

UNIVERSITY OF NAIROBI



DEPARTMENT OF CIVIL & CONSTRUCTION ENGINEERING

SCHOOL OF ENGINEERING

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**NON-USAGE OF PEDESTRIAN FOOTBRIDGES IN KENYA: THE CASE OF
UTHIRU PEDESTRIAN FOOTBRIDGE ON WAIYAKI WAY**

BY

RICHARD AMOS MANJANJA

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BY

RICHARD AMOS MANJANJA

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DECLARATION

I declare that this thesis entitled “Non-Usage of Pedestrian Footbridges in Kenya: The Case of Uthiru Pedestrian Footbridge on Waiyaki Way” is the result of my own work except as in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree in any other university that I know of.

Richard Manjanja

Date

This project report has been submitted with my approval as University Supervisor.

Professor O. O. Mbeche

Date

Lecturer,

Department of Civil Engineering,

University of Nairobi

DEDICATION

I dedicate this thesis report to my children Mary, Grace and Blessings and my wife Violet for being patient during my absence while I was away in Kenya studying for this Masters Degree course.

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I would like to express my sincere gratitude and appreciation to my supervisor, Professor Mbeche for his continued support and guidance he rendered to me during the formulation of the proposal, data collection and report preparation. I really value his contribution for the successful completion of this research.

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ABSTRACT

Pedestrian overcrossings serve many users including bicyclists, joggers and pedestrians who are either able bodied or physically challenged. These facilities can represent one of the most important elements of a community's non-motorized transportation network. Overcrossings provide critical links in the pedestrian system by joining areas separated by a variety of barriers which include deep canyons, waterways or major transportation corridors. These structures are built in response to user demand for safe crossings where they previously did not exist. They are provided at locations where high vehicle speeds and heavy traffic volumes take place, where there are hazardous pedestrian crossing conditions like in areas where there are few or no gaps in the traffic stream, conflicts between motorists and pedestrians and in locations where large numbers of school children cross busy streets.

The Government of Kenya provided pedestrian footbridges at various crossing points along the Waiyaki Way. These include Aga Khan School, Kamgemi, Rironi and Uthiru pedestrian footbridges. The main objective of the provision of pedestrian footbridges was to enhance safety of pedestrians and at the same time reduce pedestrian and traffic conflicts. However, it was noted that some pedestrians are not crossing the road using the footbridges and instead they are crossing at grade despite that a concrete barrier of 1.2 m high was constructed to discourage crossing at grade.

The study aims at establishing the Level of Service which is used to access the quality of service of operations facilities on highway. Though several studies were carried out on pedestrian facilities which include assessment of pedestrian facilities, the extent of use by pedestrians, impact of construction of pedestrian footbridge in reducing accidents, general warrants to be considered in the design and provision of pedestrian facilities and reviewing of policies in providing pedestrian facilities, there are no studies which researched on the establishing the Level of Service C for assessing operational conditions of pedestrian footbridges as stipulated in Washington Metropolitan Area Transit Authority (2005). This study has adapted the methodology from Highway Capacity Manual and Transit Capacity and Quality Service Manual to compute the pedestrian level of service for Uthiru Pedestrian Footbridge.

Several methods were used for data collection on this research. One method is the literature review and was used to review both microscopic and macroscopic parameters of pedestrian traffic, the legislation of non-motorised transport mode in

Kenya and review of related studies which were previously conducted both within and outside Kenya. A site visit was conducted in order to observe the pedestrian footbridge condition, collect bridge inventory, carry out pedestrian counting survey, oral pedestrian interview, pedestrian speed survey and traffic count and speed surveys. During the site visit, the width and length of the pedestrian footbridge were measured for computation of effective area of footbridge and average pedestrian area. 200 pedestrians were interviewed in order to get their perception on the bridge utilization and identifying proposals which could enhance footbridge utilization. The pedestrian survey count was carried out for one week in order to establish the pedestrian demand for computation of Level of Service (LOS) for the pedestrian footbridge. The pedestrian survey speed was carried out in order to determine the overall pedestrians speed on the footbridge, ascending speed, descending speed and compare the time taken by pedestrians who use the footbridge and those that cross at grade. Traffic survey in form of speed survey and traffic count was also carried out in order to check if these parameters meet the basic warrants for provision of pedestrian footbridge. Finally, a questionnaire for the stakeholders in the construction industry was used in order to have their input into the research in relation to establishment of construction cost of footbridges, determination of the height of concrete barrier and reviewing of maintenance policies on footbridges.

The results of the survey show that a total of 29,727 pedestrians used the footbridge from Monday to Sunday. A total of 9,045 pedestrians used the footbridge during the weekend representing 30% of number of pedestrians who used the pedestrian footbridge for the whole week. Only 5 cyclists used the footbridge representing less than 1%. Female pedestrians used the footbridge most followed by children and men respectively. The results further show that 10% of the pedestrians crossed the highway at grade instead of using the footbridge. 1,326 pedestrians crossed at grade during the weekend representing 45%. Most pedestrians who crossed at grade were men with over 90% and the rate was high for grade crossing over the weekend especially on Saturday. This was the case because this is a market day at Kamgemi and Kawangware; hence most traders go and buy their products for Uthiru make shift markets.

The pedestrian survey count showed that the highest pedestrian peak volume was on Monday from 17.00-18.00 registering 1,006 pedestrians followed by 923

pedestrians who were recorded on Thursday from 17.00-18.00. The lowest pedestrian demand was recorded on as 254 pedestrians on Thursday from 12.00-13.00. The LOS of the footbridge ranged from LOS E and F respectively. This meant that the pedestrian footbridge was not operating at the recommended LOS C or B. The average area for each pedestrian was found to be $0.22 \text{ m}^2/\text{pedestrian}$ which was less than 0.3 m^2 for a simplified body ellipse of $0.5 \text{ m} \times 0.6 \text{ m}$ and recommended area of 0.75 m^2 for a buffer zone for each pedestrian (HCM, 2000). The current effective width of the footbridge is 2.2 m and the designed required effective footbridge width was computed as 3.65 m. This design footbridge width was determined with respect to the impact of usage of footbridge by other NMT modes such as cyclist and microscopic parameters of pedestrian traffic stream.

In terms of legislation, it was observed that though the Traffic Act Chapter 403 recognizes non-motorized transport and pedestrianization mode of transport, the act does not state if crossing at non-designated crossing points amounts to an offence. Local Government Act Chapter 265, empowers authorities to make by-laws on various aspects including safety of pedestrians. Though the City Council of Nairobi has bylaws as General Nuisance Bylaws, the bylaws do not include specific by-laws on jay walking and do not have details of fines for offenders.

The recommendations of the study include both long term and short term solutions based on the survey results on general perception of pedestrians on footbridge usage, reasons which they feel contributed to non-usage of footbridge and proposals which should be implemented as one way of increasing utilization levels of the footbridge. Short term solutions include improvement of maintenance, provision of lighting powered by solar, barring vending on pedestrian footbridge, installation of road signs and erection of barrier leading to pedestrian footbridge to deter jay crossing. Long term solutions include some of the proposals which were made by pedestrians which should be considered in future projects but cannot be implemented on the existing footbridge because of the technical and financial implications. These include increasing height of the concrete barrier, increasing the width of the footbridge and upgrading footbridge staircase with ramps. As part of improving on the legislation, the study recommends that City Council of Nairobi should review the General Nuisance Bylaws, to include specific by-laws on jay walking and propose fines for offenders. The City Council should also improve on enforcement of the by-laws as well.

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ABBREVIATIONS

AADT	Annual Average Daily Traffic
AAGR	Annual Average Growth Rate
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway Transportation Officials
ADA	America Disability Act
ADAAG	American Disability Act Accessibility Guidelines
AWDT	Annual Weekly Daily Traffic
BPL	Below Poverty Line
BTREA	Bureau of Transport and Regional Economics of Australia
CBD	Central Business District
DFID	Department of Transport Research Laboratory
DKUoT	Dedan Kimathi University of Technology
DoT	Department of Transport
DTO	Divisional Traffic Officer
EPT	Estimated Primary Trips
FE	Formal Employment
FHWA	Federal Highway Administration
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GNP	Gross National Product
GoK	Government of Kenya
GRSP	Global Road Safety Partnership
GSPC	Grade Separated Pedestrian Crossing
HCM	Highway Capacity Manual
HPMS	Highway Performance Monitoring System
IF	Informal Employment
INTP	Integrated National Transport Policy
KeNHA	Kenya National Roads Authority
KNBS	Kenya National Bureau of Statistics
KRB	Kenya Roads Board
KURA	Kenya Urban Roads Authority

LOS	Level of Service
MoH	Ministry of Health
MoLG	Ministry of Local Government
MoPW	Ministry of Public Works
MoR	Ministry of Roads
NCC	Nairobi City Council
NCHRP	National Cooperative Highway Research Program
NHTS	National Housing Travel Survey
NMT	Non- Motorised Transport
NRSC	National Road Safety Council
NTSA	National Transport and Safety Authority
NZBS	New Zealand Bus Service
OO & P	Otieno Odongo & Partners Consulting Engineers
PFB	Pedestrian Footbridge
PPT	Potential Pedestrian Trips
QOS	Quality of Service
RFA	Roads Fund Administration
RTA	Roads Traffic Accidents
RTI	Roads Traffic Injuries
TCGT	Total Corridor Generated Trips
TCQCM	Transit Capacity and Quality Control Manual
TRB	Transport Research Board
TRL	Transport Research Laboratory
UoN	University of Nairobi
USD	United States Dollar
WHO	World Health Organisation
WMATA	Washington Metropolitan Area Transit Authority

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

The rapid increase in the number of motor vehicles on the Kenyan roads has created a major social problem—the loss of lives through road accidents. The same has been witnessed between Uthiru and City Cabanas junction road section where Uthiru Pedestrian Footbridge which is located along the A104 Northern Corridor Road linking Port of Mombasa and the boarder posts of Malaba and Busia along the Uganda boarder. The appalling human misery and the serious economic loss caused by road accidents along this road demand the attention and calls for a solution to the problem. Road accidents claim many lives every year and most of these accidents involve pedestrians. These accidents can be avoided by providing pedestrian crossing facilities coupled with strict enforcement to ensure that the facilities are put into use in addition to creating public awareness through civic education.

Pedestrian overcrossings or footbridges serve many users including cyclists, walkers, joggers, pedestrians with strollers and wheelchairs. These facilities can represent one of the most important elements of a community's non-motorized transportation network. Overcrossings provide critical links in the pedestrian system by joining areas separated by a variety of barriers. Overcrossings can address real or perceived safety issues by providing users a formalized means for traversing problem areas such as deep canyons, waterways or major transportation corridors.

According to Renfro, (2007) in most cases, these structures are built in response to user demand for safe crossings where they previously did not exist. They are provided at locations where high vehicle speeds, heavy traffic volumes take place and where there are hazardous pedestrian crossing conditions. Examples include in places where few or no gaps in the traffic stream exist or where conflicts between motorists and pedestrians at intersections are prevalent among others. Pedestrian footbridges are also provided in locations where large numbers of school children cross busy streets, or where high volumes of seniors or mobility-impaired users need to cross a major roadway (Renfro, 2007).

In Kenya, the government provided a considerable number of pedestrian footbridges on various major roads so as to ensure safe crossing of pedestrians and to reduce existing pedestrians and vehicular conflicts. However, in some cases, these facilities are often poorly maintained thereby forcing non motorised road users on to motor carriageways.

Kenya has one of the highest road fatality rates in relation to vehicle ownership in the world with an average of 7 deaths from the road crashes that occur every day. Nearly 3000 people are killed on Kenyan roads annually. This translates to approximately 68 deaths per 10, 000 registered vehicles, which is 30 – 40 times greater than in highly motorized countries according to a Report on Recommendations on Intergated National Transport Policy (2004).

According to a journal on Road Safety in Kenya (2011), the mean annual fatality rate from all road traffic accidents in Kenya is estimated at 50 deaths per 10 000 registered vehicles. The journal further points out that the numbers of reported accidents have been showing an increasing trend from 10,300 in 1990 to 16,800 in 2000 and 17,400 in 2009 respectively. In terms of pedestrian accidents, 23% of accident victims in the year 2000 were pedestrians and 14% of accidents victims in the year 2009 were pedestrians respectively (Kenya Police, 2010).

Before Uthiru Footbridge was constructed in 1989, two accidents were recorded on every week. This translated to 96 accidents annually according to Divisional Traffic Officer of Kabete Police Station. It is reported that currently on average one accident occurs in every 2 months due to jay crossing. This translates into 6 accidents for pedestrians annually. The police reported that the accidents are caused by pedestrians who cross at grade. The pedestrians cause drivers to hit the concrete barrier when drivers try to avoid hitting the pedestrians. These pedestrian related accidents are not recorded since no injuries are caused to pedestrians and the pedestrians normally run away.

Road Traffic Accidents exert a huge burden on Kenya's economy in terms of hospital costs, costs of vehicle insurance and maintenance as well as indirect costs to individuals, families and society due to loss of production and effects of disability and death (Odero 1995). The current total annual average cost to the economy of road traffic accidents amounts to Kshs 20 billion, which is approximately 6% of GDP

(Odero, 2003). In general, it is inevitable that resources which are spent on treating victims of accidents can be saved through use of pedestrian footbridges such as the Uthiru Pedestrian Footbridge.

1.2 Study Area

The project area is on the Northern Corridor which forms part of Trans Africa road network and links Uganda, Congo, Rwanda, Burundi and Nairobi. It is in particular Uthiru a small town in Nairobi located North West of City of Nairobi between Kikuyu and Kangemi. The town lies along Waiyaki Way and is about 22km from Nairobi. The footbridge is located at about 400 m above from where the concrete barrier starts as you travel from Nairobi City CBD. Land use around Uthiru Town include Commercial or office business, residential buildings, education institutions ranging from pre-primary, primary, secondary and colleges, recreational facilities such as Kabete Golf Club and institutional buildings such as Uthiru Administrative Police Unit, Uthiru Dispensary and Kabete Technical Training College. The town has a total population of 24,295 and a total of 7,374 households (Central Bureau of Statistics, 2010). In terms of employment sector, the area has 3,800 people working in formal employment sector and 16,110 residents working in informal employment sector according to KNBS Economic Survey, 2009 (See Map 1).

Map 1:Location of Uthiru Pedestrian Footbridge on Waiyaki Way



Source:<http://www.googlemap.com> , Retrieved on November 12, 2013

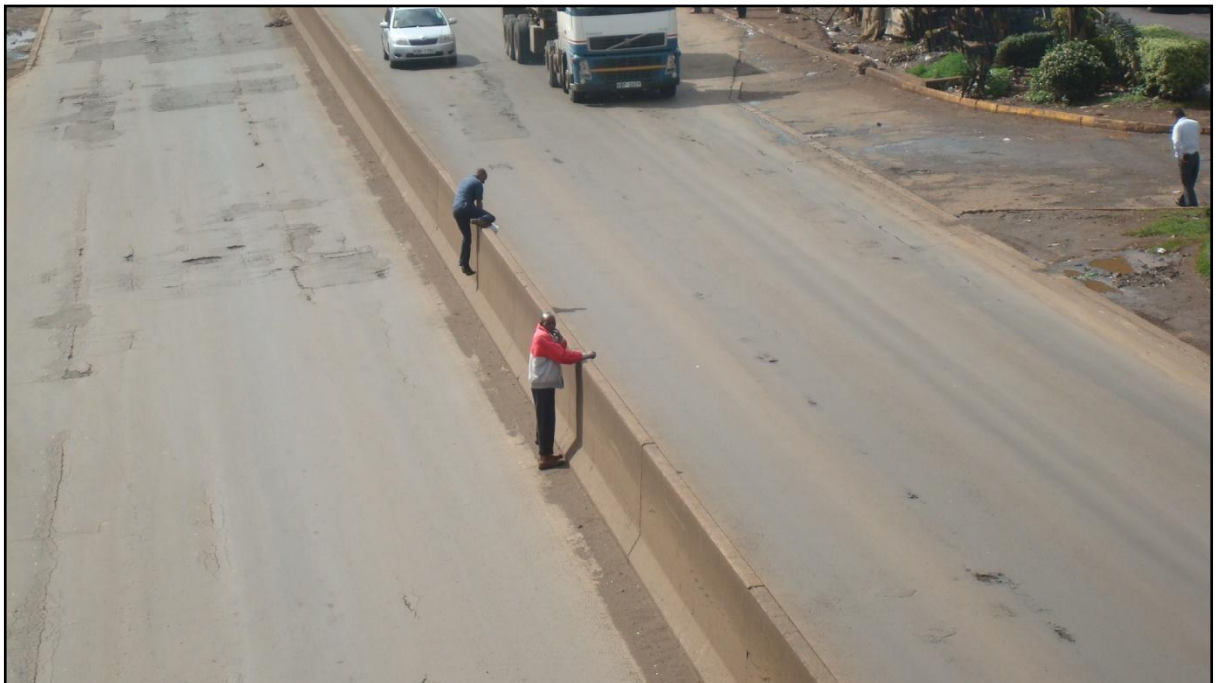
Labelling by Author

1.3 Problem Statement

Government of Kenya provided pedestrian footbridges at various crossing points along the Waiyaki Way. These include Aga Khan School, Kamgemi, Rironi and Uthiru pedestrian footbridges. The main objective of the provision of pedestrian footbridges was to enhance safety of pedestrians and at the same time reduce pedestrian and traffic conflicts.

On Waiyaki Way, a concrete barrier was provided along the trading centre which is about 1.2 m high to prevent pedestrians from crossing at grade. According to Kotahi, (2009) the barrier should be continuous, un-climbable and long enough to prevent people climbing over it. It was noted that although the barrier partly meets this specification, some pedestrians climb over the barrier as a way of crossing at grade. This is also collaborated by Zegeer, (1998) who recommends that the height of barrier should be high enough to prevent pedestrians from climbing over it. However, Zegeer, (1998) does not specify actual or minimum height (See pictures 1 and 2 showing pedestrians jumping over the concrete barrier). It has to be pointed out that the barrier also mitigates median cross-over collisions of vehicles for the divided carriageway.

Picture 1: Road section at Uthiru showing pedestrians climbing over the barrier



Source: Author, 2012

Picture 2: Pedestrians running across the road after climbing over the barrier



Source: Author, 2012

The footbridge is not user friendly for the disabled who include those who use the clutches and wheelchairs. No ramp was provided for to accommodate the disabled (Florida Pedestrian Planning and Design Handbook, 1999).

Picture 3: Some pedestrians crossing the footbridge with bicycles



Source: Author, 2013

Picture 3 is showing a general problem which is faced by cyclists who cross the highway using the pedestrians footbridge. This is the case because during the design and construction phases, the designer did not include the provision of bike gutters to allow cyclists to cross on this pedestrian footbridge.

Picture 4: Pedestrian –Scale Lighting on Eastbank Esplanade-Rose Connector



Source: Renfro, 2007

Picture 4 shows a pedestrian footbridge which is wide enough to accommodate a relative number of pedestrians to pass through it without being congested. One of the requirements of the pedestrian footbridge is that it should be wide enough to accommodate the largest number of pedestrians observed during at peak hours. The minimum width of the pedestrian footbridge should be at least 2.4m (Kotahi, 2009). The current pedestrian footbridge width is 2.2m wide (effective width). It remains to be established if this meets the LOS C as prescribed according to Washington Metropolitan Area Transit Authority (2005).

Lighting on highways including pedestrian footbridges is very important because it illuminates potential hazards so that pedestrians can avoid them and affects the feeling of security and comfort. One of the warrants for provision of the grade separated pedestrian crossings is that artificial lighting should be provided to reduce potential crimes against users of underpasses and overpasses. It may be required to light underpasses 24 hours a day and overpasses all night (Axler, 1984). Generally

pedestrians would use the pedestrian footbridges during the day because there are few concerns of security. As darkness approaches, pedestrians would not use the pedestrian footbridge if the lights are not provided at the footbridge due to safety reasons. This is the case with Uthiru Pedestrian Footbridge since no lights were provided to allow the use of the bridge at night.

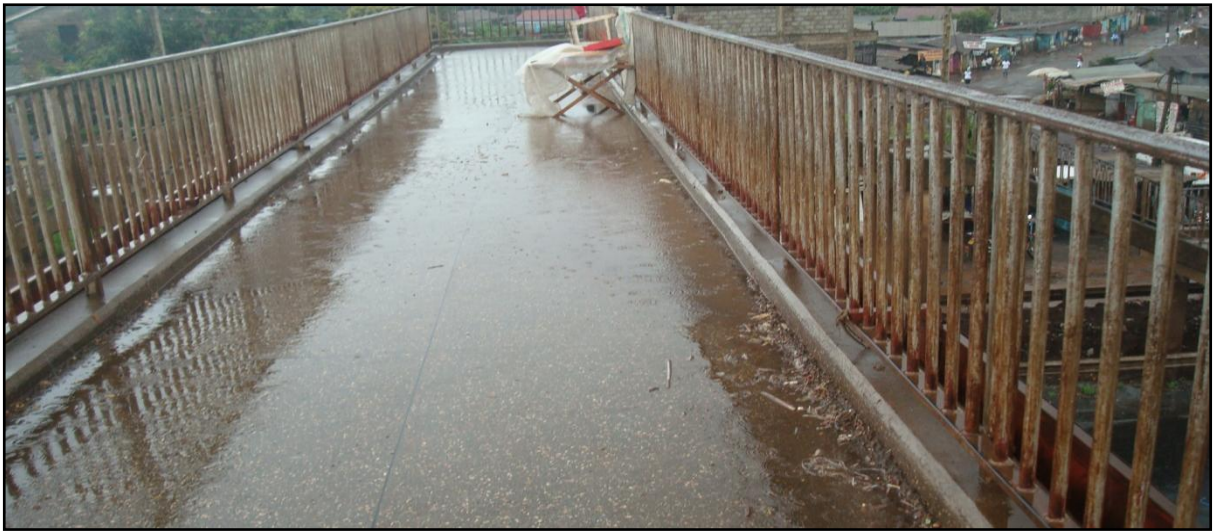
It was also observed that there is general lack of maintenance to the footbridge. The footbridge is not cleaned regularly as to ensure that it is quite attractive to pedestrians and at the same time drainage is improved. A site visit to Uthiru footbridge on 24th September, 2012 showed that lack of maintenance had an impact on pedestrian footbridge. One end of the bridge could not be used following the falling of rains on that particular day. It was noted that this part of the footbridge was not used by pedestrians due to the pool of water which accumulated because of rains. It is inevitable that during rainy season if all footbridge approaches are not properly drained, pedestrians would remain with no choice but risk themselves in crossing at grade (See pictures 5 and 6 for illustration of the problem).

Picture 5: Southern end of Uthiru pedestrian footbridge with water



Source: Author, 2012

Picture 6: Uthiru pedestrian footbridge with a pool of rainwater



Source: Author, 2012

Picture 7: Safe crossing at 87 Estate Trading Centre



Source: Author, 2012

Picture 7 shows some alternative safe crossing points which were provided at trading centres to allow pedestrians to cross at grade. The barrier is broken intermittently to allow pedestrians to cross at grade in lieu of footbridges or tunnels. This is the case because a concrete barrier was erected from Uthiru to Rironi which is about 17 km. At randomly sampled points, it was noted there were no traffic calming facilities provided as to ensure that vehicles slow down for pedestrians to cross safely.

Speed humps ought to have been installed in order to compel drivers to slow down for safe crossing of pedestrians.

In some cases, it was observed that the concrete barrier is damaged due to vehicular accidents. This gives alternative, undesignated and unsafe crossing points for pedestrians at grade. The barrier should be maintained to reinstate damaged sections (See pictures 8 and 9 for illustration of the problem).

Picture 8: Broken barriers which can be used for grade crossing



Source: Author, 2012

Picture 9: Pedestrians crossing at undesignated place



Source: Author, 2012

It was also noted that there are a number of tunnels which were provided in order to allow pedestrians to cross safely without pedestrian and vehicular conflicts. Two tunnels which are relatively close to Uthiru Pedestrian Footbridge are Mama Ngina Kenyatta Primary School tunnel which is located at 1.560 km and Kino Estate trading centre tunnel which is located at 1.960 km from Uthiru Footbridge. The problem with the tunnels is that they are not maintained on regular basis so that they are in good conditions all the time to be used by pedestrians. In some cases, the debris collects at the entrances and some rubbish is dumped in the tunnels and these demotivate pedestrians from using the tunnels. Accumulation of debris creates unpleasant walking experience to pedestrians (See Pictures 10 and 11).

Picture 10: Mama Ngina Kenyatta Primary School Tunnel which is dark, unlit and with some rubbish



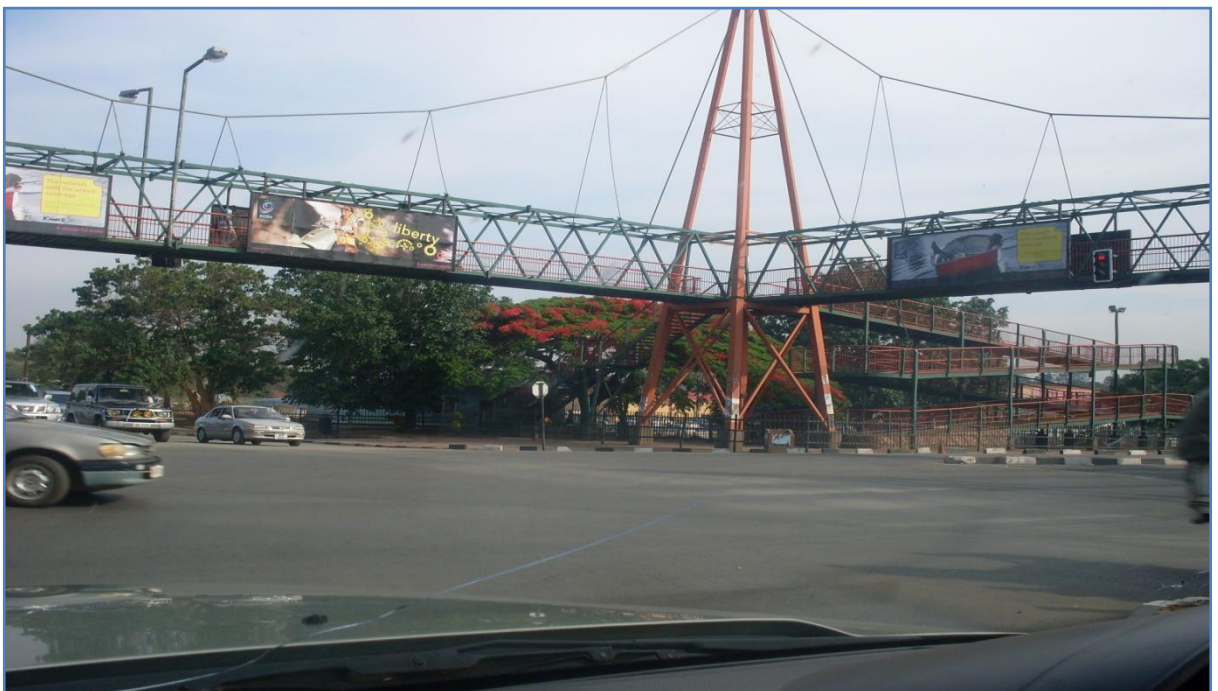
Source: Author, 2012

Picture 11: Mama Ngina Kenyatta Primary School Tunnel with debris at entrance



Source: Author, 2012

Picture 12: Manda Pedestrian Footbridge in Lusaka, Zambia



Source: Author, 2009

Picture 12 shows a pedestrian footbridge in Lusaka CBD. In Zambia, attempts have been made to provide pedestrian crossings which meet almost all the warrants

that are required in designing and construction of pedestrian footbridges. As depicted in picture 12, the footbridge has some lighting provided for the pedestrians to use the footbridge even during night hours. The footbridge is in ramp form to enable all road users including the physically challenged to use it. The footbridge is also caged as to prevent children from falling off the bridge and it is covered in fence as a measure of improving security for pedestrians since all pedestrians using the bridge can be seen by all road users. In addition, there are few adverts placed on the pedestrian bridge as these tend to hinder pedestrians using the bridge from being seen by all road users.

1.4 Research Questions

The study aims at observing the physical conditions of the bridge, establishing pedestrian perceptions, pedestrian utilization levels and establishing the economic impact of construction of the footbridge. This research therefore seeks answers for current pedestrian problems for not using the available footbridge at Uthiru and similar footbridges asking the following questions.

- What influences the utilization levels of pedestrian transport facilities especially the Uthiru Pedestrian Footbridge along or the within Northern Corridor?
- Do pedestrians prefer certain crossing facilities instead of the present one?
- Has the bridge been designed taking into account the general specifications including meeting the pedestrian level of service in terms of capacity, speed flow, space and volume or density of pedestrians?
- What is the economic impact of construction of pedestrian footbridges?

1.5 Study Objectives

The aim of this study is to examine location, design and other parameters of pedestrian overcrossings and evaluate how well they serve their intended users. This study aims to inform planners, designers and other parties in developing new pedestrian overcrossings and how to improve existing facilities.

The specific objectives of this study are to:

- Determine the extent of use of the footbridge by the pedestrians.

- Assess pedestrian perceptions on the impact of the footbridge and identify steps to improve effectiveness of footbridge utilization.
- Review the design of the pedestrian foot bridge so as to establish if the footbridge meets pedestrian expectation and check whether the design conforms to HCM, 2000.
- Establish the economic impact of the bridge usage.

1.6 Scope of Study

To fulfil the above objectives, the following scopes are formulated:

a. Use of pedestrian footbridge

The research focused on the analysis of the extent to which the pedestrian footbridge is being used by the pedestrians in crossing the road.

b. Capacity of pedestrian footbridge

The capacity of the pedestrian footbridge was determined by measuring the total width and length of the bridge. The effective width of pedestrian footbridge is 2.2m and the length of the bridge is 101.9 m. After that, the area of the pedestrian footbridge was calculated.

c. Pedestrian Volume

Data collection of pedestrian volume was only done for the peak hours of the day that is from 6.30-9.30 am and 4.00-7.00 pm. The data was collected for one week including Saturday and Sunday.

d. Calculation of Level of Service

Pedestrian LOS, as defined in the HCM was be calculated by counting pedestrians who cross over a point over a certain period of time (usually 15 minutes), reducing that figure to pedestrians minute and then dividing the effective width of the sidewalk. The resulting figure is called the flow rate. (Burden, 2006). The calculated flow rate was referred to standard table (as provided in HCM, 2000) to determine the pedestrian LOS grade, ranging from A (Free flow) to F (virtually no movement possible). In this case the aim was to establish if the LOS C would be found.

1.7 Research Limitations

The Government of Kenya provided pedestrian footbridges at various crossing points along the Waiyaki Way. These include Aga Khan School, Kamgemi, Rironi and Uthiru pedestrian footbridges. This study is limited to Uthiru pedestrian footbridge in determining the level of service as to check the adequacy and performance of the structure. The study did not determine the structural adequacy of the footbridge but in as much as whether some basic pedestrian footbridge warrants were met when the decision to construct the footbridge was reached. It is deemed that the results can be used for the future design and construction of new pedestrian footbridges.

1.8 Justification of Study

Pedestrian footbridges allow uninterrupted flow of pedestrians' movement separate from vehicle traffic. For such structures to be put in place, a lot of financial resources are required. The cost of construction of the pedestrian footbridge ranges from \$500,000 to \$4 million depending on site conditions (Zegeer, et al, 2002). It is also estimated that the construction of the pedestrian footbridge may vary from \$40,000 to \$ 250,000 (Axler, 1984). In Kenya the cost of construction of the pedestrian footbridge is estimated at \$1,318,415.28 according to Feasibility Study Report –August 2011 on “Pedestrian Crossing Facilities across Mombasa Road” done by Multi-Scope Consulting Engineers. This means that if such huge resources are used for construction of the pedestrian footbridges, these structures should be used by the pedestrians, otherwise the structures would become white elephants and the government stands to lose a lot. It is inevitable that Government of Kenya used a lot of financial resources for construction of pedestrian footbridges and these resources would have been channeled to equally important government departments like the Ministry of Health. In view of much higher costs for construction and maintenance of footbridges and subways as compared to at-grade crossing facilities, it is imperative to review the planning process of the provision of footbridges and utilization levels (Chai, 2010).

There are cases where grade separated pedestrian crossings have been built for situations that did not need them. Ultimately, these have been abandoned. The graded separated pedestrians crossings that satisfy a particular need tend to be used effectively (Axler, 1984). According to Zegeer (1998), locations that are prime candidates for

GSPCs are located in areas where the pedestrian attractors such as shopping centres, large schools, recreational facilities, or other activity centres are separated from pedestrian generators by high volume and or high speed arterial speeds. The study aims at confirming if these basic parameters were taken into account during the design and construction of the footbridge as part of justification as well.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Project Profile Area

2.1.1 Description of the Road Project

The project area which is on the Northern Corridor forms part of Trans Africa road network and links Uganda, Congo, Rwanda, Burundi and Nairobi. This connectivity is crucial for regional growth, integrity and security. The project is on a bitumen lane, six lane and dual carriageway road with acceleration and deceleration lanes at major intersections and at median breaks. The road has separate pedestrian walkways, pedestrian footbridges and underground tunnels that segregate motorized traffic from NMT on selected sections. The road is designed for through traffic and vehicle speed on this road range from 80 -120 km/hr. However, it has to be pointed out that the main study area of this research is on Uthiru Pedestrian Footbridge which is on Waiyaki Way and is located at 22 km from Nairobi CBD.

2.1.2 Land use along project area

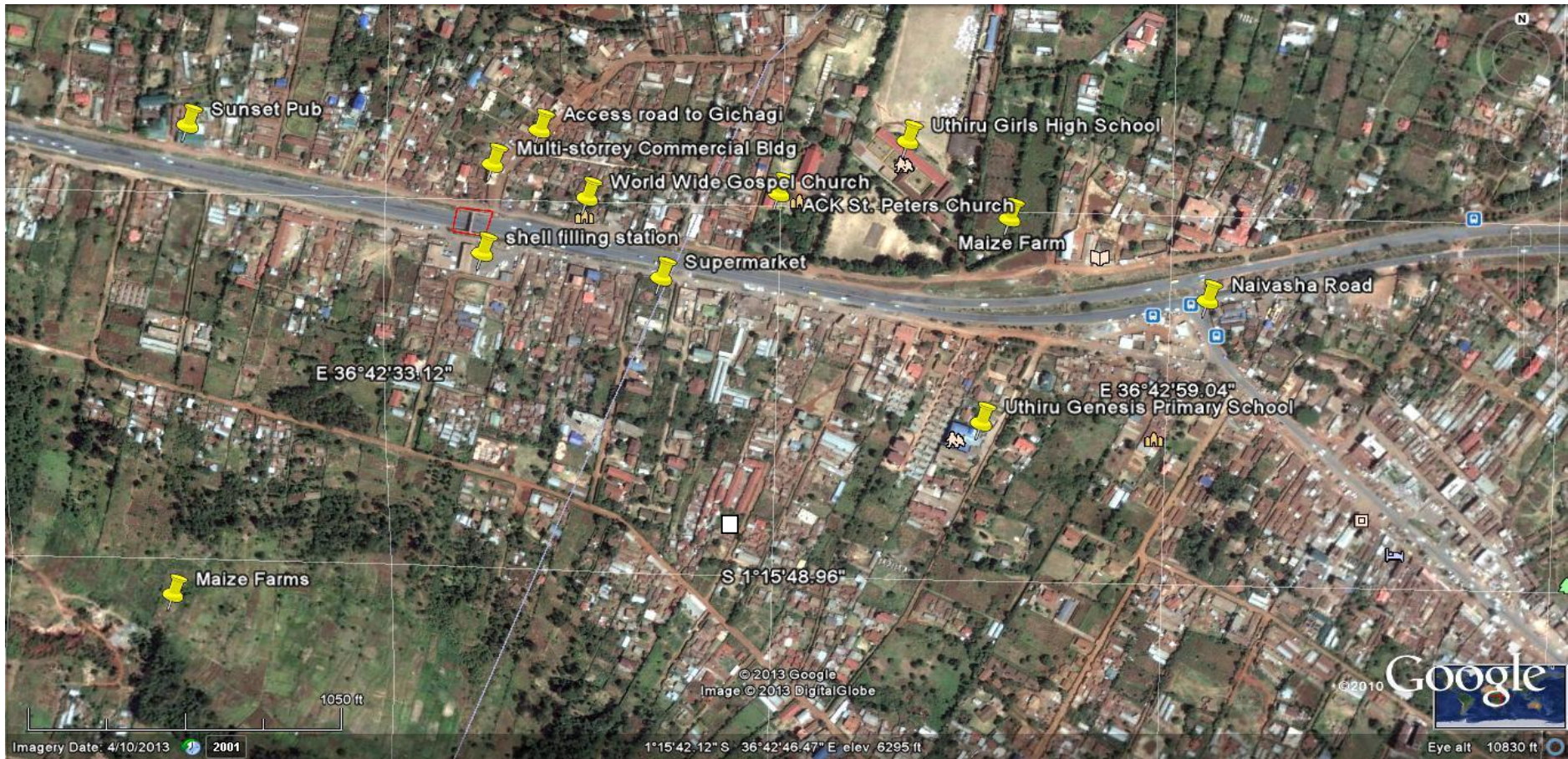
The rate of trip making within the area of study depends primarily on land use which in conjunction with socioeconomic characteristics of the area together serves to heighten travel demand there. Three characteristics of land use that have been found closely related trip generation are density, character and location of land use activities. Trips related to education, business and work have been highly responsible for NMT flows on the footbridge. Land use along this section can be classified as follows:

- i. Commercial or office business comprises banks, petrol station, supermarkets, hardware stores, grocery stores, butcheries, pharmacists and showrooms. The main enterprises located here include Equity Bank, Kenya Commercial Bank ATM outlet, E-mpesa outlets, Shell Fuel Station, Total Fuel Station, Joyland Supermarket, Uthiru Supermarket, Uthiru Wayside Supermarket, Open air markets, Uthiru Post Office, restaurants, hawkers and general vending.
- ii. Residential: The road connects a number of middle class estates such as Ndumbuini, Gichagi and informal settlements lying along the periphery of these middle class income estates. The area has residential building consisting single structure and some multi-storey buildings.

- iii. Education: There are various educational institutions which range from pre-primary, primary, secondary and tertiary education. These include Uthiru Nursery School, Uthiru Government Primary School, Cedar Groove Junior Academy, Uthiru Genesis Private Primary School, Top Choice Private Secondary School and Uthiru Girls Government School.
- iv. Recreational: The area has both local bars and big clubs which offer entertainment to the residents of Uthiru Town. These include California Club, Villagers Club, Waves Club and Kabete Golf Club.
- v. Institutional: The area has both governmental and private owned institutions. These are Kabete Police Station, Uthiru Administrative Police Unit, Uthiru Dispensary, St Peters Anglican Church of Kenya Clinic, Kabete Technical Training College, Animal Health and Industrial Training Institute and College of Agriculture and Veterinary Services, a constituent college of University of Nairobi.
- vi. Industrial: The town does not have any notable industries in the area apart from agricultural activities which include small scale farming, production of vegetables and general maize farming, zero grazing and dairy farming including poultry farming.

Different land use produces different trip rates. For example a residential area with high density dwellings can produce more trips than the one with a low density of dwellings. On the other hand, low density areas may represent dwellings of the affluent society which may produce a larger number of private trips (Kadiyali, 2002). Refer to Map 2 for land use of Uthiru Town.

Map 2: Map of Uthiru Showing Land Use



Source: <http://ww.googlemap.com> , Retrieved on November 12, 2013

Labelling by Author

2.1.3 Demographic Profile

The Kenya National Bureau of Statistics estimates the total population of the City of Nairobi to have increased from 2.14 million to 3.14 million in the 2009 census at an average growth rate of 3.3%. Nairobi City is spread over an area of 626 sq. km thereby translating to an average population of 4,511 persons per sq. km.

Since Uthiru Pedestrian Footbridge was commissioned in 1990, there has been a general growth trend in the population of the town. The population of Uthiru Town is expected to increase from 33.4% in 2009 to 36.5% in 2015 (Kenya 1999 Population & Housing Census: Analytical Report on Population Projection Vol VII).

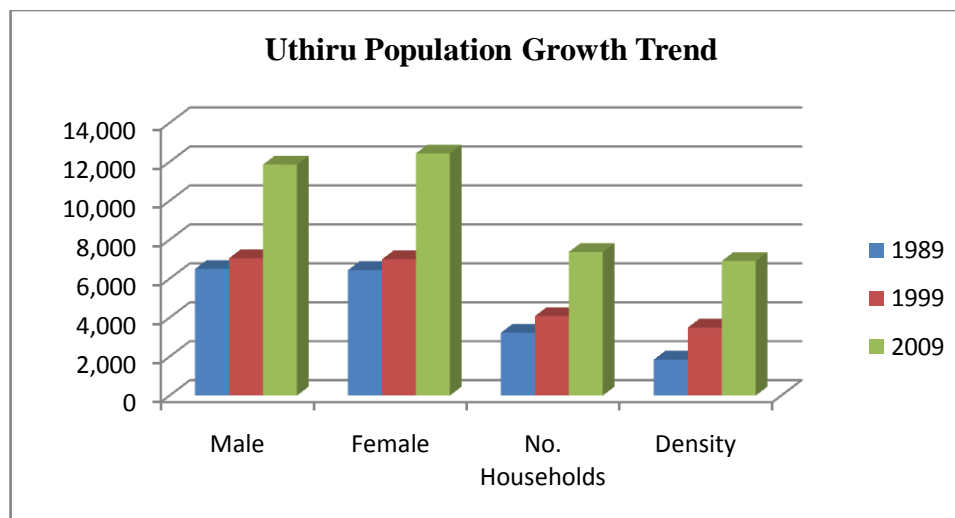
The Uthiru Pedestrian Footbridge was provided when the population of the town was very low. According to 2009 population census, the population has grown by 47.4% from the time the bridge was commissioned. With the current population growth, it was anticipated that the design of the footbridge ought to have taken into account the growth in numbers of the pedestrian users (Refer to Table 1 and Figure1).

Table 1: Population Growth Trend in Uthiru Town.

Year	Male	Female	Total	No. Households	Area sq. km	Density
1989	6,502	6,442	12,944	3,224	7	1,849
1999	7,052	6,998	14,050	4,080	3.1	3,491
2009	11,861	12,434	24,295	7,374	3.5	6,911

Source: Central Bureau of Statistics, 1989, 2001 and 2010

Figure 1: Population Growth Trend in Uthiru Town



Source: Author, 2013

2.1.4 Economic Profile

Nairobi contributes about 60% of the national GDP. The primary sector which is composed of Agriculture, Forestry, Fishing, Mining and Quarrying contributes 24.5% to GDP (KNBS Economic Survey, 2009). The remaining 75% is contributed by the secondary sector which is manufacturing and tertiary sector which includes services respectively. The secondary and tertiary sectors are mainly urban based and Nairobi is therefore a major location of these sectors. Based on the statistics provided by the Kenya National Bureau of Statistics, the estimated informal employment growth in Nairobi is presented in Table 2.

Table 2: Formal and Informal Employment Growth in Nairobi Province (in 000)

Employment Sector	2004	2005	2006	2007	2008	2009	AAGR
Formal Employment-FE	443.7	454.7	466.3	479.3	488.2	500.0	2.42
Informal Employment-IE	1,487.7	1,601.1	1,712.1	1,284.5	1,943.2	2,077.7	6.92
Total (FE + IE)	1,930.8	2,055.8	2,178.4	2,303.8	2,431.5	2,577.7	5.93
FE/IE	3.35	3.52	3.67	3.81	3.98	4.16	

Source: KNBS Economic Survey, 2009

The populations of Nairobi City and Uthiru Town were recorded as 3,138,369 and 24,295 respectively according to the Housing and Population Survey of 2009. This implies that the population of Nairobi is 129 times than that of Uthiru. Since there are no records for the informal employment of Uthiru Town was, this ratio was used to derive the informal employment of Uthiru Town (Labour Statistics Manager-KNBS, 2013). Therefore the estimated informal employment growth for Uthiru Town in Nairobi is presented in Table 3.

Nairobi has a large portion (21.3%) of its people living below poverty line (BPL) of income less than one USD per day. These cannot afford the public transport services and inevitably need to walk to other destinations for other needs (MultiScope Consulting Engineers, 2011-Consultancy Services for Feasibility, Preliminary and Detailed Design of Pedestrian Crossing Facilities across Mombasa Road). Nearly 47% of the trips generated within Nairobi are by walking (JICA, 2006). There is therefore need to provide safe pedestrian across the major highways such as Waiyaki Way.

Table 3: Formal and Informal Employment Growth in Uthiru Town (in 000)

Employment Sector	2004	2005	2006	2007	2008	2009	AAGR
Formal Employment- FE	3.44	3.52	3.61	3.72	3.78	3.88	2.42
Informal Employment- IE	11.53	12.41	13.27	9.96	15.06	16.11	6.92
Total (FE + IE)	14.97	15.93	16.88	13.68	18.84	19.99	5.93

Source: KNBS Economic Survey, 2009

2.1.5 Environmental & Social Profile

There are no major industrial activities in the area apart from agricultural activities which include maize farming, dairy farming and poultry farming respectively. As such environmental issues related to industries in this study area do not arise.

The social and cultural areas served by the project are diverse with multi-ethnic grouping and middle income, low income and urban poor. The urban poor live in the informal settlements lying on the periphery of middle income and low income areas and form a huge population that works in farms of middle and low income individuals.

2.1.6 Accident Data Profile

Kenya has one of the highest road fatality rates in relation to vehicle ownership in the world with an average of 7 deaths from the road crashes that occur every day. Nearly 3000 people are killed on Kenyan roads annually. This translates to approximately 68 deaths per 10,000 registered vehicles, which is 30 – 40 times greater than in highly motorized countries according to a Report on Recommendations on Integrated National Transport Policy (2004).

According to a journal on Road Safety in Kenya (2011), the mean annual fatality rate from all road traffic accidents in Kenya is estimated at 50 deaths per 10,000 registered vehicles. The journal further points out that the numbers of reported accidents have been showing an increasing trend from 10,300 in 1990 to 16,800 in 2000 and 17,400 in 2009 respectively. In terms of pedestrian accidents, 23% of accident victims in the year 2000 were pedestrians and 14% of accident victims in the year 2009 were pedestrians respectively (Kenya Police, 2010). According to the announcement on accident data monitored on Citizen Television on 6th December, 2012 at 9.00 pm, 3,000 accidents are recorded every year and 65% of the victims are pedestrians (National Road Safety Trust, 2012).

Before Uthiru Footbridge was constructed in 1989, two accidents were recorded every week. This translated to 96 accidents annually according to Divisional Traffic Officer of Kabete Police Station. It is reported that currently on average one accident occurs in every 2 months due to jay crossing. This translates into 6 accidents for pedestrians annually. The police reported that the accidents are caused by pedestrians who cross at grade. The pedestrians cause drivers to hit the concrete barrier when drivers try to avoid hitting the pedestrians. These pedestrian related accidents are not recorded since no injuries are caused to pedestrians and the pedestrians normally run away.

2.2 General Aspects of Pedestrian Footbridges or Overpasses

Florida Planning and Design Handbook (1999) define grade separated crossings as facilities that provide pedestrians and motor vehicles to cross at different levels. The handbook further outlines that grade separated crossings reduce vehicle conflicts and potential accidents. Grade separated pedestrian crossings play a major role which include substantial improvement of pedestrian safety, reduced vehicle

delay, increase highway capacity and reduce vehicle crashes when appropriately located and designed. The handbook defines pedestrian overpasses or bridges as passages for pedestrians which are constructed over a roadway in which stairs or ramps generally lead to the overpass.

The effectiveness of grade-separated crossings depends on their perceived ease of accessibility by pedestrians because an overpass or underpass will not necessarily be used simply because it improves security. Pedestrians tend to weigh the safety aspect of using the pedestrian footbridge over against the extra effort and time required.

Some of the general warrants for overpasses according to Florida Planning and Design Handbook (1999) include the following:

- Work best if a very high volume of both motorised traffic and pedestrian activity exists. An overpass placed where there is an almost total lack of gap, such as well used freeway or nearly saturated multi-lane highway may meet this warrant.
- Overpasses are needed across roads with high speeds and may have lanes with limited gaps. In this high risk crossing conditions, there may be more gaps, but the conditions are more risky that many pedestrians will use the overpass.
- A physical barrier to prohibit at-grade crossing of the roadway is desirable as part of the overpass and underpass design

A list of potential criteria which influence the utilisation of grade separated pedestrian crossings were developed by Axler, (1984) and these have been outlined in Table 4 and 4a.

Table 4: List of Potential Criteria for Grade-Separated Pedestrian Crossings

Criteria	Factors
Convenience	<ul style="list-style-type: none"> • Activity centre (pedestrian traffic generator) nearby GSPC • Height to ascend or descend on GSPCs` ramps or steps • Additional distance to travel using GSPC compared with crossing roadway at grade • Accessibility for the handicapped (and blind)
Alternative “Safe” crossing instead of GSPCs	<ul style="list-style-type: none"> • Traffic signal with pedestrian heads, pedestrian push buttons, advance /delay green • Pedestrian/school cross walk-marked, unmarked, signed • School crossing guard –adult, student safety control
Feasibility of Installation	<ul style="list-style-type: none"> • Right of way for ramps for GSPC
Vehicle Traffic Operations	<ul style="list-style-type: none"> • Acceptable gaps in traffic (1 per min average) • Volume of potential pedestrians using GSPC • Volume of vehicles -low, moderate and high • Percent of trucks/buses-low, moderate, and high • Speed of vehicles-less than 20 mph, 20-35 mph, over 35 mph • Directional flow (one way , two way)
Criteria	Factors
Pedestrian Safety	<ul style="list-style-type: none"> • Perception of risk • Preventable accidents i.e. fatality and injuries • Conflicts between vehicles and pedestrians
Roadway Geometrics	<ul style="list-style-type: none"> • Distance to cross roadway or to median • Number of moving traffic lane to cross to other side of roadway Freeway-usually no alternative “safe” crossing • Highway-major artery, collector , local street
Adjoining land use	<ul style="list-style-type: none"> • Residential to residential • Residential to shopping or bus terminal
Design features affecting usage	<ul style="list-style-type: none"> • Physical barrier to prevent at grade crossing • Lighting for underpass and overpass • Litter controls-routine cleaning • Signing to entrance of GSPC • Handicapped accessible-ramp slope, length and handrails • Aesthetic design

Source: Axler, 1984

Quantitative parameters were also developed by Axler, (1984) and include the following:

- Pedestrian volume should be at least exceed 300 in the highest 4 continuous hours if the vehicle speed is more than 65 km/h (40mph) or the pedestrian volume should be more than 100 pedestrians in the four highest continuous hour periods.
- Vehicle volume should be over 10,000 in the same four hour period used for pedestrian warrant if vehicle speed is over 65km/hr for the proposed sites in urban areas or vehicle volume should be over 7,500 in four hours.
- The proposed site should be at least 183m from the nearest alternative safe crossing. A safe crossing is defined as a location where a traffic control device stops vehicles to create adequate gaps for pedestrians to cross. Another safe crossing is an existing overpass or underpass near the proposed facility.
- A specific need should exist or be projected for grade separated pedestrian crossing based on existing or land use (s) adjoining the proposed site which generate trips. These land uses should have direct access to grade separated pedestrian crossing.

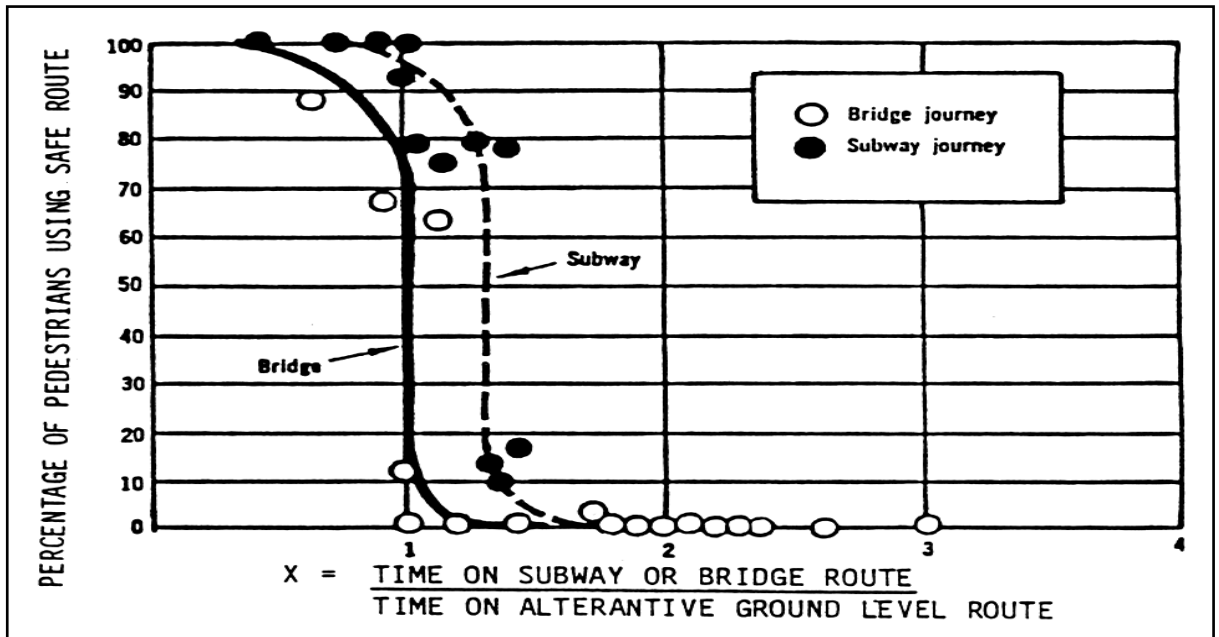
Demetsky, (1974) outlined some of the features or warrants that should be incorporated in the design of the pedestrian overpass and these include:

- The sides should be constructed of material which allows complete visibility in order to reduce the probability of criminal acts directed toward pedestrians.
- The sides should be constructed of mesh material with openings large enough to allow for free air circulation but small enough to prevent cans or other objects from being thrown at passing vehicles.
- Ramps with sharp turns to discourage speeding bike rides are preferred over stairs because they allow a more diverse use of the structure. .

Kane County Bicycle and Pedestrian Plan, (2012) considers that simple ease of accessibility is one of the elements that determine the use of pedestrian footbridge. Convenience factor, R is used. R is the ratio of time taken to travel on the overpass or underpass divided by the time to travel at grade level.

The 1965 study by Moore and Older according to Kane County Bicycle and Pedestrian Plan, (2012) indicated that 95% of pedestrians would use underpass and 70% of pedestrians would use overpass if $R=1$ (no time difference). Virtually no one would use the overpass if $R=1.5$, thus 50% time difference (See Figure 2).

Figure 2: Expected usage rate of pedestrian bridges and underpasses, relative to time needed to cross at street



Source: Moore and Older, 1965

2.3 Concept and Uses of Level of Service

2.3.1 Definition of Level of Service

LOS is a method by which a transportation facility's performance is evaluated. In general, it is a quantitative measure describing the operational conditions of the facility's traffic stream and user's perception of those conditions within the area of evaluation (Klodzinski, 2001). For the measurement of pedestrian walkway LOS, it depends on a number of factors that cannot be estimated directly but depends on the feeling of the pedestrians according to where they are comfortable, travel minimum time, it is convenient and have freedom to manoeuvre.

In general, letters are used to represent the LOS, starting with A, which indicates the most excellent operating conditions and ending with LOS F, which indicates the worst operating conditions. The LOS evaluation is very important to the

engineer to determine if the facility is performing at the desired operational level or if improvements should be made or implemented.

2.3.3 Pedestrian Level of Service

Pedestrian LOS provides a useful means of evaluating the capacity and comfort of an active pedestrian space. Pedestrian LOS thresholds related to walking are based on the freedom to select desired walking speeds and the ability to by-pass slower-moving pedestrians. Besides this other considerations related to pedestrian flow include the ability to cross a pedestrian traffic stream, to walk in reverse direction of a major pedestrian flow and to manoeuvre without other pedestrian or changes in walking speed (TRB, 2003).

Pedestrian LOS, as defined in the HCM is calculated by counting pedestrians who cross over a point over a certain period of time (usually 15 minutes), reducing that figure to pedestrians' minute and then dividing the effective width of the sidewalk. The resulting figure is called the flow rate (Burden, 2006). A planner may then look up the flow rate in the table to determine the pedestrian LOS grade, ranging from A (Free flow) to F (virtually no movement possible). The HCM's pedestrian LOS is designed to be an objective measure of congestion on a pedestrian facility.

The LOS defines the transportation capacity. The capacity requirements are intended to identify the minimum widths necessary to move people through. However, in order to provide an attractive, safe and high quality pedestrian oriented environment, wider walkways, stairways and other amenities must be considered. For planning purposes, all pedestrian facilities should be designed to provide an adequate level of service (LOS) during the period of greatest activity. For walkways and stairways, this will be generally a.m peak-period. (Washington Metropolitan Area Transit Authority, 2005).

2.4 Pedestrian Capacity Terminology

This research dwells much on pedestrian circulation. As such, definitions of key words as outlined by Olando, et al, (2003) have been included. These are pedestrian capacity, pedestrian speed, pedestrian flow rate, pedestrian flow per unit width, pedestrian density, pedestrian space, pedestrian time-space, effective width or area and platoon. Detailed definitions have been annexed in Appendix 1.

2.5 Microscopic Parameters of Pedestrian Traffic Stream

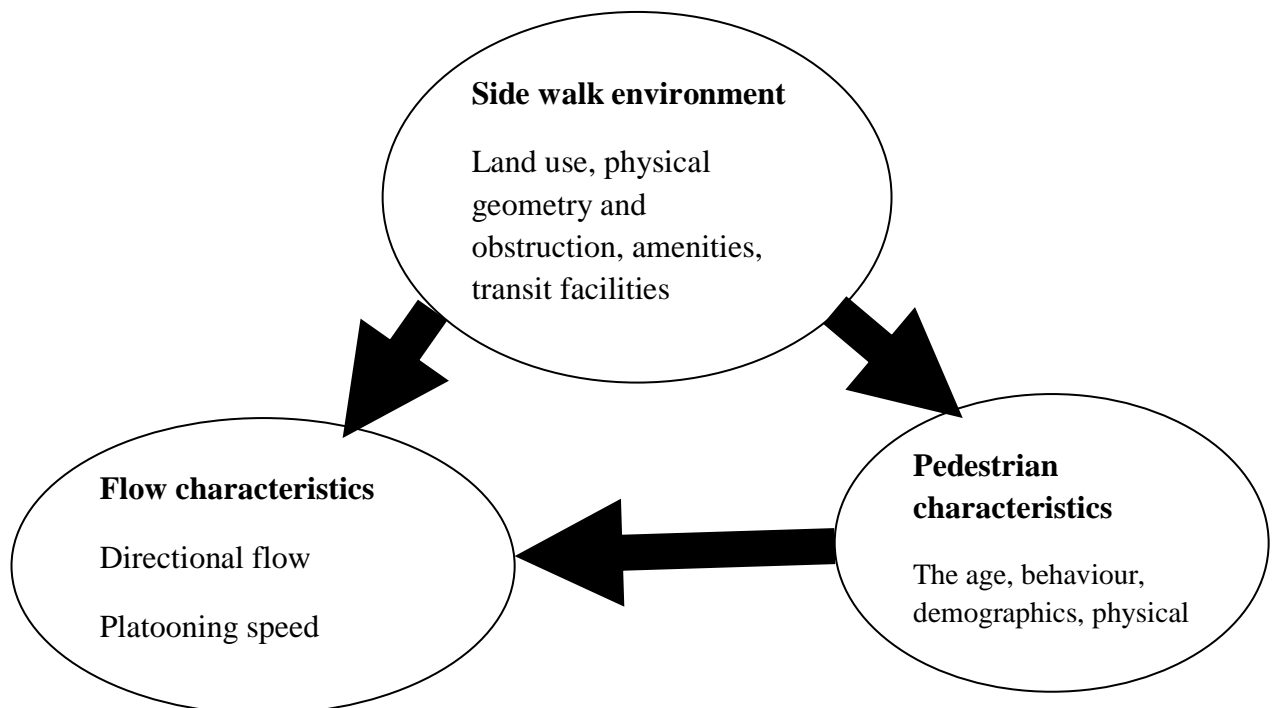
2.5.1 General Concept of Microscopic Parameters of Pedestrian Traffic Stream

Microscopic parameters treat each pedestrian as an individual agent occupying a certain space in time (Shiwakoti, 2001). According to Shiwakoti (2001), these parameters provide a valuable insight over a wide range of pedestrian behaviour. The microscopic parameters deal with factors that drive pedestrians towards destination by considering the interaction between pedestrians. Such parameters give a more realistic performance of pedestrians and play a major role in the design and provision of pedestrian facilities. One of the parameters of microscopic element includes the headway of pedestrian in a traffic stream (Teknomo, 2002).

2.5.2 Pedestrian Characteristics

In order to plan properly for any pedestrian facilities and even to develop better LOS measuring tools, it is very essential to understand pedestrian characteristics in terms of the relationship to the walkway they use and their flow (HCM, 2000). The relationship of sidewalk, pedestrians and flow has been presented in Figure 3.

Figure 3: Relationship between the sidewalk, pedestrians and the flow

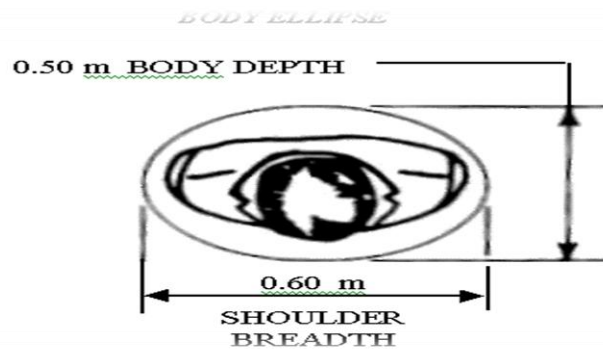


Source: Pedestrian Level of Service Study Phase I (2006), NYC DCP, Transportation Division

2.5.3 Pedestrian Space Requirements

Pedestrian facility designers use body depth and shoulder breadth for minimum space standards, at least implicitly. A simplified body ellipse of 0.5m x 0.6m with a total area of 0.3 m² is used as the basic space for a single pedestrian. This represents the practical minimum for standing pedestrians. In evaluating pedestrian facility, an area of 0.75 m² is used as the buffer zone for each pedestrian (HCM, 2000). The body ellipse plan is presented in Figure 4.

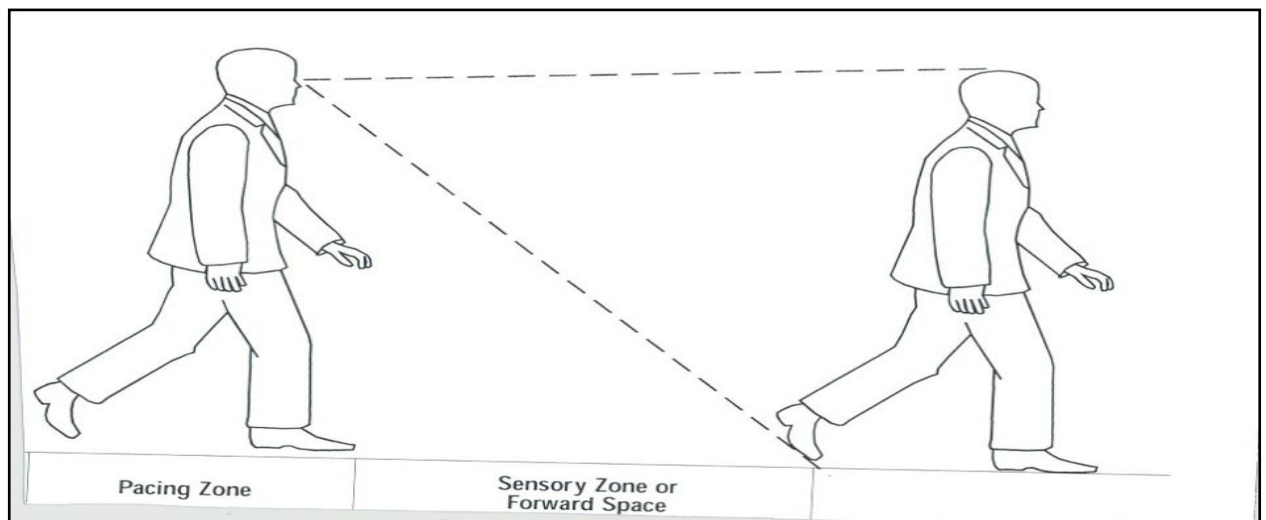
Figure 4: Body ellipse in plan view.



Source: HCM, 2000

A walking pedestrian requires a certain amount of forward space. This forward space is critical dimension since it determines the speed of the trip and the number of pedestrians that are able to pass a point in a given time period. The forward space is categorized into a pacing and sensory zone (See Figure 5).

Figure 5: Pedestrian Walking Space



Source: HCM, 2000

2.5.4 Pedestrian Walking Speeds

Highway Capacity Manual 2000 outlines that walking speed is highly dependent on the proportion of elderly pedestrians (65 years old or more) in the walking population. If 0 to 20% of pedestrians are elderly, the average walking speed is 1.2 m/s. If the elderly people constitutes more than 20% of the total pedestrians, the average walking speed decreases to 1.0 m/s. On sidewalks, the free –flow speed of pedestrian is about 1.5 m/s.

2.6 Macroscopic Parameters of Pedestrian Traffic Stream

Macroscopic parameters are basically concerned with the aggregation of pedestrian movements into flow, density and speed (Teknomo, 2002). These parameters play a major role in the design and provision of pedestrian facilities including footbridges.

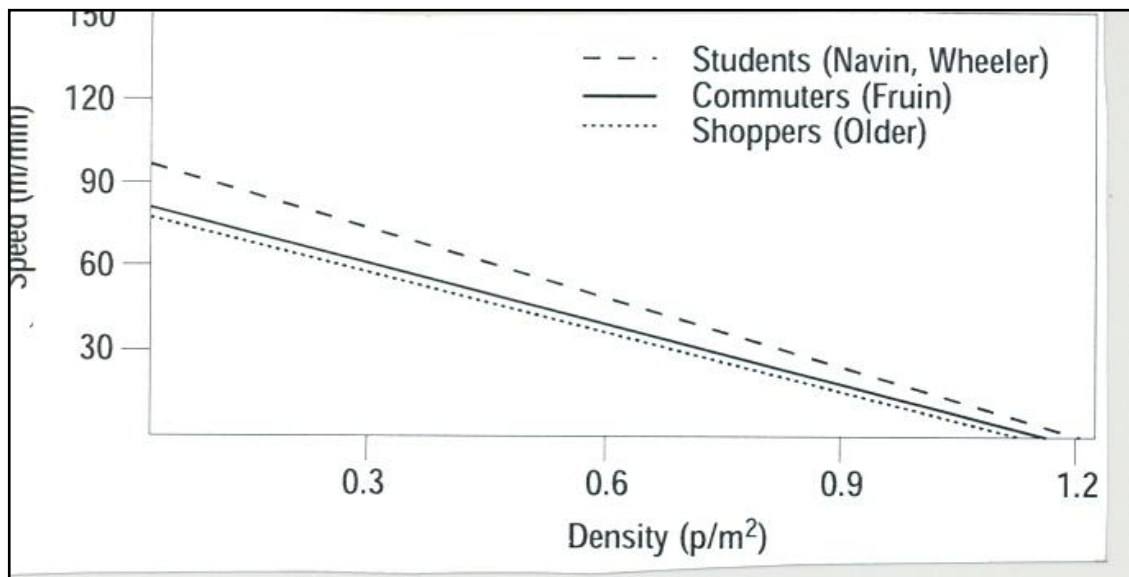
2.6.1 Principles of Pedestrian Flow

The qualitative measurement of pedestrian flow is the same as the one used for vehicular flow, such as the freedom to choose desired speeds and to bypass others (HCM , 2000). Other measures that are related to the pedestrian flow include the ability to cross a pedestrian traffic stream, to walk in reverse direction of a major pedestrian flow, to manoeuvre generally without conflict and changes in walking speed. Other factors that contribute to perceived level of service are confort, convenience , safety, security and economy of walking system.

2.6.2 Pedestrian Speed-Density Relationship

According to HCM, (2000), the relationship between speed, density and volume is similar to that of vehicular flow. As the volume and density increase, pedestrian speed declines. As density increases and pedestrian space reduces , the degree of mobility afforded to each individual declines, as well as the the average speed of pedestrian (See Figure 6).

Figure 6: Pedestrian Speed-Density Relationship



Source: Pushkarev and Zupan, 1971

2.6.3 Pedestrian Flow-Density Relationship

Olando, et al, (2003) outlines the relationship between density, speed and flow for pedestrians using the following formula: $V = S \times D$

where V = pedestrian flow per unit width (p/m/min)

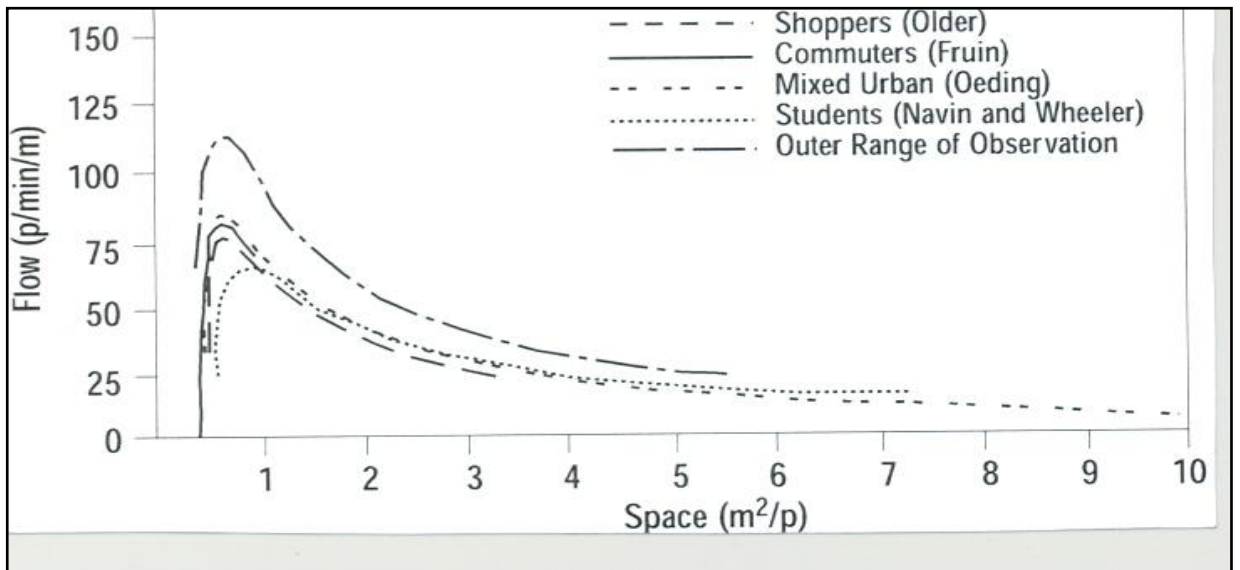
S = pedestrian speed (m/min) D = pedestrian density (p/m²)

Based on the above formula, V can be obtained by: $V = S/M$

where M = pedestrian space (m²/p)

Figure 7 shows basic relationship between flow and space. The condition at maximum flow represents the capacity of walkway facility. Figure 7 shows the average space per pedestrian varies between 0.4 and 0.9 m²/p. As the space is reduced to less than 0.4 m²/p, the flow rate declines. All movements effectively stop at minimum space allocation of 0.2 m²/p. This relationship shows that pedestrian traffic can be evaluated quantitatively by using LOS. At flow near capacity, an average of 0.4 to 0.9 m²/p is required for each moving pedestrian. However, at this level of flow, the limited area available restricts pedestrian speed and freedom to manoeuvre.

Figure 7: Relationship Pedestrian between Flow and Space

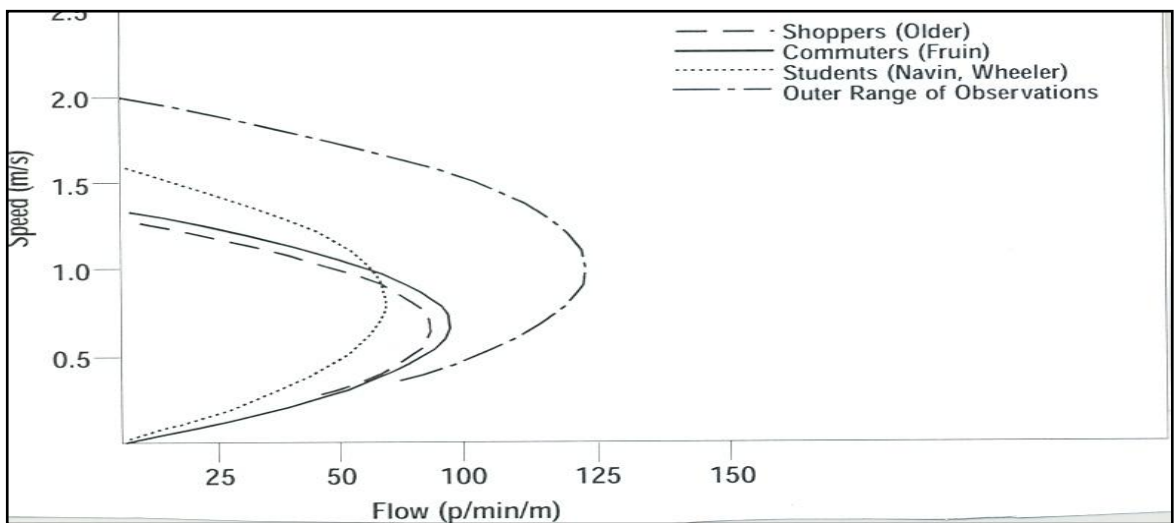


Source: Pushkarev and Zupan, 1971

2.6.4 Pedestrian Speed-Flow Relationship

Figure 8 shows the relationship between pedestrian speed and flow. The curves shown are similar to the vehicle flow curves. It means that when there are few pedestrians on a walkway or when pedestrians are at low flow levels, there is space available to choose higher walking speeds. As the flow increases, speed declines because of closer interactions among pedestrians. When critical level of crowding occurs, movement becomes difficult and both flow and speed decline (HCM, 2000)

Figure 8: Relationship between Pedestrian Speed and Flow

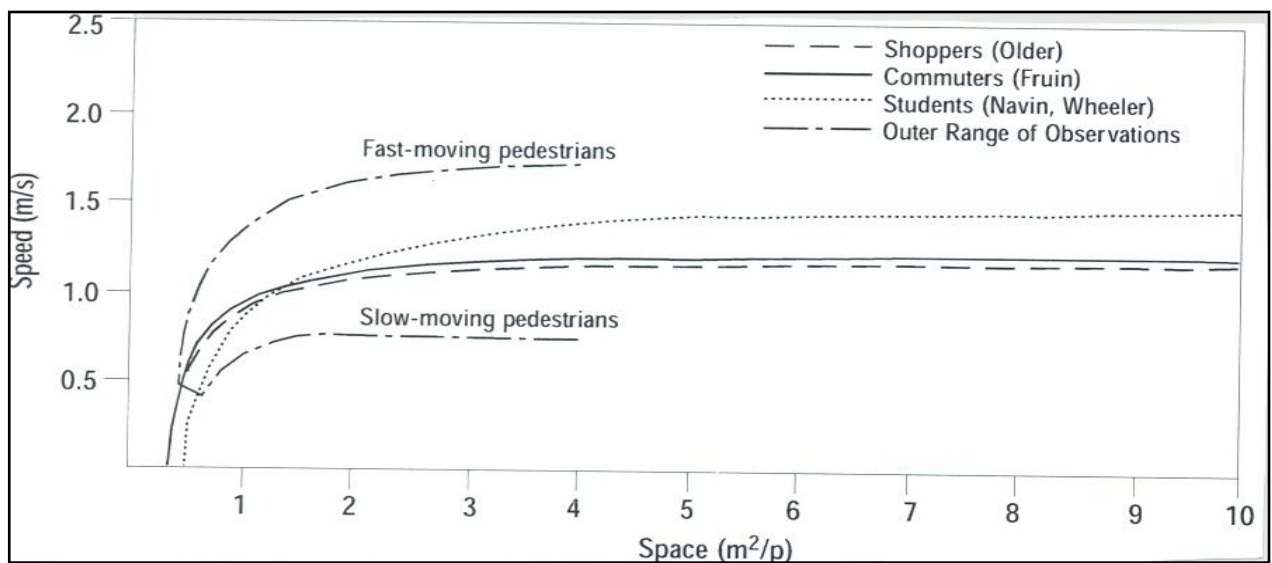


Source: Pushkarev and Zupan, 1971

2.6.5 Pedestrian Speed- Space Relationship

Figure 9 shows the relationship of walking speed and available space and suggests some point of boundary for developing LOS criteria. The outer range of observation shown in figure indicates that an average space of $1.5 \text{ m}^2/\text{p}$, even the slowest pedestrians cannot achieve their desired walking speeds. Faster pedestrians, who walk at speed of up to 1.8 m/s are not able to achieve that unless average is $4.0 \text{ m}^2/\text{p}$ or more (TRB, 2003).

Figure 9: Pedestrian Speed- Space Relationship



Source: Pushkarev and Zupan, 1971

2.7 Circulation on Stairways

The capacity of stairway is largely affected by the stairway width. People tend to walk in lines or lanes when traversing stairs. The width of a stairway determines both the number of distinct lines of people who can traverse the stair and the side-to-side spacing between people thereby affecting pedestrians' ability to pass slower-moving pedestrians and the level of interference between adjacent lines of people. The consequence is that meaningful increases in capacity are not directly proportional to the width, but occur in increments of about 0.75 m (Olando, et al, 2003).

Unlike the walkways, a minor pedestrian flow in the opposing direction on a stairway can result in a capacity reduction disproportionate to the magnitude of the reverse flow. As a result, a small reverse flow should be assumed to occupy one

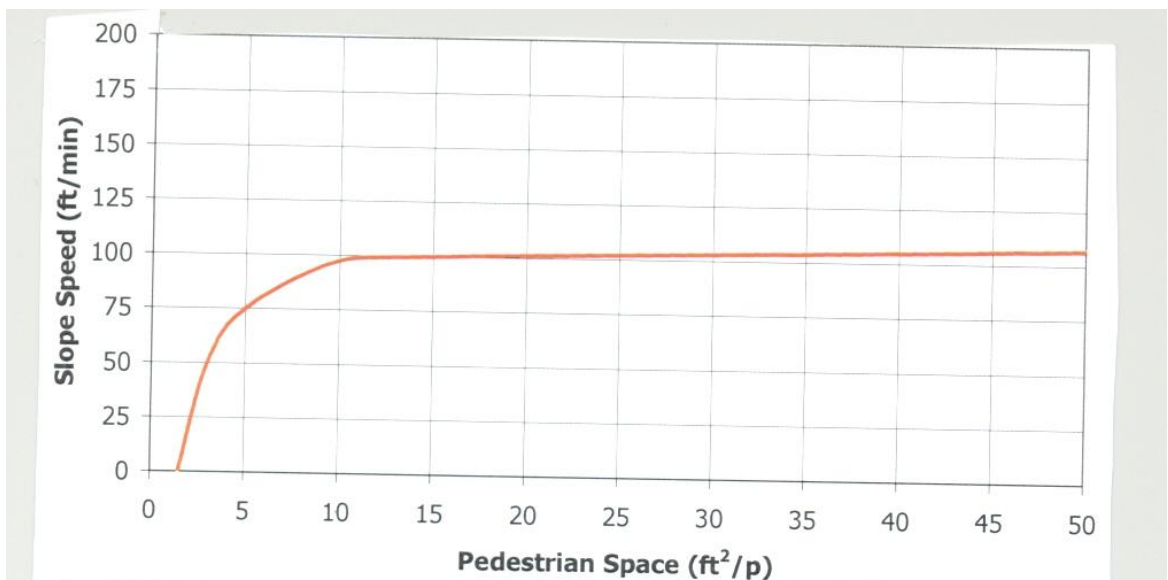
pedestrian lane of about 0.75 m. For a stair of 1.5 m wide, a small reverse flow could consume half its capacity.

Because pedestrians are required to exert a higher amount of energy to ascend stairs as compared with descending stairs, lower flow rates occur in the ascending direction. Ascending speeds on stairs have been shown to range from 12 m/min to 21 m/min, measured in vertical direction. Descending speeds on stairs range from 17 m/min to 31 m/min. Ascending speeds are slower on longer stairs because pedestrians slow as they reach the top. For general planning and design purposes, average speed of 15 m/min in the up-direction and 18m/min in the down direction are considered reasonable.

2.7.1 Relationship between ascending speeds and pedestrian space

Figure 10 illustrates the relationship between ascending speeds and pedestrian space. This exhibit reveals that normal ascending speeds on stairs are approached at an average pedestrian space of approximately 10 ft²/p (0.9 m²/p). Above approximately 20 ft²/p (1.9 m²/p), faster walking pedestrians are able to approach their natural unconstrained stair climbing speed and pass slower-moving people (Olando, et al, 2003).

Figure 10: Relationship between ascending speeds and pedestrian space

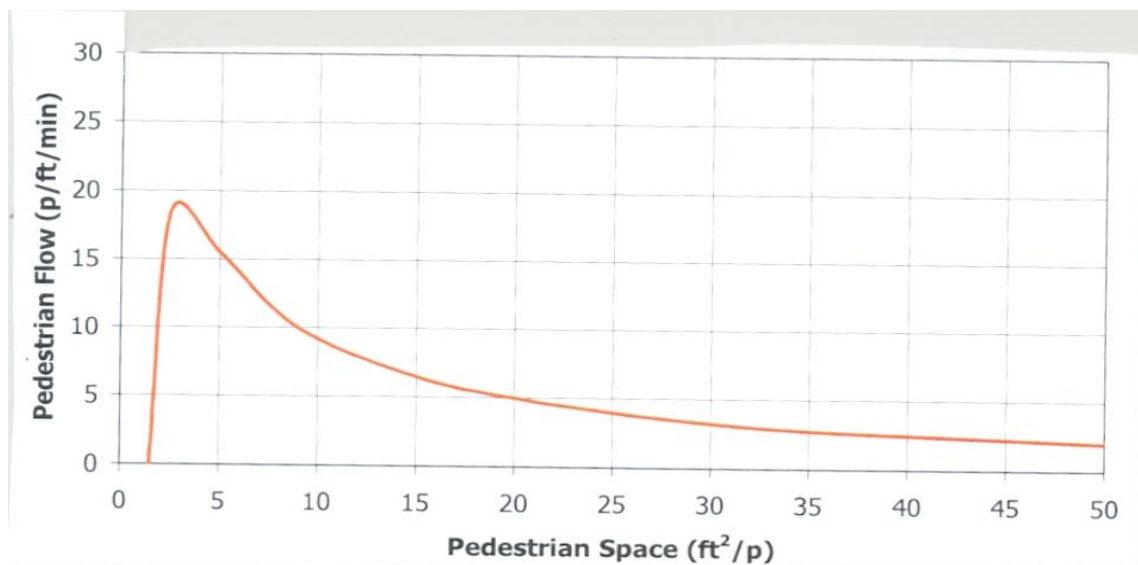


Source: Olando, et al, 2003

2.7.2: Relationship between Ascending Flow Rate and pedestrian space

Figure 11 illustrates the relationship between flow rates in the ascending direction and pedestrians` space. As observed in the exhibit, the maximum ascending flow rate occurs at a pedestrian space of approximately 3 ft²/p (0.3 m²/p) for this lower pedestrian space, ascending speeds are at a lower limit of normal range. In this situation, forward progress is determined by the slowest moving pedestrian. Above approximately 20 ft²/p (1.9 m²/p), faster walking pedestrians are able to approach their natural unconstrained stair climbing speed and pass slower-moving people (Olando, et. al, 2003).

Figure 11: Relationship between Ascending Flow Rate and pedestrian space



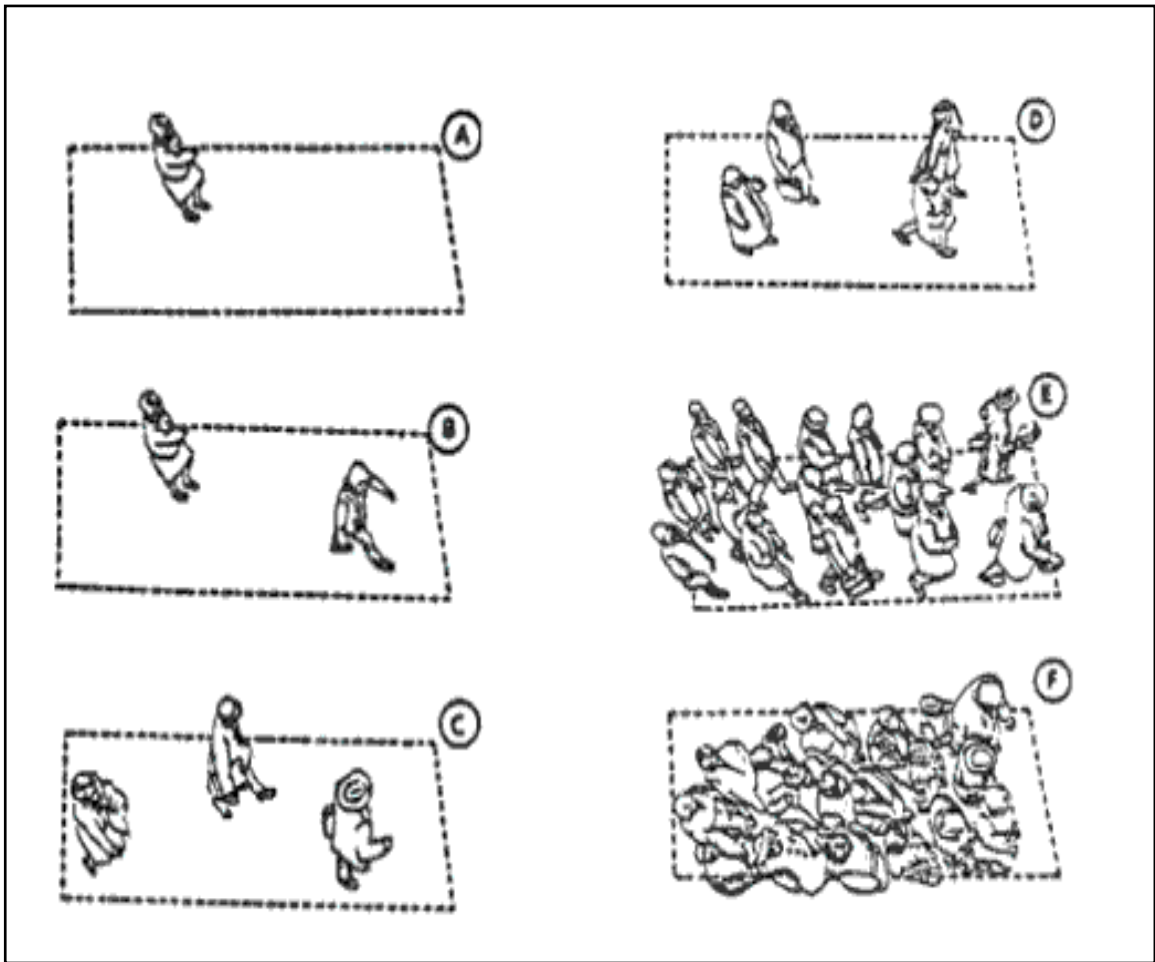
Source: Olando, et al, 2003

2.8 Pedestrian Level of Service on Non-motorized Facilities

2.8.1 Pedestrian Level of Service on Walkways

The simplest measure of LOS is space (measured in square metres per pedestrian). LOS level F (jammed) should be seen as the maximum number of pedestrians that can physically occupy a walkway or viewing platform. This is certainly undesirable from the point of view of pedestrian experience (Olando, et al, 2003). It is apparent from Figure 12 that as the density of pedestrians increases, the flow rate increases, however the average speed decreases

Figure 12: Illustration of Proposed Walkway Level of Service Thresholds.



Source: Fruin, 1971

2.8.2 Pedestrian Level of Service on Stairways

Pedestrians generally slow down when using stairways, so stairways must be wider than sidewalks to achieve LOS. The LOS concept for stairways is based on average pedestrian space available and average flow rate as demonstrated in Tables 5 and 6 respectively. The capacity of a staircase is largely affected by its width. The width of stairway affects the pedestrians' ability to pass slower moving pedestrians and to choose a desirable speed. Unlike walkways, a minor pedestrian flow in the opposing direction on a stairway can cut the capacity into half, therefore stairway design should consider directionality of flow (Olando, et al, 2003).

Table 5: Pedestrian LOS on Stairways

LOS	Average Pedestrian Space (m ² /peds)	Flow per Unit Width (peds/m/min)	Description
A	≥1.9	≤ 16	Sufficient area to freely select speed and to pass slower-moving pedestrians. Reverse flows cause limited conflicts
B	1.4-1.9	16-23	Sufficient area to freely select speed with some difficulty in passing slower-moving pedestrians. Reverse flows cause minor conflicts
C	0.9-1.4	23-33	Speeds slightly restricted due to inability to pass slower-moving pedestrians. Reverse flows cause significant conflicts
D	0.7-0.9	33-43	Speeds restricted due to inability to pass slower-moving pedestrians. Reverse flows cause significant conflicts
E	0.4-0.7	43-56	Speeds of all pedestrians reduced. Intermittent stoppages likely to occur. Reverse flows cause serious conflicts
F	≤ 0.4	Variable	Complete breakdown in pedestrians flow with many stoppages. Forward progress dependednt on slowest moving pedestrian

Source: Orlando, et al, 2003

According to the Washington Metropolitan Area Transit Authority (2005), stairways should be designed to operate at LOS C or better during the 15-minute peiod and the following methodology can be used to determine the width of a stairway needed to achieve the desired LOS:

- Estimate the peak 15-minute pedestrian demand for walkway

- Choose a target maximum pedestrian flow rate (v) that corresponds to the appropriate LOS.
- Compute the design pedestrian flow (persons/minute by dividing the 15-minute demand by 15
- Compute the required width of stairway by dividing the design pedestrian flow by the maximum pedestrian flow rate.
- Increase the stairway width by a minimum of one traffic lane (30”) when minor, reverse-flow pedestrian volumes occur.
- Adequate space for queues at both ends of stairways should also be considered.

Table 6: Recommended HCM pedestrian Level of Service (LOS) criteria for stairs,

LOS	Space (m ² /ped)	Flow Rate (ped/min/m)	Avg. Horizontal Speed	
			(m/min)	(m/s)
A	≥1.9	16	32	0.53
B	1.6-1.9	16-20	32	0.53
C	1.1-1.6	20-26	29-32	0.48
D	0.7-1.1	26-36	25-29	0.42
E	0.5-0.7	36-49	24-25	0.4
F	≤0.5	var.	<24	<0.40

Source: TRB, 1994 and Virkler, 1996

Olando, et al, (2003) outlines evaluation procedures for determining the LOS for stairways. The LOS “E” and “F” (17 pedestrians per foot of width per metre or 55 p/m/min) represents the maximum capacity of stairway.

The procedures to determine the required stairway width are based on maintaining a desirable pedestrian LOS. For normal use, it is desirable for pedestrian flows to operate at or above LOS C or D (Olando, et al, 2003). The following is a list of recommendation for determining the required stairway width:

- Based on the desired LOS, choose the maximum pedestrian flow rate from Table 6.
- Estimate the directional peak 15-minutes pedestrian demand for the stairway

- (c) Compute the design pedestrian flow (persons/minute) by dividing the 15-minute demand by 15
- (d) Compute the required width of stairway (in feet or metres) by dividing the design pedestrian flow by maximum pedestrian flow rate.
- (e) Increase the stairway width by minimum of one traffic lane (30 in or 0.75m) when minor, reverse –flow pedestrian volume occurs frequently.

Olando, et al, (2003) also outline the procedures of determining the stairway capacity. In this case the capacity of stairway is regarded as LOS “E” (51.8 p/m/min). For given stairway width, the following steps may be used to compute the capacity:

- (a) Compute the design pedestrian flow (ped/min) by multiplying the width of stairway by (51.8 p/m/min).
- (b) Adjust for friction due to bi-directional flows by deducting 0 to 20% depending on the pattern of flow.
- (c) Compute the pedestrian capacity (p/h) by multiplying the design pedestrian flow by 60.

The size of stair queuing area is also very important because it determines the ability of stairway approaches to accommodate a considerable number of pedestrians intending to use the stairway. According to Olando, et al, (2003), the following steps are adapted:

- (a) Compute the capacity of stairway
- (b) Compute maximum demand by determining the maximum number of pedestrians arriving at the approach of stairway at one time
- (c) Determine the number of pedestrians exceeding capacity by subtracting the capacity from the demand.
- (d) Compute the required queue area by multiplying the number of pedestrians exceeding capacity by 5ft^2 (0.5m^2) per pedestrians

2.8.3 Design Projection

A variety of pedestrian sketch plan methods have been developed to estimate pedestrian volumes under existing and future conditions (Federal Highway Administration, 1999). Sketch plan methods can be defined as a series of simple calculations to estimate the number of bicycles or pedestrians using a facility or area (Porker, 2009). These methods generally use pedestrian counts and regression analysis

to predict volumes as a function of adjacent land uses (e.g. sq m of office or retail space) or indicators of trip generation (parking capacity, transit volumes and traffic movements). According to Federal Highway Administration (1999), alternatively, data on surrounding population and employment may be combined with assumed trip generation and mode split rates to estimate levels of pedestrian traffic. These methods can be used to identify areas of high pedestrian traffic based on existing land use, thereby eliminating the need to conduct pedestrian cost on all facilities. They can also be used to forecast changes in pedestrian volume as result of future land use or transportation trip generation.

Matlick (1996) used household population, national transportation survey percentages and activity centre data to calculate potential walking trips in specific corridors. It is a quick method or tool to be used by planners to identify the priority areas for pedestrian facility expenditures. The following steps were developed by Matlick to determine potential walking trips.

Step 1: To represent the majority of pedestrian trips, identify a 0.8 km buffer zone around the selected corridor.

Step 2: Identify traffic generators such as the number of housing units by dwelling types, average persons per unit for each dwelling type and average number of trips per person from these locations.

Step 3: Calculate the Total Corridor Generated Trips (TCGT)

Total Corridor Generated Trips = Population x trip per person

Step 4: Calculate the Potential Pedestrian Trips (PPT)

Potential Pedestrian Trips = TCPT x (All trips < 0.8 km)

Step 5: Calculate the Estimated Primary Trips (EPT)

Estimated Primary Trips = PPT x (Percentage known walking trip < 0.8 km)

2.8.4 Design Working Life

According to Manual for Roads and Bridges Part 4-Bridges and Culverts Draft (2009), the design working life for concrete, stone and steel bridges shall be 100 years

working life. Concrete and steel culverts with an opening or diameter less than 2.0 m and all timber bridges shall be designed for 50 years working life. Based on this guideline, it should be therefore noted that the design working life for Uthiru pedestrian footbridge is 50 years. Since the bridge was constructed in 1990, it is expected that the design life year of the footbridge is the year 2040. It could be further assumed that the planner provided the 2.2 m footbridge width to cater for continuous use with better operational LOS till the year 2040.

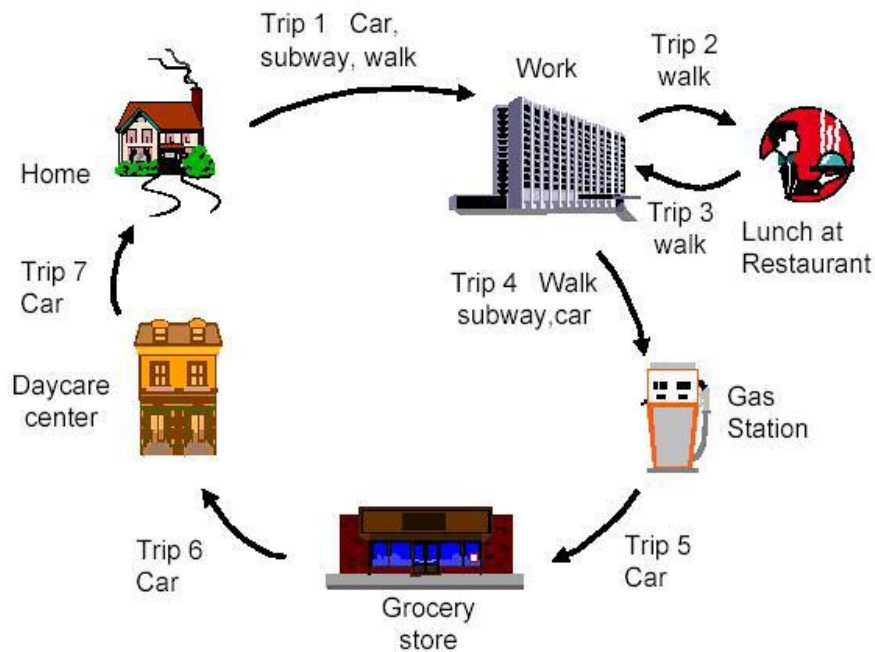
2.9 Origin and Destination

The study captured the origin and destination of pedestrians using the footbridge. This section therefore captures some concepts relating to pedestrian travel on trip purposes done on Uthiru Pedestrian Footbridge.

2.9.1 Trip Purpose

A trip is a one-way person movement by one or more modes of travel and each trip will have an origin and a destination (Salter, 1985). According to Salter (1985), these trips are divided into home-based and non-home-based trips. All trips which have one end at home are said to be generated by the home and other end of the trip is said to be attracted to the zone in which it commences or terminates. For non-home-based trips, the zone of origin is said to generate the trip and zone of destination is said to attract the trips. The trip ends are classified into generations and attractions (Kadiyali, 2002). According to Kadiyali (2002), a generation is the home end of any trip that has one end at home (i.e. of a home-based trip) and is the origin of the trip with either end home based home (i.e. of a non-home-based trip). An attraction is the non-home end of a home-based trip and is the destination of the trip with neither home-based (i.e. of a non-home-based trip). Figure 13 is an example of trips on a travel day.

Figure 13: Example of trips on a travel day



Source: Trip General Model for Pedestrians on NHTS, 2001

2.10 Legal, Institutional and Regulatory Framework

2.10.1 Nairobi Metro 2030

The Government of Kenya-Ministry of Nairobi Metropolitan Development (2008) through the policy document titled Nairobi Metro 2030 outlines that one of the key strategies would be to deploy world class infrastructures facilities and services. On road infrastructure measures, the focus will be on new construction and improvements of existing network. Improvements in the existing network would focus on highway capacity improvements, bypasses development and development of priority road network.

It is noted that this policy document has some consideration of non- motorized transport elements. For instance, the document outlines that the focus on non motorised transport will be on adequate provision for metropolitan wide non motorised transport and mobility network. It is therefore assumed that all pedestrian facilities

which include pedestrian footbridges to be provided will be wide enough to meet the recommended LOS C.

2.10.2 Traffic Act Chapter 403 Laws of Kenya

Transport issues are basically covered under the Traffic Act Chapter 403-Laws of Kenya. Even though the Government of Kenya recognizes non motorized transport and pedestrianization as a form of transport, the act does not include the definition of a pedestrian in the preliminary section of the act which contains definitions of key words used in the act (Government of Kenya, 2009).

Part X of the Traffic Act Chapter 403 incorporates miscellaneous provisions as to roads. The act outlines offences in connexion with roads, encroachment on and damage to roads and prohibition on use of tracked vehicles. An example of an offence in connexion with roads is that no person shall willfully or negligently lead or drive and animal or vehicle on footpath or in road drains. Chapter 117 of the Act outlines minor offences which includes removal of police notification of traffic offence without the approval of police, failure to appear in court for traffic offence prosecution and failure to pay fine after being found guilty of traffic offence by the court. These minor offences and offences in connexion with roads are similar to offences of crossing of roads at un-designated places which includes pedestrian footbridges. However, the act has not included if crossing at un-designated crossing points is a traffic offence and consequently no corresponding fine has been formulated.

Chapter 46 outlines the aspect of causing death by driving or obstruction an offence and punishable by minimum 10 years imprisonment. Reckless driving attracts a penalty KSh 5,000 or minimum of six months imprisonment according to section 47 of Cap 403. The fine was revised to a minimum of KSh 100,000 and maximum of KSh300, 000 or minimum of two years imprisonment (Traffic Amendment Act, 2012). The fine for driving on pavement or pedestrian walkway was introduced in section 45 and attracts a penalty of KSh 80,000 or 3-6 months imprisonment.

It was pointed out by the Divisional Traffic Manager of Kabete Police Station that some drivers end up being involved in the accidents when they try to avoid pedestrian who cross at grade. It is inevitable that the pedestrian is the main culprit.

However, the road act does not capture this as an offence to the pedestrians and attach a relevant fine or jail sentence. .

2.10.3 The Local Government Act Chapter 265 - Laws of Kenya

Part XIV of the Local Government Act Chapter 265, article 201 empowers the local authorities to make by-laws from time to time in respect of all matters as are necessary or desirable for the maintenance of health, safety and well being of the inhabitants of the area or part thereof and for the good rule and government of such area or part thereof (Government of Kenya, 2010). Based on this act, the assembly should be able to formulate bylaws on jay walking and the corresponding fines for those who contravene this law.

2.10.4 Non-Conforming Behaviour –Bylaws

2.10.4.1 Introduction to Non-Conforming Behaviour

Traffic violations occur when road users including pedestrians seek an increased mobility by disregarding traffic laws and regulations (Zaki, 2012). According to Zaki, (2012), this behaviour can come at the expense of accepting additional collision risk. There are two types of traffic violations. The first one is spatial violations where pedestrians decide to cross at non-designated crossing regions. The second one is temporal violation when pedestrians cross at an intersection during the improper signal phase. In this report, the concentration is on spatial violations which are related to jay walking.

2.10.4.2 General Nuisance By-Laws, 2007 City Council of Nairobi

The City Council of Nairobi formulated the General Nuisance Bylaws in 2007 in exercise of powers conferred to City Council of Nairobi by Section 201 of the Local Government Act, Cap 265. Part III of the by-laws consists of laws relating to “Roads and Streets”. Section 19 outlines various regulations on “Nuisance in Streets”. Section 19 (w) states that “Any person who fails to observe traffic lights or zebra crossing or any other directional signs, shall be guilty of an offence”. The by-laws do not include specific by-laws on jay walking. Even in Part I –Preliminary which consists of interpretation of terms used in the bylaws, the definition of jay walking was not included.

The by-laws do not have details of fines for the offenders on jay walking though stakeholders estimate that fine ranges between KSh 500 to KSh 1,000 per offender. The by-laws have some details of other fines which are imposed when a road user breaks the by-laws. For instance, when a pedestrian or motorist crosses the road when traffic lights are red, the road user is fined KSh10, 000.00. A pedestrian who crosses the road while talking on mobile phone is fined KSh 500.00. Passengers that are found alighting or boarding matatus at non-designated matatu stops are fined KSh 10,000.00. These fines were captured in the Kenya News Alert (2012) by Haron.

The other shortfall with the set of bylaws is that the bylaws are not comprehensive. There are some bylaws which are captured in the media but are not included in the official documents. For instance, one of the by-laws stipulates that is an offence to drag a suitcase on the street surface as this may cause destruction of road surface (The Nairobi newspaper dated 1-7 March 2013, page 2). According to the paper, the bylaws were created by John Ainsworth, Kenya's Chief Native Commissioner at that time of 20th century (See Picture 13).

Picture 13: Dragging of suitcase is illegal in Nairobi



Source: The Nairobi Newspaper, 2013

Although provisions of the Traffic Act and by-laws of local authorities recognize the use of certain non-motorized transport facilities, enforcement of these

by-laws for the benefit of other road users is weak. Enforcement is the responsibility of local authorities (Ministry of Transport, 2010). There is poor enforcement mainly because of corruption. The local assemblies though with limited human and financial resources, deploy security personnel to patrol some streets in order to enforce on some bylaws. When offenders are caught, they are supposed to pay the stipulated fines. However, offenders are not aware of the stipulated fines and are told high fines. Offenders negotiate for small fines and are released upon payment of such fines. No official receipts are issued and the security guards benefit from such clandestine activities (The Nairobi Newspaper dated 1-7 March 2013, page 2).

2.10.4.3 Town of Sidney “Streets and Traffic Regulation Bylaw No, 1966, 2010”

Sidney is a town located at the northern end of Saanich Peninsula on Vancouver Island in the Canadian Province of British Columbia. The Municipal Council of Sidney formulated by-laws on Streets and Traffic Regulations in 1966 and amended the bylaws in 2010. The by-laws include aspects of jay walking and relevant fines for contravening this by-law.

Section 68 (b) of the by-laws in Part V of the by-laws states that “ No person shall jay walk within the Town of Sidney on any street bounded by Sidney Avenue/James Boulevard to the north, Bevan Avenue to the south, the waterfront to the east and Highway 17 to the west”. Part V of the bylaws stipulates a fine of \$50 for contravening this by-law of jay walking.

2.10.4.4 By-Laws on Pedestrians in New Zealand

The Wellington City Council formulated a set of bylaws on jaywalking though details of the date of formulation were not provided. The availability of bylaws was brought to the attention of the public by the New Zealand Bus Services as one of country’s largest transporters. NZBS joined the call for the police to crackdown on jay walking. The concern was raised after it was observed that a number of pedestrians were getting hurt or killed by motorists because of jay walking on Wellington Streets. The Chief Executive of NZ Bus, Mr. Baird proposed that though jay walking is not a crime in New Zealand, pedestrians should be fined for crossing at non-designated places such as:

- “don`t cross sign”,

- those who cross within 20 m of pedestrian crossing
- those who fail to cross within 20 m of traffic lights
- those that fail to keep on the footpath

(<http://www.3news.co.nz/Bus-drivers-want-fines-for-pedestrians-who-jaywalk/tabid/423/articleID/231988/Default.aspx#ixzz2ETnGHiV5> accessed on 28th December, 2012).

Another body in New Zealand which represents drivers, proposed a fine of \$200 to those that cross at non-designated places. From 2007 to 2012, the police issued just 23 infringement notices to pedestrians in New Zealand and 10 were handed in Wellington. The fines ranged from \$10 to \$35.

2.10.5 Bylaws on Outdoor Advertising

2.10.5.1 Physical Planning Act, Cap 286

The Nairobi City Council is guided by the Physical Planning Act, Cap 286 on issues relating to advertising and outdoor billboards. Section 26 (1) state that display of advertisements in form of hanging signs shall require permission from the local authority and the director. Section 26 (2) (a and c) states that the grant of permission shall depend on location, size and colours of the billboard including traffic and pedestrian safety. Section 27 of the Act empowers the local authority to enforce removal of advertisements that affect traffic and pedestrian safety. Such advertisements include advertisements that are placed on pedestrian footbridges which end up blocking visibility of pedestrians when they are crossing the footbridge.

2.10.5.1 General Nuisance By-Laws, 2007 City Council of Nairobi- Advertisement

Outdoor advertisement is one way of raising revenue for general operation of city councils. The fee for the advertisement varies depending on the size of the advert, location and duration of display. It is believed that City Council of Nairobi charges between KSh 10,000 and KSh 30,000 per annum for billboard advertisement according to consultation done with stakeholders. The researcher was not able to source the fee schedule for outdoor advertisement for City Council of Nairobi. However, it has to be pointed out other assemblies like Municipal Council of Mombasa have detailed fee schedule for fees and charges on street name and suburban signs advertisement. This

is contained in section 22 and 23 respectively under items 174, 176, 177,178 and 180 (Refer to Table 7 for details).

Table 7: City of Mombasa Fees and Charges

Section 22. Street Name/Suburban Signs Advertisement		
174	Application Fee	KSh 2,000
	Annual Fee	KSh 20,000
Section 23. Advertisement on Billboards		
176	Billboard Development Fee (Structure)	KSh 50,000
177	Application Fee	KSh 50,000
178	Municipal Charges per year for 3.0 sq. m or less	KSh 30,000
180	Annual ground rent per site on private property	KSh 120, 000
181	Annual ground rent per site on road reserve	KSh 180, 000

Source: Mombasa City Council, 2013

Though the City Council of Nairobi has by-laws on roads and streets, not much has been documented on billboard advertisements. Section 12 of the by-laws outlines some bylaws on advertisements with projections but there are no details for easy follow up and enforcement. This is contrary to the County Council of Nakuru which formulated the by-laws on Advertisement in 2006. The by-laws include the interpretation of advertisement, outlines different advertisement material used, places where advertisements have to be placed and corresponding penalties for contravening the by-laws. For instance, a fine of KShs 2,000 is imposed on the offender or six months jail imprisonment for contravening this by-law.

The revenue which is collected by city assemblies on any advertisement is deposited in the pool account for assemblies and it is normally used for the day to day operation of the council including payment of salaries and wages to council workers. No resources are used for maintenance of the footbridge even in case where the advertisement is done on the footbridges. Besides that there is conflict in policy in

terms of responsibility of maintenance of the footbridges. In this case, Uthiru Bridge is on A104 and this under is under the jurisdiction of KeNHA. It is therefore assumed that any maintenance works to be done on the footbridges on Waiyaki way is under the jurisdiction of KeNHA under routine maintenance programs.

In terms of the impact of the advertisements to pedestrian visibility, it was generally noted that most engineers, agreed that if at all advertisements are to be placed on the footbridges, the safety of pedestrians should be considered.

2.11 Previous Studies in Other Countries

2.11.1 Motives of Disuse of Pedestrian Bridges in Arequipa

Walter, (2012) carried out a reaserch in Peru on pedestrian footbridges. The objective of the study was to find out the factors which cause the disuse of pedestrian bridges in Arequipa City. The method used was a descriptive study based on a survey gathering data on age, gender level of education, origin and destination including experience of previous accidents. 360 pedestrians which were composed of 270 males and 90 females, who moved along pathways next to three city bridges such as Avenida Venezuela Bridge, Avenida Alcides Carriion Bridge and Avenida Ejercito Bridge, were studied.

The results of the survey showed that the average age of the sample was 31.97 years and that the level of education did not influence the use of bridges. Lack of time, sloth and the fear for attacks and robbery were the most frequent motives marked by pedestrians as causes for ignoring the pedestrian bridges.

The study concluded that it was necessary to take measures in terms of security and surveillance at bridges, as well as launching awareness-raising campaigns that provide information to pedestrians on the possible risks of wrongly crossing the streets and of breaking the law. The study did not however establish the recommended LOS C as a means of evaluating the capacity of the bridge.

2.11.2 The Effect of an Overpass on Pedestrian Injuries on a Major Highway in Uganda

Mutto, et al. (2002) carried out a research on the pedestrian footbridges in Uganda. They were several objectives of the study which included describing the pedestrian population, their use of an overpass, assessing pedestrian perceptions and responses to the risk of traffic crashes, determine pedestrian injuries in relation to

traffic flow, and compare traffic crash and pedestrian injury rates before and after the overpass construction.

The study was conducted in Nakawa trading center approximately six kilometers from the center of Kampala City on a major highway. The trading center has a busy market, small retail shops, industries, a sports stadium, offices, low cost housing estates and schools. The trading centre had and an estimated population of 6,226 residents and 15.1% of the population was composed of students.

The methodology used included observing pedestrian road behavior and traffic patterns, reviewing police traffic crash records one year before and one year after overpass construction and interviewing a convenient sample of overpass and non-overpass users to assess their perceptions of risk.

The results showed that out of a total of 13,064 pedestrians that were observed, the overall prevalence of pedestrian overpass use was 35.4%. A larger proportion of females (49.1%) crossed on the overpass compared to males (29.2%). More children (79.7 %) than adults (27.3%) used the overpass. The majority of pedestrians (77.9%) were worried about their safety in traffic but only 6.6% thought of the overpass as an appropriate means to avoid traffic accidents. Traffic was not segregated by vehicle type. Mean traffic flow varied from 41.5 vehicles per minute between 0730-0830 hours, to 39.3 vehicles per minute between 1030-1130 hours and 37.7 vehicles per minute between 1730-1830 hours. The proportion of heavy vehicles (lorries, trailers, tankers, and tractors) increased from 3.3% of total vehicle volume in the morning to 5.4% in the evening, 44.0% of the collisions occurred in the evening with 35 pedestrian casualties before and 70 after the overpass intervention.

The study concluded that the prevalence of pedestrian overpass use was low with adult males least likely to use it. Pedestrians had a high perception of risk, which did not seem to influence overpass use. Pedestrians were more likely to be injured during slow traffic flows. There were more traffic crashes and pedestrian injuries but fewer fatalities after the construction of the overpass. The study did not however, establish the recommended LOS C as a means of evaluating the capacity of the bridge.

2.11.3 Pedestrian/Bicycle Overcrossings: Lessons Learned

Renfro, (2007) carried out a research on 29 pedestrian footbridges in the city of Portland as as part of the fulfilment for the award of Masters of Arts for Urban and Regional Planning at Portland State University. This study examined location, design

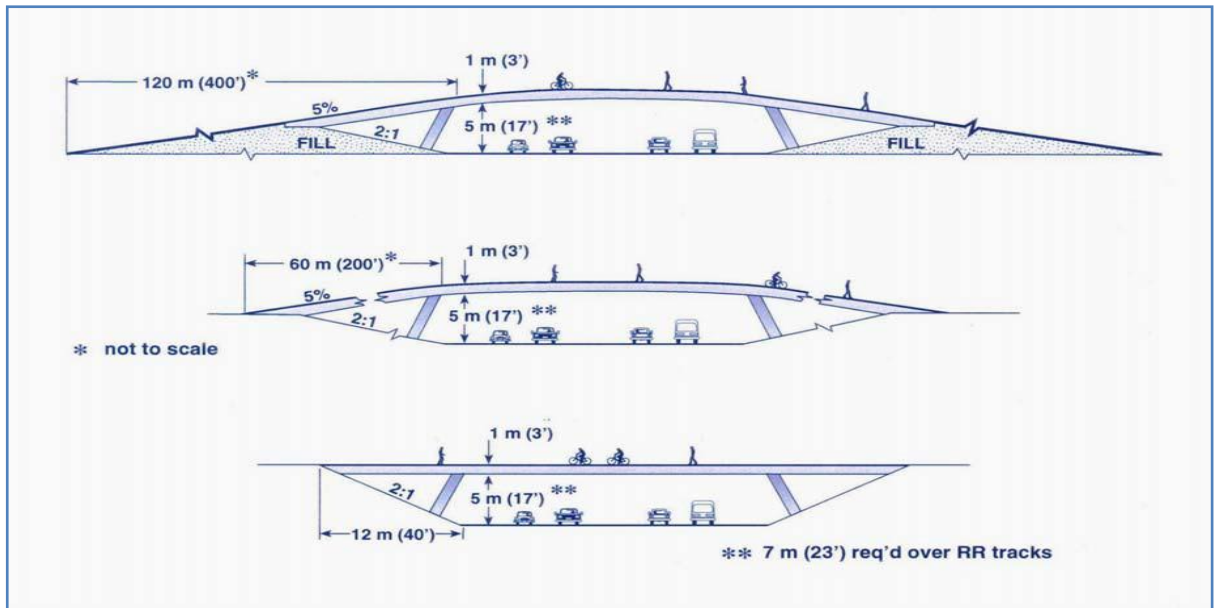
and other parameters of pedestrian/bicycle overcrossings and evaluated how well they serve their intended users. The findings were based on detailed field assessments of 29 diverse bridges in terms of age, length, access provisions, what they cross and several other elements. A review of national and local design guidelines, case studies and other reports formed part of the findings of this report. This study aimed at informing planners, designers and other parties in developing new pedestrian/bicycle overcrossings and come up with measures on how to improve existing facilities.

Site visits were conducted at each of the 29 sites to get inventory the overcrossing structure, access provisions and the surrounding pedestrian/bicycle environment. The following site measurements were done: bridge and access ramp lengths and widths, vertical and horizontal clearances, fence and railing heights and other relevant data. An inventory and other assessment was also done and included elements precluding or discouraging at-grade crossings, connections between the bridge area and the surrounding transportation system and obstructions that could complicate pedestrian or bicycle travel. In some cases, agencies provided “as-built” drawings highlighting detailed structure elements which proved useful in the inventory process.

The study reviewed the location of the pedestrian bridges in relation to pedestrian/bicycle destinations, desired routes using an overcrossing versus crossing at-grade, location of pedestrian/bicycle accommodations at nearby intersections, availability of way finding tools, provision of pavement markings and lighting on the bridges.

The research also reviewed the design elements which included overcoming vertical rises, verified the height of risers and treads of pedestrian footbridge and provision of ramps (American Disability Act, 1990). The study did not however, establish the recommended LOS C as a means of evaluating the capacity of the bridges (See Figure 14 for details of vertical height and ramp slopes).

Figure 14: Showing Overcrossings Height in relation to ground level



Source: Oregon Bicycle and Pedestrian Plan, 1995

2.11.4 Pedestrian Self-reports of Factors influencing the use of Pedestrian Bridges

Mikko, et al (2007) carried out a research on factors that influence the pedestrians to use or not to use the pedestrian footbridges. The use rate of five footbridges was observed in Central Business District of Ankara. After the observations, a survey was conducted among pedestrians using the five bridges and those crossing contrary to safe practice under them as well. A sample of 408 (n=408) was used.

In the data, the use rate of pedestrian bridges varied from 6-63%. The frequent use of the bridges when crossing was attributed to safety aspects and seeing time saving in using the footbridge. The study also established that frequent visits to CBD decreased the likelihood of using the bridge.

The study suggested that bridge use or non-use was a habit and not coincidental behaviour. For increasing the pedestrians` bridge use, escalators seem to be a good solution but traffic signals under the bridge may not increase the use rate. The use rate is likely to improve if safety benefits and convenience of using the bridge without considerable time loss are clearly visible to pedestrians. The study did not however, establish the recommended LOS C as a means of evaluating the capacity of the bridges.

2.11.5 Level of Service for Pedestrian Walkway at Bus Terminal

Azlan, (2010) carried out a research on determining the level of service at Larkin Bus Terminal in Malaysia as part of the fulfilment for the award of Bachelor Degree in Civil Engineering at Technology University of Malaysia. The main aim of the study was to determine LOS at bus terminal in order to understand the terminal operational conditions.

The researcher conducted the pedestrian survey as to determine the pedestrian demand. The dimensions of the walkway were measured for calculation of effective width and effective width area, pedestrian space and LOS. An oral interview was also conducted in order to establish the pedestrian profile using the bus terminal and their perception on the available walkway and waiting times.

The research established that the bus terminal provided the LOS E which was not in line of recommended LOS C. The designed effective width of 9.26 m was calculated against the existing 8.4 m. The short fall with study is that it concentrated in establishing the LOS at grade, thus in the terminal and did not establish LOS at grade-separated area which includes pedestrian footbridges.

2.12 Previous Studies in Kenya

2.12.1 Planning for the Pedestrian Mode of Travel Along Kibera Industrial Corridor

Ngegea, (1996) carried out a research in relation to planning for pedestrian mode of travel between Kibera residential zone and industrial area in Kibera as part of the fulfilment for the award of Masters of Arts for Urban and Regional Planning at University of Nairobi. The study looked at the operational characteristics of the pedestrian between the area with a view of coming up with proposals of enhancing their movement.

The study was able to provide some guidelines on travel pattern in Kibera relating to historical background of their journey origin and destination i.e. Kibera and industrial areas. The study also looked at those attributes of the pedestrians which aid in understanding the size, distance, social economic characteristics, directional and time pattern of routes of movement of pedestrian.

The study established that the pedestrian mode of travel has a unique role in urban transportation in Nairobi. The choice to walk in this study is a result of composite of issues namely socio-economic and behavioural characteristics. The study falls short of not designing any pedestrian facilities which include footpath, pedestrian overpass or zebra crossing in terms of adequacy in particular establishing the recommended LOS C on Kibera Pedestrian Footbridge.

2.12.2 The Problem of Pedestrian Movements in Central Nairobi.

Onyiro, (1997) carried out a research in Central Nairobi in relation to pedestrian movements as part of the fulfilment for the award of Masters of Arts for Urban and Regional Planning at University of Nairobi. The overall objective of the study was to define and examine the problem of pedestrian movement without the use of detailed quantitative analysis but rather by use of descriptive method which concentrates on exposing the major problems and to come up with viable solution to the problem. The other objectives included the identification of existing pedestrian facilities in CBD, identification of problem areas where there was pedestrian/vehicular conflict and setting out a policy for pedestrian movements in CBD.

The study reviewed the following pedestrian facilities or areas: uncontrolled crossing on Uhuru Highway, zebra crossing at Haile Selassie Avenue near Landhies roundabout, Jogoo House “B” pavement sidewalk, pavement sidewalk of a shopping area on Luthuli Avenue, pavement sidewalk on Pumwani Road, signalized pedestrian crossing on Government Road, the AgaKhan side walk and the pedestrian footpath off.

The study revealed or captures the danger to pedestrian inconveniences caused to pedestrians, visual intrusion and travel pattern. The study however did not include the evaluation on the extent to which the pedestrian bridge off Kirinyaga Road was used and establishment of LOS C as a means of evaluating the capacity of the bridges.

2.12.3 Social-Economic Characteristics and Mobility Issues of Pedestrian in CBD and Along Waiyaki Way Corridor, Nairobi.

James, G. (1998) carried out a research on socio-economic aspects and pedestrian mobility along Waiyaki Way as part of the fulfilment for the award of Masters of Arts for Urban and Regional Planning at University of Nairobi. The research focused on safety aspect of pedestrians along Waiyaki way corridor, the conflict of motor traffic and pedestrians which interferes with smooth flow of traffic

and social-economic characteristics of pedestrians along Waiyaki way corridor and CBD in Nairobi. The research, however, did not include the non-usage of pedestrian foot bridges along this road corridor and establishment of LOS C.

2.12.4 Provision of Pedestrian Transport Facilities in Nairobi City: The case of Jogoo Road

Kasuku, (2001) carried out a research on the provision of pedestrian transport facilities along Jogoo Road as part of the fulfilment for the award of Masters of Arts for Urban and Regional Planning at University of Nairobi. The study covered the assessment of the availability of pedestrian facilities and utilization levels of the pedestrian facilities. The pedestrian facilities which were evaluated included the pedestrian footbridges located at Buma /City Stadium, Makadara DC on Jogoo Road and pedestrian bridge at Hamza across railway line. The study did not however establish the recommended LOS C as a means of evaluating the capacity of the bridges.

2.12.5 Design Criteria Considerations of Pedestrian Crossings: The case of a Major Arterial in Nairobi

Mbeche , O. and Otieno, O. (2001) published a paper on the design criteria to be considered for pedestrian crossings. The paper was published after carrying out a research on the problems of pedestrian movements in Central Nairobi, along the section of Uhuru Highway, between Kenyatta Avenue and University Way roundabouts.

The aim of the study was to contribute to the discussion of non-motorized transport issues in urban road planning and design, establish the necessary criteria for efficient pedestrian movement crossing, assess pedestrian traffic requirements at junction crossings and determine the environmental statement on pedestrian movement at selected crossing.

Pedestrian survey which included general observation and manual counts, oral interviews and past literature were the methods which were used to obtain data for this research. The purpose of the manual count was to determine pedestrian volumes, their composition and directional distribution across walkways in the study area. The purpose of the interviews was to obtain information on opinion and attitude of pedestrians with regard to safety , confort and convinience at crossings. A sample of 20% was taken for oral interviews.

The pedestrian traffic surveys were analysed for their significance and implications. The pedestrian flow volume relationship indicating the number of persons walking past a given point in time (pedes/min/m) were recorded, averaged and summarized depicting time volume variations. Minima and maxima flow rates, speeds and space occupancies were also determined. The results also captured the pedestrian composition and time variations including pedestrian directional distribution in terms of those either going to town or coming from town.

The study noted that pedestrians walked during the day and rarely at night and this result resembled other previous pedestrian studies of cities elsewhere. The study established that the pedestrian flow rate of 79 peds/min/m on Kenyatta Avenue and 14 peds/min/m on University Way respectively were lower than the maximum value of 81 peds/min/m recommended by Fruin in his thesis in 1970. Similarly the pedestrian speeds observed of 1.20 m/s on crosswalk widths on Kenyatta Avenue and 1.13 m/sec on crosswalk widths on University Way were also lower than 1.02 m/sec as recommended by Fruin in his thesis in 1970. The study revealed a peak 40 pedestrians occupying standing area measuring 12.0 m² which translates into 0.3m² for each standing pedestrian and this was considered to be on lower side when compared to the 0.46 m² per person value recommended for groups waiting for traffic light (Fruin, 1971). The research noted that pedestrian space area per person investigated at Kenyatta Avenue and University Way crossings measured 0.7 m² and 3.5 m² respectively at peak hours. These figures were consistent with space ranges of 0.6 m² and 3.50 m² per person from several researchers (including those by Older, Navin and Wheeler, and Fruin between 1963-1971) reviewed by Pushkarev in 1978.

Though the study established adequacy of the pedestrian facilities which included level of service for standing pedestrians on waiting areas, the study only concentrated on grade crossing and did not attempt to determine the level of service for grade separated crossing facilities.

Tables 8 and 9 contain a summary of studies which were done outside and in Kenya and which are related to this area of study.

Table 8: Summary of Literature Review for Similar Studies done Outside Kenya

Researcher	Topic	Areas Covered	Missing Gaps
Walter, L. (2012)	Motives of disuse of pedestrian bridges in Arequipa	Degree of bridge usage and reasons associated with or non-usage	Recommended LOS C was not evaluated
Azlan, M. (2010)	Level of service at Larkin Bus Terminal in Malaysia	Determined the effective width, effective area, pedestrian space and LOS of terminal	Determined LOS for terminal which is at grade and did not establish LOS for GSPC like footbridge
Renfro, R. (2007)	Pedestrian/Bicycle Overcrossings: Lessons Learnt”	Studied general factors affecting PFB usage for 29 footbridges including design aspects	Recommended LOS C was not evaluated or determined.
Mikko, et al (2007)	Pedestrian Self-reports of factors influencing the use of pedestrian bridges	Studied rate of bridge usage by pedestrian on five bridges	Recommended LOS C was not evaluated or determined.
Mutto, et al (2002)	The effect of an overpass on pedestrian injuries on a major highway in Kampala	Studied how the construction of pedestrian footbridge contributed to reduction of accidents	Recommended LOS C was not evaluated or determined.

Source: Author, 2012

Table 9: Summary of Literature Review for Similar Studies done in Kenya

Researcher	Topic	Areas Covered	Missing Gaps
Mbeche, O. and Otieno, O. (2001)	Design Criteria Considerations of Pedestrian Crossings: The case of a Major Arterial in Nairobi	The study established pedestrian travelling time, flow rate, speeds & LOS for pedestrians occupying standing areas and pedestrian space .	The study established LOS for grade crossing and did not attempt to determine LOS for GSPC facilities.
Kasuku, S. (2001)	Provision of Pedestrian Transport Facilities in Nairobi City: The case of Jogoo Road	The study reviewed the availability of pedestrian facilities, extent of usage of footbridge along the corridor.	Recommended LOS C was not evaluated or determined.
James, G. (1998)	Social-Economic Characteristics and Mobility Issues of Pedestrian in CBD and Along Waiyaki Way Corridor, Nairobi.	The research focused on safety aspect of pedestrians , pedestrians & motor traffic conflict and social-economic characteristics of pedestrians	The research did not include the non-usage of PFB along this road corridor and establishment of LOS C.
Onyiro, G. (1997)	The Problem of Pedestrian Movements in Central Nairobi	The study identified the existing pedestrian facilities in CBD, pedestrian/vehicular conflict areas and established pedestrian movement policy	Pedestrian bridge off Kirinyaga Road was not studied & eestablishment of LOS C
Ndegea, S. (1996)	Planning For the Pedestrian Mode of Travel along Kibera Industrial Corridor	The study centred on reviewing general travel characteristics of pedestrians.	The study did not review the extent of use of pedestrian facilities like walkways and footbridge including LOS

Source: Author, 2012

CHAPTER THREE

3.0 METHODOLOGY

3.1 Desk Review

The literature review of the research was done using desk review. The secondary data was collected from the internet, journals, published and unpublished works and government policies on transport which included master plans, development plans, manuals, ordinances and acts of parliament.

3.2 Site Visit

A site visit was conducted to the area of study in order to carry out physical inspection of the existing bridge. An inventory of existing pedestrian footbridge was carried out and included the following:

- Safety-conflicts between bicyclists, pedestrians and cars
- User security
- Conformance with standards in respect to ADA.
- Lighting provision.
- Usage-appeal to different user groups and abilities and origination & desired destinations,
- Aesthetics
- Crossing location visibility- line of sight
- Land use- office or retail and adjacent sidewalk usage
- Street furniture
- Sidewalk geometry-width, length of study zone
- Sidewalk conditions- smooth surface, broken surface, obstacles and cleanliness
- Length of the footbridge, width and height

3.3 Survey Interviews

3.3.1 Interviews of Key Stakeholders

The researcher identified respondents as key informant experts from various institutions in the infrastructure industry involved in NMT planning, policy formulation, road project appraisal, construction supervision, monitoring of performance of road infrastructure, maintenance of road infrastructure and pedestrian

footbridges in particular. Table 10 outlines details of organisations which provided very valuable input into the research.

Table 10: List of Organisations contacted during the research

Institutions	Organisations
Universities	<ul style="list-style-type: none"> • University of Nairobi • Dedan Kimathi University of Technology
Government Ministries	<ul style="list-style-type: none"> • Ministry of Transport • Ministry of Public Works-Liberia • Ministry of Roads • Ministry of Local Government
Consulting Engineers	<ul style="list-style-type: none"> • Engiconsult LTD • Otieno Odongo & Partners • Gibb Africa • Cas Consultants • Stanceconsult Ltd • SMEC International Pty Ltd
Other Government Agencies	<ul style="list-style-type: none"> • Kenya Republic Police • Kenya National Bureau of Statistics
Government Road Agencies	<ul style="list-style-type: none"> • Kenya National Highways Authority • Kenya Urban Roads Authority • Road Funds Administration-Malawi
City Councils	<ul style="list-style-type: none"> • City Council of Nairobi • Municipal Council of Mombasa

Source: Author, 2013

The questionnaire was formulated based on some questions and clarification sought during the preliminary seminar which was conducted on 28th November 2012 in Civil Engineering Department in Project Room. Some guidelines adapted literature on design of pedestrian survey (S Turner, 2011) and (Krizek, 2010) (Refer to Appendix 2 for Questionnaire of Stakeholders).

3.3.1 Oral Interviews Questionnaire to Pedestrians

An oral interview questionnaire was administered by interviewing pedestrians who were crossing the footbridge as part of demographic survey. The oral interview also included the vendors selling their goods on the footbridge, business people with hawkers surrounding the footbridge and the *bodaboda*¹ business men.

A representative sample was calculated according to the total number of pedestrians using the footbridge in a day chosen at random. The following formula was used:

$$n = \frac{N}{1+Ne^2} \quad (3.1)$$

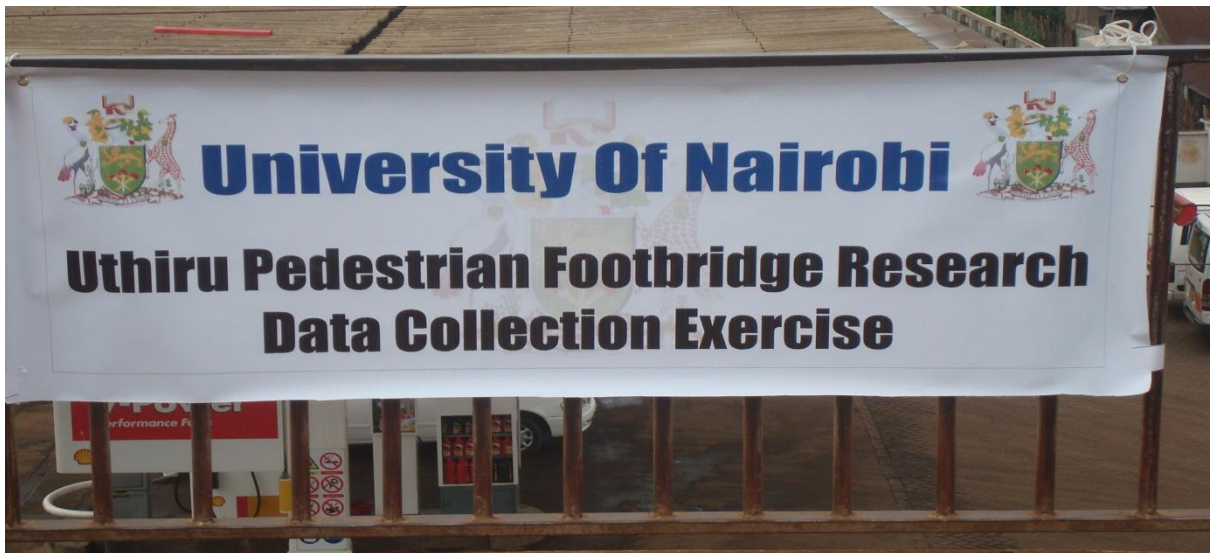
where n = Sample size

N = Peak Pedestrian population on the footbridge

e = Margin of error

In this case, sampling margin error of 5% was used which brought the results to confidence level of 95 % (Refer to Appendix 3 for oral interview questionnaire and Pictures 14 and 15).

Picture 14: Banner displayed to inform pedestrians about the research



Source: Author, 2013

¹ Bodaboda is the business of transporting pedestrians from place to place using motorcycles or bicycles

Picture 15: Research Assistant conduction oral interview on a female pedestrian



Source: Author, 2013

3.4 Pedestrian Survey Counts

Pedestrians passing through the pedestrian footbridge and those who crossed by jumping over the concrete barrier were counted using a manual counter every 15 minutes interval. The pedestrian count was carried out for one week including the weekends. The counting was done both during peak hours and off peak hours. During the peak hours, the counting was done from 6.30 -9.30 am and 4.00-7.00 pm and off peak hour counting was done from 11.00 am -1.00 pm. The pedestrian counting was carried out during peak hours of the day in order to get the maximum volume of pedestrians crossing the pedestrian footbridge.

The users of the footbridge were classified as pedestrians and cyclists. Pedestrians were classified as men, female, children and physically challenged. Pedestrian counts were done in both primary and counter flow directions. One research assistant was responsible for counting pedestrians using the footbridge from the filling station side and the other researcher was counting pedestrians using the footbridge from the other side. A third assistant researcher was responsible for counting pedestrians who were crossing at grade on either side of the pedestrian footbridge. The fourth research assistant was responsible for monitoring the 15 minutes time elapse (Refer to Appendix 5 for data sheet tallying form for pedestrians and Pictures 16 and 17).

Picture 16: Research Team that collected research data



Source: Author, 2013

Picture 17: Manual Counter used for pedestrian count



Source: Author, 2013

3.5 Vehicle Surveys

3.5.1 Vehicle Speeds

Vehicle traffic speeds were obtained by timing cars driving along a road segment on each carriageway separately. A measuring tape was used to mark the entry point and exit point. A stretch of 100 m for determining the distance of travel was

marked. Two observers were stationed at start point and other two observers were stationed at end point. One observer was responsible for identifying and describing a particular oncoming vehicle and another observer was responsible for starting the stop watch. Similarly another observer was responsible of identifying the vehicle passing through at the end point and another observer would indicate time taken by the vehicle at end point (Refer to Appendix 6 for the form used for vehicle speed survey).

3.5.2 Vehicle Counts

Picture 18: Research assistant carrying out traffic count



Source: Author, 2013

Picture 18 shows a research assistant undertaking a traffic count exercise. An hourly vehicle count was done for the number of vehicles passing along Uthiru Pedestrian Footbridge. A four hour count was done continuously for the four lane dual carriage traffic to Nairobi`s CBD and from Nairobi`s CBD. One research assistant was responsible for counting vehicles for each lane and the other was responsible for recording the time elapse of one hour.

3.6 Pedestrian Speeds

The researcher carried out the walking speeds survey for pedestrians. The distance of travel on the footbridge was measured as 62.5 m. Two research assistants were positioned at each pedestrian footbridge approach. One research assistant was

responsible for recording the time taken for each pedestrian to cross the bridge using a stop watch. The other research assistant was responsible for identifying a pedestrian to be monitored as part of the survey. The pedestrian survey was done at random and a convenient sample was surveyed. Different age groups which include the young, middle aged and the old were surveyed of either gender.

The walking speed for each pedestrian was calculated. The average speed was then calculated for the total number of pedestrians who were surveyed. The results were used to compare to the recommended ascending and descending pedestrian speeds on the staircase. The time taken by pedestrians who crossed at grade was also recorded. The results were linked to the “*convenience ratio*” determined by dividing the average time taken by pedestrians who crossed the footbridge by the average time taken by pedestrians who crossed at grade.

3.7 Data Analysis

The data was analysed using Microsoft access and Microsoft excel. In the Microsoft access, the tables were created for the entry of the questionnaire including the expected responses in the drop down menu. The form was used for entering the data collected for each respondent and the query design command was used to determine the number of responses for each question based on the total number of respondents. The Microsoft excel was then used to produce graphs for the responses generated from the query design command. .

3.8 Pictorial Presentation

Pictures were captured during site visit to depict the present site conditions. Pictures were also taken during the pedestrian count exercise, pedestrian oral interview, traffic speed survey and traffic count survey in order to depict pedestrian behaviour and general site proceedings.

CHAPTER FOUR

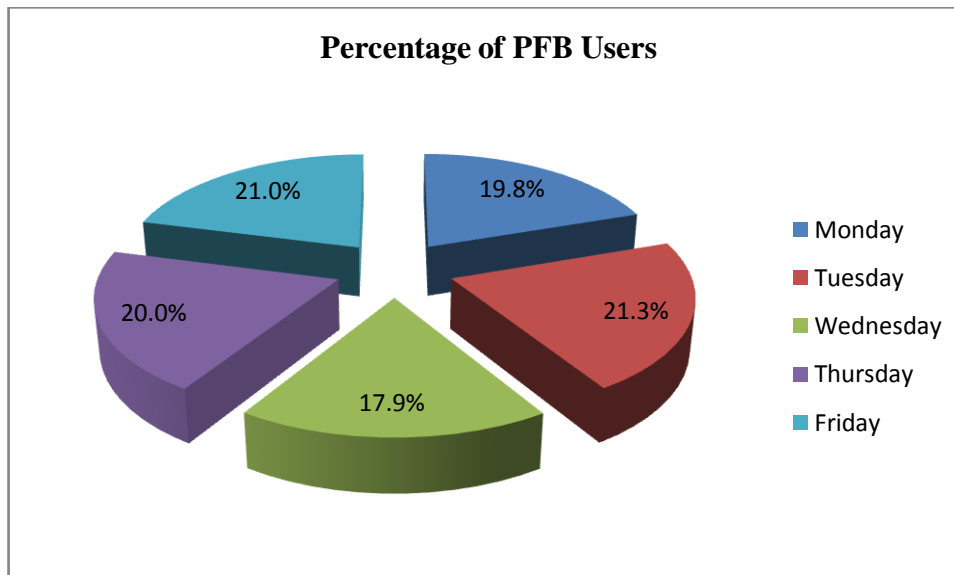
4.0 RESEARCH RESULTS

4.1 Pedestrian Count Survey`

4.1.1 Pedestrian Survey for Weekdays

A total of 20,702 pedestrians and cyclists used the pedestrian footbridge from Monday to Friday. The figure includes pedestrians and cyclists recorded both during peak and off peak hours. Out of the 20,702 footbridge users, only five were cyclists which represents about 0.024 per cent which is less than 1 per cent. This was the case because the footbridge does not have bicycle gutters which enable cyclists to use the footbridge with ease. Tuesday had the highest number of pedestrians using the bridge totalling to 4,400 pedestrians and Wednesday had the lowest number of pedestrians using the bridge totalling to 3,711 pedestrians. The results have been summarised in Table 11. The number of pedestrians using the footbridge have been illustrated in Figure 15. Picture 19 depicts cyclists crossing the Uthiru Pedestrian Footbridge and Picture 20 shows a cyclist crossing Railway Pedestrian Footbridge in Nairobi CBD.

Figure 15: Percentage of Pedestrian Footbridge Users during Weekdays



Source: Author, 2013

Table 11: Total Number of Pedestrian Footbridge Users during the Weekdays

Day	Male	Female	Child	Physically Challenged	Cyclists	Total	Ranking
Monday	1,281	1,668	1,140	6	0	4,095	4
Tuesday	1,234	1,664	1,501	1	0	4,400	1
Wednesday	1,118	1,392	1,200	0	1	3,711	5
Thursday	1,201	1,700	1,240	4	2	4,147	3
Friday	1,211	1,796	1,338	4	0	4,349	2
Total	6,045	8,220	6,419	15	3	20,702	
Ranking	3	1	2	4	5		

Source: Author, 2013

Picture 19: Some children crossing footbridge with bicycles



Source: Author, 2013

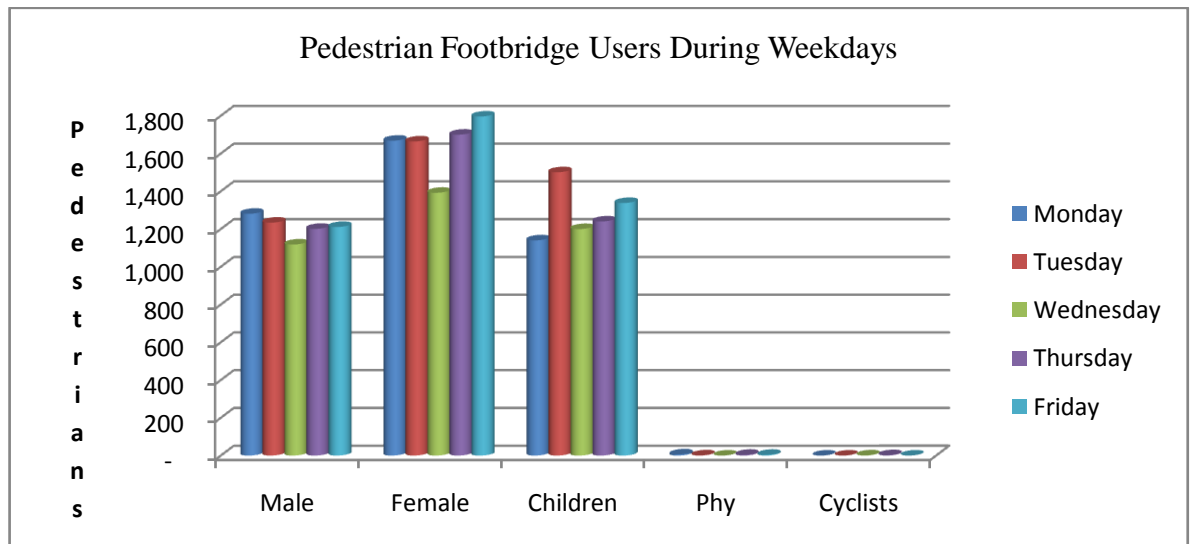
Picture 20: Railway pedestrian footbridge in Nairobi CBD



Source: Author, 2012

In terms of the classification of type of footbridge users, it was observed that females used the footbridge most, followed by children and men respectively (Figure 16). The classification of children included those that are aged from 2 to 16 years and all students attending both primary and secondary school education. The least number of users were the physically challenged and the cyclists.

Figure 16: Pedestrian footbridge users during weekdays



Source: Author, 2013

4.1.2 Statistics for Jay Crossing

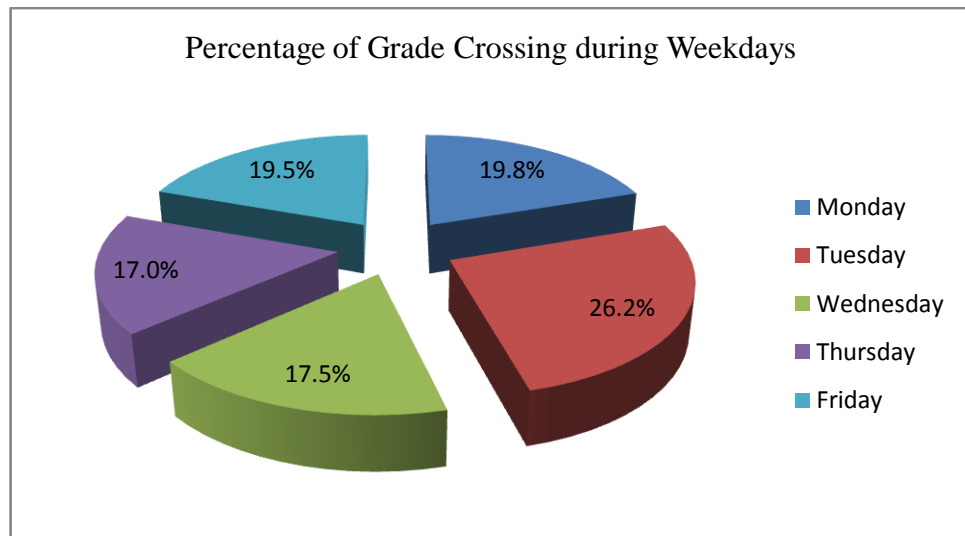
During the survey conducted, it was observed that a total of 1,633 pedestrians crossed the road by jumping over the barrier instead of using the pedestrian footbridge (See Table 12). The number of pedestrians who jay crossed the highway include figures taken both during off peak and peak hours and the number of men, females and students who opted to jump the concrete barrier. Most pedestrians jumped over the barrier on Tuesday and the least number of pedestrians who jumped the concrete barrier when crossing the highway was observed to be on Thursday. Figure 17 is a graphical presentation of the survey conducted while pictures 21 and 22 show pedestrian crossing the highway irrespective of the designated barrier.

Table 12: Figures for Grade Crossing during weekdays

Day	Grade Crossing				Ranking
	Male	Female	Students	Total	
Monday	323	0	0	323	2
Tuesday	424	1	3	428	1
Wednesday	287	0	1	286	4
Thursday	275	2	0	277	5
Friday	314	3	2	319	3
Total				1,633	

Source: Author, 2013

Figure 17: Percentage of Pedestrians who crossed at grade during weekdays



Source: Author, 2013

Picture 21: A female pedestrian jumping over the barrier



Source: Author, 2013

Picture 22: Student crossing highway by jumping over barrier



Source: Author, 2013

4.1.3 Peak Pedestrian Volume during Weekdays

Tables 13 and 14 show the results of the average pedestrian volume recorded at 15 minutes interval and corresponding one hour (60 minutes) pedestrian volumes from Monday to Friday. It was observed that the peak pedestrian volume for 15 minutes was on Monday from 17.30-17.45 pm with 394 pedestrians crossing the pedestrian footbridge. The peak volume recorded was used for determining the sample size for administering oral pedestrian interviews. The graphical presentation of average pedestrian volume recorded for 15 minutes interval for Monday, Tuesday and Friday has been presented in Figures 18. Picture 23 shows students crossing the footbridge during off-peak hours during weekdays.

Table 13: Average Pedestrian Volume for Weekdays during Morning Peak Hours

Time	Monday		Tuesday		Wednesday		Thursday		Friday	
	V ₁₅	V ₆₀	V ₁₅	V ₆₀	V ₁₅	V ₆₀	V ₁₅	V ₆₀	V ₁₅	V ₆₀
6.30-6.45	217	779	69	600	27	411	36	424	151	683
6.45-7.00	166		212		47		33		199	
7.00-7.15	216		133		162		143		181	
7.15-7.30	180		186		175		212		152	
7.30-7.45	151	494	165	648	132	499	115	531	144	576
7.45-8.00	176		186		193		174		178	
8.00-8.15	94		186		102		109		156	
8.15-8.30	73		111		72		133		98	
8.30-8.45	83	274	83	282	62	180	89	292	101	249
8.45-9.00	75		97		49		81		50	
9.00-9.15	68		56		38		67		61	
9.15-9.30	48		46		31		55		37	

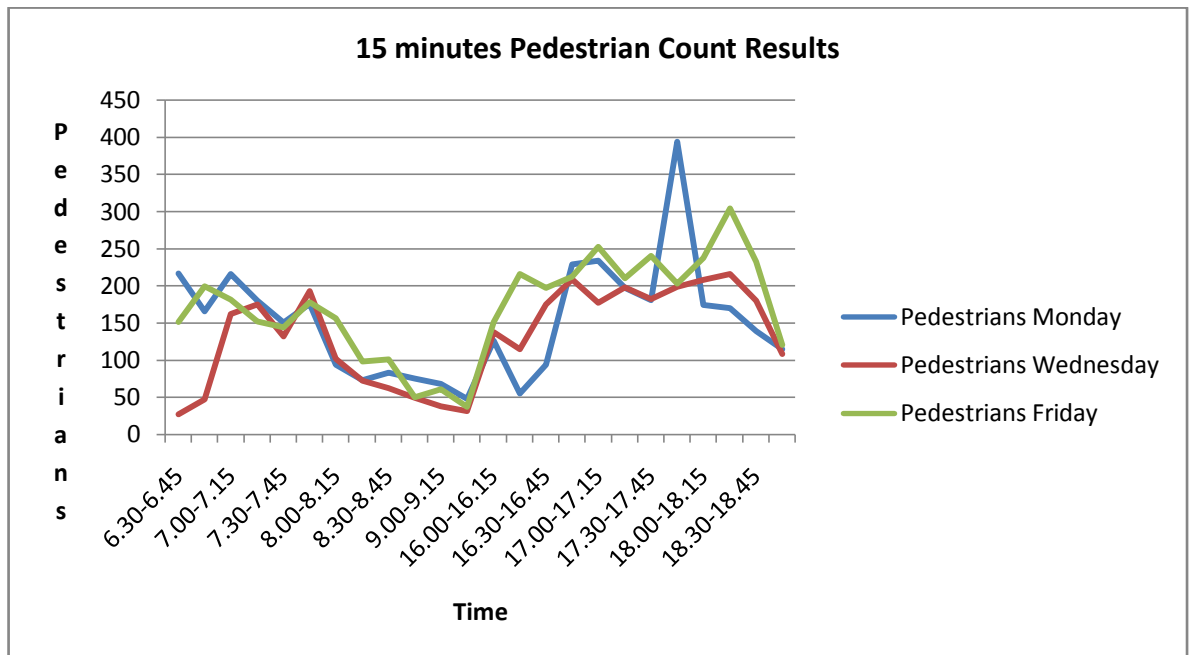
Source: Author, 2013

Table 14: Afternoon Peak Hour Pedestrian Volume Data

Time	Monday		Tuesday		Wednesday		Thursday		Friday	
	V ₁₅	V ₆₀	V ₁₅	V ₆₀	V ₁₅	V ₆₀	V ₁₅	V ₆₀	V ₁₅	V ₆₀
16.00-16.15	126	504	167	859	138	637	171	806	151	776
16.12-16.30	55		179		115		221		216	
16.30-16.45	94		257		175		198		197	
16.45-17.00	229		256		209		216		212	
17.00-17.15	234	1,006	167	879	177	756	260	923	252	905
17.15-17.30	197		201		198		205		210	
17.30-17.45	181		243		182		248		240	
17.45-18.00	394		264		199		210		203	
18.00-18.15	174	598	176	697	208	712	253	910	237	839
18.15-18.30	170		231		216		310		304	
18.30-18.45	139		164		180		226		232	
18.45-19.00	115		126		108		121		120	

Source: Author, 2013

Figure 18: 15minutes Interval Pedestrians Count



Source: Author, 2013

Picture 23: Students crossing the footbridge during off-peak hours during weekdays



Source: Author, 2013

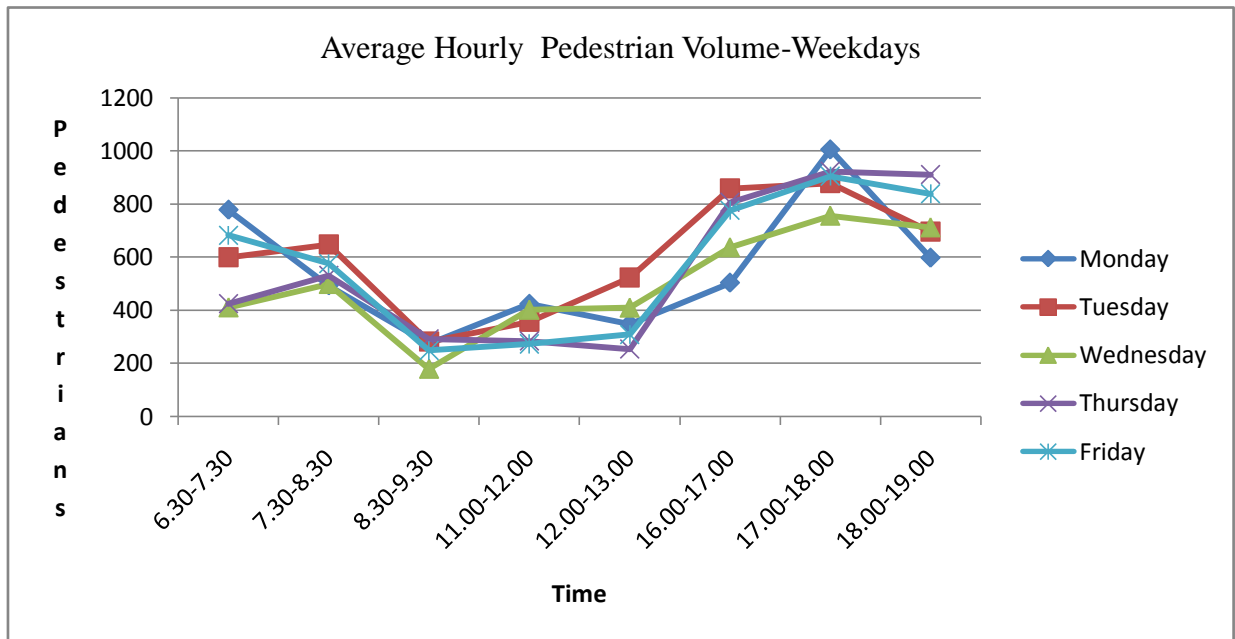
The average hourly pedestrian volume for the weekdays have been summarized in Table 15 and show the peak value of pedestrians being experienced on Monday from 17.00-18.00 as being 1,006 pedestrians. It was followed by 923 pedestrians which used the footbridge on Thursday from 17.00-18.00. The graphical presentation of average hourly pedestrian volume for weekdays thus from Monday to Friday has been depicted in Figure 19.

Table 15: Average Pedestrian Volume on hourly basis on weekday

Time, V_{hour}	Day,				
	Monday	Tuesday	Wednesday	Thursday	Friday
6.30-7.30	779	600	411	424	683
7.30-8.30	494	648	499	531	576
8.30-9.30	274	282	180	292	249
11.00-12.00	424	356	402	284	274
12.00-13.00	349	523	410	254	310
16.00-17.00	504	859	637	806	776
17.00-18.00	1006	879	756	923	905
18.00-19.00	598	697	712	910	839

Source: Author, 2013

Figure 19: Average Hourly Pedestrian Volume for Weekdays



Source: Author, 2013

4.1.4 Pedestrian Survey for Weekend

A total of 9,045 pedestrians and cyclists used the pedestrian footbridge on weekend thus on Saturday and Sunday (See Table 16). The figure includes pedestrians and cyclists who were counted from 6.30 am to 1.00 pm and from 4.00pm to 7.00 pm. The duration of counting was prolonged to 1.00 pm to have clear picture of bridge usage over the weekend considering that on every Saturday is a market day in Kangemi and Kawangware. As such there are many traders and vendors who flock to these markets to buy products to be sold in Uthiru Trading centre.

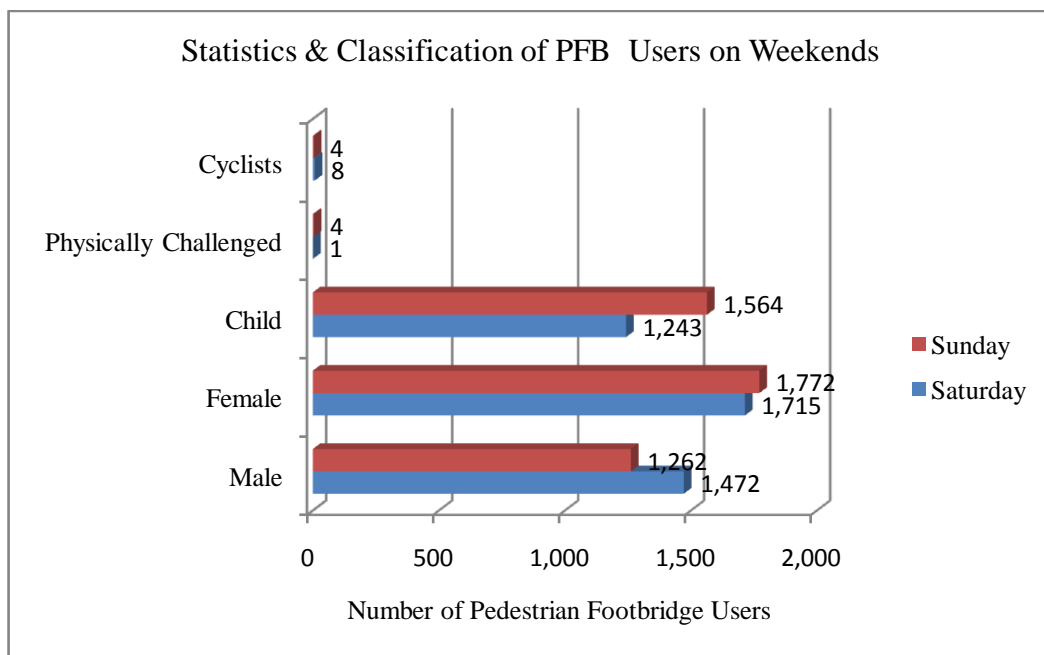
Out of the 9,045 footbridge users, only twelve were cyclists about 0.13 per cent of users which is less than 1 per cent. Sunday had the highest number of pedestrians using the bridge totalling to 4,606 pedestrians as compared to Saturday. More females used the footbridge over the weekend followed by children and men respectively. The cyclists and physically challenged used the footbridge the least because no ramp was provided to enable the physically challenged to use the footbridge (Figure 20 is the graphical presentation of the survey conducted).

Table 16: Figures & classification of pedestrian footbridge users on weekends

Day	Saturday	Sunday	Total	Ranking
Male	1,472	1,262	2,734	3
Female	1,715	1,772	3,487	1
Child	1,243	1,564	2,807	2
Physically Challenged	1	4	5	5
Cyclists	8	4	12	4
Total	4,439	4,606	9,045	
Ranking	2	1		

Source: Author, 2013

Figure 20: Figures for pedestrian footbridge users over weekend



Source: Author, 2013

A total of 1,326 pedestrians crossed the road by jumping over the barrier instead of using the pedestrian footbridge on Saturday and Sunday (See Table 17). There were more pedestrians who jumped the concrete barrier on Saturday because every Saturday is a market day in Kamgemi and Kawangware. As such there are many traders and vendors who lock to these markets to buy products to be sold in Uthiru

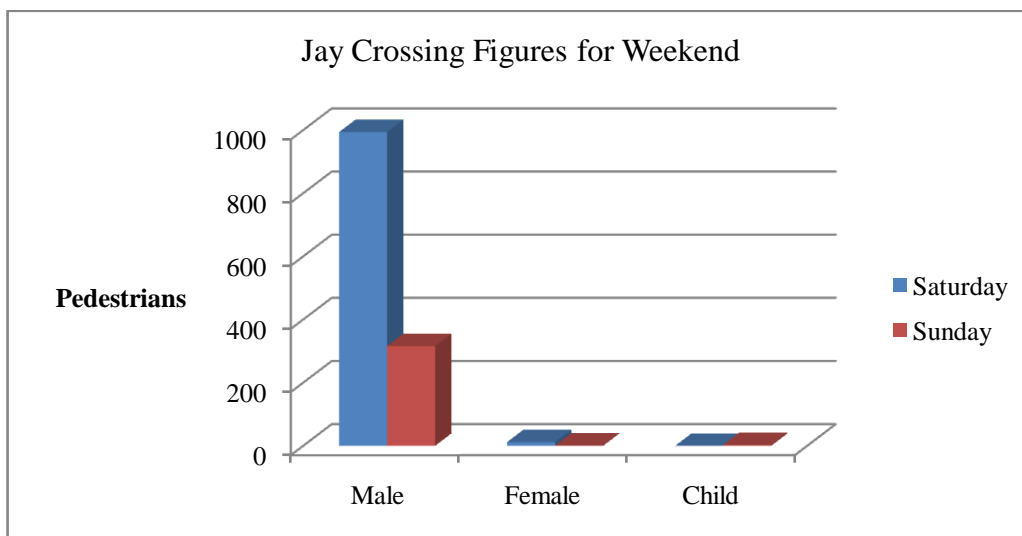
Trading centre. It was however, observed that more male pedestrians jumped over the concrete barrier over the weekend than female pedestrians. Figure 21 is the graphical presentation of the survey conducted while pictures 24 and 25 show pedestrians crossing the highway irrespective of the designated barrier.

Table 17: Grade crossing figures over the weekends

Day	Saturday	Sunday	Total	Ranking
Male	994	316	1,310	1
Female	12	1	13	2
Child	0	3	3	3
Total	1,006	320	1,326	
Ranking	1	2		

Source: Author, 2013

Figure 21: Figures for jay crossing over weekend



Source: Author, 2013

Picture 24: Traders jump over the barrier after disembarking from minibus



Source: Author, 2013

Picture 25: Traders transporting milk jug from one side of road to another



Source: Author, 2013

4.1.5 Peak Pedestrian Volume during Weekdays

The results of the average pedestrian volume for 15 minutes and corresponding one hour (60 minutes) have been shown in Table 18 for morning and afternoon for pedestrian peak volume for Saturday and Sunday. The results show that Saturday has the average pedestrian peak hourly volume of 754 pedestrians which was observed

between 6.30-7.30 am and Saturday had the average pedestrian peak volume for 15 minutes being 241 pedestrians experienced between 9.15-9.30 am.

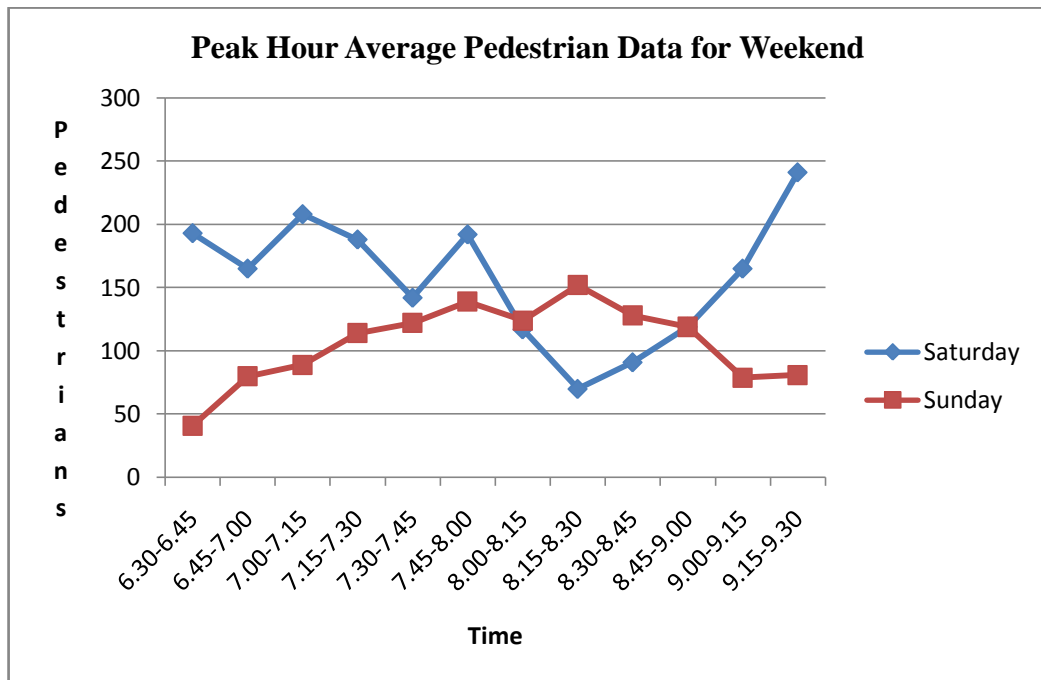
Comparison of average pedestrian volume for off peak hours for weekend days show that Sunday had the higher average hourly pedestrian volume of 874 pedestrians who used the footbridge from 7.30-8.30 am while the average pedestrian volume for 15 minutes was observed between 17.45-18.00 as being 264 pedestrians (See Figures 22, 23 and 24 for graphical presentation of the survey results).

Table 18 : Average Pedestrian Volume for Weekends during Peak Hours

Time	Saturday		Sunday		Time	Saturday		Sunday	
	V ₁₅	V ₆₀	V ₁₅	V ₆₀		V ₁₅	V ₆₀	V ₁₅	V ₆₀
6.30-6.45	193	754	41	324	16.00-16.15	142	547	167	859
6.45-7.00	165		80		16.15-16.30	104		179	
7.00-7.15	208		89		16.30-16.45	128		257	
7.15-7.30	188		114		16.45-17.00	173		256	
7.30-7.45	142	521	122	537	17.00-17.15	173	576	166	874
7.45-8.00	192		139		17.15-17.30	147		201	
8.00-8.15	117		124		17.30-17.45	139		243	
8.15-8.30	70		152		17.45-18.00	127		264	
8.30-8.45	91	616	128	407	18.00-18.15	112	492	176	697
8.45-9.00	119		119		18.15-18.30	139		231	
9.00-9.15	165		79		18.30-18.45	149		164	
9.15-9.30	241		81		18.45-17.00	92		126	

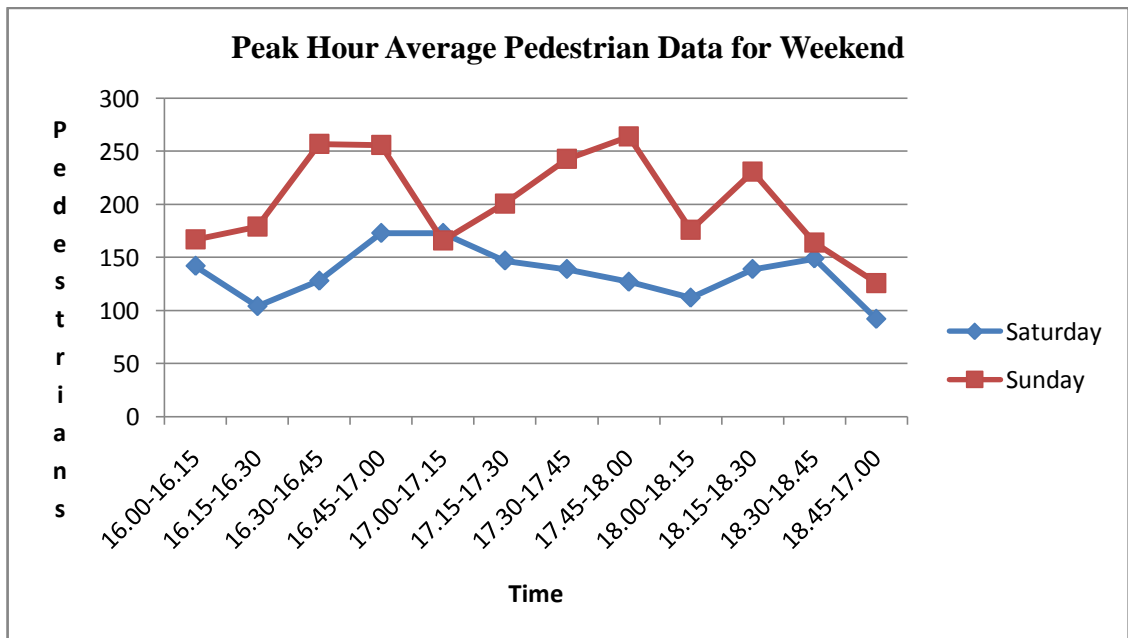
Source: Author, 2013

Figure 22: Morning Peak hour average pedestrian data for weekend



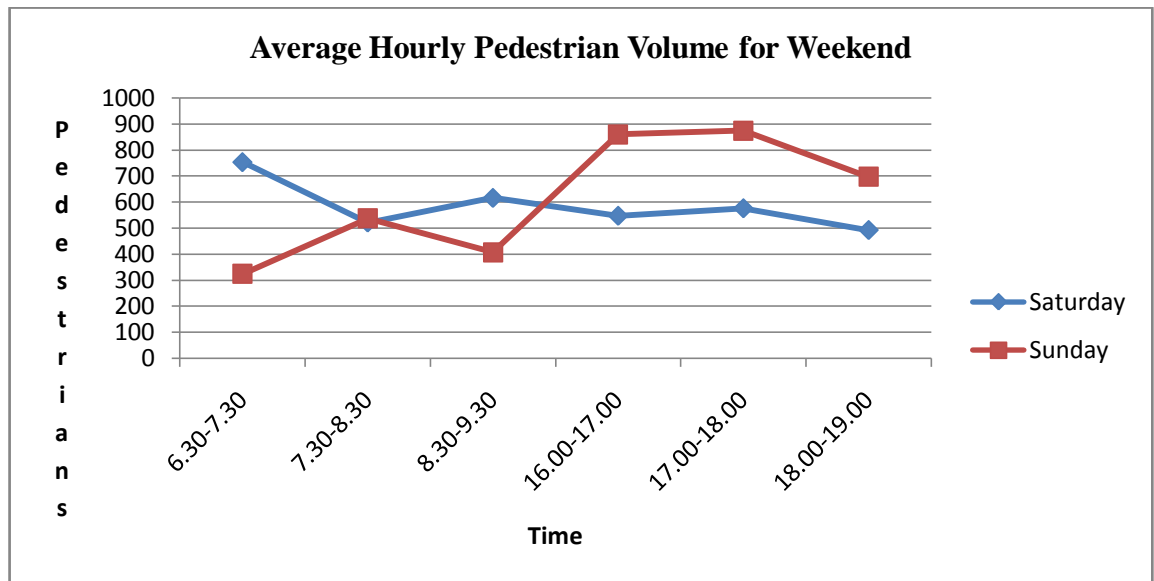
Source: Author, 2013

Figure 23: Afternoon peak hour average pedestrian volume data for weekend



Source: Author, 2013

Figure 24: Average hourly pedestrian volume for weekend



Source: Author, 2013

4.2 Results on Oral Questionnaire Interviews to Pedestrians

4.2.1 Pedestrian Sampling

The 15 minute, V_{15} peak pedestrian volume was observed on Monday from 17.45-18.00 as being 394 pedestrians. The sample size of pedestrians for oral interview was calculated using the formula below:

$$n = \frac{N}{1 + Ne^2} \quad (4.1)$$

where n = Sample size

N = 394, Peak Pedestrian population on the footbridge

e = 5%, Margin of error

$$n = \frac{394}{1 + 394 \times 0.05^2}$$

n=198 pedestrians

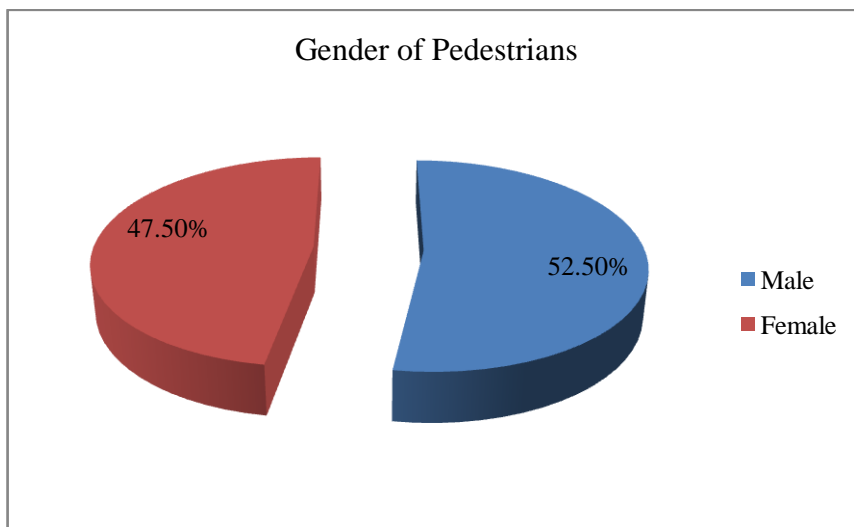
The sample size of 198 was established. The researcher therefore conducted the oral interview on 200 pedestrians selected at random.

4.2.2 Pedestrian Profile

4.2.2.1 Gender

Out of 200 pedestrians who were interviewed at random, it was observed that 105 pedestrians were male and the remaining 95 pedestrians were female (See Figure 25). This represents almost equal distribution of administering of the oral interview questionnaires.

Figure 25: Gender of Pedestrians Interviewed

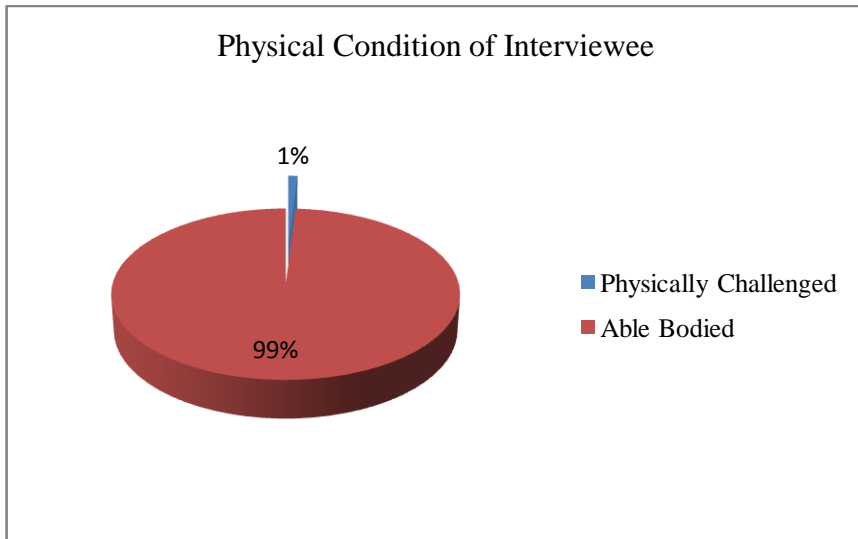


Source: Author, 2013

4.2.2.2 Interviewee's Physical Condition

Out of 200 pedestrians who were interviewed, it was observed that only 2 pedestrians were physically challenged representing 1%. The remaining 198 pedestrians were able bodied (See Figure 26).

Figure 26: Interviewee`s Physical Condition

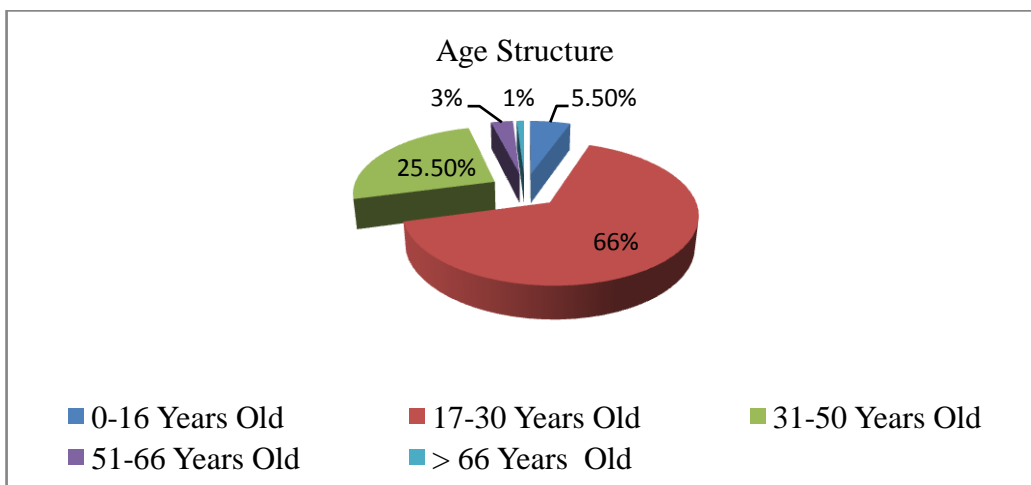


Source: Author, 2013

4.2.2.3 Age Group

According to Figure 27, the largest pedestrian age group interviewed belonged to the 17-30 years old group totalling 65% of the respondents surveyed. This is followed by 25.5% of the respondents from the 31-50 years old group and 5.5% of the respondents from 0-16 years old group. The 51-66 years old group and greater than 66 years old group formed the smallest age groups with 3% and 1% of the respondents respectively.

Figure 27: Age Structure

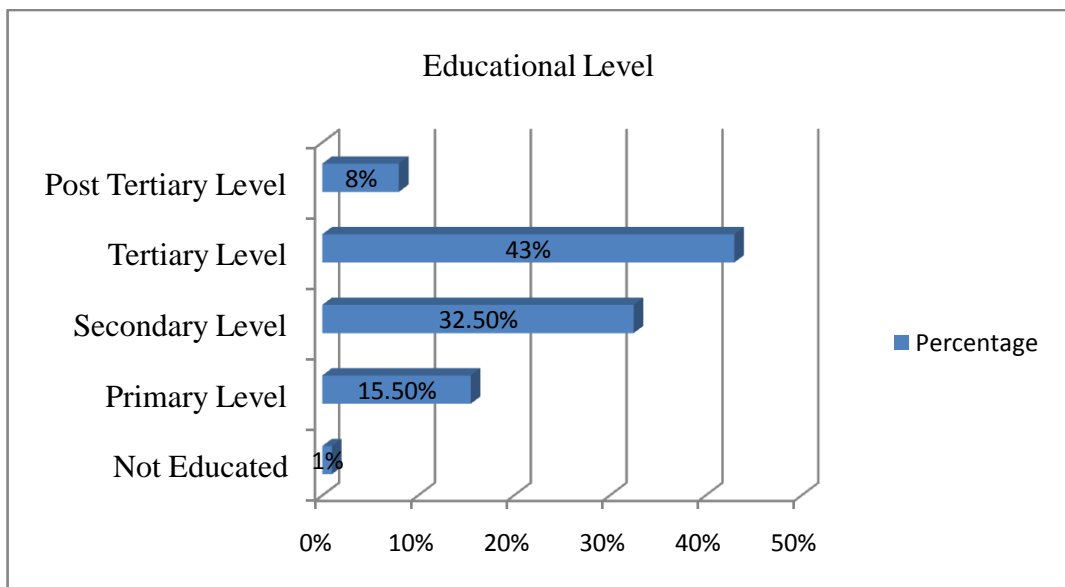


Source: Author, 2013

4.2.2.4 Educational Level

The survey shows that the highest percentage of the respondents was 43% and belonged to the tertiary level category (See Figure 28). This could be attributed to a number of colleges which are in and around Uthiru Town which include Kabete Technical Training College, Animal Health and Industrial Training Institute and College of Agriculture and Veterinary Services. The second highest percentage of the respondents is 32.5% which belongs to the secondary education category. This was the case because Uthiru Town has various secondary institutions which are either government run or privately owned and these include Top Choice Private Secondary School and Uthiru Girls Government School. The third highest percentage of the respondents is 15.5% which belongs to the primary level education category. This could be attributed to a number of primary and pre-primary schools around the Uthiru Pedestrian Footbridge which include Uthiru Nursery School, Uthiru Government Primary School, Cedar Groove Junior Academy and Uthiru Genesis Private Primary School. The lowest percentage of the respondents was 8% and 1% which belonged to the post- tertiary and non-educated levels respectively.

Figure 28: Educational Level of Respondents



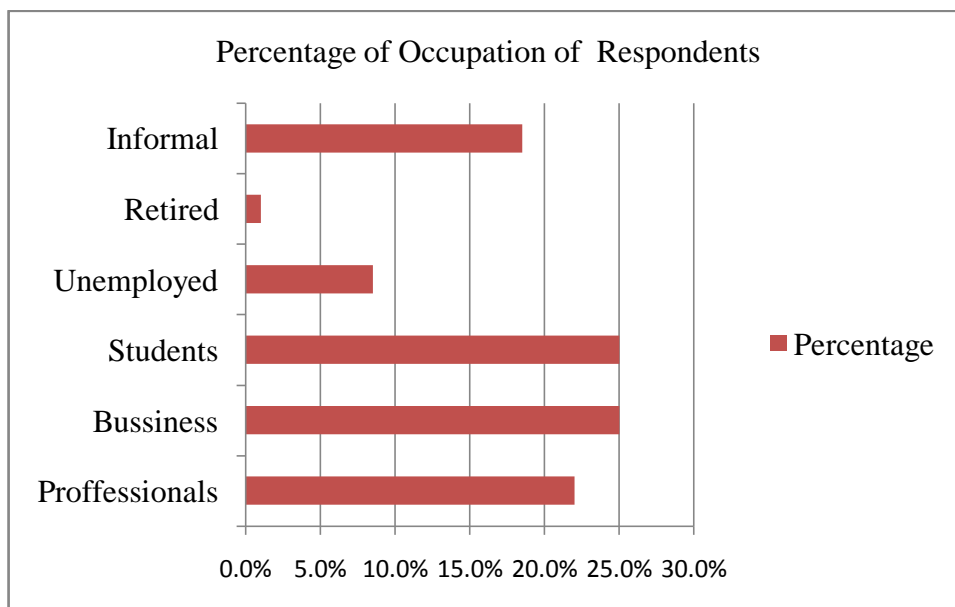
Source: Author, 2013

4.2.2.5 Occupation of Trip Maker

The occupation of the trip maker was categorized in six groups. The first group is for professional and these include engineers, doctors, lawyers, teachers, nurses, accountants and policemen. The second group is for business and is composed of businessmen and women. The third group is for students and include all students in primary, secondary and colleges which are either privately owned or run by the government. The fourth group is for the unemployed and composes of housewives and school leavers. The fifth category is for those that retired in both public and private sectors. The last group is for the informal category and includes those that are technicians, hawkers, salonists and jua kali artisans.

Results of the survey show that business and the student occupational categories have the highest percentage of respondents and each has an equal percent of 25%. The second highest percentage of respondents is from professional, followed by the informal category that formed 18.5% of the respondents. The third category was formed by the unemployed who had 8.5% of the respondents. The last group of respondents was the retired who formed only 1% of the respondents (See Figure 29).

Figure 29: Occupation of Respondents



Source: Author, 2013

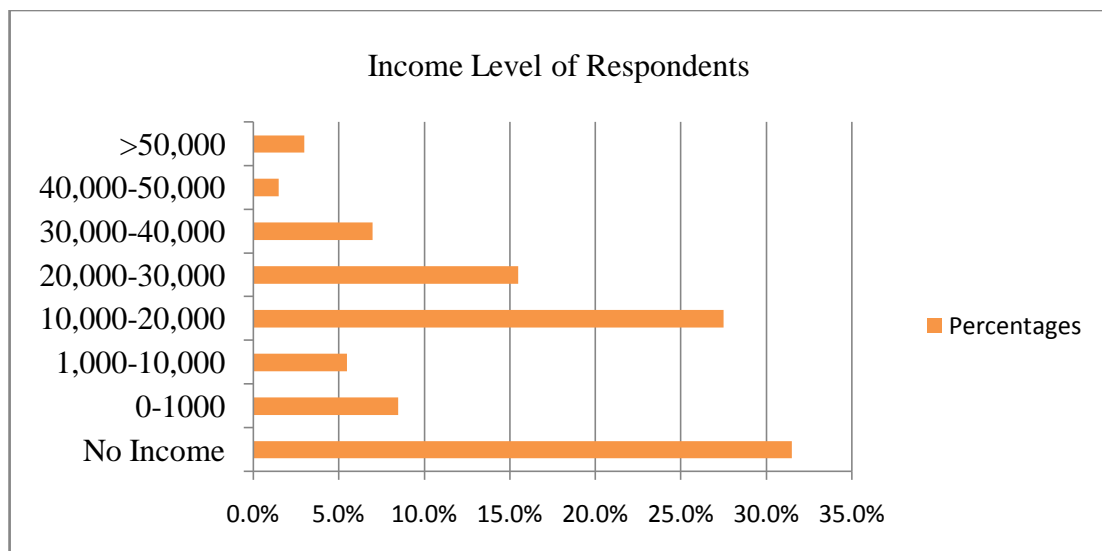
4.2.5.6 Income Levels of Pedestrians

The level of income for any individual depends on the nature of occupation. Those that are highly educated and having decent jobs earn more money than those that are not educated. Similarly, those that are not educated but are engaged in business can equally earn more money as long as they are engaged in business with high capital investment or high turnover.

From the results, it was noted that the majority of the respondents were in the no income category forming 31.5% of the respondents (See Figure 30). Those who could not earn any income on monthly basis include the unemployed, housewives or school leavers. The high percentage of respondents with no income could be attributed to high percentage of students in the occupation of trip maker forming 25% of respondents and 8.5% of unemployed in the occupation of trip maker category.

The second largest income level is the KSh 10,000-KSh 20,000 category followed by the KSh 20,000-KSh 30,000 category respectively. This could be attributed to high percentage business and informal categories of occupation of pedestrians who were interviewed forming 25% and 18.5% of the respondents respectively. The last income levels are for KSh 40,000-KSh 50,000 and greater than KSh 50,000 income levels comprising 1.5% and 3% respectively.

Figure 30: Income Level of the Respondents



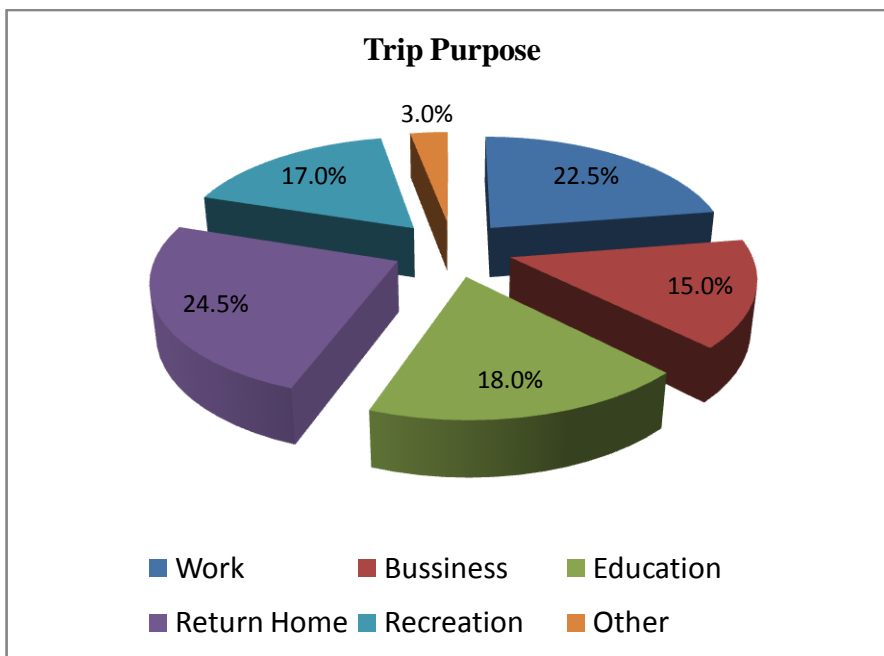
Source: Author, 2013

4.2.3 Origin and Destination

4.2.3.1 Trip Purpose

Pedestrians walk from home to other designations for various purposes which include work, shopping, jolly walking, school and even business. Figure 31 shows that the highest percentage of 24.5% of the respondents was formed by those who were returning home followed by those who work related purpose trips forming 22.5% of the respondents. There is small difference in respondents who crossed the footbridge for education, recreation and business forming 18%, 17% and 15% respectively of the respondents.

Figure 31: Trip Purpose for Pedestrians



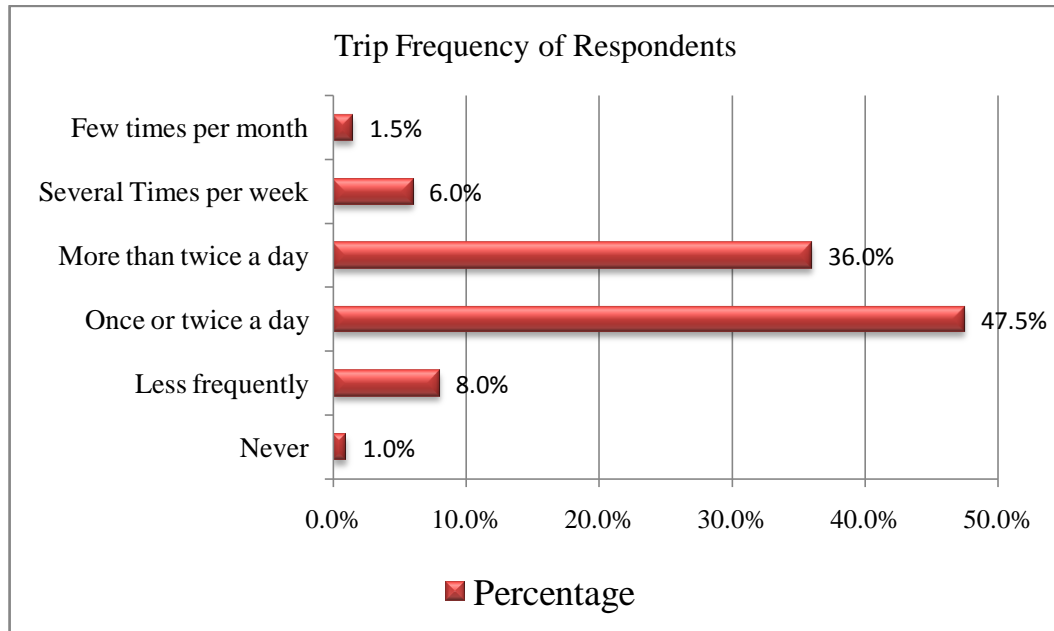
Source: Author, 2013

4.2.3.2 Trip Frequency

The trip frequency of crossing the footbridge depends on the occupation of the pedestrian who were interviewed and the purpose of the trip. Figure 32 shows that the highest percentage, 47.5% uses the footbridge once or twice a day. This could be attributed to high percentage of students who normally cross the footbridge when going and coming back from school or persons going to work in the morning and come back in the evening. The second percentage of 36% is formed by pedestrians who use the footbridge more than twice per day. These pedestrians are either in the business,

informal or unemployed occupational category. There are relatively low percentages on the pedestrians that use the footbridge less frequently and several times per week forming 8% and 6% of the respondents respectively.

Figure 32: Trip Frequency of Respondents



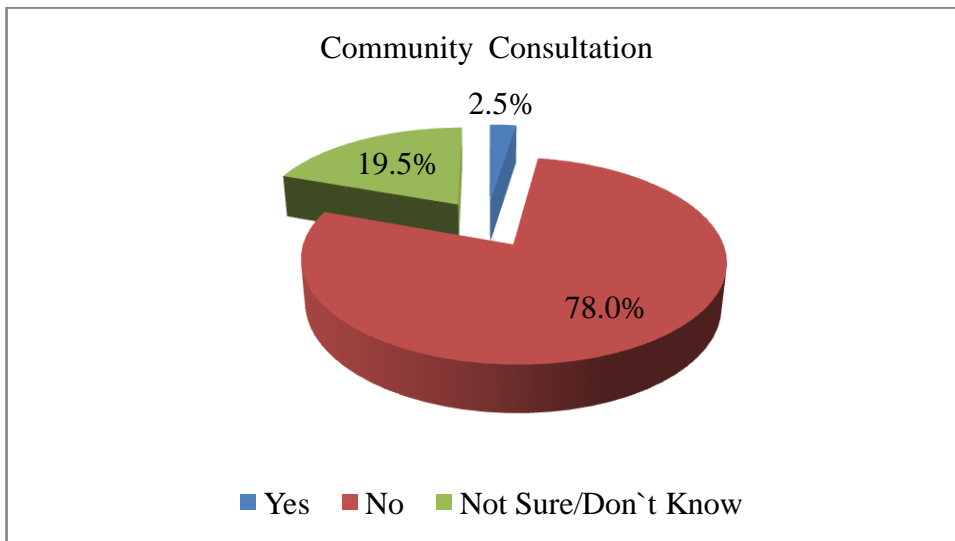
Source: Author, 2013

4.2.3 Pedestrian Perception

4.2.3.1 Community Consultation during planning stages

Figure 33 shows that 78% of the respondents indicated that they were not consulted during the planning stages of construction of Uthiru footbridge in establishing the need of the footbridge and its location.

Figure 33: Community Consultation



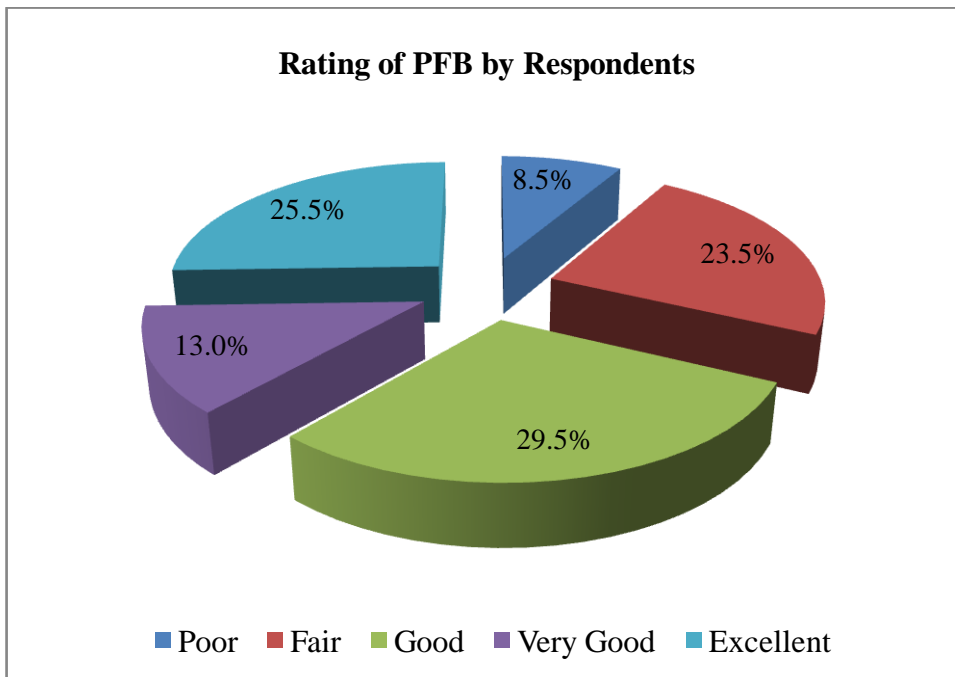
Source: Author, 2013

The footbridge was commissioned in 1990 and 23 years have elapsed since the construction of the Uthiru Pedestrian Footbridge. It was anticipated that pedestrians that are over 40 years old would be able to indicate whether they were consulted during the planning and construction stages of Uthiru Pedestrian. The sample had 59 pedestrians who were over 40 years old. Out of these 59 pedestrians, 46 respondents indicated that they were not consulted. This represented 78% of 59 pedestrians. Only 1.2% one indicated that he was consulted representing 1.2% of the respondents. The remaining 12 pedestrians forming 20.8% of the respondents were not sure if the consultation process was done.

4.2.3.2 Rating non-usage of pedestrian footbridge

Figure 34 shows that 59 respondents forming 29.5% rated the footbridge usage as good, followed by 51% of the respondents who rated the usage of footbridge as excellent. 23.5% of the respondents rated the usage of footbridge as fair. The last two categories of footbridge rating by pedestrians were composed of 13% and 8.5% as being very good and fair respectively.

Figure 34: Pedestrian Rating of Footbridge Usage

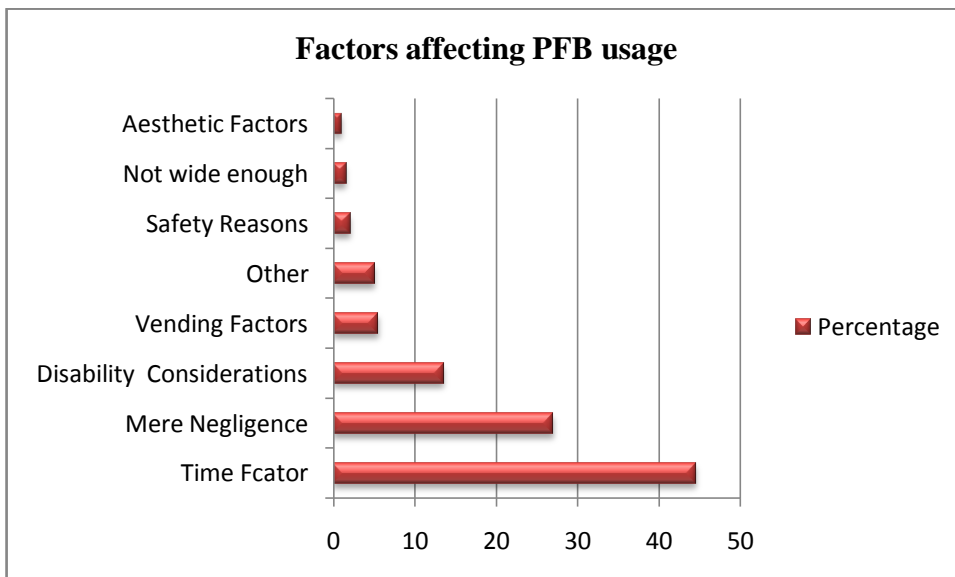


Source: Author, 2013

4.2.3.3 Reasons for shunning pedestrian footbridge pedestrians

Figure 35 shows the results of the reasons why pedestrians do not want to use the footbridge.

Figure 35: Factors affecting pedestrians' footbridge usage



Source: Author, 2013

Out of the 200 pedestrians interviewed, 89 pedestrians forming 44.5% indicated that the main reason for not using the footbridge is that it takes time to cross. 54 pedestrians forming 27% of the respondents indicated that some pedestrians shun the use of footbridge due to mere negligence.

27 pedestrians forming 13% of the respondents felt that the footbridge is not fully utilized because it is not suitable for the physically challenged since no ramp was provided for the physically challenged (See picture 26).

Picture 26: Pedestrian Overpass with ramp to cater for all users including the disabled



Source: Renfro, 2008

Picture 27: Vegetables and second hand clothes vending at footbridge



Source: Author, 2013

Picture 28: Vendor places his items on one footbridge approach everyday



Source: Author, 2013

Pictures 27 and 28 show the selling of vegetables and second hand clothes at the footbridge. 5.5% of the respondents comprising 11 pedestrians pointed out that vending business which is normally done at the footbridge especially in the afternoon is one of the factors that force pedestrians to shun the footbridge.

Out of 200 pedestrians, 10 pedestrians forming 5% of the respondents cited other reasons which force pedestrians from using the footbridge. The reasons which were recorded included non-availability of escalator, the footbridge not having a roof, footbridge having no bicycle gutters and footbridge being steep. The other reason is that sometimes heavy vehicle park on the service road close to the approaches of the footbridge resulting in blocking the entrance to footbridge (See pictures 29 and 30).

Picture 29: Stairways near the I-84 at Hollywood Transit Center Bridge include “bike gutters”



Source: Renfro, 2007

Picture 30: Truck parks along service lane and blocks entrance of footbridge



Source: Author, 2013

2% the respondents indicated that some pedestrians do not use the footbridge because of safety reasons. This could be attributed to non-provision of lighting at Uthiru Pedestrian Footbridge which can ensure safety of pedestrian during evening hours. Only 2 pedestrians forming 1% of the respondents indicated that the footbridge is not used due to aesthetic reasons. The last group of pedestrians, forming 1.5% of the respondents cited the width of the footbridge as not being wide enough to cater for a large number of pedestrians to use the footbridge at the same time as another reason which de-motivates pedestrians from using the footbridge. Picture 31 is showing students crossing the footbridge in large numbers.

Picture 31: Students crossing footbridge in large numbers

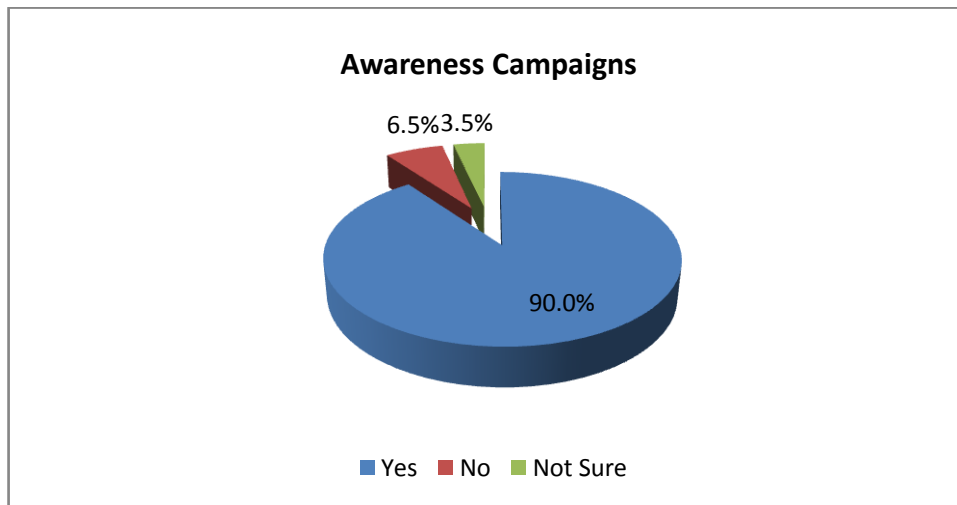


Source: Author, 2013

4.2.3.4 Impact of awareness on improving footbridge usage

Figure 36 shows that 90% of the respondents believed that awareness campaigns can motivate more pedestrians to use the footbridge while 6.5% thought awareness campaigns cannot assist in improving bridge usage among pedestrians. 3.5% of the respondents were not sure if awareness campaigns can motivate pedestrians to use the footbridge.

Figure 36: Creation of Awareness Campaign Percentage

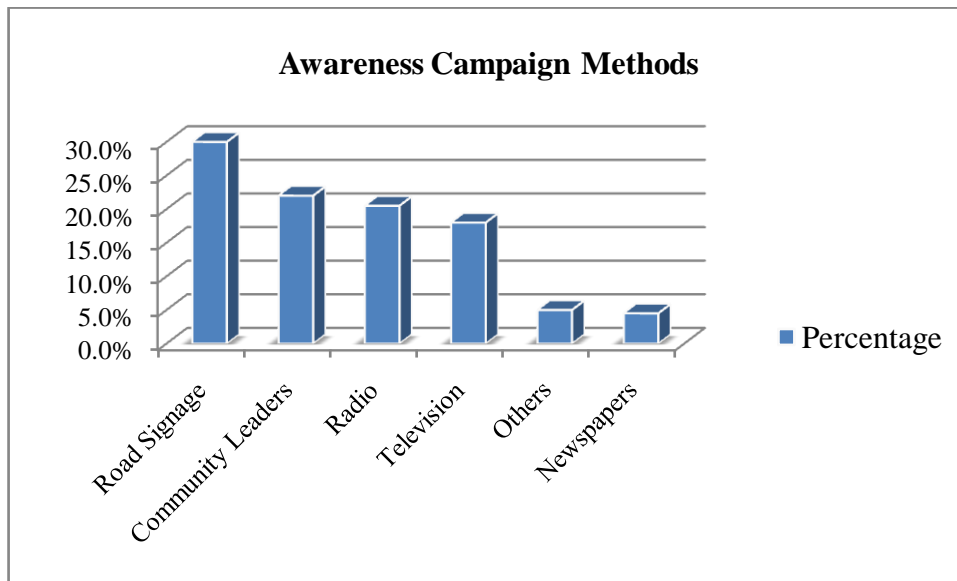


Source: Author, 2013

4.2.3.5 Awareness methods proposed by pedestrians

The research came up with the results which show the methods of bringing awareness on the use of the footbridge as one way of increasing utilisation levels of Uthiru Footbridge (See Figure 37). 30% of the respondents which was the highest preferred the use of road signs. The second percentage was 22% of the respondents who opted for sensitization of use of footbridge using community leaders in churches, at funeral ceremonies and political rallies. 20.5% of respondents preferred the use of radio as a means of spreading awareness campaigns in order to inform pedestrians on the importance of using the footbridge. This was followed by 18% of the respondents who proposed the use of television. The lowest percentages of 5% and 4.5% respectively preferred other methods and use of newspapers. Other methods proposed included use of posters, mobile vehicles with public address and efforts done by Road Safety Council campaigns.

Figure 37: Awareness Campaign Methods



Source: Author, 2013

4.2.3.6 Damaged Concrete Barriers

The researcher established the causes of the some damaged concrete barrier sections. This was one of the issues which was raised by the delegates who attended the preliminary seminar on this research. Most of the pedestrians forming 65% of the respondents indicated that the concrete barrier damage was caused by vehicle accidents (See Table 19).

Table 19: Causes of concrete barrier damage

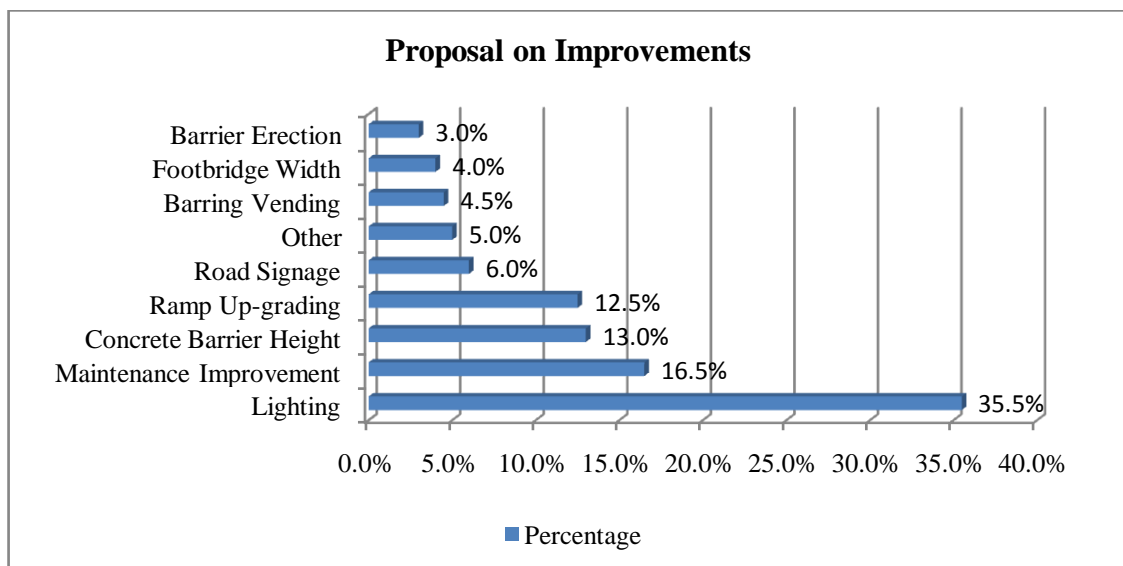
Causes of barrier damage	Pedestrians No	Respondents %	Ranking
Vehicle Accidents	130	65	1
Structural Failure	25	12.5	2
Vandalism	22	11	3
Don't Know	20	10	4
Other	3	1.5	5

Source: Author, 2013

4.2.3.6 Respondents` proposals on ways to improve pedestrian footbridge usage

Figure 38 shows the results of the survey on proposals to enhance the use of footbridge. The highest percentage of respondents was 35.5% who proposed the need for provision of lighting for security and safety. The second percentage of 16.5% of the respondents sought the need for improvement of the maintenance of the footbridge ranging from general cleanliness of the footbridge, de-silting of weep holes, painting of the handrails and de-silting side drains lying along the sides of footbridge. The third percentage was 13% of the respondents and these suggested the height of the concrete barrier be increased in order to dissuade pedestrians from crossing at grade. This was followed by 12.5% of the respondents who sought the footbridge be up-graded with ramps in order to allow all users to use the footbridge. Such users include cyclists and the physically challenged using wheelchairs. 6% of the respondents preferred the use of road signs as one way of facilitating the improvement in the use of the footbridge. 5% of the pedestrians proposed the provision of other facilities like escalators and roofing of footbridge as other means of attracting pedestrians in using the footbridge. The lowest percentage of 4.5%, 4.0% and 3% suggested that vendors should be barred from operating on the footbridge and that the width of footbridge be increased as to allow more pedestrians to pass at the same time. In addition, they proposed erecting a barrier on the side of footpath leading to footbridge in order to deter jay crossing.

Figure 38: Proposal on Improvements on Footbridge



Source: Author, 2013

4.3 Microscopic Parameters observed during the survey

During the survey, the general behaviour of pedestrians which affect the movement of other pedestrians was observed and included idling on footbridge by some pedestrians, social behaviour, use of mobile phones, negotiating of fare prices on goods which are sold at the footbridge and carrying of goods or luggages by some pedestrians.

4.3.1 Idling Behaviour

Picture 32 shows some pedestrians who are idling on the footbridge while some students are crossing the footbridge. This behaviour affected the mobility of pedestrians. It was observed that some pedestrians could just come to the footbridge and start chatting with their friends. They could spend more time just chatting. In some cases, a group of women could come and hold their mini-meeting on the footbridge. This really affected mobility of pedestrians especially during peak hours since these women block the footbridge passage.

Picture 32: Some pedestrians are idle while students cross the footbridge



Source: Author, 2013

4.3.2 Social Behaviour

Some pedestrians who use the footbridge include lovers or those pedestrians who are dating. It was observed that some lovers hold their hands and walk side by

side whilst crossing the footbridge. Other pedestrians are forced to give way to the lovers as to avoid interfering in their social life. As such, other pedestrians take more time to cross the footbridge and at the same time this behaviour makes the couple to cover more space which was supposed to be used by other pedestrians.

4.3.3 Use of Mobile Phones

The use of mobile phones while crossing the footbridge also affected the movement of other pedestrians. Some pedestrians could just stand at the middle of footbridge walkway when answering their mobile phones without considering moving to the sides of footbridge walkway in order not to block the footbridge walkway. This resulted into pedestrians passing on the sides of footbridge walkway. This behaviour can affect use of footbridge if the number of pedestrians behaving in this manner increases.

4.3.4 Vending at footbridge

The footbridge is used for selling of vegetables and second hand clothes. This inevitably blocks the passage of pedestrians. In some cases, pedestrians who want to buy the goods have to bargain for lower prices. In the process, those willing to buy and bargaining for lower prices block the passage of pedestrians resulting into congestion at the footbridge (See picture 33).

Picture 33: Woman admires second hand clothes displayed on footbridge



Source: Author, 2013

4.3.5 Carrying of Goods

Pedestrians normally carry goods whenever they are travelling. Some goods are carried on their heads and are wider in length and affect the mobility of other pedestrians. Some goods are carried by two pedestrians and they walk side by side. This means that other pedestrians are forced to give way to those carrying goods because they require more space than pedestrians who are not carrying any goods. The same applies to those who are using umbrellas when crossing the footbridge. More space is required especially when the pedestrians have different heights (See pictures 34, 35 and 36).

Picture 34: Pedestrians carrying charcoal stove while crossing footbridge



Source: Author, 2013

Picture 35: Pedestrian carrying a bag of Irish potatoes while crossing the footbridge



Source: Author, 2013

Picture 36: Female pedestrians carrying a gas cylinder across the footbridge.



Source: Author, 2013

4.3.6 Other NMT Behaviour

Other NMT modes which used the footbridge include the cyclists and baby carrying push bikes. In such cases, more space is required to avoid interfering with mobility of other NMT modes. This generally affects mobility of other pedestrians because they have to give way to these NMT modes of transport (See picture 37).

Picture 37: Cyclist and woman with umbrella crossing the footbridge



Source: Author, 2013

4.4 Research Input from Stakeholders

4.4.1 Profile of Stakeholders

A total of 25 engineers completed the questionnaire which was submitted to them either electronically or by hand. These experts or engineers are working in different hierarchy levels in the field of urban transportation and NMT planning either in government or private sector. One of the respondents was a female. The list of all individuals who provided the detailed technical input and any valuable support at any stage of this research is documented in Appendix 4.

4.4.2 Factors which influenced Pedestrian Footbridge Location

4.4.2.1 Location of PFB in relation to occurrence of accidents

The engineers confirmed that the location of the Uthiru footbridge was related to occurrence of accidents which used to occur frequently before the bridge was constructed. The place was regarded as ideal because it is close to the bus bay and would enable the pedestrians to access the footbridge at ease. Besides that the town has a number of traffic generators which include pre-primary and primary schools. It was therefore imperative to provide a pedestrian footbridge in order ensure that pupils and students cross safely including other pedestrians.

4.4.2.2 Relation to location of filling station

Land use is one of the areas which were covered in this study. The study therefore established the impact of the location of the footbridge in relation to the filling station. It was established that the pedestrian footbridge was the one which was constructed first. The filling station was constructed some years later. The development was approved by the city council and was within the land use requirements.

4.4.3 Technical Aspects of Pedestrian Footbridge

4.4.3.1 Construction Cost of footbridge

The researcher requested the engineers to give the estimated cost for construction of footbridges in Kenya with Uthiru Pedestrian Footbridge in particular. The engineers indicated that the average cost of construction of Uthiru Footbridge was over KSh 10 million. The present value of the footbridge construction can be over KSh 25 million.

4.4.3.2 Maintenance of footbridge

It was indicated that there is no specific budget for maintenance of footbridge. The footbridge is normally maintained under routine maintenance programs. The kind of maintenance which is done includes grass cutting, replacement of vandalised handrails, and painting of handrails and general cleaning of the footbridges in cases where the general public used the footbridge as public toilet.

According to Road Act, different road agencies in Kenya are responsible for different road classes. In this case, the A104 road is under the jurisdiction of KeNHA. The role of city assemblies in maintaining the roads and footbridge has to be clarified so that the general public should know where to report in case of any emergency work to be carried out on the pedestrian footbridge.

4.4.3.3 Determination of Height of Concrete Barrier

The researcher requested the engineers to outline factors which were used for determining the height of the concrete barrier. It was established that the height of concrete barrier was determined using engineering specifications. It was also indicated that aesthetic and economical aspects were taken into account. From the aesthetic view, it was noted that the concrete barrier would not be beautiful if it was too high as it would look like a prison wall. While from the economic part, it was argued that any

increase of concrete barrier height would results into increase of volume of concrete, hence increase in cost.

4.5 Analysis of Pedestrian Survey Data

4.5.1 Calculation of Level of Service

4.5.1.1 Calculation of Pedestrian Level of Service

According to Olando, et al (2003), the average area occupied by the pedestrian can be computed by dividing the area of the effective walkway width with the peak hour pedestrian volume and the formula is given below:

$$\text{Average Pedestrian Area} = \frac{\text{Area of Effective Walkway width}}{\text{Peak hour pedestrian volume}} \quad (4.2)$$

Based on the data collected, the LOS for the stairway can be identified. The example for calculation of LOS has been outlined below in Table 20. The example is based on the time interval from 6.30-7.30 am on Monday.

Table 20: Calculation of Level of Service

Item	Formula	Calculations	Results
Effective width of the staircase	$W_E = W_1 - W_2$ (4.3)	=2.4-0.2 m	2.2m
Total length of the staircase, L			101.9 m
Area of Effective walkway width	Area= $W_E \times L$ (4.4)	=101.9m x 2.2 m	224.18 m ²
Pedestrian Peak Volume, V_P			779 Peds.
Average pedestrian space	APA = $\frac{\text{Area}}{V_P}$ (4.5)	$\frac{224.18\text{m}^2}{779 \text{ ped}}$	0.29 m ² /p
Level of Service Equivalent			LOS F

Source: Author, 2013

The Level of Service has been determined by referring to section 2.8.2, Table 5

Table 21 summarises the results of LOS which were calculated for different peak hour demand for the week including weekends.

Table 21: PeakHour Pedestrian Demand

Period	Day	Time	Vp	APA	LOS
Morning Peak hours during weekdays	Monday	6.30-7.30	779	0.29	F
Off Peak hours during weekdays	Tuesday	12.00-13.00	523	0.43	E
Afternoon Peak hours during weekdays	Monday	17.00-18.00	1,006	0.22	F
Morning Peak hours during weekends	Saturday	6.30-7.30	754	0.3	F
Afternoon Peak hours during weekends	Sunday	17.00-18.00	874	0.26	F

Source: Author, 2013

4.5.1.2 Calculation of LOS for Shared Pedestrian and Bicycle Facilities

The LOS which has been presented in Table 22 represents the LOS which was calculated based on the data of peak pedestrian volume only. Since some non-motorized modes such as bicycles also use the footbridge, it was therefore important to analyse the impact of cyclists on LOS of pedestrian volume. LOS for shared paths is based on hindrance (HCM, 2000). According to HCM (2000), because pedestrians seldom overtake other pedestrians, the LOS on shared paths depends on the frequency that average pedestrian is overtaken by bicyclist. In this case, since the footbridge is operating at either LOS F or E, the presence or use of footbridge will inevitably result into more congestion. This implies that the LOS will worsen to LOS F.

4.5.2 Determination of the required width of footbridge walkway

4.5.2.1 Based on Pedestrian Peak Volume

The LOS of staircase determines the level of comfort of the pedestrians. The current LOS of staircase shows that pedestrians are congested, thus at LOS either E or F. When designing the width of the staircase, the planner or architect should choose the level of service that is going to operate at staircase and take onto account the level of comfort of pedestrians (Azlan, 2010). The desirable peak-period pedestrian flows should operate at LOS C or above (TRB, 2003 and TCQSM, 2003). Based on the above guidelines, the researcher calculated the required width of the staircase at assumed LOS B and C respectively (for comparison of the results with existing footbridge width) as depicted in Tables 22 and 23.

Table 22: Calculation of Pedestrian Footbridge Width at assumed LOS B

Item or Description	Formula	Calculations	Results
Assume the chosen maximum pedestrians as LOS B			Maximum Pedestrian Flow Rate =23 ped/m/min See section 2.8.2 Table 5
Pedestrian Demand, V_p			1,006 pedestrians (From section 4.1.1.4, Table 16)
Design Pedestrian Flow	$DPF = \frac{V_p}{15 \text{ min}}$ (4.6)	$= \frac{1,006}{15}$	67 ped/min
The required width	$W = \frac{DPF}{\text{Max. Ped}}$ (4.7)	$= \frac{67 \text{ p/min}}{23 \text{ p/m/min}}$	2.90 m

Source: Author, 2013

Table 23: Calculation of Pedestrian Footbridge Width at assumed LOS C

Item or Description	Formula	Calculations	Results
Assume the chosen maximum pedestrians as LOS C			Maximum Pedestrian Flow Rate =33 ped/m/min See section 2.8.2 Table 5
Pedestrian Demand, V_p			1,006 pedestrians (From section 4.1.1.4, Table 16)
Design Pedestrian Flow	$DPF = \frac{V_p}{15 \text{ min}}$ (4.6)	$= \frac{1,006}{15}$	67 ped/min
The required width	$W = \frac{DPF}{\text{Max. Ped}}$ (4.7)	$= \frac{67 \text{ p/min}}{33 \text{ p/m/min}}$	2.03 m

Source: Author, 2013

4.5.2.2 Based on Shared Pedestrian and Bicycle Facilities

Cyclists need more space on shared pedestrian and bicycle facilities. This applies to both on general walkway and footbridges. In order to accommodate any minor reverse-flow which occurs frequently in pedestrian volume or to accommodate other non-motorized modes, the footbridge or stairway width should be increased by a minimum of one traffic lane of 0.75 m (Washington Metropolitan Area Transit Authority, 2005). Based on the above guideline, the researcher added 0.75 m to the calculated pedestrian footbridge in order to accommodate non-motorized modes such as bicycles. Table 24 summarises the results of required width of footbridge.

Table 24: Required Effective Width Summary

Operational LOS	Adapted LOS	Required Width	Additional Width for NMT	Total Width	Existing Width	Difference
E	B	2.90 m	0.75 m	3.65 m	2.20 m	1.45 m
	C	2.03 m	0.75 m	2.20 m	2.78 m	0.58 m

Source: Author, 2013

According to Manual for Roads and Bridges: Part 4-Bridges and Culverts Draft, 2009, the width for pedestrians overpasses should have a minimum width of 3.0 m in order to accommodate three pedestrians, bicycle and a pedestrian in width. From the calculation above, the required width of footbridge to enable the staircase to serve at LOS B is 3.65 m and this width takes into account the provision of other NMT modes which may use the footbridge which includes cyclists or those with wheelchairs. The design effective width of Uthiru footbridge is 3.65 m and is above the revised minimum footbridge width. This means that the width of staircase ought to have been enlarged to provide a better operational condition.

4.5.3 Determining the Footbridge Capacity

Given the comfort zone at LOS B the staircase capacity ranges between 960 and 1,380 pedestrians/m/hr. There was need just check if the maximum capacity is within the level of service.

The procedure of carrying out the calculations according to Olando, et al, (2003) has been outlined in Table 25.

Table 25: Determining Pedestrian Footbridge Capacity

Item	Formula	Calculations	Result
Effective width of the staircase, W_E	$W_E = W_1 - W_2$ (4.3)	=2.4-0.2 m	2.2m
Design Pedestrian Flow	$DPF = W_E \times \text{Capacity of stairway at LOS E}$ (4.8)	(See section 2.8.2 Table 5) =2.2 m x 51.8p/m/min	113.96 p/min
Design Pedestrian Flow	$DPF_1 = DP \times 60 \text{ mins}$ (4.8)	=60 min x 113.96 p/min	6,837.6 ped
Adjust for friction due to bi-directional flows for Design Pedestrian Flow	$DPF = 20\% \times DPF_1$ (4.9)	=80% x 6,837.6 ped	5,470 ped
Comparison with existing capacity	Maximum pedestrian peak volume, V_p is 1,006 pedestrians. This implies the design at LOS E this peak volume.		

Source: Author, 2013

4.5.4 Pedestrian Density

Table 26: Determining Pedestrian Density

Item	Formula	Calculations	Results
Effective width of the staircase	$W_E = W_1 - W_2$ (4.3)	=2.4-0.2 m	2.2m
Total length of the staircase, L			101.9 m
Area of Effective walkway width, A	$A = W_E \times L$ (4.4)	=101.9 x 2.2	224.18 m ²
Pedestrian Peak Volume, V _P			1,006 pedestrians
Average pedestrian space, APA	$APA = \frac{\text{Area}}{V_P}$ (4.5)	= $\frac{224.18 \text{ m}^2}{1006 \text{ ped}}$	0.22 m ² /p
Comment	Area of each pedestrian is less than the minimum area of 0.3 m ²		

Source: Author, 2013

Table 26 shows calculations of the area covered by each pedestrian. The researcher calculated the area occupied by each pedestrian during the peak hour in order to verify if this area conforms to the required area of 0.75 m² if the buffer zone for each pedestrian is included (See section 2.5.3 and Figure 4). The results show that the area for each pedestrian is less than the recommended minimum area of 0.3 m²/person.

4.5.5 Design Projection Calculations

4.5.5.1 Design Calculations in 2013

Two models were used for projection of population. The first model used was the uniform growth factor. This was used to project the population of Uthiru Town from the year 2009 when the last pollution was undertaken to the year 2013. This was the case because the period of projection is less than five years. For the projection of population from the year 2013 to 2030, a compound population growth model was adapted (www.censusbureauworldpopulationclock accessed on 14/6/2013). The design projection year chosen was 2030 because this is consistent with the forecast year used in Kenya Vision 2030.

The potential walking trips for the year 2013 were calculated based on sketch-plan method developed by Matlick (1996) and have been shown in Table 27.

Table 27: Design Calculations in 2013

Item	Formula	Calculations	Results
Projection of population from 2009 to 2013	$P_{2013}=P_{2009} \times 1.039$ (4.10)	$P_{2013}= 24, 295 \times 1.093$	26, 554 residents
Calculate Total Corridor Generated Trips	$TCGT=P_{2013} \times \text{trip per person}$ (4.11)	Assume 2 trips per person $TCGT= 2 \times 26, 554$	53, 108 trips
Calculate the Potential Pedestrian Trips	$PPT = TCPT \times (\text{All trips} < 0.8 \text{ km})$ (4.12)	Assume 95% of TCGT $PPT= 53, 108 \times 0.95$	50, 452 trips
Calculate the Estimated Primary Trips	$EPT= PPT \times (\text{Percentage known walking trip} < 0.8 \text{ km})$ (4.13)	Assume 80% of PPT $EPT = 50, 452 \times 0.8$ trips	40, 362 trips
Calculate Trips Related to the Pedestrian Footbridge	$TRPFB= EPT \times (\% \text{ known PFB trips})$ (4.14)	Assume 25% of EPT $TRPFB= 40, 362 \times 0.25$	10, 090 trips

Source: Author, 2013

The results of the calculations show that it has been estimated that 10, 090 trips are going to be generated in the year 2013 on Uthiru Pedestrian Footbridge. These trips relate to LOS at the footbridge which has been established based on the re-designed effective pedestrian footbridge of 3.65 m. The estimated number of trips in 2013 was used to focus the number of trips that shall be generated in 2030 on the footbridge. The ultimate aim was to establish if the design of 3.65 m width of footbridge shall allow the footbridge to operate at recommended LOS B or C.

4.5.5.2 Design Projection Calculations in 2030.

The potential walking trips for the year 2030 were calculated based on sketch-plan method developed by Matlick (1996) and have been shown in Table 28.

Table 28: Design Calculations in 2030

Item	Formula	Calculations	Results
Projection of population from 2009 to 2013	$P_{2013}=P_{2009} \times 1.039$ (4.10)	$P_{2013}= 24, 295 \times 1.093$	26, 554 residents
Projection of population from 2013 to 2030	$P_2 = P_1 \times e^{kt}$ (4.15)	$P_{2030} =26, 554 \times e^{0.031 \times 17}$	44, 978 residents
Calculate Total Corridor Generated Trips	$TCGT=P_{2013} \times \text{trip per person}$ (4.11)	Assume 2 trips per person $TCGT= 2 \times 44, 798$	89, 956 trips
Calculate the Potential Pedestrian Trips	$PPT = TCPT \times (\text{All trips} < 0.8 \text{ km})$ (4.12)	Assume 95% of TCGT $PPT= 89, 956 \times 0.95$	85, 458 trips
Calculate the Estimated Primary Trips	$EPT= PPT \times (\% \text{ known walking trip} < 0.8 \text{ km})$ (4.13)	Assume 80% of PPT $EPT = 85, 458 \times 0.8 \text{ trips}$	68, 366 trips
Calculate Trips Related to the Pedestrian Footbridge	$TRPFB= EPT \times (\% \text{ known PFB trips})$ (4.14)	Assume 25% of EPT $TRPFB= 68, 366 \times 0.25$	12, 075 trips
Pedestrian Peak Volume in 2030	$= \frac{TRPFB_{2030} \times \text{Peak Design Hour}_{2013}}$ (4.16)	$\frac{TRPFB_{2013}}{10, 090} = \frac{12, 075 \times 1, 006}{10, 090}$	1, 205 ped/hr

Source: Author, 2013

The results in Table 28 the projected number of trips in the year 2030 and this number was used for determination of LOS of Uthiru Pedestrian Footbridge based on the re-designed pedestrian footbridge width of 3.65 m.

4.5.5.3 Projected Level of Service in 2030.

The researcher calculated the projected LOS in the year 2030 in order to establish the operating condition of pedestrian footbridge. The Level of Service has been determined by referring to section 2.8.2, Table 6. The calculations of LOS have been presented in Table 29.

Table 29: Calculation of Level of Service

Item	Formula	Calculations	Results
New Designed Effective Width			3.65 m
New Ramp Length of PFB			300 m
New Area of Effective walkway width	Area= $W_E \times L$ (4.4)	=300 m x 3.65 m	1, 095 m ²
Pedestrian Peak Volume, V_P in 2030			1, 205 ped/hr
Average pedestrian space	APA = $\frac{\text{Area}}{V_P}$ (4.5)	$\frac{1,095\text{m}^2}{1, 205 \text{ ped}}$	0.29 m ² /p
Level of Service Equivalent			LOS C

Source: Author, 2013

The results in Table 29 show that Uthiru Pedestrian Footbridge is expected to operate at LOS C in the year 2030.

4.6 Review on Conformation to Basic Warrants

4.6.1 Vehicle speed

The speed survey was carried out on both lanes of the highway. An average of 10 vehicles was sampled. The vehicle classification included cars (saloons), pick-ups, matatus or minibuses, busses, light trucks, medium trucks and heavy trucks. The speed survey was mainly carried out on the inner lane since this is where vehicles move at high speed. The outer lane is normally used by slow moving vehicles especially matatus and big busses which would like to stop at bus bays in order to pick and drop passengers.

From the results tabulated in Table 30, it was observed that motor vehicles pass through this section on Waiyaki Way at speeds greater than 60 km/hr. The traffic composition ranged from saloon cars to trailer trucks.

Table 30: Vehicle speeds along Uthiru Pedestrian Footbridge

Towards Nairobi CBD Direction					Away from Nairobi CBD Direction				
Vehicle Reg.	RC*	Time (s)	Distance (m)	Speed (km/hr)	Vehicle Reg.	RC*	Time (s)	Distance (m)	Speed (km/hr)
0547S	Car	5	100	72	967T	PU	5	100	60
402Z	PU	6	100	60	283Y	Car	4	100	90
903X	M	5	100	72	266G	Car	6	100	60
760M	B	10	100	36	719J	PU	5	100	60
829T	LT	5	100	72	752B	M	4	100	90
385V	HT	6	100	60	653A	B	7	100	51.4
452K	MT	4	100	90	621L	LT	5	100	60
980G	MT	5	100	72	137D	MT	8	100	45
324C	LT	4	100	90	399D	HT	7	100	51.4
574M	HT	6	100	60	245B	M	4	100	90
Average		5.6	100	68.4			5.5	100	65.8

Source: Author, 2013

*RC-Road Classification,

MT-Motor cycle,

M-Matatu or minibus,

B-Bus, LT-Light truck,

MT-Medium truck,

HT-Heavy truck

PU-Pick-up,

4.6.2 Traffic Survey

A four hour continuous traffic count was carried out and the results are presented in Table 31.

Table 31: Vehicular traffic volumes

Time	No of Vehicles travelling to Nairobi CBD Direction			No of Vehicles travelling from Nairobi CBD Direction		
	Inner Lane	Outer Lane	Total	Inner Lane	Outer Lane	Total
7.00-8.00 am	785	700	1,485	783	715	1,498
8.00-9.00 am	650	750	1,400	836	699	1,535
9.00-10.00 am	534	698	1,232	705	799	1,504
10.00-11.00 am	435	637	1,072	630	700	1,330

Source: Author, 2013

The minimum traffic volume in an hour was recorded as 1,072 vehicles and the maximum volume of traffic was recorded as 1,535 vehicles respectively. There is little difference in the directional distribution of traffic on the two carriageways. The traffic composition ranged from saloon cars to trailer trucks.

4.6.3 Review of Pedestrian Speed

4.6.3.1 General Pedestrian Speed on Uthiru Footbridge

Table 32 shows the results of average pedestrian speed survey conducted on Uthiru footbridge. Eleven pedestrians were sampled at random to check the accuracy of data in terms of the practical pedestrian speed. It was observed that on average, it takes 1.56 minutes for a pedestrian to cross the footbridge and the average speed is 44.68 m/min.

Table 32: Average Pedestrian Speed on footbridge

Serial No.	Pedestrian Type	Time - Minutes	Footbridge Length-m	Speed-m/min
1	Female	2.45	62.7	25.6
2	Female	1.13	62.7	55.5
3	Male	2.39	62.7	26.23
4	Female	1.08	62.7	58.06
5	Male	1.18	62.7	53.14
6	Female	1.23	62.7	50.98
7	Male	1.70	62.7	36.88
8	Female	2.03	62.7	30.89
9	Male	1.90	62.7	33.00
10	Male	1.03	62.7	60.87
11	Male	1.04	62.7	60.29
Total		17.16		491.44
Average		1.56		44.68

Source: Author, 2013

4.6.3.2 Ascending and Descending Pedestrian Speed on Uthiru Footbridge

Table 33 shows the results of average ascending and descending pedestrian speed survey conducted on Uthiru footbridge. It was observed that on average, it takes on average about 0.69 minutes to ascend and 0.45 minutes to on the footbridge. The average ascending speed was found to be 34.72 m/min as opposed to an average descending speed of 45.66 m/min.

Table 33: Ascending and Descending Pedestrian Speeds

Pedestrian Type	Time -Minutes		Footbridge Length-m	Speed-m/min	
	Ascending	Descending		Ascending	Descending
Female	0.40	0.45	19.6	49.0	43.56
Student	0.33	0.33	19.6	58.8	59.39
Female	1.06	0.38	19.6	18.49	51.13
Male	0.88	0.50	19.6	22.19	39.20
Female	0.5	0.70	19.6	39.2	28.0
Elderly Male	1.25	0.50	19.6	15.68	39.2
Male	0.53	0.42	19.6	36.98	46.67
Elderly Female	1.00	0.32	19.6	19.6	61.25
Student	0.38	0.50	19.6	51.58	39.20
Male	0.55	0.40	19.6	35.64	49.00
Total	6.88	4.5		374.16	456.6
Average	0.69	0.45		34.72	45.66

Source: Author, 2013

4.6.4 Time for Grade Crossing

Table 34 shows the results of the survey which was mainly conducted to establish the difference of average times taken by pedestrians when they cross using the footbridge versus the time taken when some pedestrians cross at grade. This is denoted by R and is called Convenience factor. It was observed that on average a pedestrian takes 1.56 minutes to cross the footbridge and an average of 1.06 minutes when a pedestrian crosses at grade. This translates into an average Convenience factor

of 2.37. According to Kane County Bicycle and Pedestrian Plan, (2012) 95% of pedestrians would use underpass and 70% of pedestrians would use overpass if R=1 (no time difference). Virtually no one would use the overpass if R=1.5, thus 50% time difference. The results indicate that the convenience ration is much higher and this contributes to non-usage of footbridge by pedestrians.

Table 34: Grade crossing versus grade- separated crossing

Serial No.	Time taken for PFB crossing in minutes, x	Time taken for grade crossing in minutes, y	Convenience Factor, x/y
1	2.45	1.00	2.45
2	1.13	1.50	0.75
3	2.39	0.55	4.35
4	1.08	0.50	2.16
5	1.18	1.05	1.12
6	1.23	0.90	1.37
7	1.70	1.20	1.42
8	2.03	1.00	2.03
9	1.90	0.35	5.43
10	1.03	0.50	2.06
11	1.04	2.05	0.51
Total	17.16	10.60	23.65
Average	1.56	1.06	2.37

Source: Author, 2013

4.7 Comparison of Uthiru PFB with Pedestrian Footbridges on Thika Highway

The researcher carried out a comparison of Uthiru Pedestrian Footbridge with the footbridges on Thika Highway. This comparison was done in order to review if key warrants for provision of footbridge were met on Thika Highway since Thika Highway is a newly modernized and commissioned road project in Kenya.

4.7.1 Staircase Configuration

The length and configuration of the pedestrian footbridges provided on either Thika Highway or Waiyaki Way depends on the number of lanes on which the pedestrian footbridges is traversing. For instance, the Uthiru Pedestrian footbridge has four legs or approaches constructed across a four lane roadway and all the legs are in form of staircase. Along the Thika Highway, the footbridge provided around Pangani Trading Centre has five legs and three of the legs are in ramp form to enable the physically challenged to use the footbridge. As such the total length of the pedestrian footbridge is much longer than the Uthiru Pedestrian Footbridge. Still on Thika Highway at Muthaiga, the footbridge consists of four legs and the footbridge is provided across an eight lane on the highway. Two of the pedestrian legs are in ramp form as well to enable the physically challenged to use the bridge. The bridge length is longer as compared to Uthiru Pedestrian Footbridge due to the inclusion of the ramp which is constructed on a gradient slope. The pedestrian footbridges on Thika Highway are roofed to shield pedestrians from the effect of sunshine and can be used as shelters when it rains while the Uthiru Pedestrian Footbridge is open (See pictures 38-43).

Picture 38: Uthiru Pedestrian Footbridge Layout Configuration



Source: Author, 2012

Picture 39: Pangani Pedestrian Footbridge



Source: Author, 2012

Picture 40: Muthaiga Pedestrian Footbridge



Source: Author, 2012

Picture 41: Ramp on Pangani Pedestrian Footbridge



Source: Author, 2012

Picture 42: Pedestrians crossing Pangani Footbridge using ramp section



Source: Author, 2012

Picture 43: Muthaiga Pedestrian Footbridge showing staircase approach

Source: Author, 2012

4.7.2 Surface Texture of Staircase

The surface of pedestrian access routes shall be firm, stable and slip resistant (United States Access Board, 2011). The surfaces of both Uthiru and Thika pedestrian footbridges are both firm and stable since the footbridges were constructed of concrete. They have rough surfaces which make them slip resistant in order to allow pedestrians to move on the surfaces comfortably even during rainy season when the surface is wet.

4.7.3 Structural Dimensions

The structural dimensions provided on Uthiru Pedestrian Footbridge and on those provided on Thika Highway are almost similar. The bridges have standard dimensions of 140 mm high risers and 300 mm long treads. The width of the ramps on Thika Pedestrian Footbridges is 2 m wide and the deck section is 2.2 m wide while the staircase width on Uthiru Pedestrian Footbridge is 2.2 m respectively. The head room for the covered roof on Thika Pedestrian Footbridges is 2.9 m and the height of the handrails on both Thika Pedestrian Footbridges and Uthiru Pedestrian Footbridge is

about 1.0 m. The roadway clearances of the bridges on both highways are 5.0 m which is the recommended height (See Picture 44).

Picture 44: Researcher on Muthaiga Pedestrian Footbridge Deck

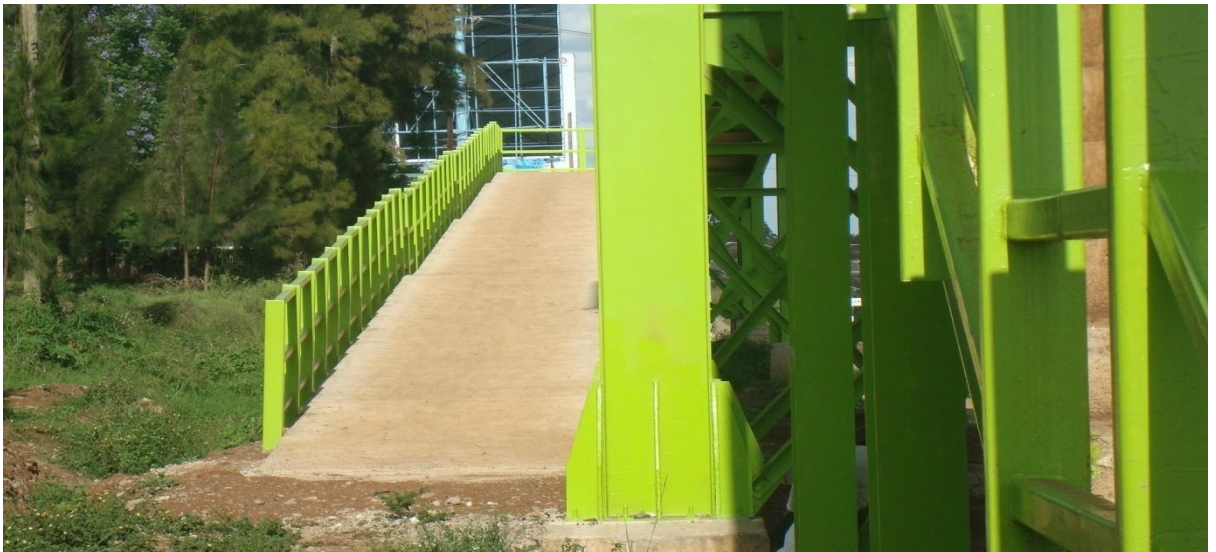


Source: Author, 2012

4.7.4 Channelisation Aspects

Channelisation is very important in non-motorised transport system because it guides pedestrians on their travel paths. The walkways have been provided on both Thika and Waiyaki Highways respectively leading to the pedestrian footbridges. The walkways on Uthiru Pedestrian Footbridge are in fair condition due lack of maintenance by the relevant authorities. The walkways on Thika Highway are in good condition since the highway has just been recently commissioned. However, it was noted that on Muthaiga Pedestrian Footbridge, one approach has not been completely constructed as part of channelisation to allow the physically challenged to use this part of the footbridge. In addition to that, the surface finishes are not good enough for smooth movement of wheelchairs (See picture 45).

Picture 45: One approach on Muthaiga Pedestrian Footbridge with uncompleted walkway



Source: Author, 2012

4.7.5 Provision of Lighting

One of the warrants for provision of the grade separated pedestrian crossings is that artificial lighting should be provided to reduce potential crimes against users of overpasses (Axler, 1984). This warrant was not met at Uthiru Pedestrian Footbridge since no lights were provided to allow the use of the bridge at night. This is the similar case with pedestrian footbridge provided on Thika Highway. Since Thika Highway is modern investment, it is least expected that lighting on pedestrian footbridge was not considered. This therefore entails that the steel footbridges will not be used during the night for safety reasons.

CHAPTER FIVE

5: DISCUSSION OF THE RESEARCH RESULTS

5.1 Basic Warrants for Provision of Pedestrian Footbridge

5.1.1 Volume of Traffic

One of the general warrants for overpasses is that pedestrians footbridge should be provided where there is very high volume of motorised traffic, lack of gap or nearly saturated multi-lane (Florida Planning and Design Handbook 1999). Axler, (1984) outlined that the vehicle volume should be over 7,500 in 4 hours for the proposed sites in urban areas. A total of 11,356 vehicles were recorded during a four hour traffic survey on both lanes. This figure is well above the minimum stipulated of 7,500 vehicles in four hours. It can therefore be concluded that the provision of the footbridge met this specification of traffic volume.

5.1.2 Speed of Vehicle

Overpasses are needed across roads with high speeds and may have lanes with limited gaps. In these high risk crossing conditions, there may be more gaps, but the conditions are more risky that many pedestrians will cross the overpass (Florida Planning and Design Handbook 1999). The pedestrian footbridge should be provided across highways where the vehicle speed is more than 65 km/h (Axler, 1984). From the results which have been tabulated in Table 30 , it was observed that most vehicles pass through this section and indeed on Waiyaki Way travelling at speeds greater that 65 km/hr and this basically meet the warrant for speed of vehicles

5.1.3 Volume of Pedestrians

One of the general warrants for overpasses is that the pedestrian footbridge should be provided where high volume pedestrian activity exists (Florida Planning and Design Handbook 1999). Pedestrian volume should at least exceed 300 in the highest 4 continuous hours or the pedestrian volume should be more than 100 pedestrians in the four highest continuous hour periods (Axler, 1984). It can be seen from Table 35 that the minimum volume of 100 pedestrians per hour was exceeded for the hourly count done for pedestrians. It could be concluded that the provision of the footbridge met this criteria.

Table 35: Average Pedestrian Volume on hourly basis for whole week

Time, V_{hour}	Day						
	Mon	Tue	Wed	Thur	Fri	Sat	Sun
6.30-7.30	779	600	411	424	683	754	324
7.30-8.30	494	648	499	531	576	521	537
8.30-9.30	274	282	180	292	249	616	407
11.00-12.00	424	356	402	284	274	N/A	N/A
12.00-13.00	349	523	410	254	310	N/A	N/A
16.00-17.00	504	859	637	806	776	574	859
17.00-18.00	1006	879	756	923	905	576	874
18.00-19.00	598	697	712	910	839	492	697

Source: Author, 2013

5.1.3 Traffic Generators related to Land

One of the general warrants for overpasses is that the pedestrian footbridges should be provided where high volume pedestrian activity exists (Florida Planning and Design Handbook 1999). Adjoining land use should be taken into consideration as well and examples include residential to residential or residential to shopping or bus terminal (Axler, 1984). The area should also have potential walking demand between the generator and attractors such as residential, school, residential-shopping, residential creation and residential-recreation (Demetsky, 1974).

The area has the trip the generators and attractors based on current land use which include commercial or office business; residential for both simple and multi-storey buildings; education institutions which include pre-primary, primary; secondary and tertiary education; recreational facilities like Kabete Golf Club and other government and non-governmental institutions like Kabete Police Station; Uthiru Administrative Police Unit; Uthiru Dispensary; St Peters Anglican Church of Kenya Clinic; Kabete Technical Training College; Animal Health and Industrial Training Institute; and College of Agriculture and Veterinary Services.

5.1.4 Alternative “Safe” crossing instead of GSPCs

The barrier is broken intermittently to allow pedestrians to cross at grade in lieu of footbridges and tunnels. The openings in the concrete barrier form part of safe crossing points. It has to be pointed out that at these openings, the relevant authorities did not put traffic calming measures as to allow high speed vehicles to slow down for pedestrians cross safely. Speed humps would be ideal to force drivers reduce vehicle speed. Road signs such as reduce speed, slow down and zebra crossing would be also ideal in warning drivers of pedestrian crossing ahead. Road marking for zebra crossing would be another preferred method.

Other safe crossing points are tunnels. It was noted that rubbish is dumped into these tunnels and silts accumulates at tunnel entrances due to storm water. Lack of maintenance on these tunnels de-motivates pedestrians from using the pedestrian footbridges.

5.1.5 Roadway Geometrics

Roadway geometrics play a role in the determination of pedestrian footbridge. A pedestrian footbridge works well if it is located on four or more number of moving traffic lane to cross to other side of roadway or highway-major artery, collector , local street (Axler, 1984). The Waiyaki Way is a dual lane highway and it is suitable to have pedestrian footbridges. As such it can be concluded that condition of providing pedestrian footbridges on multi-lane was met.

5.1.6 Design features affecting usage

Axler, (1984) outlined some design features which affect bridge usage. These include physical barrier to prevent at grade crossing, lighting for underpass and overpass, litter controls-routine cleaning, signage to entrance of GSPC, handicapped accessible-ramp slope and handrails.

One of the reasons for carrying out the site visit was to carry out the inventory of the footbridge and check if the above parameters were in place. It was noted that though there is a barrier to prevent grade crossing, it was not high enough to prevent grade crossing. The site did not have the lighting for safety of pedestrians at night and there was general poor maintenance in terms of litter controls and general cleaning. No signage was put in place to guide pedestrians to use the pedestrian footbridge and the bridge was not disability friendly as no ramp was provided. Besides that the footbridge does not have a roof cover.

5.1.7 Other Design features affecting usage

It was observed that the design and construction of the footbridge meets some warrants that are supposed to be incorporated in the design of the pedestrian overpass warrants for safety of pedestrians. The sides are constructed of material which allows complete visibility in order to reduce the probability of criminal acts directed toward pedestrians (Demetsky, 1974). Demetsky recommends that the sides of the pedestrian footbridge should be constructed of mesh material with openings large enough to allow for free air circulation but small enough to prevent cans or other objects from being thrown at passing vehicles. No mesh wire was used for construction of the sides of Uthiru Footbridge. However, the round steel bars which were used for sides of the footbridge allow free circulation of air.

5.2 Discussion on Staircase Geometric Design

Olando, et al (2003) recommends that the riser heights should be kept below 180 mm in order to reduce energy expenditures and increase traffic efficiency. The current riser height of Uthiru Pedestrian Footbridge is 140 mm high and this shows that the riser height is within the specification.

The bridge has standard dimension 300 mm long treads. The minimum length of the tread is 220 mm for safe and comfortable landing of pedestrian foot (Olando, et al 2003). It can therefore be concluded that the dimension of the tread is in line with the specification.

The width of Uthiru footbridge width is 2.2 m. The minimum width of the footbridge should be 1.8 m wide (Demetsky, 1974). According to Kotahi (2009), the minimum width of staircase should be 2.4 m. The researcher calculated the width of the footbridge to be 3.65 m in order to have the footbridge to operate at the required LOS B or C. This is above the minimum width of 2.2 m as specified by Kohati (2009).

The roadway clearance of the bridges on the highway is 5.0 m which is the recommended height. This is in line with the minimum height of 5.0 m according to Oregon Bicycle and Pedestrian Plan, (1995). The Pedestrian Planning and Design Guide of New Zealand, (2009) recommends a minimum roadway clearance of 4.9 m. Going by both standards, the roadway clearance is within the specifications.

The roadway clearance is subject to debate when it comes to some other circumstances. For instance it was reported in the Daily Nation Newspaper dated Monday 1st April, 2013 that eight students of Pangani Girls High School were injured when a trailer brought down the footbridge (See pictures 46, 47 & 48). It was reported that the driver of the trailer under-estimated the height of footbridge, thereby hitting it and bringing the steel pedestrian footbridge and part of it down. The trailer was overloaded to higher height than the normal height. The students were in the middle of the footbridge when it came apart on the impact, leaving the students suspended on one side.

According to Manual for Roads and Bridges: Part 4-Bridges and Culverts Draft, 2009, the roadway clearance has been revised to 5.6 m. This height is expected to accommodate trailers which overload and hit the underside of footbridges.

Picture 46: Picture of footbridge brought down by trailer



Source: Daily Nation, 1st April, 2013

Picture 47: Damaged pedestrian steel footbridge



Source: Author, 2013

Picture 48: Pangani High Girls footbridge requiring major maintenance after it was brought down by trailer



Source: Author, 2013

5.3 Discussion on Review of Pedestrian Speed

5.3.1 General Pedestrian Speed on Uthiru Footbridge

The average pedestrian speed on Uthiru footbridge was found to be 44.68 m/min and takes an average of 1.45 minutes for a pedestrian to cross the footbridge. The researcher was not able to relate the average pedestrian speed found after the

survey to the actual design of footbridge or warrants because no relevant literature is available to relate this.

5.3.2 Ascending and Descending Pedestrian Speed on Uthiru Footbridge

The average ascending speed was found to be 34.72 m/min according to the speed survey. According to Olando, et al (2003), the ascending speeds on stairs or footbridges have shown to range from 12 m/min to 21 m/min. For general planning and design purposes, an average ascending speed of 15 m/min is recommended. Ascending speeds are slower on longer stairs because pedestrians slow as they reach at the top. Most pedestrians had to rest when they reached the deck slab and as a result pedestrians took longer to cross the footbridge.

The average descending speed was found to be 45.66 m/min according to the speed survey conducted. The descending speeds on stairs or footbridges have shown to range from 17 m/min to 31 m/min (Olando, et al 2003). For general planning and design purposes, an average descending speed of 18 m/min is recommended. Pedestrians took longer time to descend because of the resting element which was experienced even on the ascending of pedestrian movement.

5.3.3 Time for Grade Crossing

Convenience factor, R from the survey was found to be 2.37. Convenience factor is the ratio of time taken to travel on the overpass or underpass divided the time to travel at grade level (Kane County Bicycle and Pedestrian Plan, 2012). It was reported that 70% of pedestrians would use overpass if $R=1$ (no time difference) and virtually no one would use the overpass if $R=1.5$, thus 50% time difference (Moore and Older, 1965). As per the results, it is inevitable that the convenience factor is much larger and this contributes to some pedestrians in crossing at grade. It has to be mentioned that time taken for grade crossing varied with time. During peak hours, pedestrians took more time to cross as compared to crossing during off peak hours. However, the safety of pedestrians should be paramount when the convenience factors are taken into account.

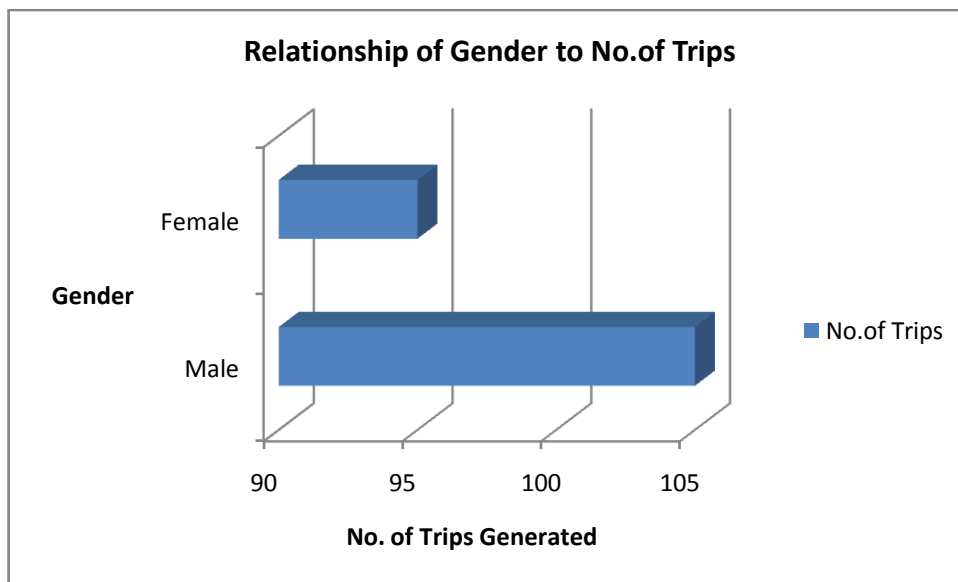
5.4 Oral Pedestrian Interview Results

5.4.1 Pedestrian Profile

5.4.1.1 Gender

Gender is one of the factors that influence the amount of walking. Women complete fewer walking trips (Kockelman, 1996). Historical research finds that men walk further than women (Demetsky and Perfater, 1975). However Agrawal and Schimek (2007) found no difference in mean walk trip length between genders and that men completed fewer pedestrian trips compared to women. The results of trips generated based on gender are shown in Figure 39 and indicate that men made more trips than women. The results seem to agree with above theory (Figure 39).

Figure 39: Relation of Gender to Number of Trips Generated



5.4.1.2 Interviewee`s Physical Condition

The researcher included the establishment of the pedestrian`s physical condition as one of the aspects in the demographic elements. This was very essential in order to establish the degree to which the pedestrian footbridge is being used by the physically challenged. This is one of the requirements that transportation engineers need to be aware of sizeable proportion of individuals falling in the disability category.

In order to integrate the physically challenged aspects when providing pedestrian facilities, it is essential that the transportation engineer understands the meaning or definition of what disability is all about. Most civil rights statutes define disability as a physiological or psychological disorder or condition, cosmetic

disfigurement, or anatomical loss affecting one or more systems of the body (Zegeer, 1998). According to Zegeer (1998), for engineering purposes, a disability can be classified in three functional categories: mobility impairments, sensory deficits or cognitive impairments.

Zegeer (1998) further explains that a person with mobility impairment is any person who because of some physical problem or circumstances is limited in his or her method or ability to move about. These would include those who use wheelchairs, braces, crutches, canes and walkers. It also includes persons with balance stamina problems and may even include pregnant women. Sensory deficits are most often associated with blindness, deafness, partial hearing or vision. Cognitive impairments are related to diminished ability to process information and make decisions. For instance, cognitive impairments apply to those who are retarded or who have dyslexic type of learning disability and include those who are unable to read.

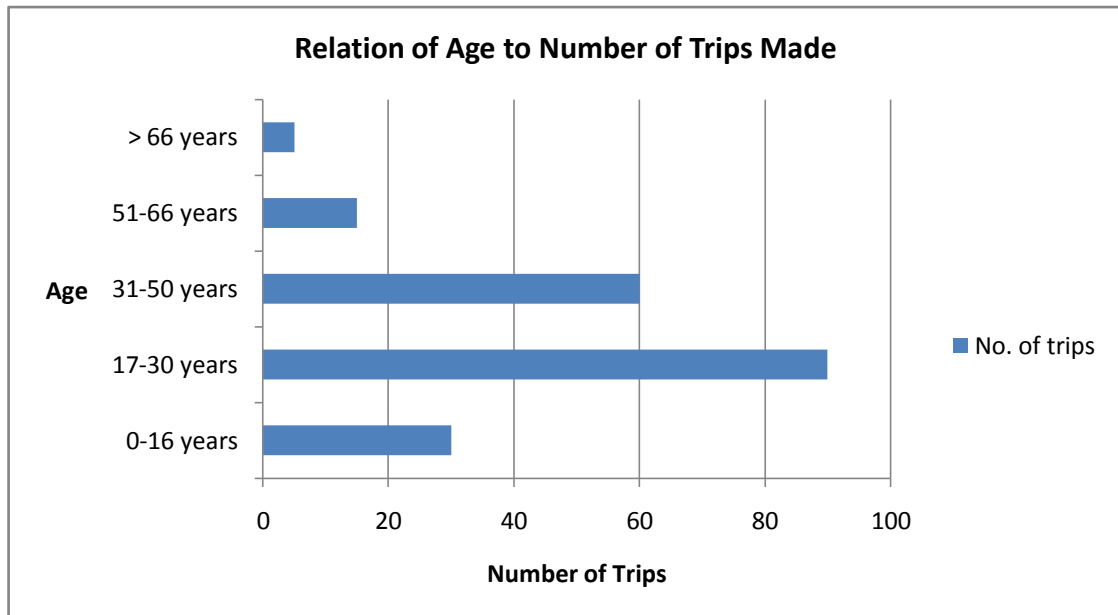
A person with disability travelling independently is usually a shopper, student or employee going about normal business and it is the job of the transportation engineer to refrain from erecting barriers or obstructions that would impede movement (Zegeer, 1998). The American Disability Act, (1990) advocates for provision of pedestrian facilities which accommodate the physically challenged. In this case, it states that stairway or steps should be avoided. The results show that only 2 pedestrians were physically challenged representing 1% are the ones that were observed to have used the pedestrian footbridge. This could be attributed to the fact that the footbridge does not have a ramp to accommodate those that have mobility impairments.

5.4.1.3 Age Group

Demographics which include age affect the mode of choice and travel behaviour. Age affects commuting distances with older individuals commuting shorter distances than young people (Schneider, 2011). The age structure of the family also governs the trip rates. Older persons are not expected to generate as many trips as young ones (Kadiyali, 2002). Figure 40 shows the relationship of the age structure of pedestrians to the number of trips made. The highest percentage belonged to the 17-30 years category and this the age group that made highest number of trips. The second largest percentage belonged to the 31-50 years category and made the second highest

number of trips. There were few trips which were made by pedestrians in the 51-66 years old group and greater than 66 years old group as depicted on the graph. This trend conforms to theory developed by Schneider (2011) and Kadiyali (2002) in relationship of age versus the rate of making trips or distances commuted.

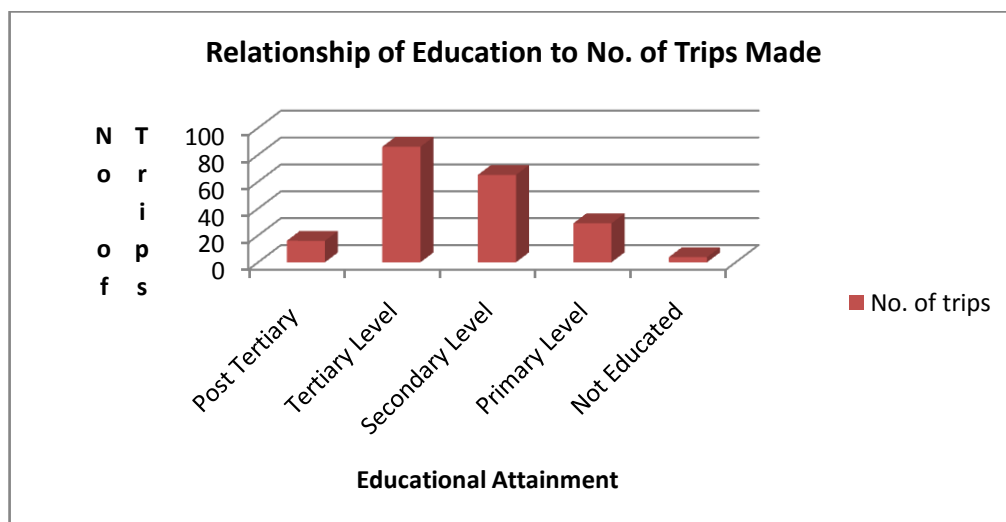
Figure 40: Relationship of Age Structure of Pedestrians to Number of Trips Made



Source: Author, 2013

5.4.1.4 Educational Level

Figure 41: Relationship of Educational Attainment to Number of Trips



Source: Author, 2013

Figure 41 shows the relationship of educational attainment with number of trips made. Education attainment affects mode of choice and travel behaviour (Schneider, 2011). Trost (2002), discovered consistent findings of a positive correlation between educational attainment and physical activity in general. After controlling income, Agrawal and Schimek (2007) agree those with graduate degree were more twice likely to take a recreational walk trip than those with only a high school degree. The survey results seem to follow this trend established by Agrawal and Schimek (2007) with the highest number of trips being made by those with tertiary education and the least number of trips being made by those not educated. The highest number of graduates and corresponding high number of trips made by those in the tertiary level could be attributed to a number of colleges which are in and around Uthiru Town which include Kabete Technical Training College, Animal Health and Industrial Training Institute and College of Agriculture and Veterinary Services. The area has various secondary institutions which are either government run or privately owned. As such, second highest number of trips is made by those in the secondary level education. It was generally observed that level of education did not influence the use of pedestrian footbridge since safety becomes paramount.

5.4.1.5 Occupation of Trip Maker

Trip generation is associated with socioeconomic factors which includes employment. According to Mousavi, (2012) those that are employed are likely to make more trips to work and that college and high school students tend to make more additional trips and stops. It can be argued in this case that those that are in business of any kind including vendors are likely to make more trips due to the nature of their work.

It is inevitable that those employed make daily trips to work. The same is the case with students who are supposed to go to school daily resulting into daily trip generation. Even those who are engaged in business are forced to make trips by virtue of their profession. The pedestrians who are not employed make trips whenever it is necessary and the retired rarely make trips. This trend has been depicted in Figure 42. The highest number of trips was made by the pedestrians in business and students category with lowest being made by the retired category.

Figure 42: Relationship of Occupation of Trip Maker to Number of Trips Made



5.4.1.6 Income Levels of Pedestrians

Family income which represents the ability to pay for a journey affects the number of trips generated by a household (Kadiyali, 2002). Uthiru has a total number of 7,374 households according to 2009 Housing and Population Survey done by Central Bureau of Statistics. The incomes of these households determine the rate of trip generation. According to Kadiyali (2002), a general trend is that the higher the income, the higher the trip generation rate.

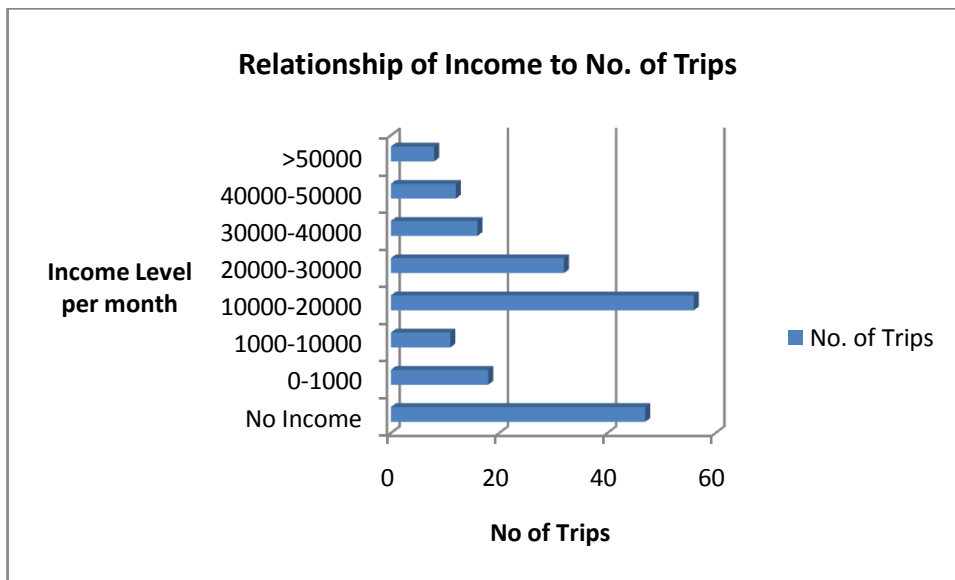
Redmond and Mokhtarian (2001) found that income is always positively related to travel and that people with higher income travel greater distances and more often for entertainment. Income also impacts the distance and mode selected to commute to school and work. According to Redmond and Mokhtarian (2001), income also affects long distance travel with higher income demographic having more expendable income and having greater access to vehicles or air travel. Those in the lower income demographic show moderate levels of long distance by automobile potentially because driving is more economically feasible when compared to air travel (Schneider, 2011). Equally, it can be implied that those in much lower income demographic category have to use walking as a means of transportation and public transport.

The above theory just portrays the trend of the pedestrian travel results with the majority of the respondents were in the no income category forming 31.5% of the

respondents. Traditionally those respondents in the KSh 0- KSh 1,000 ought to have been the second highest group to use the footbridge based on income levels but the trend is different on this survey. It can be argued that the occupation also determines the rate of trip generation. In this case, the second percentage, 25% was formed by respondents in the KSh 10,000-KSh 20,000 and this could be attributed to both informal and formal business taking place around Uthiru Town.

There are few trips which are done by those in the higher income levels (KSh 40,000-KSh 50,000 and greater than KSh 50,000) comprising 1.5% and 3% of the respondents respectively because most of those with high income levels tend to use personal cars or private cars (See Figure 43)

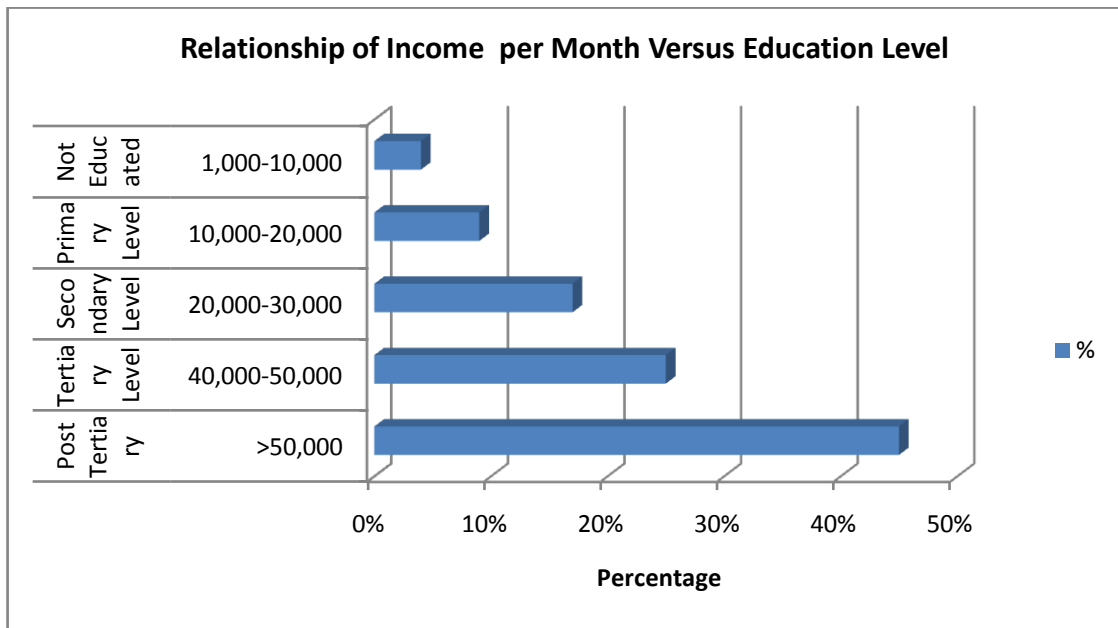
Figure 43: Relationship of monthly income level to trip generation



Source: Author, 2013

Figure 44 shows the relationship of income generation versus educational level. From the figure, it can be shown that those with higher education level earn more income than those that are not educated. For instance, it can be seen that those with post-tertiary education earn more than KSh 50, 000 per month when compared to those that are not educated. This could be attributed to government policy on remuneration of employees in line with educational qualifications. Those that are not educated are assumed to be engaged in casual work and as such they are not highly remunerated.

Figure 44: Relationship of Income versus Educational Level



Source: Author, 2013

5.4.2 Origin and Destination of Trips

5.4.2.1 Trip Purpose

Trips are made for different purposes and classification of trips is necessary (Kadiyali, 2002). According to Kadiyali (2002), the break-up of trips by purpose is normally done for home-based trips which represent nearly 80-90% of the total trips. This seems to be in tandem with the results of trip purpose since the largest percentage of the respondents of 24.5% formed by pedestrians who were returning home from different places be it work or business.

The second highest percentage of 22.5% was formed of respondents who travelled for work related purposes. Residents of Uthiru Town either work in Nairobi CBD area or in places around Uthiru Town. Work-related trips could be attributed to the need for the pedestrians to have accessibility to public transport system by travelling from home to bus stops to go to work and back.

This production of trips can also be attributed to land use characteristics. Different land uses produce different trip rates (Kadiyali, 2002). For example, residential area with high density of dwellings can produce more trips than the one with a low density. On the other hand, low density areas may represent dwellings of more affluent society which may produce a large number of private trips. Land use

also encompasses use of adjacent land. Since the area has a number of educational institutions which range from pre-primary, primary secondary and tertiary ones, it is no wonder that the second largest of respondents, 18%, is formed by pedestrians who made trips related to education.

17% of the trips were formed by pedestrians who were just walking for recreational trips and 15% of the trips were related to business trips. Since Uthuru Town has open markets and a considerable number of vendors including those in “*jua kali*”² areas, it was anticipated that travel purposes would capture this trends.

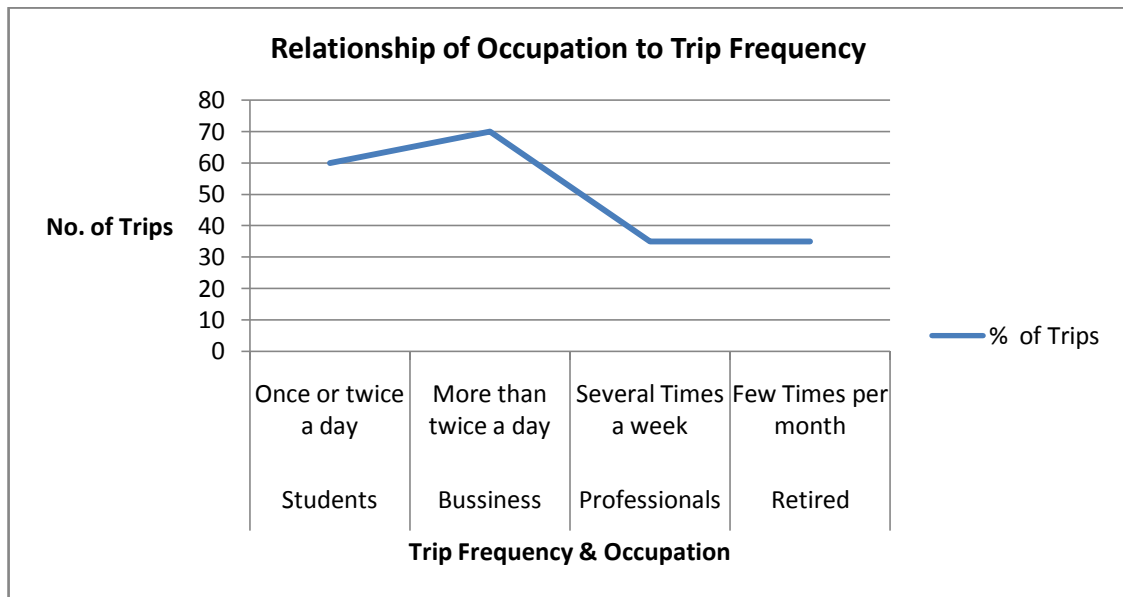
5.4.2.1 Trip Frequency

The trip frequency can be associated to Mousavi theory of trip generation. According to Mousavi, (2012) those that are employed are likely to make more trips to work and that college and high school students tend to make more additional trips and stops. It can be argued in this case that those that are in business of any kind including vendors are likely to make more trips due to the nature of their work.

The results indicate that the highest percentage is 47.5% and formed by pedestrians who use the footbridge once or twice a day. This could be attributed to high percentage of students who normally cross the footbridge when going and coming back from school or professionals who go to work in the morning and come back in the evening. The second percentage of 36% is formed by pedestrians who use the footbridge more than twice per day. These pedestrians are either in the business, informal or unemployed occupational category. There were few trips made by the retired, hence the frequency of trip generation was few times per month (Figure 45).

² Jua kali is small scale business ventures

Figure 45: Relationship of Pedestrian Occupation to Trip Frequency



Source: Author, 2013

5.4.3 Pedestrian Perception

5.4.3.1 Community Consultation during planning stages

It was generally revealed that the communities were not consulted during the planning stages of the footbridge in terms of location and their general input by the Nairobi City Council in establishing the need of the footbridge and its location. KeNHA is the one which constructed the footbridge as such any consultation ought to have been done by KeNHA.

5.4.3.2 Rating Pedestrian Footbridge Usage by Pedestrians

It was generally observed that the pedestrians appreciate the existence of the pedestrian footbridge. To that effect, the pedestrians rated the use of the footbridge positively with 29.5% of the respondents rating the usage of footbridge usage as good, followed 23.5% of the respondents who rated the usage of footbridge as excellent. 13% of the respondents rated the use of footbridge as very good. This implies that about 68% of the respondents rated the use of the footbridge as satisfactorily. A total of 32% of the respondents composed of 23.5% rated the use of pedestrian footbridge as fair and 8.5% who rated the use of footbridge as poor indicate the use of footbridge as unsatisfactory.

5.4.3.3 Reasons for shunning pedestrian footbridge by pedestrians

One of the major reasons which were highlighted by pedestrians why they do not use the footbridge is the time factor. The time factor is related to the time taken to cross the footbridge. There was a general feeling that it takes more time to cross the footbridge. 44.5% indicated that the main reason for not using the footbridge is that it takes time to cross. This can be linked to ease of accessibility that determines the use of pedestrian footbridge (Kane County Bicycle and Pedestrian Plan, 2012) . Convenience factor, R is used. $R = \text{ratio of time taken to travel on the overpass or underpass divided by the time to travel at grade level}$. The 1965 study by Moore and Older according to Kane County Bicycle and Pedestrian Plan, (2012) indicated that 95% of pedestrians would use underpass and 70% of pedestrians would use overpass if $R=1$ (no time difference). Virtually no one would use the overpass if $R=1.5$ (50% time difference). It has to be pointed out that though the time factor is crucial to determine the use of the footbridge, is inevitable that there the pedestrian would take more time to cross at grade-separated than at grade. The overall aim of pedestrian safety should be the principal concern for provision of pedestrian footbridge and the time factor should come secondary.

27% of the respondents indicated that some pedestrians shun the use of footbridge due to mere negligence. This is one of the non-conforming behaviours of pedestrians which are related to traffic violations. Traffic violations occur when road users including pedestrians seek an increased mobility by disregarding traffic laws and regulations (Zaki, 2012). According to Zaki (2012), this behaviour can come at the expense of accepting additional collision risk. Jay crossing is spatial type of traffic violation where pedestrians decide to cross at non-designated crossing regions.

There are no bylaws for jay crossing in the City Council of Nairobi General Nuisance Bylaws of 2007. As such, no relevant fines are in place for jay walking offences. However, the set of by-laws have fines for other offences related to pedestrians. For instance pedestrians who cross the road when the traffic lights are red are fined KSh10, 000.00. Pedestrians who cross the road while talking on mobile phone are fined KSh 500.00 while those found alighting or boarding at non-designated matatu stops are fined KSh 10,000.00 respectively. The Nairobi City Council should emulate examples of by-laws of Town of Sidney which imposes a fine of \$50 for

contravening this by-law of jay walking. Wellington City Council of New Zealand has fines ranging from \$10 to \$35.

Upon formulation of the by-laws on jay walking, the assembly should look into issues of enforcement seriously. There is general lack of enforcement of the by-laws due to lack of resources in the assembly which include human resources and vehicles. It was observed that corruption is one of the major factors affecting enforcement of the by-laws. City assembly security officers who are sometimes deployed to monitor compliance with other bylaws engage in corrupt practices. Would be offenders are requested to pay a small amount to the security officers instead of paying the recommended fine to the assembly coffers so that they are set free (Nairobi Newspaper, 1-7 March, 2013).

27 pedestrians forming 13% of the respondents felt that the footbridge is not fully utilized because it is not suitable for the physically challenged since no ramp was provided for the physically challenged. This is a very important aspect to consider in the future design of pedestrian footbridges in Kenya. The author is happy to indicate that there are improvements in the design of other footbridge which were constructed recently which included the ramps for use by the physically challenged. This is the case on Thika Highway which provided pedestrian footbridge with one approach having a ramp to cater for the physically challenged and those who are cycling. The other pedestrian footbridge is University of Nairobi pedestrian footbridge which has been completed on University Way near Central Police Station.

5.5% of the respondents comprising 11 pedestrians pointed out that vending business which is normally done at the footbridge especially in the afternoon is one of the factors that force pedestrians to shun the footbridge. The City Council of Nairobi General Nuisance Bylaws of 2007 has bylaws which bar vendors from operating in any public places apart from the designated selling stalls. For instance a bylaw relating to selling of fruits and vegetable states that “A licensed vendor shall not carry out on a business of a fruit or vegetable seller in any premise other than from a stall in a public market; provided however, that notwithstanding the provisions of this bylaw, the council may license private premise which have been approved in writing by the Medical Officer of Health for the sale of fruits and vegetables.

This is commendable because the City Council does not condone the vending of goods on footbridges because the presence of many vendors on the footbridge to sell their goods especially in the peak hours of the afternoon inconveniences many pedestrians who cross the footbridge at this time of the day. It still remains the issue of enforcement of this bylaw. The City Council ought to be conducting periodic checks on vending on pedestrian footbridges. It can be argued that the council ought to have come with stiffer penalties which range from impounding their products, imposing of hefty fines and even imprisonment jail terms.

2% of the respondents indicated that some pedestrians do not use the footbridge because of safety reasons. This is the case because the footbridge does not have lights for use in the evening. The issue of security is a very important one. Future designs and construction considerations should include lighting on bridges for safety of pedestrians during the night.

Though Only 2 pedestrians forming 1% of the respondents indicated that the footbridge is not used due to aesthetic elements, it is important to provide footbridge with aesthetic design. Examples of better footbridges include those on newly commissioned Thika Highway.

1.5% of the respondents cited the width of the footbridge as not being wide enough to cater for a large number of pedestrians to use the footbridge as one factor which dissuades pedestrians from using the footbridge. This issue has been covered under the calculation of level of service at which the footbridge is operating. It was observed that the footbridge is operating at LOS F. The calculation of the desired width of the footbridge was found to be 3.65 m in order to have the operation of footbridge at LOS B.

5.4.3.4 Impact of awareness on improving footbridge usage

The research requested the pedestrians to indicate if awareness campaigns can motivate the general public to use the footbridges. 90% of the respondents believed that awareness creation or campaigns for use of footbridge can motivate more pedestrians to use the footbridge thereby increasing the rate of usage. This entails that the city council or even planners should consider creating awareness of pedestrian usages in order to increase the utilization levels of the pedestrian footbridge.

5.4.3.5 Methods of awareness as proposed by pedestrians

It was observed that 30% of the respondents opted for installation of road signs as a means of creation of awareness of increasing the footbridge utilisation. 22% of the respondents opted for sensitization of use of footbridge using community leaders in churches, at funeral ceremonies and political rallies. 20.5% of respondents chose the use of radio as a means of spreading awareness campaigns. 18% of the respondents opted for television use for awareness campaigns. The lowest percentages of 5% and 4.5% respectively preferred other methods and use of newspapers.

The researcher believes that the use of road signs as one way of informing the general public on the presence and importance of using the pedestrian footbridge is the most ideal one. This is because all pedestrians who come to bridge site would be able to see the road signs and follow instructions. Use of radio, television, newspapers is also important but the awareness should be done for general use of footbridges. In the advertisement, the general public should be informed of the risks associated with crossing of highways at un-designated places, the importance of safety and the economic impact of accidents to the general public and nation at large. Currently, the message on safety is being aired on different television channels by the National Transport and Safety Authority which is a new body mandated by Kenyan Government to look into issues of road safety.

5.4.3.6 Damage of Concrete Barriers

It was observed that the damage of concrete barrier was mainly by vehicle accidents as indicated by 65% of the respondents. Structural failure was also mentioned as the second factor which 12.5% of the respondents and finally vandalism. The damage of concrete barrier attracts pedestrians to cross at grade in such places where there are openings. It is therefore imperative that maintenance of damaged places should be done on annual basis as part of routine maintenance by KeNHA.

5.4.3.7 Proposals by pedestrian footbridge

The pedestrians proposed the inclusion of some features in order to increase the utilisation levels of the footbridge and enforcement of some bylaws which affects the footbridge usage (Refer to Table 36 for details). Table 36 outlines short terms and long terms improvements which can be done on the footbridge in order to address the

concerns of the pedestrians. Some improvements have financial implication and require the technical input from both the City Council and KeNHA.

Table 36: Impact of Proposals on the footbridge

Serial No	Proposal	%	Comments
1	Lighting	35.5%	Can be supplied at present footbridge
2	Improvement on maintenance	16.5%	Can be implemented
3	Increasing height of the concrete barrier	13%	Not easily done unless demolition is done and is costly
4	Up-graded with ramps	12.5%	Not easily done unless demolition is done and is costly
5	Road signs	6%	Can be supplied at present footbridge
6	Escalators and roofing	5%	Only roofing can be done but costly
7	Barred vending on footbridge	4.5%	Can be done by NCC
8	Widen width of footbridge	4.0%	Not easily done unless demolition is done and is costly
9	Erecting a barrier	3%	Can be easily done

Source: Author, 2013

5.5 Discussion on Microscopic Parameters

It was generally observed that the behaviour of pedestrians affect the movement of other pedestrians. As such, this general behaviour is supposed to be considered in the design and provision of pedestrian footbridge in order to maintain the required Level of Service. Such behaviour includes idling on footbridge, holding of hands as they walk side by side on footbridge, use of mobile phones while crossing the footbridge, bargaining for lower prices on items which are sold on the footbridge, carrying of goods while crossing the footbridge and use of footbridge by other NMT modes which include cyclists.

5.6 Macroscopic Parameters

5.6.1 Level of Service

5.6.1.1 Level of Service of Uthiru Pedestrian Footbridge

The LOS of staircase determines the level of comfort of the pedestrians. The current LOS of footbridge shows that pedestrians are congested, thus at LOS either E or F. When designing the width of the pedestrian footbridge, the planner or designer should choose the level of service that is going to operate at footbridge and consider comfort of pedestrians (Azlan, 2010). The desirable peak-period pedestrian flow should operate at LOS C or above (TRB, 2003 and Olando et al, 2003). From calculations in this study, the required footbridge width to enable the footbridge to serve at LOS B is 3.65 m. This means that the width of footbridge ought to have been enlarged by 1.45 m in order to provide a better operational condition.

5.6.1.2 LOS for Shared Pedestrian and Bicycle Facilities

It is very important to analyse the capacity and LOS of facilities which serve pedestrians. This helps analysts to investigate the effects other NMT modes have on pedestrian facility as well as the effect of pedestrian volume on flow and LOS. Shared pedestrian facilities are open to use by non-motorized modes such as bicycles, skate boards and wheelchairs (HCM, 2000). In Kenya, there are few paths exclusively for pedestrians; hence most off-streets paths are shared including pedestrian footbridges. The use of other NMT modes on footbridges can have a negative effect on pedestrian capacity and LOS.

The LOS of Uthiru footbridge has been observed to be operating at LOS E and F respectively based on peak pedestrian volume. This has not taken into account other NMT modes. During the pedestrian survey exercise, it was observed that some non-motorized modes such as bicycles also use the footbridge though the number was on the lower side. LOS for shared paths is based on hindrance (HCM, 2000). According to HCM (2000), because pedestrians seldom overtake other pedestrians, the LOS on shared paths depends on the frequency that average pedestrian is overtaken by cyclist. In this case, since the footbridge is operating at either LOS F or E, the presence or use of footbridge will inevitably result into more congestion. This means that the LOS will come to LOS F.

5.6.1.3 Calculation of Footbridge Width Based on other NMT Modes

Cyclists need more space on shared pedestrian and bicycle facilities. In order to accommodate any minor reverse-flow which occurs frequently in pedestrian volume or to accommodate other non-motorized modes, the footbridge or stairway width should be increased by a minimum of one traffic lane of 30 inches (Washington Metropolitan Area Transit Authority, 2005). Based on the above guideline, the researcher decided to add 0.75 m to the calculated pedestrian footbridge in order to accommodate non-motorized modes such as bicycles. From the calculation, the required width of footbridge to enable the staircase to serve at LOS B is 3.65 m and this width takes into account the provision of other NMT modes which may use the footbridge which includes cyclists or those with wheelchairs. This means that the width of staircase ought to have been enlarged to provide a better operational condition.

5.6.1.4 Validation of the Width of Uthiru Pedestrian Footbridge

The researcher carried an inventory of a number of existing pedestrian footbridges in Nairobi as to establish their widths. This was done as one way of validating the designed effective width of Uthiru Pedestrian Footbridge. The researcher also captured some case studies from other countries (Refer to Tables 37 to 39 for details of existing dimensions for the widths of footbridges). From the Tables, it can be seen that the footbridges in Virginia, Nyayo, Madaraka and at Wilson Airport are wide enough to accommodate peak volume of pedestrians though they are at low utilisation. The pedestrian footbridge on High Selassie is also wide enough to accommodate more pedestrians at peak hours and it is highly used by pedestrians.

The widths of High Rise Estate and Marighiti pedestrian footbridges in Nairobi are not wide enough yet they were constructed in areas where there are high pedestrian traffic activities. For instance, there is a lot of pedestrian traffic in Kibera which cannot be accommodated within the current pedestrian area on the footbridge even during off-peak hours. The width of Nairobi Railway pedestrian footbridge is also not wide enough to accommodate pedestrians who use this footbridge. This is one of the busiest pedestrian footbridges connecting the commercial area with residential and industrial area and the width of the footbridge ought to have been wider than the standard width of 2.4 m which was provided.

The effective width of Westlands, Agha Khan and Uthiru footbridges on Waiyaki Way is 2.2 m wide. It could be assumed that the planners opted to adapt the standard width of 2.4 m without consideration of pedestrian traffic volume.

According to Manual for Roads and Bridges: Part 4-Bridges and Culverts Draft, 2009, the width for pedestrians overpasses should have a minimum width of 3.0 m in order to accommodate three pedestrians, bicycle and a pedestrian in width. The design effective width of Uthiru footbridge is 3.65 m. The design effective width of 3.65 m can therefore be validated since there is a difference of about 0.65 m if the researcher was to adopt this requirement (See Pictures 48 and 49 on pages 150 & 151).

Table 37: Designed Effective Width on Various Pedestrian Footbridges in Virginia

Serial No	Name of Pedestrian Footbridge	Total Width	Effective Width	Status
1	Interstate 264- Eastern Virginia	3.05 m	N/A	Highly used by students. 90% of users observed were students
2	Interstate 64- Eastern Virginia	3.05 m	N/A	Highly used by students. 95% of users observed were students
3	Interstate 95- Eastern Virginia	2.44 m	N/A	Highly used by female for shopping. 55% of users observed were female

Source: Demestky, 1974

Table 38: Pedestrian Footbridges on Langata Road and Mbangathi Way in Nairobi

Serial No	Name of Pedestrian Footbridge	Total Width	Effective Width	Status
1	Nyayo Stadium	3.7 m	3.1 m	Hardly used by pedestrians. Used for exercise in the morning hours by joggers
2	Madaraka PFB	3.7 m	3.1 m	Hardly used by pedestrians.
3	Wilson Airport on Langata Road	3.7 m	3.1 m	Hardly used by pedestrians. Used by few students
4	High Rise PFB on Mbangathi Way	2.4 m	1.80 m	Not highly used but located within the market of pedestrian activity- Kibera

Source: Author, 2013

Table 39: Various Footbridges on Haile Selassie & Waiyaki Way Highway in Nairobi

Serial No	Name of Pedestrian Footbridge	Total Width	Effective Width	Status
1	Railway PFB in Nairobi CBD	2.4 m	2.4 m	Highly utilised by pedestrians
2	Haile Selassie PFB near Time Towers	3.5 m	3.0 m	Highly utilised by pedestrians
3	University of Nairobi PFB on University Way	3.7 m	3.10 m	Under construction
4	Marighiti PFB on Haile Selassie	2.15 m	1.65 m	Not highly used but located within the market of pedestrian activity
5	Westlands PFB Waiyaki Way	2.66 m	2.2 m	Low utilisation
6	Agha Khan PFB on Waiyaki Way	2.66 m	2.2 m	Low utilisation

Source: Author, 2013

Picture 49: University of Nairobi PFB under construction



Source: Author, 2013

Picture 50: Part of High Selassie PFB



Source: Author, 2013

5.6.2 Design Projection

According to Axler, (1984), a specific need should exist or be projected for grade separated pedestrian crossing based on existing or land use (s) adjoining the proposed site which generate trips. These land uses should have direct access to grade separated pedestrian crossing. To provide framework for future transportation system needs, the plan must consider the transportation needs of future growth (Washington Metropolitan Area Transit Authority, 2005). The design projection year which has been chosen is 2030. The year 2030 is consistent with the forecast year used in Kenya Vision 2030.

It was observed that the population forecast in 2030 will be 40, 250 and this translates into 1.5 times the design population projected population design in the year 2030. The author projected that LOS₂₀₃₀ for operating of footbridge will be LOS C. The design of the footbridge, therefore has been done to ensure that the footbridge remains in better operating LOS for long period at Uthiru Pedestrian Footbridge.

5.6.3 Pedestrian Density

Pedestrian density is the average number of persons per unit area within a walkway or queuing area, expressed as persons per square foot or meter (HCM, 2000). The average area for each pedestrian was found to be 0.22 m²/pedestrian. Pedestrian

facility designers use body depth and shoulder breadth for minimum space standards, at least implicitly. A simplified body ellipse of 0.5m x 0.6m with a total area of 0.3 m² is used as the basic space for a single pedestrian as this represents the practical minimum for standing pedestrians. In evaluating pedestrian facility, an area of 0.75 m² is used as the buffer zone for each pedestrian (HCM, 2000). From the results of the survey, it was observed that the area of each pedestrian during peak design volume was less than both the body ellipse and buffer zone area for each pedestrian.

5.7 Discussion on Legal, Institutional and Regulatory Framework

5.7.1 Nairobi Metro 2030

Nairobi Metro 2030 is a very important policy document for the Government of Kenya which is under Ministry of Nairobi Metropolitan Development. The document outlines key strategies of development of world class infrastructure facilities and services. The document has some consideration of non- motorized transport elements. For instance, the document outlines that the focus on non motorised transport would be on adequate provision for metropolitan wide non motorised transport and mobility network. It is therefore assumed that all pedestrian facilities which include pedestrian footbridges to be provided will be wide enough to meet the recommended Level of Service C.

5.7.2 Traffic Act Chapter 403 Laws of Kenya

The Traffic Act Chapter 403 recognizes non motorized transport and pedestrianization as an important mode of transport. However, the act does not include the definition of a pedestrian in the preliminary section of the act which contains definitions of key words used in the act.

Though Part X of the Traffic Act Chapter 403, especially Chapter 117 of the Act outlines minor offences, the act has not included if pedestrian crossing at un-designated crossing points of a roadway is a traffic offence and consequently no corresponding fine has been formulated.

Pedestrians who cross at grade may cause accidents. Drivers sway as they try to avoid hitting pedestrians who cross at grade and end up hitting the concrete barrier. In such situations, drivers are blamed for the occurrence of the accidents despite that the accident was caused by a pedestrian who was crossing at grade. The act does not

capture this as an offence in such eventualities. Such pedestrians ought to be arrested and fined or jailed for such conduct. The pedestrian can even be made responsible for compensating the driver for the damage caused to the vehicle.

5.7.3 Local Government Act Chapter 265 - Laws of Kenya

Local Government Act Chapter 265, article 201 empowers the local authorities to make by-laws from time to time in respect of all matters as are necessary or desirable for the maintenance of health, safety and well being of the inhabitants of the area or part thereof and for the good rule and government of such area or part thereof (Government of Kenya, 2010). The City Council have the mandate to review the existing by-laws to include jay walking and crossing of roadway at un-designated places by pedestrians as an offence. It has the mandate to formulate relevant fines to be paid by offenders and at the same time look into aspects of strict enforcement of the bylaws.

5.7.4 Review of Nairobi City Council Bylaws on Non-Conforming Behaviour

The City Council of Nairobi has bylaws on General Nuisance Bylaws which were formulated in 2007 in accordance with the Local Government Act, Cap 265. The by-laws do not include specific by-laws on jay walking. The preliminary part of the bylaws which consists of interpretation of key words in the by-laws does not include the definition of jay walking. The bylaws do not have details of fines for the offenders though stakeholders estimated that fine ranges between KSh 500 to KSh 1,000 per offender.

The Council should emulate examples of other city councils that have comprehensive bylaws which include in jay walking and have corresponding fines for jay walking. The Municipal Council of Sidney with “Streets and Traffic Regulation Bylaw No, 1966, 2010 and Wellington City Council with By-Laws on Pedestrians in New Zealand are good examples.

5.7.5 Review of Nairobi City Council Bylaws on Outdoor Advertisement

5.7.5.1 Physical Planning Act, Cap 286

Physical Planning Act, Cap 286, guides the Nairobi City Council on issues related to advertising and outdoor billboards. The act emphasizes that the granting of permission for placing of billboards shall have consideration on traffic and pedestrian

safety. Section 27 of the Act empowers the local authority to enforce removal of advertisements that affect traffic and pedestrian safety. Such advertisements include advertisements that are placed on pedestrian footbridges which end up blocking visibility of pedestrians when they are crossing the footbridge.

5.7.5.1 General Nuisance By-Laws, 2007 City Council of Nairobi-Advertisement

City Council of Nairobi has by-laws on roads and streets but not much has been documented on billboard advertisements. This is contrary to the County Council of Nakuru which formulated the by-laws on Advertisement in 2006. The by-laws include the interpretation of advertisement, different advertisement material used, places where advertisements have to be placed and corresponding penalties for contravening the by-laws. Another example is the Municipal Council of Mombasa which has detailed fee schedule for fees and charges on street name and suburban signs advertisement.

Nairobi City Council is responsible for outdoor advertisement. This is done to raise revenue for general operation of the council. The advertisements are even placed on footbridges. In some cases, the issue of safety is not taken as a priority by the City Council. Therefore, collaboration with road agencies like KURA or KeNHA will ensure that all advertisements are placed with safety aspects of pedestrians as a major consideration (See picture 51).

Picture 51: High Rise PFB on Mbagathi Way with road signs



Source: Author, 2013

It was observed that there was general low enforcement of bylaws due to a number of reasons which range from lack of resources and corruption. The enforcement affects both the jay walking, vending in non-designated places and removal of billboards that affect pedestrian safety especially on footbridges.

5.8 Discussion on Stakeholders Input

5.8.1 Cost of footbridge

There was a general consensus from all the engineers interviewed that construction of footbridge requires a lot of resources and varies according to site conditions. Though it is estimated construction cost of Uthiru footbridge was over KSh 10 million, this amount is quite significant in terms of monetary value. It is therefore assumed that other footbridges within the city such as Westlands and Agha Khan were constructed at the same cost. If therefore the footbridges are not used, then this becomes a great loss of resources for the government.

5.8.2 Maintenance of footbridge

Major maintenance works on footbridge are under the mandate of KURA or KeNHA. In this case, Uthiru Bridge is on A104 and is under the jurisdiction of KeNHA. It is therefore assumed that any maintenance works to be done on the footbridges on Waiyaki way ought to be taken care of by KeNHA under routine maintenance programs. However, the researcher suggests minor works such as cleaning and de-silting of weep holes should be done by Nairobi City Council because the City Council has a lot of general labourers who are deployed to do such cleaning work in the CBD.

5.8.3 Determination of Height of Concrete Barrier

The current concrete barrier is 1.2 m high. As one way of discouraging pedestrians from crossing at grade, the stakeholders proposed that in future, the height of the concrete barrier should be between 1.4 and 1.6 m. The researcher proposes an average height of 1.5 m. The height of the steel barrier on Haile Selassie is 1.7 m. This seems to be reasonable increase considering the cost implication of a concrete barrier which is higher than 1.2 m. Another proposal would be to maintain the same height of 1.2 m but add some steel railings on top of about 300 mm. These could be pointed at top like the barrier which is on Haile Selassie Way.

5.8.4 Involvement of Community in Planning of Pedestrian Facilities

It was noted that the construction of the footbridge was done without involvement of the community or general public. According to Hong Kong Transport Department (2010), one of the factors for consideration in planning pedestrian crossing facilities is the input of public opinion. It is therefore very important that future projects should have public input if it is deemed necessary.

5.9 Design Improvements to Uthiru Pedestrian Footbridge

The researcher has come up with the following design improvements on Uthiru Pedestrian Footbridge following the feedback from the survey and response from key stakeholders.

5.9.1 Composite Design of Pedestrian Footbridge

The researcher proposes that the footbridge should have both the ramp and staircase on either side. The provision of a ramp will enable physically challenged pedestrians to use the footbridge. Ramps increase the distance and are ideal for physically challenged persons, wheelchairs and cyclists (ADA, 1992). The American Disability Act requires that new and altered facilities be accessible to and usable by persons with disabilities or physically challenged. The provision of the ramp will also enable cyclists to use the bridge with ease and it will not be necessary to provide bike gutters (<http://www.cbdg.org.uk/tech2> accessed on 28/12/12). The other approach shall be of staircase form. Able-bodied persons prefer accessing via shorter distances and normally use the staircase. Additionally, the staircase form allows able-bodied pedestrians to exercise their bodies.

5.9.2 Provision of Lighting

Lighting is very important at pedestrian footbridges because it can improve safety of pedestrians and increase their comfort and sense of security. Pedestrian lighting is recommended in areas of pedestrian travel at intersections or other pedestrian crossing and in other areas where there is significant dusk or night time pedestrian activity (Minnesota Department of Transport, 2003). The researcher proposes providing lighting at the footbridge. Solar lighting has been proposed due to its low capital cost and sustainability (See pictures 52, 53 and 54).

Picture 52: Vertical Mount Style Luminaires



Source: Minnesota Department of Transport, 2003

Picture 53: Solar powered street lights along parliament road in Nairobi



Source: Author, 2013

Picture 54: Solar powered robot on Makongoro Road in Arusha, Tanzania



Source: Author, 2013

5.9.3 Parapet Materials and Height

There are various types of materials which are used for construction of parapet walls or sides of the footbridge which include steel bars, iron sheets and mesh wire. Special fencing is required to protect pedestrians, secure the bridge and make it difficult for people to jump from the bridge. According to Demetsky, (1974), the sides should be constructed of material which allows complete visibility in order to reduce the probability of criminal acts directed toward pedestrians and the sides should be constructed of mesh material with openings large enough to allow for free air circulation but small enough to prevent cans or other objects from being thrown at passing vehicles. Based on the above guidelines, the researcher has opted for the mesh wire as the materials for the construction of the parapet walls for deck or sides for deck. The height of the parapet wall or deck sides has been changed from 1.0m high to 1.150m high specification as outlined in Highway Agency,(2006), (See picture 55).

Picture 55: Bridge with sides protected by mesh



Source: Centre for Urban Design, 2012

5.9.4 Signage and Advertising

With exceptions of name plates and navigation signs, signage should be kept off bridges if at all possible. They add clutter and complexity besides obstructing views such bridges (Centre for Urban Design, 2012). According to Centre for Urban Design (2012), if a bridge and its location is deemed suitable as an outdoor advertising site, then the advertising structure needs to be designed as an integrated bridge element with consideration of its visual effect. As a minimum, the soffit of the bridge should not be obscured and the signs should not block views of structural elements such as cables, arches and bearing or view from the bridge. In the review of the design, the advert has been placed on top as to ensure that pedestrians are not blocked as they pass through the bridges.

5.9.5 Provision of Road Signs

Road signs are very important because they serve the purpose of guarding, warning and helping to regulate traffic flow for motorists, cyclist and pedestrians. These signs need to be given proper attention and respected by both drivers and pedestrians for their own safety. Currently, there are no any road signs which were installed to inform pedestrians, passengers and other road users about the existence and requirement to use the footbridge. As such the researcher is proposing that road signs

should be included as part of design review. These directional signs guide pedestrians to use the footbridge (See pictures 56 and 57).

Picture 56: Pedestrian road sign with inscribed fine of \$100 for jay walking



Source: www.austinluce.co.uk/articles/the-importance-of-road-signs, 2009

Picture 57: Pedestrian road sign for use of footbridge



Source: www.austinluce.co.uk/articles/the-importance-of-road-signs, 2009

5.9.6 Pedestrian Channelization

Channelizing devices for pedestrians should provide understandable guidance along the intended pedestrian route. One of the simplest methods of pedestrian channelization involves the use of either handrails or guiderails. Both handrails and guiderail barriers provide channelizing guidance to all pedestrians through vision and tactile (Minnesota Department of Transport , 2010). The researcher is proposing the use of guiderails in establishing the pedestrian route travel. The guiderails shall be provided along the walkway and on one side of walkway which is close to the carriageway. These barriers are essential in deterring jay walking and spatial violations.

5.9.7 Improvements on Concrete Barrier

The height of the concrete barrier had been adjusted from 1.2m to 1.5m as to discourage pedestrians from climbing over it. This is based on the input from engineers who completed the questionnaires.

5.9.8 Aesthetics

According to Macquarie Concise Dictionary, “aesthetics” is defined as “Relating to the sense of beautiful or science of aesthetics that is the deduction from nature and taste of rules and principles of beauty”. Pedestrians and cyclists spend more time on a pedestrian and shared path than a traffic bridge. Therefore the view from a bridge takes an added significance and detail and material are more closely appreciated (Centre for Urban Design, 2012). As such pedestrians are attracted to use the footbridges which was aesthetically designed and built (Refer to picture 58 for an example of a beautiful bridge). In view of this, the researcher has provided an arc on the pedestrian footbridge bearing a notification to the general public to use the pedestrian footbridge.

Picture 58: Bridge over Pacific Highway at Bilinudgel



Source: Centre for Urban Design, 2012

5.9.9 Design Drawings for Uthiru Pedestrian Footbridge

Based on the above considerations, the researcher has produced some drawings for Uthiru footbridge to reflect the changes to be proposed in order to enhance usage of the bridge (Refer to Appendix 7 for details).

CHAPTER SIX

6.0 CONCLUSIONS

6.1 Basic Warrants for Provision of Pedestrian Footbridge

6.1.1 Volume of Traffic

Axler, (1984) outlined that the vehicle volume should be over 10,000 in 4 hours if vehicle speed is over 65km/hr or vehicle volume should be over 7,500 in 4 hours for the proposed sites in urban areas. A total of 11,356 vehicles were counted during a four hour traffic survey on both lanes. This figure is well above the minimum stipulated of 7,500 vehicles in four hours. It can therefore be concluded that the provision of the footbridge met this specification of traffic volume.

6.1.2 Speed of Vehicle

The pedestrian footbridge should be provided across highways where the vehicle speed is more than 65 km/h (Axler, 1984). The results show that vehicles on Waiyaki Way travel at speeds greater than 60 km/hr and this basically meet the warrant for speed of vehicles

6.1.3 Volume of Pedestrians

Pedestrian volume should at least exceed 300 in the highest 4 continuous hours or the pedestrian volume should be more than 100 pedestrians in the four highest continuous hour periods (Axler, 1984). Results show that the minimum number of pedestrians were recorded on Wednesday from 8.30-9.30 am as being 180 vehicles. The remaining hours recorded more hours and this leads to conclusion that the provision of the footbridge met this criteria.

6.1.4 Traffic Generators related to Land

Trip generation and attraction based on current land use include commercial or office business, residential for both simple and multi-storey buildings, education institutions which include pre-primary, primary, secondary and tertiary education and recreational facilities. This meets the warrant which advocates for provision of overpasses in areas where there is high volume of pedestrian activities (Florida Planning and Design Handbook 1999).

6.1.5 Alternative “Safe” crossing instead of GSPCs

Alternative safe crossing points were provided. These include openings to facilitate grade crossing in concrete barriers and tunnels along the highway. However, the relevant authorities did not put traffic calming measures as to allow high speed vehicle to slow down for grade crossing of pedestrians and there is poor maintenance to tunnels which discourage pedestrians to use these tunnels.

6.1.6 Roadway Geometrics

Roadway geometrics play a role in the determination of pedestrian footbridge. A pedestrian footbridge works well if it is located on four or more number of moving traffic lane to cross to other side of roadway or Highway-major artery, collector , local street (Axler, 1984). The footbridge therefore meets this criteria.

6.2 Conclusion on Staircase Geometric Design

The staircase has the recommended geometric dimensions for treads, risers and roadway clearance. The current footbridge width of 2.2 m operates at LOS F. Though roadway clearance of 5.0 m is ideal, consideration should be made increase the roadway clearance slightly higher as to prevent overloaded trailers from hitting the base of pedestrian footbridges.

6.3 Conclusion on Review of Pedestrian Speed

6.3.1 General Pedestrian Speed on Uthiru Footbridge

The average pedestrian speed on Uthiru footbridge was found to be 44.68 m/min. This is slower speed when compared descending speed of 18 m/min.

6.3.2 Ascending and Descending Pedestrian Speed on Uthiru Footbridge

The average ascending speed of 34.72 m/min was found to be out of recommended range of between 12 m/min and 21 m/min because of pedestrian behaviour. Most pedestrians prefer to rest when they reached the deck slab or some had to reduce the walking pace which resulted as part of resting.

The average descending speed of 45.66 m/min found to be out of recommended range of between 17 m/min and 31 m/min because of pedestrian behaviour. Most pedestrians prefer to rest when they reached the deck slab or some had to reduce the walking pace which resulted as part of resting.

6.3.3 Time for Grade Crossing

Convenience factor, R from the survey was found to be 2.37. It is inevitable that the convenience factor is much larger and this contributes to some pedestrians in crossing at grade. Time taken for grade crossing varied with time. During peak hours, pedestrians took more time to cross as compared to crossing during off peak hours. However, the safety of pedestrians should be paramount when the convenience factors are taken into account.

6.4 Conclusion on Oral Pedestrian Interview Results

6.4.1 Pedestrian Profile

The footbridge is used by both men and women at a fairly balanced level. The footbridge is not used by pedestrians who are physically challenged especially who have mobility impairment because it does not have a ramp. In terms of age, it was observed that the footbridge is used by pedestrians of all varying ages with the younger ones using the footbridge most. Pedestrians with different educational qualifications and various occupations used the footbridge.

The results also show that the pedestrian footbridge was being used by pedestrians with different levels of income with those with high income using the footbridge most. In terms of trip purpose and trip frequency, it was noted home-based trips were more as compared to other trip purposes which included work-related or educational trips. A total of 68% of the respondents rated the use of the footbridge as satisfactorily and the remaining 32% of the respondents rated the use of footbridge as unsatisfactory. Various factors were raised on why the pedestrians shun the use of the footbridge and several proposals were made by pedestrians on what they feel should be done on the footbridge in order to improve on footbridge utilisation levels.

6.4.2 Community Consultation during planning stages

It was generally revealed that the communities were not consulted during the planning stages of the footbridge in terms of location and their general input by the Nairobi City Council/KeNHA in establishing the need of the footbridge and its location.

6.4.3 Impact of awareness on improving footbridge usage

There was an overwhelming positive response on the need to engage awareness campaigns as one way of increasing the utilization levels of the pedestrian footbridge.

6.4.4 Methods of awareness as proposed by pedestrians

Installation of road signs came as the top priority option of creating awareness on footbridge. Other methods of awareness which include the radio, television, community leaders and newspapers should be used in general for encouraging pedestrians to use footbridges in Kenya.

6.4.5 Damage of Concrete Barriers

The concrete barrier is mainly damaged by vehicle accidents. There is therefore need for KeNHA to carry out maintenance of damaged sections preferably every year as part of routine maintenance.

6.4.6 Proposals by pedestrian footbridge

There are some improvements which can be done on the existing footbridge which were pointed out by pedestrians. These are provision of lighting, improvement of maintenance, barring vendors from pedestrian footbridge, installation of road signs and erection of barrier leading to pedestrian footbridge to deter jay crossing.

Some of the proposals that include increasing height of the concrete barrier, increasing the width of the footbridge and upgrading with ramps cannot be effected on the existing footbridge because of the technical and financial implications. However, these aspects can be considered in future designs of the pedestrian footbridge.

In terms of siting of pedestrian footbridges, the Manual of Specifications and Standards of Government of India (2010) recommend that footbridges should be located at 1.5 km depending on land use and population. It however, recommends the footbridges to be located at 5.0 km intervals. This has been the case on Waiyaki Way since on average the footbridges are placed at more than 5 km intervals.

6.5 Discussion on Microscopic Parameters

It was generally observed that the behaviour of pedestrians such as idling on footbridge, holding of hands as they walk side by side on footbridge, use of mobile phones while crossing the footbridge, bargaining for lower prices on items which are sold on the footbridge, carrying of goods while crossing the footbridge and use of

footbridge by other NMT modes which include cyclists affect the movement of other pedestrians. As such, this general behaviour is supposed to be considered in the design and provision of pedestrian footbridge in order to maintain the required Level of Service.

6.6 Macroscopic Parameters

6.6.1 Conclusion on Level of Service of Uthiru Pedestrian Footbridge

The current LOS of footbridge shows that pedestrians are congested, at LOS either E or F as opposed to LOS C or above when calculated based on peak pedestrian volume. If the LOS is to be determined with the inclusion of NMT such as cyclist, it will inevitably be worse thus at LOS F. The required effective footbridge width to enable the staircase to serve at LOS B is 2.9 m based on peak pedestrian volume. When other NMT modes are included, the designed footbridge width becomes 3.65 m as opposed to the existing 2.2 m wide. This is above the recommended footbridge width of 3.0 m according to Manual for Roads and Bridges: Part 4-Bridges and Culverts Draft, 2009. This width of 3.0 m wide is meant to accommodate three pedestrians, bicycle and a pedestrian in width. This design will be able to cater for population increase which has been projected to 2030 in line with Vision 2030 based on the 50 years working life. This is the case because the projected LOS for the year 2030 is LOC C.

6.6.2 Pedestrian Density

The average area for each pedestrian was found to be 0.22 m²/pedestrian. The area for body ellipse for each pedestrian is 0.3 m² and the buffer zone area is 0.75 m². The results of the survey show that the area of each pedestrian during peak design volume was less than both the body ellipse and buffer zone area for each pedestrian.

6.7 Conclusion on Legal, Institutional and Regulatory Framework

6.7.1 Nairobi Metro 2030

Nairobi Metro 2030 as key policy document for GoK outlines key strategies of development of world class infrastructures facilities and services including some consideration of non- motorized transport elements which are expected to operate at the recommended Level of Service C.

6.7.2 Traffic Act Chapter 403 Laws of Kenya

Though the Traffic Act Chapter 403 recognizes non motorized transport and pedestrianization mode of transport, the act does not include the definition of a pedestrian in the preliminary section of the act which contains definitions of key words used in the act.

Part X of the Traffic Act Chapter 403, especially Chapter 117 of the Act outlines minor offences and the act does not have an offence for pedestrians who cross at non-designated crossing points including the corresponding fines.

The act does not indicate whether vehicle accidents which are caused by spatial violation behaviour of pedestrians amounts to an offence. No punitive measures are documented like fine or jail term including compensating to the driver for the damage caused to the vehicle.

6.7.3 Local Government Act Chapter 265 - Laws of Kenya

The local authorities are empowered to make by-laws based on Local Government Act Chapter 265, article 201. The bylaws are in various disciplines which include health or safety of the inhabitants of the city.

6.7.4 Review of Nairobi City Council Bylaws on Non-Conforming Behaviour

The City Council of Nairobi has bylaws as General Nuisance Bylaws but do not include specific by-laws on jay walking and do not have details of fines for offenders.

6.7.5 Conclusion on Review of Nairobi City Council Bylaws on Outdoor Advertisement

6.7.5.1 Physical Planning Act, Cap 286

The Physical Planning Act, Cap 286 is quite clear on traffic and pedestrian safety aspects when it comes to outdoor advertising including billboards. The Act empowers the local authority to enforce removal of advertisements that affect traffic and pedestrian safety including those that are placed on pedestrian footbridges. Hence the City Council should ensure that all advertisements which affect pedestrian safety are immediately removed in order to avoid the risk which is associated with placing of such advertisements.

6.7.5.2 General Nuisance By-Laws, 2007 City Council of Nairobi-Advertisement

The City Assembly does not have comprehensive bylaws on outdoor advertisement which ought to focus on pedestrian safety apart from raising revenue. All the advertisement which are placed on the footbridges should be jointly approved by NCC and KeNHA so that the aspects of pedestrians safety are guaranteed.

6.7.5.3 Enforcement of Bylaws

There is weak enforcement of traffic bylaws due various reasons which range from lack of resources and corruption among city council security officers.

6.8 Conclusion on stakeholders Input

6.8.1 Cost of footbridge

There is considerable amount of money which is spent on construction and provision of pedestrian footbridges. The cost of construction varies with site condition, design and the fluctuation of material prices. Non-usage of pedestrian footbridges defeats the purpose of safety and wastage of government investment.

6.8.2 Maintenance of footbridge

There is need to develop maintenance guidelines between NCC and KeNHA. KeNHA should carry major maintenance works on footbridges and NCC should carry minor works like general cleaning.

6.8.3 Height of Concrete Barrier

The current concrete barrier which is 1.2 m high is too low and should be adjusted to 1.5m. If the same height is maintained, then steel rails should be placed on top of about 0.3 m as a way of increasing the height

6.8.4 Involvement of Community in Planning of Pedestrian Facilities

It was noted that the construction of the footbridge was done without involvement of the community or general public.

6.9 Conclusion of Research Results in relation to research objectives

6.9.1 Utilization Levels of Pedestrian Footbridge

The first specific objective of this study was to determine the extent of use of the footbridge by the pedestrians. This was achieved by conducting the pedestrian survey count. In this survey the researcher counted the number of pedestrians using the footbridge during morning and afternoon peak hours including off peak hours for

one week. The data collected was used for the calculation of pedestrian area which was eventually used in establishing the Level of Service of pedestrian footbridge.

6.9.2 Pedestrian perceptions on pedestrian footbridge

The second specific objective of this study was to assess pedestrian perceptions on the impact of the footbridge and identify steps to improve effectiveness of footbridge utilization. This objective was established by administering the pedestrian oral interview. In the interview, the pedestrians were requested to outline factors which they feel contributes to low on non-utilization of the pedestrian footbridge.

Various reasons were outlined which included the time factor, non-provision of ramp to cater for the physically challenged, width of the footbridge not wide enough, non-provision of lighting for safety of pedestrian during night and vending of goods on the footbridge which blocks pedestrians.

The pedestrians were also asked to outline proposals which ought to be incorporated as one way of increasing the utilization levels of the footbridge. Various options were outlined which included provision of lighting, barring vending on footbridge , improvement of maintenance of footbridge, up-grading with ramps to allow the physically challenged to use the footbridge with ease, installation of road signs, increasing the height of concrete barrier as to deter jay crossing and erection of barrier leading to footbridge so as to deter jay crossing.

6.9.3 Review the design pedestrian footbridge

The third specific objective of this study was to review the design of the pedestrian foot bridge so as to establish if the footbridge meets pedestrian expectations and check whether the design conforms to HCM. The idea was to establish the current operational level of service of the footbridge and check whether it is within the prescribed levels.

The current LOS of footbridge shows that pedestrians are congested, thus at LOS either E or F. The desirable peak-period pedestrian flow should operate at LOS C or above. The required footbridge width to enable the staircase to serve at LOS B is 3.65 m. This means that the width of staircase ought to have been increased to provide a better operational condition. .

6.9.4 Economic impact of the bridge usage.

The fourth specific objective of this study was to establish the economic impact of the bridge usage. The researcher reviewed the initial cost of construction of the pedestrian footbridge. The research established that there is considerable amount which is spent on construction and provision of pedestrian footbridges. The cost of construction varies with site condition, design and the fluctuation of material prices.

CHAPTER SEVEN

7.0 RECOMMENDATIONS

This chapter reviews action oriented issues which must be implemented in order to improve the utilization levels of pedestrian footbridges. It recommends review of relevant policies that affect the use of pedestrian footbridges.

7.1 Basic Warrants for Provision of Pedestrian Footbridge

- Traffic calming measures should be put in places where openings are provided at grade crossings as alternative safe crossing points. These include construction of speed humps, zebra crossing road marking and installation of road signs such as slow down and zebra crossing road signs. The responsibility lies with the road authority in charge. .
- All the tunnels should be properly maintained in order to attract pedestrians to fully use the tunnels as alternative safe crossing points. The responsibility lies with the road authority in charge.
- The roadway clearance for footbridges should be adjusted from 5.0 m to slightly higher as to allow trailers to pass through with ease. Ministry of Transport and Infrastructure should provide necessary guidance in the road manual specifications. .
- Informative road signs on pedestrian footbridge showing roadway clearance should be placed in order to warn drivers of overloading to heights greater than provided. The responsibility lies with the road authority in charge.

7.2 Oral Pedestrian Interview Results

- Various proposals were made by pedestrians in order to increase the utilization levels of pedestrian footbridges. Relevant authorities should take note of these proposals and put them into use when designing pedestrian footbridge.
- The following proposals by pedestrians should be implemented on existing Uthiru Pedestrian Footbridge:
 - i. Regular maintenance on pedestrian footbridge
 - ii. Provision of lighting powered by solar
 - iii. Barring vending on pedestrian footbridge
 - iv. Installation of road signs

- v. Erection of barrier leading to pedestrian footbridge to deter jay crossing.
- Some of the proposals which were made by pedestrians should be considered in future projects but cannot be effected on the existing footbridge because of the technical and financial complications and these include:
 - i. Increasing height of the concrete barrier
 - ii. Increasing the width of the footbridge
 - iii. Upgrading staircase with ramps.
- The study recommends that there should be community consultation when planning and providing these pedestrian facilities.
- The stakeholders should appreciate and take necessary steps in ensuring that there is awareness campaigns that can assist in improving the utilization levels of the footbridge

7.3 Level of Service of Uthiru Pedestrian Footbridge

- Future pedestrian footbridges should be designed to operate at the recommended LOS C or above.
- The LOS for footbridges should encompass the effect of NMT modes that also use the footbridge as well.
- The LOS should include microscopic parameters.
- The design should be projected to cater for changes in land use, trip generation and population increase.
- The effective footbridge width of 3.65 m should be adopted for provision of footbridges which are able to operate at LOS B including the provision of other NMT modes.

7.4 Legal, Institutional and Regulatory Framework

- Traffic Act Chapter 403 Kenya should be revised to capture spatial violation as an offence and include any penalties for the offence.
- The act should also be revised to include that it is an offence for a pedestrian who causes an accident due to jay crossing.
- Stiffer penalties should be proposed as to deter pedestrians from crossing at grade and causing accidents.

- The City Council of Nairobi should revise the General Nuisance Bylaws of 2007 to include bylaws on jay walking and formulate relevant fines.
- The City Council of Nairobi should review its bylaws on outdoor advertisement and there should be coordination with relevant road authority in case the advertisement is to be placed on pedestrian footbridge as to ensure that the safety of pedestrians is not compromised.
- There should be strict enforcement of the bylaws without fear and favour.

7.5 Stakeholders Input

- There is need to implement provision of pedestrian facilities such as footbridges after undertaking a thorough study.
- There is considerable amount of money which is spent on construction and provision of pedestrian footbridges. Non-usage of pedestrian footbridges defeats the purpose of safety and wastage of government investment.
- There is need to come up with maintenance schedule for footbridges
- Major maintenance work on footbridges should be done by KeNHA and minor maintenance work should be done by NCC.
- For future projects involving construction of concrete barriers to deter jay crossing on pedestrian footbridge location, the concrete barrier should be at least 1.5 m high.

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Appendix 1: Definition of Pedestrian Terminology

- **Pedestrian Capacity:** It is the maximum number of people who can occupy or pass through a pedestrian facility or element, expressed as persons per unit of area or as persons per unit time. Both maximum capacity reflecting the greatest possible number of persons who can pass through and design capacity representing the maximum desirable number of pedestrians are applied in appropriate ways.
- **Pedestrian speed:** It is the average walking speed, generally expressed in units of meters per second.
- **Pedestrian flow rate:** It is number of pedestrians passing a point per unit time, expressed as persons per 15 minutes.
- **Pedestrian flow per unit width:** It is the average flow of pedestrians per unit of effective walkway width, expressed as persons per foot or meter per minute.
- **Pedestrian density:** It is the average number of persons per unit area within a walkway or queuing area, expressed as persons per square foot or meter.
- **Pedestrian space:** It is the average area used by or provided for each pedestrian in a walkway or queuing area, expressed in terms of square feet or meters per pedestrian. The space normally required by people varies according to the activity they are engaged in and increases with walking speed. For example, an area required by a person using a wheelchair or transporting luggage or packages is greater than a person standing without items.
- **Pedestrian time-space:** It is the space normally required by pedestrians for various activities (walking, queuing, and conversing, shopping e.t.c) multiplied by the time spent doing the activity within a specific area.
- **Effective width or area:** It the portion of a walkway or stairway`s width or the area of a space that is normally used by pedestrians. Areas occupied by physical obstructions and buffer spaces adjacent to walls and obstructions are excluded from the effective width or area.
- **Platoon** refers to a number of pedestrians walking together in group, usually involuntarily, as a result of signal control and other factors.

Appendix 2: Questionnaire for Stakeholders in Road Industry

My name is Richard Manjanja, MSc in Civil Engineering Student in the University of Nairobi. I am carrying out a thesis research on “Non-Usage of Pedestrian Footbridges in Kenya: The Case of Uthiru Pedestrian Footbridge on Waiyaki Way” The data or information provided towards this research will be treated with utmost confidentiality and will be used for academic purposes only.

Part 1: Respondent’s profile

Name of
Respondent:.....

Name of
Organisation:.....

Designation/Position:.....
.....

Gender

1.0 Male

2.0 Female

Part 2: Historical background of the bridge

When was the bridge constructed?

1.0 Last 10 years

2.0 Last 15 years

3.0 Last 20 years

4.0 Last 25 years

5.0 Last 30 years

6.0 More than 30 years ago

7.0 Don` t know

Was the bridge location related to occurrence of accidents?

1.0 Yes

2.0 No

3.0 Not sure/Don't know

What was the construction cost of the bridge?

1.0 KSh1,000,000

2.0 KSh 1 million – KSh 2 million

3.0 KSh 2 million- KSh 5 million

4.0 KSh 5 million –KSh 10 million

5.0 Greater than KSh 10 million

6.0 Not sure/Don't Know

Part 3: Community participation

Were the communities involved during the planning and construction of the footbridge?

1.0 Yes

2.0 No

3.0 Not sure/Don't know

If the community was consulted, to what extent were they involved?

1.0 Through the radio

2.0 Through the television

3.0 Through community leaders

4.0 Other.....

5.0 Not sure/Don't know

Part 4: Bridge design

There was concern that the pedestrian footbridge was located near the filling station. Which development took place first?

1.0 Filling station

2.0 Pedestrian footbridge

3.0 Don't know

Do you think the location of the bridge is compatible with the planning of Nairobi City Council?

- 1.0 Yes
- 2.0 No
- 3.0 Not sure/Don` t Know

Is there any maintenance plan for the footbridge?

- 1.0 Yes
- 2.0 No
- 3.0 Not sure/Don` t Know

What is the schedule of maintance of the footbridge?

- 1.0 Every three months
- 2.0 Every six months
- 3.0 Every year
- 4.0 Every 2 years
- 5.0 Not sure/Don` t Know
- 6.0 Other.....

There is no maintenance plan for the footbridge due to the following reasons

- 1.0 No budget for maintenance of footbridge in the assembly
- 2.0 No suitable personnel to carry out the maintenance
- 3.0 Not included in the annual programme of works for assembly
- 4.0 Other.....
- 5.0 Not sure/Don` t know

At planning level, was the design of 1.2m height of concrete barrier based on specific guidelines?

- 1.0 Yes
- 3.0 No
- 3.0 Not sure/Don` t Know

The guidelines for determination of height barrier of 1.2 m included the following.

- 1.0 Road Manual Design of Kenya
- 2.0 Engineering book
- 3.0 Journal article
- 4.0 Article in periodical magazine
- 5.0 Website
- 6.0 Conference paper or proceedings
- 7.0 Interview
- 8.0 Other.....
- 9.0 Not sure/Don't know

What do you think will be the appropriate height of the concrete barrier to discourage pedestrians from climbing over it?

- 1.0 1.2m -1.4m
- 2.0 1.4m -1.6m
- 3.0 1.6m-1.8m
- 4.0 Greater than 1.8m
- 5.0 Other.....
- 6.0 Not sure/Don't know

Part 5: By-laws on jay walking

Are there any by-laws or regulations on jay walking?

- 1.0 Yes
- 2.0 No
- 3.0 Don't know/Not sure

If there are by-laws for jay walking, what do you think are the related penalties which are associated with jay walking?

- 1.0 Less than KSh 500
- 2.0 KSh 500-KSh 1,000

- 3.0 KSh 1,000-KSh 5,000
- 4.0 KSh 5,000-KSh10, 000
- 5.0 KSh 10,000-KSh 20, 000
- 6.0 Greater than KSh 20,000
- 7.0 Don` t know/Not sure Don` t know/Not sure

Are these by-laws on jay walking adequately enforced?

- 1.0 Yes
- 2.0 No
- 3.0 Don` t know/Not sure

These by-laws are not enforced because of the following reasons

- 1.0 Lack of personnel to enforce in local assembly
- 2.0 Corruption
- 3.0 No resources are provided for enforcement
- 4.0 Not aware of the by-laws
- 5.0 No strong punitive measures are given to offender
- 6.0 Other.....
- 7.0 Not sure/Don` t know

Part 6: By-laws on outdoor advertisement

Are there any by-laws on outdoor and billboards advertisement?

- 1.0 Yes
- 2.0 No
- 3.0 Don` t know/Not sure

What are the guidelines for advertisement on footbridges?

- 1.0 Adverts should be placed on any footbridge
- 2.0 Adverts should block the passage of pedestrian visibility
- 3.0 Adverts should consider safety aspects

4.0 Other.....

5.0 Not sure/Don't know

What is the average cost or fee for placing of adverts on pedestrian footbridge?

1.0 KSh 2, 000 –KSh 5,000

2.0 KSh 5,000 –KSh10, 000

3.0 KSh10, 000-KSh 30,000

4.0 KSh 30,000 –KSh 50,000

5.0 Greater than KSh 50,000

6.0 Not sure/Don't know

Explain briefly how the revenue sourced from the advertisement on footbridge is used.

1.0 Bridge maintenance

2.0 Road maintance

3.0 Building maintenance

4.0 Other.....

5.0 Not sure/Don't know

Please state any comment you would like to make on this survey and/or issues addressed

.....

.....

.....

.....

.....

.....

THANK YOU VERY MUCH FOR YOUR TIME/ASANTE SANA

Appendix 3: Oral Interview Questionnaire for pedestrians

My name is Richard Manjanja, MSc in Civil Engineering Student in the University of Nairobi. I am carrying out a thesis research on “Non-Usage of Pedestrian Footbridges in Kenya: The Case of Uthiru Pedestrian Footbridge on Waiyaki Way” The data or information provided towards this research will be treated with utmost confidentiality and will be used for academic purposes only.

Name of Interviewer: _____

Date of Interview: _____

Part 1: Pedestrian profile

Gender

- 1.0 Male
- 2.0 Female

Age Group

- 1.0 0-16 years
- 2.0 17-30 years
- 3.0 31-50 years
- 4.0 51-66 years
- 5.0 Greater than 66 years

Income Level in Kenyan Shillings per month

- 1.0 No income
- 2.0 Less than KSh 1,000
- 3.0 KSh 1,000 –KSh10,000
- 4.0 KSh 10,000-KSh 20,000
- 5.0 KSh 20,000- KSh 30,000
- 6.0 KSh 30,000- KSh 40,000
- 7.0 KSh 40,000- KSh 50,000
- 8.0 Greater than KSh 50,000

Educational Level

- 1.0 Not educated
- 2.0 Primary Level
- 3.0 Secondary Level
- 4.0 Tertiary Level
- 5.0 Post Tertiary Level

Occupation of Trip Maker

- 1.0 Professionals -(Engineers, doctors, lawyers, teachers, nurses, accountants)
- 2.0 Business (businessmen and women)
- 3.0 Student (college, secondary and primary school pupils)
- 4.0 Unemployed (housewives, school leavers)
- 5.0 Retired
- 6.0 Informal (technicians, hawkers, salonists, jua kali artisans)

Interviewee`s Physical Condition

- 1.0 Able Bodied
- 2.0 Physically Challenged

Part 2: Origin and destination

Trip Purpose

- 1.0 Work
- 2.0 Business
- 3.0 Education
- 4.0 Return Home
- 5.0 Recreation
- 6.0 Other

Trip Frequency on bridge usage

- 1.0 Never
- 2.0 Less Frequently
- 3.0 Once or twice a day
- 4.0 More than twice per day
- 5.0 Several Times per Week
- 6.0 Few Times per Month

Part 3: Pedestrian Perception

Were you consulted during the planning stage of the bridge construction?

- 1.0 Yes
- 2.0 No
- 3.0 Not sure/Don't know

How do you rate the rate of footbridge usage?

- 1.0 Poor
- 2.0 Good
- 3.0 Fair

- 4.0 Very Good
- 5.0 Excellent

The bridge is not used by some pedestrians because of the following reasons

- 1.0 Takes time to cross
- 2.0 Not suitable for the physically challenged
- 3.0 Not safe to cross at night
- 4.0 Vendors block the way
- 5.0 Not beautiful
- 6.0 Mere negligence
- 7.0 Not wide enough to cater for a large crowd
- 8.0 Other.....

Do you consider awareness creation on usage among pedestrians would improve use of the footbridge?

- 1.0 Yes
- 2.0 No
- 3.0 Not sure/Don't know

What sort of awareness do you think should be used to increase awareness of bridge usage?

- 1.0 Television
- 2.0 Radio
- 3.0 Newspapers
- 4.0 Road signage
- 5.0 Community leaders like in church, funerals, political rallies
- 6.0 Other.....

Some sections of concrete barrier are broken. What do you think are the causes of this breakage?

- 1.0 Vandalism
- 2.0 Vehicle
- 3.0 Structural Failure
- 4.0 Don't know
- 5.0 Other.....

What do you think are any specific facilities needed on this footbridge to enhance usage?

- 1.0 Lighting
- 2.0 Improve on maintenance

- 3.0 No vending on footbridge
- 4.0 Upgrade with ramps
- 5.0 Increase the height of concrete barrier
- 6.0 Include road signs
- 7.0 Erect barrier on footpath leading to footbridge
- 8.0 Increase the width of the bridge
- 9.0 Other.....

Please state any comment you would like to make on this survey and/or issues addressed

.....

.....

.....

.....

.....

THANK YOU VERY MUCH FOR YOUR TIME/ASANTE SANA

Appendix 4: List of People Contacted or Interviewed

Name	Position	Organisation
Eng. Merin Koitalek	Assistant Engineer	KURA
Eng. Wilfred Oginga	Senior Engineer	
Eng. Geoffrey Tirop	Assistant Engineer	
Eng. J.M. Onyinkwa	Manager (D & C)	
Eng. E. Chepkwony	Engineer	
Eng. Paul Odak	Senior Land Surveyor	
Eng. Esther Amimo	Engineer	Ministry of Roads
Eng. Francis Gitau	Senior Engineer	KeNRA
Eng. David Muuhilia	Project Technical Team Leader	
Eng. Njuguna Gatitu	Maintenance Manager	
Eng. Eric Wambua	Highway Engineer	MoPW –Liberia
Eng. James Massaquoi	Resident Engineer	
Eng. Rawlings Kesselly	Civil Engineer	Mombasa Municipal
Eng. Micar Omono	Principal Assistant Engineer	
Eng. Tikollo Sylvanus	Works Officer-Structures	
Eng. Thomas Karatai	Divisional Engineer-Highway	City Council of Nairobi
Eng. Martin Ngari	Graduate Teaching Assistant	DKUoT
Eng. M. Mndala	Technical Auditor	RFA-Malawi
Eng. S. Gondwe	Technical Auditor	
Eng. Kelvin Were	Highway Engineer	Stanceconsult Ltd
Eng. Symon Miringu	Assistant Engineer-Highway	SMEC International
Eng. Gedion Onyuka	Highway Engineer	Cas Consultants Ltd
Eng. Oscar Wafula	Seniors Graduate Engineer	Gibb Africa
Eng. Victor Odula	Highway Engineer	OO & Partners
Eng. Robert Wendot	Highway Engineer	Engiconsult Ltd

Source: Author, 2012

Appendix 4a: List of People Contacted or Interviewed Cont`d

Name	Position	Organisation
CI Wesley Kiprono	Divisional Traffic Officer	Kabete Police Station
Mr. Njoroke Nyoike	Labour Statistics Manager	KNBS
Mr. Martin Mburu	Technologist	Uo N
Mr. Ezekiel Kabera	Research Assistant	
Mr. Anthony Mbai	Research Assistant	
Miss. Sahar Omai	Research Assistant	
Miss. Mercy Okisa	Research Assistant	

Source: Author, 2012

Appendix 5: Pedestrian Count Tally Sheets on Uthiru Pedestrian Footbridge

Date. _____, 2013

Time	Male	Female	Child	Physically Challenged	Grade Crossing
6.30-6.45 am					
6.45-7.00 am					
7.00-7.15 am					
7.15-7.30 am					
7.30-7.45 am					
7.45-8.00 am					
8.00-8.15 am					
8.15-8.30 am					
8.30-8.45 am					
8.45-9.00 am					
9.00-9.15 am					
9.15-9.30 am					

Note-Column 5 stands for the physically challenged

Appendix 7: Pedestrian Footbridge Design Drawings