are often constructed to serve pedestrians on city streets, at airports, in subways, and at bus terminals. These pedestrian facilities include straight sections of sidewalk, terminals, stairs, and cross-flow areas where streams of pedestrians cross.

Table 2.12-1. Average Flow LOS Criteria for Walkways and Sidewalks

LOS	Average Space (ft <sup>2</sup> /p)	Related Measures			Comments
		Flow Rate (p/min/ft) <sup>a</sup>	Average Speed (ft/s)	v/c Ratio <sup>b</sup>	
A	>60	≤5	>4.25	≤0.21	Ability to move in desired path, no need to alter movements
B	>40–60	>5–7	>4.17–4.25	>0.21–0.31	Occasional need to adjust path to avoid conflicts
C	>24–40	>7–10	>4.00–4.17	>0.31–0.44	Frequent need to adjust path to avoid conflicts
D	>15–24	>10–15	>3.75–4.00	>0.44–0.65	Speed and ability to pass slower pedestrians restricted
E	>8–15 <sup>c</sup>	>15–23	>2.50–3.75	>0.65–1.00	Speed restricted, very limited ability to pass slower pedestrians
F	≤8 <sup>c</sup>	Variable	≤2.50	Variable	Speeds severely restricted, frequent contact with other users

**Notes:** <sup>a</sup> does not apply to walkways with steep grades (>5%). See the Special Cases section for further discussion.

<sup>b</sup> Pedestrians per minute per foot of walkway width.

<sup>c</sup> v/c ratio = flow rate/23. LOS is based on average space per pedestrian.

<sup>d</sup> In cross-flow situations, the LOS E–F threshold is 13 ft<sup>2</sup>/p.

Table 2.22-2. Platoon-Adjusted LOS Criteria for Walkways and Sidewalks

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LOS	Average Space (ft <sup>2</sup> /p)	Related Measure		Comments
		Flow Rate <sup>a</sup> (p/min/ft) <sup>b</sup>		
A	>530	≤0.5		Ability to move in desired path, no need to alter movements
B	>90–530	>0.5–3		Occasional need to adjust path to avoid conflicts
C	>40–90	>3–6		Frequent need to adjust path to avoid conflicts
D	>23–40	>6–11		Speed and ability to pass slower pedestrians restricted
E	>11–23 <sup>c</sup>	>11–18		Speed restricted, very limited ability to pass slower pedestrians
F	≤11 <sup>c</sup>	>18		Speeds severely restricted, frequent contact with other users

**Notes:** <sup>a</sup> Rates in the table represent average flow rates over a 5-min period. Flow rate is directly related to space; however, LOS is based on average space per pedestrian.  
<sup>b</sup> Pedestrians per minute per foot of walkway width.  
<sup>c</sup> In cross-flow situations, the LOS E–F threshold is 13 ft<sup>2</sup>/p.

Source: Highway Capacity Manual 2010

**Stairways**

Research has developed LOS thresholds based on the Institute of Transportation Engineers stairways standards, which provide space and flow values listed below in table 2.3. These modified LOS criteria are to ensure that the basic equation of traffic flow is satisfied. The volume to capacity (v/c) ratios are based on a stairway capacity of 530 p/min/ft.

Table 2.3.2-3. LOS Criteria for Stairways

LOS	Average Space (ft <sup>2</sup> /p)	Related Measures		Comments
		Flow Rate (p/min/ft) <sup>a</sup>	v/c Ratio <sup>b</sup>	
A	>20	≤5	≤ 0.33	No need to alter movements
B	>17–20	>5–6	>0.33–0.41	Occasional need to adjust path to avoid conflicts
C	>12–17	>6–8	>0.41–0.53	Frequent need to adjust path to avoid conflicts
D	>8–12	>8–11	>0.53–0.73	Limited ability to pass slower pedestrians
E	>5–8	>11–15	>0.73–1.00	Very limited ability to pass slower pedestrians
F	≤5	Variable	Variable	Speeds severely restricted, frequent contact with other users

**Notes:** <sup>a</sup> Pedestrians per minute per foot of walkway width.  
<sup>b</sup> v/c ratio = flow rate/15. LOS is based on average space per pedestrian.

Source: Highway Capacity Manual 2010

**Interrupted-Flow Pedestrian Facilities**

Another procedure applies to an unsignalized intersection with a pedestrian crossing against a free-flowing traffic stream or an approach not controlled by a stop sign. However, if there are zebra-striped crossings at an unsignalized intersection, this procedure does not apply, because pedestrians have the right-of-way; instead, pedestrian delay can be estimated using the method for two-way stop-controlled (TWSC) intersections.

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Pedestrian LOS at two way stop control intersections is defined for pedestrians crossing a traffic stream not controlled by a STOP sign; it also apply to midblock pedestrian crossings. LOS criteria for pedestrians are given below in table 2.4

Table 2.4-4. LOS Criteria for Pedestrian at TWSC

LOS	Control Delay (s/pedestrian)	Comments
A	0–5	Usually no conflicting traffic
B	5–10	Occasionally some delay due to conflicting traffic
C	10–20	Delay noticeable to pedestrians, but not inconveniencing
D	20–30	Delay noticeable and irritating, increased likelihood of risk taking
E	30–45	Delay approaches tolerance level, risk-taking behavior likely
F	>45	Delay exceeds tolerance level, high likelihood of pedestrian risk taking

Note: Control delay may be interpreted as s/pedestrian group if groups of pedestrians were counted as opposed to individual pedestrians.

Source: *Highway Capacity Manual 2010*

### 2.5.2 Other Performance Measures

The HCM acknowledges that pedestrian facilities are far more complex to design as compared with vehicle facilities, although Illinois Institute of Technology, Chicago, Ill. 60616 agreed the same. The LOS concept is used in both cases. Although the quantitative measures of flow, density, and speed affect such convenience factors as the ability to select walking speeds, bypass slower pedestrians, and avoid conflicts, the HCM makes it abundantly clear that additional environmental factors, such as comfort, convenience, safety, security, and the economy of the walking system, should be taken into account because these factors contribute to the walking experience and ultimately to the perceived level of service. However, no guidelines are given on how to measure or make use of these environmental factors in designing or assessing pedestrian facilities.

The basic input to the task of selecting potential performance measures (PMs) for assessing the environmental factors are, in alphabetical order, attractiveness, comfort, convenience, safety, security, system coherence, and system continuity.

1. Attractiveness:

This PM encompasses much more than aesthetic design. The PM goes far beyond the manifest or instrumental functions of safety, convenience, and comfort by considering latent functions, such as pleasure, delight, interest, and exploration.

2. Comfort:

Such factors as weather protection, climate control, properly designed shelters, condition of walking surface, cleanliness of terminals, and provision of adequate seating arrangements can be considered to provide comfort. One could even include such factors as odor, ventilation, noise, vibration, and crowding.

3. Convenience:

Walking distances connected with attributes such as pathway directness, grades, sidewalk ramp locations, directional signing, activity maps and directories, convenient connections

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between frequently used locations, and other features making walking easy and uncomplicated are qualities of convenience. Sidewalk obstructions and circuitous trip linkages are considered a source of inconvenience to pedestrians. Properly ramped curb cuts for the handicapped and tactile trails for the blind are considered assets.

4. Safety:

The reduction of pedestrian-vehicle conflicts can be considered a basic factor promoting safety. Ease of movement in walking, even in vehicle-free areas such as malls, passageways, sidewalks, stairs, elevators, ramps, and escalators, is considered part of safety. Particularly in heavily trafficked street networks, the provision of properly designed control devices, providing adequate time and space separation from vehicular movement is an essential part of safety.

5. Security:

The ability to provide pedestrian facilities that provide clear observation by the public and the police through unobstructed lines of sight, good lighting, absence of concealed areas, and television surveillance is considered a measure of good performance'. The pedestrian should feel reasonably safe and secure, commensurate with the neighborhood and level of street activity prevailing.

6. System Coherence:

Mental imagery and selectivity play a major role in perceiving and understanding the world of time and space. For instance, an able-bodied pedestrian using an unfamiliar street system would generally be looking impatiently for primary orientation and direction in reaching his or her destination rather than admiring the aesthetics of the setting, particularly if it was getting dark and the street lighting was not adequate. There is a strong correlation between activity systems and the cognitive images people have of the physical environment. Distortion in imagery reflects and affects the perceptions people have of such things as the location of shops, parks, and other facilities. Even the perception of the distance of facilities is affected by such things as the geometry of paths. A path that is circuitous or full of junctions is perceived to be longer than one of the same length that is straight.

7. System Continuity:

A well-designed pedestrian system may have all the attributes alluded to in the PMs mentioned earlier but lack an essential feature of continuity and connectivity. Continuity is particularly important for multimodal facilities connected to pedestrian paths that unify the system efficiently.

Major urban traffic generators produce considerable pedestrian activity and movement, and therefore an important factor is the planning, designing, operating, and evaluating of transportation systems. The HCM provides guidance in designing and evaluating pedestrian facilities based only on quantitative measures of pedestrian flow, walking speed, and flow density, resulting in six levels of service, similar to those for vehicular flow. However, it recommends that additional environmental factors that contribute to the walking experience, and therefore to the perceived level of service, be considered, but does not spell out a methodology of how to do so.

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Additional environmental factors that contribute to the walking experience, and therefore, to perceived level of service are the comfort, convenience, safety, security, and economy of the walkway system. Comfort factors include weather protection, climate control, arcades, transit shelters, and other pedestrian amenities. Convenience factors include walking distances, pathway directness, grades, sidewalk ramps, directional signing, directory maps, and other features making pedestrian travel easy and uncomplicated.

### 3. Research Approach and Methodology

#### 3.1. Scope of research

This research focus on pedestrian crossing and safety along Winget to Ayertena Ring Road which is part of Addis Ababa City Ring Road. This road section has a length of 10km and consist of eleven pedestrian bridges (overpass or footbridge) and seven zebra stripped crossing provided for pedestrian.



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Figure 3-13-4 Research Area

Source: Google Map

Crossing behavior of pedestrians in Addis Ababa City, Ethiopia is rarely in compliance with the pedestrian regulations, though drivers contribute to this as they do not yield at pedestrian crossings. There are also infrastructure factors that contribute to illegal crossing behavior: there are relatively few legal crossing points, and center medians are sometimes difficult or impossible for pedestrians to negotiate, and in recent years the traffic lights in Addis Ababa (which should halt traffic to allow a pedestrian phase) have been turned off because their unlinked fixed-phase operation contributes to greater congestion. At other locations there are interactions between behavioral and infrastructure factors. For example, It is worth noting that, according to the Ethiopian traffic rules, drivers are not liable for such pedestrian injuries or fatalities because it is a fully access-controlled road.

One implication is that significant emphasis should be given to engineering measures that separate pedestrians in space and time (Retting, et al., 2003). On the other hand, despite the availability of elevated pedestrian crossings on the fully access-controlled Addis Ababa ring road, illegal crossing is a major issue that increases the risk of fatal injuries. To address this problem, strict enforcement in the form of fines could be applied to pedestrians and supplemented by education campaigns and awareness programs.

On average, about 56 per cent of the road traffic accident fatalities are pedestrians, 36 percent are passengers, and only 8 percent are drivers. The figure of pedestrian fatalities rises in built-up areas. For example in the city of Addis Ababa, pedestrian fatalities are about 90 per cent of the total road accident fatalities in the city. These figures are indicators of the poor safety behavior of road users and lack of pedestrian facilities and respect for them (UNECA, 2009) Therefore this study will be conducted on Winget- Torhayloch- Ayertena ring road which is exposed to traffic accident mostly for pedestrian while crossing the ring road.

### **3.2. Methodology**

The research methodology employed in this thesis plans the steps used to answer research questions which are described under section 1.4 above. The research design used for this research are Observational, Qualitative and Quantitative survey.

After identifying the basic parameters that affect the performance of crossing facilities and major factors forcing pedestrian for illegal crossing, a possible counter measures shall be suggested to mitigate the respective problem.

#### **3.2.1 Assessment on pedestrian crossing**

The research also include an operational analysis of existing pedestrian crossing facilities of the road. The analysis is based on the indicator stated in HCM (pedestrian speed, flow rate, space and volume/capacity ratio) and other qualitative indicators.

The Highway Capacity Manual (HCM) is widely used in the United States and throughout the world to determine the capacity and operating characteristics of various types of transportation facilities.

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### Method 1: Evaluation of LOS of pedestrian overpass based on space per pedestrian:

Traffic Flow and Capacity Concepts, pedestrian flow rates and speeds are directly related to the average space occupied by a pedestrian. These values are given for reference in the space-based LOS tables along with the corresponding range of volume-to-capacity (V/C) ratios; however, the actual LOS in those tables are based on space per pedestrian. Which is a measure of pedestrian comfort and mobility. The LOS thresholds are based on user perception research where available and in other cases on expert judgment.

The next chart illustrates the steps taken to determine the LOS for pedestrian Stairways (Overpass)

**Step 1:** Determine the effective walkway width

**Step 2:** Calculate the pedestrian flow rate

**Step 3:** Calculate the average pedestrian space

**Step 4:** Determine LOS

**Step 5:** Calculate the volume-to-capacity ratio

### Step 1: Determine Effective Walkway Width

The effective walkway width at a given point along the walkway is computed as follows:

$$W_E = W_T - W_0 \quad \text{Eqn. 3.1}$$

Where,

$W_E$  = effective walkway width,

$W_T$  = total walkway width at a given point along walkway, and

$W_0$  = sum of fixed-object effective widths and linear-feature shy distances at a given point along walkway.

The allowance for small reverse flows, when used, is included as part of the  $W_0$  term

### Step 2: Calculate Pedestrian Flow Rate

Walkways and Cross-Flow Areas

Hourly pedestrian demands is used as an input to the analysis. LOS is based on the busiest 15 consecutive minutes during an hour:

$$V_{15} = \frac{V_h}{4 \times PHF} \quad \text{Eqn. 3.2}$$

Where,

$V_{15}$  = pedestrian flow rate during peak 15 min (p/h),

$V_h$  = pedestrian demand during analysis hour (p/h), and

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PHF =peak hour factor.

However, if peak-15-min pedestrian volumes are available, the highest 15-min volume can be used directly without the application of a peak hour factor.

Next, the peak 15-min flow is converted into a unit flow rate (pedestrians per minute per foot of effective path width):

$$V_p = \frac{V_{15}}{15 \times W_e} \quad \text{Eqn. 3.3}$$

Where  $V_p$  is pedestrian flow per unit width (p/ft/min) and all other variables are as previously defined. The upward flow rate should be used for analysis and design.

### Step 3: Calculate Average Pedestrian Space

The service measure for walkways is pedestrian space, the inverse of density. Pedestrian space can be directly observed in the field by measuring a sample area of the facility and determining the maximum number of pedestrians at a given time in that area. The pedestrian unit flow rate is related to pedestrian space and speed:

$$A_p = \frac{S_p}{V_p} \quad \text{Eqn. 3.4}$$

Where,

$A_p$ = pedestrian space (ft<sup>2</sup>/p),

$S_p$ = pedestrian speed (ft/min), and

$V_p$ = pedestrian flow per unit width (p/ft/min).

### Step 4: Determine LOS

Research has developed LOS thresholds based on the Institute of Transportation Engineers stairway standards, which provide the space and flow values given in Table below. Stairway LOS is described by the service measure of pedestrian space, expressed as square feet per pedestrian.

Table 3.13-1. LOS Criteria for Pedestrian Overpass

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LOS	Average Space (ft <sup>2</sup> /p)	Related Measures		Comments
		Flow Rate (p/min/ft) <sup>a</sup>	v/c Ratio <sup>b</sup>	
A	>20	≤5	≤ 0.33	No need to alter movements
B	>17–20	>5–6	>0.33–0.41	Occasional need to adjust path to avoid conflicts
C	>12–17	>6–8	>0.41–0.53	Frequent need to adjust path to avoid conflicts
D	>8–12	>8–11	>0.53–0.73	Limited ability to pass slower pedestrians
E	>5–8	>11–15	>0.73–1.00	Very limited ability to pass slower pedestrians
F	≤5	Variable	Variable	Speeds severely restricted, frequent contact with other users

**Notes:** <sup>a</sup> Pedestrians per minute per foot of walkway width.

<sup>b</sup> v/c ratio = flow rate/15. LOS is based on average space per pedestrian.

Source: Highway Capacity Manual 2010

**Method 2: Evaluation of LOS of pedestrian overpass based on selected qualitative indicators**

This is a qualitative assessment of pedestrian overpass with a scale of 0 to 5 indicating a quality range of very poor to Excellent which correspond to a LOS of F to A.

The selected qualitative indicators for this research are

- I. **Comfort:**  
Such factors as weather protection, climate control, condition of walking surface,
- II. **Convenience:**  
Walking distances connected with attributes such as pathway directness, grades, sidewalk ramp locations, directional signing, activity maps and directories,
- III. **Safety:**  
The reduction of pedestrian-vehicle conflicts can be considered a basic factor promoting safety. Ease of movement in walking,
- IV. **Security:**  
The ability to provide pedestrian facilities that provide clear observation by the public and the police through unobstructed lines of sight, good lighting, absence of concealed areas
- V. **Freedom:**  
Freedom to choose your desire speed and freedom while walking in a reverse direction of major flow

Having this data, the performance measure are computed and LOS of pedestrian crossing facilities in the road section will be determined.

**3.2.2 Assessment on pedestrian involved traffic accidents**

The research approach in this thesis involves quantitative analysis of traffic accident along the road section. This will help to examine the magnitude of traffic accident which involves

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pedestrian and will help to identify that how much of the accident resulted due to illegal crossing behavior of pedestrians.

### **3.2.3 Assessment on pedestrian behavior**

Pedestrian behavior toward the pedestrian crossing facilities provided on the road section is also assessed through interviews and/or questioner. This will aid to detect the contributing factors for illegal crossing of pedestrians toward the performance and preference of crossing facilities provided in the road section.

### **3.3. Data Collection Techniques**

Different primary and secondary data sources were used for the purpose of investigating the different dimensions of the research objective. These different data were collected using different techniques. A combination of the following techniques was employed in the study.

- I. Review of Records - A traffic accident data of Addis Ababa City and Kolfe Keranio Sub city was collected from the respective Police Commission. A crash record book is kept at each Sub city police stations and each Sub city police station reports summarized crash data to Addis Ababa City Police Commission. The researcher also tries to identify the accident happened along the study area.
- II. Measurement of Crossing Facilities- This study focus on the stairways the geometric measurement, which include length, width, and grade of the crossing facilities, shall be investigated from as-built drawing of the road plan and profile. This data shall be available at Addis Ababa City Roads Authority (AACRA). However due to the documentation problem of the office the researcher unable to get the data. Hence same shall be done by actual measurements and visual inspection on the site.
- III. Counting Pedestrian Traffic Data- pedestrian traffic count was conducted on the selected pedestrian crossings to analyze performance of pedestrian crossings. This was conducted by counting number of pedestrian crossing the road for every five minute from 6:00 AM to 6:00 PM on both working and weekend days.
- IV. Survey of pedestrian opinion – Random survey was done for pedestrian to assess their crossing behavior and usage of crossing facilities. This data was collected through questioner and structured interviews.

### **3.4. Collected Data**

The following data were collected in order to meet the objectives of the research. For this study purpose, due to time and budget constraint, representative samples were taken at different locations of the Road to derive a generalized conclusion.

#### **a) Traffic Accident Data**

Road traffic crash data were supplied by the Addis Ababa City and Kolfe Keranio Sub-City Police Commission for the period July 2012 to June 2016 (Five years), which was the latest data available at the time.

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Road traffic crash data were collected by the Addis Ababa Police Commission and ten sub city police departments. The Addis Ababa Police Commission is responsible for collecting fatal crash data and the sub city police departments are responsible for recording the details of serious injuries, slight injuries, and property damage in their respective sub city.

Road traffic injuries in Ethiopia are often classified into three groups including fatal, serious, and slight injuries. According to Ethiopian practice, a road traffic fatality is a road user who died within 30 days of the traffic crash. Serious injury is when the person is hospitalized for a period of at least 24 hours or more, and slight injury is when a person suffers from a road traffic injury and is hospitalized for less than 24 hours.

### **b) Pedestrian Crossing Facilities**

Since the researcher unable to get the geometric data of the road section, due to the documentation problem of the office, same shall be collected by actual measurements and visual inspection on the site. Actual measurements were taken along the ring road between Winget and Ayertena roundabouts using tape meter and odometer. This ring road is a 10 km long having eleven stairways and seven zebra crossings, which were provided for pedestrian to cross the ring road. The measurement was conducted to obtain the following characteristics of the facility, but not limited to:

- **Location of crossing facilities**  
This measures the distance of the facility from Ayertena round about. The measurement performed by using odometer of vehicle by setting 0+00 at Ayertena round about and driving to Winget Interchange along the road section. This expresses the actual position of the crossing facilities.
- **length and width of crossing facilities**  
The total length through which pedestrian moves to cross the road and the horizontal width provided for pedestrian crossing was measured manually by using tape meter.
- **Spacing between each crossing facilities**  
Having the distance of all facilities from Ayertena round about it is possible to have the spacing of each facilities by simple subtraction calculation.

The following characteristics of facilities are also examined through site observation of the pedestrian overpasses

- **Quality of each crossing facilities**  
This take account of condition of walking surface, weather protection and climate control
- **Accessibility of crossing facilities**  
This consist of ramp location, walking distance, grade of the stair
- **Security of crossing facilities**  
This includes open line of site, good lighting, clear observation by the public and police

### **c) Pedestrian Traffic Data**

The data used for the performance analysis of pedestrian Stairways was obtained by conducting manual traffic count nearby of the crossings with the aid of stop watch. Among the crossings three stair ways was taken as a sample of crossings. The traffic data counted from 6:00am to

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6:00pm, (since the maximum volume of pedestrian observed during day time where civil servant, student and merchants rush to their office, school or shop at the same time) with an interval of 5minute and finally this converted to consecutive 15 minute volume to provides a peak 15minute pedestrian crossing volume.

The time required by pedestrians to cross the road through the facilities also recorded using stop watch which enables to determine the followings but not limited to:

- Pedestrian speed  
Pedestrian speed is the average pedestrian walking speed calculated by dividing the total walking length of the crossing facility by the average time taken by pedestrians, expressed in time per second or feet per second.
- Pedestrian flow rate  
Pedestrian flow rate is the number of pedestrians passing a point per unit of time, expressed as pedestrians per 15 min or pedestrians per minute. Point refers to a line of sight across the width of a walkway perpendicular to the pedestrian path.
- Space per pedestrian  
Pedestrian space is the average area provided for each pedestrian in a walkway or queuing area, expressed in terms of square feet per pedestrian.
- Volume to Capacity (V/C) ratio of crossing facilities

**d) Pedestrian Behavior**

The researcher detected the contributing factor that directed pedestrians for illegal crossing through observation, interview and/or questioners. 300 pedestrians were randomly selected along the section of the ring road. The minimum sample size was determined statistically as follows.

$$n = \hat{p}\hat{q} \left( \frac{Z_{\alpha/2}}{E} \right)^2$$

Where,  $n$  = minimum sample size  
 $E$  = the maximum error of the estimate  
 $p, q$  = percentage of respondent ( $p=1-q$ )  
 $Z_{\alpha/2}$  = Z values of confidence interval (obtained from Z-chart)

The researcher wants to estimate with 90% confidence interval and a maximum error of 0.05. For a confidence interval of 90%  $\alpha$  become 0.1 and the corresponding Z value will be 1.65. If no approximation of  $p$  is known, you should use  $p= 0.5$ . This value will give a sample size sufficiently large to guarantee an accurate prediction, given the confidence interval and the error of estimate. The reason is that when  $p$  and  $q$  are each 0.5, the product  $p \cdot q$  is at maximum (0.25). Therefore, the minimum sample size  $n= 0.5 \cdot 0.5 (1.65/0.05)^2 = 272.25$  when rounded up  $n= 273$ .

Most of the data collected for the study was derived from primary sources among them was through structured interviews, counting and actual site measurements. However, some data are

**Commented [AK3]:** As my observation, peak pedestrian periods in most congested locations of the city are:  
 Morning from: 7AM-9AM  
 Afternoon: 4:30 PM – 7:30PM  
 You also need to come up with scientific explanation on this one.

## **Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)**

secondary data which were acquired through reviews in the police recorded data. This collected data used directly or indirectly for the results and analysis part of the research.

## **4. Results and Discussion**

### **4.1. Results**

#### **4.1.1. Assessment on road environment**

The assessed road has a length of 10km between Winget and AyerTena round about the road pass through AyerTena, Zenebework, Torhayloch, Asrasimint, AtenaTera and Winget. Along this stretch eleven overpasses and seven zebra striped crossings provided for pedestrian to cross the ring road.

Table 4.14.1. Pedestrian Crossing Facilities

NO	Crossing Type	Cod	Statio	Spacin	Location	remar
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**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
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		e	n (KM)	g (M)		k
1	Ayertena Round About	BOP	0		Ayertena Round about	
2	Zebra Stripped	Z1	0.05	50		
3	Stairway	S1	0.9	850	Ayertena college	
4	Zebra Stripped	Z2	1.4	500	Zenebework	
5	Zebra Stripped	Z3	1.45	50		
6	Zebra Stripped	Z4	2.6	1150	Total	
7	Zebra Stripped	Z5	2.68	80		
8	Stairway	S2	3.5	820	Minaye bldg	
9	Stairway	S3	4.1	600	Augusta	
10	Torhayloch	TT	4.6	500	Torhayloch	
11	Stairway	S4	5.6	1000	Holand Embassy	
12	Stairway	S5	6.4	800	Torhayloch to Asrasimint	
13	Stairway	S6	7.1	700		
14	Zebra Stripped	Z6	7.5	400	Asrasimint Crossection	
15	Zebra Stripped	Z7	7.56	60		
16	Stairway	S7	7.8	240	Ewkete wegene school	
17	Stairway	S8	8.5	700	Atenatera	
18	Stairway	S9	8.8	300	Bisrat Primary school	
19	Stairway	S10	9.3	500	Atenatera to Winget	
20	Stairway	S11	9.8	500		

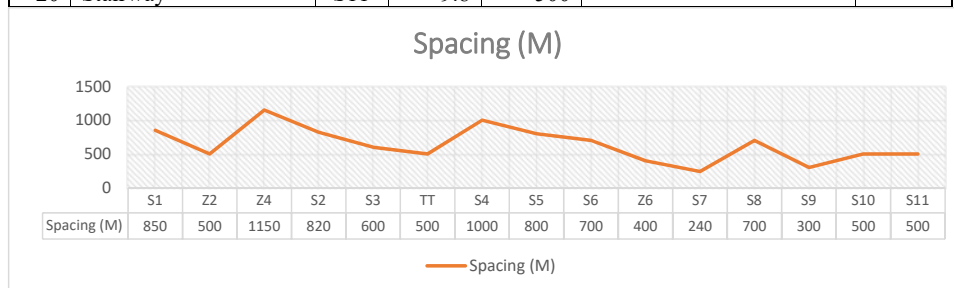


Chart 4-1 Spacing between each Pedestrian Crossings

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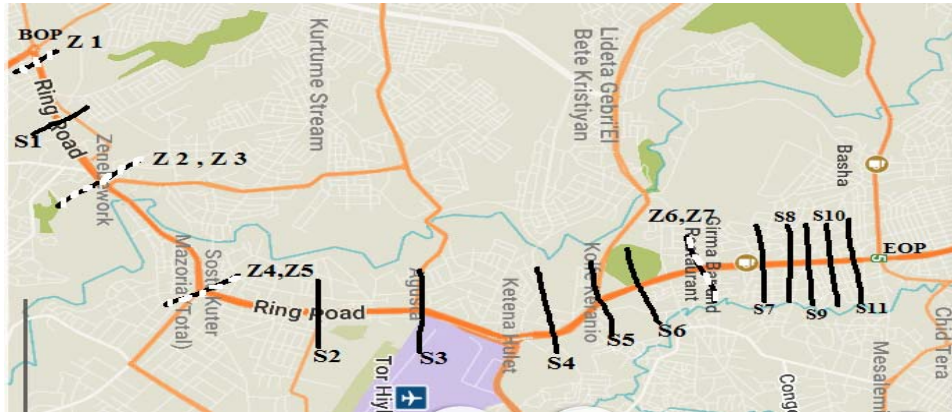


Figure 4-141 location of pedestrian crossing

Table 4.242. Parts of Typical Pedestrian Overpass (Stairway) in the Road Section

NO.	Stairway part	Code	Length (m)	Width (m)	Slope (%)
1	Ramp 1	R1	20.35	2.5	4.87
2	Landing 1	L1	3.75	2.5	0
3	Ramp 2	R2	22.45	2.5	4.87
4	landing 2	L2	39.30	2.5	0
5	Ramp 3	R3	22.20	2.5	5.38
6	Landing 3	L3	3.95	2.5	0
7	Ramp 4	R4	21.50	2.5	5.38
	<b>Total</b>		<b>133.50</b>		



Figure 4-242 Parts of Stairway

## Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)

The assessed road environment data indicated that pedestrian overpasses and zebra striped crossings were provided at different location with an average spacing of 610 meter. The maximum spacing is 1150 meter which is between zebra crossing of Zenebework (Z2,Z3) and Total (Z4,Z5) roundabouts. The maximum space between pedestrian overpass is 800 meter which is between S4 and S5 along the road Torhayloch to Asrasimint cross section. Whereas the minimum space is 240 meter, which is between Z7 (Asrasimint cross section) and S7 (Ewketu Wegene Primary School).

The data shows that 71% of Zebra crossing were found on the first half (AyerTena to Torhayloch) of the road whereas 73% of overpass located on the second half of the road (Winget to Torhayloch).

All of the ~~overpass have~~overpasses have the same geometrical dimension having a slope of 5% and a total walking distance of 133.5 meter and a width of 2.5 meter. Out of the eleven ~~overpass~~overpasses only two of them have distinct ramp arrangement.

### 4.1.2. Pedestrian Traffic Data and LOS

~~4.1.2.~~ As has been noted, the level of service is the overall measure of all service characteristics that affect users of a system. The HCM provides guidelines for evaluating level of service, based primarily on performance elements, such as flow, speed, and density. In addition it is necessary, as pointed out before, that qualitative elements, such as freedom, comfort, convenience, security, and safety, be taken into account the combined effects of these two categories of performance measures (the quantitative and the qualitative) contribute to the level of service of a particular facility.

#### 4.1.2.1. Method 1: Evaluation of LOS of pedestrian overpass based on space per pedestrian:

This evaluation is based on HCM 2010. Accordingly pedestrian traffic data was collected by manual counting for the three randomly selected representative overpasses. The ~~evaluation~~ ~~compare~~evaluation compares two cases with and without consideration of street vendors.



Figure 4-3-3 Baggers and Dealers on the Overpass's Walk Way

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**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
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**I. LOS analysis for S8 (Atenatera)**

The count performed both in working and weekend days and the maximum 15 minute pedestrian volume who used overpasses to cross the ring road is presented here under in a tabular form. A maximum value of the three day count will be used for the analysis

*Table 4-4.33 Maximum 15 Minute Pedestrian Traffic Volume at S8*

Date	Day	From	To	Max 15 min Volume
03/12/2017	Monday	07:10	07:25	1375
06/12/2017	Thursday	07:15	07:30	1368
08/12/2017	Saturday	06:45	07:00	1277

**Case 1: Considering venders**

**Step 1: Determine Effective Walkway Width of Overpass**

Effective walkway width can be calculated using equation 3.1 which is arithmetic difference of total walkway width and sum of fixed-object effective width and linear feature shy distance. Even if there is no fixed object on the overpass walk way we need to consider a shy distance which is 1.5ft for a fence or low wall is present. However during night time baggers and dealers reduces pedestrian’s effective walk way width. The effective width of vending stand is variable. The obstacle width occupied by baggers and dealers is not uniform throughout the bridges however the researcher use an average value of 0.7 m= 2.29 ft to calculate LOS of pedestrian overpasses along the ring road.

$$W_E = W_T - W_o$$

$$W_T = 2.5m = 8.2ft$$

$$W_o = 1.5ft + 2.29ft = 3.79ft$$

$$W_E = 8.2 - 3.79 = 4.41ft$$

**Step 2: Calculate Pedestrian Flow Rate**

Since a peak-15-min pedestrian volume was measured in the field, it is not necessary to use Equation 3.2 to determine  $V_{15}$ . The unit flow rate for the walkway  $V_p$  is determined from Equation 3.3 as follows:

$$V_p = \frac{V_{15}}{15 \times W_e}$$

$$V_p = (1375 \text{ ped} / 15 \text{ min}) / (15 \times 4.41 \text{ ft})$$

$$V_p = 20.786 \text{ p/ft/min}$$

**Step 3: Calculate Average Pedestrian Space**

Average pedestrian space is determined by Equation 3.4. Pedestrian speed is calculated by dividing the total length of overpass by the time taken to move the distance. The researcher measure the average pedestrian speed of pedestrian to cross the overpass which is 3.96 which is very near to the standard pedestrian walking speed.

## Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)

$$A_p = \frac{SP}{v_p}$$

$$A_p = (4 \text{ ft/s}) * (60 \text{ s/min}) / (20.786 \text{ p/ft./min})$$

$$A_p = 11.54 \text{ ft}^2/\text{p}$$

### Step 4: Determine LOS

Table 3.1 should be used to determine the LOS. A value of  $11.54 \text{ ft}^2/\text{p}$  corresponds to LOS D, since  $8 < 11.54 < 12$ , that means pedestrian have limited ability to pass slower pedestrians.

### Case 2: Considering if there is no vendors

During night time baggers and dealers reduces pedestrian's effective walk way width. If we displace them from the overpass, the effective walkway width changes and which intern change the LOS of the overpass.

### Step 1: Determine Effective Walkway Width of Overpass

Effective walkway width can be calculated using equation 3.1 which is the difference of total walkway width and a shy distance which is 1.5ft.

$$W_E = W_T - W_o$$

$$W_T = 8.2 \text{ ft} - 1.5 \text{ ft} = 6.7 \text{ ft}$$

### Step 2: Calculate Pedestrian Flow Rate

Since a peak-15-min pedestrian volume was measured in the field, it is not necessary to use Equation 3.2 to determine  $V_{15}$ . The unit flow rate for the walkway  $V_p$  is determined from Equation 3.3 as follows:

$$V_p = \frac{V_{15}}{15 \times W_e}$$

$$V_p = (1375 \text{ p}) / (15 * 6.7 \text{ ft})$$

$$V_p = 13.68 \text{ p/ft./min}$$

### Step 3: Calculate Average Pedestrian Space

Average pedestrian space is determined by Equation 3.4

$$A_p = \frac{SP}{v_p}$$

$$A_p = (4 \text{ ft/s}) * (60 \text{ s/min}) / (13.68 \text{ p/ft./min})$$

$$A_p = 17.54 \text{ ft}^2/\text{p}$$

### Step 4: Determine LOS

Table 3.1 should be used to determine the LOS. A value of  $17.54 \text{ ft}^2/\text{p}$  corresponds to LOS B, since  $17 < 17.54 < 20$ , that means pedestrian occasionally need to adjust their path to avoid

**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
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conflicts. This shows that street vendors on this overpass which is located on Atenatera reduces the LOS of the overpass from B to D.

**II. LOS analysis for S2 (around minaye building):**

*Table 4.4.4-4 Maximum 15 Minute Pedestrian Traffic Volume at S2*

Day	Date	From	To	Max 15 min Volume
04/12/2017	Tuesday	07:50	08:05	587
07/12/2017	Friday	07:55	08:10	573
09/12/2017	Sunday	08:30	08:45	401

A maximum value of the three day count, which is 587 pedestrian per 15 minute is used for the analysis

**Case 1: Considering vendors**

**Step 1: Determine Effective Walkway Width of Overpass**

Effective walkway width can be calculated using equation 3.1 which is the difference of total walkway width and the sum of effective width of vendors (2.29ft) and a shy distance of 1.5ft.

$$W_E = W_T - W_o$$

$$W_T = 8.2\text{ft} - (2.29\text{ft} + 1.5 \text{ ft})$$

$$W_T = 4.41\text{ft}$$

**Step 2: Calculate Pedestrian Flow Rate**

The unit flow rate for the walkway  $V_p$  is determined from Equation 3.3 as follows:

$$V_p = \frac{V_{15}}{15 \times W_e}$$

$$V_p = (587\text{p}) / (15 \times 4.41\text{ft})$$

$$V_p = 8.87 \text{ p/ft/min}$$

**Step 3: Calculate Average Pedestrian Space**

Average pedestrian space is determined by Equation 3.4

$$A_p = \frac{S_p}{v_p}$$

$$A_p = (4 \text{ ft/s}) \times (60 \text{ s/min}) / (8.87 \text{ p/ft./min})$$

$$A_p = 27.05 \text{ ft}^2/\text{p}$$

**Step 4: Determine LOS**

Table 3.1 should be used to determine the LOS. A value of 27.05  $\text{ft}^2/\text{p}$  corresponds to LOS A, since 27.05 > 20, which means pedestrian does not need to alter movement.

**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
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**Case 2: Considering if there is no vendors**

**Step 1: Determine Effective Walkway Width of Overpass**

Effective walkway width can be calculated using equation 3.1 which is the difference of total walkway width and a shy distance which is 1.5ft.

$$W_E = W_T - W_o$$

$$W_T = 8.2\text{ft} - 1.5\text{ft} = 6.7\text{ft}$$

**Step 2: Calculate Pedestrian Flow Rate**

Since a peak-15-min pedestrian volume was measured in the field, it is not necessary to use Equation 3.2 to determine  $V_{15}$ . The unit flow rate for the walkway  $V_p$  is determined from Equation 3.3 as follows:

$$V_p = \frac{V_{15}}{15 \times W_e}$$

$$V_p = (587p) / (15 \times 6.7\text{ft})$$

$$V_p = 5.84 \text{ p/ft/min}$$

**Step 3: Calculate Average Pedestrian Space**

Average pedestrian space is determined by Equation 3.4

$$A_p = \frac{S_p}{v_p}$$

$$A_p = (4 \text{ ft/s}) \times (60 \text{ s/min}) / (5.84 \text{ p/ft./min})$$

$$A_p = 41.09 \text{ ft}^2/\text{p}$$

**Step 4: Determine LOS**

Table 3.1 should be used to determine the LOS. A value of 41.09  $\text{ft}^2/\text{p}$  corresponds to LOS A, since 41.09 > 20, which means pedestrian does not need to alter movement. This shows that street vendors on this overpass reduces the effective walkway width, but due to the smaller volume of pedestrian, the LOS remain the same.

**III. LOS analysis for S1 (Ayertena medical college):**

*Table 4.54-5 Maximum 15 Minute Pedestrian Traffic Volume at S1*

Date	Day	From	To	Max 15 min Volume
05/12/2017	Wednesday	08:00	08:15	632
10/12/2017	Monday	08:05	08:20	<b>643</b>
08/12/2017	Sunday	08:45	08:50	441

A maximum value of the three day count, which is 643 pedestrian per 15 minute is used for the analysis

## Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)

### Case 1: Considering venders

#### Step 1: Determine Effective Walkway Width of Overpass

Effective walkway width can be calculated using equation 3.1 which is the difference of total walkway width and the sum of effective width of venders (2.29ft) and a shy distance of 1.5ft.

$$W_E = W_T - W_o$$

$$W_T = 8.2\text{ft} - (2.29\text{ft} + 1.5\text{ft})$$

$$W_T = 4.41\text{ft}$$

#### Step 2: Calculate Pedestrian Flow Rate

The unit flow rate for the walkway  $V_p$  is determined from Equation 3.3 as follows:

$$V_p = \frac{V_{15}}{15 \times W_e}$$

$$V_p = (643\text{p}) / (15 \times 4.1\text{ft})$$

$$V_p = 9.72\text{p/ft/min}$$

#### Step 3: Calculate Average Pedestrian Space

Average pedestrian space is determined by Equation 3.4

$$A_p = \frac{S_p}{v_p}$$

$$A_p = (4\text{ft/s}) \times (60\text{s/min}) / (9.72\text{p/ft./min})$$

$$A_p = 24.69\text{ft}^2/\text{p}$$

#### Step 4: Determine LOS

Table 3.1 should be used to determine the LOS. A value of 24.69  $\text{ft}^2/\text{p}$  corresponds to LOS A, since 24.69 > 20, which means pedestrian does not need to alter movement.

### Case 2: Considering if there is no venders

#### Step 1: Determine Effective Walkway Width of Overpass

Effective walkway width can be calculated using equation 3.1 which is the difference of total walkway width and a shy distance which is 1.5ft.

$$W_E = W_T - W_o$$

$$W_T = 8.2\text{ft} - 1.5\text{ft} = 6.7\text{ft}$$

#### Step 2: Calculate Pedestrian Flow Rate

Since a peak-15-min pedestrian volume was measured in the field, it is not necessary to use Equation 3.2 to determine  $V_{15}$ . The unit flow rate for the walkway  $V_p$  is determined from Equation 3.3 as follows:

## Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)

$$V_p = \frac{V_{15}}{15 \times W_e}$$

$$V_p = (643p) / (15 \times 6.7ft)$$

$$V_p = 6.39 \text{ p/ft/min}$$

### Step 3: Calculate Average Pedestrian Space

Average pedestrian space is determined by Equation 3.4

$$A_p = \frac{S_p}{V_p}$$

$$A_p = (4 \text{ ft/s}) \times (60 \text{ s/min}) / (6.39 \text{ p/ft./min})$$

$$A_p = 37.55 \text{ ft}^2/p$$

### Step 4: Determine LOS

Table 3.1 should be used to determine the LOS. A value of 37.55 ft<sup>2</sup>/p corresponds to LOS A, since 37.55 > 20, which means pedestrian does not need to alter movement. This shows that street vendors on this overpass reduces the effective walkway width, but due to the smaller volume of pedestrian, the LOS remain the same.

Therefore considering the LOS of the three overpass the major factors affecting the serviceability of the overpass are walkway width and Pedestrian volume.

#### 4.1.2.2. Method 2: Evaluation of LOS of pedestrian overpass based on selected qualitative indicators using statistical analysis

The above LOS value, which bases on HCM, may not represent the actual service level of our country since we have not ~~develop~~developed our manual. Therefore it is better to evaluate using some qualitative indicators. And this will be analyzed and presented in this section

:

The basic input to the task of selecting potential performance measures (PMs) for assessing the environmental factors was derived from a literature review of traffic engineering and environmental psychology. Nearly 20 different PMs were extracted from this review and reduced by elimination (on the basis of duplication, relevance, and data availability) to 5. They are, in alphabetical order, comfort, convenience, freedom, safety and security. Each PM measured on a scale of 5 through 0, with 5 representing the best and 0 the worst.

~~The alternative assessment of LOS for selected pedestrian crossing facilities is based on the qualitative performance measure which includes comfort, convenience, safety, security and other qualitative measurement with a scale of 0 to 5 indicating a quality range of very poor to Excellent:~~

5 = Excellent      4 = Very Good      3 = Good  
2 = Fair            1 = Poor            0 = Very Poor

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The next step was to prioritize the PMs and to assign weights to each. This was done by applying a weighting-factor methodology.

**Weighting Factors**

The constant-sum, paired-comparison method is a systematic approach for determining the relative importance of each of a large number of factors, using group consensus. Thus, not only is a ranking of factors by importance obtained, but also the relative importance or weight of each factor with respect to all other factors is found. The researcher tries to distribute a constant bundle of values (out of 10) between each pair of factors. If Factor A is far more important than Factor B, a score of 10 for Factor A and a score of 0 for Factor B are noted in the cell. If, on the other hand Factor A is about equal to Factor B, the score would be 5 for A and 5 for B.

For this research the next Figure 4.4 shows a simple matrix that indicates all possible pair comparisons (A versus B, A versus C, A versus D, B versus A, and so on). The bottom left portion of the matrix is simply the mirror image of the top right portion.

	A	B	C	D	E	
A		6/4	5/5	6/4	3/7	$\Sigma A = 22 \div 100 = 0.22$
B	4/6		6/4	8/2	6/4	$\Sigma B = 24 \div 100 = 0.24$
C	5/5	4/6		3/7	7/3	$\Sigma C = 19 \div 100 = 0.19$
D	6/4	2/8	7/3		6/4	$\Sigma D = 21 \div 100 = 0.21$
E	3/7	4/6	3/7	4/6		$\Sigma E = 14 \div 100 = 0.14$
	100					

Figure 4-4 Sample calculation of constant-sum, paired-comparison method.

The scores for the factors listed on the left side of the matrix are then summed for each row (e.g. the bottom portion of row A is 6+5+4+7=22). The sum of rows is taken (22+24+19+21+14=100) and used to normalize each of the row sums as shown in Figure 4.4. In this case, Factors B, A, D, C and E which stands for Convenience, Comfort, Safety, Freedom and Security carry weights of 0.24, 0.22, 0.21, 0.19 and 0.14 respectively in descending order of importance.

Before applying the weighting-factor methodology, it was necessary to measure the five PMs on a 5-point scale from LOS A = 5 (the best) to LOS F = 0 (the worst), as shown in Table 4.6. This type of scaling and assignment of points seemed to be a realistic way of measuring the feeling of satisfaction or dissatisfaction expressed by the public while using the facility in question.

Table 4-6 Measurement of PMs on 5-Point Scale

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LOS A	greater or equal to 85% satisfied	5 points
LOS B	greater or equal to 60% satisfied	4 points
LOS C	greater or equal to 45% satisfied	3 points
LOS D	greater or equal to 30% satisfied	2 points
LOS E	greater or equal to 15% satisfied	1 point
LOS F	Less than 15% satisfied	0 points

The evaluation is performed by randomly selected pedestrian for the three selected overpasses provided for pedestrian on the ring road. The collected evaluation presented below in a summarized way by converting each respondent's score in to average score of the overpass.

The application of the constant-sum, paired-comparison methodology to the seven selected PMs was taken up next and yielded the results shown in Table 4.7-4.9.

*Table 4.67 Qualitative Assessment of Overpass S8*

	<u>Performance Measure</u>	<u>% Satisfied</u>	<u>LOS</u>	<u>Points</u>	<u>Weight</u>	<u>Total (P*W)</u>
1	Comfort	44	D	2	0.22	0.44
2	Convenience	56	C	3	0.24	0.72
3	Freedom	50	C	3	0.19	0.57
4	Security	72	B	4	0.21	0.84
5	Safety	60	B	4	0.14	0.56
						<b>3.13</b>

The overall total of 3.13 indicates that the LOS is slightly better than C.

*Table 4.78 Qualitative Assessment of Overpass S2*

	<u>Performance Measure</u>	<u>% Satisfied</u>	<u>LOS</u>	<u>Points</u>	<u>Weight</u>	<u>Total (P*W)</u>
1	Comfort	50	C	3	0.22	0.66
2	Convenience	48	C	3	0.24	0.72
3	Freedom	52	C	3	0.19	0.57
4	Security	68	B	4	0.21	0.84
5	Safety	54	C	3	0.14	0.42
						<b>3.21</b>

The overall total of 3.21 indicates that the LOS is slightly better than C

*Table 4.89 Qualitative Assessment of Overpass S1*

	<u>Performance Measure</u>	<u>% Satisfied</u>	<u>LOS</u>	<u>Points</u>	<u>Weight</u>	<u>Total (P*W)</u>
1	Comfort	50	C	3	0.22	0.66

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<u>2</u>	<u>Convenience</u>	<u>56</u>	<u>C</u>	<u>3</u>	<u>0.24</u>	<u>0.72</u>
<u>3</u>	<u>Freedom</u>	<u>58</u>	<u>C</u>	<u>3</u>	<u>0.19</u>	<u>0.57</u>
<u>4</u>	<u>Security</u>	<u>78</u>	<u>B</u>	<u>4</u>	<u>0.21</u>	<u>0.84</u>
<u>5</u>	<u>Safety</u>	<u>68</u>	<u>B</u>	<u>4</u>	<u>0.14</u>	<u>0.56</u>
						<u>3.35</u>

The overall total of 3.35 indicates that the LOS is better than C

with a representing value of LOS as follow:

5 = LOS A      4 = LOS B      3 = LOS C  
2 = LOS D      1 = LOS E      0 = LOS F

Based on the assessment the LOS of the representative pedestrian Overpasses: S8, S2 and S1 is 3.1, 2.8 and 2.7 respectively. Generally the results are around 3 therefore their LOS is C.

*Table 4-6 Results of Pedestrian Evaluation for Selected Pedestrian Crossing Facilities*

No.	Description for Pedestrian Overpass	AVG of S1	AVG of S8	AVG of S2	TOTAL
<b>1</b>	<b>Comfort</b>	2.5	2.3	2.5	2.4
1.1	Weather protection	2.1	2.2	2.3	2.2
1.2	Climate control	2.1	2.3	2.4	2.3
1.3	Condition of walking surface	3.3	2.4	2.8	2.8
<b>2</b>	<b>Convenience</b>	2.8	2.8	2.4	2.7
2.1	Walking distance	3.3	3.3	2.4	3.0
2.2	Pathway directness	3.2	3.3	3.0	3.2
2.3	Grade	3.4	3.4	2.7	3.2
2.4	Ramp location	3.4	3.1	2.9	3.1
2.5	Directory map	0.6	0.7	1.0	0.8
<b>3</b>	<b>Safety</b>	3.9	3.6	3.4	3.6
3.1	Reduction of pedestrian-Vehicle conflict	4.0	3.7	3.4	3.7
3.2	Ease of movement in walking	3.9	3.5	3.3	3.6
<b>4</b>	<b>Security</b>	3.4	3.0	2.7	3.0
4.1	Good lighting	3.0	2.8	2.4	2.7
4.2	Open lines of sight	3.8	3.3	2.9	3.3
4.3	Clear observation by the public and police	3.5	2.8	2.9	3.0
<b>5</b>	<b>Other qualitative measurements</b>	2.9	2.5	2.6	2.7

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**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
(The case of Winget-Torhayloch-Ayertena Road)**

No.	Description for Pedestrian Overpass	AVG of S1	AVG of S8	AVG of S2	TOTAL
5.1	Freedom to choose your desire speed	3.0	2.8	2.7	2.8
5.2	Freedom while walking in a reverse direction of major flow	2.9	2.2	2.6	2.5
-	<b>Total LOS</b>	<b>3.1</b>	<b>2.8</b>	<b>2.7</b>	<b>2.9</b>

*The result of the qualitative assessment considers Comfort, Convenience, Safety, Security and other qualitative measures having equal weights and the result shows that the percentage of each indicators evaluated out of 5 is: Comfort 48% (2.4/5), Convenience 54% (2.7/5), Safety 72% (3.6/5), Security 60% (3/5). The average value of each indicator is calculated to be 2.9 or 58% which means a LOS of C. This qualitative result shows that pedestrian feels good on the serviceability of the said overpasses.*

The assessment on LOS of pedestrian overpass conducted in two ways using the High way Capacity Manual 2010 and the result of the two way shows slight differences. Quantitative LOS assessment which is based on peak 15 minute pedestrian volume resulted a LOS of B, A, and A while operating without any obstacle for S8, S2 and S1 respectively. However taking dealers and baggers on the overpass walkway in to consideration the LOS result changed in to D, A and A respectively for S8, S2 and S1. Whereas, the qualitative measurement based on performance measure results a LOS of C. This result will be summarized in the next table

Table 4.9/10/4-7 Summarized Result of LOS Analysis for S8, S2 and S1

	Selected Pedestrian Overpass	Based on Quantitative Evaluation, in consideration of vendors	Based on Quantitative Evaluation without the presence of vendors	Based on Qualitative Evaluation
1	S8	LOS B	LOS D	LOS C
2	S2	LOS A	LOS A	LOS C
3	S1	LOS A	LOS A	LOS C

**4.1.3. Assessment on accidents**

Road traffic injuries in Ethiopia are often classified into three groups including fatal, serious, and slight injuries. According to Ethiopian practice, a road traffic fatality is a road user who died within 30 days of the traffic crash. Serious injury is when the person is hospitalized for a period of 24 hours or more, and slight injury is when a person suffers from a road traffic injury and is hospitalized for less than 24 hours.

**A. Accident on Addis Ababa city**

The following chart and tables presents the assessment of accident happened generally in the city Addis Ababa as well as specifically in the Kolfe Keranyo sub city and particularly in the Winget-Torhayloch-Ayertena ring road. The last five year accident record shows that the accident is increasing in terms of injury and property damages.

Table 4.10/11/4-8 Five Year Accident Record of Addis Ababa City

No	Description	2009 E.C	2008 E.C	2007 E.C	2006 E.C	2005 E.C	Total
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**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
(The case of Winget-Torhayloch-Ayertena Road)**

<b>1</b>	<b>Fatal</b>	458.00	439.00	416.00	391.00	367.00	2,071.00
<b>2</b>	<b>Serious</b>	1,996.00	1,924.00	1,673.00	1,484.00	1,336.00	8,413.00
<b>3</b>	<b>Slight</b>	973.00	1,165.00	1,098.00	1,128.00	1,263.00	5,627.00
<b>4</b>	<b>Property</b>	23,510.00	19,411.00	17,249.00	14,901.00	12,849.00	87,920.00
<b>5</b>	<b>Total (1+2+3)</b>	3,427.00	3,528.00	3,187.00	3,003.00	2,966.00	16,111.00
<b>6</b>	<b>G. Total (4+5)</b>	<b>26,937.00</b>	<b>22,939.00</b>	<b>20,436.00</b>	<b>17,904.00</b>	<b>15,815.00</b>	<b>104,031.00</b>

The last five year accident record of Addis Ababa shows that the accident is increasing in terms of injury and property damages. However the injured persons by traffic accident in the Kolfe Keranio sub city shows a decreasing manner for the last three years in reverse the property damage is increasing from year to year.

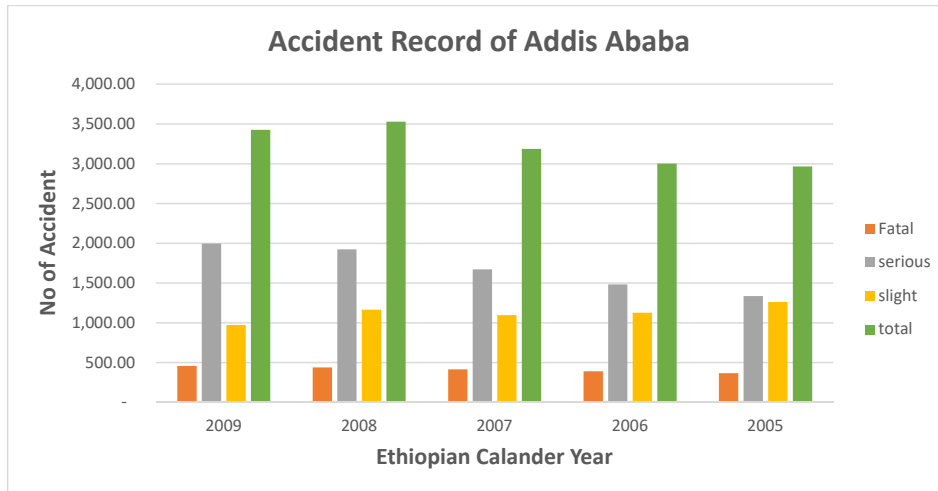


Chart 4-2 Five Year Accident Record of Addis Ababa City

**B. Accident on Kolfe keranio sub city**

The city Addis Ababa comprises ten sub cities and Kolfe keranio is one in which the subject ring road founds. The last five year accident trend shown below through table and chart. The data shows that the total accident is increasing in terms of injuries and property damage. However the injured persons by traffic accident shows a decreasing manner for the last three years in reverse the property damage is increasing from year to year.

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The result of assessment on accident shows that generally the accident pattern is increasing from year to year and this shows that the city or the sub city is losing many peoples and properties by the accident. The result shows that Kolfe Keranio sub city shares 16% of the total accident occurred in the last five years of the city Addis Ababa.

Table 4.11-24-9 Five Year Accident Record of Kolfe Keranio Sub City

No	Description	2009 E.C	2008 E.C	2007 E.C	2006 E.C	2005 E.C	Total
1	Fatal	61	63	60	58	53	295
2	Serious	293	315	315	249	192	1364
3	Slight	148	166	200	187	208	909
4	Property	1716	1461	1207	1074	867	6325
5	Total (1+2+3)	502	544	575	494	453	2568
6	G. Total (4+5)	3,934.00	3,466.00	2,989.00	2,642.00	2,187.00	8,893.00

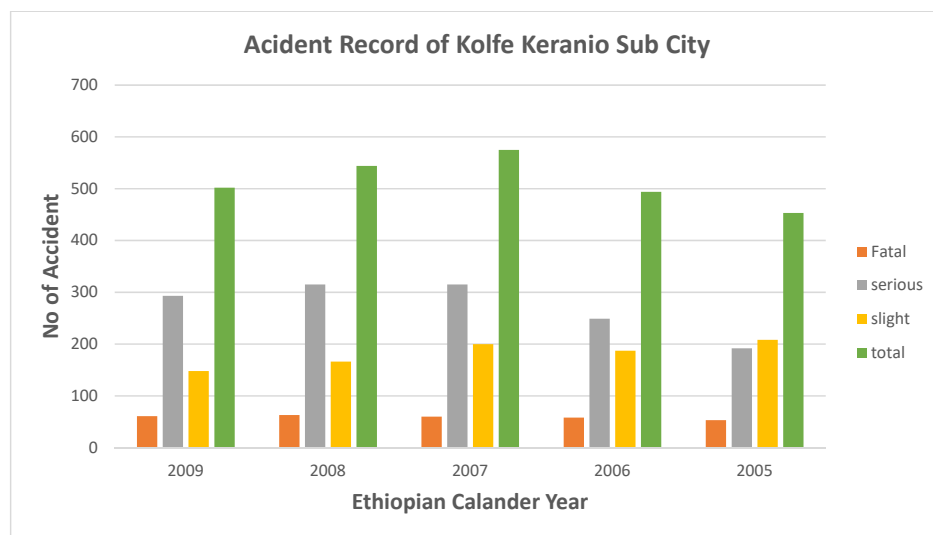


Chart 4-3 Five Year Accident Record of Kolfe Keranio Sub City

**C. Accident on Winget-Torhayloch-Ayertena Ring Road**

As shown in the table below the accident record on Winget Torhayloch Ayertena ring road shows a decreasing pattern from 2008 EC in terms of injuries whereas the property damage is increasing from year to year. The Property damage have a share of 79% out of the total accident happened in the road. The percentage of accidents happened in the ring road reaches 13% out of

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the total accident of the sub city which shows that a lion share of accident happened in this 10 km ring road.

Table 4.12-13-4-10 Three Year Accident Record of Winget-Torhayloch-Ayertena Ring Road

No	Description	2009 E.C	2008 E.C	2007 E.C	Total	% Injury	% Accident
1	Fatal	7	8	7	22	10%	-
2	Serious	41	42	39	122	57%	-
3	Slight	20	23	24	67	33%	-
4	Property	324	271	232	827	-	79%
5	Total (1+2+3)	68	73	70	211	100%	21%
6	G. Total (4+5)	392.00	344.00	302.00	1,038.00		100%

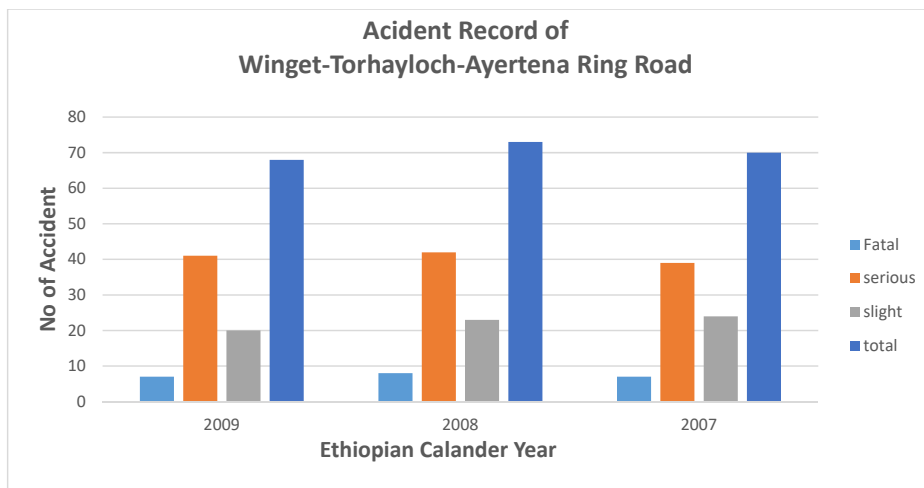
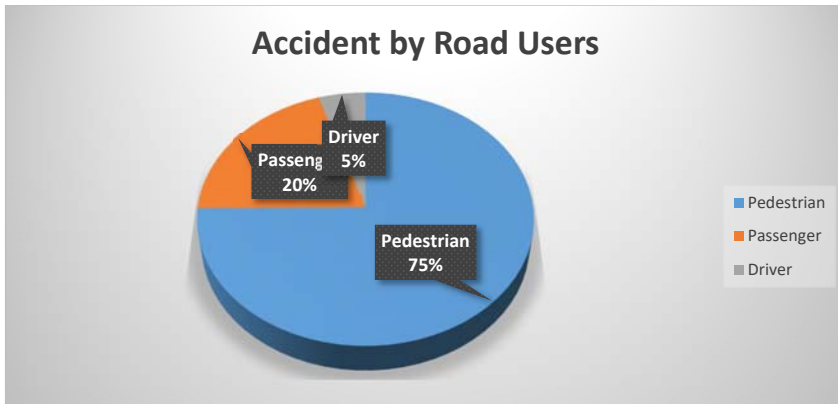


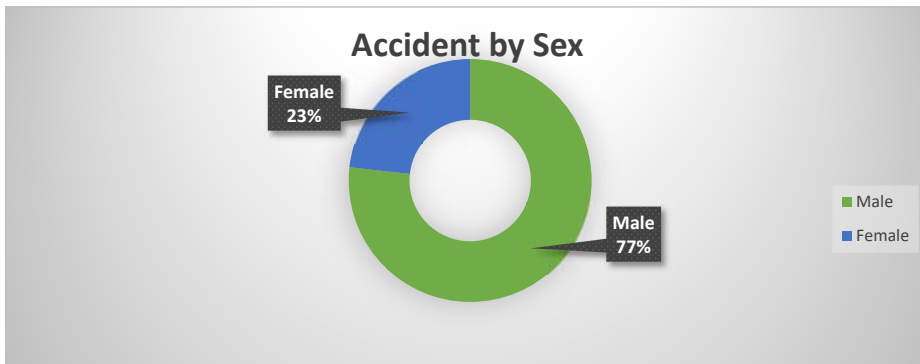
Chart 4-4 Three Year Accident Record of Winget-Torhayloch-Ayertena Ring Road

**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
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*Chart 4-5 Proportion of Accident by Road Users for Winget-Torhayloch-Ayertena Ring Road*

The result of the assessment also shows that 75% of the accident goes to pedestrian and only 30% resulted on the people in the vehicle. This tells that pedestrian are the most victim road users. And the assessment bases on sex indicated that male are more exposed (77%) for accident than female.



*Chart 4-6 Proportion of Accident by Sex for Winget-Torhayloch-Ayertena Ring Road*

**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
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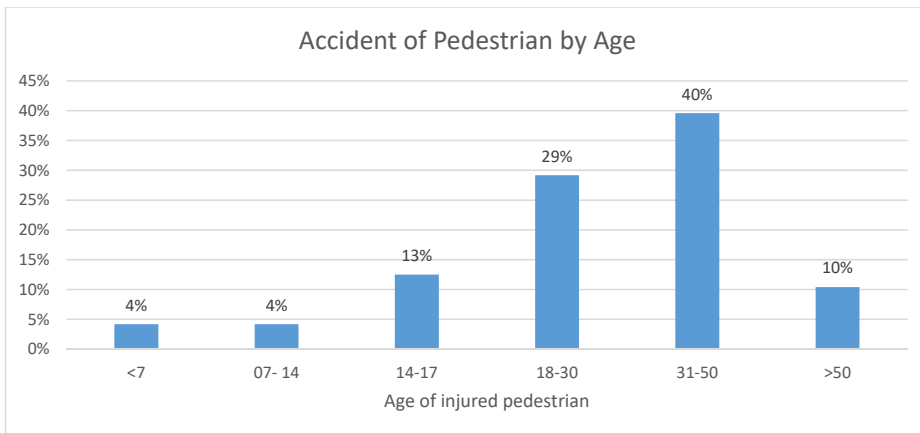


Chart 4-7 Percentage of Accident of Pedestrian by Age

The result of accident shows that 82% of pedestrian accident goes to age group of 14 up to 50. This indicate that teenagers and youths are mostly subjected to traffic accident. Pedestrian movement have a great role for the severity of accident and the assessment result shows that 52% of pedestrian accident occurred while the pedestrian crosses the ring road and 23% of pedestrian accident happened when the pedestrian stands or seats nearby the ring road.

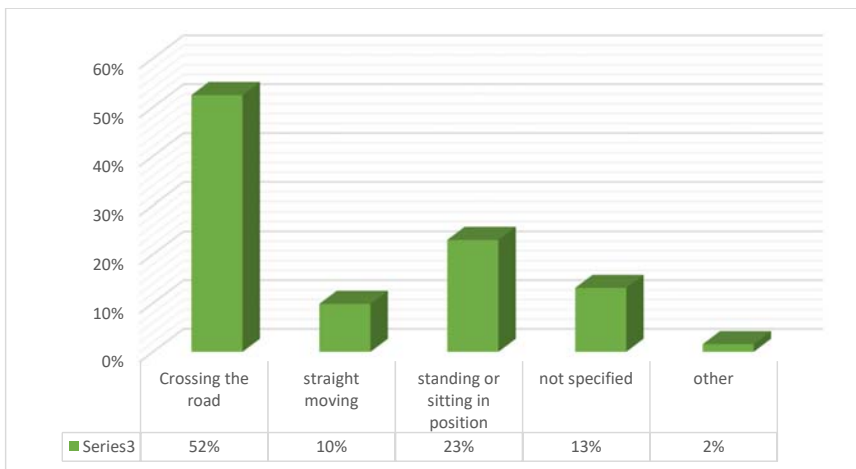


Chart 4-8 Pedestrian Movement in the Accident time for Winget-Torhayloch-Ayertena Ring Road

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Most of accidents (81.3%) occurred in day light and the weekend share of accident is only 24.2%. This means that most of the accident (75.5%) happened in working days. The peak hour of accident is in the morning 7:00 AM to 9:00 AM where most pedestrian rushes to their office, school, business or the like.

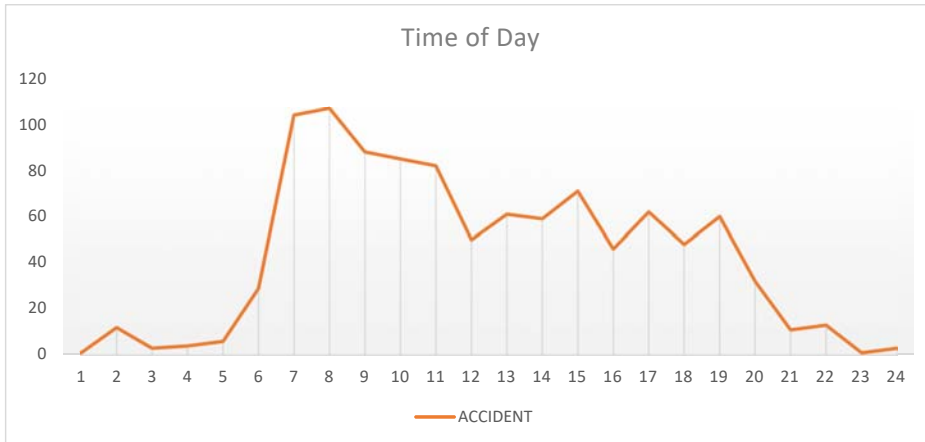


Chart 4-9 Accident by Time of the Day for Winget-Torhayloch-Ayertena Ring Road

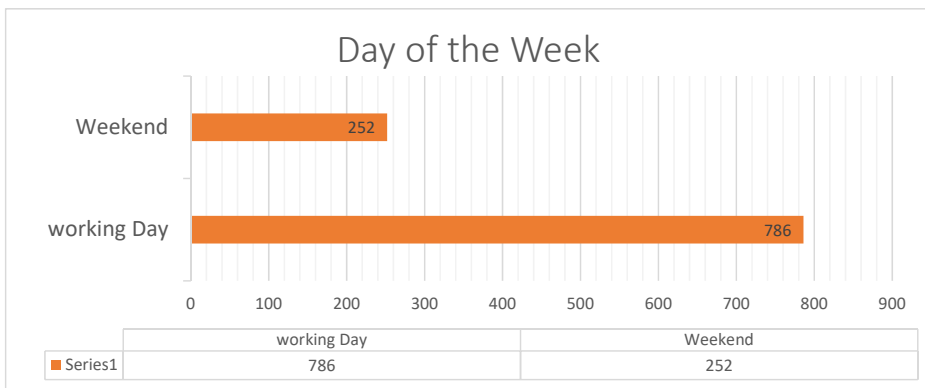


Chart 4-10 Accident by Day of the Week for Winget-Torhayloch-Ayertena Ring Road

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(The case of Winget-Torhayloch-Ayertena Road)**

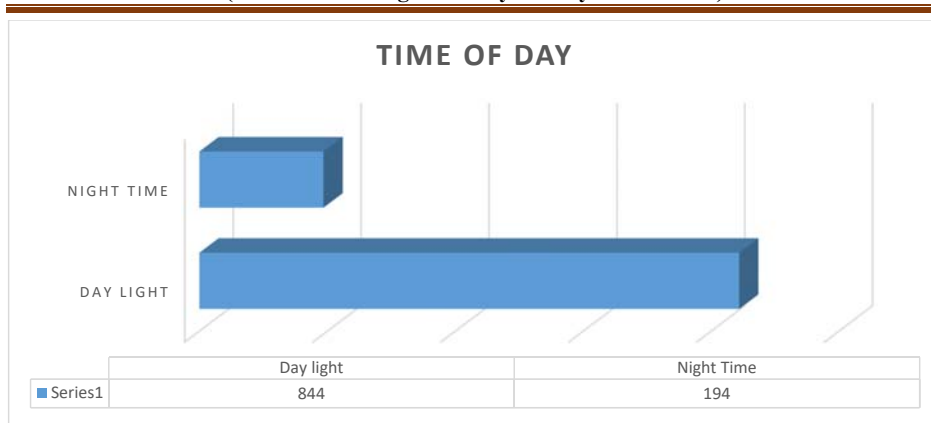


Chart 4-11 Proportion of Night time and Day time Accidents for Winget-Torhayloch-Ayertena Ring Road

**4.1.4. Assessment on pedestrian behavior**

Result of the assessment which is collected from randomly selected pedestrians through structured interview is presented below in a tabular form (table 5.1). This result is based on randomly selected pedestrian’s response. Among the respondent 39.6% were captured while crossing legally through the crossing facilities, 24.4% of respondent were selected while crossing the ring road illegally by jumping the fence and the rest respondent were either working in their office, shop, school or while walking or sitting nearby the road section.

Table 4.13-44-11. Results of Pedestrian Interview

NO	Code	Description	Amount	Percentage
1		<b>Sex</b>		
1.1	M	Male	295	69.1%
1.2	F	Female	132	30.9%
2		<b>Age</b>		
2.1	A1	Under 18	24	5.6%
2.2	A2	18-25	282	66.0%
2.3	A3	25-40	80	18.7%
2.4	A4	above 40	41	9.6%
3		<b>Ring Road crossing frequency through Overpass (per day)</b>		
3.1	A	Never	63	14.8%
3.2	B	1-3 times	266	62.3%
3.3	C	4-6 times	74	17.3%

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NO	Code	Description	Amount	Percentage
3.4	D	>6 times	24	5.6%
4		<b>Ring Road crossing frequency through Zebra Crossing (per day)</b>		
4.1	A	Never	49	11.5%
4.2	B	1-3 times	225	52.7%
4.3	C	4-6 times	69	16.2%
4.4	D	>6 times	84	19.7%
5		<b>Ring Road crossing frequency through Jumping the Fence (per day)</b>		
5.1	A	Never	258	60.4%
5.2	B	1-3 times	125	29.3%
5.3	C	4-6 times	44	10.3%
5.4	D	>6 times	0	0.0%
6		<b>What do you feel about crossing the ring road through jumping the fence?</b>		
6.1	S1	Very Safe	4	0.9%
6.2	S2	Safe	4	0.9%
6.3	S3	Partly Safe	31	7.3%
6.4	S4	Dangerous	151	35.4%
6.5	S5	Very Dangerous	234	54.8%
7		<b>What do you think the reason for pedestrian that jump over the fence?</b>		
7.1	R1	Distance of overpass location	172	40.3%
7.2	R2	Difficulty in climbing up stairs	25	5.9%
7.3	R3	To save time	203	47.5%
7.4	R4	Empty road	8	1.9%
7.5	R5	Reluctant to use crossing facilities	19	4.4%
8		<b>What is the effect of crossing the road through jumping the fence?</b>		
8.1	E1	Lead to traffic accident	355	83.1%
8.2	E2	Breach the traffic law	24	5.6%
8.3	E3	Disturb Vehicular movement	48	11.2%
9		<b>Do you think that crossing the ring road through jumping the fence is legal?</b>		
9.1	Y	YES	38	8.9%
9.2	N	NO	389	91.1%
10		<b>Who should take the responsibility if a</b>		

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NO	Code	Description	Amount	Percentage
		<b>pedestrian is hit by a car while crossing illegally?</b>		
10.1	P	Pedestrian	412	96.5%
10.2	D	Driver	7	1.6%
10.3	R	Roads Authority	8	1.9%
11		<b>They still cross illegally if there is a fine and it is strictly enforced?</b>		
11.1	Y	YES	145	34.0%
11.2	N	NO	282	66.0%

The data in this study indicate that 39.6 % of pedestrian cross illegally by jumping the fence at least once per day. However 90.2 % of pedestrian knows that illegal crossing is dangerous or very dangerous. In addition 83.1% of pedestrian knows that illegal crossing may lead to traffic accident. The reason for their illegal crossing is saving time (47.5%) and distance of overpass location (40.3%) or the gap between each crossing facilities.

Furthermore, the tabulated data also shows that 8.9% of pedestrian thinks that jumping over the fence is legal. However, 96.5% of them agreed that the pedestrian will be responsible for any accident if a pedestrian crashed by a vehicle while jumping or crossing the ring road.

66% of the respondent agreed that fine and strict enforcement on pedestrian may reduce the amount of illegal crossing so that pedestrian related accident will also be reduced.

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Figure 4-5644 pedestrians illegal crossing along the ring road

However, the researcher field observation shows that most of male pedestrian used to jump the fence even below the overpass, especially when the traffic volume gets smaller.

#### 4.2. Discussion

The highway capacity manual is widely used throughout the world to determine the capacity and operating characteristics of various types of transportation facility. The quantitative LOS analysis depends on average pedestrian space. This result majorly influenced by pedestrian volume and walkway width.

According to the result the LOS of overpass S1 and S2 is LOS A, meaning pedestrian can move with their desire speed without altering their movement. The result for overpass S8 with

### **Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)**

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consideration of venders is LOS D, meaning that pedestrian have a limited freedom to choose their desire speed and without venders it become LOS B, meaning pedestrian occasionally need to adjust their path to move with their desire speed. This shows that street venders reduces the effective walkway width which intern reduces the LOS of overpass.

However the result of qualitative analysis of the above said overpasses shows that pedestrian's satisfaction in respect of Comfort, Convenience, Safety, Security and Freedom to choose a desire speed is LOS C, which is below the quantitative analysis result.

This indicates that HCM lacks some other criteria like spacing which needs to take in to consideration. From the assessment of road environment it is known that pedestrian crossing facilities were provided with an average space of 0.6km, (with a maximum of 1.1km and minimum of 0.24km) spacing between crossing facility should be considered as one of the LOS.

The behavioral analysis also supports this idea since most of the respondent stats that the main reason to jump over the fence is due to the distance of overpasses and time saving that may be wasted due searching the overpasses.

Therefore the result of qualitative analysis of the overpass is more descriptive for the service level provided for pedestrian to cross the road along this road section.

The LOS of pedestrian crossing facilities have an influence on pedestrian crossing behavior. If the crossing facility were up to the satisfaction of pedestrian, this much percentage of pedestrian will not use to jump over the fence.

The result on behavioral analysis showed that 39.6% pedestrian cross illegally at least once per day along the road section. Among the respondent above 90% knows that illegal crossing is dangerous or very dangerous, which may lead them to road traffic accident but they used to take the risk by themselves and to cross illegally by waiting the adequate gap between moving vehicles.

This illegal crossing was a major cause for pedestrian involved traffic accident. The result on assessment of accident indicates that road traffic injurie shows an increment pattern from year to year and among these accidents the lion share goes to pedestrian involved accident. Most of the victim pedestrians are males and with an age group of 18 to 50, which are economically active groups of the country.

The pedestrian accident directly related with LOS of crossing facilities. The assessment on pedestrian overpass results a lower LOS value this leads pedestrian to look at other crossing options even if it is not permitted legally. Most of them take the risk of illegal crossing and used to cross the road by jumping through the fence of ring road.

According to Ethiopian traffic rules driver are not liable for pedestrian injuries or fatalities on a fully access-controlled road like Addis Ababa City Ring Road, but still there are fewer rules for pedestrian than for drivers.

## Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)

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### 5. Conclusion and recommendation

#### 5.1. Conclusion

Based on the above stated results and discussions the main conclusions of the study are the following:

- Qualitative assessment of selected pedestrian overpasses considering Comfort, Convenience, Safety, Security and Freedom to choose desire speed results a LOS of C, which corresponds to a satisfaction rate of Good.
- Quantitative assessment (based on pedestrian average space) of overpass S8 located at Atenatera results a LOS of D, which means pedestrians have limited freedom to choose their speed due to venders and major flow in reverse direction. This LOS value will be improved to LOS B, if the venders displace from the overpass walkway.
- Quantitative assessment overpass S1 and S2 located at Ayertena and Torhayloch results LOS A, which means pedestrian can move with their desire speed. Due to the smaller volume of pedestrians using the Overpass, presence of venders doesn't alter the LOS value.
- Walkway width and pedestrian volume affects the serviceability level of pedestrian overpasses.
- The police recorded traffic accident on the Winget-Torhayloch-Ayertena Ring Road is increasing with an average rate of 14% for the last three Years. From the traffic accident 75% of the accident occurred on pedestrians whereas, the rest portion of injurie is happened on passengers and drivers.
- Out of the injured pedestrian 77% were male and females accounts for 23%, this means, males are more exposed to traffic accident than females. 69% of injured pedestrian were in the age of 18 up to 50 which belongs to active economical participants of the country.
- Illegal crossing is the major reason for traffic accident in ring road, 52% of pedestrian accident resulted while the pedestrian cross the road. LOS of crossing facility and pedestrian road crossing behavior plays a significant role for the increment of Road Traffic Accidents on the road section.
- The major factor for pedestrian illegal crossing is the distant gap between consecutive crossing facilities and the other factor for pedestrian illegal crossing is the lengthy time needed to move the total length of pedestrian overpass for crossing a small section of roadway.
- The next contributing factor for pedestrian illegal crossing is the gap between consecutive pedestrian overpass and
- The narrowness of existing overpasses walkway width restricts pedestrian freedom to move with their desired speed. And this is another contributing factor for pedestrian to cross illegally rather than using the overpasses.

## **Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)**

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### **5.2. Recommendations**

Based on the outcomes of this research the following are recommended:

- Improvement of LOS of pedestrian overpasses must be achieved by providing additional overpasses, this in turn will divert illegally crossing pedestrians' traffic to overpasses
- Dealers and baggers found on the walkway of the overpass reduces the effective walkway width. Therefore either they should be displaced from the walkway or the walkway width must be increased for the future provided overpasses. This is also the other way to improve LOS of overpasses.
- Road safety education and promotional campaign must be conducted to change the attitude of road users toward illegal crossing behavior.
- Enforcement of pedestrian will reduce the number of illegally crossing pedestrian and this will force them to develop a legal road crossing behavior.

## Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road (The case of Winget-Torhayloch-Ayertena Road)

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### References

1. Addis Ababa Police Commission. (2012). Annual road traffic crashes statistics.
2. Cherry, C., Donlon, B., Yan, X., c, S. E. M., & Xiong, J. (2011). Illegal mid-block pedestrian crossings in China: gap acceptance, conflict and crossing path analysis. *International Journal of Injury Control and Safety Promotion*, 19(4), 320-330.
3. Damsere-Derry, J., Ebel, B. E., Mock, C. N., Afukaar, F., & Donkor, P. (2010). Pedestrians' injury patterns in Ghana. *Accident Analysis & Prevention*, 42(4), 1080-1088
4. Dessie, T., Larson, C. (1991). The occurrence and driver characteristics associated with motor vehicle injuries in Addis Ababa, Ethiopia. *Journal of Tropical Medicine Hyg*, 94, 395-400.
5. Diaz, E. M. (2002). Theory of planned behavior and pedestrians' intentions to violate traffic regulations. *Transportation Research Part F: Traffic Psychology and Behaviour*, 5(3)
6. Federal Police Commission of Ethiopia. (2013). Traffic Accident Data. Ethiopian Police Commission. Addis Ababa, Ethiopia
7. Fruin, J. Pedestrian Planning and Design. Metropolitan Association of Urban Designers and Environmental Planners, Inc., New York, 1971.
8. Getachew, A. (2010). Brief information on the transport sector of Ethiopia in view of NMT in urban road infrastructure: the case of Addis Ababa. Addis Ababa.
9. Goswami A, Sonowal R. *A statistical analysis of road traffic accidents in Dibrugarh City*, Assam, India. Division of Epidemiology and Nutrition, Regional Medical Research Centre, 2009.
10. Ibrahim, J. M., Day, H., Hirshon, J. M., & El-Setouhy, M. (2011). Road risk-perception and pedestrian injuries among students at Ain Shams University, Cairo, Egypt. *Injury & Violence*, 1-8
11. IRIN. Ethiopia: Government moves to address road accident toll, 2011 [Coted 1 April 2012]; Available at: URL:<http://www.irinnews.org/report/94165/3thiop-government-moves-to-address-road-accidenttoll>.
12. King, M. J., Soole, D., & Ghafourian, A. (2009). Illegal pedestrian crossing at signalized intersections: Incidence and relative risk. *Accident Analysis and Prevention*, 41(3), 485-490.
13. Oxley, J.A.; Ihsen, E.; Fildes, B.N.; Charlton, J.L.; Day, R.H. 2005. Crossing Roads Safely: An Experimental Study of Age Differences in Gap Selection by Pedestrians, *Accident Analysis and Prevention*. DOI: <http://dx.doi.org/10.1016/j.aap.2005.04.017>, 37(5): 962-971.
14. Retting, R. A., Ferguson, S. A. & McCart, A. T. (2003) A Review of Evidence-Based Traffic Engineering Measures Designed to Reduce Pedestrian–Motor Vehicle Crashes. *American Journal of Public Health*, 49, 1455-1462
15. Ribbens, H. (1996). Pedestrian Facilities in South Africa: Research and Practice *Transportation Research Record: Journal of the Transportation Research Board*, 1538 / 1996, 10-18.
16. Road Transport Authority. Highlights of road traffic accident in Ethiopia in 2003 [Cited 12 December 2013]; Available at: URL:<http://www.rta.gov.et/accident.htm>,

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17. Rosenbloom, T.; Ben-Eliyahu, A.; Nemrodov, D. 2008. Children's Crossing Behavior with an Accompanying Adult, *Safety Science*. DOI: <http://dx.doi.org/10.1016/j.ssci.2007.07.004>, 4 6(8): 12 48–1254.
18. Segni G. Causes of road traffic accidents and possible counter measures on Addis Ababa Shashemene roads. [MA Thesis]; Addis Ababa University, 2007.
19. Special Report 209: Highway Capacity Manual. TRB, National Research Council, Washington, D.C., 1985
20. Sun, J.; Yang, Y.; Wang, H. 2011. Development and Application of a Simulation-Enhanced Platform for Pedestrian Crossing Behaviors Experiment. Available from Internet: [http://assets.conferencespot.org/files/29122/29122\\_filename/12k71e.pdf](http://assets.conferencespot.org/files/29122/29122_filename/12k71e.pdf)
21. T. Subramani, Study On Existing Pedestrian Traffic and Facility Study on Major Roads in Salem and Formulate Suggestions for Its Improvement, *International Journal of Modern Engineering Research (IJMER)* Vol.2, Issue.3, May-June 2012 pp-758-762 ISSN: 2249-6645
22. Tulu, G. S. Washington S. & King, M. J. 2013. Characteristics of Police-reported Road Traffic Crashes in Ethiopia over a Six Year Period, *The Road Safety Research, Policing and Education Conference 2013 (RSRPE2013)*, 2013 Brisbane, Queensland-Australia.
23. Tulu, G. S., Washington, S., King, M. J., & Haque, M. M. (2013). Why are pedestrian crashes so different in developing countries? A review of relevant factors in relation to their impact in Ethiopia. Paper presented at Australian Transport Research Forum Brisbane, Queensland\_Australia.
24. United Nations. Case study: Road safety in Ethiopia, 2009 [Cited 23 August 2013]; Available at: [URL:http://repository.uneca.org/bitstream/handle/10855/5250/bib.%205641](http://repository.uneca.org/bitstream/handle/10855/5250/bib.%205641)
25. United Nations Economic Commission for Africa. (2009). Case Study: Road Safety in Ethiopia. [Cited 23 August 2013]; Retrieved from [http://repository.uneca.org/bitstream/handle/10855/5250/bib.%2035641\\_1.pdf?sequence=1](http://repository.uneca.org/bitstream/handle/10855/5250/bib.%2035641_1.pdf?sequence=1)
26. Wang, W., Guo, H., Gao, Z., & Bubb, H. (2011). Individual differences of pedestrian behavior in midblock crosswalk and intersection. *International Journal of Crashworthiness*, 16(1), 1-9.
27. WHO. (2013a). Global status report on road safety 2013: supporting a decade of action. Retrieved from [http://www.who.int/violence\\_injury\\_prevention/road\\_safety\\_status/2013/en/](http://www.who.int/violence_injury_prevention/road_safety_status/2013/en/)
28. WHO (2013b) *Pedestrian Safety: a road safety manual for decision-makers and practitioners*
29. World Health Organization (WHO). *Global status on road safety: Time for action*. Geneva; WHO, 2015.
30. WSDOT Design Manual M 22-01.10 Page 1510-37&38, July 2013
31. Zhuang, X., & Wua, C. (2011). Pedestrians' crossing behaviors and safety at unmarked roadway in China. *Accident Analysis & Prevention*, 43(6), 1927-1936.

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## Appendix

### Appendix 1. Interview questioner for pedestrian

My name is Wondwossen Getahun and I am working on Master's thesis for the partial fulfillment of MSc degree in Road and Transport Engineering at Addis Ababa University Institute of Technology.

This Questionnaire has designed to assess pedestrians crossing behavior and operational analysis (Level of Service) of pedestrian crossing facilities in the road section of Winget-Torhayloch-Ayertena Ring Road.

The data collected will be used for academic purpose and will be confidential. I would like to thank you in advance for providing me the appropriate information for the following questions.

- N.B
1. You don't need to write your name
  2. Put a mark "x" inside the box of your appropriate choice
  3. The student researcher has scheduled to get the filled questionnaire back within 3 days

#### Part One: General information

1. Personal information of the pedestrian
  - 1.1 Sex: M  F
  - 1.2 Age: Under 18  18-25  25-40  above 40
  - 1.3 Work: Student  Business man  Worker  Other
  - 1.4 Familiarity with the District: Familiar  Not familiar
2. Category of pedestrian
  - 2.1 Legal crossing:  
 Crossing through Overpass  
 Crossing through Zebra
  - 2.2 Illegal crossing:  
 Crossing illegally nearby crossing facilities  
 Crossing illegally far away from crossing facilities
  - 2.3 while working at:  
Office  Shop  School  Other
3. Ring Road crossing frequency (number of crossing per day)
  - 3.1 Using Pedestrian Overpass:  
Never  1-3 times  4-6 times  more than 6 times
  - 3.2 Using Zebra crossing:  
Never  1-3 times  4-6 times  more than 6 times
  - 3.3 jumping the fence  
Never  1-3 times  4-6 times  more than 6 times

**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
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**Part Two: Illegal crossing**

4. What do you feel about crossing the ring road through jumping the fence?
- Very Safe  
 Safe  
 Partly Safe  
 Dangerous  
 Very Dangerous
5. What do you think the reason for pedestrian that jump over the fence of the Ring Road?
- Distance of overpass location  
 Difficulty in climbing up stairs  
 To save time  
 Empty road  
 Reluctant to use crossing facilities
- Other \_\_\_\_\_.
6. What is the effect of crossing the road through jumping the fence
- Lead to traffic accident  
 Breach the traffic law  
 Disturb Vehicular movement
- Other \_\_\_\_\_.
7. Do you think that crossing the ring road through jumping the fence is legal?
- Yes  
 No
8. Who should take the responsibility if a pedestrian is hit by a car while crossing illegally?
- Pedestrian  
 Driver  
 Roads Authority
9. Would they still cross illegally if there is a fine and it is strictly enforced?
- Yes  
 No

**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
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**Part Three: Alternative Assessment of LOS for Selected Pedestrian Crossing Facilities**

Allocate a point out of five (5) for the following description as per the scale shown below

- Scale: 5 = Excellent**  
**4 = Very Good**  
**3 = Good**  
**2 = Fair**  
**1 = Poor**  
**0 = Very Poor**

No.	Description	Pedestrian Overpass (S1, S2 or S3)
<b>1</b>	<b>Comfort</b>	
1.1	Weather protection	
1.2	Climate control	
1.3	Condition of walking surface	
<b>2</b>	<b>Convenience</b>	
2.1	Walking distance	
2.2	Pathway directness	
2.3	Grade	
2.4	Ramp location	
2.5	Directory map	
<b>3</b>	<b>Safety</b>	
3.1	Reduction of pedestrian-Vehicle conflict	
3.2	Ease of movement in walking	
<b>4</b>	<b>Security</b>	
4.1	Good lighting	
4.2	Open lines of sight	
4.3	Clear observation by the public and police	
<b>5</b>	<b>Other qualitative measurements</b>	
5.1	Freedom to choose your desire speed	
5.2	Freedom while walking in a reverse direction of major flow	

**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
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**Appendix 2. Pedestrian traffic volume data**

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**Appendix 3. Summary of pedestrian interview**

**Assessment on Pedestrian Illegal Crossing and Safety on the Addis Ababa City Ring Road  
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**Appendix 4. Sample of police recorded traffic accident**

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