UNIVERSITY OF NAIROBI

AN INVESTIGATION INTO THE IMPACT OF FAILURE IN THE PLANNING PHASE OF MEGA INFRASTRUCTURE PROJECTS

(CASE STUDY: ROAD SAFETY ON THIKA SUPERHIGHWAY)

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JULY, 2015

DECLARATION

I, MAINA GLADYS NDUTA, hereby declare that this research project is my original work and has not been presented for examination in any other university.

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DECLARATION OF THE SUPERVISOR

This research project has been submitted for examination with my approval as a University Supervisor in the Department of Real Estate and Construction Management.

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DEDICATION

To my son, Jeffrey Macharia

May you soar to greater heights.

To my husband, Peter Kiige

Thank you for your unconditional love, encouragement and support.

To my parents, Mr. and Mrs. Maina

Thank you for instilling in me the values and virtues that guide me and for sacrificing considerably to ensure that I got education. May Almighty God reward you abundantly.

To my brothers and sister

May God grant you the desires of your hearts.

ABSTRACT

The aim of this study was to investigate the impact of failure in the planning phase of a mega construction as exemplified by road safety challenges on the Thika Superhighway. These challenges are exemplified by for example, frequent accidents on the densely populated parts of the highway; crossing the highway posed a challenge as the footbridges were spread wide apart and pedestrians were tempted to cross the highway without using the footbridges hence increasing the incidences of pedestrians being knocked down. It was also difficult for the disabled to cross from one side of the highway to the other since they had challenges in using the footbridges and could also not cross the highway without risking being knocked down by speeding motorists. There were also no provisions for cars that break down or run out of fuel while on the highway and need to pull aside to fix the problem. Accordingly, a comparison of the planned road safety measures vis a vis the best practice was conducted as an indication of failure by planners to access/utilize available information. Further, the study sought to identify the planned road safety measures that were implemented and the challenges thereof to interrogate planning implementation.

The study covered various aspects of road safety that should be considered during the planning phase of a mega infrastructure project such as the best practice road safety measures, what the planning phase within the construction project lifecycle entails and the institutional and legislative framework on road safety in Kenya. The key challenges in the management of road safety were also considered.

The study relied on information from the key informants/opinion leaders from KeNHA, Traffic police, APEC Limited, KARA and the contractors who had been directly involved in the project. The data from the key informants was collected via interviews and questionnaires. Residents along the highway were involved in focus group discussions (FGDs). Data was also collected via direct observation, photography and the scrutiny of project documents.

The research findings were that some of the best practice road safety measures for a project of such magnitude that should have been considered during the planning phase were not considered. This is an indication of failure by the planners to utilize available information. There was failure by the planners to identify and use an appropriate design manual and to identify innovative ways of addressing safety issues which were bound to come up within the limitation of finances and space. There was also failure to include all the stakeholders during the planning phase who would have raised some of the safety issues which were likely to occur. Some of the planned road safety measures were also not adequately implemented. This was because either the road safety measures did not match the road users' safety requirements or did not comply with the design standards. The implemented road safety measures therefore did not comply with the best practice. Various challenges were also identified to have been faced during the implementation of the planned road safety measures such as inadequate resources, poor human behavior and ineffective communication and coordination which is an indication of failure by planners to consider road safety during the planning phase of the project.

The study recommends the adoption of a context-sensitive approach to road-building. The project implementers should also consider the use of alternative materials such as fibre and plastic for safety signs and guard rails etc. which are not targeted by vandals and the use of modern technology such as real time surveillance systems to track down traffic offenders. The government should also emphasize the need for public participation and stakeholder engagement during the planning phase of mega road infrastructure projects in line with the Constitution of Kenya (2010) including road safety awareness-creation initiatives. NTSA's participation during the planning phase of mega road infrastructure projects should also be clearly stated as one of their mandates.

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ACRONYMS

ADF – Africa Development Fund

APEC–Aviation Projects and Engineering Consultants

CES – Consulting Engineering Services

CSUD – The Centre for Sustainable Urban Development

FGD – Focus Group Discussion

FHWA – Federal Highway Administration

GDP – Gross Domestic Product

GDCF – Gross Domestic Capital Formation

GHA –Ghana Highway Authority

GNP – Gross National Product

ILO – International Labour Organization

KARA – Kenya Alliance of Residents Associations

KeNHA – Kenya National Highway Authority

KeRRA – Kenya Rural Roads Authority

KURA – Kenya Urban Roads Authority

MoR – Ministry of Roads

MUTCD – Manual on Uniform Traffic Control Devices

NMT – Non-Motorized Transport

NRSC – National Road Safety Council

NTSA – National Transport and Safety Authority

OSH – Occupational Safety and Health

RSA – Road Safety Audit

THIP – Thika Highway Improvement Project

UNCHS – United Nations Centre for Human Settlements

WHO – World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The construction industry is an important part of the economy in any country and often seen as a driver of economic growth especially in developing countries. Typically, the construction industry contributes to 11% of gross domestic product (GDP) in most developing countries (Wells and Hawkin, 2007; Giang and Pheng, 2010). In Kenya, the sector plays a major role in the country's economic development through its contribution to gross domestic product (GDP), gross domestic capital formation (GDCF), creation of employment and production of capital facilities and assets required for production in other sectors (UNCHS,1996).

Through the construction industry a number of facilities have been created such as transportation infrastructure, housing, health facilities, markets, electricity and water supply which also stimulate development of sectors such as agriculture, manufacturing industries, tourism and transportation. In addition, the construction industry is one of the major providers of employment in urban areas, especially for the urban poor who do not have much education or skill as construction projects are normally labour intensive (Ibid).

However, many construction activities have inherent health and safety risks such as working at height, working underground, working in confined spaces and close proximity to falling materials, handling load manually, handling hazardous substances, noises, dusts, using plant and equipment, fire, exposure to live cables, poor housekeeping and ergonomics. In an urban context, the number of health and safety accidents is relatively higher due to the fact that high rise buildings remain predominant with the fast growing complexities of domain-wide construction projects to cope with modernizing cities arena and high demand for housing, offices, services and other infrastructures due to the high urbanization. Despite its importance, therefore, construction industry is considered as being risky with frequent and high accidents rate and ill-health problems to workers, practitioners and end users (Hinze, 2005).

According to Mohammed (2003), the construction industry is concurrently recognized as a major economic force and one of the most hazardous industries. Accidents not only result in considerable pain and suffering but marginalize productivity, quality, time and negatively affect the environment and consequently add to the cost of construction. Construction accidents may cause many problems, such as demotivation of workers; disruption of site activities; delay of project progress; and adversely affecting the overall cost, productivity and reputation of the construction industry. Considering the adverse impacts of accidents, construction health and safety management is of genuine concern to all stakeholders in the construction industry. In most developing countries however, health and safety consideration in construction project delivery is not given priority, and employment of safety measures during construction is considered a burden (Mbuya and Lema, 2002).

According to Adan (2004), health and safety has been identified as a parameter which should be used along with the traditional parameters: cost, quality and time, to measure the success of projects. Smallwood (1996) ranked the extent to which inadequate or the lack of health and safety negatively affects other project parameters with productivity and quality being predominant followed by cost, client perception, environment and schedule respectively. The reasons for considering safety and health are human factor, legislation and financial issues (Adan, 2004).

Although significant progress has been made in improving the industry's occupational safety and health (OSH) standards over the years, the number of deaths, injuries and cases of ill-health are still unacceptably high. The pain and suffering of those directly affected – the individuals, families, friends and colleagues is self-evident. However, for the industry, accidents and ill-health also have a huge financial cost, which makes for a compelling business case for improving safety and health (Konkolewsky, 2004).

Tregenza (2004) states that construction may be seen as a three-phase activity.

a) **Pre-build**. Research indicates that two thirds of fatal accidents occurring on building sites are due to decisions taken at the design and planning phase. Key players at this phase include client, architects, designers, contract managers and those procuring goods and services for the building phase.

b) **Building phase**. During this time, safety and health coordinators, project managers and supervisors, employers, subcontractors and workers all have to cooperate to eliminate or reduce risks.

c) **Post-construction phase**. Decisions made during the pre-build and building phase have a long-term impact on the health and safety of those who maintain and work in the building. At this phase, building owners and maintenance contractors are among the most important stakeholders (Tregenza, 2004).

Action is required by all involved: the clients, designers, architects, engineers, employers, employees and contractors. These key players make important decisions at procurement, planning, during construction and after completion. These decisions can result in action being taken to reduce risks, and make the construction industry safer and healthier (Konkolewsky, 2004). Haywood (2004) notes that good standards of safety and health on a construction project starts with the decisions made by the client who procures the work. It is at this stage that the whole safety and health climate of a project is established.

Contracts need to be awarded on value for money grounds, not lowest price tenders. Value for money means achieving, at the end of the construction project, something that is fit for purpose, fulfills user needs, and achieves a balance between quality and costs throughout its life (Haywood, 2004). Haywood however notes that too many contracts are awarded on the basis of lowest price tenders, only to see the final price increase significantly through contract variations, failure to meet quality standards or time deadlines. Additionally, costs arising from poor safety and health performance impinge on the client. Reputations also suffer by being associated with construction companies that have a poor health and safety image.

It is important that clients understand that having construction work carried out is the same as any other business investment. The client's business requirements are only successful if they can be operated without adversely affecting the safety and health of those who carry out the construction work, or occupy and use the finished building or structure. It is therefore of fundamental importance to the client, when selecting contractors and others, to ensure that those appointed are able to carry out the work competently (Haywood, 2004).

Construction projects are unique in nature in terms of complexity, location, project participants and the legal framework within which the project is being executed. It is therefore necessary to carry out extensive background study of the project to establish the risk associated with a particular project. This will assist the major stakeholders in the planning phase to adequately plan for the risk associated with the project given its unique context.

The Case Study: The Thika Superhighway

Before plans for Nairobi-Thika Superhighway were designed, few would have imagined that this grand infrastructure project, one of the key pillars of Kenya's Vision 2030, would lead to a complete transformation of Nairobi. That is exactly what the 50-kilometre Nairobi-Thika Superhighway, which links Nairobi and the industrial and agricultural towns of Ruiru and Thika, has done (Kabukuru, 2011).

Construction of this highway began in January 2009 and was being undertaken by three Chinese construction giants - China Wu Yi, Shengli and Sino Hydro. The key objective for the road expansion was to decongest the city and reduce the numerous traffic snarl-ups associated with this road, which is estimated to carry 70,000 vehicles daily, transiting between Nairobi and the countryside. Thika road construction project which kicked off in 2009, involved changing the road from a four to eight-lane superhighway (Ibid).The project whose initial cost was estimated to be Sh.27 billion ended up costing Sh.31 billion due to inflation and additional features that changed design work (Ngetich, 2012).

The project included construction of interchanges, flyovers, box culverts and standard pipe culverts. The highway was split into three sections for construction works totalling 50.4km of multiple lane road. These sections were Muthaiga Roundabout to Uhuru Highway, Muthaiga Roundabout to Kenyatta University (KU) and KU to Thika (Lugaria, 2012).

1. Uhuru Highway – Muthaiga Roundabout (12.4 km)

On Uhuru Highway – Muthaiga Roundabout section construction works involved expansion of University Way to eight lanes from six, provision of four lane flyover across Globe Roundabout, expansion of Murang'a Road to six lanes, construction of underpass at Pangani, flyover on Muthaiga roundabout and provision of footpaths. Works on the Forest Road-Museum Road-

Museum Hill roundabout section involved expansion of Forest Road to six lanes from four lanes, expansion of Museum Hill road to six lanes, provision of forked flyover on Limuru Road and provision of footbridges (Lugaria,2012) .

2. Muthaiga Roundabout –Kenyatta University (14.1km)

On the Muthaiga roundabout-KU section, which had been designed as a high-speed superhighway with limited access and exits, works involved expansion of the carriageway to eight lanes – (Muthaiga-Kasarani) and 6 lanes (Kasarani –KU), construction of underpasses at Kahawa and KU, provision of interchange at GSU roundabout, flyovers at Kasarani and Githurai roundabouts, underpass at former Nakumatt Thika Road, subway at Survey of Kenya and provision of footbridges (Ibid).

3. Kenyatta University-Thika (23.9km)

Works on the KU-Thika section included expansion of the carriageway to six lanes up to Juja, construction of six lane flyover at Eastern Bypass, underpass at Ruiru Sports Club and at Mangú High School as well as provision of footbridges (Ibid).

The expansion of the road from four to eight-lane superhighway was expected to contribute immensely to the economic and social development of Kenya and the neighbouring countries. The highway was also expected to improve mobility and transport linkages between the Nairobi Metropolitan Area satellite towns along the highway (Mwongela, 2010).

1.2 Problem Statement

The gains of the expanded Thika road cannot be overemphasized, but some crucial social implications may have been overlooked. As many celebrate the ease of traffic flow occasioned by the Nairobi-Thika Superhighway, residents living along the highway were concerned about the social-economic impact the new road would have on their lives (Muiruri, 2011).

The reality of such effects came to the fore in a recent brainstorming forum held between August and September, 2011 organized by the Kenya Alliance of Residents Associations (KARA) and attended by those living or doing business along the superhighway and officials from the then

Ministry of Roads. The meeting was the culmination of six other public forums held with residents along the highway (Muiruri, 2011).

KARA 'divided' the highway into sections and held one Focus Group Discussion (FGD) in each of the following areas:

1. Parklands / Pangani area (August 3,2011,Impala Hotel-Nairobi,13 Participants)
2. Muthaiga, Utalii, Kasarani (August 10,2011 at Sportsview Hotel-Kasarani,24 Participants)
3. Githurai, Kahawa, Weomererie (August 17,2011 at Sportsview Hotel-Kasarani,20 Participants)
4. Kenyatta University / Ruiru (August 24,2011 at Digithu Hotel-Ruiru,52 Participants)
5. Juja (September 1,2011 at Senate Hotel-Juja,50 Participants);and
6. Thika (September 7,2011 at Coconut Grill Hotel-Thika,33 Participants)

The FGDs provided a platform for the public to give their views on project planning and implementation, socio-economic impact on their lives and livelihoods, their involvement or otherwise in the project, and issues of local planning and land use in relation to the project as well as any other concerns (KARA & CSUD, 2012) . During the forum, residents isolated several negative effects that were likely to occur during and after the completion of the project ranging from health, economic, social, environmental and road safety (Muiruri, 2011).

Road Safety

Livingstone Waiganjo, an official with Kahawa Sukari Resident Association, lamented the fact that children in the neighbourhood no longer meet and play as they used to due to the danger associated with crossing the new road in areas where there were no footbridges. Then, there were only ten footbridges along the entire 49.9km stretch of the new highway. This was especially a matter of concern for Peter Kariuki, a disabled person who found it challenging to cross the highway. They proposed building of more footbridges as the existing ones were spread wide apart and pedestrians were tempted to cross the highway even where there was no footbridge.

There was also lack of adequate provision for the other Non-Motorized Transport (NMT), hence increasing the chances of accidents. Other issues had to do with the design of the road itself. Some residents noted that there were no designated spots where motorists could pull over in case of mechanical problems or other emergencies (Muiruri, 2011).

"There are no provisions for cars that break down or run out of fuel while on the highway to pull aside and fix the problem. This is bound to lead to accidents as vehicles on high speed can easily ram on to the stationery vehicle." KARA's Treasurer, Ephraim Kanake said. On road safety, Kanake further noted that inadequate signage on the road especially for diversions had been blamed for numerous accidents (Rajab, 2011).

A financier of the magnificent Thika Superhighway blamed the numerous deaths occasioned by road accidents on the Chinese contractors. The contractors had been accused of not putting up enough traffic safety management system in the course of construction, an allegation they had denied, blaming it on vandals. African Development Bank, who financed lot three of the superhighway running from Kenyatta University to Thika, and built by Shengli Engineering, said that the road was "very unsafe to use as there was no proper signage" (Sangira, 2012).

The general feeling was that there was minimal information relayed to the local residents and users of the highway regarding the project. Information about the design, land use, time frame, cost, and project partners was not easily accessible. Communication during the implementation of the project such as when and where diversions would be made was not effectively provided to local residents and users of the highway. There was also lack of knowledge both by motorists and pedestrians on how to use the highway (KARA, 2012).

Deputy Traffic Commandant Samuel Kimaru called on pedestrians to exercise caution and cross the highway using footbridges, tunnels and zebra crossings along the highway. With most of the provisions not yet in place as the highway was still under construction, pedestrians were urged to be extra careful when they needed to cross the road where there were no provisions (Sangira, 2012).

Kenya National Highways Authority Director General, Engineer Meshack Kidenda said the many accidents could have been avoided if motorists followed instructions given by the contractors. But deputy traffic boss Leonard Katana differed with the representative blaming motorists for the accidents. He said a new culture should have been entrenched as the superhighway "was a new ball game all together". A representative from the bank, Dr. Girma Berhanu Bezabeh said motorists and pedestrians should have been educated on the use of the road so as to minimise traffic accidents as the construction came to a close (Sangira, 2012).

The Kenya Alliance of Resident Associations called on the government and the contractors working on Thika Superhighway to resolve all issues surrounding the construction. The association also called on Kenya National Highways Authority to conduct thorough civic education on the highway's usage before it was officially commissioned. To reduce accidents and to promote proper use of the highway KeNHA called on KARA to educate both the pedestrians and motorists on how to use the road (Rajab, 2011).

Although there may be little redress to many of the matters raised due to the advanced progress of the project, participants hoped the emerging issues would inform other major infrastructural upgrading works still in the pipeline. *"As much as the issues we are raising were factored in the planning phase of the project, having such an interactive debate will ensure that the residents' concerns are heard by the relevant authorities and, where possible, adjustments made*," said Stephen Mutoro, KARA's chief executive officer (Muiruri,2011).

From the above, it is evident therefore that construction of the project was accompanied by a number of safety issues some of which have been identified above suggesting possible failure by the planners to consider road safety during the planning phase of the project. Were the issues raised by the various stakeholders factored in during the planning phase? If yes, were they adequately implemented? This then gives rise to the need to investigate which road safety measures were planned for vis a vis the best practice as an indication of the failure by planners to access/utilize available information; whether the planned road safety measures were implemented and the challenges thereof to interrogate planning implementation. The aim of this study therefore was to investigate the impact of failure in the planning phase of a mega construction as exemplified by road safety challenges on the Thika Superhighway. In particular the study sought to answer the following research questions:

a) Which road safety measures were considered during the planning phase of the project and how do they compare with the best practices thereof?

b) Were the planned road safety measures adequately implemented?

c) What challenges were faced in the implementation of the planned road safety measures?

1.3 Objectives of the Study

1. To compare the road safety measures considered during the planning phase of the project with the best practice.

2. To evaluate whether the planned road safety measures were adequately implemented.

3. To identify the challenges faced in the implementation of the planned road safety measures.

1.4 Research Proposition

The road safety measures identified during the planning phase of the project were not adequately implemented leading to increased accidents on the Thika Superhighway.

1.5 Justification and Significance of the study

The Thika Superhighway project was chosen in particular because although there may be little redress to many of the matters raised due to the advanced progress of the project, the emerging issues will inform other major infrastructural works still in the pipeline. Such projects include Konza City IT project, the on-going completion of construction of major road by passes for Nairobi and roads infrastructure for Nairobi and the crown jewel of all the projects being the launch of the construction of the Lamu Port and the Lamu-Isiolo-South Sudan and Ethiopia road network. The fore-going infrastructural projects are going to define the Kenyan economic trajectory for the next fifty to one hundred years.

Even before the completion of the project there had been several negative safety issues which had been isolated by KARA and the media. Further, very little research has been done with the specific aim of investigating the impact of failure in planning and plan implementation of mega infrastructure projects in Kenya especially from the road safety perspective. This research therefore will aim to bridge this knowledge gap and provide a guideline to improving road safety of infrastructure projects of such magnitude with the Thika Superhighway project being the reference point. It is hoped that this research will help improve both the process and outcomes of the on-going and future very important infrastructure projects in the country in line with Kenya Vision 2030.

1.6 Research Methodology

1.6.1 Data Collection

The research adopted both primary and secondary methods of data collection. Primary data was collected through conducting direct interviews, focus group discussions and administering questionnaires. This data helped to compare the road safety measures considered during the planning phase of the project with the best practice, to evaluate whether the planned road safety measures were implemented and to identify the challenges faced in the implementation of the planned road safety measures. This is because despite these issues being factored in during the planning phase, the same issues kept on coming up during project implementation. This is evident through the research conducted by KARA between August and September 2011 where residents kept on raising the same concerns.

Direct observation and photography were also incorporated to find out the impact of failure of appropriate planning and plan implementation on mega infrastructure project. The data so collected was used to examine the views of different groups of people about the concerned topic as well as their recommendations.

Secondary data was sourced from the various published and unpublished journals relating to mega infrastructure project management, textbooks, internet, workshops and reports. Other thesis and unpublished work were also studied to give view of the topic. Articles on construction review and other scholarly works touching on the topic were also used to achieve a contemporary edge to the research.

1.6.2 Data Analysis

First, data mining, the process of sorting through large amounts of data and picking out relevant information was done so as to obtain relevant categories of qualitative and quantitative data sets. Frawley, Piatetsky-Shapiro & Matheus (1992) describe data mining as “the nontrivial extraction of implicit, previously unknown, and potentially useful information from data” and “the science of extracting useful information from data sets or data bases” Data analysis is the process of examining and summarizing data with the intent to extract useful information and develop conclusions (Hand, Mannila & Smyth, 2001). For purposes of analysis, Ms Excel, a computer program used for statistical analysis was used.

1.6.3 Data Presentation

The data so analyzed was presented in form of tables, charts and plates. Figure 1.1 below illustrates the methodology flow chart of this study.

1.7 Definition of Terms

Safety

Safety is protection of people from physical injury (Hughes and Ferret, 2008). Safety also means a state in which no danger of damage causing accident exists (Kheni, 2008).

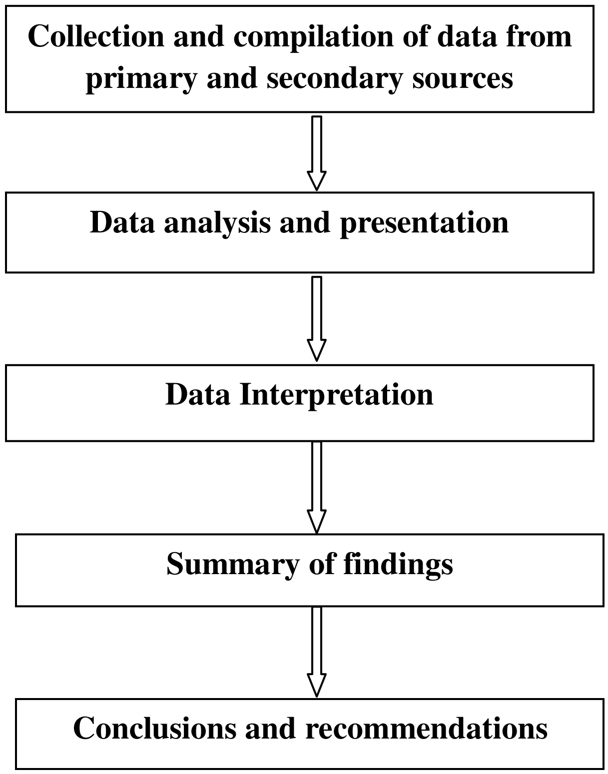
Accident

Accident is an incidental or unplanned event that could have been prevented had circumstances leading up to the accident been recognized, and acted upon, prior to its occurrence (Robertson, 2015).

Stakeholder

A stakeholder is defined as individuals or groups who will be impacted by, or can influence the success or failure of an organization’s activities (Bourne, 2009).

Figure 1.1: Methodology flow chart



Source: Cooper & Schindler, 2003

Resident

A resident is a person living in a particular place usually for a long time or working regularly at a particular place (Merriam-Webster Learner's Dictionary, 2013).

Road Work Zone

A road work zone is defined as the part of a road facility influenced by works occurring on, near or above it. Besides the area actually occupied by the road works, a road work zone thus defined also includes: the complete road section(s) where signs, markings and other roadwork-related traffic control are effective, the roadside area used for the physical placement of traffic control measures and other road equipment (such as protective devices), the buffer area(s) separating the work area from traffic (NTUA, 1998).

Superhighway

A superhighway is a multi-lane (six or more lanes) highway (as an expressway or turnpike) designed for high speed traffic. A superhighway can also be defined as a large and wide highway used for travelling at high speeds over long distances (Merriam-Webster Learner's Dictionary, 2013).

Megaproject

A Megaproject is a unique endeavor, a project whose special conditions make it even more special than normal projects, for higher time, budget and/or resources allocated than in similar projects. Risks, requirements and difficulties to perform it are commonly high as well. There is therefore not a rule of thumb to define when a project should be considered as a Megaproject. Some authors consider that projects exceeding USD 1 billion must be included in the list, but it will always depend on the context (Nothmann Research, 2015).

1.8 Scope and Limitations of the study

Due to financial and time constraints, the research was limited to a manageable geographical and conceptual scope.

a) **Geographical -** Nairobi and Kiambu Counties were chosen being the areas under which the road lies.
b) **Conceptual** – there are many parameters for measuring the success or failure of a construction project but for the purpose of this study, research was limited to the impact of failure in the planning and plan implementation of mega infrastructure projects as exemplified by road safety challenges on the Thika Superhighway. Mega infrastructure projects were chosen due to their unique nature.

Due to the sensitivity of organization's ethics, certain elements of the data cannot be accurately given therefore for the purpose of this study, the mega infrastructure projects were assumed to have been designed by qualified design consortium and also faced with the same external environment.

1.9 Organization of the Study

The research was organized in five sections as follows:

Chapter one is the introductory section. It briefly introduces the problem statement, objectives, proposition, research methodology, scope and justification of the study.

Chapter two discusses the literature reviewed and the theoretical framework, which is the basis for the research study. It includes what the planning phase within the construction project lifecycle entails and the best practice road safety measures to be factored therein.

Chapter three is the research methodology section. It lays down the background of the research and the population being studied. It also shows the sampling techniques used in this particular study and clearly shows how the sample sizes were systematically arrived at. The data collection instruments and procedures are also discussed.

Chapter four is the data presentation and analysis section. In this section, the information that is collected from the field is organized, analyzed using a computer program Ms Excel and presented in the form of tables, charts and plates. The responses of various groups to whom questionnaires are administered as well as oral interviews and focus group discussions conducted are tabulated, analyzed and presented. A summary of findings are given and the problems encountered in the field are also annotated.

Chapter five gives conclusions and recommendations made based on the results of the findings. Suggested areas of further study are also mentioned.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter contains literature covering the various aspects on safety considerations during the planning phase of mega road infrastructure projects. Information relating to which road safety measures were considered during the planning phase of the project is compared with the best practice; evaluation of whether the planned road safety measures were adequately implemented and the challenges faced in the implementation of the planned road safety measures is covered. Finally the chapter draws a conclusion and ends with a conceptual model.

2.1.1 Health and Safety in Construction

Health refers to the protection of bodies and minds of people from illness resulting from materials, processes or procedures used in the work place whereas safety is protection of people from physical injury (Hughes and Ferret, 2008). Safety means a state in which no danger of damage causing accident exists. Health and safety at construction sites therefore deals with both physical and psychological well-being of workers on construction sites and other persons whose health is likely to be adversely affected by construction activities (Kheni, 2008).

The Collins English Dictionary (2000) defines infrastructure as *"a stock of facilities, services and equipment in a country including factories, roads and schools that are needed for it to function properly."* There is no doubt that other important components of national infrastructure include the electrical power grid, telecommunications networks and transport systems such as roads, railways and airports. Because a country cannot function properly without infrastructure, it is of national strategic importance to develop and upgrade an adequate infrastructure to meet the increasing demands that are arising from economic and population growth. Infrastructure is thus very important for an economy and indeed one major difference between a developed economy and a less developed economy is the quality of infrastructure (National Roads Authority, 2000).

Despite the attractiveness of the construction industry in nation building, its activities sadly pose serious health risks to workers, users of construction facilities and the public. ILO (2005) notes that developing countries show evidence of relatively high proportion of accidents on construction sites as compared to developed countries. Hazards frequently encountered in the construction industry include: dangerous chemicals; dust; exposure to vibration; high noise levels; manual lifting of heavy weights; unguarded openings; ionizing radiations; fire; exposure to live cables; and, moving mobile construction plant on site. The risks that these hazards pose are often unacceptably high on construction sites. Traditionally, measures are taken to eliminate these hazards where possible, or reduce their risks to an acceptable level on construction sites. However, measures taken to control risks of hazards on construction sites in developing countries are inadequate resulting to unhealthy and unsafe sites (Haupt and Smallwood, 1999).

The construction industry has therefore earned the reputation of being a dangerous or highly hazardous industry because of the disproportionately high incidence of accidents and fatalities that occur on construction sites around the world (Rowlinson, 2000; Smallwood and Haupt, 2005). Bomel Consortium (2001) noted that construction activity presents hazards to people working in the industry as well as to the public in proximity to the sites. Similarly, Sohail (1999) labels the construction industry as very hazardous. Internationally, construction workers are two to three times more likely to die on the job than workers in other industries while the risk of serious injury is almost three times higher (Site Safe, 2000).

Health and safety breaches lead to accidents that cost life of workers and users, permanent and temporary disabilities, injuries, and diseases. This is additionally manifested by reduced productivity, non-conformance to quality standards, time overrun and cost overrun of the projects. Though much improvement in construction safety has been achieved over the last 10 years, the industry still continues to lag behind other industries with regard to safety in many countries (Mbuya and Lema, 2002).

Based on the occupational health and safety statistics presented by different researchers (Haupt 2005), it was determined that the injury and fatality rate in the construction projects is very high in comparison to other sectors of industry in the majority of countries. Again, it has been acknowledged that 25–40% of fatalities in the world's occupational settings are contributed by construction (ILO, 2005). Available statistics in different countries show that the construction industry accounts for 30% of fatal industry accidents across the European Union (EU), yet employs only 10% of the working population. In the United States of America (USA) the sector accounts for 20% of fatal accidents and only 5% of employment, in Japan construction fatalities account for 30-40% of industrial fatal accident (ILO, 2005). In developing countries, very few statistics of fatality in the construction sites are available due to the fact that most of the accidents are not reported. Nevertheless, ILO estimates that at least 60,000 fatalities occur at construction sites around the world every year. This means that, one fatal accident occurs every 10 minutes in the sector (Mbuya and Lema, 2002).

Accidents at work occur either due to lack of knowledge or training, lack of supervision or lack of means to carry out the task safely, or due to an error of judgment and carelessness (Adan, 2004). In addition, the short term and transitory nature of the construction industry, the lack of controlled working environment and the complexity and diversity of the size of construction firms, all have an effect on construction projects' health & safety (Adan, 2004). According to Mohammed (2003), unsafe behaviour in construction is also considered to be the most significant factor in the cause of site accidents and therefore provides evidence of a poor safety culture. Health and safety therefore is an economic as well as humanitarian concern that requires proper management control.

Research carried out by Gibb and Bust (2006) on health and safety in developing countries identified a number of factors having a negative impact on health and safety management in developing countries which include poor infrastructure; problems of communication due to low literacy level; unregulated practices on construction sites; adherence to traditional methods of working; non availability of equipment; extreme weather conditions; improper use of equipment and corruption. Further the construction industry is a project based industry which exists in a dynamic and ever changing environment (Lindgard and Rowlinson, 2005). Therefore, health and safety management can be totally different from one construction project to another and requirements constantly change as the work moves from one stage to another. Moreover in construction projects there is extreme diverse range of people from wide range of occupational culture and background, different gender including people in unskilled, craft, managerial, professional and administrative position (Giang and Pheng, 2010).

According to Gibb and Bust (2006), the culture of the construction industry in developing countries also does not promote health and safety. The practices of competitive tendering and award of most public contracts to the lowest bidder in many developing countries compels contractors to drive their prices low while cutting costs which in turn affect health and safety. Safety and health is often discussed in site management meetings as a priority, while in reality safety and health takes a low priority to budget and time discussions.

One of the most common myths that have plagued this industry is that health & safety comes at a cost. Construction managers tend to believe that introducing and executing measures that ensure health and safety in construction sector will lead to higher cost, and hence lower profitability. However, it has been proved that investment in construction health and safety actually increases the profitability by increasing productivity rates, boosting employee morale and decreasing attrition. A safe working environment also results in fast execution of project plans, thereby reducing the overall cost of the project (Mohammed, 2003).

2.1.2 Health and Safety Management Systems

The state of the construction industry in a country is symptomatic of the state of its national economy. This means that the fate of any national economy cannot be separated from that of the construction industry. This is a consequence of the forward and backward linkages the construction sector forges with the rest of the economy (Giang and Pheng, 2010). A high standard of occupational health and safety correlates positively with high GNP per capita. The countries investing most in occupational health and safety show the highest productivity and strongest economy, while the countries with the lowest investment has the lowest productivity and the weakest economies. Thus, active input in occupational health and safety is associated with positive development of the economy, while low investment in occupational health and safety is disadvantage in the economic competition (WHO, 2007).

Construction can be a hazardous business. This is widely recognized by OSHA, and everyone in the construction industry. When accidents happen, the costs are high –in people, profits and productivity (Safe Site, 2000). Construction managers are obviously concerned with injuries to the workers, but their prime concern should be with the dangerous conditions that produced the injury. On a construction site there are many more “incidents” than injuries. A dangerous act can be performed hundreds of times before it results in an injury, and it is to eliminate these potential dangers that managers' efforts must be directed. They cannot afford to wait for human or material damage before doing anything (ILO, 1999).

Improving the health and safety management of the construction projects has repeatedly been shown to save life, time, money, increase business goodwill and good reputation (Kikwasi, 2010). Meanwhile, the right to safe and healthy working conditions and environment has been a central issue for the global campaign. Clearly the need for safe and healthy construction workplaces has been recognized at both international and national level as current health and safety laws and regulations in different countries have separate sections specifically for the construction industry. In most countries, legally all employers are required to maintain health and well-being of the workers and other persons at the working places. At the same time safer and healthier work conditions can make an important contribution to poverty alleviation and sustainable development (ILO, 2005). Meanwhile, health and safety performance is now being recognized as competitive advantage and performance evaluation criteria for the construction projects (Health and Safety Executive, 2004).

ILO (1999) indicated that the improvement of safety, health and working conditions depends ultimately upon people working together, whether governments, employers or workers. Safety management involves the functions of planning, identifying problem areas, coordinating, controlling and directing the safety activities at the work site, all aimed at the prevention of accidents and ill health. Therefore, safety management means applying safety measures before accidents happen. Effective safety management has three main objectives; to make the environment safe, to make the job safe and to make workers safety conscious (ILO, 1999). Construction site safety management can therefore be defined as the efficient and effective implementation of the policies and tasks necessary to satisfy the safety of a construction firm's employees and management and it focuses on the careful management of the processes involved in the production and distribution of products and services within construction sites (Bernold et al., 1993).

Management approach to health and safety in construction industry can be seen in three important ways – firstly, from legal point of view, the need to abide by the rules and regulations of the place; second, the socio-humanitarian aspects which is to consider human lives involved; and finally, the financial-economic aspects of the accidents which have high direct and indirect costs (Kheni, 2008). A number of construction businesses manage the health and safety function in their businesses by carrying out health and safety activities aimed at minimizing or eliminating the risk of hazards on their sites. A growing number of construction businesses, particularly larger ones, have tended to adopt health and safety management systems which have their origin in Deming's Plan-Do-Check-Act model of continuous quality improvement (Hamid et al., 2004).

Helledi (1999) reported on the adoption of a simple, non-bureaucratic health and safety management system in the Finnish construction industry which proved effective in bringing down the numbers of site accidents experienced by contractors. The elements of the health and safety management system comprised: a planning phase involving the assessment of risk; an implementation phase involving communication of critical tasks to be carried out on site; a control phase involving monitoring the activities; and, a follow up phase which provides feedback and enables corrective measures to be taken.

The adoption of comprehensive health and safety management systems however, has been shown to be a difficult task in the construction industry because of the nature of the industry. There is, therefore, reason to doubt the applicability of comprehensive health and safety management systems to construction sites. Participants in a project have a role to play in improving the health and safety performance of construction sites and completed projects. Current thought on health and safety in construction put emphasis on integrating health and safety management into the entire construction process (Kheni, 2008).

Construction processes in developing countries share similar characteristics in terms of the adoption of technology, construction methods, cultural environments and regulations. Therefore inadequate information and the lack of education and training about workplace safety and health is a great concern in the construction industry. The culture and attitudes of construction workers, supervisors, and companies about health and safety often condone risk taking and unsafe and unhealthy work practices, passing "bad" habits from one generation of workers to the next (Adan, 2004).

Adan (2004) further argues that lack of information and experience limit the intervention process of improving healthy and safe working environment in the construction sites. Although many accidents and ill health problems remain unreported, there is concern that existing situation is alarming. The situation is further compounded in construction projects in Kenya by the extremely diverse range of people with different levels of education, cultural background among the workers as most labourers migrate from rural to urban, cultural differences between employer (contractor) and workers performing the actual work in the construction sites and have different levels of health and safety awareness and requires different ways of training and communication.

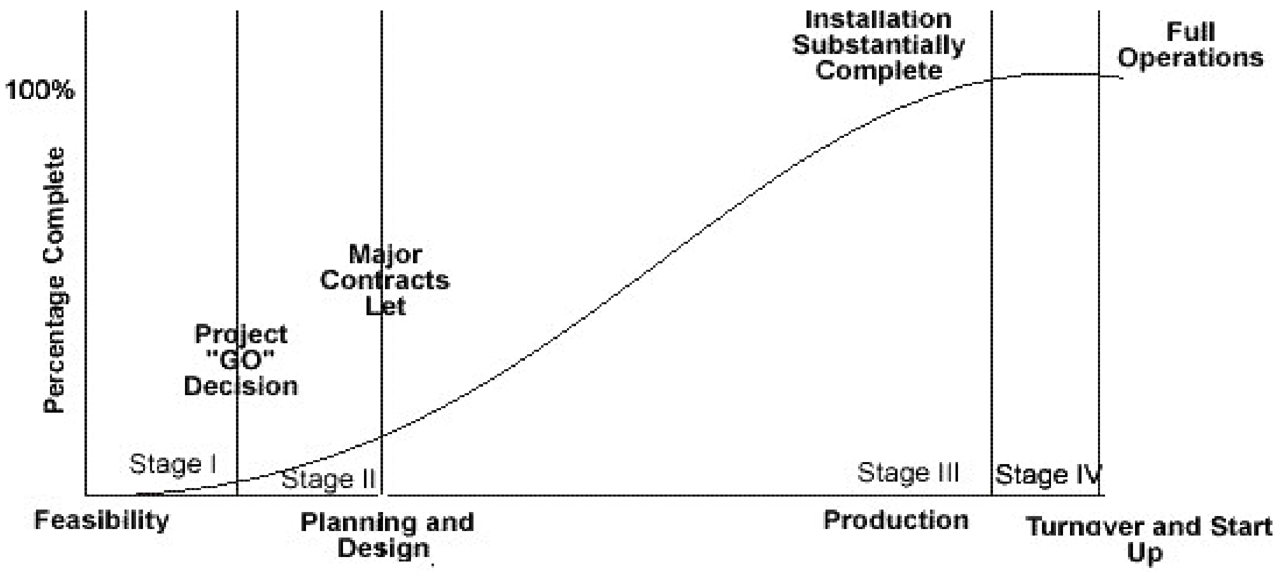
To manage health and safety effectively, it is essential that owner/managers have the right attitude and perceptions about hazards on construction sites. Unfortunately, this is not the case in the construction industry where health and safety risks are often wrongly perceived to be low. Most owner/managers misconceive the risk levels of their businesses and rarely involve their workers in decision-making relating to health and safety matters (Kheni, 2008). The Health and Safety Commission in the UK (Department of Environment, Transport and the Regions (DETR) (2000) for instance, has identified ignorance amongst other factors preventing the construction industry from taking the opportunity to improve their competitive position through better health and safety management.

Kaimong (1990) argues that the management of construction sites in Kenya is either too lax or not aware of health and safety as shown by the numerous past accidents. Members of the public are also exposed to the dangers arising out of construction sites. As people pass by the site they stand a risk of being hit by objects falling from high-rise construction sites if proper safeguards have not been incorporated to protect them (Mwangi, 1989).A general survey in the construction industry indicates that adequate measures for health and safety in the sites have not been put in place and also various challenges are encountered in the management of health and safety in construction. This manifests itself on construction sites as numerous accidents/ injuries, health problems which result to hospitalization and absenteeism. This is due to laxity in the enforcement of health and safety regulation requirements in the construction project sites amongst other reasons (Muiruri, 2012).

2.2 Construction Project Life Cycle

Each construction project has a pre-determined duration with a definite beginning and an identifiable end. Each project is divided into several phases. A project starting point is the time when the idea or the need is conceived by the client and its end marks the time when the mission is accomplished. The time between the start and completion of a project represents the project life cycle. Collectively, a project life cycle comprises of the project phases, from the beginning to the end of the project (Chitkara, 2009). A life cycle pattern of a typical construction project is illustrated in Figure 2.1.

Figure 2.1 Typical Construction Project Life Cycle Pattern: Cumulative Effort v/s Time



Source: Chitkara, 2009

In a project life cycle, there is a gradual build up in the use of resources from the start of the project. It is followed by a long duration plateau during the execution phase, where most of the expenses are incurred and towards the end, there is a rapid run-down as the project draws to a conclusion. According to the Project Management Institute (1996), the cost and staffing levels are low at the start, higher towards the end, and drop rapidly as the project draws to a conclusion. Chitkara (2009) argues further that the probability of successfully completing the project is lowest at the start of the project and hence the risk and uncertainty are the highest. The probability of completion gradually increases and the risks reduce as the project progresses.

The ability of the stakeholders to influence the final cost of the project is highest at the start and gets progressively lower as the project continues .A major contributor to this phenomenon is that the cost of changes and error correction generally increases as the project continues (PMI, 1996). This generally implies that since risks and uncertainty are highest and costs are lowest at the start of the project, the project stakeholders are in a better position to influence project parameters such as cost, time, quality and safety at the onset of the project unlike during the course of the project or even at the end. It is therefore crucial that important decisions are made during the planning phase of the construction project since this will have an impact on subsequent phases of the project especially the construction phase.

2.2.1 Feasibility or Inception

The major construction projects are undertaken to meet particular needs of a client. Generally, a client is well informed and clear about what he needs but sometimes what he thinks he wants and what he really needs may actually be different. The first step in the development of a project is to analyze the needs of the client. This requires a critical examination of the needs through feasibility studies. The feasibility studies evaluate project potential by examining technical feasibility, economic viability and financial implications. The subject to be covered in the feasibility report of a construction project will depend upon the purpose of the report and the nature of the project (Chitkara, 2009).

The feasibility report, if found favourable, is followed up with investment appraisal. The purpose of appraisal is to conduct an objective assessment for investment decision. It involves critical examination of the techno-economic analysis of feasibility findings, with particular reference to: demand analysis, technical specifications feasibility, SWOT analysis, environment implications, financial analysis and economic analysis. The process of formulation of needs, collection of information, critical examination of concepts and re-examination of needs, may have to be repeated several times over before a project inception finally takes shape (Ibid).

Finally, the feasibility studies and its appraisal leads to definition of the following aspects relating to the project: broad scope of work involved, project objectives, outline execution methodology, preliminary time plan, resource forecasts, cash flow patterns and sources of funding, outline organization and potential risks and problem areas (Chitkara, 2009).A go/no-go decision is made at the end of this phase (PMI, 1996).

2.2.2 Planning or Mobilization or Preparation

According to Chitkara (2009), the mobilization stage aims at processing the project preliminaries so as to enable commencement of the construction stage. This is achieved by the following:

a) Compiling detailed designs and drawings, specifications and bills of quantities, so as to complete all the documents necessary for contracting works.
b) Planning project execution. This includes the work programme, manpower plan, materials plan, plant and machinery utilization plan, work organization and mobilization plan and project budget or cost plan. This process also continues during the construction stage.
c) Tendering and appointing contracts, especially those needed for commencement of the work.

The composition of the team to prepare for commencement of the project depends upon many factors such as size and nature of the project, project characteristics and the time and cost objectives. The team is led by the project manager. The other participants of the team include the following: architects and design engineers, construction engineers from HVAC, civil, mechanical or electrical branches, tendering staff like the contracts manager and quantity surveyors and specialist consultants such as town planners, geologists and environmentalists (Chitkara, 2009).Major contracts are let at the end of this phase (PMI,1996)

2.2.3 Execution or Production

Most of the construction projects are executed through the contract system. The contract documents define the contracted scope of the work of each contractor. They also provide the contractual relationship between the construction manager of the contractors and the project manager. The contract agreement is based on mutual trust between the contracting parties both of whom have their share of responsibilities and obligations. Construction at the site of the contracted projects is supervised and carried out by two separate agencies. These are the client team led by the project manager and the contractor workforce managed by his construction manager (Chitkara, 2009). Both teams have the common goal of completing the project in time within specified costs and quality specifications. The facility is substantially complete at the end of this phase (PMI, 1996).

2.2.4 Turnover and Start up

According to Chitkara (2009), the completion of the construction phase of the project includes certain follow-up actions necessary to ensure that the facility constructed functions satisfactorily. These are as follows:

a) The post-completion maintenance is usually entrusted to an agency familiar with the construction. In most cases, the contractor responsible for construction is given this responsibility one year after completion and this aspect is included in the scope of work of the contractor.
b) A proper record of operating instructions and as-built drawings is maintained.
c) The staff and workers necessary for operating and maintaining the facility are trained prior to its taking over.
d) The site is cleared of the left-outs of the construction and unwanted materials
e) The client fully safeguards his interests prior to rendering the completion certificate to the contractor and also before making the final payments.

After completion by the contractor, it is the project team of the client that hands over the project to him. The team also prepares a project completion report which includes the scope and schedule of work, the important events, the contract executed, the addresses of the suppliers of materials and equipment, the equipment maintenance manual, the as-built drawings, the cost involved, the problems encountered during execution, the lessons learned and the minor defects noticed at the time of handing over (Chitkara, 2009).The facility is in full operation at the end of this phase (PMI, 1996).

This study focused on the planning phase as discussed in 2.2.2 above and entailed examining the design and the project budget in order to establish whether road safety was considered during the planning phase. It was also necessary to consider the execution phase as discussed in 2.2.3 above in order to interrogate plan implementation and any challenges thereof. The next section will look specifically at the implementation of the road work zone.

2.3 Implementation of a Road Work Zone

2.3.1 Road Work Zone Phases

The implementation of a road work zone consists of the following five phases:

Phase 1 - Planning

According to National Technical University of Athens (1998), during the planning phase fundamental decisions about the road work zone are made, taking into account the wider context of managing the maintenance and/or construction of the affected road. When determining the timing, form and type of road works, a balance should be achieved between the following:

a) Safety of road users and workers
b) Traffic flow and road user inconvenience
c) Efficient work zone scheduling and economical traffic operation
d) Environmental impact and other quality requirements

The impact of the road works as regards space, time and cost should be minimized as far as possible; at the same time, safety, environmental and other quality standards must be met (Ibid).

Phase 2 - Design

The design phase is subdivided into the following actions:

a) Data collection

Information is collected on the characteristics of the road segment directly affected and the adjacent road network, including: alignment; traffic volumes, patterns and composition; accident data; current (permanent) traffic control devices and other equipment; and alternative traffic routes. If available, national data bases could also be consulted. In addition, information should be collected on the type and methods of work to be carried out - as well as on road works on alternative routes and other adjacent sections. Finally, requirements on environmental protection should be known (NTUA, 1998).

b) Road work zone design

The design involves the following steps:

1. selection of the appropriate road work zone type - where possible, on the basis of typical layouts
2. preparation of a traffic control plan, specifying the type and location of safety measures;
3. consideration of relevant aspects of work site operation and organization (e.g. entry/exit points, truck frequency);
4. formulation of an emergency plan, specifying actions to be taken in case of incidents or accidents;
5. specification of processes for monitoring the operation and safety performance of the work zone (Ibid).

c) Check and approval

The design should be checked and, if necessary, revised prior to its approval (Ibid).

Phase 3 – Installation

The installation phase is subdivided into the following actions:

a) Instructions to workers. The workers should be informed about the organization and operation of the site, including all safety aspects, as well as about the emergency plan. Instructions should also cover the placement and removal of safety measures. Members of the site personnel should be assigned responsibilities and/or duties concerning safety.

b) Placement of safety measures. The safety measures should be installed according to the approved traffic control plan and positioned in the direction of traffic flow.

c) Pre-opening check. It is desirable to conduct both an internal check (by the site personnel) and, afterwards, an external one (NTUA, 1998).

Phase 4 - Operation

The operation phase is subdivided into the following actions:

a) **Observance of safety provisions.** It should be ensured and checked that work zones operate according to the specified plans and procedures. However, it should be possible to alter the traffic control plan (or other safety provisions) at short notice, to enable whatever changes are made necessary for safety reasons, e.g. due to an unexpected emergency.

b) **Check/audit.** Road work zones should be checked closely and frequently (e.g. periodically). The frequency of such checks should be determined by the importance of the road - for motorways, internal checks every 24 hours are recommended. Unannounced external audits should also be performed. Checking and auditing reinforces the importance of safety measures and identifies areas for improvement.

c) **Evaluation.** Aspects of the operation and safety performance of road work zones should be monitored and registered, according to the processes specified in the design phase. The feedback from evaluation can contribute to the improvement of road work zone safety practices as well as to the better training of road workers. It is desirable to collect such information using a standard format, so that it can be evaluated afterwards. Interim evaluation may also be feasible at longer-term work zones, leading - if necessary - to alterations of the traffic control plan (NTUA, 1998).

Phase 5 - Removal

The removal phase is subdivided into the following actions:

a) **Withdrawal of temporary safety measures.** This should be accompanied by provision of the correct permanent setting of traffic control and other safety devices. The safety measures should be removed against the direction of traffic flow.

b) **Final check.** This is a necessary last step. In countries where the road safety audit process is applied, the final check at work zones involving road construction/upgrading may be part of the so-called "pre-opening audit" - i.e. an examination of road safety aspects before the road is (re-) opened to traffic (NTUA,1998).

2.3.2 Road Work Zone Actors

These are the actors (individuals, teams or bodies) who are directly involved in the implementation of a road work zone. Road work zone safety depends to a large extent on the contribution of all actors and on the existence and application of proper procedures (NTUA, 1998). The actors involved in the implementation of a road work zone include:

a) The **client (CL)** - that is, the ordering body for the road work zone. The highway authority /administration is the client in many common types of road works (e.g. construction, maintenance). However, for certain types of work the client is a separate body (e.g. a utility company), which must cooperate with the authority managing the road. The client may be represented by a project manager.

b) The **designer (D)** The design of the road work zone may be commissioned independently of the construction (in which case the designer reports directly to the client) or included in the construction contract (whereby the designer reports to the contractor, e.g. in design-and-build contracts).

c) The **contractor (CR)** - that is, the company responsible for installing, operating and removing the road work zone. It is possible for the installation and removal of a road work zone to be undertaken by a special contractor (i.e. other than the contractor that has undertaken the road works).

d) The **site personnel (SP)** - that is, the workers employed by the contractor for carrying out the road works. They are headed by the site manager (SM). Safety issues are managed by the safety responsible (SR), who reports to the SM.

e) The **traffic police and/or other bodies (P/OB)** having responsibility for road safety. Depending on national or local circumstances, other bodies may include the traffic safety division of the highway authority and/or an independent (third-party) administration or agency. These bodies may be represented by auditors/checkers (NTUA, 1998).

The responsibilities of the actors involved in the different phases of the implementation procedure. In general:

a) the **client** has the responsibilities of planning, supervising and approving
b) the **designer** has the responsibilities of collecting data and carrying out the design of the work zone;
c) the **contractor** has the responsibilities of supervising the site manager and checking the installation and operation
d) the **site personnel** carry out the actual field work of installation, operation and removal; they are supervised and instructed by the **safety responsible**, who reports to the **site manager**
e) the **police and/or other bodies** are responsible for the checking, auditing, and evaluation (NTUA,1998).

2.4 Megaprojects

According to Nothmann Research (2015), the following are the most common characteristics of Megaprojects and the problems typically associated with them.

a) Communication – as these projects often involve hundreds of people, communication is very difficult. In addition, there are often many layers of subcontractors, making fluent communication very difficult.

b) Stakeholders – there are usually many stakeholders (interested parties) and interest can be diametrically opposed. There are also political interests if the project is a public or involving the State.

c) Management – it is typically more complex, having many stakeholders and staff to manage. The management hierarchy is not always followed properly.

d) Technology challenges – most of the Megaprojects are technologically very advanced, and seek to design and build very complex systems ever created. This creates a high risk component that is often difficult to manage.

e) **Costs** – in the Megaprojects Paradox overspending can be at least 50% to 150% of baseline. Much more than if the project had been fragmented and carried out in separate stages .

f) **Quality** – because many times the project is critical for life, quality takes the bulk of the budget to ensure that there are no problems.

g) **Subcontracting** – there are usually many and poorly managed.

h) **Time/schedule** – although it is decided to keep a tight schedule, Megaprojects usually extend in time. That makes the stakeholders' flow to change throughout the project life and that the initial interest in it diminishes over time. In the absence of good planning and/or communication, delays are common (Nothmann Research, 2015)

Nothmann Research (2015) further argues that Megaprojects tend naturally to fail. Special care as well as a reliable and feasible project plan are essential to the success of these projects and project managers must pay special attention to risks and stakeholders. Megaprojects can take various forms such railways, airports, roads etc. but for the purpose of this study road safety with specific emphasis on the planning phase was considered.

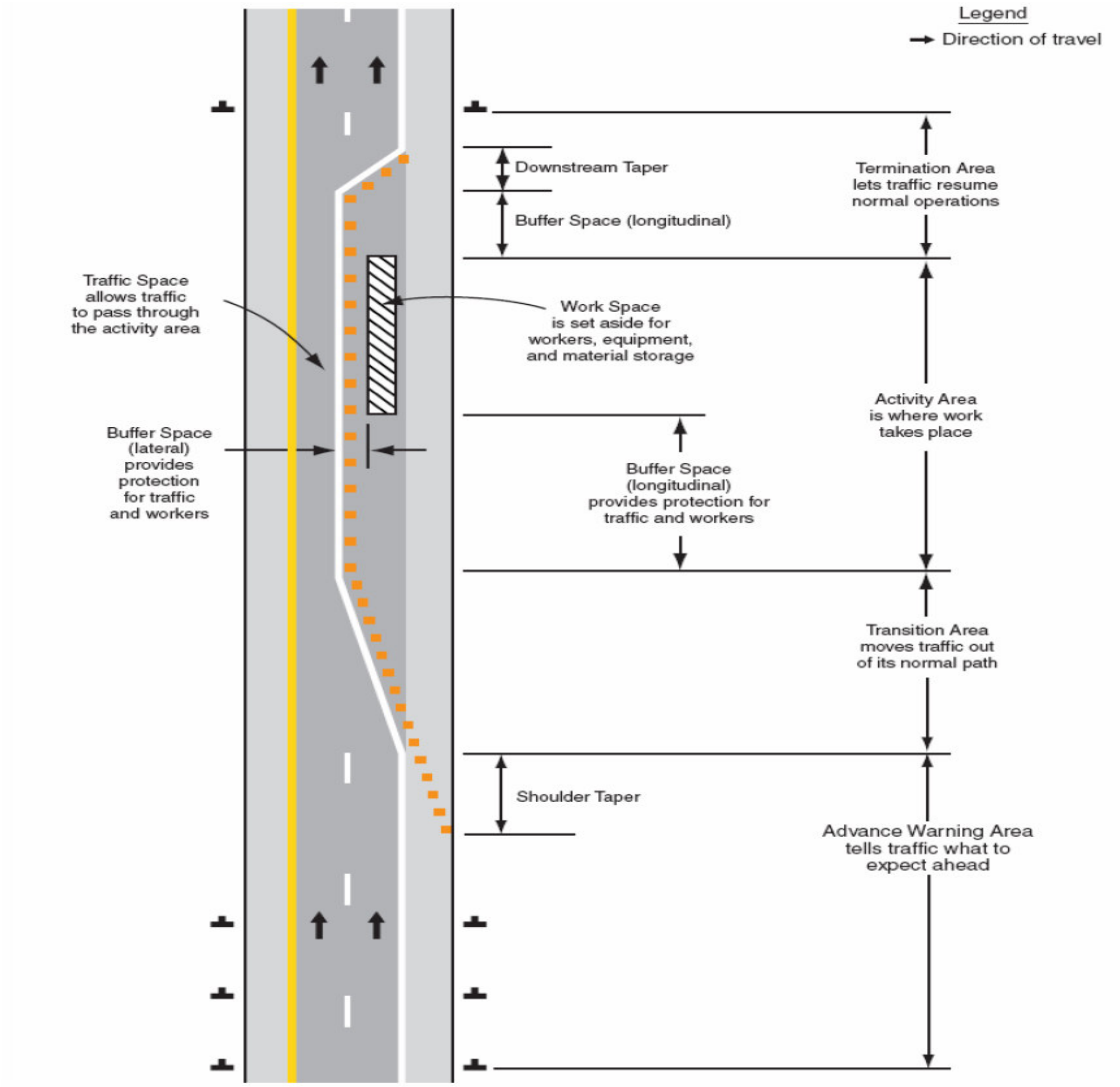
2.4.1 Highway Work Zone

A highway work zone refers to a road section where a construction or maintenance project is carried out. Manual on Uniform Traffic Control Devices (MUTCD) divides a work zone into four areas, as shown in Figure 2.2: the advance warning area, the transition area, the activity area, and the termination area (FHWA, 2003). Road users traveling through a work zone are warned of the upcoming hazardous area in the advanced warning section and then are directed out of their normal path in the transition area. The transition area frequently forms a bottleneck which could dramatically reduce the traffic throughput. The termination area is the section following activity area where road users return to their normal path (Bai & Li, 2006)

In the advance warning section, road users are informed about the upcoming work zone or incident area. The motorists are advised they are approaching a work zone by warning signs, rumble strips, and radar transmitters. If an alternate detour route is available so motorists can choose to avoid the work zone entirely, advisory and directional instruction signs should be placed prior to its exit. Signage is designed and must be placed to give drivers clear information and instruction about what they must do to safely pass through the rest of the zone. Sign messages must be clear, short, and spaced correctly so that the needed information is understood in time for the driver to safely perform the necessary maneuvers. Spacing will be based on the speed limit where drivers first encounter the signs. If warning lighting is in use, make sure that the light levels are adjusted in a timely manner. Bright daytime lighting can dazzle drivers during hours of darkness. Dimmer night light levels will not be readily visible in daylight hours. It has been found that the most effective warning device is an occupied, marked police vehicle with its warning lights flashing. These should be used whenever possible for zones on highways with high speed limits where the traffic control zones allow relatively high speeds. They should also be employed in urban areas where there will be extra heavy traffic and where work areas have to be very close to the traffic control lanes (Texas Department of Insurance).

Next, traffic enters the transition section where road users are redirected out of their normal path. Channeling devices such as cones and barricades will direct it into the safe lanes. The transition zone must be laid out so that motorists don’t have to make abrupt changes of speed or direction. The third area is the activity section, where the work activity takes place. It is comprised of the work space, the traffic space, and the buffer space. The work space is that portion of the highway closed to road users and set aside for workers, equipment, and material. Work spaces are usually delineated for road users by channelizing devices or, to exclude vehicles and pedestrians, by temporary barriers. The traffic space is reserved for the motorists. Buffer spaces may be positioned either longitudinally or laterally with respect to the direction of road user flow. An adequate buffer zone between the traffic control zone and the work zone has to be constructed as part of the plan. A buffer zone needs to be of sufficient depth, with strong barriers placed between traffic and workers. Deflecting barriers should be placed where traffic will be running closely parallel to the work zone. The final section of the traffic control zone is the termination area where channeling devices and signage return traffic to normal speed and lane configuration. shall be used to return road users to their normal path. The termination area shall extend from the downstream end of the work area to the last temporary traffic control device such as END OF ROAD WORK signs, if posted (Ibid).

Figure 2.2 Component Areas of a Highway Work Zone



Source: FHWA, 2003

2.4.2 Ghana's George Walker Bush Highway

The safety issues during road/highway construction are not unique to the Thika Superhighway and Kenya alone but it has been observed to be a serious problem in other countries in the world. A case in point is the George Walker Bush Highway in Ghana.

In 2006, Ghana secured $547 from the US Millennium Challenge Account (MCA) to undertake a number of development projects, including the construction of the motorway extension from the

Tetteh Quarshie Interchange to the Mallam Junction. The prime objective of constructing the highway was to ease the chronic traffic situation on the Tetteh Quarshie-Mallam Junction and the Kaneshie-Mallam routes by about 80 per cent, according to the project consultants. That objective may have been achieved but at a very huge cost to human life, considering the rampant accidents on the highway and the number of people killed as a result. Vehicular crashes and knockdown of motor riders and pedestrians crossing the highway in horrific circumstances had become regular occurrences on the 14.1-kilometre three-lane, high-speed dual carriageway (Daily Graphic 12th February, 2013).

Some of the cause of the deaths had been attributed to inadequate provisions for pedestrian walkways from one side of the road to the other. The footbridges were too far apart and there were no footbridges at densely populated locations where they were needed most. Many pedestrians, after alighting from commercial vehicles, found it burdensome to access the footbridges. They just walked or ran across the highway. Drivers were also speeding through the densely populated areas, simply because it was now a highway. The service lanes on both sides were also not marked and it was obvious some motorists were not aware that the service lanes were two-way lanes, for which reason they drove recklessly, thus endangering safety. There was also poor lighting in the night at some sections of the road. A few of the streetlight poles had even been knocked down following vehicular crashes but nobody was attending to them (Ibid).

The Ghana Highway Authority (GHA), in collaboration with some road safety institutions, had undertaken a safety audit during the designing stage of the highway to find out whether the project satisfied all the requisite principles of safety. Some key recommendations were made after the safety audit but information gathered indicated that not all of them were implemented. According to sources, some of the recommended safety measures were sacrificed for cost and time, as the contractors raced to beat the January 31, 2012 deadline of Ghana's Millennium Challenge Accounts (MCA) compact. After that deadline, Ghana was required to return any money that had not been used under its MCA compact. One of the safety audit recommendations was to construct more than six footbridges on the 14.1-kilometre highway, especially at densely populated locations (Ibid).

After the inauguration of the highway, the National Road Safety Commission (NRSC), in collaboration with some road safety institutions, undertook a safety audit on the highway and made some pertinent recommendations to enhance safety and minimize the spate of accidents and deaths. But it appears the nation had to grapple with more spillage of blood on the George Walker Bush Highway for some time to come. That was because the Ghana Highway Authority (GHA) was still searching for funds to provide recommended safety facilities on the highway to help minimize the spate of knockdowns of pedestrians. While the GHA was making frantic efforts to secure funds for the construction of the additional four footbridges and safety accessories, road safety managers were intensifying public education to help minimize the spate of accidents and deaths on the N1 Highway. The Director of Communications at the NRSC, Kwame Kodua Atuahene, said the commission was continuing road user sensitization in communities along the highway. He said the NRSC had also requested for constant police presence on the highway in order to enhance safety. But the police were not at post 24/7, especially during the night, and anytime the traffic lights go off at night, danger loomed as pedestrians made frantic effort to cross the three-lane, high-speed motorway (Daily Graphic 12th February, 2013).

2.5 Road Work Zone Safety Objectives

According to NTUA (1998), in order to avoid or mitigate road work zone safety problems, the following main safety objectives can be defined:

a) Assist road users by relevant, reliable, correctly-timed and updated information, warning and guidance, to ensure proper adaptation of their behaviour:

1. **Inform** them about traffic disruptions, restrictions and alternative routes.
2. **Warn** them about the work zone and unusual conditions or hazards.
3. **Guide** them to the path that must be followed.

b) Apply traffic **regulations** at the work zone to achieve appropriate driver behaviour - and ensure the **enforcement** of regulations.

c) Provide adequate **protection** for road workers (safe working environment) - as well as for road users, especially the more vulnerable ones (avoidance of hazardous elements and conditions) (Ibid).

2.5.1 Information, warning and guidance of road users

In general, the basic safety principles governing the design of permanent roads should also govern the design of the road work zone areas. Transitions to sections where lower speeds are necessary should be smooth and adequately signed. Moreover, available sight distances should correspond to the expected operating speeds of traffic; if this cannot be achieved - for example, if the work zone is situated near or on a bend - approaching drivers should be adequately warned well in advance. To be effective in achieving the desired behaviour of road users, measures used to promote safety at road work zones should be: accurate, properly-spaced and properly-timed, perceptible and "readable", comprehensible, ensure alertness and reasonable (NTUA, 1998).

2.5.1.1 Specific requirements for traffic control

The following requirements are important for road work zone traffic control:

a) Compatibility/standardization: The general design of different types of road signs, such as warning, regulatory and information signs (Vienna Convention) should be followed at road works. Yellow is specified in the guidelines of several European countries as a colour differentiating work zone from permanent signing and markings.

b) Physical properties and condition: Higher-quality materials should be used for traffic signs and markings in road work zones than in normal signing, especially in difficult traffic situations, such as unfavourable weather characteristics, pedestrian crossings, school area, and night driving. Examples of such materials are fluorescent retro-reflective signs and self-adhesive retro-reflective tapes. Maintaining the good quality (e.g. cleanness) of road work signs, markings and devices is important and should be secured by procedures and protocols for maintenance/operation.

c) Minimum signing: The traffic signs that should be used as a minimum in work zones are: (a) those that warn on the existence of the work zone (workman with shovel); (b) those indicating the reduced speed limits; and (c) those showing the type of deviation (to the right, to the left, contraflow, lane closure, etc.) caused to the normal traffic flow by the work zone (Ibid).

d) Consistency with travel paths and adaptation to local situation: Signing, markings and other safety devices used should be consistent with intended travel paths; generally, they should be adapted to the local situation/conditions. The inconsistent signs, markings and devices should be replaced, covered or altered to suit the circumstances - ensuring that at all times the signing represents the prevailing conditions accurately (NTUA, 1998).

e) Consideration of traffic flow requirements: For the safety of road workers, it is important to provide adequate space in the work and buffer areas. For this purpose, it may be necessary to reduce the number of lanes. However, if it is possible to keep the original number of lanes, in one or both streams - without compromising on the safety requirements for workers - then it is preferable to avoid lane closure. In that case, the lanes could be narrowed, without going below a specified minimum width. Lane reduction could result not only in congestion and queuing problems (especially on higher-volume roads) but also in increased probability of accidents, since the merging of traffic streams constitutes a potential traffic conflict point. Even if the utmost care has been taken in selecting and applying proper measures for the warning, information and guidance of road users in work zones, it will be necessary to support these measures with traffic regulations. In many cases, the need for regulations is self-evident, such as - for example - in the case of alternate one-way traffic, where the remaining carriageway width is simply too narrow for two-way flow. However, in almost all work zone cases, certain changes in driver behaviour are necessitated for safety reasons; since drivers may not automatically make these changes, corresponding restrictive regulations are necessary. Typically, these regulations concern speed limits and prohibition of overtaking (Ibid).

2.5.2 Regulation and enforcement

2.5.2.1 Speed Limits

According to NTUA (1998), there are several reasons why speed limits at work zones should be lower than at non-work sections. Important factors in determining appropriate speed limits are:

a) Adjustment to reduced roadway standards: Narrowed lanes, deviations (e.g. to/from the contraflow) or reduced shoulders are common changes in highway geometry at road work zones, necessitating lower speeds in order to avoid running off the roadway (and colliding with fixed objects) .

b) Protection of road workers: Even if there is no effect on the geometric standards of the roadway (i.e. no narrowing or deviation), the presence of workers calls for a reduction in traffic speeds, for reducing the probability or severity of vehicle-worker collisions.

c) Queuing: On motorways and other higher-volume roads, lane closures may result in queuing, which could increase the probability of rear-end crashes due to vehicles unexpectedly approaching a queue - unless speeds are reduced well in advance (NTUA,1998).

Speed limits should be realistic, reasonable and justifiable. Commonly, nation-specific maximum speed limits for work zones are defined. These can be adjusted downwards if necessary for safety reasons. However, low speed limits should not be prolonged through extremely long stretches. Moreover, to achieve smooth traffic flow, road work zone speed limit values should not be extremely low (Ibid).

It is possible to use signs that inform drivers of the upcoming speed limit reduction; these are positioned in advance of the work zone and repeated as necessary, permitting traffic to reduce speed comfortably to the desired level. If information signs are placed too far in advance and not reinforced, there is a risk that they will be judged as premature by the drivers - and thus ignored at the critical point. A recommended technique is to use successive, gradually-reduced speed limits, in properly-spaced steps of no more than 20 km/h (Ibid).

According to NTUA (1998), the layout of road works and the feedback given when passing should contribute to low speed levels. Motorists' acceptance of (and compliance to) speed limits may be enhanced through:

a) compatible dimensioning (reduction) of lane width;
b) dynamic speed limits adaptable to the situation (e.g. through variable-message signs);
c) wall-like portable systems at the edges of the reduced-width carriageways or lanes;
d) techniques such as "convoy-working" or "pace cars", giving drivers no choice other than to travel at the required speed .

Enforcement is an important accompanying measure for supporting speed limit regulation (NTUA, 1998).

2.5.2.2 Overtaking Prohibitions

Overtaking prohibitions are necessary in cases where it is important that vehicles should stay in their lane. Examples of such cases include:

a) Narrowing and/or transition areas of multi-lane roads, such as motorways - to avoid side-swipe accidents.
b) Contraflow areas without physical separation of the opposing traffic streams - to avoid head-on collisions.
c) Overtaking prohibitions are applied by using the no-overtaking sign and/or continuous road markings (NTUA, 1998).

2.5.2.3 Enforcement

Enforcement at a road work zone may concern various aspects of driver behaviour but is primarily focused on traffic speed. Even if work zone speed limits are appropriately chosen, there is still the danger that a significant proportion of drivers will ignore them, or that other important traffic rule, such as overtaking prohibitions, will be disregarded (NTUA,1998).

Police enforcement can be performed in different ways. Direct detection and punishment of violations is one possibility. However, enforcement via speed camera - where legally applicable - has the advantage of making more efficient use of police resources. This is especially the case when "real" and "dummy" camera units are used together. Cameras may be manned or unmanned; the latter have the disadvantage of being vulnerable to vandalism (Ibid).

Warning the drivers of the existence of speed cameras can function as a deterrent against speeding or other inappropriate behaviour. A similar effect can be achieved through the presence of police cars at a location where they are clearly visible. The selection of the appropriate method, with emphasis either on full visibility or on hidden enforcement, depends on the strategy of the police force responsible for the road concerned (Ibid).

2.5.3 Protection

According to NTUA (1998), at road work zones, protection is necessary against a number of risks and hazards, including:

a) Different types of collisions, involving traffic participants, road workers and/or works vehicles.
b) Obstacles within the work area, such as trucks, materials and construction machines
c) Other hazards within the work area, such as removed surface or holes for the renewal of cables
d) Emergency situations, disabled vehicles or dealing with run-off-road incidents

Protection is applied by means of the following types of measures:

a) Protective road equipment
b) Provision and maintenance of roadside recovery areas / buffers
c) Proper design of entering/exiting areas - where possible, using dedicated slip roads and parking spaces
d) Provision of adequate space for pedestrian movement
e) Appropriate storage of works vehicles, material, debris etc.
f) Preventing obstruction of sight lines
g) Warning clothing for road workers
h) Safe design of works vehicles (e.g. equipping them with rear-view cameras or audio warning devices)
i) Safe operation of works vehicles (Ibid)

Protection of road workers is of special importance. The road as a working place should be ranked equal with other working places. The following principles are important regarding the safety of road workers:

1. Avoid exposure of workers to traffic. The risks for collisions with through traffic are large when work is done outside the work area. When it is necessary to proceed outside the work area, one should always carefully estimate the traffic amount and wait for a quiet moment. While working it is important to face the through traffic as much as

possible; this applies especially when setting up or dismantling a work zone. In addition, flagging or hand-signalling practices should be avoided.

2. Make workers visible to road users, both by ensuring adequate visibility for drivers and by providing suitable clothing (e.g. retro-reflective fluorescent jackets) for road workers.

3. Provide physical protection of workers from traffic. Even in short-term road work zones, buffer zones should be foreseen as a minimum. Work should not begin before all the foreseen safety measures have been installed.

4. Protect workers from accidents involving works vehicles. The movements of works vehicles - either within the work area or while entering / exiting the work area - should be adequately perceived by workers. An especially critical manoeuvre of works vehicles is reversing - this should be carried out only when all-round visibility is assured. Exposure of workers to works vehicles should be avoided.

5. Avoid excessive work hours. European and national legal requirements regarding work hours (and working conditions in general) must be observed. Fatigue can contribute to increased risk for road workers. (NTUA, 1998)

2.6 Safety Measures

Safety Measures include a wide variety of devices and techniques used for reducing the probability and/or severity of traffic accidents at road work zones (NTUA, 1998).The ultimate goal is to develop certain improvement measures to mitigate the circumstances leading to the accidents. The measures to decrease the accident rates are generally divided into three groups engineering, enforcement and education (Mathew, 2014). The safety measures are described below:

2.6.1 Safety measures related to engineering

The various measures of engineering that may be useful to prevent accidents are enumerated below:

2.6.1.1 Weaving, Merging and Diverging

The following section related to weaving, merging, and diverging has been reproduced from the American Association of State Highway and Transportation Officials (AASHTO),A Policy on Geometric Design of Highways and Street, 6th Edition, 2011, the Ministry of Transportation, Quebec (MTQ), Tome I – Ouvrages routiers, 2010 and the Transportation Association of Canada (TAC),Geometric Design Guide for Canadian Roads, 1999.

a) Weaving

Weaving sections are highway segments where the pattern of traffic entering and leaving at contiguous points of access results in vehicle paths crossing each other. Where the distance in which crossing is accomplished is relatively short in relation to the volume of weaving traffic, operations within the highway section will be congested and conflicts between vehicles will increase. Some reduction in operating efficiency through weaving sections can be tolerated by highway users if the reduction is minor and the frequency of occurrence is not high. It is generally accepted that a reduction in operating speed of about 10km/h below that for which the highway as a whole operates can be considered acceptable. Operating conditions within weaving sections are affected by both the length and width of the section as well as the volume of traffic in the several movements (Timcon, 2012).

b) Merging and Diverging (Acceleration/Deceleration Lanes)

Drivers leaving a highway at an interchange are required to reduce speed as they exit onto a ramp. Drivers entering a highway from a turning roadway accelerate until the desired highway speed is reached. Because the change in speed is usually substantial, provision should be made for acceleration and deceleration to be accomplished on auxiliary lanes to minimize interference with through traffic and to reduce crash potential. Such an auxiliary lane, including tapered areas, may be referred to as a speed-change lane. The terms “speed-change lane,” “deceleration lane,’’ or “acceleration lane” as used herein apply broadly to the added lane that joins the travelled way of the highway to the turning roadway and do not necessarily imply a definite lane of uniform width (Ibid).

A speed-change lane should have sufficient length to enable a driver to make the appropriate change in speed between the highway and the turning roadway. Moreover, in the case of an acceleration lane, there should additional length to permit adjustments in speeds of both through and entering vehicles so that the entering driver can find a gap in the through-traffic stream and then manoeuvre into the stream before the acceleration lane ends. This latter consideration also influences both the configuration and length of an acceleration lane (Timcon, 2012).

2.6.1.2 Road Safety Devices

a) Clear zones

The following section related to clear zones has been reproduced from the Ministry of Transportation, Ontario (MTO), Roadside Safety Manual, 1993.

Any hazard within the clear zone which cannot be removed or made forgiving must be protected by an approved barrier system or crash cushion. On lower volume roads the clear zone may be reduced to the offsets (Ibid).

b) Roadside Barriers

The following section related to roadside barriers has been reproduced from the American Association of State Highway and Transportation Officials (AASHTO), Roadside Design Guide, 2002.

A roadside barrier is a longitudinal barrier used to shield motorist from natural or manmade obstacles located along either side of a travelled way. It also may be used to protect bystanders, pedestrians, and cyclists from vehicular traffic under special conditions. The primary purpose of all roadside barriers is to prevent a vehicle from leaving the travelled way and striking object or terrain feature that is less forgiving than striking the barrier itself. Containing and redirecting the impacting vehicle using a barrier system accomplishes this (Ibid)

Roadside barriers are usually categorized as flexible, semi-rigid, or rigid, depending on the deflection characteristics on impact. Flexible systems are generally more forgiving than the other categories since much of the impact energy is dissipated by the deflection of the barrier and lower impact forces are imposed upon the vehicle (Ibid).

Plate 2.1 Flexible barrier

Source: Timcon, 2012

Plate 2.2 Semi-rigid barrier

Source: Timcon, 2012

Plate 2.3 Rigid Barrier

Source: Timcon, 2012

2.6.1.3 End Treatments

According to Timcon (2012), the portion of a roadside protection system intended to prevent the barrier from spearing an errant vehicle on impact is called an end treatment. These generally apply to semi-rigid systems. Examples of end treatments are presented below.

Plate 2.4 Extruder

Source: Timcon, 2012

Plate 2.5 Eccentric Loader

Source: Timcon, 2012

Plate 2.6 Inertial barrier modules

Source: Timcon, 2012

Plate 2.7 Quadguard

Source: Timcon, 2012

2.6.1.4 Traffic Calming Measures

The following section related to traffic calming measures has been reproduced from the Transportation Association of Canada (TAC), Canadian Guide to Neighbourhood Traffic Calming, December 1998, and Traffic Calming Speed Humps and Speed Cushions, 2011.

a) Rumble Strips

Rumble strips are raised buttons, bars or grooves closely spaced at regular intervals on the roadway that create noise and vibration in a moving vehicle. The purpose of a rumble strip is to alert motorists to unusual conditions ahead. With rumble strips, motorists are alerted by minor vertical deflection of vehicle wheels and audible warning created as vehicle wheels pass over. Generally the buttons and bars are coloured white to provide visual identification (Timcon, 2012).

They are only used when standard warning or regulatory signing has been shown to be ineffective. Rumble strips are most commonly used on approaches to Stop signs, often in situations where visibility of Stop signs is limited (Ibid).

b) Speed Humps

A speed hump is a raised area of a roadway, which deflects both the wheels and frame of a traversing vehicle. The purpose of a speed hump is to reduce vehicle speeds.
With speed humps:

1. The vertical deflection of vehicle wheels produces an uncomfortable sensation for vehicle occupants travelling at speeds higher than the design speed
2. The design speed is determined by the dimensions of the speed hump, and the spacing between speed humps
3. The speed humps extends across the roadway with gaps for drainage at the curbs
4. Bicycles do not require special provisions and
5. Installation of a speed hump sign and an advance warning sign are considered mandatory (Timcon, 2012).

c) Pavement Marking and Delineation

The following section related to pavement markings and delineation has been reproduced from the Ontario Traffic Manual, Book 11, Pavement, Hazard and Delineation Markings, March 2000.

Pavement markings provide guidance and information to road users without diverting their attention from the road. Markings may be used as the sole source of guidance or control for road users, or to supplement other traffic control devices such as signs, signals and other marking. Road delineation may include devices with audible and tactile features such as bars, profiled surfaces, and roadway pavement markers. By generating noise and vibration when they are traversed by motor vehicle tires, these types of markings alert the motorist to changes or warn of unsafe deviations from the normal travel lane (Ibid).

Pavement markings have limitations related to their visibility, durability and applicability:

a) Pavement markings are not necessarily clearly visible on wet pavement, and can be obscured by accumulations of debris, dust, or dirt, particularly adjacent to a median, curb or unpaved shoulder. The view of pavement markings, particularly transverse markings or mid-lane symbols, can be blocked by traffic
b) Pavement markings have limited durability on surfaces exposed to heavy traffic wear

c) Pavement markings cannot be applied to unsealed roads
d) Certain types of pavement markers affect skid resistance, particularly for motorcycles and bicycles. If motorcycles and bicycles are expected to use the road, pavement marking materials should be carefully chosen and requirements for large marked surfaces should be carefully reviewed (Timcon, 2012).

2.6.1.5 Traffic Signs

The following section related to traffic signs has been reproduced from the Ontario Traffic Manual, Book 1B, Sign Design Principals, 2001.

Road signs are important devices for the control of traffic as well as information aid to the road users. They also assist in guiding and regulating traffic by the information transfer to the drivers about road condition, highway routes, directions etc. Road signs are integral part of safety as they ensure safety of the driver himself (warning signs) and safety of the other vehicles and pedestrians on road (regulatory signs). Driver should be able to read the sign from a distance so that he has enough time to understand and respond. It is essential that they are installed and have correct shape, colour, size and location. It is required to maintain them as well, without maintenance in sound condition just their installment would not be beneficial (Ibid).

a) Mandatory/Regulatory Signs

These are to be provided to inform certain laws and traffic regulation for the safety and free flow of traffic.

b) Cautionary/Warning Signs

These signs are used to warn road user of the existence of certain hazardous conditions either on or adjacent to the roadway, so that motorists are cautious and take the desired action.

c) Informatory Signs

These are informatory in nature and will make the travel easier, safe and pleasant (Ibid).

Traffic Informatory, Warning and Mandatory signs, placed at appropriate locations are provided for guidance, information, warning and control of traffic to the road users. All signs should be of retro-reflective sheeting and high intensity grade and as per Road Design Manual or other international practices (Timcon, 2012).

General

A consistently applied set of sign design principles is necessary to facilitate driver understanding of, and response to, sign messages. For the sign design principles to be effective, they must realistically be based on the visual and mental abilities of road users. High travel speeds and increasingly complex driving environments require that signs be readily detected and understood at a glance. Uniformity and simplicity in design, position and application are crucial for speedy detection and recognition. It is therefore important that sign design principles be consistently applied and that signs installed on highways conform to recognized designs and standards (Ibid).

Uniformity in design includes sign shape, colour, dimensions, symbols, wording, lettering and reflectorization or illumination. Uniformity of application is also an important element of standardization. Similar conditions should be signed in the same manner, regardless of actual location. It is recognized, however, that urban conditions differ from rural conditions with respect to speed, frequency of intersections, traffic congestion, parking and competing lights and displays. Where such differences in the driver environment impact the sign message, sign application must take into account these differences (Ibid).

a) Shape and Colour

Signs that are similar in function are typically designed to be the same shape and to use the same colour combinations for legends, backgrounds and borders. Shape and colour codes serve to organize pieces of information into larger units and establish message redundancy. Drivers can recognize sign shapes and colours well before they can distinguish symbols or read sign text. The shape and colour codes alert the driver to the general function of the sign. They simplify the driving task by enabling the road user to judge in advance the nature of the expected response and to prepare accordingly. For example, drivers can recognize the shape and colour of the STOP sign before they can actually read the sign text. Infact, the STOP sign is one case where the shape and colour convention has made the sign so familiar to drivers that actually reading the text has become unnecessary (Timcon, 2012).

b) Dimension

A number of factors must be considered to ensure signs are legible at an appropriate distance. The following steps should be used to determine the minimum letter height on a text sign or the symbol size on a symbol sign, to accommodate the majority of the driving population.

1. **Reading time**-calculate the time required to read a sign with a given message
2. **Perception-reaction time**-determine the time required to make a decision and initiate a manoeuvre (if one is required)
3. **Manoeuvre time** – determine the time to complete the required manoeuvre before reaching the sign
4. **Required Legibility distance**-determine the distance at which the sign must be legible, based on the travel speed (usually the speed limit) and the sum of the times obtained in Steps 1,2 and 3 above
5. **Minimum letter height**-calculate minimum letter height using set ratios for legibility-distance-to-letter-height, specific to the font type used
6. **Symbol legibility**-calculate symbol size based on legibility distance and the width of the critical detail in the symbol (Ibid).

This process, while based on reasonable driver requirements, tends to be conservative, since it does not fully account for redundant information. For example, the presence of advance guide signs will likely reduce the time required to recognize and read a sign at a freeway exit. In some situations, it may be desirable to increase the sign size over those shown in the available guidelines. Font type, letter size, symbol size and sign layout with appropriate spacing and borders can be used to determine whether increased sign size should be used. The standard sign size can then be adjusted to fit the next larger standard sign blank size available (Ibid).

Some of the situations where larger sign size may be desirable include the following:

1. If there is a known challenged population driver population in a given area, such as in the vicinity of a Senior Citizens' centre, consideration should be given to moving up to the next largest blank size.

2. If there are factors that impact the amount of time a driver can devote to reading the sign, such as a complex and distracting background environment, heavy traffic volumes and a high density of intersections and driveways requiring complex choices, consideration should be given to moving up to the next largest blank size to increase the distance at which the sign is legible

3. If the required sign size is prohibitively large and if attempts to redesign the sign have not succeeded in the short term, consideration should be given to using a higher intensity sheeting to improve night time legibility

4. It may not be economically feasible to install all new signs and to replace all damaged and aged signs with the sizes required to accommodate 85% of the driving population. In this case, priority should be given to signs that are higher on the sign hierarchy (Timcon, 2012).

c) Symbols

Symbols can convey in a single image the same message that may require several words of text. Therefore the symbol size is generally considerably larger than individual letters, making the sign legible at greater distances than the equivalent word message. Due to the significant legibility benefits of symbol signs, their use is encouraged wherever practical. In order to be effective, though, the meaning of the symbol must be understood by a high percentage of the driver population. It is therefore recommended that, when a new symbol is designed, it is tested with representative drivers and not simply shown to other traffic practitioners. Testing, which is followed by any redesign necessary to eliminate driver confusion, should alleviate difficulties in comprehension. Where symbols are understood by fewer than 85% of drivers, educational tabs may be used to assist comprehension. Good initial design will avoid signs which are ineffective and/or which require expensive educational campaigns to inform drivers of their meaning (Ibid).

d) Wording

For purposes of reduced reading time and increased legibility, it is important to minimize the message length, provided that the message does not become ambiguous. A sign with a longer message will have to be legible from further back, and will therefore need to have larger text and a larger overall size, than a sign with a shorter message in the same environment and requiring the same driver response. Message length will determine letter height, and therefore sign size. The method, which considers driver visual capabilities, reading time, perception-reaction time and manoeuvre time, should be used to calculate letter height (Timcon, 2012).

e) Lettering

Many of the signs in available guidance are text-based as it is difficult to convey certain complex messages clearly using symbols. In determining the text to be used on a sign, font type, letter height and the use of upper case versus mixed case letters must be considered. The font type determines not only the appearance of the letters, but the ratio of letter height to letter width, stroke width of the letter relative to letter height, the kerning or space between letters and the spacing between words (Ibid).

In order for a sign to be effective, it must be legible at a distance which allows a driver to read it and carry out any required actions before reaching the sign. When the message is lengthy (e.g. several destination names, or complex construction information) drivers will need more time to read the entire message than for a sign with a single symbol or a word or two. In addition, if the driver must carry out some action, such as a lane change or a stop before reaching the sign, then it must be legible at a distance that allows the driver both to read it and respond before reaching the sign. One of the key factors in ensuring sign legibility at the required distance is the letter height (Ibid).

In terms of legibility, mixed case text is better than upper case text, as long as the maximum height of the lower case letters is the same as the height of the upper case capitals. Words in mixed case are easier to recognize since each word forms a distinctive shape with a unique pattern of ascenders, descenders, dots and other features. Word shape pattern recognition enables the driver to identify a word before it can actually be read. While this is a distinct benefit of mixed case over upper case lettering, it must be traded off against motorist familiarity with signs that have been in upper case for many years. Signs in most of the sign classes have traditionally used upper case letters. For most signs, it is desirable from the standpoint of driver familiarity and uniformity to maintain consistency with existing sign standards. However, in the case of directional guide signs, other information signs and new sign series, mixed case should be used to support improved word recognition. Cardinal directions on information signs (e.g., north, west) may be shown in upper case when used in a mixed case context, to draw attention to the word and to make the word function almost as a symbol (Timcon, 2012).

f) Reflectorization or Illumination

Signs that convey messages of warning, important regulations or essential directional information that are relevant during the hours of darkness need to be legible and conspicuous at night, as well as during the day. Since conspicuity depends to some degree on colour code recognition, the colour of the sign must appear the same by night as by day. The engineering tools used for maintaining a reasonable level of sign legibility and conspicuity at night are reflectorization and illumination (Ibid).

Most signs are assembled by applying thin adhesive sheeting materials in the background and legend colours to a rigid sign blank. Some types of sheeting contain tiny glass beads or prisms that refract the light so most of it is reflected straight back to the source, which is a vehicle with headlights. Therefore, the light from the headlights is very sufficiently used, with a significant amount of it reflected back towards the driver's eyes. Material having this property is known as retro reflective sheeting. As an alternative or supplement to high intensity sheeting, external or internal illumination of the sign may be used. As with retro reflective sheeting all sign illumination must result in sign colours appearing the same by night as by day. Illumination may be by one of the following means:

1. A light behind a translucent sign face, illuminating the legend and/or background
2. An attached or independently mounted light source designed to direct essentially uniform illumination over the entire sign face
3. Luminous tubing shaped to the legend or symbol (Ibid)

Ordinary street or highway lighting does not meet the requirements for sign illumination. However, street lighting can aid visibility. The presence of street lighting should be taken into consideration in selecting the exact placement of signs which are not required to be reflectorized or illuminated (Timcon, 2012).

2.6.1.6 Construction Work Zone Devices

The following section related to construction work zone devices has been reproduced from the Ontario Traffic Manual, Book 7, Temporary Conditions, March 2001.

Risk to both drivers and workers can be reduced by the provision of a predictable, familiar roadway environment, to the extent practicable. The consistent and appropriate application of traffic control devices increases the probability of roadway users exhibiting the desired behaviour and helps ensure the safety of workers. Work zones must be designed with explicit consideration of worker and traffic safety (Timcon, 2012).

Worker and traffic safety must be designed into construction and maintenance projects, rather than applied on a makeshift basis. Positive guidance, and the avoidance of violating driver expectation, should be used. Roadway work zones should be designed around the following basic principles:

a) Worker Safety
b) Motorist Safety
c) Motorist Mobility
d) Advanced Warning (provision of advance notice to motorists that they are approaching a work zone)
e) Work Site Identification (visible identification of the work area by passive and/or active traffic control devices to show road users where work is taking place)
f) Positive Guidance (provision to drivers of the information they need to avoid hazards, when and where they need it, in a form they can best use it) (Ibid).

2.6.1.7 Other methods

According to Mathew (2014), various other methods of traffic accident mitigation are described below:

a) **Street lighting** Street lighting of appropriate standard contributes to safety in urban area during night time due to poor visibility. Installation of good lighting results in 21% reduction in all accidents, 29% reduction in "all casualty" accidents, 21% reduction in "non pedestrian casualty" accidents, and 57% reduction in "pedestrian casualty" accidents.

b) **Improvement in skid resistance** If road is very smooth then skidding of the vehicles may occur or if the pavement is wet then wet weather crashes occur which account about 20-30%. Thus it is important to improve the skid resistance of the road. Various ways of increasing the skid resistance of road are by constructing high-friction overlay or cutting of grooves into the pavement.

c) **Driver reviver stops** Driver reviver stop are generally in use in countries like U.S.A where driver can stop and refresh himself with food, recreation and rest. They play a very important part in traffic safety as they relieve the driver from the mental tension of constant driving. These stops are required to be provided after every 2 hour travel time.

d) **Constructing flyovers and bypass** In areas where local traffic is high bypasses are required to separate through traffic from local traffic to decrease the accident rate. To minimize conflicts at major intersections flyovers are required for better safety and less accident rate.

e) **Regular accident studies** Based on the previous records of accidents the preventive measures are taken and after that the data related to accidents are again collected to check the efficiency of the measures and for future implementation of further preventive measures (Mathew, 2014).

2.6.2 Safety measures related to enforcement

Mathew (2014) further notes that there are various measures of enforcement that may be useful to prevent accidents at spots prone to accidents which are enumerated below. These rules are revised from time to time to make them more comprehensive.

2.6.2.1 Speed control

Checks on spot speed of all vehicles should be done at different locations and timings and legal actions on those who violate the speed limit should be taken.

2.6.2.2 Training and supervision

The transport authorities should be strict while issuing license to drivers of public service vehicles and taxis. Driving license of the driver may be renewed after specified period, only after conducting some tests to check whether the driver is fit.

2.6.2.3 Medical check

The drivers should be tested for vision and reaction time at prescribed intervals of time (Mathew, 2014).

2.6.3 Safety measures related to education

The various measures of education that may be useful to prevent accidents are enumerated below (Mathew, 2014).

2.6.3.1 Education of road users

The passengers and pedestrians should be taught the rules of the road, correct manner of crossing etc. by introducing necessary instruction in the schools for the children and by the help of posters exhibiting the serious results due to carelessness of road users.

2.6.3.2 Safety drive

Imposing traffic safety week when the road users are properly directed by the help of traffic police as a means of training the public. Training courses and workshops should be organized for drivers in different parts of the country.

2.7 Safety Measures at Road Work Zones

The term "safety measures" includes a wide variety of devices and techniques used for reducing the probability and/or severity of traffic accidents at road work zones (NTUA, 1998). Four main categories of safety measures can be defined:

2.7.1 Physical design

Physical design of road work zones aims at the provision of smooth transitions between the normal roadway and the work area, as well as at provision of adequate space (buffer area) for separating the travelled way from the road works. Elements of physical design include:

a) lead-in taper and exit taper, providing a smooth change in the lane width
b) longitudinal and lateral buffer width (NTUA,1998).

2.7.2 Traffic control

Traffic control aims at providing information, warning and/or regulations for road users, in order to help them make sound decisions regarding their speed, lane choice and other parameters of their behaviour. Traffic control is applied through traffic signs, traffic lights (signals) and traffic markings. At road work zones, it is common to emphasize traffic control alterations, for example by using special types of signs (e.g. routing panels, variable-message signs, or retro-reflective signs) or by supplementing markings with road reflectors (Ibid).

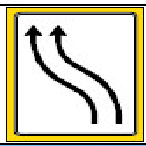
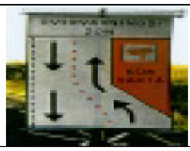
2.7.3 Road equipment can be distinguished into three main sub-categories, depending on the function of the measures:

a) warning / information
b) closure / guidance
c) protection

The first two sub-categories are, essentially, a complement to physical design and traffic control. It is possible that some devices may serve multiple functions; for example, a mobile trailer is used for purposes of both warning and closure (Ibid).

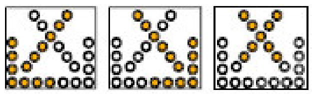
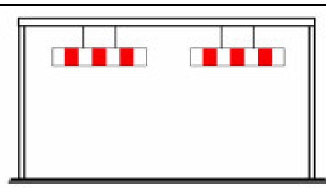
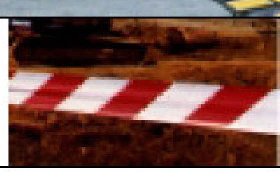
2.7.4 Miscellaneous. This category includes devices and techniques that do not fall into one of the previous categories. Examples of such measures include protective clothing for road workers and traffic information on the radio (Ibid).

Figure 2.3 Traffic Control Devices

Traffic control devices	A road work zone usually requires drivers of vehicles to temporarily change their behaviour (e.g. their speed or path). Traffic control devices, such as signs, markings and traffic lights, can help to inform drivers about the presence of work zones, the current traffic regulations, and the recommended paths to be followed.	
Portable traffic lights		Traffic lights can be used to control the traffic passing through roadworks in alternate directions (case "e": alternate 1-way). The portable version illustrated here can be used for relatively short periods of time, anywhere. The "stop" (red) and "go" (green) phases are controlled to cause as little disturbances as possible to the bi-directional traffic flows.
Road reflectors		A metallic or plastic road marking projecting slightly above the road surface or the hard shoulder, designed to be safely run over by a vehicle travelling at any speed.
Routing panels		Oblong rectangular signs indicating, by means of appropriate combinations of arrows, the change in the number and/or direction of traffic lanes necessitated by the road work zone.
Traffic markings		At long-term work zones, when roadworks necessitate the use of vehicle paths other than the lanes normally used, two types of markings may be used: painted markings or self-adhesive tape. It is recommended to use yellow traffic markings at road work zones.
Traffic signs		Traffic signs at road work zones may include both conventional signs (as used on non-works sections) and high-intensity (retro-reflective) signs. Traffic signs could be used jointly with (steady) lights. It is recommended to use traffic signs with a yellow background (internal or external) at road work zones.
Two signs in one		Two ordinary signs are mounted behind each other and are combined in one set.
Variable message sign (VMS)		VMS gives the drivers, in real time, accurate messages generated from a central unit using an on-line connection. The current information (e.g. closed lanes, routing or speed advice) can be displayed on the frontal part as a steady, flashing or scrolling message (using a disk, rotating drum matrix, bulb or LEDs).

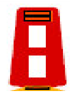
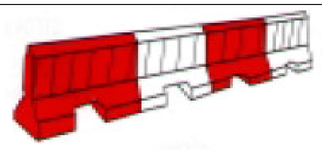
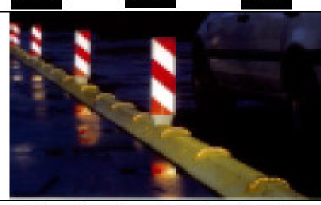
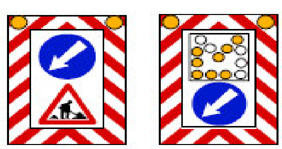
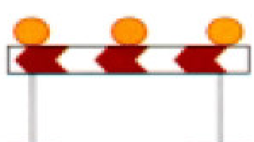
Source: NTUA, 1998

Figure 2.4 Information and Warning Equipment

Information and warning equipment	This sub-category includes devices used to warn and inform the drivers about the presence of a work zone as well as about its effects on their route choice, lane choice, speed and other parameters of their behaviour.	
Flashing arrow		Warning equipment consisting of a set of lights creating a signal picture in the shape of an arrow or cross (X). It is used as a preliminary-warning equipment or as a supplement of transverse closures and mobile trailers.
Light		Individual electrically-operated device emitting a light of a single colour. The light could be used alone as a danger lamp, in combination with different traffic equipment (or traffic signs) as warning light, or as a set of three to ten functionally-fixed warning lights as "running lights". It is recommended to use steady lights, rather than flashing lights, to avoid confusion to drivers.
Portable mould bridge		Used as a "pre-signal" to indicate the maximum height of vehicles on each lane. The device can also create a "gate effect" and help reduce traffic speeds. The bridge could be repeated several times and/or linked to an automatic detection system or to warning lights.
Speed reducer in rubber - Bumps		Bumps are mounted across the road near the entrance of a road work zone, to reduce the speed of passing vehicles, especially in urban areas.
Warning tape		Used for visual guidance and for emphasizing work areas outside the carriageway.

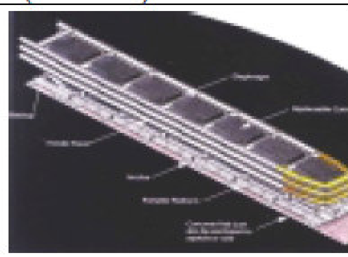
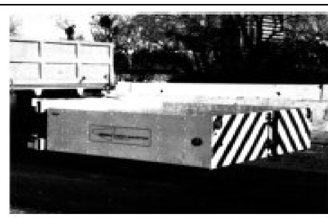
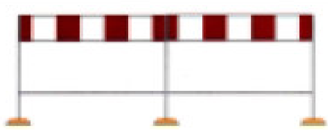
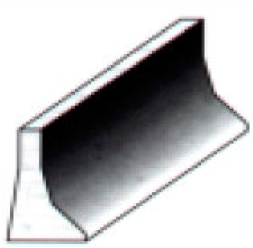
Source: NTUA, 1998

Figure 2.5 Closure and Guiding Equipment

Closure and guiding equipment	This type of road work zone traffic equipment serves to establish transverse and longitudinal closures, to guide and funnel / channelize the traffic, and/or to create a visual and physical separation of opposite-way lanes.	
Emphasizing beacon		Applied in work zones especially for purposes of visual guidance and, partly, for the physical separation of opposite-way lanes.
Guiding barrier		Typically a plastic wall (with several possible lengths, widths or heights) filled with water, sand or other material, each part coloured uniformly (e.g. red or white), used to separate opposite-way lanes on motorways or other high-volume roads.
Guiding beacon (Bake)		A rectangular sign with sloping stripes, mounted directly on a support. It is used for funnelling the traffic in the direction of the slant of the stripes - and, at the same time, creating transverse and longitudinal closures.
Guiding hump		Guiding humps and protective dams are used in work zones primarily to separate the opposite-way lanes on motorways, in combination with guiding beacons.
Guiding traffic closure		Device used when a change of direction occurs as a result of a road closure, e.g. by transferring the traffic to a by-pass (detour). See also *traffic closure*.
Mobile trailer		Vehicle equipped with signs and danger lamps at the rear. It is used for creating transverse lane closures, for channelizing traffic in the direction indicated by a traffic sign and/or a flashing arrow - and for warning the traffic.
Traffic closure		A barrier comprising a rigid horizontal rail, which carries a vertical sign, as well as means for supporting the rail and sign at the approximate eye level of a car driver. It is used to control traffic by closing, restricting or delineating all or a portion of the carriageway. Not recommended on motorways. See also *guiding traffic closure*.
Traffic cone		A three-dimensional device of conical shape comprising one or more parts including a base plate, cone body, and retroreflective surface or surfaces. Placed in single file, cones have the same sense as a longitudinal line. Recommended for use especially on short-term work zones.

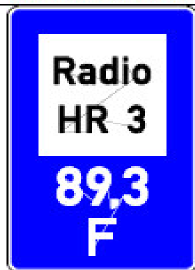
Source: NTUA, 1998

Figure 2.6 Protective Equipment

Protective equipment	This type of traffic equipment serves primarily to prevent the entrance of vehicles or pedestrians inside the work area and to reduce the consequences of accidents involving vehicles running off the roadway. At the same time, it also fulfils the function of defining and physically separating the work area (closure).	
Crash barrier		Protective device of a height between 120 and 250 mm and a width between 250 and 350 mm, continuously laid on the road surface, without anchoring. It is used as a closure device at the entrance of the work area, or as protection to fixed obstacles on motorways and other dual-carriageway roads. This energy-absorbing device slows a vehicle which hit an obstacle head-on or impacted it from the side; in case of lateral impact, it redirects the vehicle to the original path.
Crash cushion - Truck-mounted attenuator (TMA)		A protective device which is mounted on the rear, e.g., of a truck (used as working, warning or protecting vehicle) and which absorbs the energy of a possible impact. The system consists on a resilient nose, a modular cartridge and an energy-absorbing structure.
Fence		A barrier comprising: (a) a rigid horizontal rail carrying a vertical sign, at such a height so that it can serve as a handrail for pedestrians; (b) at least one further rigid horizontal rail set at such a height as to facilitate detection by a blind person's stick; and (c) means for supporting these rails at the required height.
Safety barrier		Safety barrier of steel or concrete for usage in work zones. It is not fixed on the road and must be tested by crash test in regard to EN 1317-2. This protective equipment prevents vehicles from entering the work area.

Source: NTUA, 1998

Figure 2.7 Miscellaneous

Miscellaneous	These measures do not belong to one of the categories detailed previously, but are nevertheless important for road work zone safety.	
Traffic Information on Radio		The existence of a work zone (and in particular, its location, its duration, and the type of inconvenience for drivers) may be announced on the radio, to inform drivers and permit them to make any necessary decisions (e.g. route change) in advance.
Protective clothing for workers		The commonest relevant item is retroreflective fluorescent jackets, following EN 471 standard.

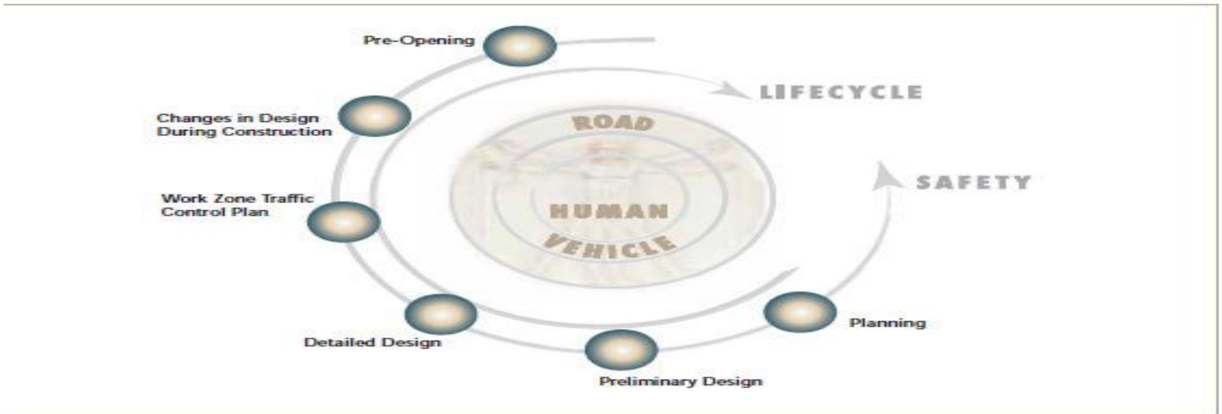
Source: NTUA, 1998

2.8 Road Safety Audit

Road safety audit (RSA) is an excellent tool for identifying opportunities to improve safety at all stages of a roadway's life-cycle as illustrated in Figure 2.8. It involves the establishment of an independent audit team which focuses exclusively on safety, conducts a formal review, and provides specific, safety related recommendations for consideration by the design team. RSAs build on other road safety improvement strategies and techniques already in place and do not replace them. RSAs enhance other road safety strategies (FHWA, 2006).

The essential elements of an RSA include a formal examination, team review, an independent RSA team, a qualified team, focus on road safety issues, include all road users, proactive nature, qualitative nature and field reviews (Ibid).

Figure 2.8 Road Project's Lifecycle



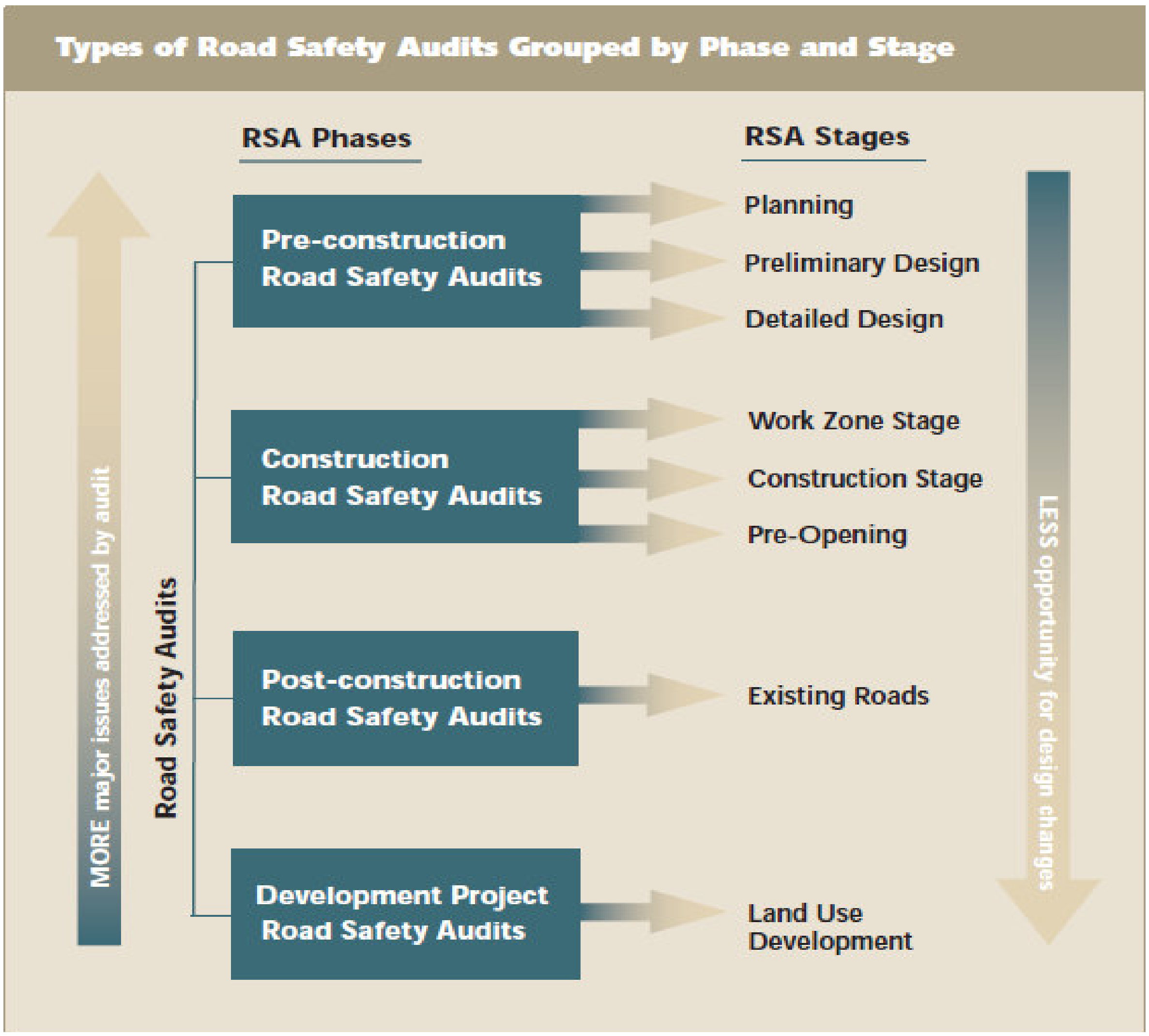
Source: FHWA, 2006

Figure 2.9 The typical eight-step RSA procedure

Source: FHWA, 2006

RSAs may be conducted practically at every stage in the lifecycle of a transportation facility. RSAs applied early in the planning and preliminary (functional) design of roads offer the greatest opportunity for beneficial influence. As a design progresses into detailed design and construction, changes that may improve safety performance typically become more difficult, costly, and time-consuming to implement (FHWA, 2006).

Figure 2.10 Types of Road Safety Audits Grouped by Phase and Stage



Source: FHWA, 2006

Figure 2.10 illustrates a method of grouping RSAs by phase (pre-construction, construction,and post-construction) and by stage (planning, preliminary design, etc. An overview of each RSA phase and stage follows.

2.8.1 Pre-construction Phase Road Safety Audits

Pre-construction RSAs are performed at those points in the project lifecycle before the construction of the facility begins. In this phase, changes may still be made with limited delay to the project and with less expense. There are three RSAs that may be conducted during this phase. These include:

a) Planning (feasibility) RSAs.
b) Preliminary design RSAs (functional design RSAs).
c) Detailed design RSAs (final design RSAs) (FHWA, 2006).

a) Planning Stage

Planning projects, by their nature, have little information about the details of the design.
A preliminary layout or route may be available along with information about the basic design issues (e.g. functional classification, general intersection configuration).Despite limited information, at this stage there may be significant opportunity to incorporate safety enhancements into the design at the lowest cost. The audit team may give special consideration to issues such as the accommodation of all user groups, design consistency, and operational features. The RSA suggestions at this stage may include major changes such as different route options, cross-section options, changes to spacing of intersections/interchanges, construction stages, pedestrian/bicycle routing and facility options (Ibid).

b) Preliminary Design Stage RSA (plans 30-40% complete)

At this stage plans are 30-40% complete, and projects should have sufficient information about the details of the design, such as alignment and grade or lane and shoulder widths, so that the auditors may begin to identify critical design details and make suggestions regarding safety. While fundamental decisions concerning route choices are already made at this stage, substantive safety improvements may still be made without significant costs or delays. The RSA suggestions may include: changes to access points, horizontal and/or vertical alignments, provision of a median, lane and shoulder width, provision of bicycle lanes and sidewalks, channelization, landscaping, lighting, etc (Ibid).

c) Detailed Design Stage RSA (plans 60-80% complete)

At this stage, plans are 60-80% complete. This is a critical stage as this is the audit team's last opportunity to review the design before it is finalized and construction begins. Right of-way acquisition has likely commenced, so it is vital that the RSA is thorough. Efforts to undertake major physical changes in the design at this stage may be both time-consuming and expensive, and may delay project tendering. The RSA suggestions may include changes to signs, delineation and road marking, traffic signal placement/operation, roadside safety hardware (types and placement), raised channelization, landscaping, lighting etc (FHWA,2006)

2.8.2 Construction Phase Road Safety Audits

Construction RSAs are generally performed during preparations for construction, during actual construction, and during the pre-opening period. In this phase, the audit team may actually view the project as-built, along with the final detailed plans, so that their review may be more comprehensive. There are three RSAs that may be conducted during this phase, as follows:

a) Work Zone Traffic Control Plan RSAs.
b) Changes in Design during Construction RSAs.
c) Pre-opening RSAs (Ibid).

a) RSA of Work Zone Traffic Control Plan

RSAs may be conducted to ensure that safety is adequately considered in the Maintenance of Traffic Plan and the Work Zone Traffic Control Plan. This RSA could be accomplished before the project is tendered to construction, before the work zone is open to traffic, and/or after it is open. When performing this type of RSA, the team needs to be mindful of several issues. They must evaluate the safety of all temporary roadways and transition areas. They should consider the appropriateness of all traffic control devices and be cognizant of any conflicting information given to the road users by the permanent and/or the temporary traffic controls. Further, they need to think about the other road users besides passenger automobile operators (e.g., pedestrians, including the disabled; bicyclists; large trucks; school buses; etc.) because work areas often fail to properly accommodate users from these other groups (Ibid).

b) RSA of Changes in Design During Construction Stage

RSAs conducted at this stage relate to situations where a construction process leads to identification of unforeseen construction problems or cost saving design alternatives that may not have been obvious during the design process. Some of the changes may have a bearing on safety and may need to undergo an RSA (FHWA, 2006).

c) Pre-Opening Stage RSA

These RSAs are similar in nature to detailed design RSAs in that they offer another opportunity for the team to consider the safety aspects of the design before the facility is opened to the public. It should be noted that this is the first time the reviewers will be able to actually see and drive (walk, bicycle) the facility in its finished state instead of relying on the design plans. This field review must be comprehensive and thorough. The RSA suggestions will likely focus on changes to illumination, signs, delineation, pavement markings, roadside barriers, removal of fixed object hazards or minor structural changes (e.g., addition of a wheelchair ramp). Yet even minor changes to the road facility may significantly reduce safety risk at a minimal cost (Ibid).

2.8.3 Post-construction Phase Road Safety Audits

RSAs of existing roads are conducted on a previously opened roadway or intersection. This type of RSA is somewhat different from those conducted during the pre-construction or construction phases. The procedure used for conducting an RSA of an existing road uses different project data; specifically, if plans are reviewed, they should be "as built" plans. By performing a day and night review the audit team will be able to observe how road users are interacting with the road facility. Near the conclusion of the field review portion of a post-construction phase RSA, or even as a part of reviewing project information, some public agencies encourage the review of existing crash data. However, an RSA of existing roads is intended to be different than a traditional analysis of a high crash location (Ibid).

The real objective for this type of RSA is to identify road safety issues for different road users that might result in a crash given the operational characteristics of the road in question. For this reason, RSAs of existing roads are proactive. Available crash data are used to validate RSA results and make sure that existing safety problems are not overlooked. RSAs of existing roads may be conducted even if crash data are unavailable (FHWA, 2006).

2.8.4 Development Project Phase Road Safety Audits

Development project RSAs may be conducted on industrial, commercial, or residential land use development projects that may have an impact on the characteristics of the existing adjacent roads. Since development projects have a great potential to change the traffic volumes, traffic patterns, vehicle mix, road environment, or user perception of the road, a development RSA would consider the internal layout of the new development as well as impacts to the existing road network (Ibid).This study will focus on the pre-construction and construction road safety audit.

2.9 Institutional and Legal framework on road safety

Currently, several institutions exist that deal with matters touching on road safety. These institutions include the Traffic Police, the Ministry of Transport and Infrastructure, the Transport Licensing Board, the Ministry of Devolution and Planning, the Registrar of Motor Vehicles (RMV), the Insurance industry, the Kenya Roads Board, the Motor Vehicle Inspection Unit (MVIU) and the recently reconstituted National Transport and Safety Authority among others. Most of the institutions do not have road safety as their core business and therefore have not been able to deal with road safety challenges effectively (Ngeso, 2012).

Currently, road design, construction and maintenance in Kenya are shared among various institutions. These includes the three Authorities formed under the Ministry of Transport and Infrastructure; Kenya National Highway Authority (KeNHA), Kenya Rural Roads Authority (KeRRA) and Kenya Urban Roads Authority (KURA), Kenya Roads Board (KRB), County Governments, Kenya Wildlife Services, Kenya Forest Services, National Youth Services, Members of Parliament through Constituency Development Funds (CDF) and the private sector (Ibid).

For the purpose of this study, the key institutions that currently deal with road safety matters during the planning and construction of a superhighway are the Ministry of Transport and Infrastructure through the Kenya National Highway Authority (KeNHA) and the Traffic police.

Table 2.1 Shows Institutional Arrangement for Road Safety in Kenya

Institution	Functions
Kenya police	Traffic law enforcement, prosecution, emergency services , public education, driver training and testing, national crash data systems
Ministry of Finance	Policy approval, policy formulation and funding
Attorney General	Policy formulation, prosecution
Ministry of Transport	Policy formulation , policy approval
Transport Licensing Board	Transport licensing and regulation
National Road Safety Council	Road safety education, road safety audit, road safety research and road safety data
Motor Vehicle inspection Unit	Road worthiness inspection, national crash data systems and traffic law enforcement
Ministry of Roads and Public Works	Policy formulation, policy approval, road construction, road maintenance and road safety research
The Insurance Industry	Issuing of Insurance cover
Kenya Roads Board	Road construction and maintenance funding
Kenya National Highway Authority	Road construction and maintenance
Kenya Rural Roads Authority	Road construction and maintenance
Kenya Urban Roads Authority	Road construction and maintenance
Registrar of Motor Vehicles	Vehicle licensing and registration
Ministry of Local Government	Policy formulation, policy approval, road construction and maintenance and management of traffic within the local authorities.

Source: Ministry of Transport cited in Ngeso (2012)

The government policy on road transport is to provide efficient and reliable road network to spur social, economic and security improvement. The following legislation guide road construction in Kenya.

2.9.1 Way Leaves Act (Cap.292)

Section 3 of the Act states that the Government may carry out any works through, over or under any land whatsoever provided it shall not interfere with any existing building or structures of an on-going activity. Notice, however, will be given one month before carrying out any such works (section 4) with full description of the intended works and targeted place for inspection. Any damages caused by the works would then be compensated to the owner as per section. Finally section 8 states that any person without consent causes any building to be newly erected on a way leave shall be guilty of an offence and any alterations will be done at his/her costs.

2.9.2 Land Acquisition Act (Cap.295)

This Act provides for compulsory or otherwise acquisition of land from private ownership for the benefit of the general public. Section 3 states that when the Minister is satisfied on the need for acquisition, notice will be issued through the Kenya Gazette and copies delivered to all the persons affected. Full compensation for any damage resulting from the entry onto land to things such as survey upon necessary authorization will be undertaken in accordance with section 5 of the Act. Likewise where land is acquired compulsorily, full compensation shall be paid promptly to all persons.

Part II of the Act allows for the temporary acquisition of land for utilization in promotion of the public good for periods exceeding 5 years. At the expiry of the period, the Commissioner of Land shall vacate the land and undertake to restore the land to the conditions it was before. Any damages or reduction of value shall be compensated to the land owners.

2.9.3 Public Roads and Roads of Access Act (Cap.399)

Section 8 and 9 of the Act provides for the dedication, conversion or alignment of public travel lines including construction of access roads adjacent lands from the nearest part of a public road. Section 10 and 11 allows for notices to be served on the adjacent land owners seeking permission to construct the respective roads.

2.9.4 The Limitations of Actions Act (Cap. 22)

There is currently no law in Kenya that provides for recognition and protection of the rights or for compensation for loss of these rights for squatters. Squatters do not have legally recognized rights to public land which they occupy. The above provisions relate to compensation for those who have a legal right to land and whose land has been compulsory acquired for public purposes. However, if squatters have been in occupation of private land for over twelve (12) years, then they would have acquired rights as adverse possessors of that land provided under the Limitation of Actions Act, section 7.They would however need to seek a declaration from the High Court and prove that their entry into the land was open, without consent of land owner and was uninterrupted for 12 years if the land is Government land (as is the case for this project).Then they have no rights to it, as the doctrine adverse possession cannot be invoked against the government.

2.9.5 The Land Planning Act (Cap.303)

Section 9 of the subsidiary legislation (The development and use of land regulations 1961) under this Act, requires that before the local authorities submit any plans to the Minister for approval, steps should be taken as may be necessary to acquaint the owners of any land affected by such plans. Particulars of comments and objections made by the landowners should also be submitted. This is intended to reduce conflict with other interests such as settlement and other social and economic activities.

2.9.6 The Occupational Safety and Health Act, 2007

In Kenya, the health, safety and welfare of workers was regulated by the Factories Act Cap 514.However, this Act was repealed in 2007 to the Occupational Health and Safety Act (OSHA) in 2007 which is currently in force. This Act was enacted to provide for the safety, health and welfare of workers and all persons lawfully present at workplaces, and also to provide for the establishment of the National Council for Occupational Safety and Health and for connected purposes. The purpose of this Act is to secure the safety, health and welfare of persons at work; and to protect persons other than persons at work against risks to safety and health arising out of, or in connection with, the activities of persons at work.

This Act applies to all workplaces where any person is at work, whether temporarily or permanently. Therefore the Act and its provisions apply to the construction industry since the construction site is regarded as a factory. The Act provides for duties of both employer/occupier and the employees in ensuring the safety, health and welfare at work.

2.9.7 The National Transport and Safety Authority Bill, 2012

This Act was passed into law by President Mwai Kibaki in October 2012.It is an Act of Parliament to provide for the establishment of the National Transport Safety Authority (NTSA), its powers and functions and for connected purposes.

The National Transport and Safety Authority Bill, 2012 is a welcome move in Kenya. It is hoped that it may put in place strategies that may contribute to a reduction in the dramatic rise in road traffic crashes and deaths which are being experienced in Kenya today. Road traffic crashes exert huge burden to the Kenyan economy. There has been a dramatic increase in traffic deaths in Kenya from 548 in 1963 to 3,158 in 2008, a 476% increase over a period of 45 years. All efforts should be employed to ensure that strategies that are tested and proven to be protective to transport users and existing good practice in transport safety planning to prevent the rising trend in traffic deaths and injuries are systematically applied. We learn from the experience of several countries like Sweden and United States that effective strategies for improving safety have a greater chance of success if there is a distinct government agency with the power and resources to plan and implement its activities. And that is why the idea of the NTSA is a welcome move (Ogendi, 2012).

2.9.8 The Kenya Vision 2030 and the Flagships for Infrastructure Development

The publication is a summary of Kenya's long-term national planning strategy, officially known as Kenya Vision 2030.The strategy for the Kenya Vision 2030 is to identify the best options for fulfilling Kenya's enormous potential. The vision therefore singles out three pillars on which to realize the goal.

The first pillar is to ensure that we achieve and sustain an average economic growth of over 10 per cent per annum over the next twenty five years. The second pillar seeks to build a just and cohesive society, with equitable social development, clean and secure environment. The third pillar aims at producing a democratic system that nurtures issue-based politics, the rule of law, and protects all the rights and freedoms of every individual and society.

It also provides a run-down of major (or flagship) projects to be embarked upon during the first five years of the vision i.e.2007-2012.The Government believes good infrastructure development is an important factor in enhancing productivity and the overall performance of the economy. While the impact on the economy will not be immediate, there is no doubt investment in infrastructure is an important ingredient to the realization of poverty reduction objective.

Similarly, there exist several legal instruments that deal with road safety matters. These include the Traffic Act Cap 403, the Transport Licensing Act Cap 404, the Kenya Road Board Act Cap 408 and the Local Government Act Cap 265 among others. There also exists a myriad of legal notices introduced to address the challenges of road accidents. The New Constitution provides in the preamble a commitment to nurturing and protecting wellbeing of individuals, their family, communities and nations. Article 85 of the Constitution (Bill of Rights) recognizes the right to life as one of the rights that Kenyans are entitled to. It is also worth noting that there exist several international and regional instruments dealing with road safety matters, some of which Kenya is a signatory to. These include the Vienna Convention on Road Traffic, the 1968 Convention on Traffic Road Signs and Signal, the Accra Declaration, the Moscow Declaration, the African Road Safety Action Plan. The United Nations has also declared the years 2011 to 2020 a Decade of Action for Road Safety (Ngeso, 2012).

Under the Global Plan for the Decade of Action for Road Safety 2011-2020, it was recommended that in order to ensure that funding is sufficient for activities to be implemented to help in realizing the goals of the Decade of Action, 10% of infrastructure investment funds is to be used in road safety activities (Ibid).

Table 2.2 Key Challenges Associated with road safety

Author(s) and Year	Summary of Research	Key Constraints to effective road safety
Ngeso (2012)	The study explored ways of addressing road safety challenges in Kenya	The study brought out several issues relating to road safety challenges in Kenya: 1. Legal and institutional framework 2. Road Infrastructure 3. Human Behaviour 4. Traffic Enforcement 5. Lack of accurate data on road safety matters

		6. Attitude of commuters ,drivers and other road users 7. Lack of funding 8. Road maintenance
Rizavi (2009)	The study examined road safety challenges in developing countries	The study identified the following as the elements important in the management and implementation of road safety 1. Crash data collection/reporting 2. Traffic/transportation management 3. Policies and strategies 4. Insurance 5. Community initiatives 6. Road safety responsibility and action 7. Enforcement and legislation
Chiduo & Minjo (2011)	The study examined the problems of road safety in Tanzania	The study identified the following as the problems related to road safety: 1. Organization of road safety work 2. Driver training 3. The pedestrian 4. Road user education 5. Speed limits 6. Vehicle inspection 7. Road Engineering

		a) Road signs and markings b) Traffic signals 8. Penalties for traffic offences Medical and rescue services 9. Accident data
Sikdar (2005)	The study explored the major issues in managing road safety	The study found out the following as the major issues in managing safety: 1. Planning for safety 2. Road Traffic Aspects a) Control Devices b) Encroachment and Parking c) Road User Behaviour and Skills 3. Traffic Legislation and Enforcement 4. Institutional framework 5. Designing for safety 6. Traffic Management 7. Road Safety Education and Publicity
Odero,Khayesi & Heda (2003)	The study analyzed the magnitude, causes and status of intervention of Road Traffic Injuries in Kenya	The study identifies impediments to road traffic injury prevention to include; 1. Ineffective coordination 2. Inadequate resources and personnel

		3. Limited capacity to implement and monitor interventions
Asingo & Mitula (2007)	The study analyzed the implementation of road transport measures in Kenya Policy issues and challenges	This study evaluates and analyzes the implementation of road safety measures in Kenya: 1. Accident data collection 2. Policy, legal and institutional framework for road safety is weak 3. Behavioural and attitudinal problems of road users 4. Road infrastructure design 5. Inadequate road markings and road signs, poor street lighting and inadequate parking space 6. Bus stops are inconveniently located and improperly designed 7. Lack of compliance with legal requirements 8. The existing training programme for the police are inadequate

Source: Author, 2015

2.10 Summary and Conceptual Framework

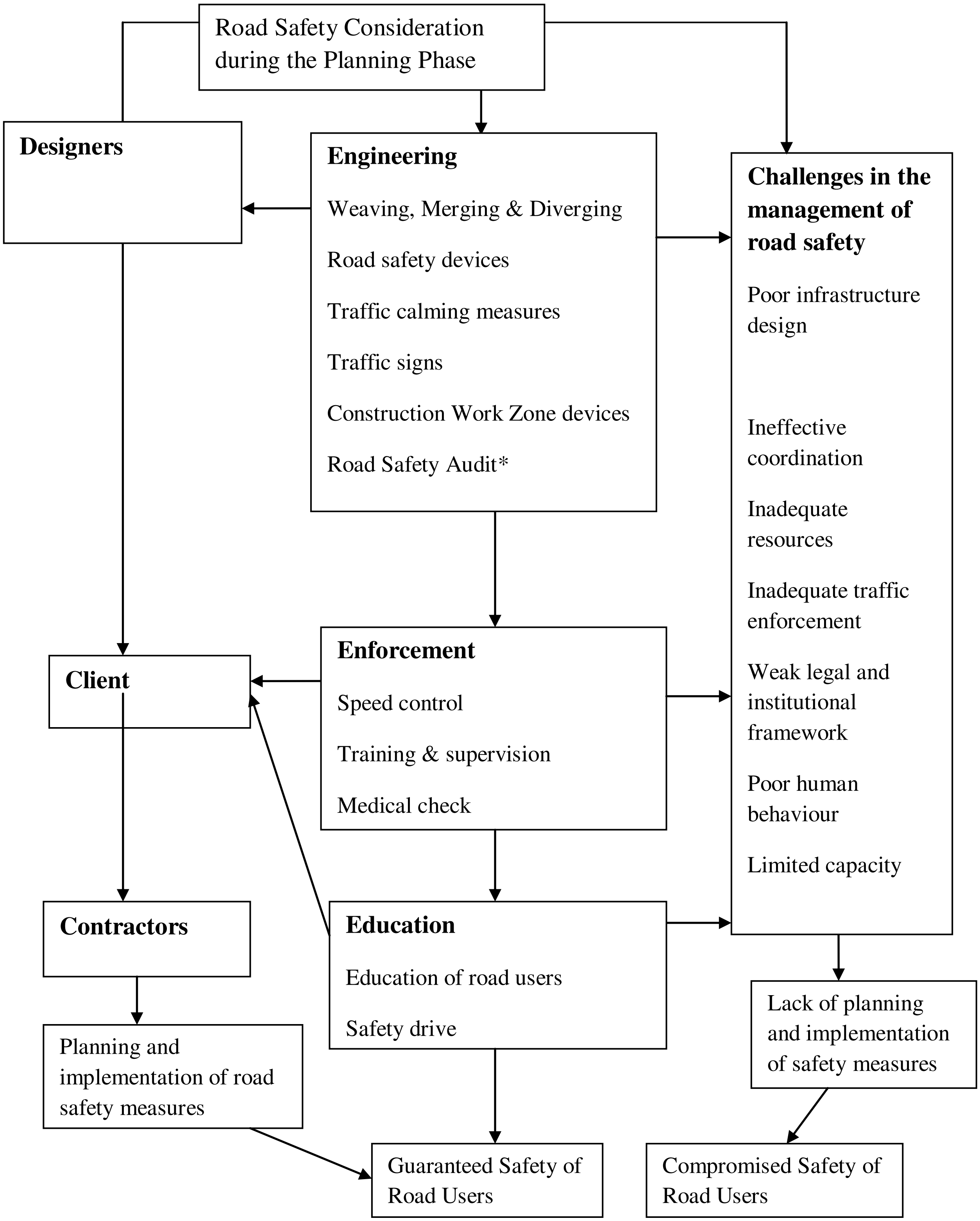
Safety measures have been identified in order to decrease the accident rates and are generally divided into three groups; engineering, enforcement and education. The safety measures related to engineering include weaving, merging and diverging, road safety devices, traffic calming measures and traffic signs. There are also specific safety measures for road work zones (construction work zone devices) and these include the physical design, traffic control, road equipment and miscellaneous (traffic information on radio). The safety measures related to enforcement include speed control, training and supervision and medical check. The safety measures related to education include education of road users and safety drive. Road safety audit has also been identified as an excellent tool for identifying opportunities to improve safety at all stages of a road's lifecycle. All these categories of road safety measures work hand in hand to ensure safety of the road users and should therefore be considered during the planning phase of the project.

The construction project lifecycle is comprised of various phases such as feasibility, planning and design, production, turnover and start up. The planning phase entails compiling detailed designs and drawings, planning project execution and tendering and appointing contracts. It is therefore at the planning phase that critical decisions are made which will determine the success or failure of a construction project.

The challenges identified in the management of road safety include weak policy, legal and institutional framework, inadequate resources, poor human behaviour, lack of adequate traffic enforcement, poor infrastructure design, ineffective coordination and limited capacity to implement and monitor interventions.

The literature reviewed formed the theoretical framework for this study and further informed the methodology used in accomplishing the objectives the study.

Figure 2.11 Conceptual Framework



Source: Author, 2015

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

Research methodology refers to a specific plan for studying the research problem and constitutes the blue print for the proposed data collection and analysis (Bryman, 2001).Mugenda and Mugenda (2003) assert that research methodology provides details regarding the procedures used in conducting a study. This chapter describes the research methodology and details of methods used in data collection, data measurement and data analysis needed to accomplish the research objectives. It also contains the research design, population and the sampling frame required in generating reliable data for this study as well as essential ethical considerations.

3.2 Research Design

Zikmund (2003) defines research design as a master plan specifying the methods and procedures for collecting and analysing data. According to Bryman (2001), after a researcher has identified a research problem and has reviewed the relevant literature, the next step involves developing a research design for conducting the research. The choice of a research design is largely determined by the purpose of the research, the method of analysis and the type of research being undertaken (Dattalo, 2008).

Yin (2003) notes that the design comprises descriptive research, case study, survey, exploratory, historical research, causal comparative/experimental research, correlation and observational research. Mugenda and Mugenda (2003) explain that a case study is an in-depth investigation of an individual, group, institution or phenomenon. The primary purpose of the case study is to determine factors and relationship among the factors that have resulted in the behaviour under study. The investigation therefore makes a detailed examination of a single subject, group or phenomenon. This is why most case studies are based on the premise that a case can be located that is typical of many other cases. Kumar (2009) further describes a case study as an approach to studying a social phenomenon through analysis of individual cases. It gives an opportunity for intensive analysis so that generalization may be made that is applicable to other cases of the same type. Another essence of a case study as a research strategy is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented and with what results. A case study approach of design was therefore adopted in this study because Thika Superhighway being the first superhighway to be built in Kenya, its findings would inform such future projects.

3.3 Study Area

According to CES & APEC (2008), the project road is part of International Trunk corridor (A2) which connects Kenya with Ethiopia and located in the central part of Kenya. The road lies within Nairobi and Kiambu counties. The project road starts from Globe Cinema Roundabout inside the Nairobi City and ends in Thika near the bridge across Thika River after the flyover leading to Thika town.

Starting from Globe Cinema roundabout, the project road transverses towards northeast following the Muranga road up to Muthaiga roundabout passing through Pangani roundabout. The length of this link is about 3.5km.The project road continues in northeast direction towards Thika Town connecting the towns Kasarani, Githurai, Ruiru and Juja enroute and ends at Thika near the Thika bridge across Thika river on A2.The total length of the project road from Globe Cinema to Thika is about 42.0km (Ibid).

The City Arterial Connectors comprises improvement of three Major Arterials connecting Nairobi-Thika road at Pangani roundabout with Uhuru Highway (A104) at different locations along it. Total length of these connectors is 12.4km.The three connectors are:

Connector 1: Forest Road from Museum Roundabout on Uhuru Highway to Pangani Roundabout on Nairobi-Thika Road (3.6 Km)
Connector 2:University Way & Muranga Road via Globe Cinema from University Roundabout on Uhuru Highway to Muthaiga Roundabout via Pangani Roundabout on Nairobi-Thika Road (4.5 Km)
Connector 3: Haile Sellasie Avenue-Race course road & Ring Road Ngara from Uhuru Highway to Pangani roundabout on Nairobi-Thika road (4.3Km) (Ibid).

3.4 Population

Population is the total collection of elements about which the researcher wishes to make some inferences (Cooper & Schindler, 2003). The researcher sought to access information from opinion leaders/key informants who were directly involved in the project and who had in-depth information about the project. The researcher also sought to obtain information from the residents who were directly affected by construction of the project especially with regard to road safety. The population for this study therefore consisted of the following:

Kenya National Highways Authority (KeNHA) which is an authority under the Ministry of Transport and Infrastructure was responsible for the management and supervision of the rehabilitation and upgrading of the Thika Highway project which forms part of the international trunk corridor (A2).A total of 19 personnel were directly involved in the Thika Superhighway project.

APEC Limited. Consulting Engineering Services (India) Pvt Ltd had partnered with a local engineering firm APEC Ltd to offer consulting and supervisory services in the project. CES is a foreign consultancy firm that had been awarded the contract for the consultancy and supervision of the Thika Superhighway project. The contract ended upon completion of the highway therefore they were not available during data collection. APEC Ltd being a local consultancy firm was easily accessible by researcher. A total of 55 personnel from APEC Ltd were directly involved in the Thika Superhighway project.

Traffic Police department is part of the Kenya Police Service and are responsible for enforcing traffic regulations in Kenya. The primary role of the traffic police officers during the planning phase was to provide design engineers with traffic data during design. During construction the traffic police officers were responsible for enforcing the traffic regulations. The police stations under whose jurisdictions the Thika Superhighway fall include the Central, Pangani, Muthaiga, Kasarani and Juja police stations. The Traffic Police Headquarters also lies along the highway. A total of 41 traffic police officers were directly involved in the project.

Kenya Alliance of Residents Association is the apex body representing the voice and pro-active action of resident associations on consumers and taxpayers' rights countrywide.2 officers from KARA were directly involved in the Thika Superhighway project.

Contractors are the personnel who carried out the actual construction of the highway therefore key informants of the study. The contractors were not involved during the planning phase but only came in just before construction began. A total of 93 site supervisors from the three construction companies China Wu Yi, Shengli and Sino Hydro were directly involved in the project. The site supervisors considered in the study were those who had attained a degree in Civil engineering hence had both the technical and managerial expertise to answer the issues being studied.

Residents are those people living or doing business along the superhighway. The residents were further categorized into two groups: motorists and pedestrians. Motorists include public service vehicle drivers (matatus, buses, trucks and lorries), boda boda/tuk tuk operators and private car owners. Pedestrians are those people who walk along or across the road. The residents therefore had first hand information about safety issues along the highway. According to the Population and Economic Census Report (2009), there were 843,526 people living or doing business along the Thika Superhighway. 85,849 people within Lot 1 which is between Uhuru Highway and Muthaiga Roundabout, 406,199 people within Lot 2 which is between Muthaiga roundabout and Kenyatta University (KU) and 351,478 people within Lot 3 which is between KU and Thika.

3.5 Sample Size

Cramer and Hewitt (2004) define a sample size as the actual number of elements, cases or entities in a population that will be studied. Mugenda and Mugenda (2003) assert that the size of a sample is an important element in determining the statistical precision with which population values can be estimated.

Kenya National Highways Authority had a total of 19 personnel who were directly involved in the project however only 11 personnel were involved throughout the project from its inception to completion having worked with the then Ministry of Roads. They therefore had in depth information about the project and being key informants were purposively chosen to represent the sample of the study.

APEC Limited had a total of 55 engineers who were directly involved in the Thika Superhighway Project. However, only 37 personnel were available at the head office during the period of study, the other personnel were on duty in other parts of the country. The researcher further made effort to reach the personnel who were unavailable through numerous phone calls and emails however no response was forthcoming within the entire period of study. Hence, the 37 personnel were easily accessible for data collection and being key informants were purposively chosen to represent the sample of the study.

Traffic police officers who were directly involved in the project were 41.However, due to the nature of their work (time schedules, shifts, transfers) only 21 traffic police officers were available for data collection and they provided the researcher with all the required information. Due to time and financial constraints, it was therefore not necessary to reach the traffic police officers who were inaccessible. The 21 traffic police officers being key informants were purposively chosen to represent the sample of the study.

KARA had a total of 2 officers who were directly involved in the project. One of the officers however dealt with the administrative issues of the project (making calls, writing and receiving letters) while the other was involved technically in the project. The technical personnel being a key informant had the requisite information about the project was therefore purposively chosen to represent the sample of the study.

In social science research, the following formula can be used to determine the sample size (Chava and Nachmias, 1996).

$$n = \frac{Z^2pqN}{e^2 (N-1) + Z^2pq}$$

Where N = Population size

n = Sample size

p = Sample population estimated to have characteristics being measured

q = 1-p

e = acceptable error (e=0.05, since the estimated should be 5% of the true value)

Z = the standard normal deviate at the required confidence level = 1.96

When determining the sample size a confidence level of 95% of the target population was adopted and that the response achieved from the sample was within –ve 5 or +ve 5 of the true state of the population targeted. This was in a bid to enhance precision (Ibid).

Site Supervisors

$$n = \frac{1.96^2 0.95*(1-0.95)*93}{0.05^2 (93-1) + 1.96^2 0.95(1-0.95)}$$

= 41 site supervisors

For ease of data collection the highway was divided into three lots through stratified random sampling. The sample size was equally distributed within the three lots in a bid to achieve the desired representation. However, 16 of the site supervisors were Chinese nationals who could not communicate at all in English. The researcher went further to involve language translators but still it was impossible to obtain any significant information from them. Hence only 25 respondents were chosen to represent the sample of the study.

Residents

Lot 1

$$n = \frac{1.96^2 0.95*(1-0.95)*85849}{0.05^2 (85849-1) + 1.96^2 0.95(1-0.95)}$$

= 73 residents

Lot 2

$$n = \frac{1.96^2 0.95*(1-0.95)*406199}{0.05^2 (406199 -1) + 1.96^2 0.95(1-0.95)}$$

= 73 residents

Lot 3

$$n = \frac{1.96^2 0.95*(1-0.95)*351478}{0.05^2 (351478-1) + 1.96^2 0.95(1-0.95)}$$

= 73 residents

For ease of data collection the researcher organized the sampled residents into homogeneous groups of 12 participants each. The study was organized into three lots. Each of the three lots could therefore have 6 FGDs consisting of 2 FGDs for pedestrians and 2 FGDs for boda boda /tuk tuk operators and 2 FGDs for private car owners. The matatu saccos were based either in Nairobi or Thika town, it was therefore not possible to obtain information from matatu saccos operating within each lot. The researcher therefore had 1 FGD with matatu drivers from the matatu saccos plying the Nairobi-Thika route. The drivers were drawn from the main matatu saccos plying the Nairobi-Thika route such as Kenya Mpya, Manchester Travellers, Chania and Iska Investments.

The researcher contacted local leaders i.e. religious leaders and local administration in order to find members within the community who had the requisite characteristics. The number of years the residents had lived or done business along the highway and whether the residents were pedestrians or motorists were the main criterion for selection. Only those residents who had lived or done business along the highway for five or more years were considered since they had first hand information about the project through their experiences before, during and after construction. The local leaders were asked to provide a list of the members for each of the category of road users within their lots. The specific days and venue for the FGDs were decided upon and the participants were notified of the same.

3.6 Sampling method

Sampling is the process of selecting items, persons and objects from a target population so that it is representative. Mugenda and Mugenda (2003) explain that non-probability sampling is used when a researcher is not interested in selecting a sample that is representative of the population and when the main focus of the study is on in-depth information. According to William (2004), probability sampling is used when each member of a given research population has an equal chance of being selected. It involves, literally, the selection of respondents at random from the sampling frame, having decided on the sample size. This type of sampling is more likely if the theoretical orientation of the research is positivist, and the methodology used is likely to be quantitative. In non-probability sampling, the population does not have an equal chance of being selected; instead, selection happens according to some factor such as: convenience, purpose or quota.

William (2004) explains that in purposive sampling, the researcher samples with a purpose in mind. Purposive sampling can be very useful for situations where the researcher needs to reach a targeted sample quickly and where sampling for proportionality is not the primary concern. According to Mugenda and Mugenda (2003), purposive sampling is a non-probability technique that allows the researcher to use cases that have the required information with respect to the objectives of his or her study. Cases of subjects are therefore handpicked because they are informative or they possess the required characteristics. A researcher who proposes to use purposive sampling must specify the criteria for choosing the particular cases.

For the purpose of this study, purposive sampling was used since the main focus of the study was on in-depth information which would allow the researcher to obtain the required information with respect to the objectives of the study. The study dealt only with officers that worked on the Thika Superhighway (key informants) and this therefore became the criteria for selection.

According to Leedy (1985) and Mugenda and Mugenda (2003), the rule of thumb should be to obtain as big a sample as possible. However, time and resources tend to be the major constraint in deciding on the sample size to use. Leedy (1985) further argues that the researcher should consider three factors in making any decision as to the sample size. The degree of precision required between the sample population and the general population, what the variability of the population is (standard deviation) and what method of sampling should be deployed.

For the purpose of this study, stratified random sampling was also used. The superhighway was divided into three lots and simple random sampling was used within each lot in order to obtain a sample size which is representative of the whole population and so that each resident had an equal chance of being selected.

3.7 Data Collection Methods and Techniques

Data collection is an important aspect of any type of research study. According to Buckley (2007), selecting the appropriate methodology is essential for the effectiveness of any research. Inaccurate data collection can impact the results of a study and ultimately lead to invalid results. According to Voehl et al. (2014), consequences from improperly collected data include inability to answer research questions accurately, inability to repeat and validate the study, distorted findings and also wasted resources. For this reason, the researcher needs to choose wisely the data collection method to be used so as to give valid results.

3.7.1 Data Collection Tools

Zikmund (2003) defines data collection tools as the instruments used to collect information in research or the methods employed to collect research data. The main data collection tools for research purposes include: questionnaires, interviews, observation, conference method, Delphi technique and use of focus group discussions. The choice of the methods to use is influenced by the nature of the problem and by the availability of time and money.

The researcher collected information with the aim of investigating the impact of failure in the planning phase of a mega construction as exemplified by road safety challenges on the Thika Superhighway. The methodological approach for this research consisted of an in-depth qualitative and quantitative data collection. Creswell and Clark (2007) note that mixed methods provide a more comprehensive approach to examining a research problem than either one of quantitative or qualitative methods.

The primary data collection methods included the following:

3.7.1.1 Interviews

Interviews are often used to gather detailed qualitative descriptions of how population operate, perceive themselves or are perceived by others and are done on personal one-to-one basis. To obtain maximum cooperation from the respondents, the researcher must establish friendly relationship (Miller & Salkind, 2002).

Interviews were used as one of the sources of collecting primary data. The interviews were conducted amongst the key informants of the Thika Superhighway project such as KeNHA, APEC Limited and KARA. According to Nkwi et al. (2001), key informants are people believed to be knowledgeable on the topic under investigation. This involved the use of key informant interview guide. The researcher sought to find out the following information from the key informants; what safety measures were planned for during the planning phase, whether the planned safety measures were adequately implemented and the challenges faced in the implementation of the planned safety measures. It was also important to find out whether the various stakeholders were involved during the planning phase of the project.

Interviews entailed:

a) Tape recording

In this method, the interviewer’s questions and the respondent’s answers are recorded more commonly using a tape recorder. Tape recording the interview reduces the tendency for the interviewer to make unconscious selection of data in the course of the recording and the taped interview can be played back and studied more thoroughly. Communication is not interrupted and a tape recorder speeds up the interview because no writing is involved. It also allows a person other than the interviewer to evaluate and categorize responses and also makes it possible to reanalyze the data in order to test objectives or hypotheses which may not have been there originally (Mugenda & Mugenda, 1999).

However, tape recording has several drawbacks such as the respondents may get nervous when they know that whatever they are saying is being recorded especially where there is sensitive information. Transcribing the tapes and then analyzing the information is time-consuming and tedious (Mugenda and Mugenda, 1999).

Tape recording was used when interviewing the KARA officer who was the only technical personnel directly involved in the project. This was because he had very little time for the interview hence tape recording was used to gather as much information as possible from him. This was only done after seeking prior permission from the respondent.

Tape recording was also used during the Focus Group Discussions (FGDs) with the residents in order to obtain in depth information about the subject under discussion. Communication was also not interrupted and this saved on time.

b) Note taking

According to Mugenda & Mugenda (1999), note taking is the method of recording in which the interviewer records the respondent's responses during the interview. The responses are recorded as the respondent talks. The interviewer should record the respondent's answer exactly as expressed. It is also important to have some comments on the margin regarding observed gestures. Note taking facilitates data analysis since the information is readily accessible and already classified into appropriate categories by the interviewer. It also ensures that no information will be left out owing to forgetfulness or any other kind of omission. Note taking however, has several drawbacks such as it interferes with the communication between the respondent and the interviewer and if note taking is delayed, important details may be forgotten. Note taking also makes the interview lengthy and boring (Mugenda and Mugenda, 1999).

Note taking was used when interviewing officers from KeNHA and APEC Limited. This was to ensure that no information was left out during the interview and could also facilitate data analysis by referring to the notes already taken.

3.7.1.2 Focus Group Discussions

Powell and Single (1996) define a focus group as a group of individuals selected and assembled by researchers to discuss and comment on, from personal experience, the topic that is the subject of the research. Fern (1982) also defines focus groups as small group discussions, addressing a specific topic, which usually involves six to 12 participants either matched or varied on specific characteristics of interest to the researcher. According to Kitzinger (1995), the idea behind focus group methodology is that group processes can help people to explore and clarify their views in ways that would be less accessible in a one on one interview. In this sense, focus groups often reach aspects of knowledge that other methods cannot reach; this can reveal dimensions of understanding that often remain untapped by more conventional data collection techniques.

Focus group discussions were used to obtain information from the residents in order to find out the safety challenges they experienced before, during and after construction of the highway. The sampled residents were organized into homogeneous groups. The need for homogeneity was to ensure freedom among the participants to express themselves about the reality on the ground based on their experiences. For example, the experience of the pedestrians could not be the same as those of the boda boda/tuk tuk operators or even motorists. The nature of information sought could not have been easily obtained using the other data collection methods such as interviews or even questionnaires.

3.7.1.3 Questionnaires

A questionnaire is a data collection tool, designed by the researcher and whose main purpose is to communicate to the respondents what is intended and to elicit desired response in terms of empirical data from the respondents in order to achieve research objectives (Mugenda & Mugenda, 2003). It is a means of eliciting the feelings, beliefs, experiences, perceptions, or attitudes of some sample of individuals (Zikmund, 2003).

Questionnaires can cover a large number of people and a researcher can use them to reach a wide geographical coverage. They are relatively cheap and no prior arrangements are needed before posting. They avoid the embarrassment on the part of the respondents as it allows them to consider responses, especially where there are pre-coded options. They also allow for possible anonymity of respondents and have no interviewer bias if administered correctly (Kothari, 2004; Cooper & Schindler, 2003).However, questionnaires have several drawbacks such as low response rate, and time delay whilst waiting for responses to be returned. They also assume no literacy problems on the part of the respondents and there is no control over who completes it .It is not possible to give assistance if required leading to problems with incomplete questionnaires (Kothari, 2004; Cooper & Schindler, 2003).

Questionnaires were used as the main source of data collection because they are easy to standardize, can reach large numbers of people quickly, easily and efficiently through hand delivery and because the nature of information being sought is confidential. The questionnaires were self-administered to the Traffic police and the contractors who were required to fill them in. The researcher sought to find out what safety measures were implemented and the challenges faced by the contractors during the implementation of the project. The researcher also sought to find out from the traffic police, the traffic composition and accident statistics along the superhighway before, during and after construction. It was also important to find out whether the traffic police were involved during the planning phase of the project.

a) Questionnaire Pre-testing

According to Mugenda & Mugenda (2003), pre-testing is the trying out of the questionnaire in the field to a selected sample which is similar to the actual sample which the researcher plans to use in the study. Pre-testing helps to identify and change confusing, awkward, or offensive questions and techniques thereby enhancing the validity and reliability of the research instruments (Babbie, 1998).

Validity is the accuracy and meaningfulness of inferences, which are based on the research results. Reliability is a measure of the degree to which a research instruments yields consistent results or data after repeated trials (Mugenda & Mugenda, 2003).The questionnaires were pretested amongst five respondents for each set of questionnaires to receive comments and suggestions. The responses were scrutinized in order to detect ambiguities in the asked questions and to refine the instruments further. This included rephrasing of ambiguous questions to make them clearer to the respondents while some questions were totally omitted to avoid repetition. With pretesting of the questionnaires, this gave proof of the validity and reliability of data.

3.7.1.4 Observations

According to the Centers for Disease Control and Prevention (2008), observation is a way of gathering data by watching behaviour, events or noting physical characteristics in their natural setting. Observations can be overt (everyone knows they are being observed) or covert (no one knows they are being observed and the observer is concealed). The benefit of covert observation is that people are more likely to behave naturally if they do not know they are being observed. However, you will typically need to conduct overt observations because of ethical problems related to concealing your observation. Observations can also be either direct or indirect .Direct observation is when you watch interactions, processes, or behaviours as they occur while indirect observations are when you watch the results of interactions, processes, or behaviours (CDC,2008).

Observations allow you to directly see what people do rather than relying on what people say they do. It also does not rely on people's willingness or ability to provide information. It also allows data to be collected where and when an event or activity is occurring. However, observations have several drawbacks which include susceptible to observer bias, can be expensive and time-consuming compared to other data collection methods, it also does not increase your understanding of why people behave as they do. Observation is also susceptible to the "hawthorne effect" that is people usually perform better when they know they are being observed although indirect observation may decrease this problem (Ibid).

Direct observation was used and this involved seeking authority and permission from KeNHA and visiting the Thika Superhighway project site. This approach was used because of the need to collect data without ambiguity. The researcher was guided by a checklist. The researcher sought to compare planned safety measures with the existing safety measures and the international best practice.

3.7.1.5 Photography

According to Kothari (2004), photography is a direct way of data collection. Photography was used to critique the existing safety measures by capturing the existing road safety measures in comparison with the planned safety measures and the international best practice.

3.7.1.6 Desk Review

The study of relevant internal documents such as the Feasibility Study and Detailed Engineering Design, Environmental and Social Impact Assessment Report, Road Safety Audit, Traffic Operations Report and contract documents among others from KeNHA, APEC Limited, Traffic

Police and KARA was also conducted. The method allowed an additional tool of verification of the results obtained by means of interviews, questionnaires, direct observations and photography.

3.8 Data Analysis and Presentation

Data analysis involved both qualitative and quantitative methods depending on the nature of the data. The raw data obtained was edited, coded and entered into the computer for analysis using Microsoft Excel. The analysis of the data was in form of descriptive statistics and percentages were used to compare the data. The data was presented in form of graphic representations i.e. tables, charts and plates.

3.9 Ethical Issues

Mugenda and Mugenda (2003) argue that ethics are rules of conduct or set of principles that are used in conformity to the conduct of a given profession or group. Researchers must be people of integrity who will not undertake research for personal gain or a research that will have a negative effect on others (Zikmund, 2003). A significant proportion of the information used for this research will be privately held information. The researcher protected the respondents' identity by keeping information given confidential and not disclosing the names of respondents where appropriate or expressly required. The researcher also conformed to the principle of voluntary consent where the respondents willingly participated in the research.

3.10 Summary

A case study approach of design was adopted in this study because Thika Superhighway being the first superhighway to be built in Kenya, its findings would inform such future projects. The study relied on information from the key informants/opinion leaders from KeNHA, Traffic police, APEC Limited, KARA and the contractors who had been directly involved in the project. The data from the key informants was collected via interviews and questionnaires. Residents along the highway were involved in focus group discussions (FGDs). Data was also collected via direct observation, photography and the scrutiny of project documents. The raw data obtained was edited, coded and entered into the computer for analysis using Microsoft Excel and presented in form of tables, charts and plates.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 Introduction

This chapter focuses on the analysis and presentation of data obtained from the field. The field survey was set out to investigate the impact of failure in the planning phase of mega infrastructure projects, a case study of road safety on Thika Superhighway. The prime aim of this research project was to compare the road safety measures considered during the planning phase of the project with the best practice, evaluate whether the planned road safety measures were adequately implemented as well as to identify the challenges faced in the implementation of the planned road safety measures. The data analysis was based on the samples chosen.

Table 4.1 Response rate

Respondent	No.	Response No.	Response %
KeNHA	11	9	82%
APEC	37	28	76%
Traffic Police	21	15	71%
KARA	1	1	100%
Contractors	25	18	72%
Residents	219	134	61%

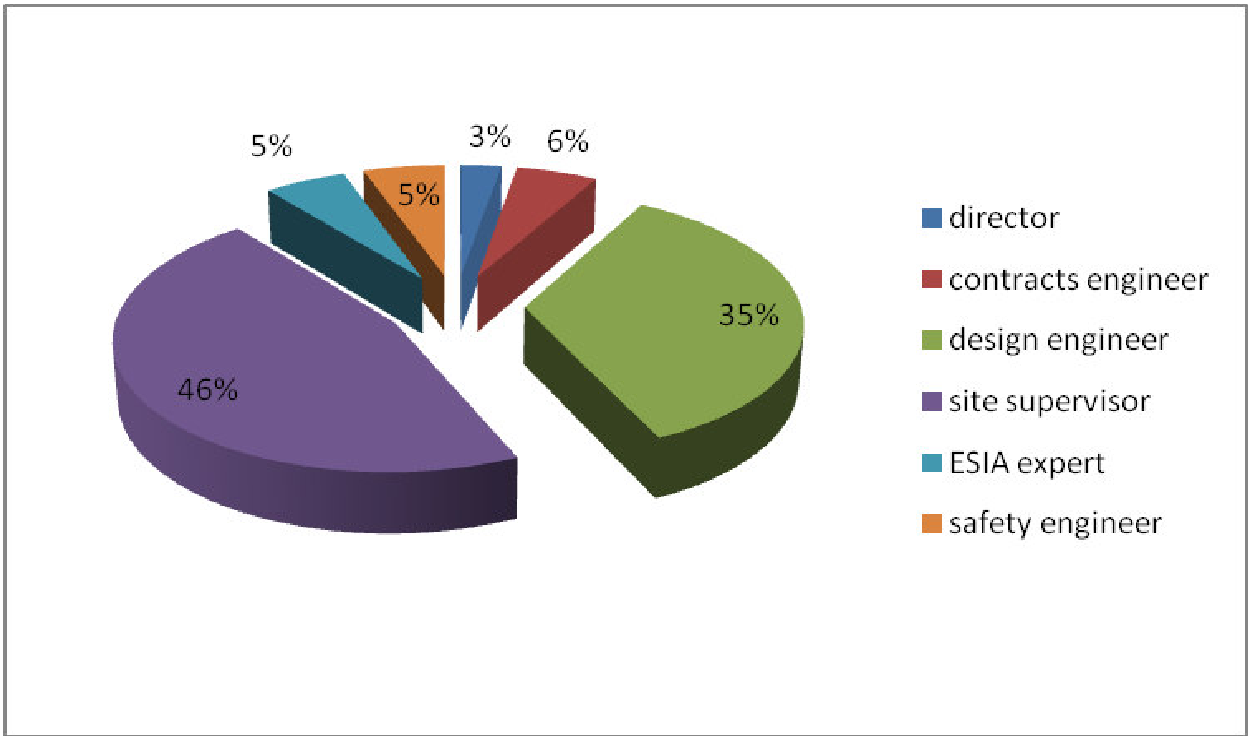
Source: Field Survey, 2015

Mugenda and Mugenda (2003) assert that in questionnaire administration, a response rate of 50% is adequate for analysis and reporting. Furthermore, Babbie (1998) suggested that any return rate of 50% can be reported, that over 60% is good, and that over 70% is excellent. Therefore the average response rate of 77% in this study was very good and sufficient for data analysis, reporting and drawing conclusions.

4.2 Background Information

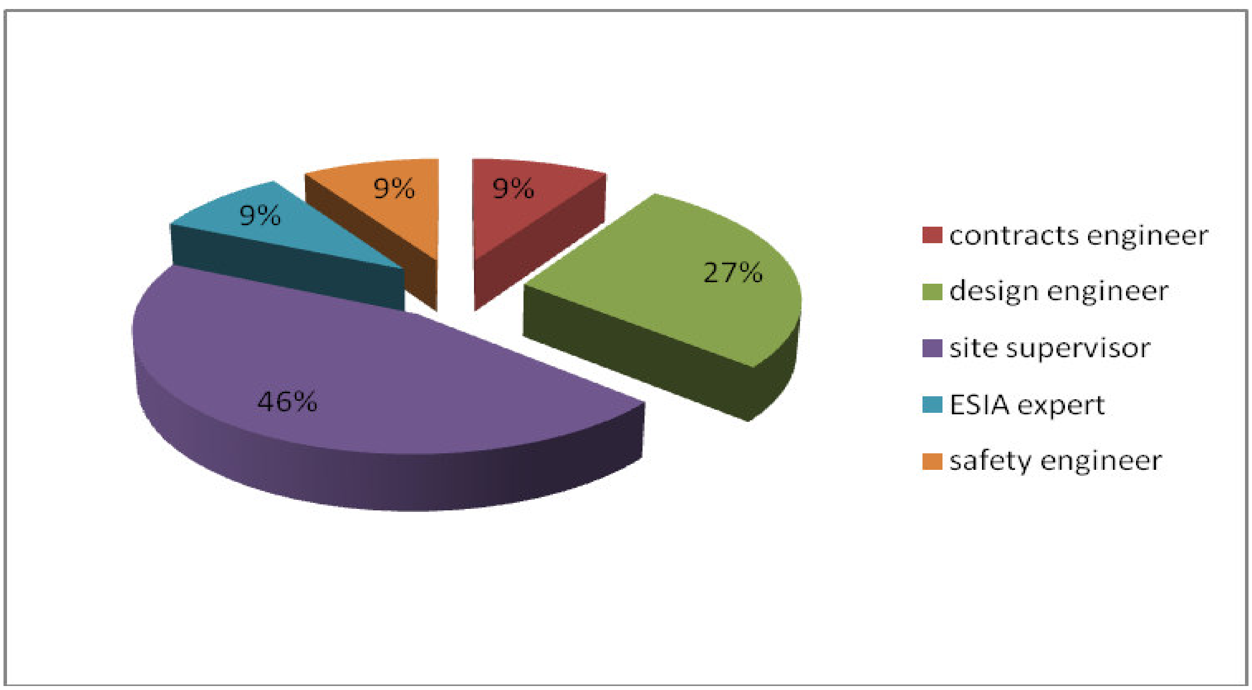
The purpose of this section was to collect general information from the various respondents e.g. job designation and working experience.

Figure 4.1 Job designation at APEC



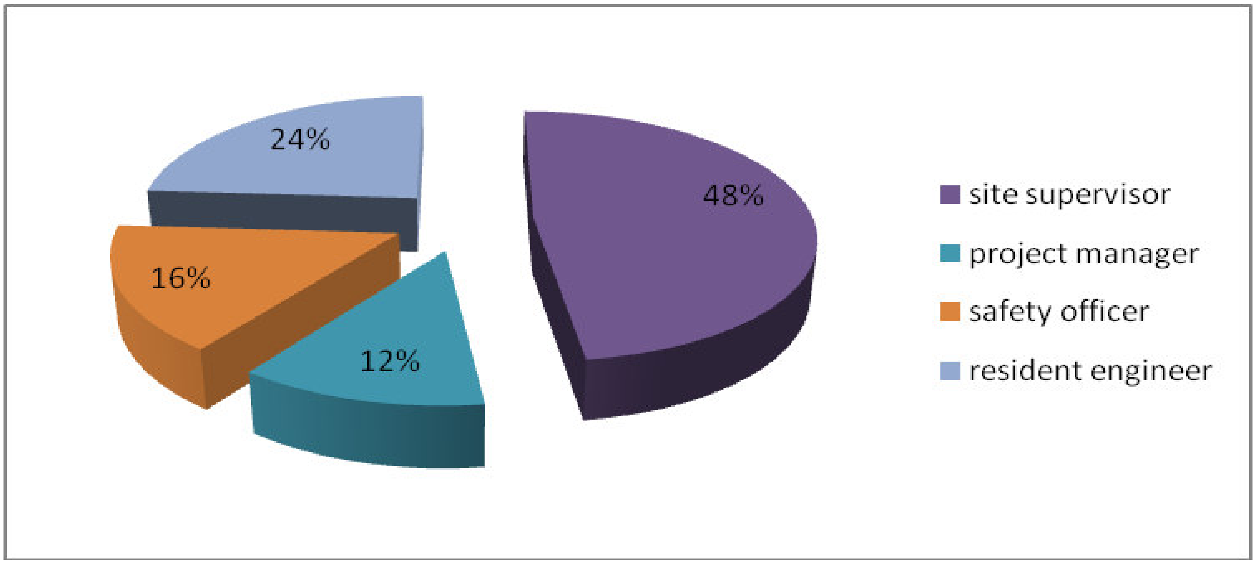
Source: Field Survey, 2015

Figure 4.2 Job designation at KeNHA



Source:Field Survey, 2015

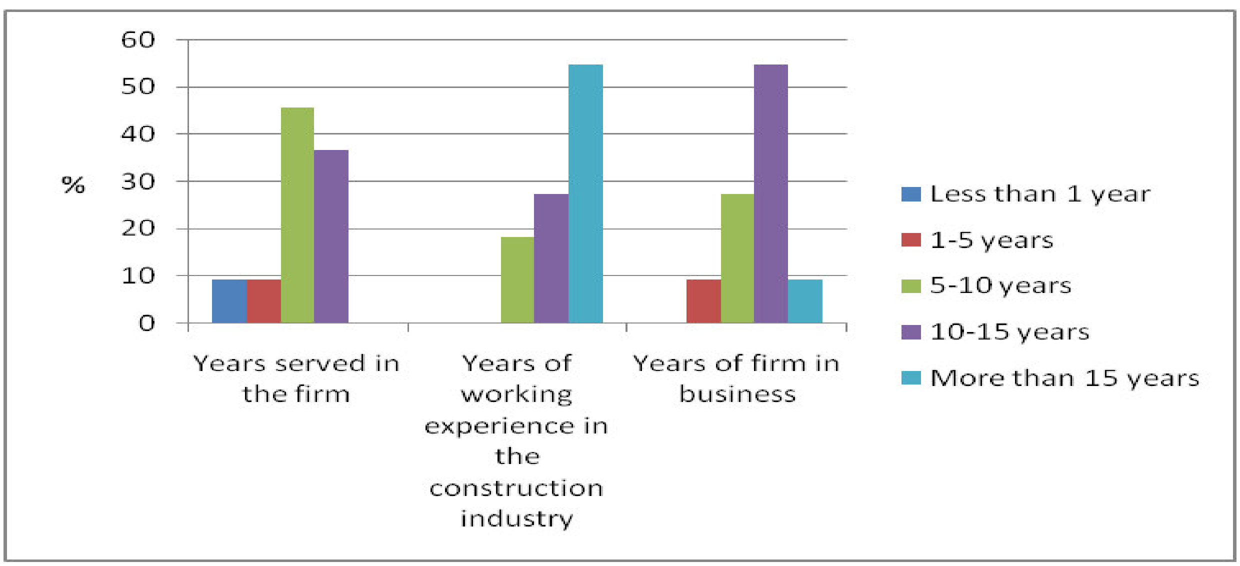
Figure 4.3 Job designation at China Wu Yi / Shengli / Sino Hydro



Source: Field Survey, 2015

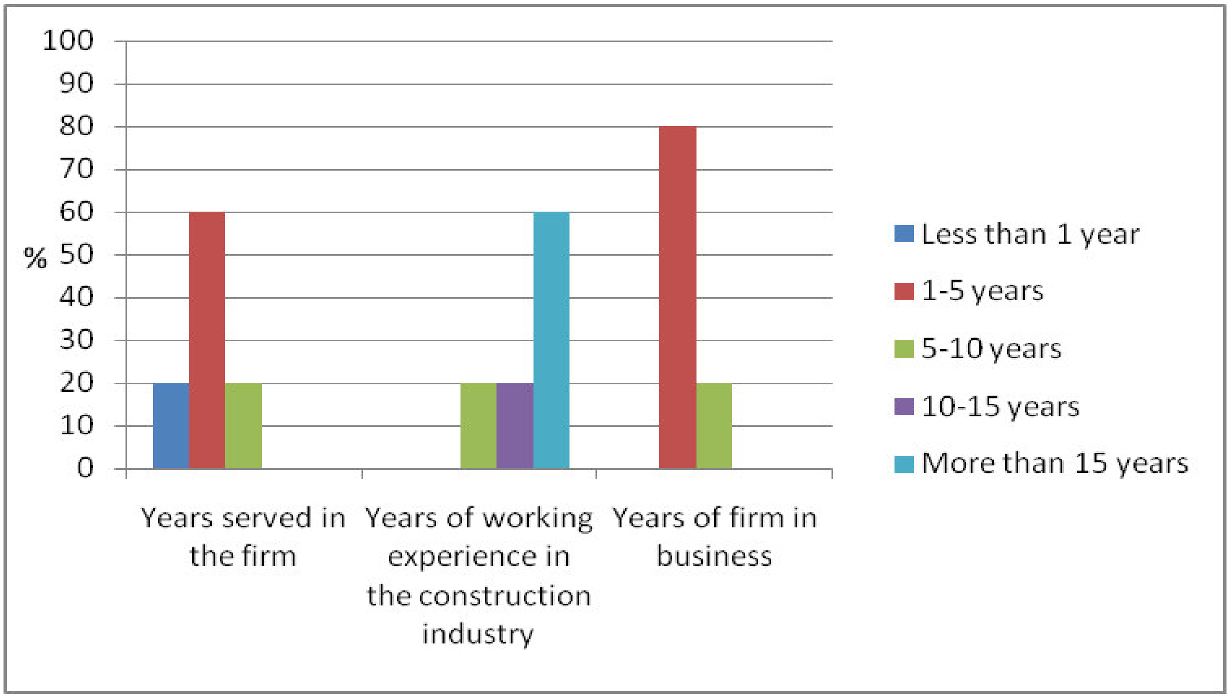
The information sought was only directed to those who were directly involved in the project. The site supervisors from the various firms were the main respondents since they were the personnel involved during the actual construction on site. Further, given that the respondents were in different job designations, they had different exposure to technical and managerial operations in the firm.

Figure 4.4 Respondents working experience at APEC



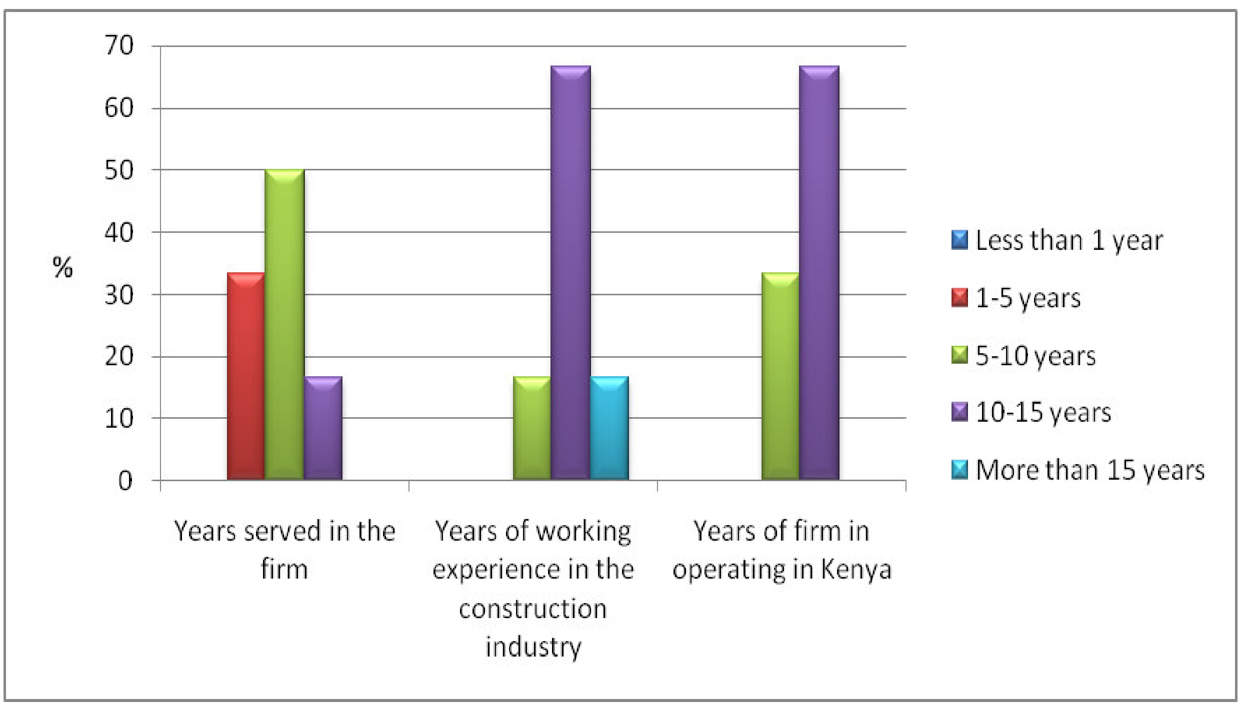
Source: Field Survey, 2015

Figure 4.5 Respondents working experience at KeNHA



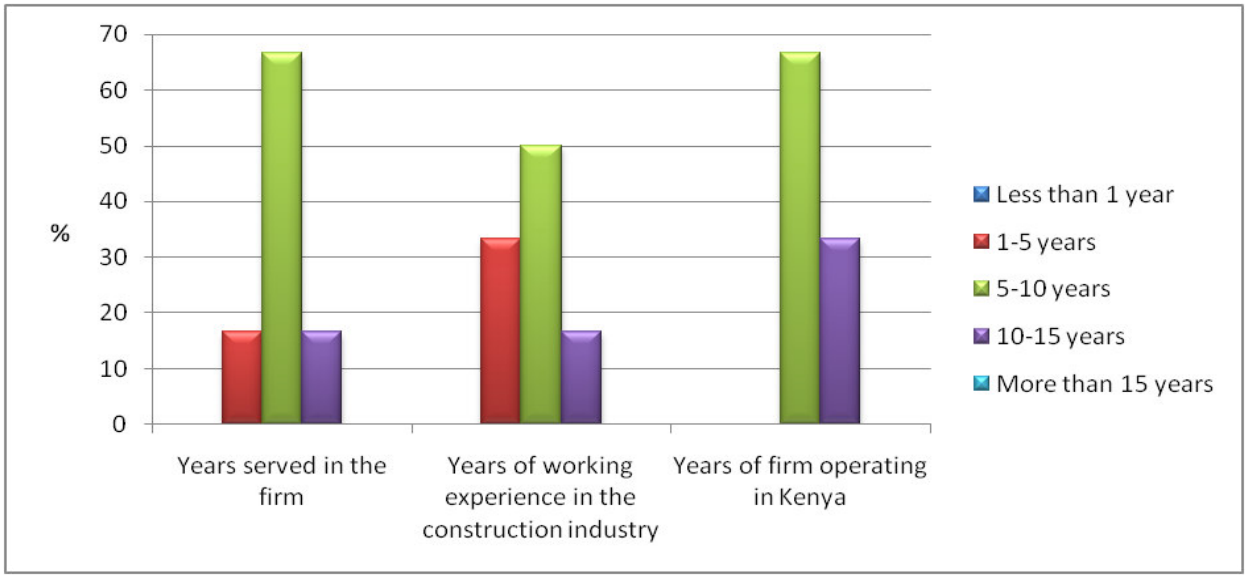
Source: Field Survey, 2015

Figure 4.6 Respondents working experience at China Wu Yi



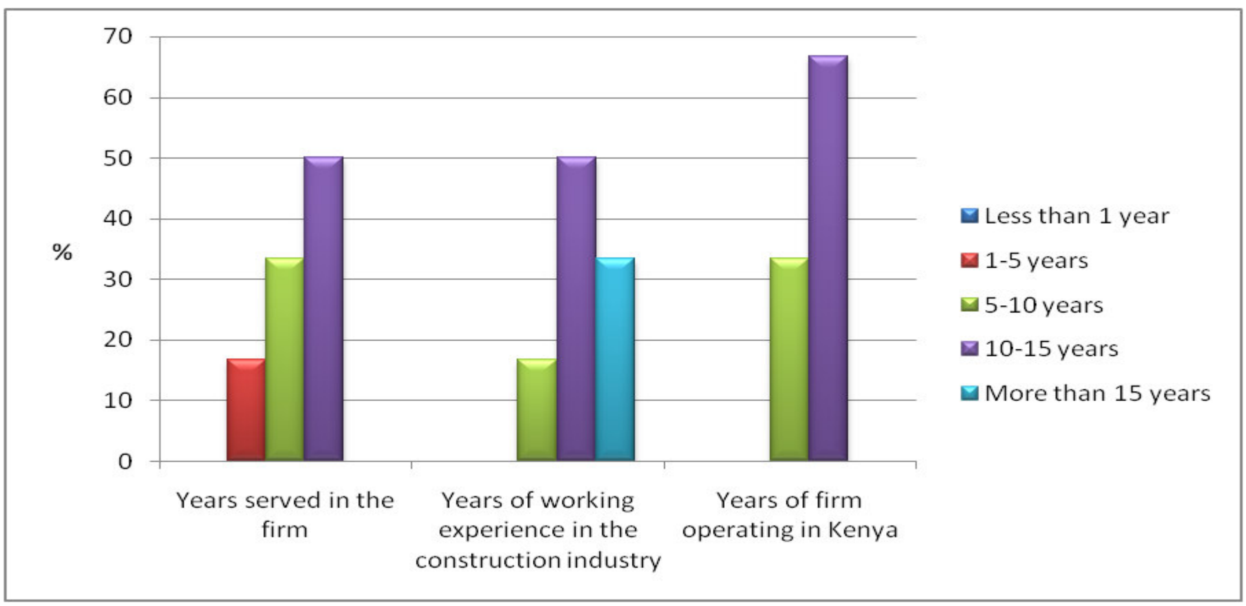
Source: Field Survey, 2015

Figure 4.7 Respondents working experience at Shengli



Source: Field Survey, 2015

Figure 4.8 Respondents working experience at Sino Hydro



Source: Field Survey, 2015

The above figures clearly show that the respondents had considerable experience (average 15 years) in the construction industry and therefore would answer the questions satisfactorily. The three construction firms were foreign construction companies registered under NCA1 which meant the value of projects they could undertake was unlimited.

Table 4.2 Parameters important to a contractor

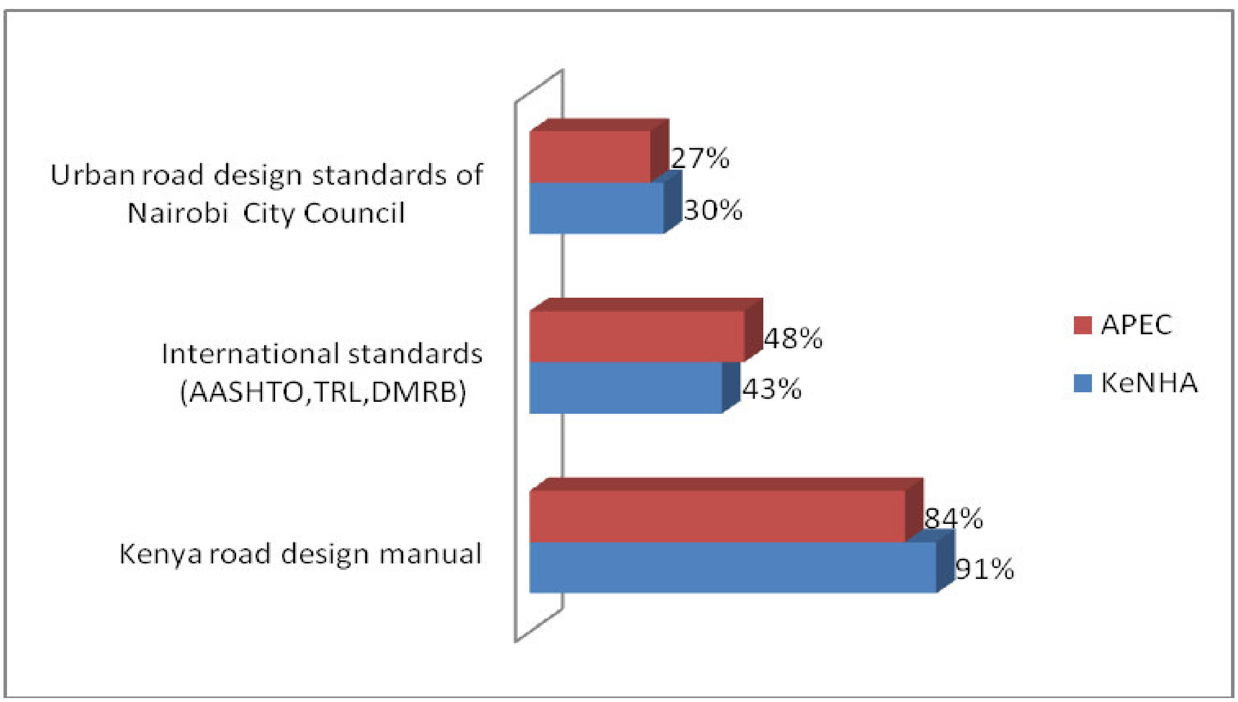
Levels of influence: Very Influential=VI(5), Influential = I (4) Somewh6at influential =SI (3), Less influential = LI (2) , Not Influential =NI (1) , TR= Total Response , MR =Mean Rate								
Parameters important to a contractor	Level of Importance to the contractor					TR	MR	Rank
	VI	I	SI	LI	NI			
	5	4	3	2	1			
Safety consciousness	9.50%	0.00%	23.80%	19.00%	23.80%	25	7.23	4
Quality consciousness	14.30%	9.50%	42.90%	4.80%	0.00%	25	9.91	3
Time consciousness	23.80%	42.90%	19.00%	4.80%	0.00%	25	14.29	2
Cost consciousness	76.20%	19.00%	0.00%	0.00%	0.00%	25	18.28	1

Source: Field Survey, 2015

The contractors indicated that safety is given the least consideration as compared to cost, time and quality. This means that safety is viewed as an "add on'' expense and a reduction in the contractor's profit hence not as important as completing the project within the stipulated cost, time and quality.

4.3 Planning Phase

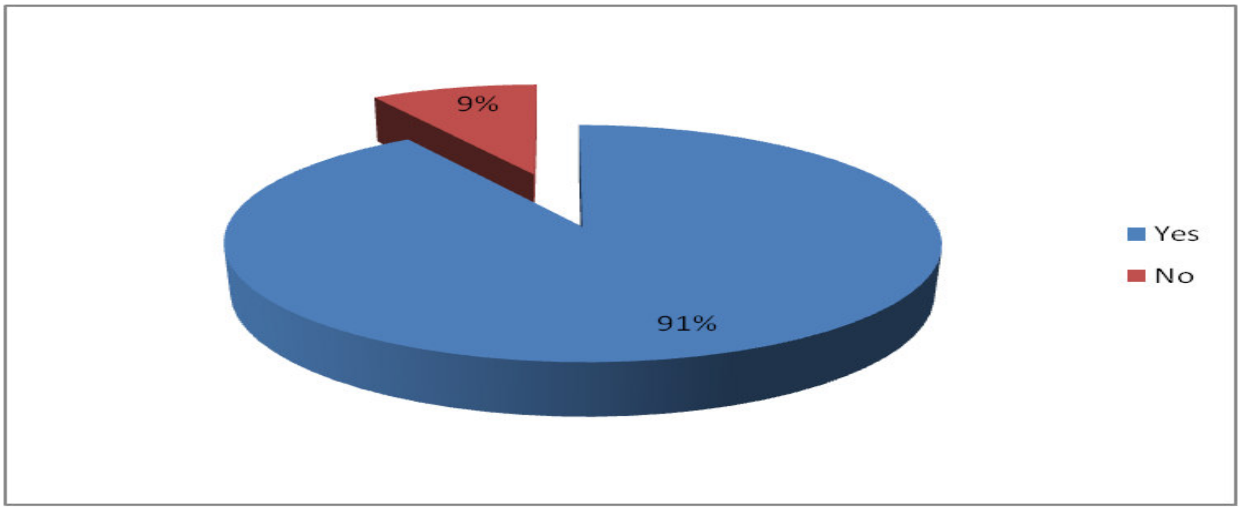
Figure 4.9 Road design standards



Source: Field Survey, 2015

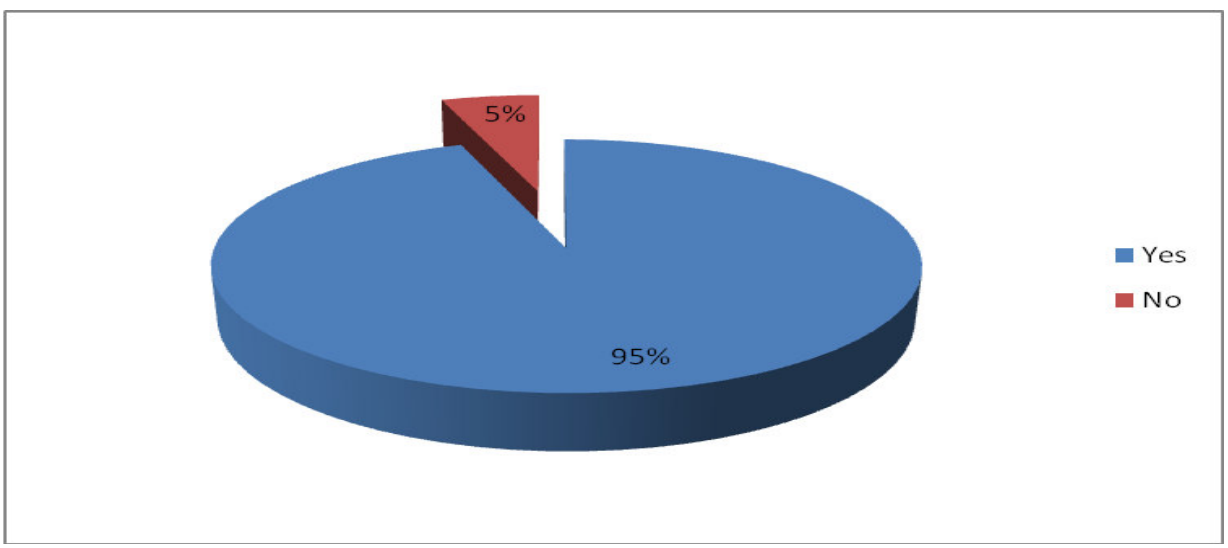
The design for the Thika Superhighway project was mainly based on the Kenya road design manual according to both KeNHA and APEC at 91% and 84% respectively .This indicates that the design for the highway may not have incorporated some of the safety measures required in a project of such magnitude since the guidelines in the Kenya road design manual are less adequate. All the respondents were of the opinion that the various road design standards should factor safety.

Figure 4.10 Road safety considerations during the planning phase of the project –KENHA



Source: Field Survey, 2015

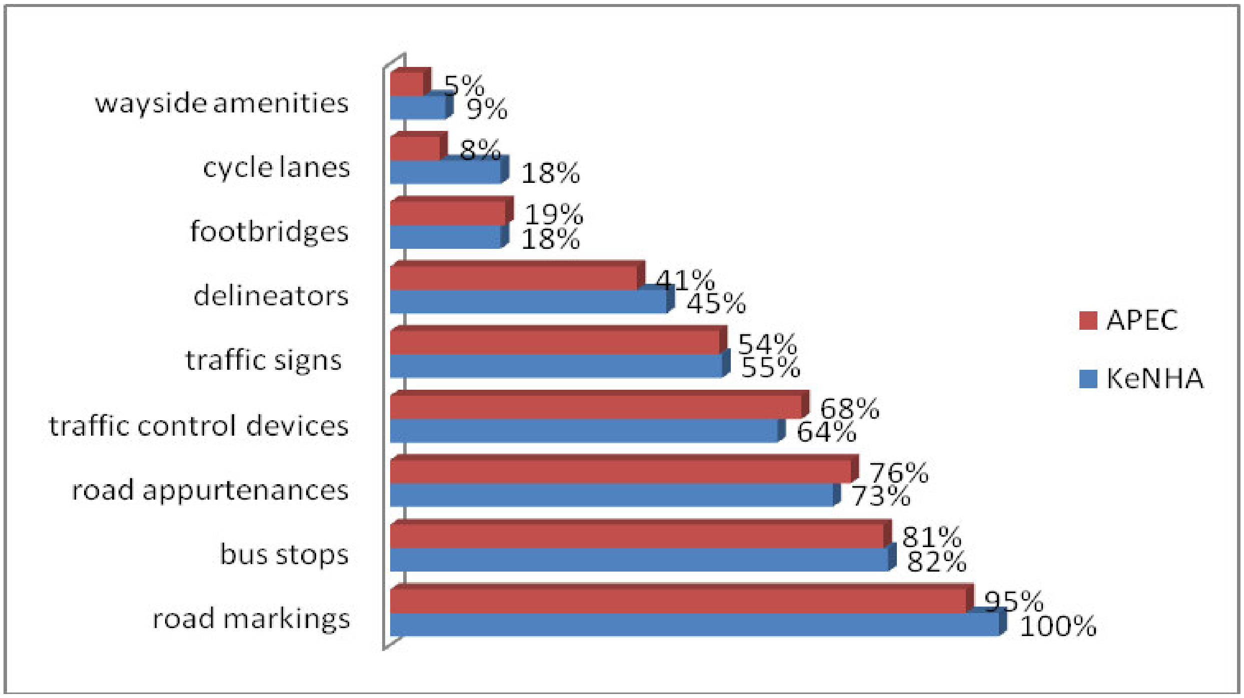
Figure 4.11 Road safety considerations during the planning phase of the project - APEC



Source: Field Survey, 2015

Both KeNHA and APEC indicated that road safety was considered during the planning phase of the project at 91% and 95% respectively as shown in Figures 4.10 and 4.11 above. Those with contrary opinion cited reasons such as the use of the Kenya road design manual which may not have incorporated some of the safety measures, insufficient budgetary allocation as well as lack of enough space/land to accommodate for the Non-Motorized Transport.

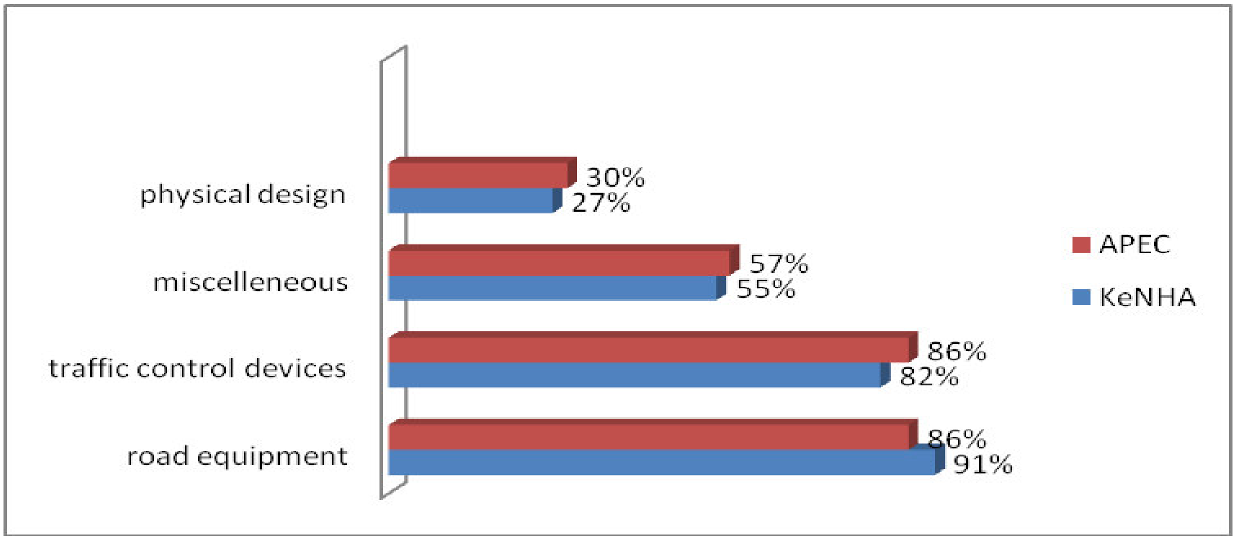
Figure 4.12 Planned road safety measures



Source: Field Survey, 2015

Road markings, bus stops, road appurtenances and traffic control devices respectively were highly considered during the planning phase as indicated by both KeNHA and APEC. This was so because these measures were part of the main construction project unlike delineators, footpaths, cycle lanes and wayside amenities which were considered as road finishes. This means that the technology behind the construction of roads tends to favour the safety of motorists as compared to the other road users. This can also be attributed to space, time and cost constraints. The other reason cited was that since the design of the highway was mainly based on the Kenya road design manual, some safety measures such as footbridges and cycle lanes were not provided for in the design.

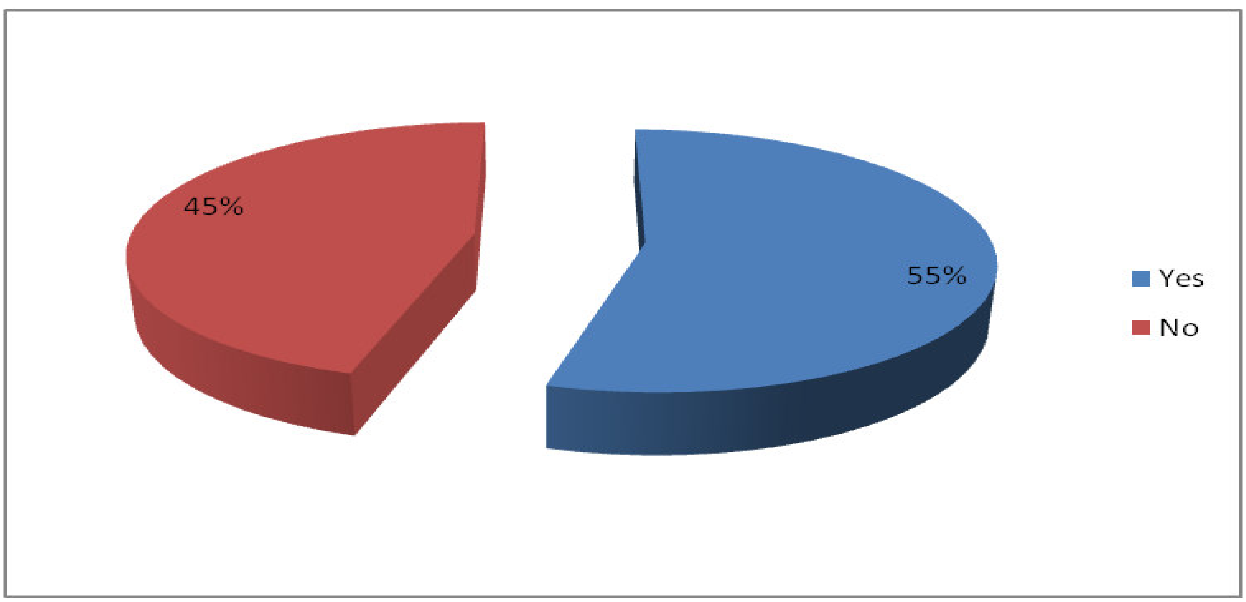
Figure 4.13 Planned construction work zone devices



Source : Field Survey, 2015

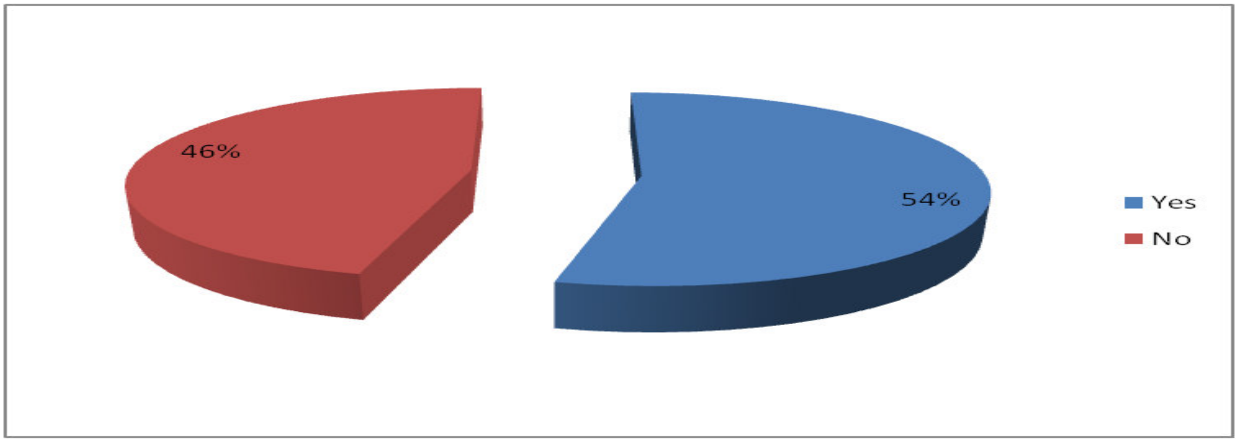
Physical design was the least considered during the planning phase as indicated by both KeNHA and APEC at 27% and 30% respectively.The reason cited was that there was inadequate land to provide for separating the traffic from the road work zones.This implies that motorists could easily collide with construction equipment,materials and even construction workers as they manouvred through the workzone.

Figure 4.14 Planned road safety audit – KeNHA



Source: Field Survey, 2015

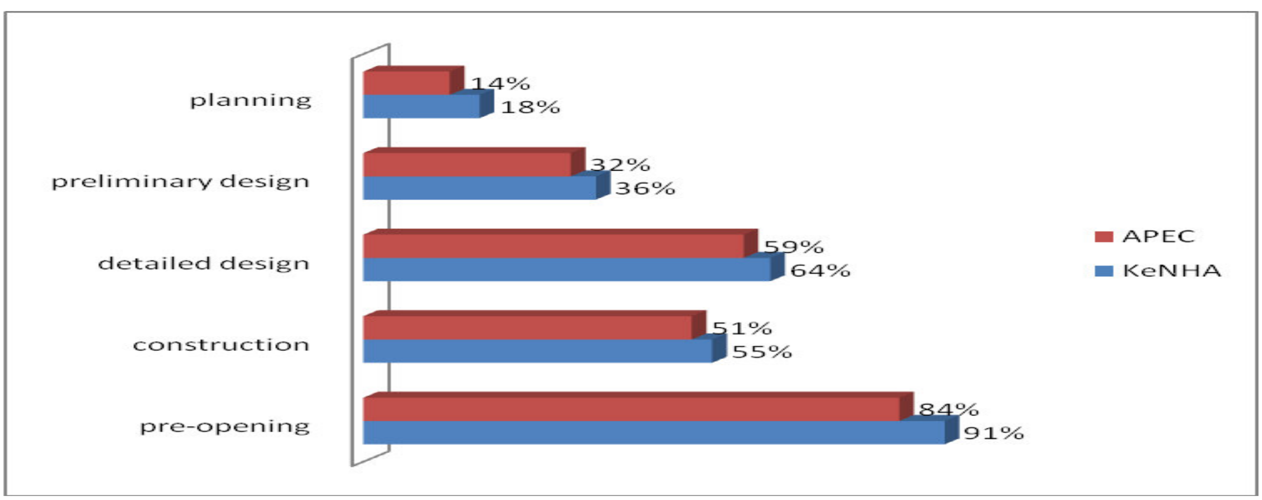
Figure 4.15 Planned road safety audits – APEC



Source: Field Survey, 2015

45% and 46% of the respondents from KeNHA and APEC respectively indicated that road safety audits were not considered during the planning phase of the project as shown in Figures 4.14 and 4.15 above. The main reasons cited were that road safety audits were not adequately provided for in Kenya Road Design Manual. It was also time-consuming and involving therefore wastage of time and financial resources which could otherwise have been used for the actual construction of the project. This implies that the designers did not envisage the need to evaluate the project and put in remedial measures at all the stages of the project life cycle with regard to safety of road users.

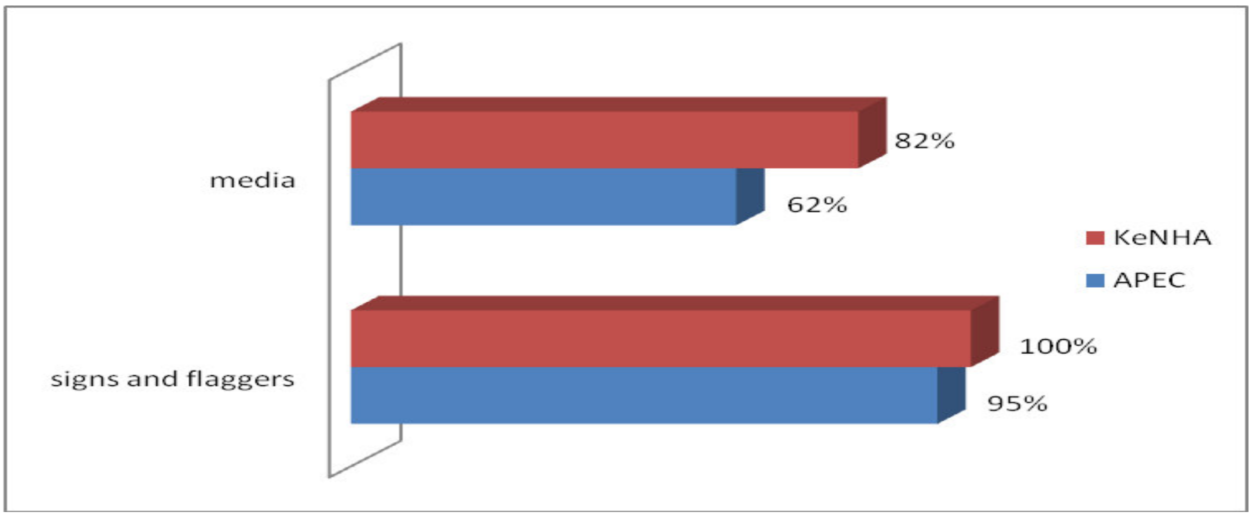
Figure 4.16 Planned road safety audits



Source: Field Survey, 2015

55% and 54% of the respondents from KeNHA and APEC respectively who had indicated that road safety audits had been considered during the planning phase stated that they had been given the highest consideration during the pre-opening phase with the least consideration being at the planning phase. Road safety audits were not considered important during the planning phase due to the perception that this was the preliminary phase of the project with "no major issues" to be tackled. Road safety audits at the pre-opening phase even though given the highest priority during the planning phase present less opportunities for design changes hence compromising the safety of road users. See Figure 2.10 on page 65.

Figure 4.17 Planned means to inform residents about the existence of a work zone



Source: Field Survey, 2015

There were plans to inform the residents about the existence of work zones as indicated by both KeNHA and APEC. This could be through the media and signs and flaggers. Signs and flaggers were the most predominant means at 100% and 95% as compared to the media at 82% and 62% according to KeNHA and APEC respectively. This was because informing the residents through signs and flaggers was considered cheaper than communicating through the media. Signs and flaggers however, meant that residents were not informed of the work zones well in advance. For example, a day before which could have allowed most residents especially motorists to decide on alternative routes. However, other means of informing residents such as through the local residents association were not explored. The local residents association could have ensured information reached a larger population which could have been cheaper and more effective as compared to the media which is an expensive means and does not reach a large population due to issues such as non-affordability and illiteracy among the public.

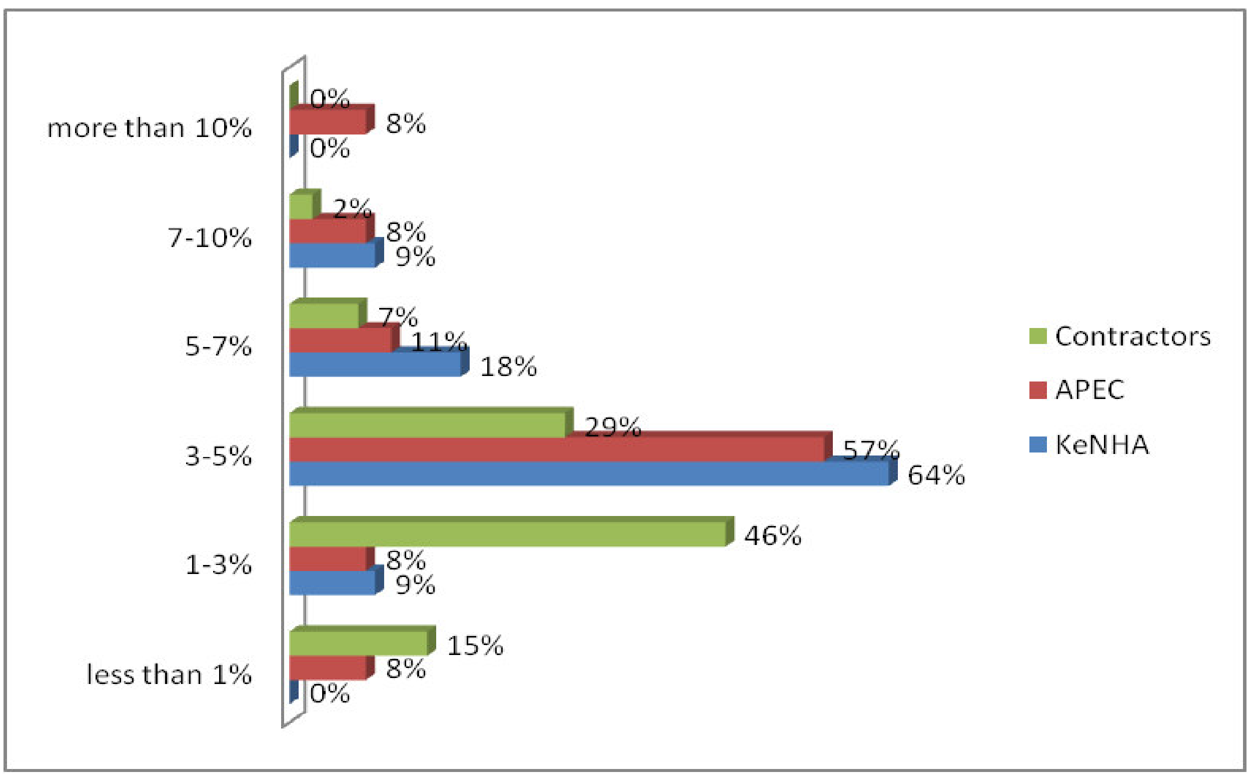
Table 4.3 Provision for road safety measures in the total contract sum

	KeNHA	APEC	Contractors
Yes	73%	68%	14%
No	27%	32%	86%

Source: Field Survey, 2015

KeNHA and APEC who were the supervisory agency and consulting firm respectively indicated that road safety measures were provided for in the total contract sum at 73% and 68% respectively. However, this was agreed upon by only 14% of the contractors. These divergent views indicate that the amount of money provided for road safety measures in the total contract sum may not be perceived as such by the contractors.

Figure 4.18 Road safety as a percentage of the total contract sum



Source: Field Survey, 2015

KeNHA and APEC further indicated that the amount of money provided for road safety measures in the total contract sum was adequate at 64% and 57% respectively.46% of the contractors however stated that this amount was inadequate and that in most of the cases they were not in the financial position to provide some of the safety measures such as footbridges and cycle lanes which were critical safety measures for ensuring safety of pedestrians and cyclists. Even though KeNHA and APEC had indicated that the amount of money provided for road safety at 3-5% of the total contract sum was adequate, this was less than the 10% recommended for adequate implementation of road safety as cited by Ngeso (2012).See page 74.

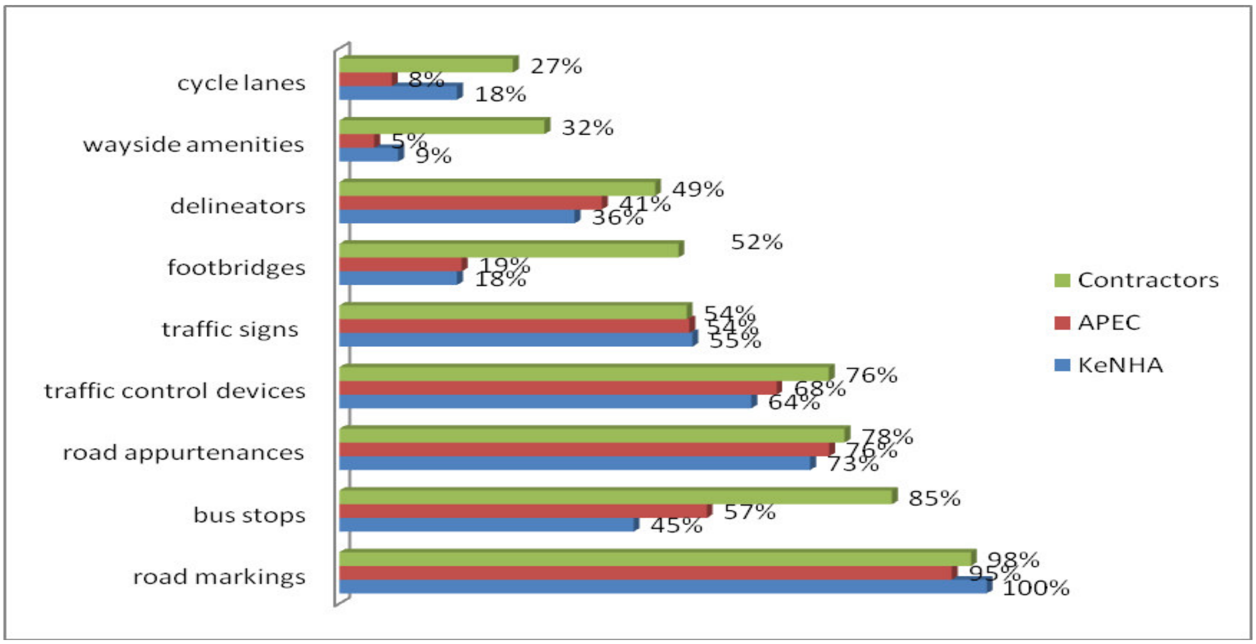
It is clear from the findings above that some of the best practice road safety measures for a project of such magnitude that should have been considered during the planning phase were not planned for. Some of the reasons cited for not considering safety of road users during the planning phase of the project were the use of the Kenya Road Design Manual, insufficient budgetary allocation and lack of enough space/land to accommodate for safety measures. The design of the highway was mainly based on the Kenya Road Design Manual whose guidelines were said to be less adequate. This is an indication of failure by the planners in identifying and using an appropriate design manual. This means that the design may not have incorporated some of the road safety measures required in a project of such magnitude.

Even though there were provisions for road safety measures in the total construction budget, 46% of the contractors were of the opinion that the amount of money provided 1-3% of the total contract sum was inadequate hence they were not in a financial position to provide for some of the safety measures such as footbridges. There was also insufficient land to provide for the separation of the traffic from the road work zones. This meant that motorists could easily collide with construction equipment, materials and even construction workers as they manouvred through the work zone. This is also a clear indication of the failure by the planners in identifying innovative ways of addressing the safety issues which were bound to come up within the limitation of finances and space.

Education and enforcement were not planned for but were only incorporated during the construction phase on an emergency basis when safety challenges got out of hand**.** Road safety audits were planned for at the planning, preliminary design and detailed design, construction and pre-opening phases but it was not planned for at the work zone phase and yet this was the phase where the actual work was being carried out hence increased safety risk as a result of collisions and falls. The failure to plan for the safety measures can be attributed to the failure to include all the stakeholders during the planning phase of the project who would have raised some of the safety issues which were likely to occur. The planned road safety measures did not therefore comply with the best practice. This can further be attributed to the failure by the planners to utilize available information.

4.4 Construction Phase

Figure 4.19 Implemented road safety measures



Source: Field Survey, 2015

Even though road markings, traffic control devices, traffic signs and road appurtenances were considerably implemented they were not properly installed. Traffic control devices for example guard rails, not installed adequately will not retain vehicles properly during an impact and guard rails and barriers extremities will induce injury to passengers and vehicles. Guard rails were installed too close from sidewalks, the space provided between the space of the guard rail and the face of the curb is larger than 0.2m. It was also noted that in some instances no guard rails were provided or if guard rail was present, there was no rigidity transition between guard rail and concrete barrier. There were no guard rails installed on some of the overpass bridge approach.

Narrow median with guard rail, two closely spaced guard rails in the median were also noted. There was also no end treatment for barrier, guard rail and gore area.

Plate 4.1 Guard rails not installed adequately

Source: Field Survey, 2015

Spacing provided between the face of the guard rail and the face of the curb is larger than 0.2m, a vehicle hitting the curb will be projected into the air and will not hit the guard rail at the proper height or angle.

Plate 4.2 No guard rail installed on the overpass bridge approach

Source: Field Survey, 2015

No guard rail installed on the overpass bridge approach (bridge on Museum Road ramp) in case of loss of control, the vehicle will end up on the underpass.

Plate 4.3 No end treatment in gore area

Source: Field Survey, 2015

The "gore", which is the area at the beginning of the divergent island, must be protected as it is an opportunity for a vehicle to hit the curb and overturn on high speed road.

Plate 4.4 Clear zone

Source: Field Survey, 2015

Steep slopes not protected by guard rail, vehicles may fall. This situation violates the concept of the "clear zone". There must be sufficient space beside a road to allow a driver to make an error, run slightly off the road and recover without striking an object or the terrain causing the driver to lose control. This bridge abutment was a serious hazard which was too close to the road. The curbing was not sufficient to deflect an errant vehicle back away from the abutment.

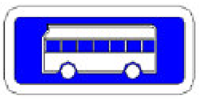
There were too many destinations shown on the directional information sign, types of messages provided and the sign types were inconsistent, sign letter heights were too short. For the regulatory signs, there was no consistency in sign dimensions and sign messages between lots, confusing messages were presented on some signs and the speed limits recommended were not adequate for road environment. Materials used for signs; some signs were painted on the structure and did not have the appropriate visibility especially at night. Sign locations, the sign designs showed that signs were only planned for installation on the left side of the roadways, regardless of the situation. When there were multiple lanes in one direction, some drivers in the median or middle lane may not see the signs. Advertising and non-traffic signs were located too close from the roadway. There were no guide signs and warning signs at the time the road was opened to the public. This meant that road users especially motorists were more susceptible to increased accidents due to insufficient or even confusing information communicated to them leading to poor judgement while driving. These could have been avoided if the best practice road safety measures had been planned for and adequately implemented. See page 50-55 on traffic signs.

Plate 4.5 Too many destinations are shown on a directional information sign

Source: Field Survey, 2015

When more than 3 messages are provided on a sign, drivers do not have sufficient time to read all the indications and maneuver in an adequate and safe manner.

Plate 4.6 Sign inconsistency-bus stops

Lots 1 and 3	Lot 2
	

Source: Field Survey, 2015

Bus stops signs show different pictograms at different locations in the lots

Plate 4.7 Sign Inconsistency - crosswalk

Lot 1	Lot 2
	

Source: Field Survey, 2015

Signage indicating a crosswalk was represented differently among lots 1 and 2. In Lot 1, the sign included a triangle with the silhouette of a pedestrian. In Lot 2, there was no "crosswalk" sign but a sign indicating a speed bump was used.

Messages not immediately recognized increase driver reaction time and increase driver workload. In complex environment where multiple lanes are provided and the driving task is very complex, time devoted to read and understand sign should be minimized.

Some signs were painted on the structures. These signs did not have the appropriate visibility especially at night. Provide illumination for these signs or change sign to provide a retro-reflective type of sign for better guidance during night time.

There were also no street light operating in tunnels and no delineation in tunnels at the time the road was opened up to the public. Abrupt change in lighting conditions between light and darkness in tunnels created temporary loss of sight. Situation exacerbated by the fact that few vehicles have head lights functioning during daytime. This meant that there was increased risk of rear-end collisions and/or impacts to the wall.

Plate 4.8 Materials used for signs

Source: Field Survey, 2015

For road markings and road appurtenances, drivers were not informed in time of the presence of traffic calming measures (no signs). Speed humps are not typically used on higher speed roadways. Understanding that there may be a particular need in some locations chosen, this still means that the speed humps should be signed both at the hump and in advance, as well as be marked with pavement markings. Broken line pavement markings painted on carriageway indicate that passing was permitted in high speed locations and where sight distance was limited.

Plate 4.9 Speed humps on carriageway

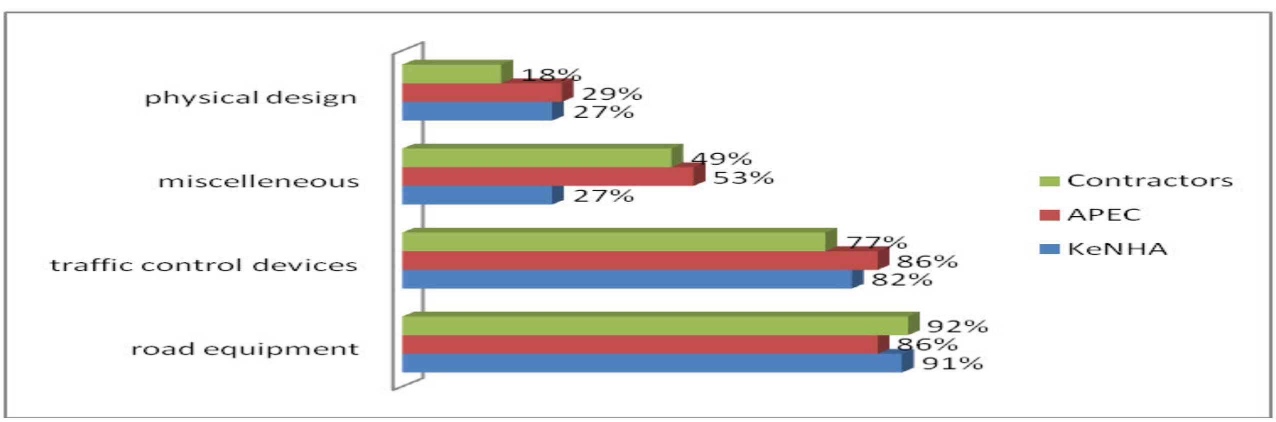
Source: Field Survey, 2015

Public transport users had not been provided with bus stops or the bus stops were located far from where pedestrians were coming from hence transit users stood a few hundreds of metres from the bus stops. The bus stops had also not been provided with adequate space hence forcing buses and matatus to stop on the carriage way when passengers were boarding and alighting from them. There were also not enough wayside amenities along the highway like petrol stations and repair centres and also there were no provisions for cars that broke down or ran out of fuel. This posed safety hazard where the car that had broken down could easily be run over by a vehicle travelling at high speed. Construction of sidewalks and pedestrian elevated structures such as cycle lanes and footbridges was delayed until the opening of the carriageway and interchanges affecting pedestrian safety.

Plate 4.10 Buses stopping on the main carriageway

Source: Field Survey, 2015

Figure 4.20 Implemented construction work zone devices



Source:Field Survey, 2015

Road equipment and traffic control devices were the most used construction work zone devices. The road equipment used included warning tapes, traffic cones and speed bumps and traffic signs for the traffic control devices. Some of the road equipment devices used such as drums filled with concrete, brick and stones did not have appropriate visibility especially at night contributing to collisions of the motorists into construction equipment,materials and waste and even falls into open excavations. The contractors cited the reasons for using such devices was to cut down on the cost due to inadequate provision of such safety measures in the total contract sum. Traffic markings were not also used since these were considered road finishes.

Traffic information on radio was also used but this was done once in a long while due to the cost associated with it hence residents especially motorists were not informed in advance of road work zones on a specific day. Physical design was the least considered.This was due to inadequate space/land therefore the contractors had to store the construction materials and waste and also construction equipment at the road work zones which were sources of fatal collisions with motorists especially driving at high speed at night.

Plate 4.11 Closure and guiding of vehicles

Source:Field Survey, 2015

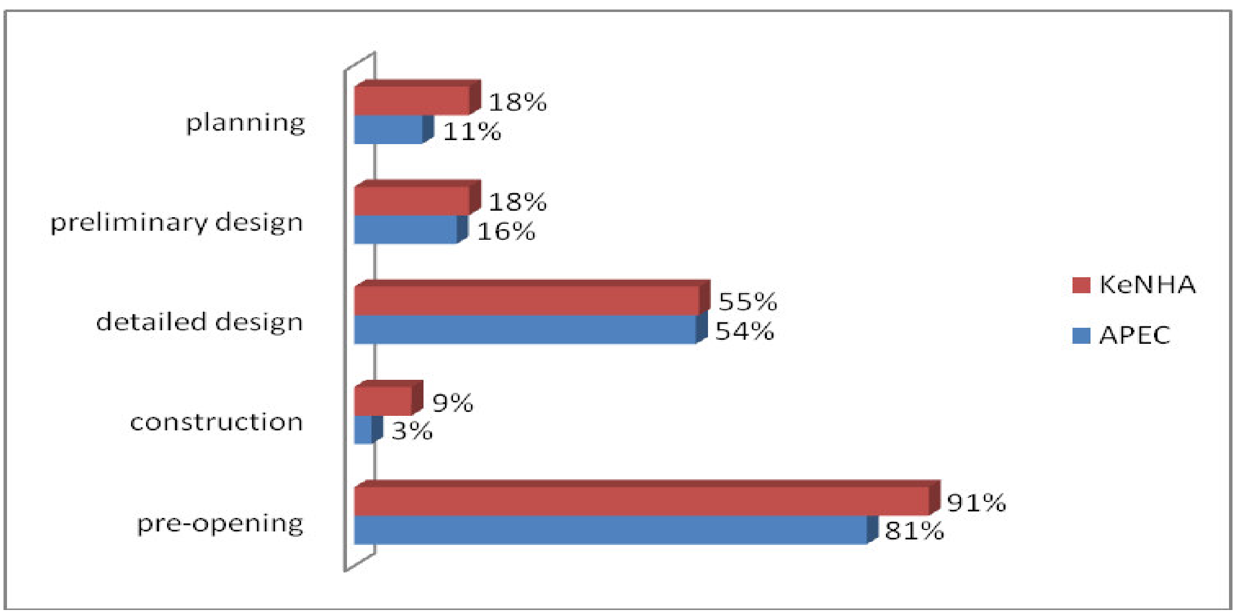
Bricks and stones used to guide drivers (exit of flyover towards Kariakor Road)

Plate 4.12 Signage in work zone

Source: Field Survey, 2015

No signage in work zone to increase conspicuity of work zone. Work zones were not signed sufficiently in advance to allow drivers to adjust their speed and change lane in the presence of obstructed lanes and workers on the roadway.

Figure 4.21 Implemented road safety audits



Source: Field Survey, 2015

Road safety audits were carried out at the pre-opening phase at 91% and 81% and at the detailed design phase at 55% and 54% according to KeNHA and APEC respectively. The very first audit combined feasibility, preliminary design and detailed design contrary to what had been planned for and the best practice of carrying out the road safety audits separately at each of the phases. See Figure 2.10 on page 65. Further, instead of the audit being carried out by an independent audit team, it was only conducted by CES/APEC who were the same people who did the designs for the project hence lack of impartiality. A road safety audit should be conducted by an independent audit team which focuses exclusively on safety, conducts a formal review and provides specific safety related recommendations for considerations by the design team. See Page 63.

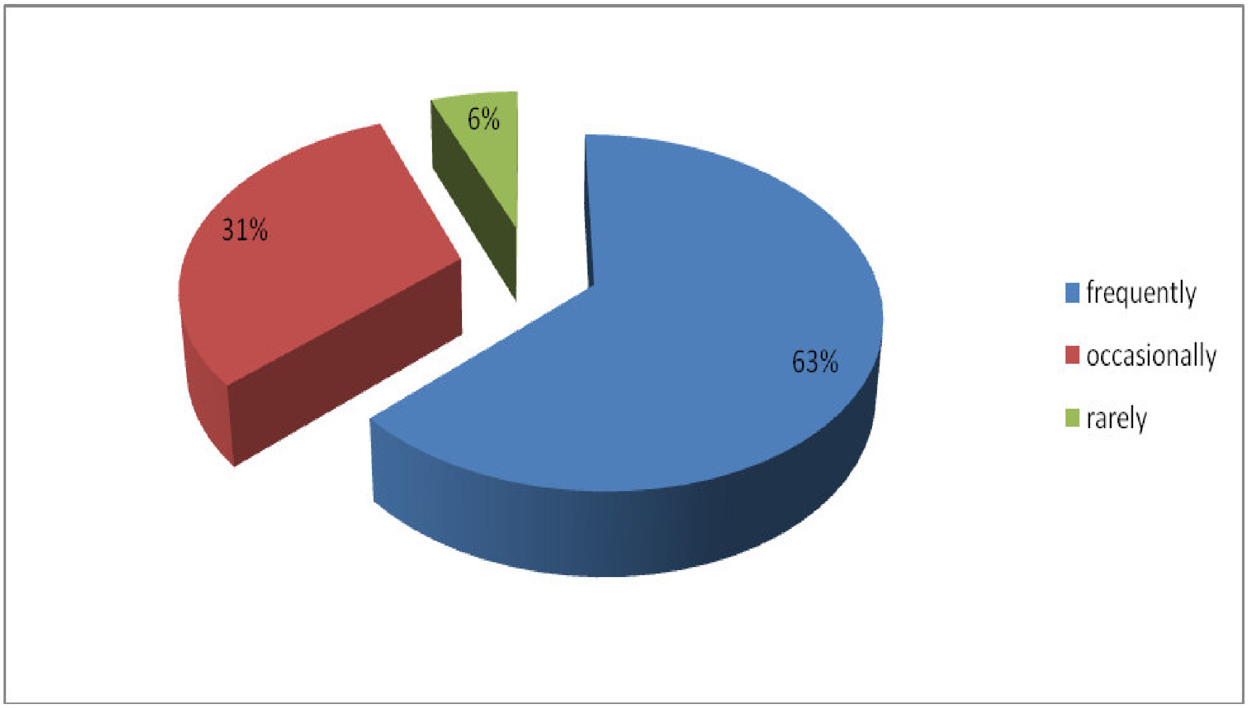
The lack of importance placed on the road safety audits at the initial phases of the project only meant that there was less opportunity for design changes as the project progressed. The pre-opening audit was however done by an independent safety auditor who was able to critic the project. This meant that more emphasis was given on the pre-opening audit as compared to the audit at the planning, preliminary and detailed design phase where there was a greater chance of influencing the design to cater for the safety of all road users.

Road safety audits were not carried out at the work zone and construction phases yet these were the phases when the actual construction was being carried out. This meant that there was no opportunity to re-evaluate the safety measures in place and put in remedial measures to include safety measures not envisaged earlier in the design. It is also important to note that even though some key recommendations were made after the road safety audits, information gathered indicated that not all of them were implemented. Some of the recommended safety measures such as additional footbridges were sacrificed for cost and time as the contractors raced to beat the deadline.

4.4.1 Response from the Residents

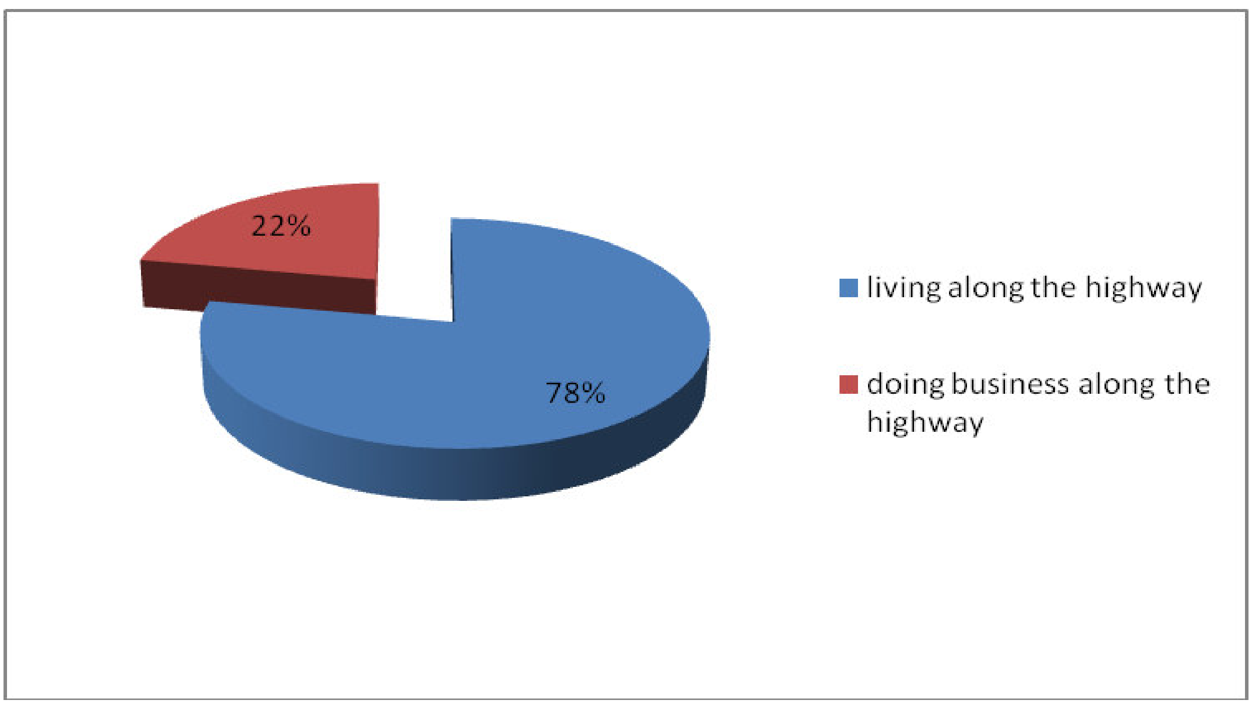
The study sought to find out the opinion of the residents with regard to their safety before, during and after construction of the highway. This was also aimed at evaluating the success or failure in the planning and implementation of the road safety measures.

Figure 4.22 Frequency of using the highway



Source: Field Survey, 2015

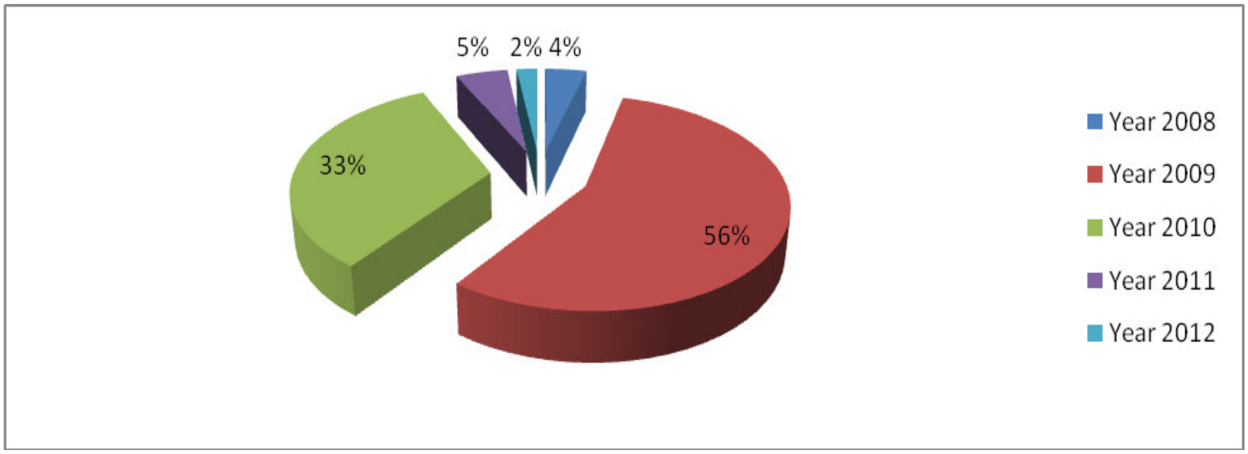
Figure 4.23 Resident by virtue of doing business or living along the highway



Source: Field Survey, 2015

63% of the residents frequently used the highway of which 78% lived along the highway as shown in Figures 4.22 and 4.23 above. They therefore had first hand information about the safety issues before, during and after completion of the highway.

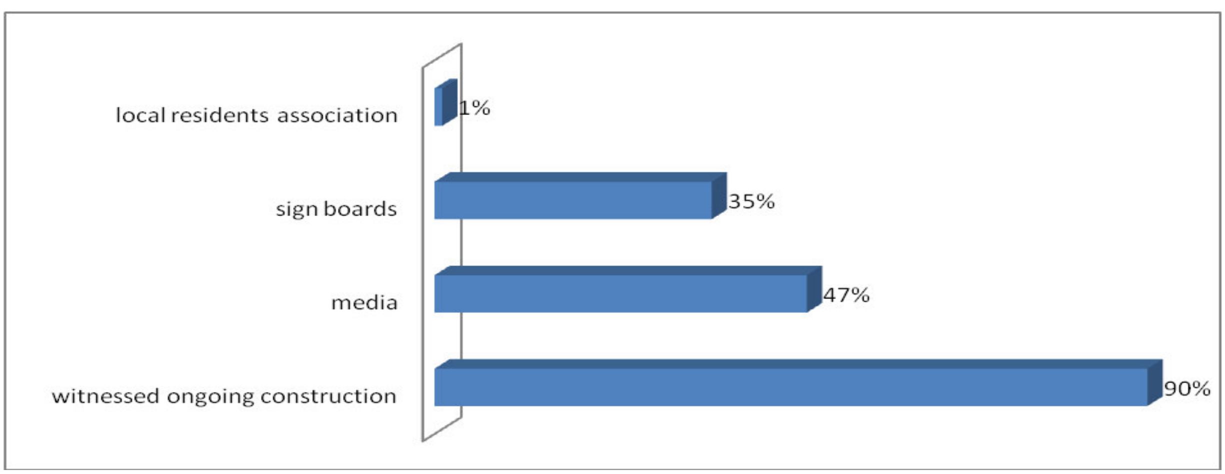
Figure 4.24 First learn of upgrade to Thika Superhighway



Source: Field Survey, 2015

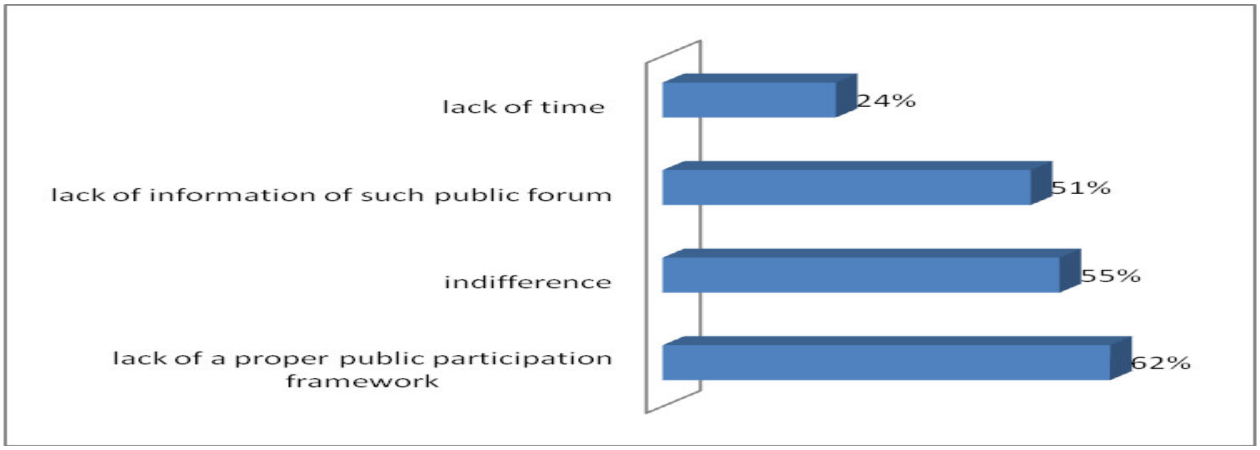
Majority of the respondents 56% and 33% learnt about the project in the year 2009 and year 2010 respectively while only a few 4% had learnt about the project in the year 2008. This implies that the residents though being important stakeholders in a construction project of such magnitude they were not involved prior to the commencement of the project. This means that their views and opinions were not taken into consideration during the planning phase of the project.

Figure 4.25 Means of learning about the upgrade



Source: Field Survey, 2015

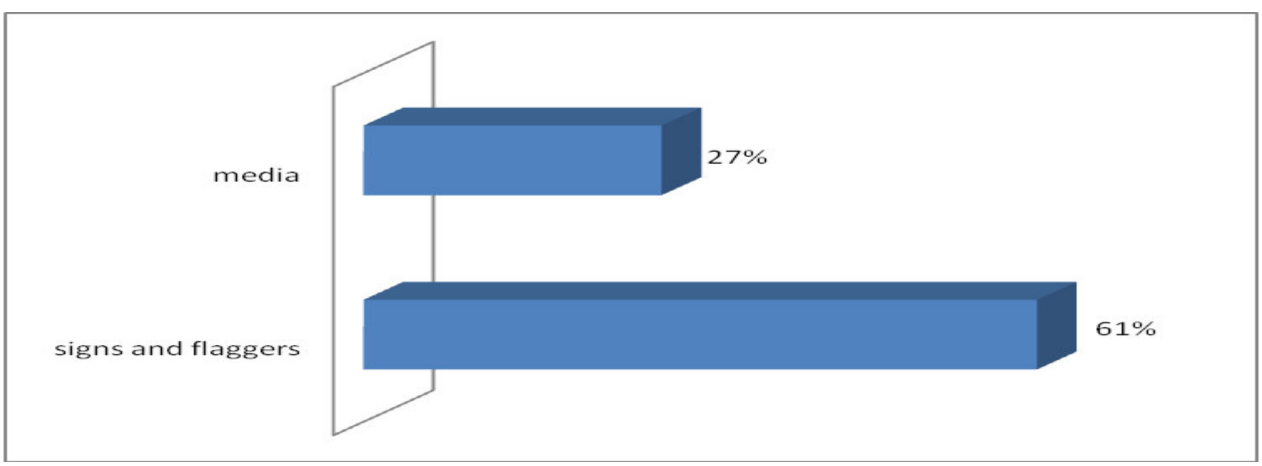
Figure 4.26 Reasons for lack of involvement



Source: Field Survey, 2015

The government does not consider public participation as an important component of a construction project due to reasons such as fear of opposition of the project. There was also lack of interest among the residents as a result of the government not involving them right from the beginning of the project. The various forms of communication used to relay the information to the residents such newspapers might have been ineffective because of illiteracy among the residents and also not everyone could afford them. The venue and timings for the meetings for example weekdays could also not have been convenient for most people especially those employed. The residents were also not informed about the venue and timings of the meetings well in advance.

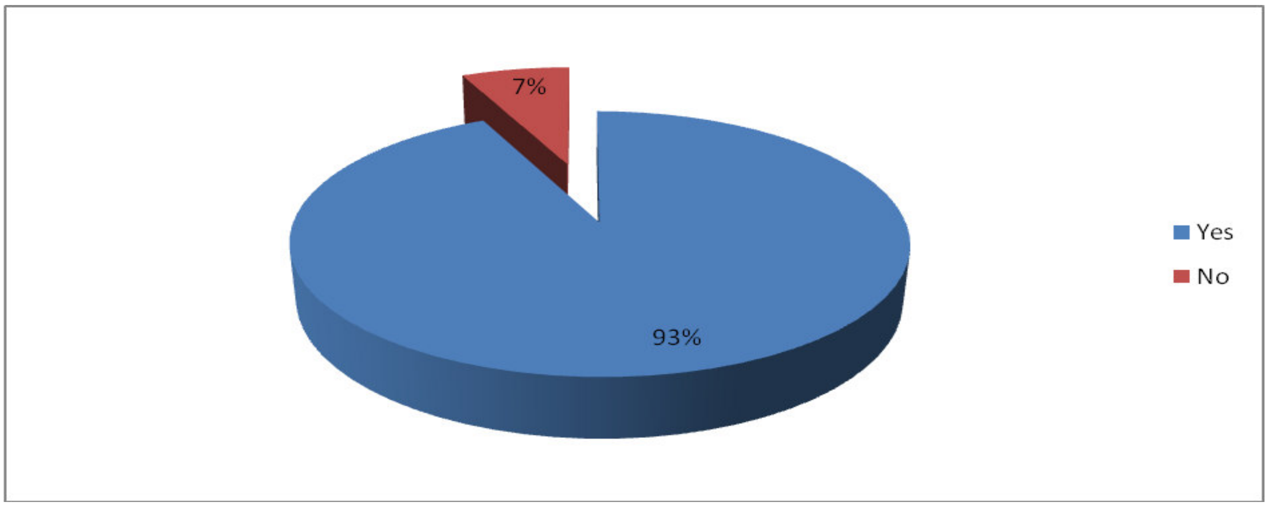
Figure 4.27 Means residents were informed



Source: Field Survey, 2015

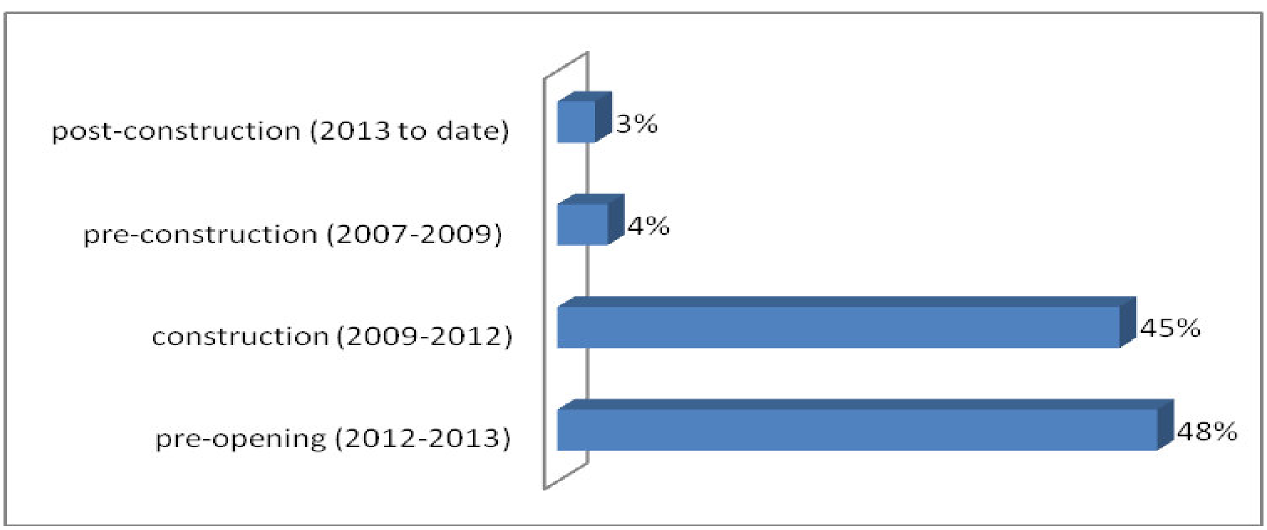
The media was given the highest consideration during the planning phase but this was not the case during implementation at 27% where the public was mainly informed of the work zones through signs and flaggers at 61%. This could be attributed to the high cost of making the announcements through the FM radios and newspapers hence the use of signs and flaggers. Signs and flaggers are not very effective since road users are not informed of the work zones well in advance but only get aware when they are already in the work zone unlike the media where road users can be informed even a week or a few days before.

Figure 4.28 Increase in the number of accidents



Source:Field Survey, 2015

Figure 4.29 Period prone to most accidents



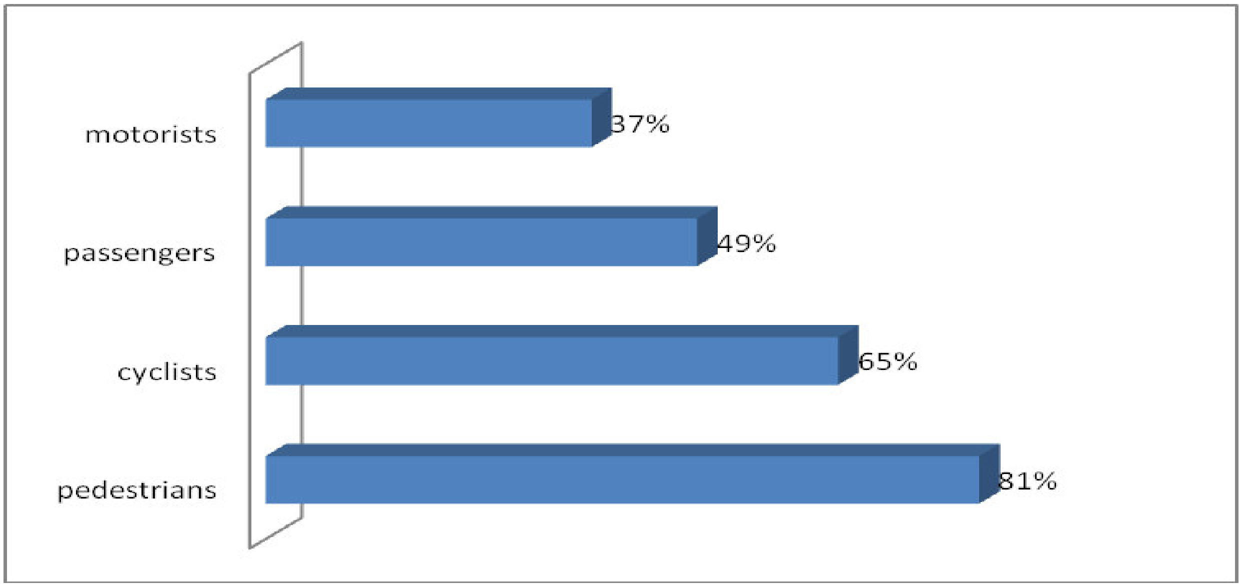
Source:Field Survey, 2015

93% of the residents indicated that the rate of accidents had increased since the construction began with the majority of accidents happening during the pre-opening phase and construction phase at 48% and 45% respectively as shown in Figures 4.28 and 4.29 above.

The residents further indicated that immediately after construction commenced most of them did not know how to use the road which at the same time was being constructed. Motorists continued driving at high speeds oblivious of the hazards they were exposing themselves to such as open excavations, construction materials and other waste like mountains of soil and construction equipment left on the road work zones. The pedestrians also crossed the high speed highway at non designated areas risking being knocked down by the speeding motorists. The commencement of construction in the year 2009 was therefore characterized by an increase in accidents. With time however, the road users got aware of the hazards they were exposed to and adjusted accordingly for example, motorists reduced vehicle speed and the number of accidents started going down.

Upon opening up of the road to the public in the year 2012, drivers were speeding through the densely populated areas simply because it was now a highway. The service lanes on both sides were also not marked and it was obvious some motorists were not aware that the service lanes were two-way lanes, for which reason they drove recklessly, thus endangering safety. The footbridges some of which had now been installed were too far apart and there were no footbridges at densely populated locations where they were needed most. Many pedestrians after alighting from commercial vehicles, found it bothersome to access the footbridges. They just walked or ran across the highway. This led to the increase in the number of accidents during the pre-opening phase. The increase in accidents could be attributed to the failure by the government to plan and implement safety education and awareness campaigns and the lack of road safety measures i.e. footbridges and cycle lanes for the Non-Motorized Transport (NMT) and physical design to separate the traffic from the road work zones. There was also inadequate enforcement of traffic regulations such as adherence of the stipulated speed limits at the various phases of the project.

Figure 4.30 Category of road users most affected

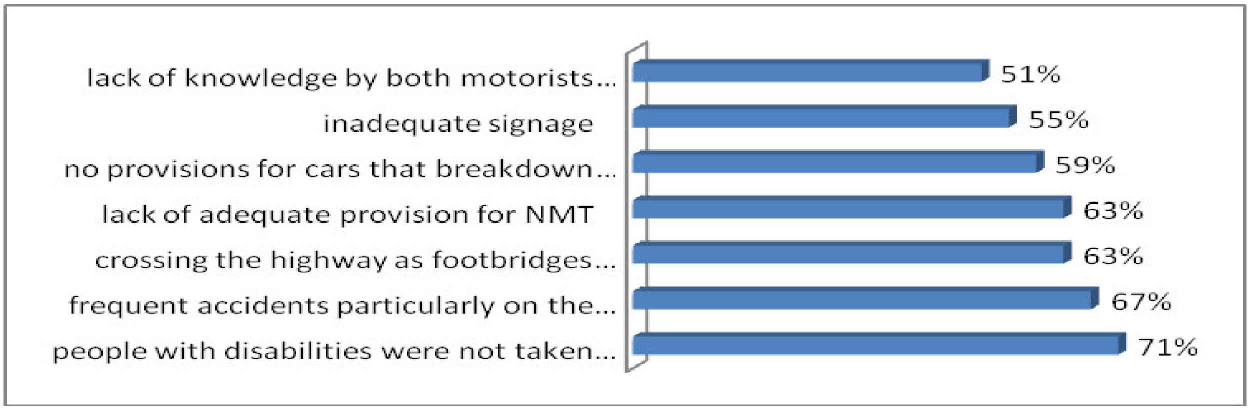


Source: Field Survey, 2015

Pedestrians and cyclists were the most affected road users at 81% and 65% respectively. This could be attributed to the few footbridges which were far apart and pedestrians were forced to cross the road at non designated areas. In some areas, footbridges were incomplete and where they were present hawkers had invaded the footbridges and cycle lanes which were meant for pedestrians and cyclists forcing them to use the service roads and the main carriage way being used by motor vehicles. Cyclists were also forced to use the main carriageway where there were no cycle lanes leading to conflicts with motor vehicles. Pedestrians were also knocked down by boda boda operators who used the foot bridges as shortcuts when moving from one side of the highway to the other and also at the numerous markets encroaching into the roadway.

Bus stops were not provided with enough space and also they were situated far from where people were coming from, this forced passengers to board and alight at the main carriageway hence increased likelihood of being knocked down by vehicles moving at very high speeds and in some instances the matatus themselves being knocked causing deaths of passengers instantly. Motorists were also affected as a result of reckless driving and collisions with other vehicles, falling into open excavations, falling from steep slopes, ramming into construction equipment, materials and even waste such as mountains of soil left on the road.

Figure 4.31 Safety challenges faced by the residents



Source: Field Survey, 2015

The main challenge cited by the residents was that people with disabilities such as the blind and disabled were not taken into consideration during the planning phase of the project at 71%.There were also frequent accidents particularly on the densely populated parts of the highway such as Githurai at 67%.It was also a challenge to cross the highway as the footbridges were spread wide apart and there was also inadequate provision for the other NMT at 63% .The other challenge cited at 59% was that there were no provisions for cars that broke down or ran out of fuel while on the highway and needed to pull aside to fix the problem. Inadequate signage and lack of knowledge both by motorists on how to use the highway were also cited as challenges at 55% and 51% respectively. It was therefore evident that failure to consider road safety during the planning phase contributed to increased accidents during the construction of the project.

Figure 4.32 Reasons for lack of safety

Source: Field Survey, 2015

The failure to include all the stakeholders during the planning phase of the project was cited as the main reason for lack of safety at 83%. The different stakeholders for example the residents did not get the opportunity to give their views and opinions about their safety and this contributed to the design not incorporating their safety requirements also where safety measures were implemented they did not match the road users' safety requirements. For example, bus stops were located far from where people were coming from hence forcing passengers to board and alight at non designated areas hence exposing them to accidents. Some footbridges were constructed in areas where there was low human traffic for example next to Mang'u high school while at Juja pedestrians and vehicles had to share the same overpass while crossing from one side of the road to the other. The involvement of all the stakeholders could have ensured that the road users' requirements were taken into consideration and incorporated into the design of the project and also road users could have adopted the right attitude towards the project in as far as their safety was concerned.

Design flaws were the other reason cited at 79%. For example, footbridges were far apart which tempted pedestrians to cross the high speed highway, speed bumps/zebra crossings were located next to footbridges hence confusing pedestrians on which one to use, bus stops were not provided with enough space forcing buses and matatus to pick and drop passengers at the main carriageway. Pedestrians were also not provided with sidewalks in some areas forcing them to use the service roads and the main carriageway. The distance provided for weaving, merging and diverging was also insufficient for vehicles to perform safe manoeuvres. See Plate 4.13 below. Hand cart pullers also were not accommodated on the cycle lanes forcing them to use the main carriageway. This was further attributed to the failure to comply with design standards.

Poor communication and coordination was also cited as a reason for lack of safety at 71%. The contractors did not inform the motorists for example through traffic signs of the presence of open excavations, construction equipment and materials on the roads thereby exposing the motorists to hazards such as falling into open excavations and colliding with construction equipment and materials. The residents were also forced to use unfamiliar diversions due to the failure of the contractors to communicate to them in advance about such closures/diversions. The other reason cited was poor human behaviour at 69% which included reckless driving, people crossing at non designated areas, vandalism of road furniture such as traffic signs and guard rails and cycle lanes and foot paths being invaded by hawkers and motorbikes thus discouraging cyclists and pedestrians. This was further attributed to the failure by the planners to plan for and implement road safety awareness programs.

There was also inadequate supervision of contractors and inadequate enforcement of traffic regulations at 65%. The contractors could close the road without any advance warning and without notifying the traffic police, they could also leave open excavations, construction plant and equipment, waste and construction materials on the road being used by motorists. The sign inconsistency within the Lots can further be attributed to poor supervision of the contractors. There was also inadequate enforcement of traffic regulations since the traffic police were not mandated to arrest and prosecute the contractors in case of offences such as the contractors leaving open excavations, construction equipment and materials on the roads thereby exposing the motorists to accidents. There was also lack of stringent laws on how to deal with vandals and road users who damaged road furniture and lack of modern technology to assist the police in tracking and prosecuting traffic offenders such CCTV surveillance cameras. The existing training programme for the police was also found to be inadequate with regard to road safety. The inadequate enforcement of traffic regulations was further attributed to weak legal and institutional framework.

The other reason cited was the need to meet project time deadline at 63%. The different stakeholders i.e. KeNHA, APEC and the contractors were under pressure to complete the project within the given timelines such that the road was opened even before they finished implementing some of the road safety measures such as road markings, traffic signs and footbridges. There was also inadequate resources i.e finances and land at 47% to cater for the safety of the Non-Motorized Traffic such as footbridges and cycle lanes. The contractors were also forced to store construction materials and waste and even construction equipment on the road work zones due to lack of space which led to more accidents as motorists ran over them. The finances allocated to the project to cater for the safety measures of the various road users were said to be inadequate.

Distance provided in weaving, merging or diverging in carriageway was insufficient to perform safe manoeuvre. This induced deceleration and acceleration on the carriageway instead of auxiliary lanes, induced sudden lane change and vehicle entering free flow with unsafe gaps and increased risk of vehicle encroaching in the gore area or losing control.

Plate 4.13 Weaving length insufficient

Source: Field Survey, 2015

4.4.2 Response from KARA

KARA was formed in the year 2000 with the mission to represent Kenya resident associations in achieving progress by defining and demanding the highest standards of good governance, transparency and ethical behaviour through negotiation with public bodies for better service delivery and accountability. KARA first learnt of the plan to upgrade Thika Road to Thika Superhighway in 2007 through the media and local residents associations. KARA was however not invited to participate in any consultative public meetings during the planning phase of the project for reasons such as frustration from the government to resist opposition of the project and inadequate resources (time and finances).

KARA only got involved in the year 2011 when KARA came together with Center for Sustainable Urban Development (CSUD) to examine emerging issues around the Thika Highway Improvement Project (THIP). KARA held a series of Focus Group Discussions (FGDs) for residents and users of the highway, along with a stakeholder meeting and public forum.

Some of the views raised by the residents in as far as road safety was concerned included:

a) Frequent accidents particularly on the densely populated parts of the highway such as the Githurai area.

b) Inadequate signage on the roads, especially for the diversions, thus causing a safety risk as some motorists found themselves on the wrong side of the road.

c) Lack of knowledge both by the motorists and pedestrians on how to use the highway that would lead to accidents.

d) Lack of adequate provision for Non-Motorized Transport (NMT), hence increasing the chances of accidents.

e) People with disabilities such as the blind and disabled were not taken into consideration in the design and implementation of the project. It would be difficult for the disabled to cross from one side of the highway to the other since they had challenges in using the footbridges and could also not cross the highway without risking being knocked down by the speeding motorists.

f) Crossing the highway was posing a challenge as the footbridges were spread wide apart and pedestrians were tempted to cross the highway without using the footbridges. Due to the high speed of vehicles on the highway, it was likely that there would be increased incidences of pedestrians being knocked down.

g) There were no provisions for cars that broke down or ran out of fuel while on the highway and needed to pull aside to fix the problem. This was bound to lead to accidents as vehicles at high speeds could easily hit the stationary vehicle.

It was after the focus group discussions that KARA invited the government through KeNHA. It was however, too late to make any necessary design adjustments at this point. The government representatives however were categorical that during the planning phase for the project, they made every effort to involve the public by inviting them (through the media) to public meetings which only a handful attended. This obviously points to the ineffectiveness of the strategies employed by the Government to mobilize public participation on critical issues. The general sentiment was that public participation was not well thought out and was generally lacking.

KeNHA only embarked on public awareness and road safety campaign after concerns were raised by the public to which they approached KARA to assist with mobilizing the public to attend. KeNHA's effort to reach out to the public with information regarding the highway was important, but there was concern that it was very late in the construction and some of the issues of concern to the public regarding the design aspect of the project may not be addressed at that stage.

According to KARA, there was an increase in the number of accidents at the commencement of construction with a slight increase at the pre-opening phase. The pedestrians were the most affected category of road users followed by cyclists. Some of the main reasons for lack of safety were cited as the failure to include all the stakeholders during the planning phase of the project, design flaws and poor communication and coordination. The other reasons included the need to meet project time deadline, inadequate resources, inadequate supervision of contractors, inadequate traffic enforcement and poor human behavior.

Probable recommendations by KARA to ensure safety of residents and other road users include:

a) A series of awareness-creation initiatives and public events to educate citizens on highways and transportation plans and policy more generally.

b) More engagement by professionals to make government officials and practicing engineers more aware of the need for context sensitive road-building and of their responsibilities in designing safe roads.

c) In line with the Kenya Open Data Initiative, more open access to all information from the GoK on issues surrounding the THIP and other transportation projects. This includes Environmental and Social Impact Assessments, Traffic Data, Road Designs, Resettlement Action Plans and Project Updates to avoid unforeseen closures and diversions and create better independent monitoring mechanisms.

d) More materials such as brochures and booklets with simplified information about the usage of the highway might also be published and disseminated by the GoK in partnerships with civil society organizations like KARA.

e) More careful research on transportation infrastructure policy, projects and processes by universities in support of improving how the GoK and citizens develop and use such infrastructure in future.

f) More effort should be made to address the issues raised by citizens as regards to Thika Highway and to mitigate possible negative impacts. This may involve some re-designing.

It is clear from the findings that some of the planned road safety measures were not adequately implemented. This is because the road safety measures either did not match the road users' safety requirements or did not comply with the design standards. The misplaced priorities are as a result of the failure to involve all the stakeholders during the planning phase of the project. For example, the location and the number of the footbridges, the respondents were of the opinion that they were placed in sparsely populated areas such as near Mang'u high school instead of densely populated areas such as Juja where the Non-Motorized Transport were forced to use the same overpass with motorized transport. This therefore exposed pedestrians on the densely populated parts of the highway to the danger of being knocked down when crossing the high speed highway. Some key recommendations were made after the road safety audits but not all of them were implemented as they were sacrificed for cost and time. This implies the failure by the planners to plan for resources i.e. finances, time and space/land. Sufficient resources should have been planned for right from the planning phase of the project within the financial, time and space constraints of the project.

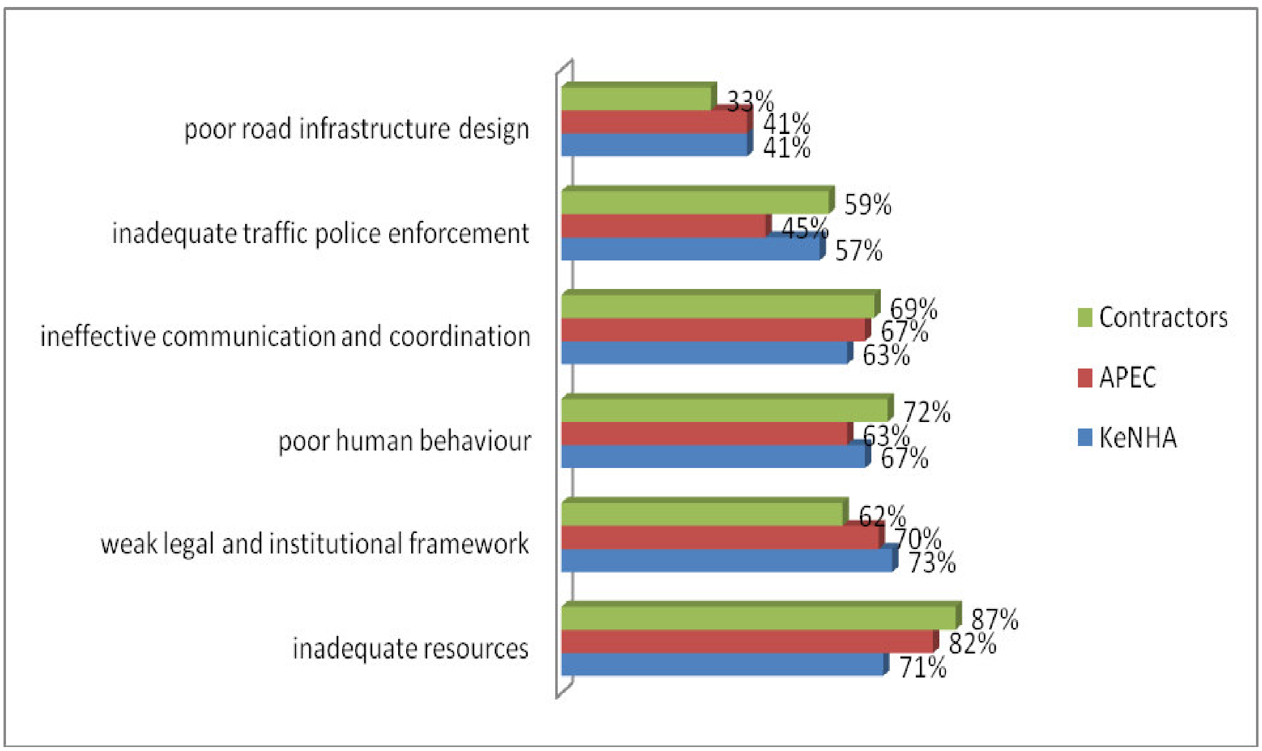
It was also observed that in addition to not matching the safety requirements of the road users, some of the road safety measures implemented also did not comply with the design standards thereby exposing the road users to various safety challenges. For example, the materials used for signs did not have appropriate visibility especially at night. Road safety audits were planned for at the planning, preliminary and detailed design phases, construction and pre-opening phase but when it came to implementation the audit at the construction phase was omitted. Further, instead of the audit being carried out by an independent audit team, it was only conducted by CES/APEC the same people who carried out the design hence lack of impartiality. The pre-opening audit however, was done by an independent safety auditor who was able to critic the project. The implemented road safety measures therefore did not comply with the best practice. This further emphasizes the failure by planners to use a design manual which was adequate which led to the implementation of designs which did not meet the design standards hence compromising safety of road users.

The planned road safety measures were therefore not adequately implemented. This was further exemplified by the various road safety challenges such as frequent accidents particularly on the densely populated parts of the highway like Githurai.

4.5 Challenges faced during the implementation of the planned road safety measures.

The following challenges were faced by the project implementers as a result of failure by the planners to consider road safety during the planning phase of the project.

Figure 4.33 Challenges faced by KeNHA, APEC and the contractors



Source: Field Survey, 2015

The main challenge faced by KeNHA, APEC and the contractors during project implementation was inadequate resources at 71%, 82% and 87% respectively. This was in terms of space/land, finances and time. The amount of money which had been provided for in the contract sum for implementation of the safety measures was inadequate therefore the contractors were not able to implement some of the safety measures such as footbridges. Land/space for accommodating some of the safety measures was insufficient. Physical design for example, which was meant to separate the traffic from the road work zone was not adequately implemented due to insufficient land. This meant that motorists especially those driving at high speeds could easily collide with the construction equipment and materials. There was also high likelihood that the speeding motorists could run into construction workers and fall into open excavations. There was also pressure to meet the project time deadline such that the road was opened up to the public even before some of the safety measures were in place for example footbridges, road markings, street lighting etc. Odero, Khayesi and Heda (2005) also identified inadequate resources as a challenge in the management of safety.

The other main challenge faced was the weak legal and institutional framework at 73%, 70% and 62% according to KeNHA, APEC and the contractors respectively. The Thika Superhighway being the first mega road infrastructure project to be built in Kenya, there was lack of a clear structure on the planning of the project especially as far as road safety was concerned. There was no stringent law to regulate the scrap metal industry which is the main market for vandalized road furniture like traffic signs and guardrails. There was also no stringent law on motorists who damaged road furniture for example knocking down guard rails during an accident and road users such as pedestrians who destroyed or removed guardrails in order to be able to cross the road at non designated areas. Weak legal and institutional framework was also identified as a challenge by Sikdar (2005).

Poor human behavior was also identified as a challenge by KeNHA, APEC and the contractors at 67%, 63% and 72% respectively. This included reckless driving, people crossing at non designated areas, vandalism of road furniture such as traffic signs and guard rails and cycle lanes and foot paths being invaded by hawkers and motorbikes thus discouraging cyclists and pedestrians from using them. Footbridges which were meant to be used by pedestrians and even people with disabilities were being used as shortcuts by boda boda operators to move from one side of the highway to the other. There was also dumping of debris on the foot paths and cycle lanes thus discouraging pedestrians and cyclists from using them and they instead used the main carriage way. Poor human behavior can further be attributed to the failure by the planners to plan for and implement road safety awareness programmes. Ngeso (2012) cited poor human behavior as a challenge in the management of road safety.

Pedestrians crossing service road and carriageway. The presence of guard rails and barriers increases risk of fall when crossing the multiple high speed lanes. The clutter on the sidewalk means insufficient space for pedestrians.

Plate 4.14 Pedestrians crossing at non designated areas

Source: Field Survey, 2015

Plate 4.15 Lack of maintenance has the same effect as if the sidewalk was not present

Source: Field Survey, 2015

There was also ineffective communication and coordination among the different project stakeholders at 63%, 67% and 69% according to KeNHA, APEC and contractors respectively. There was duplication of roles where each party assumed the other will perform for example, in the carrying out of road safety education programs between traffic police, and KeNHA. Response to safety issues raised by either party i.e contractor or APEC/ KeNHA took too long due to long channels of communication further compromising on the safety of road users. Ineffective coordination was also identified as a challenge in the management of road safety by Odero, Khayesi and Heda (2003).

Inadequate enforcement of traffic regulations was also cited as a challenge at 57%, 45% and 59% respectively according to KeNHA, APEC and the contractors. The traffic police did not have the mandate to arrest and prosecute rowdy contractors for example, contractors who left construction plant and equipment, construction materials and waste on the roads especially at night when visibility was limited which contributed to increased number of accidents. The traffic police could not arrest and prosecute vandals and road users who damaged road furniture due to lack of stringent laws. There was also lack of modern technology which could have assisted the police in tracking down traffic offenders for example CCTV surveillance cameras. Sikdar (2005) also noted that inadequate enforcement of traffic regulations is a challenge in the management of road safety.

Poor infrastructure design was another challenge at 41%, 41% and 33% for KeNHA, APEC and the contractors respectively. For example, the footbridges which were far apart which tempted pedestrians to cross the high speed highway at non designated areas, speed bumps/zebra crossings being located next to footbridges hence confusing pedestrians on which one to use, bus stops not being provided with enough space forcing buses and matatus to pick and drop passengers at the main carriageway and the bus stops being located away from where people were coming from. Hand cart pullers were not accommodated on the cycle lanes forcing them to use the main carriageway. Poor infrastructure design was further attributed to the lack of accurate data on road safety matters. This meant that at times the contractors had to redo the work to capture emerging safety issues which had not been envisaged earlier in the design hence additional cost and time for the project. Poor infrastructure design was also cited by Asingo & Mitula (2007) as a challenge in the management of road safety.

Plate 4. 16 No sidewalk along service road

Source: Field Survey, 2015

No sidewalk provided for pedestrians along the service road forcing the pedestrians to use the service road. Carts present on the carriageway since no path has been provided for them.

Plate 4.17 Carts present on carriageway

Source: Field Survey, 2015

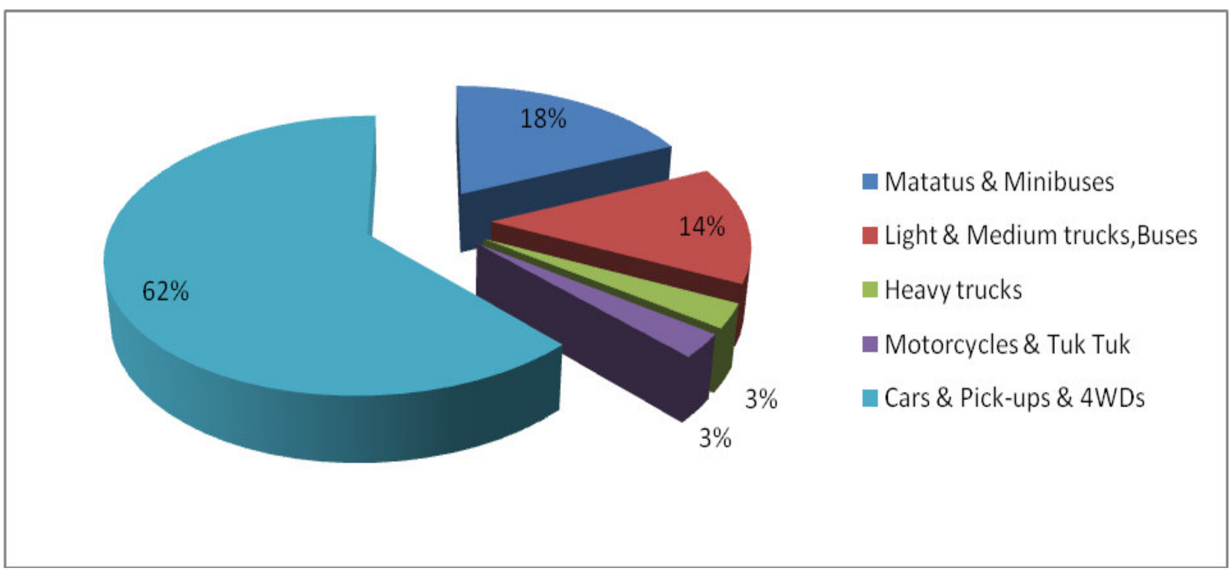
The various challenges faced by the project implementers are an indication of failure by the planners to consider road safety during the planning phase of the project. Poor human behavior for example could have been avoided by carrying out public participation and stakeholders engagement right at the planning phase of the project. This could have ensured the road users especially the local residents 'owned' the project thereby reducing incidences of vandalism of the road furniture, dumping of debris on the footpaths and cycle lanes, reckless driving and crossing the highway at non designated areas. The roles of the different stakeholders and also channels of communication should also have been spelt outright during the planning phase of the project to avoid the duplication of roles and conflicts which were observed during the implementation of the project which further compromised the safety of road users.

The various resources required for the implementation of the road safety measures should also have been considered during the planning phase of the project. For example, the availability of space/land to accommodate the various safety measures such as bus stops, footbridges, physical design should have been considered. This is so because even though bus stops were provided for they had inadequate space forcing buses and matatus to pick and drop passengers on the main carriageway further compromising on the safety of the road users. The above challenges indicate failure by planners to consider road safety during the planning phase of the project as exemplified by the road safety challenges on the Thika Superhighway.

4.6 Traffic Composition and Accidents along the Thika Superhighway

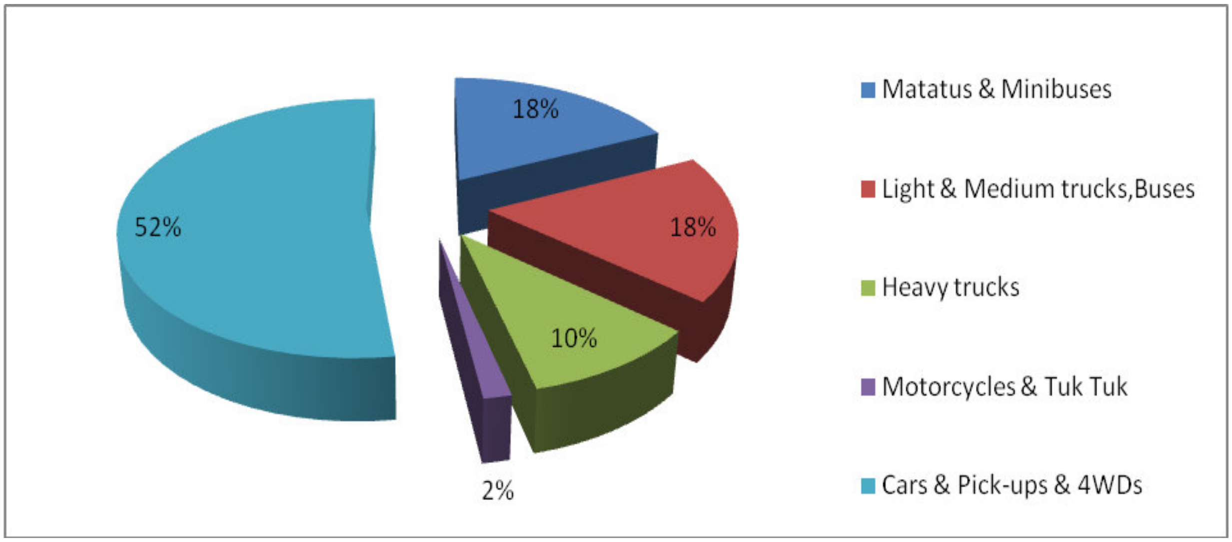
The study also sought to find out the traffic composition along the Thika Superhighway from the Traffic police. This was to enable the researcher have a general overview of the main users of the highway.

Figure 4.34 Lot 1 Traffic Composition



Source: Field Survey, 2015

Figure 4.35 Lot 2 & 3 Traffic Composition

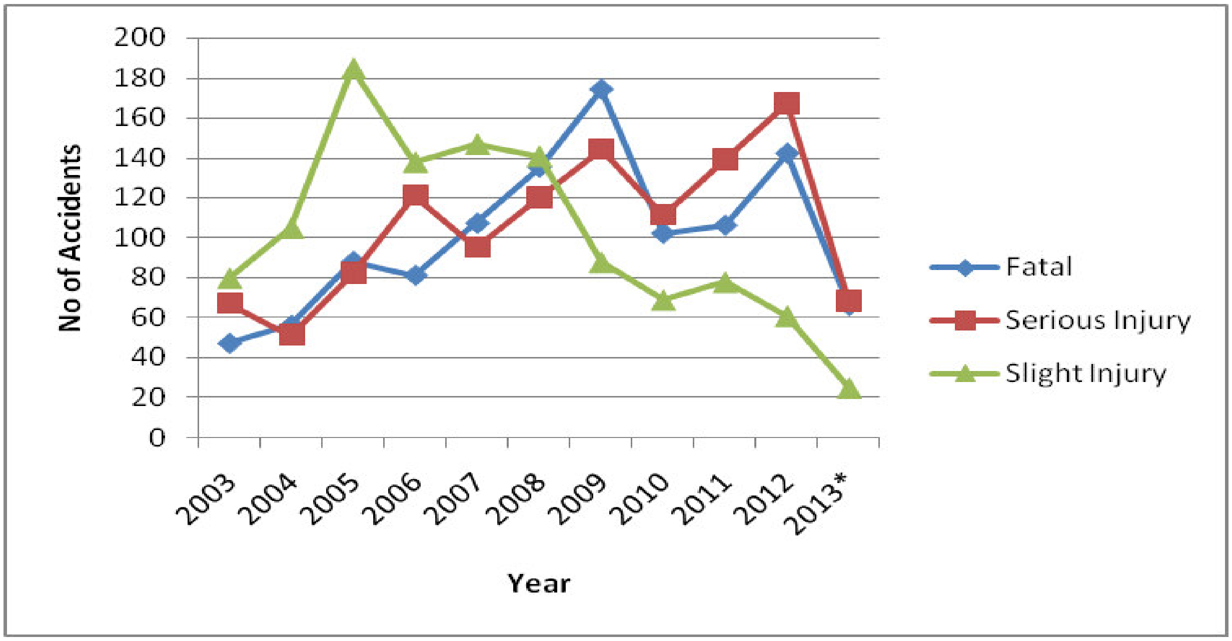


Source: Field Survey, 2015

Cars, pick-ups and 4WDs comprise the largest type of vehicles in all the three Lots at 62% for Lot 1 and 52% for Lot 2 and Lot 3. The composition of trucks and buses rises slightly within Lot 2 and Lot 3 to 18% from 14% in Lot 1. Matatus and minibuses were evenly distributed along elements of the highway both within and outside the City at 18%. Considering the road was planned for and designed by the same firm and the traffic composition was almost similar, it was expected that the rate of accidents could be relatively constant throughout the highway.

The study also sought to evaluate the trend of accidents before, during and after the construction of the highway. This was aimed at evaluating the success or failure in the planning and implementation of the safety measures.

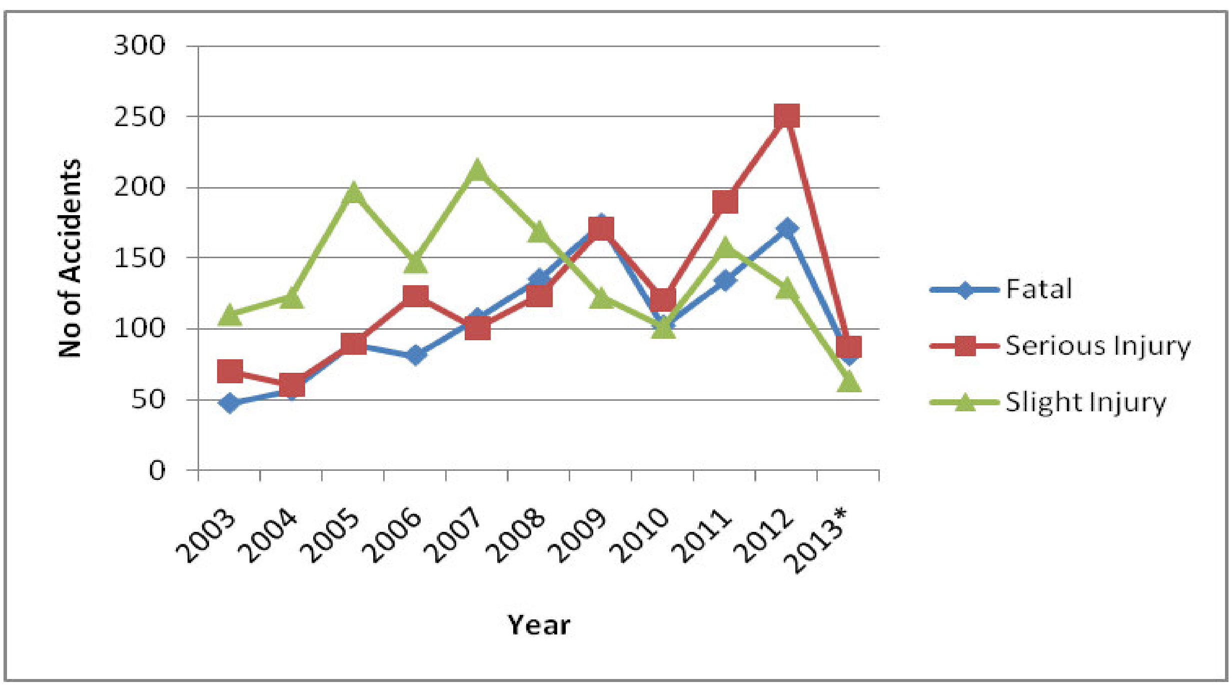
Figure 4.36 Cumulative Accidents and Severity – Lot 1



2013* - data up to end of May 2013

Source: Field Survey, 2015

Figure 4.37 Cumulative Accidents and Severity – Lot 2 & 3



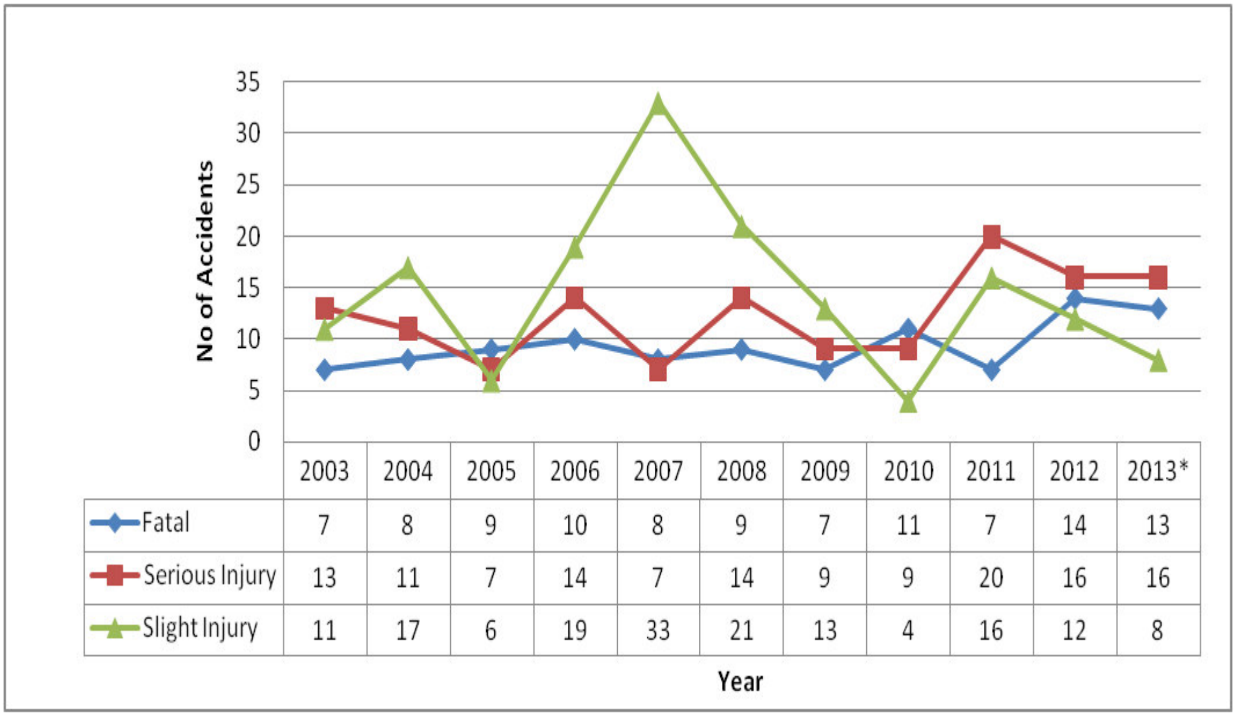
2013* - data up to end of May 2013

Source: Field Survey, 2015

As illustrated in Figures 4.36 and 4.37 above, immediately after construction commenced most of the residents did not know how to use the road which at the same time was being constructed. Motorists continued driving at high speeds oblivious of the hazards they were exposing themselves to such as open excavations, construction materials and other waste like mountains of soil and construction equipment left on the road work zones. The pedestrians also crossed the high speed highway at non designated areas risking being knocked down by the speeding motorists. The commencement of construction in the year 2009 was therefore characterized by an increase in accidents. With time however, the road users got aware of the hazards they were exposed to and adjusted accordingly for example, motorists reduced vehicle speed and the number of accidents started going down.

Upon opening up of the road to the public in the year 2012, drivers were speeding through the densely populated areas simply because it was now a highway. The service lanes on both sides were also not marked and it was obvious some motorists were not aware that the service lanes were two-way lanes, for which reason they drove recklessly, thus endangering safety. The footbridges some of which had now been installed were too far apart and there were no footbridges at densely populated locations where they were needed most. Many pedestrians after alighting from commercial vehicles, found it bothersome to access the footbridges. They just walked or ran across the highway. This led to the increase in the number of accidents during the pre-opening phase. The increase in accidents could be attributed to the failure by the government to plan and implement safety education and awareness campaigns and the lack of road safety measures i.e. footbridges and cycle lanes for the Non-Motorized Transport (NMT) and physical design to separate the traffic from the road work zones. There was also inadequate enforcement of traffic regulations such as adherence of the stipulated speed limits at the various phases of the project.

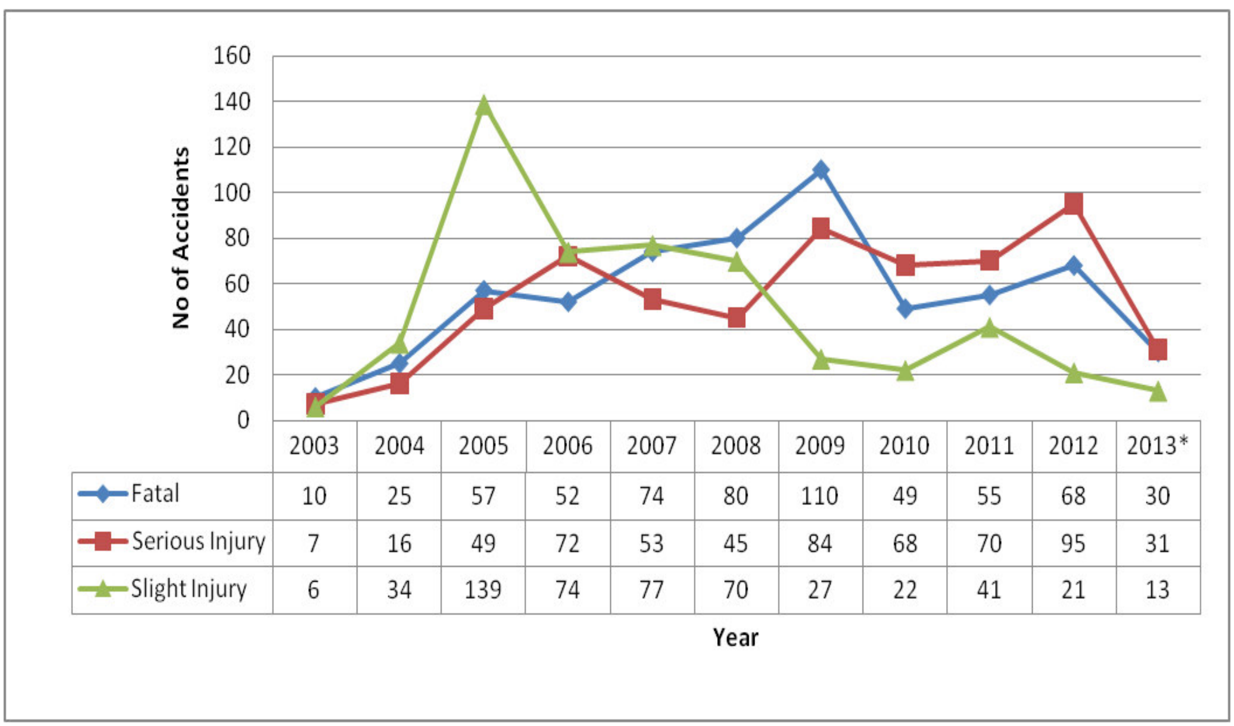
Figure 4.38 Yearly Accident Record for Contract Lot 1



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013*
Fatal	7	8	9	10	8	9	7	11	7	14	13
Serious Injury	13	11	7	14	7	14	9	9	20	16	16
Slight Injury	11	17	6	19	33	21	13	4	16	12	8

Source: Field Survey, 2015

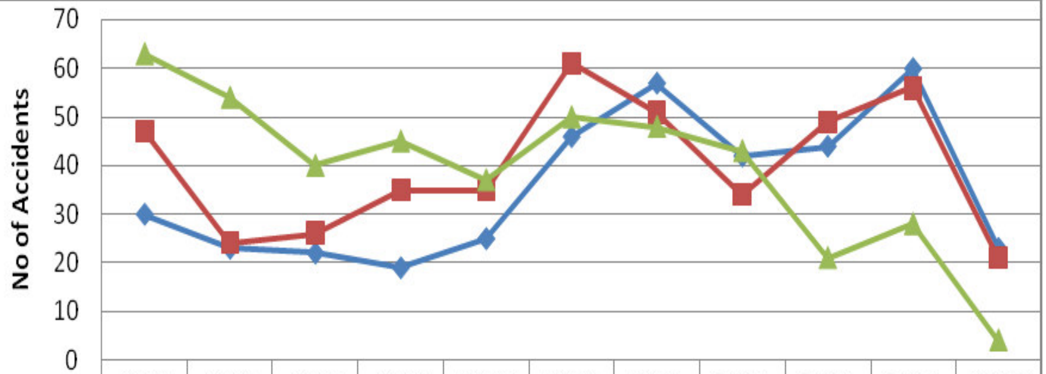
Figure 4.39 Yearly Accident Record for Contract Lot 2



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013*
Fatal	10	25	57	52	74	80	110	49	55	68	30
Serious Injury	7	16	49	72	53	45	84	68	70	95	31
Slight Injury	6	34	139	74	77	70	27	22	41	21	13

Source: Field Survey, 2015

Figure 4.40 Yearly Accident Record for Contract Lot 3



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013*
Fatal	30	23	22	19	25	46	57	42	44	60	23
Serious Injury	47	24	26	35	35	61	51	34	49	56	21
Slight Injury	63	54	40	45	37	50	48	43	21	28	4

Year

Source: Field Survey, 2015

4.7 Study Proposition

Figures 4.38, 4.39 and 4.40 above indicate that Lot 2 had the most fatal accidents at 110 as compared to 7 and 57 for Lot 1 and Lot 3 respectively. Considering the road was planned for and designed by the same firm and the traffic composition was almost similar, it was expected that the rate of accidents could remain relatively constant throughout the highway but this was not the case. This then gave rise to the need to interrogate planning and plan implementation of road safety measures on the Thika Superhighway.

It is important to note that Lot 1 was 12.4 km with a population of 85,849; Lot 2 was 14.1 km with a population of 406,199 and Lot 3 was 23.9km with a population of 351,478. See page 83. This means that the population per kilometer of the highway was highest in Lot 2 at 28,808 as compared to Lot 1 and Lot 3 at 6,923 and 14,706 residents per kilometer of the highway respectively. Increased population means increased movement of both vehicular and human traffic hence additional need for road safety measures such as footbridges, cycle lanes, bus stops etc. The high number of accidents in Lot 2 implies that there was failure by the planners to take into consideration the distinct characteristics of each lot in this case population ending up with the same design throughout the entire highway. For example, the number of footbridges that were planned for in the original scope were 2, 4 and 4 but as a result of increased accidents an additional 4, 2 and 2 were installed in Lot 1, Lot 2 and Lot 3 respectively (CES & APEC,2012). This means that there were 6 footbridges at each of the three lots irrespective of the population in each lot. This therefore implies failure by the planners to consider population as an important aspect of design when considering road safety hence the planned road safety measures did not comply with the best practice.

There was also the issue of non compliance with the design standards. The design of the road was mainly based on the Kenya road design manual, it was therefore expected that the traffic signs could relatively be the same throughout the highway. The contractors implementing Lot 1 and Lot 3 complied with the design standards but the contractor implementing Lot 2 did not. See Plate 4.6 and 4.7 above. This can be attributed to poor supervision of the contractors by APEC and KeNHA leading to inadequately implemented road safety measures. The non compliance to design standards and failure to consider the population might have contributed to the high number of accidents witnessed in Lot 2.

This implies that assuming everything else remains constant, safety has a direct relationship with the decisions made during the planning phase and the resultant number of accidents in the subsequent phases of the project especially the construction phase. This confirms the research proposition that the road safety measures identified during the planning phase of the project were not adequately implemented leading to increased accidents on Thika Superhighway.

In summary, the research findings were that some of the best practice road safety measures for a project of such magnitude that should have been considered during the planning phase were not considered and those which were planned for were not adequately implemented. Various challenges were also identified to have been faced during the implementation of the planned road safety measures leading to increased accidents on Thika Superhighway.

4.8 Problems encountered in the field

There were various problems that were encountered during the field survey. They included:

a) Excessive bureaucracy in a number of places. This resulted in the researcher spending a lot of time before being directed to the concerned persons and also in obtaining a research authorization from the Kenya Police Service. In some cases it took five weeks to obtain such permits.
b) Some contractors denied the researcher authorization to carry out research in their firms. In fact they were not willing to discuss the matter further.
c) The researcher could not obtain some information about the project which were considered highly confidential.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The aim of this study was to investigate the impact of failure in the planning phase of a mega construction as exemplified by the road safety challenges on the Thika Superhighway project

The study aimed at achieving the following objectives:

1. To compare the road safety measures considered during the planning phase of the project with the best practice.

2. To evaluate whether the planned road safety measures were adequately implemented.

3. To identify the challenges faced in the implementation of the planned road safety measures.

This chapter therefore presents in summary the main findings, conclusions and discusses the recommendations made in light of the study objectives.

5.2 Main Findings

The main findings of the study as discussed in the data analysis can be summarized in line with the objectives as follows;

Some of the best practice road safety measures for a project of such magnitude that should have been considered during the planning phase were not considered which is an indication of failure by the planners to utilize available information. There was failure by the planners to identify and use an appropriate design manual and to identify innovative ways of addressing safety issues which were bound to come up within the limitation of finances and space. There was also failure to include all the stakeholders during the planning phase who would have raised some of the safety issues which were likely to occur.

Some of the planned road safety measures were not adequately implemented. This was so because either the road safety measures did not match the road users' safety requirements or did not comply with the design standards. The misplaced priorities can be attributed to the failure to include all the stakeholders during the planning phase of the project. For example, the location and number of footbridges was a concern. The respondents were of the opinion that footbridges were placed in sparsely populated areas such as near Mang'u High School instead of densely populated areas such as Juja where Non-Motorized Transport had to use the same overpass as motorized transport. This therefore exposed pedestrians on the densely populated parts of the highway to the danger of being knocked down when crossing the high speed highway. This also implied failure by planners to plan for resources i.e finances and land. The distance provided for weaving, merging and diverging was insufficient for safe manouvre of vehicles hence compromising safety of road users. The materials used for signs also did not have appropriate visibility especially at night. The implemented road safety measures therefore did not comply with the best practice. This further emphasizes the failure by planners to use a design manual which was adequate which led to implementation of designs which did not meet the design standards.

Various challenges were identified to have been faced during the implementation of the planned road safety measures which is an indication of failure to consider road safety during the planning phase of the project. Poor human behavior for example, could have been avoided by carrying out public participation and stakeholders engagement right from the planning phase of the project including a series of road safety awareness creation initiatives. This could have ensured that the road users especially the residents 'owned' the project thereby reducing incidences of vandalism of the road furniture, dumping of debris on the footpaths and cycle lanes, reckless driving and crossing the highway at non designated areas.

5.3 Conclusions

In summary, the research findings were that some of the best practice road safety measures for a project of such magnitude that should have been considered during the planning phase were not considered. This is an indication of failure by the planners to utilize available information. There was failure by the planners to identify and use an appropriate design manual and to identify innovative ways of addressing safety issues which were bound to come up within the limitation of finances and space. There was also failure to include all the stakeholders during the planning phase who would have raised some of the safety issues which were likely to occur.

Some of the planned road safety measures were also not adequately implemented. This was either because the road safety measures did not match the road users' safety requirements or did not comply with the design standards. The implemented road safety measures therefore did not comply with the best practice. Various challenges such as inadequate resources, poor human behavior and ineffective communication and coordination were also identified to have been faced during the implementation of the planned road safety measures which is an indication of failure by planners to consider road safety during the planning phase of the project.

From the foregoing, failure to consider road safety measures during the planning phase can have serious repercussions throughout the various phases of a road construction project. This can be exemplified by the road safety challenges on the Thika Superhighway such as frequent accidents particularly on the densely populated parts of the highway. People with disabilities such as the blind and disabled were not taken into consideration in the design and implementation of the project it was therefore difficult for the disabled to cross from one side of the highway to the other without risking being knocked down by speeding motorists. There were also no provisions for cars that broke down or ran out of fuel while on the highway and needed to pull aside to fix the problem. This was bound to lead to accidents as vehicles at high speeds could easily hit the stationary vehicle. This further confirms the research proposition that the road safety measures identified during the planning phase were not adequately implemented leading to increased accidents on Thika Superhighway.

5.4 Recommendations

This study would be incomplete without recommending strategies to improve road safety consideration during the planning phase of mega infrastructure projects. The recommendations are drawn from insights given by the respondents and are done in line with the study objectives.

There is need for more engagement by professionals to make government officials and practicing engineers more aware of the need for context sensitive road-building (getting input from users and those affected by the road prior to design and construction) and of their responsibilities in designing safe roads.

Public participation and stakeholders engagement should be taken into consideration right from the planning phase of road infrastructure projects in line with the Constitution of Kenya (2010) including a series of road safety awareness-creation initiatives and public events to educate citizens on highways and transportation plans and policy.

There is also need to consider the use of alternative materials such as fibre and plastic material for safety signs and other road furniture for example guard rails to replace iron and other metals which are targeted by vandals.

It is important to plan for acquisition of lands to be used for road construction and expansion right at the planning phase of the project.

NTSA's participation during the planning phase of mega road infrastructure projects should be clearly stated as one of their mandate.

It is also important to consider modern technology such as real time surveillance systems right at the planning phase of the project. These include CCTV surveillance cameras and speed cameras which will be used in tracking down and prosecuting traffic offenders such as motorists and vandals.

5.5 Areas of Further Study

Further research can be done on:

a) Safety of construction of workers during the construction of mega road infrastructure projects.
b) An evaluation of whether the amount of money set aside in the total contract sum are adequate for implementation of road safety measures and whether they are actually used for that purpose.
c) The role of stakeholder engagement and public participation in mega road infrastructure projects.

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APPENDICES

Appendix i– Research Authorization

Maina Gladys Nduta

School of the Built Environment

Department of Real Estate and Construction Management

University of Nairobi

P.O. Box 30197-00100

Nairobi.

January 24th, 2015

To Whom It May Concern,

Dear Sir/Madam,

RE: APPLICATION FOR RESEARCH PERMIT

I am a Masters student at the University of Nairobi, conducting a research on **"Safety Considerations during the Planning Phase of Mega Infrastructure Projects"** Case Study of Thika Superhighway as part fulfillment for the award of Masters of Arts in Construction Management Degree.

I kindly request you to allow me access relevant material or information that I require to enable me complete my project successfully.

DECLARATION

THE INFORMATION COLLECTED THROUGH USE OF QUESTIONNAIRE(S), INTERVIEWS AS WELL AS YOUR IDENTITY SHALL BE TREATED AS CONFIDENTIAL AND SHALL BE USED FOR RESEARCH PURPOSES ONLY.

Your assistance will be highly appreciated.

Yours faithfully,

Gladys Maina (Researcher)

B50/62545/2011

UNIVERSITY OF NAIROBI
DEPARTMENT OF REAL ESTATE AND CONSTRUCTION MANAGEMENT
P.O. Box 30197, 00100 Nairobi, KENYA, ***Tel: No. +254-2-2724529***
E-mail: *dept-recm@uonbi.ac.ke*

20th March 2013

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

RE: MAINA GLADYS NDUTA – B50/62545/2011

This is to certify that the above named is a student in the Department of Real Estate and Construction Management, pursuing a course leading to the Masters of Arts in Construction Management degree .

She is carrying out research on **"Health and Safety during the Planning Phase of Mega Infrastructure Projects – Case Study Thika Superhighway"** in partial fulfillment of the requirements for the award of a Masters Degree in Construction Management submitted to University of Nairobi.

The purpose of this letter is to request you to allow her access to any kind of material she may require to complete her research. The information will be used for research purposes only.

CHAIRMAN
DEPARTMENT OF REAL ESTATE
AND CONSTRUCTION MANAGEMENT
UNIVERSITY OF NAIROBI

Mary Kimani, PhD. MBS
Chair and Senior Lecturer
Dept. of Real Estate and Construction Management

D:\LAND_2008 BACKUP\STUDENT MATTERS\B50- research letter 2012_gladys.doc

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

Date:

28th November, 2014

NACOSTI/P/14/4914/1647

Gladys Nduta Maina
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Safety considerations during the planning phase of Mega Infrastructure Projects,"*** I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for a period ending **1st May, 2015.**

You are advised to report to **the County Commissioner and the County Director of Education, Nairobi County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. S. K. LANGAT, OGW
FOR: SECRETARY/CEO

Copy to:

The County Commissioner
Nairobi County.

The County Director of Education
Nairobi County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Goverment Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 3763

CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MS. GLADYS NDUTA MAINA
of UNIVERSITY OF NAIROBI, 104428-101 Nairobi,has been permitted to conduct research in *Nairobi County*

on the topic: *SAFETY CONSIDERATIONS DURING THE PLANNING PHASE OF MEGA INFRASTRUCTURE PROJECTS*

for the period ending:
1st May,2015

Permit No : NACOSTI/P/14/4914/1647
Date Of Issue : 28th November,2014
Fee Recieved :Ksh 1,000

....
Applicant's Signature

....
Secretary
National Commission for Science, Technology & Innovation

Kenya National Highways Authority
Quality Highways, Better Connections

Blue Shield Towers, Hospital Road, Upper Hill **P.O. Box** 49712 – 00100 Nairobi
Tel 020 – 8013842 **Email** dg@kenha.co.ke / info@kenha.co.ke **Website** www.kenha.co.ke

DESIGN & CONSTRUCTION DEPARTMENT

Ref No: KeNHA/D&C/TH/GEN/VOL.9/(7) 16th April, 2013

M/s CES/APEC Consulting Engineers Ltd,
P. O. Box 9699-00300,
NAIROBI.

Attn: Chief Resident Engineer

Dear Sirs

NAIROBI – THIKA HIGHWAY IMPROVEMENT PROJECT
CONTRACT NO RD. 0530/0531/0532

RESEARCH AUTHORISATION FOR MS. MAINA GLADYS NDUTA

The above named student of University of Nairobi is conducting a research on "Health and Safety during the Planning of Mega Infrastructure Projects" Case study of the above mentioned project as part fulfillment for the award of Masters of Arts in Construction Management Degree.

She has requested for permission to access any relevant material or information regarding the project to facilitate her study strictly for research purposes.

This is to authorize you to cooperate and provide her with the necessary and relevant information she may require and which shall be treated as confidential and for research purposes only.

Yours faithfully,

Eng. C. N. Makau
For: GENERAL MANAGER (DESIGN AND CONSTRUCTION)
Encl.

Cc:
- Project Implementation Team
  Attn: Eng. J. M. Mwatu and Eng. K. Nyakuti.
- Ms. Maina Gladys Nduta

KENYA POLICE SERVICE

Telegraphic Address: "VIGILANCE", Nairobi
Telephone: Nairobi 341411–6
Fax: 330495
When replying please quote

POLICE HEADQUARTERS
P.O. Box 30083–00100
NAIROBI

Ref. No. A/EST 6/1/2 VOL. V/ (27)
and date

2nd May, 2014., 20..............

Maina Gladys Nduta
School of the Built Environment
Department of Real Estate and
Construction Management
University of Nairobi
P.O. Box 30197-00100
NAIROBI

RE: APPLICATION FOR PERMISSION TO CARRYOUT RESEARCH

This is in reference to your letter to Inspector General dated March 24th 2014 on the above subject.

I write to inform you that your request has been approved, and you may now proceed on in liaison with the relevant offices.

PHILIP NDOLO, MBS
FOR: DEPUTY INSPECTOR GENERAL
KENYA POLICE SERVICE

Copy to: The Commandant
Traffic Department
P. O. Box 10742 - 00100
NAIROBI

The County Police Commander
Nairobi County
P. O. Box 30051 - 00100
NAIROBI

Appendix ii – Data Collection Tools

UNIVERSITY OF NAIROBI

DEPARTMENT OF REAL ESTATE AND CONSTRUCTION MANAGEMENT

INTERVIEW GUIDE FOR APEC / KeNHA

INSTRUCTIONS

Please tick and/or state the appropriate answer in the space(s) or box (es) provided. More than one answer may be ticked or stated where applicable.

Background Information

1. In what capacity do you serve at APEC/KeNHA?

2. How many years have you served at APEC / KeNHA?

3. How many years have you been working in the construction industry?

4. How many years has APEC / KeNHA been in operation?

General Information

5a) Was road safety one of the issues given consideration during the planning phase of the Thika Superhighway Project?

b) If No, in a) above give reasons?

6a) Which design standards was the Thika Superhighway road design based on?

b) Do the design standards in a) above factor road safety during road design?

c) If No, in b) above give reasons?

7a) Which road safety measures were considered during the planning phase of the project?

b) Which construction work zone devices were planned for?

c) Were road safety audits planned for?

d) If Yes in c) above, at which phases of the project lifecycle were road safety audits planned for?

e) If No in c) above give reasons?

8 a) Were there plans to inform road users especially drivers about the existence of a work zone in order to permit them to make any necessary changes (e.g. route change) in advance?

b) If Yes, in a) above how was it to be achieved?

c) If No, in a) above give reasons?

9a) Was there a provision for road safety in the total budget?

b) If Yes in a) above, what was the road safety budget as a percentage of the total contract sum?

c) If No, in a) above give reasons?

10 a) Which road safety measures were implemented during the construction of the Thika Superhighway project?

b) Which construction work zone devices were implemented?

c) At which phases were the road safety audits carried out?

11. What challenges did APEC/KeNHA face during implementation of the planned road safety measures?

12. By citing probable recommendations, give advice on how to ensure road safety measures are considered during the planning phase of projects of such magnitude.

UNIVERSITY OF NAIROBI

DEPARTMENT OF REAL ESTATE AND CONSTRUCTION MANAGEMENT

INTERVIEW GUIDE FOR KARA

INSTRUCTIONS

Please tick and/or state the appropriate answer in the space(s) or box (es) provided. More than one answer may be ticked or stated where applicable.

General Information

1a) When and how did KARA first learn of the plan to rehabilitate Thika road to Thika Superhighway?

b) Was KARA involved in any of the consultative public meetings during the planning phase of the project?

c) If Yes in b) above, when did you first get involved?

d) If No in b) above, what are the reasons for lack of involvement?

e) If Yes in b) above, was road safety one of the issues given consideration during the planning phase of the Thika Superhighway Project?

2a) Was there an increase in the number of accidents on the highway since the commencement of the project?

b) If it's an increase in a) above which period within the road project lifecycle was it prone to most accidents hence more injuries and fatalities?

3. What are some of the safety challenges residents and road users experienced during the highway construction?

4a) In your opinion, which category of road users' safety was not adequately planned for and implemented?

b) What could have led to a) above?

5. By citing probable recommendations, give advice on how to ensure safety considerations are factored in during the planning phase of projects of such magnitude.

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DEPARTMENT OF REAL ESTATE AND CONSTRUCTION MANAGEMENT

INTERVIEW GUIDE FOR RESIDENTS

1a) How often do you use the Thika superhighway?

b) Do you live or do business along the highway?

c) When and how did you first learn of the plan to rehabilitate Thika road to Thika Superhighway?

d) Were you involved in any of the consultative public meetings during the planning phase of the project?

e) If Yes in d) above, was the safety of road users and local residents given considerations in the public meetings?

f) If No in d) above, what are the reasons for lack of involvement?

g) If Yes in d) above, were there plans to inform road users especially drivers about the existence of a work zone in order to permit them to make any necessary changes (e.g. route change) in advance?

h)If Yes in g) above how was it to be achieved?

2a) In your opinion, was there an increase in the number of accidents on the highway since the commencement of the project?

b) If it's an increase in a) above which period within the road project lifecycle was it prone to most accidents hence more injuries and fatalities?

c) In your opinion, which category of road users' safety was not adequately planned for and implemented?

d) What could have led to c) above?

3. What are some of the safety challenges that residents and other road users experienced during the highway construction?

4. By citing probable recommendations, give advice on how to ensure road safety measures are considered during the planning phase of projects of such magnitude.

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DEPARTMENT OF REAL ESTATE AND CONSTRUCTION MANAGEMENT

QUESTIONNAIRE TO THE TRAFFIC POLICE

INSTRUCTIONS

Please tick and/or state the appropriate answer in the space(s) or box (es) provided. More than one answer may be ticked or stated where applicable.

1 a). What is the traffic composition along the Thika Superhighway?

Vehicle type	**Lot 1**	**Lot 2**	**Lot 3**
Cars, Pick-ups & 4WDs			
Matatus and minibuses			
Light and medium trucks, buses			
Heavy trucks			
Motor cycles and Tuktuk			

b). What are the cumulative casualties and their severity along the Thika Superhighway for the last five years (2008 -2012)?

Year	**Fatal**	**Serious Injury**	**Slight Injury**
2008			
2009			
2010			
2011			
2012			

c) From **b)** above which period within the road project lifecycle was it prone to most accidents hence more injuries and fatalities?

a.Pre-construction (2007-2009) ☐

b.Construction (2009-2012) ☐

c.Pre-opening (2012-2013) ☐

d.Post-construction (2013 to date) ☐

d). Which category of road users' safety was most affected?

a. Motorists ☐

b. Cyclists (pedal cyclists) ☐

c. Passengers ☐

d. Pedestrians ☐

e. All of the above ☐

2. By citing probable recommendations, give advice on how to ensure road safety measures are considered during the planning phase of projects of such magnitude.

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QUESTIONNAIRE TO CHINA WU YI/SHENGLI/SINO HYDRO

INSTRUCTIONS

Please tick and/or state the appropriate answer in the space(s) or box (es) provided. More than one answer may be ticked or stated where applicable.

Background Information

1. In what capacity do you serve in this firm?

   a. Director ☐

   b. Project Manager ☐

   c. Site Manager/Agent ☐

   d. Site Supervisor ☐

   e.Others (Specify)...

2. How many years have you served in this firm?

   a. Less than 1 year ☐

   b. 1-5 years ☐

   c. 5-10 years ☐

   d. 10-15 years ☐

   e. More than 15 years ☐

3. How many years has your firm been in business?

   a. Less than 1 year ☐

   b. 1-5 years ☐

   c. 5-10 years ☐

   d. 10-15 years ☐

   e. More than 15 years ☐

4. How many years has your firm been operating in the Kenyan construction industry?

a. Less than 1 year ☐

b. 1-5 years ☐

c. 5-10 years ☐

d. 10-15 years ☐

e. More than 15 years ☐

5. Under what category of contractors registration by the National Construction Authority (NCA) is your firm registered?

a.NCA1 ☐

b.NCA2 ☐

c.NCA3 ☐

d.NCA4 ☐

e.NCA5 ☐

f.NCA6 ☐

g.NCA7 ☐

General Information

6. The following parameters are considered important to a contractor? Please indicate their level of importance to your firm.

Level of importance: Very Important = VI (5), Important = I (4), Somewhat Important =SI (3), Less Important LI (2) and Not Important=NI (1)

Parameters important to a contractor	**Level of Importance to the contractor**				
	VI	**I**	**SI**	**LI**	**NI**
	5	**4**	**3**	**2**	**1**
Safety consciousness					
Quality consciousness					
Time consciousness					

Cost consciousness					

7 a) Which road safety measures did your firm implement during construction of the Thika Superhighway in order of priority? (Tick where appropriate)

Safety Measures	
Wayside amenities	
Bus stops	
Delineators	
Road appurtenances	
Traffic signs	
Road markings	
Traffic control devices	
Cycle lanes	
Footbridges	

b) Which construction work zone devices were implemented during construction of the highway

Safety Measures	**Highest priority**
Physical design	
Traffic control devices	
Miscelleneous	
Road equipment	

8 a) Was there a provision for road safety in the total contract sum?

Yes ☐ No ☐

b) If **Yes** in **a**) above, what was the road safety as a percentage of the total contract sum?

a. Less than 1% ☐

b. 1-3 % ☐

c. 3-5 % ☐

d. 5-7% ☐

e. 7-10% ☐

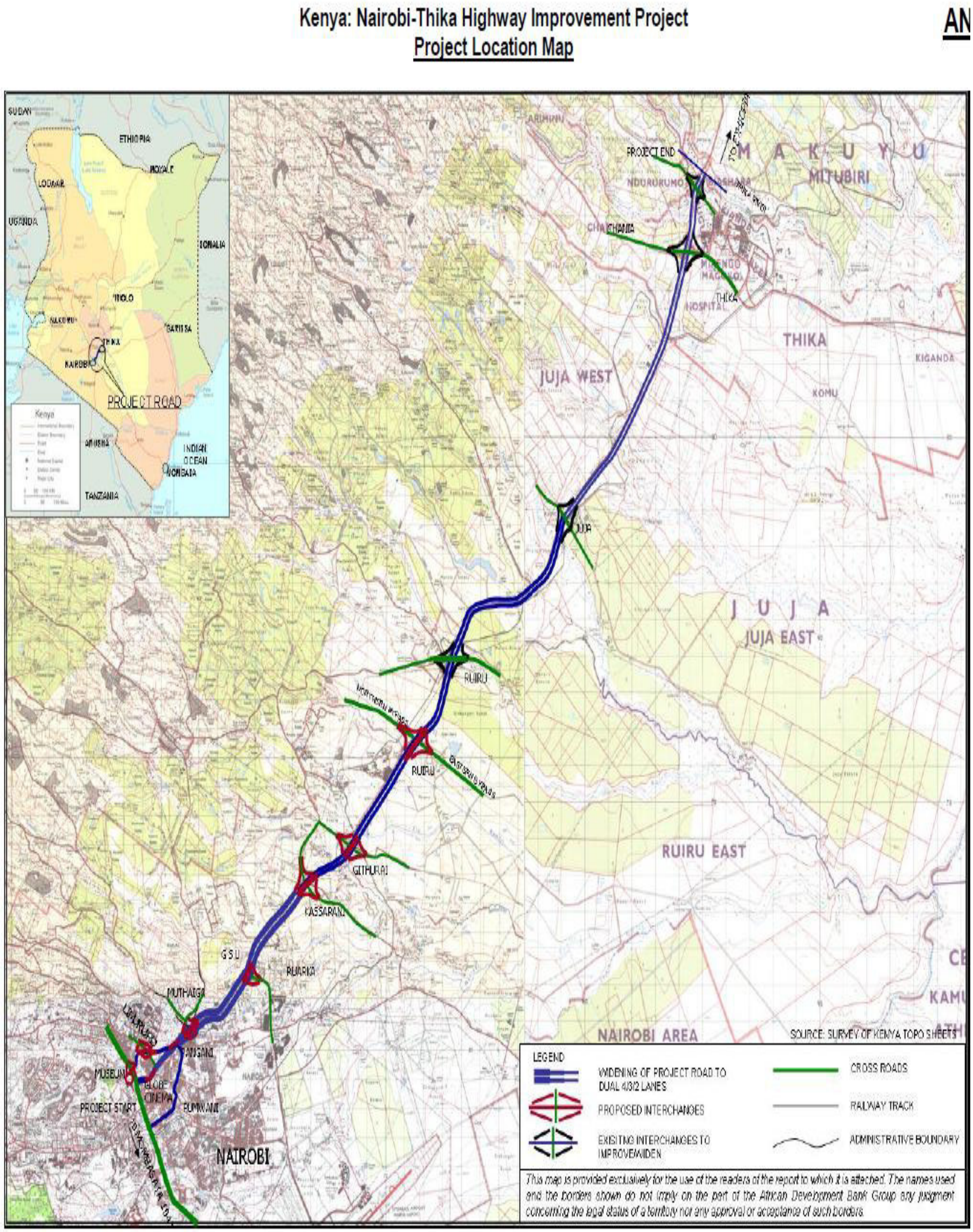
f. More than 10% ☐

9. What challenges did **China Wu Yi/Shengli/Sino Hydro** face during implementation of the safety measures?

	Most Likely	**Likely**	**Least Likely**
Weak policy, legal and institutional framework			
Inadequate resources			
Poor human behaviour			
Inadequate Traffic enforcement			
Poor road infrastructure design			
Ineffective communication and coordination			

10. By citing probable recommendations, give advice on how to ensure road safety measures are considered during the planning phase of projects of such magnitude.

Appendix iii – Map of Nairobi-Thika Superhighway



Source:ADF,2007