SUSTAINABLE EXCAVATION WASTE MANAGEMENT ON CONSTRUCTION SITES; CASE OF NAIROBI COUNTY, KENYA

BY

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A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILLMENT FOR THE REQUIREMENTS OF THE AWARD OF THE DEGREE MASTER OF ARTS IN CONSTRUCTION MANAGEMENT IN THE SCHOOL OF THE BUILT ENVIRONMENT, DEPARTMENT OF REAL ESTATE AND CONSTRUCTION MANAGEMENT.

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DECLARATION

DECLARATION BY THE CANDIDATE

This research project is my original work and hasn't been presented for a degree in any other University. No part of this research project may be reproduced without prior permission from the author and/or University of Nairobi.

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DECLARATION BY THE SUPERVISORS:

This research project has been submitted for examination with my approval as the University supervisor.

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DEDICATION

To my mother, Elizabeth Chepkirui Kibowen, for the much you did to allow me to live a good and carefree existence. This is dedicated to you, and I pray that I too, just like you, shall be a woman of Proverbs 31.

ACKNOWLEDGEMENT

This work has been a product of much contribution and assistance from not only individuals but institutions as well. For it to have reached this stage I am greatly indebted.

Foremost, I give thanks to the almighty God for giving me strength during the assignment, (Psalms 9:1).

A special thank you to Dr. Isabella Njeri Wachira-Towey for reading this paper and guiding me from the beginning to the end. Her patience is admirable; she is truly a great teacher.

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To my boys Eli and Colin who bring to my life great joy. My heartfelt gratitude to my husband Denis for his love and encouragement as I completed this task. To my cherished brothers Evans and Peter, words are powerless to express my gratitude. I am indebted to my father Joseph, for the sacrifices made during my upbringing - no greater man exists.

None of the persons named for their contributions to the completion of this project are responsible for any errors of fact, omission or commission. The author takes full responsibility for the contents of this project.

ABSTRACT

This project looked into the management of excavated waste within the construction industry specifically targeting Nairobi, Kenya. The aim was to investigate sustainable excavation waste management practices in construction sites. The specific objectives looked into the identification and sustainability of waste management techniques applied and the challenges faced in managing excavation waste. The study is important to drive towards a sustainable construction industry as excavation waste produced by the sector contributes to the waste stream and affects the environment.

The research design applied was a case study research. The target population were NCA 1 contractors' sites with commercial building projects commissioned during the period 2011-2016. A random selection of the registered NCA 1 building contractors was done and 45 questionnaires were sent out to NCA 1 contractors' sites. The three part Questionnaire was used as the main instruments of data collection in the study.

Data was analysed using both qualitative and quantitative techniques. Findings indicated that the main type of waste was uncontaminated soil and sand with the volumes majorly determined by the excavation method used. The contractors used site waste management plans to manage excavation waste and were aware of the environmental and economic benefits of the same. The type of waste, the extent and cost were the major challenges faced in implementation of sustainable techniques.

The study recommends proper recording of excavation waste activities and construction companies be encouraged to reuse the waste for a sustainable industry.

CONTENTS

ABBREVIATIONS

BREEAM	- Building Research Establishment's Environmental Assessment Method
C&D	- Construction and Demolition
DFE	- Design for Environment
EMCA	- Environmental Management and Coordination Act
GDP	- Gross Domestic Product
GDPCF	- Gross Domestic Private Capital Formation
GoK	- Government of Kenya
I.C.E.	- Institute of Civil Engineers
ISWM	- Integrated Solid Waste Management
JICA	- Japan International Cooperation Agency
KPIs	- Key Performance Indicators
KNBS	- Kenya National Bureau of Statistics
LEED	- Leadership in Energy and Environmental Design
MLIT	- Ministry of Land, Infrastructure, Transport and Tourism
NCA	- National Construction Authority
NCC	- Nairobi City County
OSHA	- Occupational Safety and Health Administration
SWM	- Solid Waste Management
UK	- United Kingdom
US	- United States

WRAP	- Waste Resources and Action Program

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CHAPTER ONE: INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Due to the importance of the construction industry, it is necessary that its performance be sustainable so that its contributions to all aspects of development in the country such as socio-economic and environmental will not be compromised. Waste produced by the industry is however excessive albeit the economic and social gains it proffers. In England and Wales alone, Construction and Demolition (C&D) waste accounts for ninety million tonnes every year (ICE, 2014). Nagalli (2012) noted that in Brazil, the robust development of the industry created a high concern for construction waste problem and management. According to South Africa's National Waste Information Baseline Report (2012), C&D waste contributed to 21% of all municipal waste streams on average. This amounted to 4,725,542 tonnes of which only 16% was recycled.

Increased demand by the public and new laws enacted on managing the environment, trigger better waste management. Increased demand is also mounting for the development of environmentally friendly products and processes (Browne et al., 1995). In Finland, for example, there is a classified waste charge by its toxicity, and thus contractors find it economically viable to invest in waste reduction processes (VTT, 1997).

The EMCA (Waste Management) Regulation of 2006, Part 1 under preliminary provisions gives emphasis or specific definition to different types of waste such as domestic waste and industrial waste with little regard to excavation or general construction waste. In part II, Section 4 (1), "*prohibits disposal of waste on a public highway, street, road, recreational area or any public place. All waste ought to be disposed in designated waste* *locations*" while Section 5 (1) requires waste generators to reduce their waste by instituting cleaner production processes.

Two major expenses arise in the handling of waste by contractors, that is, transportation and disposal of site waste (Macozoma, 2002). Infrastructure projects experience costs of up to 30% of the project's budget for handling and hauling of excavation waste (Magnusson et al., 2015). Construction companies can also be fined substantially for illegal dumping or for work that results in pollution of the environment which then negatively impacts their overall profits.

Pollution of the environment by waste generated also impacts an economy. Funds are apportioned in corrective measures after the environmental damage is conducted. Contaminants arising from the construction process perturbs labourers and the neighbourhood. The surrounding ground, air quality, and aquatic ecosystems are also afflicted. The natural environment is threatened by the exploitative nature of construction practitioners in this industry who are faced with the problem of balancing sustainable construction methods on their projects and the human need for shelter and development in a cost-effective manner. Garbage heaps, clogged drainage and sewers, landfills abutting residential areas and diseases resulting from the waste also plague our cities.

Therefore, despite the importance of the construction industry to the economy of Kenya, it is necessary to explore its performance on aspects of sustainability in relation to excavated waste, so that its contributions to all aspects of development in the country are not compromised.

1.2. STATEMENT OF THE PROBLEM

The impact of waste generated by the construction industry is a severe issue for any economy. The impact of waste on the sector is vital in regards to financial gains by its practitioners. The products of the construction industry additionally contribute to resource depletion and pollution of the environment.

Construction activities include a significant component of excavation. This includes but is not limited to road construction, commercial or residential developments including utility services installation. Two types of excavated materials experienced can be classified as either clean (that is uncontaminated, subjected to spills of a petroleum product, hazardous waste or co-mingled with other types of solid waste) and contaminated material (Bilitewski et al., 2013). Ferguson et al. (1995) noted that recycling for domestic waste has been a significant subject for a while, yet construction waste (including excavation waste) has not received the same sort of attention. C&D waste constitutes 15-30% of the cumulative waste that ends up in dump sites in several countries on average (McDonald et al., 1996). The excavated material makes up the most significant percentage of Construction and demolition waste, that is, 76% by weight (Bilitewski et al., 2013).

Kioko (2007), in his study on the identification of waste determining factors in Kenyan Construction Industry, proposes that the problem of waste which is inherent in most construction processes is due to lack of awareness by design professionals and contractors on various sources and types of waste occurring at different stages of a project.

An observation of building contractors operating within Nairobi shows an attempt to reuse some of the waste generated during the substructure works although a sizeable chunk of the excavated waste is carted away to landfills or sometimes illegally dumped. Some contractors do not utilise new strategies for excavation waste management and are often \reluctant to implement sustainable waste management techniques as they believe these practices will increase their project costs. These practices are a nuisance to the public in many countries worldwide. For instance, in Istanbul, problems caused by the subway excavation ranged from dust in summer and mud covering roads and pedestrian paths during winter (Ocak, 2009).

The wrong disposal of excavation waste is a global problem with effects including clogging of drains resulting in stagnation of water and flooded roads after rain spells. In turn, this encourages the breeding of mosquitoes or the contamination of water bodies. Ocak (2009) notes that excavated material piled on sites (or other suitable locations) before dumping causes the material to drop around and cause sour sights.

Solid waste in Nairobi is primarily from industrial waste, and mismanagement of the waste pollutes the environment and poses danger to the public health (UNEP, 2005 and Ikiara et al. 2006). In Nairobi, collection of solid waste by the County Council is estimated to be as low as 25% of the estimated 1500 tonnes generated daily (JICA, 1998). The Nairobi County Council has inadequate capacity to tackle the total waste generated leaving industries with the responsibility of collection and disposal of waste in designated landfills. The cost of handling excavation waste and applying corrective measures after damaging the environment impacts on the industry's profits and in turn the economy.

Therefore, this research examines the practice of construction excavation waste management by NCA 1 construction firms in Nairobi, Kenya.

1.3. RESEARCH QUESTIONS

The research questions for theis study were:

- What are the excavation waste volumes on office block construction sites in Nairobi County?
- What are the excavation waste management techniques applied by NCA 1 building contractors on these sites?
- How sustainable are the excavation waste management techniques to NCA 1 building contractors in Nairobi County?
- What challenges do NCA 1 building contractors experience in effecting sustainable excavation waste management techniques?

1.4. RESEARCH OBJECTIVES

The primary objective of this research is to investigate sustainable excavation waste management practices in construction sites in Nairobi County.

Specific objectives of this research project are:

1. To examine the volumes of excavated waste on office block construction sites in Nairobi County.
2. To identify the excavation waste management techniques applied by NCA 1 building contractors on these sites.
3. To evaluate the sustainability of excavation waste management techniques amongst NCA 1 building contractor sites.
4. To examine challenges experienced by NCA 1 building contractors in effecting sustainable excavation waste management techniques.

1.5. PROPOSITION OF THE STUDY

Excavation waste management techniques applied in construction sites in Nairobi have a significant correlation with excavated waste volumes.

1.6. JUSTIFICATION OF THE STUDY

The construction industry in Kenya needs to be sustainable in its performance so that its contributions to all aspects of development in the economy are maximised. The excavation waste produced by the sector contributes to the waste stream and causes environmental damage. This study addresses the issue of excavation waste in the industry as it affects the environment.

This study is also vital in the drive to change the perception of the sector of being dirty, dull and dangerous and move forward to a sector that is sensitive to the environment and one that protects it.

1.7. SIGNIFICANCE OF THE STUDY

This research may benefit persons seeking information on sustainable excavation waste management in the Kenyan Construction Industry, and its findings may be of interest to the following:

The government, its agencies, and policymakers by gaining insight on sustainable excavation waste management techniques in construction sites to ensure sustainability.

The study is envisaged to add to the existing field of knowledge of sustainable waste management in construction sites to ensure sustainability in the Construction Industry in

Kenya. This study can be used as a basis for further research in the area of sustainability in the Construction Industry.

The study stands to benefit all the professionals within the Construction Industry both in the public institutions and private sectors as they will understand the best practice of sustainable excavation waste management within the construction sites to ensure sustainability in the Construction Industry.

1.8. ASSUMPTIONS

This study assumes that NCA 1 contractors apply sustainable techniques while carrying out excavation works during construction.

1.9. SCOPE OF THE STUDY

1.9.1. Conceptual Scope

Many factors notably affect sustainability within the construction industry primarily in a building construction site. The study focuses on the sustainable excavation waste management techniques applied in the Kenyan construction sector to improve sustainability within the industry. The evaluation of the excavation waste management techniques is based on the general environmental sustainability theories and concepts.

The study further evaluates the effectiveness of the excavation waste management techniques in the Kenyan Construction industry relative to the prevailing environmental management legal and institutional framework. The study additionally establishes the techniques applied in other countries, which could be adopted by Kenya to ensure sustainability in the construction industry.

1.9.2. Physical Scope

To achieve the objectives of the study, building construction sites operated by the NCA 1 contractors in Nairobi were used as a case study. Nairobi City is considered to be the nerve of commercial activities in Kenya, and so the relative volume of construction of commercial structures in the city is very high. Construction firms in the Kenyan Construction industry comprise of all the contractors registered by the National Construction Authority. However, the study restricted itself to those firms which undertake work of unlimited amount of Kenyan shillings. These are firms in category '1'. It is known that projects such as commercial buildings undertaken by NCA 1 construction firms are required by law to ensure environmental sustainability within the construction. Therefore, commercial buildings which were undertaken by NCA 1 contractors provided a better case of sustainable excavation waste management practices which was significant to this study.

1.10. DEFINITION OF TERMS

Built Environment: Man-made spaces where humans live, work and entertain daily. (Roof and Oleru, 2008).

Commercial buildings: Structures used for office related activities such as general, professional, or administrative offices (U.S. Energy Information Administration, 2007)

Construction Industry: Economic activities involving construction of physical structures, such as buildings and infrastructure. (Omar, 2006)

Construction waste: as the "*non-hazardous by-product resulting from activities during construction*" (Macozoma, 2002)

Excavation waste: Reinhard (2014) defines it as "*excess material that arises from excavation and site clearance works, and chiefly consists of topsoil and subsoil. To qualify as excavation waste, any other material must already be present in the ground prior to excavation*."

Natural Environment: "*The non-human surroundings within which people and their products live in*" (Sutton, 2007).

NCA 1 Contractor: For this study, the NCA 1 Contractor is one who is capable of carrying out work of unlimited contract value (Contractors- Building).

Solid Waste Management: "*All activities related to the control, collection, transportation, processing, and disposal of waste in accordance with the best principles*" (Munala and Moirongo, 2011).

Sustainability: defines it as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (World Commission, 1987).

Sustainable construction: Refers to "*the application of sustainable development to the construction industry*" (AggRegain, 2007).

Waste Management: Any process that "*avoids, eliminates or reduces waste at source*" (Crittenden, 1995).

Waste: "*Any substance or object that is or is intended to be discarded*" (Nema, 1999).

1.11. ORGANIZATION OF THE STUDY

The study was arranged into five sections;

Chapter One forms the introduction and contains the preliminary items forming the background, statement of the problem, objectives, research questions, scope and justification and finally the organization of the study.

Chapter Two looks into the existing literature, articles, and researches related to sustainable excavation waste management in theory and practice. The theories and concepts in the literature became the basis for identifying and understanding sustainable waste management within the construction industry.

Chapter Three delves into the methodological guide on conducting the research particularly the data to be gathered, gathering method, analysis approaches, and ethical concerns of the research.

Chapter Four gives data presentation and analysis seeking to answer the problems identified.

And finally, Chapter Five contains the conclusions and recommendations of the study based on the findings from the data presented and analysed.

CHAPTER TWO: LITERATURE REVIEW

2.1. INTRODUCTION

This chapter delves into the literature on issues of sustainable excavation waste management systems especially about the construction industry; the sources of excavation waste in the construction industry; types of excavation; management techniques for excavated waste and legal and institutional framework for excavation waste management in the Kenyan construction industry. The literature review includes secondary materials on conceptual issues in sustainable excavation waste management within the construction industry.

2.2 POLICY AND REGULATIONS FOR WASTE MANAGEMENT IN KENYA

Kenya has extensive laws, regulations and policies dealing with management of waste. The United Nations Environmental Programme taskforce (2009) for Integrated Solid Waste Management Project analysed and summarised these as follows:

2.2.1 Existing Laws and Acts of Parliament

a. Environmental Management and Co-ordination Act (EMCA) No. 8 of 1999

i. Waste Segregation and Reduction at Production and Consumption Levels

This act establishes the institutional framework for environmental management pertaining to the handling and disposal of waste such as excavation waste. It requires waste generators to minimize waste through treatment, reclamation and recycling. The act also appropriates punishment for those contravening the law (sub-section 5). The act, in this context, directs the reduction of construction waste at source level.

ii. Primary Storage, Collection, Transportation and Transfer Stations

Section 87(2), paragraphs (a) and (b) of EMCA provides "*That no person shall transport any waste other than- in accordance with a valid license to transport waste issued by the Authority; and to a waste disposal site established in accordance with a license issued by the Authority*".

iii. Treatment and Landfills

Section 87(5) of the Environmental Management and Co-ordination Act (EMCA) emphasizes the need to treat the waste that is generated by any source by employing measures to minimize waste. Section 86(2) stipulates that "*The Standards and Enforcement Review Committee established under section 70 shall, in consultation with the relevant lead agencies, recommend to the Authority measures necessary to: prescribe standards for waste, their classification and analysis, and formulate and advise on standards of disposal methods and means for such wastes*". These standards are not strictly followed case in point the Dandora landfill site in Nairobi County.

iv. Resource Recovery and Construction and Demolition Waste

The general provision in the waste management regulations states "*That a waste generator shall minimize the waste generated by enabling the recovery and re-use of the product where possible and reclamation and recycling*." Section 87(4) of EMCA states that "*every person whose activities generate waste shall employ measures essential to minimize wastes through treatment reclamation and recycling*." Contravening this section attracts "*Imprisonment for a term of not more than two years or a fine of not more than one million shillings or both imprisonment and fine*."

b. City Council of Nairobi (Solid Waste Management) By-Laws of 2007

i. Solid Waste Segregation and Reduction at Production and Consumption Levels

The County Council of Nairobi has the primary duty of regulating and managing the solid waste that is generated within the city limits.

Section 4(7) of the City By-laws states that "*The occupier or owner of any residential dwelling or trade premises within area of jurisdiction of the County Government shall deal with the waste arising from the premises in accordance with the directions issued by the Council either specifically or under the scheme or arrangement established by the County Government under these By-laws for the management of domestic and trade waste arising in the area where the particular occupier or owner resides or carries on business or other activities*."

According to section 8(4) "*It shall be the duty of every occupier and every owner of premises wherein any hazardous waste or clinical waste is generated to make suitable arrangements, including the separation of such waste from other non-hazardous waste or nonclinical waste, to the satisfaction of the council*." This is hardly done in the construction sector thus the broken link between the practice and the provisions.

ii. Resource Recovery and Construction and Demolition Wastes

According to section 9(8), the council shall "*Make provision for small-scale resource recovery activities to be undertaken by organized groups at designated sites before disposal*." The council, however, does not make provisions for such activities as stipulated in its by-laws but does not also charge any persons who do as it's seen as an informal activity meant to help the council to reduce solid waste.

c. The Building Code of 1987

Construction and Demolition waste is not provided for in most of the Kenyan acts, but the building code does provide for its handling. Section 239(1) provides "*That any person who except with either the prior consent of the council deposits or causes or permits to be deposited any builder's debris upon any street shall be guilty of an offense*." Sub-section (2) allows the council without prejudice to cart away the same and may, if it deems fit, to sell such material, plants and debris. The council in removing the debris shall recover any expenses from the person(s) who deposited or caused or permitted to be deposited, such materials. Section 240(4) states that "*The owner or contractor shall on completion of the demolition ensure that all materials and debris, not forming part of any remaining structure or in any way supporting any other structure, be removed from the site and that the site is left in a clean and tidy condition*."

If found guilty of contravening or failing to comply, the accused shall be, "*Liable to a fine not exceeding two thousand shillings or imprisonment for a term not exceeding six months or to both such fine and such imprisonment and of the offence is of a continuing nature to a further fine not exceeding twenty shillings for every day or part thereof during which such offence shall continue but in any event the aggregate of such fine imposed shall not in any case of any one continuing breach of the by-laws exceed two thousand shillings.*"

The disparity, however, is that the law does not address disposal of C&D waste though section 142(1) says that "*Before a certificate of completion is issued in respect of any building, by the council, the means of refuse disposal shall be completed and the receptacles or containers provided*."

Currently, Construction and Demolition waste in Nairobi is at the Dandora dumpsite, and anyone found dumping elsewhere is guilty of an offense and is therefore arrested by the city council's officers.

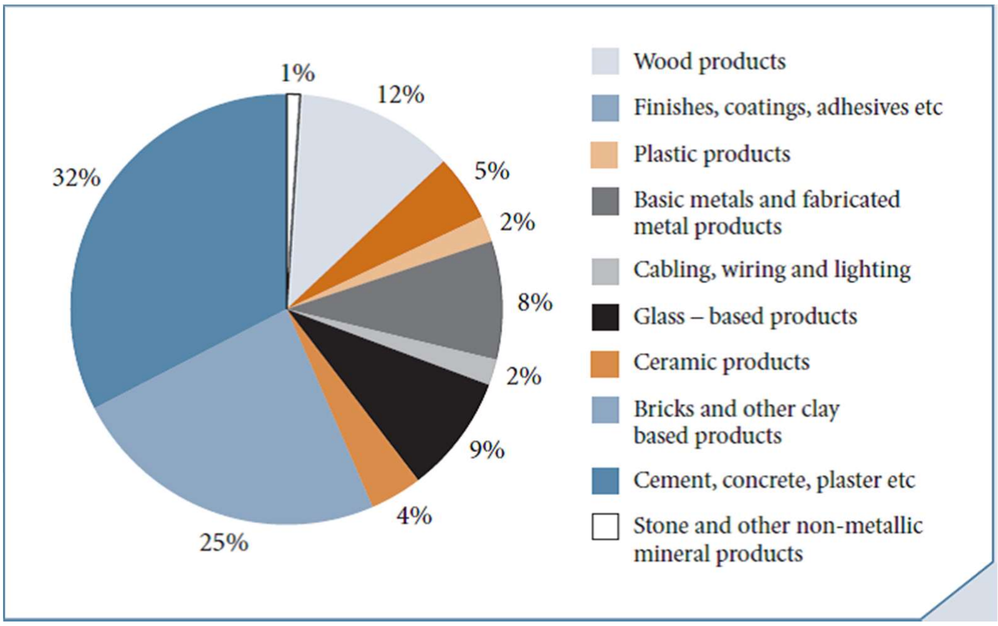
2.3. CONSTRUCTION AND DEMOLITION WASTE

Waste produced by the building sector is on the increase in Kenya due to the significant growth of the industry. Throughout the life cycle of the building encompassing the design and construction phase, usage, renovation and demolition, waste is produced. Arslan et al. (2012) noted that generation of Construction and Demolition waste depends on the type and function of the project during the entire life cycle. He also pointed out that 10% of materials used at construction turn into waste whereas demolition and renovation processes produce ten times this amount.

Much of this waste consists of buidling blocks, concrete, and wood. This can be up to 10 to 15% of the materials that go into construction (Abhijith et al., 2014), a higher percentage than the 2.5-5% assumed by quantity surveyors (Skoyles, 1987).

Various materials consist the waste found in the industry. Fig. 2.1 below shows types of wastes from construction materials and products generated.

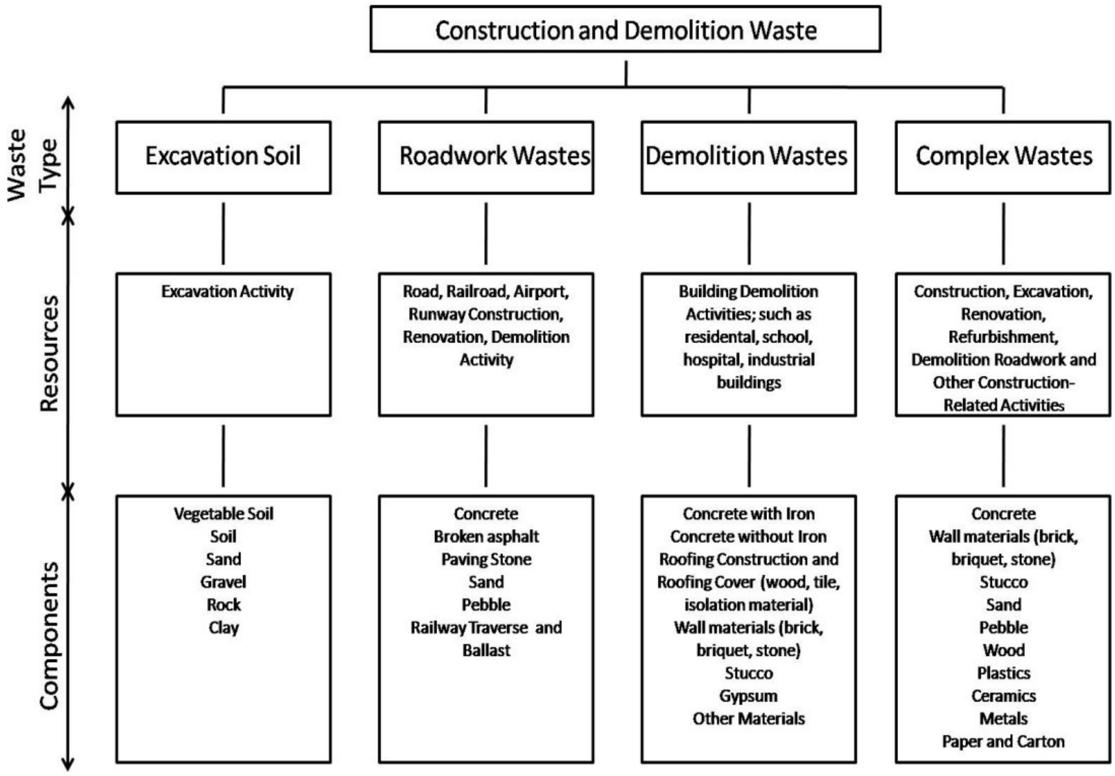
Fig. 2.1: Waste from construction materials and products



Source: Bradley (2012)

Arslan et al. (2002) grouped Construction and Demolition waste as figure 2.2 below. Excavation and noted that the primary methods used to dispose of the waste included landfill, incineration, and recycling.

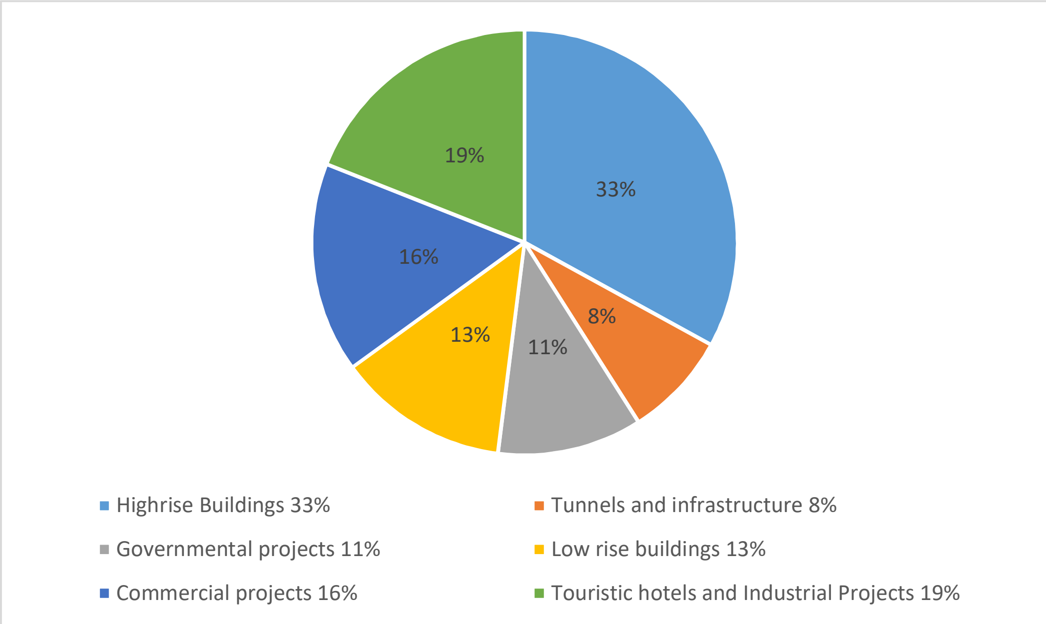
Fig. 2.2 Construction and Demolition waste grouping.



Source: Arslan et al. (2012)

It is estimated the waste output on a construction site can be estimated to be up to 30% of the total weight of materials supplied to the site (Fishbein, 1998). The quantity and quality of construction waste produced in a project vary depending on the project's complexity and materials involved as shown in the case of Egypt by figure 2.2 below.

Fig. 2.3: Projects generating construction waste in Egypt



Source: S. Haggar (2010)

Haggar (2010) found that High rise buildings generated the most waste at 33% while touristic hotels and industrial projects followed at 19% with commercial projects close by at 16%.

2.4. EXCAVATION

Excavation is a fundamental step in most infrastructure developments. Occupational Safety and Health Association - OSHA (2015) defines excavation as any "man-made cut, cavity, trench, or depression in the earth's surface as formed by earth removal" covering building to dams and highways. Excavation includes earthwork, trenching, creating of wall shafts, cut and fill of inclined grounds and tunneling.

2.4.1. Excavation Methods

Though excavation is mostly performed using mechanical means, the technique used depends upon a number of factors such as nature of subsoil, size of excavation, scale of work, groundwater condition, surrounding condition, budget, construction period, adjacent excavations, available construction equipment, foundation types of adjacent buildings, condition of adjacent buildings and the increased control over the job location (Wong, 2010). Some commonly used methods for excavation are the "full open cut method, braced excavation, the island excavation method, the anchored excavation method, the top down construction method and the zoned excavation method" (Ou, 2006). Wong (2010) notes that removal of the excavation waste can be as diverse as manual (e.g., using wheelbarrow), bucket and lift, hoist rack, gantry crane, conveyor belt and use of dump truck.

2.4.2. Excavation Waste

Reinhard (2014) defines excavation waste as "*material that arises from excavation and site clearance works, and chiefly consists of topsoil and subsoil*."

In 2012 in Japan it was estimated that the excavation waste amounted to approximately 140 million cubic meters (Ministry of Land, Infrastructure and Transport, 2014). In geotechnical and geo-environmental engineering, it is thus prudent to adequately consider the management of these generated soils (Katsumi, 2015).

2.4.3. Classification of Excavation Waste

Hyder (2011), classifies excavation waste emanating from civil and site preparation works in the following categories:

a. Rock and Excavation Stone

The rock and stone excavated depends on the geology of an area and can be produced as a bi-product (Hyder, 2011).

b. Soil / Sand

Large volumes of fine materials generated during excavation which unless reused on site will require treatment and/or disposal (Hyder, 2011).

2.4.4. Excavation Waste Volumes

Hyder (2011) notes that excavation waste is a complicated and problematic material stream in C&D waste. This is because of the high volume of material generated and a combination of two factors: one, is the potential for significant contamination, and the two is the perception by industry practitioners that any excavated waste is benign 'clean fill.'

Magnusson et al. (2015) noted that material flow analysis is an ordinarly used for describing the metabolism and regional flows of materials in the industry. McEvoy et al. (2004) used this method to study the flow of aggregates in the North West region of England and by Huang and Hsu (2003) to study regional flows of materials in Taipei excavated construction waste.

2.4.5. Excavation Hazards

The process of excavation if not handled appropriately can result in dangerous incidents and at times fatalities. According to the Ontario Ministry of Labour (2017), hazards experienced during excavation works include "*Cave-ins, falls, tripping, falling objects, exposure to underground or overhead services, unstable adjacent structures, mishandled* *or poorly place materials, hazardous atmosphere, toxic gases and incidents involving vehicles or other mobile equipment.*"

Reasonable precautions stipulated in OSHA section 25 (2) (h) to be considered are as follows: "*Determine the entry and exit of the excavation site, planning of tools and equipment, environmental hazards, vehicles and nearby equipment and train the workers.*"

2.5 SUSTAINABLE DEVELOPMENT AND WASTE MANAGEMENT IN KENYA

There have been increased calls to address environmental degradation in the later half of the 20th century. As a developing country aspiring to achieve developed country status by 2030, Kenya is faced with the same challenge of balancing economic growth and preserving the environment (JICA, 1998). This is a central theme of the Kenyan Vision 2030 and demonstrates the Government's commitment to sustainable development. UNEP (2002) acknowledges that "*There is not much literature on the Kenyan waste management sector with the exception of Nairobi*". Information available for Nairobi however mainly deals with household waste and the poor management of solid waste by the county government (Ikiara et al, 2006).

2.5.1 Construction Industry and Sustainable Development

Hendrickson (1998), stated that "*The construction industry is a conglomeration of diverse fields and participants that have been loosely lumped together as a sector of the economy.*" The sector contributes to national welfare through its products ranging from residential housing, office blocks, industrial buildings and infrastructure projects (Hendrickson, 1998). He further asserts that the influence of the industry goes beyond the value of its output or its contribution to employment, but also the role of its products which provide the basis for industrial production. To be more specific, construction refers to all types of activities usually associated with the erection and repair of immobile facilities.

The construction industry plays a significant role to achieve societal goals and contribute to the national output. It accounts for a sizeable chunk in the Gross Domestic Product (GDP) of developed and developing countries (Tse and Ganesan 1997). The importance of the sector can be perceived from the following statistics in a developed country like UK. In 2014, the output was 203 billion pounds, attributing to the total economy by 6.5%. This was an increase of 9.5% from the previous year. It contributed 6.5% of the Gross Value Added (GVA) and 6.3% of the workforce jobs (Rhodes, 2015). These figures are reflected in most developed and developing economies worldwide (Kwakye, 1997).

In Kenya, the industry is one of the leading economic engine drivers supporting the Kenyan national economy through significant contribution to the GDP. Infrastructure for both private and public use such as services, utilities, and industries are provided by the industry which in turn recruits directly and indirectly many individuals. Table 2.1 below presents the contribution of the construction industry to GDP, Gross Domestic Private Capital Formation (GDPCF), Wage Employment and Labour Earnings, for the period 2012 to 2016.

Table 2.1: The contribution of the Construction Industry to Kenya's Economy.

	2012	2013	2014	2015	2016
Key Indicator (Output) - Kshs. million	513,390	582,896	683,376	805,703	819,448
Gross Domestic Product as an Activity (At Market Prices) Kshs. million	190,851	213,565	262,090	309,046	359,656
Gross Domestic Product as an activity (At Constant 2009 Prices) Kshs. million	154,796	164,220	185,696	211,430	230,984
Growth Rates of GDP as an industry	11.3%	6.1%	13.1%	13.9%	9.2%
Sources of GDP growth, 2012-2016	10.6%	4.7%	11.0%	11.7%	8.2%
Percentage Contributions to GDP by Activity (Current Prices)	4.5%	4.5%	4.9%	4.9%	5.0%
Employment as an industry, 2012-2016 (in '000s)	98.7	111.6	132.9	148.0	163.0

Source: Economic Survey KNBS (2017)

This shows the steady growth of the sector as an activity whilst also increasing persons employed by the sector each year. In 2016 alone, 163,000 persons were employed by the industry alone while it contributed 5% to the GDP. Given its importance, it is necessary that the performance of the industry be efficient so that its contribution will not be compromised, but instead offer a holistic sustainable development.

2.5.2 Concept of Sustainable Construction Waste Management

Sustainable Construction is explained as applying sustainable development in the industry (AggRegain, 2007). The construction industry can be defined "*As all who produce,* *develop, plan, design, build, alter, or maintain the built environment*" (Ding et al., 2001). Ding et al. (2001) further expounded that the industry incorporates building material suppliers, manufacturers, clients, end users, and occupiers. Sustainable construction is as a subset of sustainable development. It covers tendering, material selection, site planning, recycling, and waste reduction during the construction process.

Hendrickson (1998) noted that promoting sustainable construction is difficult because of the fragmentation of the industry and lack of set mechanisms to ensure methods employed are directed towards environmental conservation. Design professionals and contractors who do not embrace changing technologies, due to fears of high development costs, are usually driven out of the mainstream design and construction arena (Hendrickson, 1998). Due to the efficiency (by performance and economic gains) of new technologies, the industry's quality and cost can be escalated.

Waste management is "*Any technique that either avoids, eliminates or reduces waste at its source*" (Crittenden, 1995). The focus of this research is on 'source reduction' techniques that ensure waste minimization during the excavation process.

Ball (1988) notes that the construction industry attracts negative publicity as being messy, high risk and insensitive to the environment. Its failure to adapt to new technologies gives it a reputation of being backward and immature (Santos, 1999). Therefore, it necessitates research especially on sustainable waste management to redeem its image.

Managing the construction process, to ensure that there is no waste to handle, is the best management approach to waste (Keys et al., 2000). This can be performed by designing out waste at the onset of the building process, though it may prove to be challenging. The concept of sustainable construction waste management begins by querying if the waste can be minimized or eliminated.

2.5.3 Causes of Waste in the Construction Process

Waste generation throughout the construction process is complicated because of the various processes, materials and players (clients, professionals, contractors, sub-contractors and suppliers) involved in creating the construction project (Cerna, 2013). Table 2.2 below summarises the leading causes of construction waste.

Table 2.2: Sources and causes of construction waste

Source	**Cause**
Design	• Erroneous contract documents • Incomplete contract documents • Design alterations .
Procurement	• Errors in procurement • Suppliers error
Material Handling	• Damages at transportation • Poor storage
Operation	• Workers errors • Equipment failure • Poor weather • Injuries on site • Damage caused by subcontractors • Material mishandling
Residual	• Poor workmanship • Offcuts • Packaging
Other	• Theft • No SWMP

Adapted from: Gavilan and Bernold (1994); Craven et al. (1994)

The above illustrates the various variables involving waste generation affecting the design and construction process. Design alterations during excavation, innefective transportation, poor storage, errors by workers, materials mishandling and a lack of an SWMP will increase excavation waste experienced in sites.The construction industry is thus rising to the presented opportunities to reduce waste in light of the increment of costs related to disposal (Baldwin, 2000).

2.6.SUSTAINABLE EXCAVATION WASTE MANAGEMENT TECHNIQUES

Government, industry, and environmentalists have a role to play in promoting sound environmental practices in the built environment during whole life cycle of structures. Management of excavation waste experienced during the construction processes is also an important consideration. According to Parsons and Hume (1997), the following waste management practices are performed in order of decreasing preference:

- Waste avoidance i.e. practices that prevent the production of waste
- Waste reduction i.e. practices that reduce waste
- Waste re-use i.e. direct re-use of waste materials
- Waste recycling or reclamation i.e. using components of waste in other process
- Waste treatment i.e. to reduce hazard, usually at the site of generation
- Waste disposal.

Excavation waste is mostly handled using the last three options. Due to limited capacity of dumping sites, reuse of excavated soils should be promoted and disposal of waste minimized (Kastsumi, 2015).

2.6.1. Sustainable Project/Product Design

Designers' decisions determine the type of waste experienced through the life cycle of the building including how the waste is handled whether (Gould et al., 1996). Design for Environment (DFE), is "*The process of minimising environmental impact (including waste) without sacrificing function and quality*" (Keys et al., 2000). Brezet (1998) describes the four types of eco-design as "*Product innovation, product re-design, function innovation and system innovation*".

Eco-design focusses mainly on innovation and redesign. Function innovation includes natural ventilation strategies and green design strategies while system innovation focusses on technology and investigates the purpose of the build. The strategy adopted is important in understanding the fundamental elements of product design. The waste streams ought to be determined by the designers in order to adopt a waste reduction strategy. Waste reduction approaches

Table 2.3: Waste Reduction Approaches

- Use of prefabrication and off-site prefabrication
- Standard component
- Realistic component size, capacity and specification
- Minimising temporary works
- Optimising design lives
- Allowing specification of recycled materials in design
- Designing for recycling and ease of disassembly
- Identification of materials/products which create waste
- Poor communication

Source: Baldwin (2000)

2.6.2. Site Waste Management Plan

There are various practices for dealing with construction waste, one of which is a Site Waste Management Plan (SWMP) (Oladiran, 2009). Oladiran (2009), explains that a WMP is "*A pictorial format of possible waste incidences and strategies to minimize them*". An SWMP assists construction practitioners in forecasting and recording waste likely to be experienced during the construction process. The SWMP also assists in management actions and decision making pertaining the reduction of waste to be sent to dump sites (Waste Resources and Action Program - WRAP, 2007). Waste removal processes are also recorded to assist in illegal dumping and resource efficiency by implemneting the 3Rs that is, reuse, recovery and recycling (Defra, 2009).

Some developed countries like the US, UK and Australia use SWMPs as a tool in construction to minimise the industry's impact on the environment and their economies

(Papargyropoulou et al, 2001). Cooperation in implementing the SWMPs involves all parties involved in the construction projects which is initiated at the pre-design stage and carried out to the decommissioning of the project.

Various countries have frameworks to rate the environmental sustainability of construction projects and practices. The US uses Leadership in Energy and Environmental Design (LEED), the UK has the Building Research Establishment's Environmental Assessment Method (BREEAM), the Green Building Index certification (Real Estate and Housing Property Developers' Association Malaysia, 2010) is used in Malaysia, Green Mark in Singapore, Green Star in Australia and many more. The projects are rated according to adherence to sustainable resource and waste management practices adopted.

The project manager provides information about the project and identifies the administrator of the SWMP and core persons involved in implementation during the various stages of the project. The KPIs are also agreed on at this stage.

Table 2.4 presents a general outline of a SWMP.

Table 2.4: Proposed Outline of SWMP

Project Stage	SWMP Actions
Project Set Up	• Enter project details
Concept Design	• Record waste prevention actions
Detail Design	• Forecast waste • Record waste reduction actions
Pre Construction	• Specify waste carriers • Plan waste destinations • Record waste management and recovery actions
Construction	• Enter actual waste arisings, reduction, recovery and management activities. • Carry out training, monitoring and recording.
Post Construction	• Compare actual against forecast waste management activities • Assess performance based on KPIs • Suggest improvement for next project

Source: WRAP (2011)

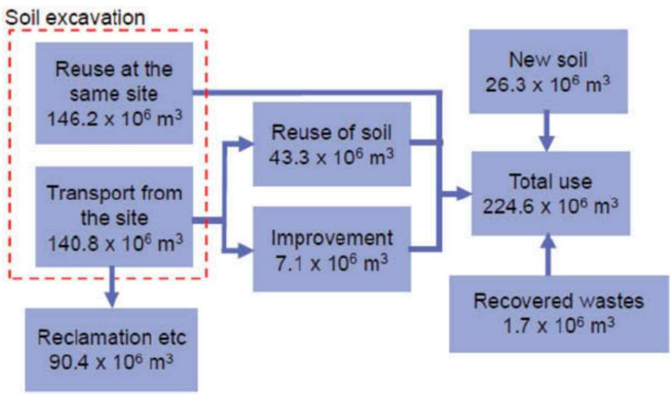
2.6.3. Sustainability in handling Excavation Waste

Excavation of soil and rock associated with the building process is synonymous with construction, especially in urban areas. The result of this is the excavated waste of which practitioners within the construction industry should not be allowed to avoid responsibility. The local government authorities should empower building inspectors to enforce sustainability regulations as part of their regular site inspections.

Contractors should be encouraged to reduce disposal at dump sites by reusing the excavated soils on the site or on other sites making the excavation waste valuable and less likely to be illegally dumped. Introduction of a landfill tax can foster and encourage practitioners to re-use and recycle more.

In Japan, excavated material is not categorised as waste but requires proper management, and of the 140 million cubic metres generated, 43 million is reused (Katsumi, 2015) as seen in Figure 2.4 below.

Fig. 2.4 Flow of soil excavation and utilization.



Source: Japanese Ministry of Land, Infrastructure, Transport and Tourism (2014)

Possible alternatives for excavated soil and rock management include: "use on site, use in other projects, pre-treated before use in other projects, store for later use and use as landfill cover or dispose at land fill" (Lafebre et al., 1998 and Eras et al., 2013)

2.7 PRINCIPLES OF SUSTAINABLE CONSTRUCTION WASTE MANAGEMENT

Construction projects should be designed to meet the dynamic needs of the society by providing spaces for people to enjoy, live and work efficiently.

Kibert (1996) proposed 6 principles for sustainable construction as:

1. Minimization of resource consumption;
2. Maximization of resource reuse;
3. Use renewable and recyclable resources;
4. Protect the natural environment;
5. Create a healthy and non-toxic environment; and
6. Pursue quality in creating the built environment.

2.8 EXTENT OF THE PROBLEM

Solid waste in Nairobi is primarily from industrial waste and mismanagement of the waste pollutes the environment and poses danger to the public health (UNEP, 2005 and Ikiara et al 2006).

Solid Waste Management "*is one of the important obligatory functions of any urban local authority"* (Munala et al, 2011). In Kenya, SWM is a challenge in that though it has been the responsibility of county governments, they have inadequate capacity to manage the waste within their counties. NEMA's facts about waste state that municipal waste generated have industrial waste adding up to 21% of the total (JICA, 1998). Industries in Nairobi are responsible for disposal of their waste at a municipal dumpsite.

According to Kenya's Vision 2030 (the second Medium Term Plan), the overall goal on the Environment, Water and Sanitation sector is to "*Attain a clean, secure and sustainable environment*" by the year 2030. The report also points out the importance of achieving this goal because environmental matters affect all sectors whereby 42% of Kenya's GDP is linked to natural resources.

2.9 CONCLUSION

Waste generated by the building industry is in the increase in Kenya due to the significant growth of the industry. Excavation and the waste generated from the process was considered from various angles. Excavation waste as defined by Reinhard (2014) is "*Material that arises from excavation and site clearance works and chiefly consists of topsoil and subsoil*." Excavation waste was classified as being either rock and excavation stone or soil and sand. Also, the study has looked into the hazards involved while handling the waste and the sustainable techniques employed to handle the waste which included the reuse on site, in other projects or pre-treating before reuse. Policy and regulations affecting waste management in Kenya showed that there is minimal focus on excavation waste and not much support offered by the governing authorities on its disposal.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

This chapter presents the research methodology of the study. It describes and justifies the methods and processes that were used in order to collect data was used in answering the research questions. It is presented under the following divisions namely: research design, population, sample size and sampling procedures, research instruments and data analysis.

3.2 RESEARCH DESIGN

A research design indicates the "*framework for the collection and analysis of data*" (Bryman, 2001). It is this regard that this research evaluated the sustainable waste management techniques applied in the construction industry. Zikmund (2003) defines a research design as "*A master plan specifying the methods and procedures for collecting and analysing data*". This study adopts a descriptive research design which according to Yin (2003) is a "*Study designed to depict the participants in an accurate way*".

The research was a case study of 'NCA 1" contractors' construction sites, which have been running and commissioned between the years 2011-2016. A case study is "An empirical inquiry that investigates a contemporary phenomenon within its real-life context whereby only a very small geographical area or number of subjects of interest are examined in detail" (Yin, 2003). The study narrows down to 'NCA 1' contractors registered in Kenya with the National Construction Authority. These are the firms which are responsible for carrying out building and civil construction works of unlimited amounts of money, usually running into billions of shillings. This class of contractors has been chosen for the study since they are licensed to handle big projects which more often required by law to ensure sustainable waste management within the construction sites and the anticipation that the larger the construction site the larger the quantity of excavation waste generated. Moreover these large firms are more likely to adopt appropriate waste management practises that may not be affordable to smaller firms.

A case study was preferred to other research designs because it provided an in-depth analysis into the concept of waste management in the construction industry, which was the object of the research. This was geared to help in identifying specific characteristics of the group chosen (Yin, 2003) that are typical of other similar cases.

3.3 SOURCE AND NATURE OF DATA

3.3.1 Area of Study

This research was carried out in Kenya, Nairobi County. This is because most of the 'NCA 1' contractors are located in this part of the country, and this region has been chosen to facilitate easy accessibility.

3.3.2 Target Population

The study targeted 165 'NCA 1' contractors who were registered by the National Construction Authority to carry out building works of unlimited amounts in the year 2016. The sites studied were those which excavation works have been carried out within the past five years. The persons targeted to answer the questionnaires at the construction sites for analysis included the site managers in charge of the operations of the sites.

3.4 SAMPLING

3.4.1 Sampling frame

The sampling frame included all the 'NCA 1' contractors registered by NCA in the year of the study 2016 and had construction sites within Nairobi between 2011-2016.

3.4.2 Sampling Technique and size

The 'NCA 1' contractors to be considered as respondents were sampled using a simple random sampling without replacement method. Since nothing much was known about the population, Nassiuma's formula (2000) was used to determine the appropriate sample size needed for the study using and acceptable coefficient of 30% and relative standard error of 5% on the 165 registered NCA 1 construction firms.

$$N = \frac{NC^2}{C^2 + (N-1)\,e^2}$$

Where 'n' is the sample size to be determined.

N is the total population of the NCA 1 contractors

C is the coefficient of variation 30%

e is the relative standard error, 5 % is acceptable

The sample size for the study was hence calculated as seen in table 3.1 below:

Sample frame (NCA 1 contractors)	Sample size	Sent Questionnaires	Realised response
165	30	45	39

$$n = \frac{(165x\,(30/100))^2}{(30/100)^2 + (165-1)x\,5^2/100} = \frac{14.85}{(0.09 + 164)x0.002} = \frac{14.85}{0.5}$$

n= 29.7 =30

After determining the targeted sample size of 30, the sample was drawn from the sample frame using a universal random sampling table (see appendix 3). The digits of the total population within the sample frame was considered. Three number digits were required; 001-165 with numbers exceeding 165 not usable and passed over while those less than 165 but repeating themselves were considered only once. Considering the first three digits of the table appended, selection begun at line 365 and random numbers were picked by reading across the columns, left to right, on each successive line. The obtained numbers were then marked on the sample frame to identify the specific firms to be interviewed that is 30 number. The survey was kept open for the selected firms as some firms had more than one construction site running between 2011- 2016. 45 questionnaires were thus sent out to the site supervisors to increase the chances of meeting the targeting sample size.

3.5 DATA COLLECTION

This section outlines the data collection instruments and the data collection procedure that were used in the research. The data was basically primary data for the study and the instruments that used were questionnaires and guided oral interviews to the target population which were the site managers and the construction managers.

3.5.1 Data Collection Instruments

The instruments designed for the study had 3 parts questionnaire that assisted in the collection of the data from the respondents (see appendix II). This data collection instrument allowed for both subjective and objective views of respondents to be assessed and also allowed the respondent ample time to answer the question. The part two and three had the 5 Likert scale that was used to collect data on the identified 'NCA" construction sites with Nairobi County. The likert scale allowed the respondents to choose an option that bests aligns with their view by asking the extent to which they agree or disagree with a particular statement.

3.5.2 Data Collection Procedures

Data for study was collected from both primary and secondary sources. A descriptive approach was applied to collect primary data. According to Naoum (2008) descriptive aims to answer questions as to: How many? Who? What is happening? Where and When?

3.5.3 Questionnaires

Data was collected through administering of both structured and unstructured questionnaires. Unstructured questionnaires; where questions are opened ended to the construction site managers and construction site workers basically to capture wide variety of responses without limiting the respondents, while the structured questionnaire guided the responses to the predetermined nature of the responses determined by the study. This was done to establish their understanding of sustainable waste management systems, to find out the various sustainable excavation waste management systems being undertaken by their firms in applying the concept and also the challenges arising therein.

The structured and unstructured questionnaires were designed using the reviewed literature as a basis, as it outlines the various forms of sustainable waste management systems that may have been identified in the construction industry. Beiske (2003) listed the advantages enjoyed in the use of questionnaires to collect data included but are not limited to; "practicality, large amounts of information collected from considerably large number of people in a short period of time and in a relatively cost effective way, the results of questionnaires could be quickly and easily quantified by either a researcher or through the use of a software package, possible to analyze data more 'scientifically' and objectively than other forms of research, after data had been quantified and easy to compare and contrast".

3.5.4 Review of Documents

The study of relevant internal documents such as the waste management reports, waste management plans, the sources of solid waste in the Kenyan construction industry, legal and institutional frameworks that govern waste management in the Kenyan construction industry among others were reviewed.

3.5.5 Piloting of Questionnaires

Ten (10) questionnaires were pilot tested to check the relevance of the questions, the understanding of respondents, identify any ambiguities, as well as the general availability of the various categories of information needed. The questionnaires were pretested before embarking on data collection exercise, which was administered to construction site managers and workers at the various NCA 1 construction sites identified within Nairobi

County. This was to ensure that out the responses given are in line with the expectations and if not amendments were done early enough.

3.6 DATA ANALYSIS AND PRESENTATION

Analysis of the data was done using both qualitative and quantitative analytical techniques. Tables, charts, percentages and textual write-ups of the data collected were used in the case of the quantitative technique, while descriptions were used in the case of the qualitative analysis.

The data collected was first cleaned to eliminate errors made during data collection. This was then coded and entered into the computer for analysis using Statistical Package for Social Sciences (SPSS version 15).

3.7 LIMITATION OF DATA COLLECTION

The data was collected from NCA 1 contractors practicing within the Nairobi County. As a result, the applicability of the findings to other geographical areas is uncertain and requires to be investigated.

CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS

4.1 INTRODUCTION

This chapter presents the findings of the study that was carried out to investigate sustainable excavation waste management on construction sites the case of Nairobi, Kenya. The objectives of the study were fourfold and included: To examine the excavation waste volumes on construction sites of office blocks in Nairobi County; to identify the excavation waste management techniques applied by NCA 1 building contractors on these sites; to examine challenges experienced by NCA 1 building contractors in effecting sustainable excavation waste management techniques and to evaluate the sustainability of excavation waste management techniques in NCA 1 building contractors' sites.

Questionnaires were used as the main instruments of data collection in the study. In this chapter, the data obtained from the research instruments were examined, analysed and interpreted in line with the purpose and objectives of the study, with a summary of the findings presented at the end of the chapter.

4.2 THE RESPONSE RATE

The survey targeted 45 respondents, mainly being site supervisory staff or the construction site managers' in-charge of the construction sites. From the total sample size of 45 sites run by NCA 1 contractors, 39 (86.67%) positively responded to the survey request. The percentage of those interviewed is statistically adequate as Babbie (2007) suggested that "any return rate over 50% can be reported, that over 60% is good, and that over 70% is excellent" as indicated by the survey's response rate. The response rate is further summarized as indicated in Table 4.1 below.

Table 4.1: The Response Rate

Questionnaires:	Sent	Returned	Response Rate (%)
Site Supervisory Staff	45	39	86.67%

Source; Author, 2016

The response rate of 86.67% is very good and sufficient for data analysis, reporting and drawing conclusions.

4.3 CHARACTERISTICS OF RESPONDENTS

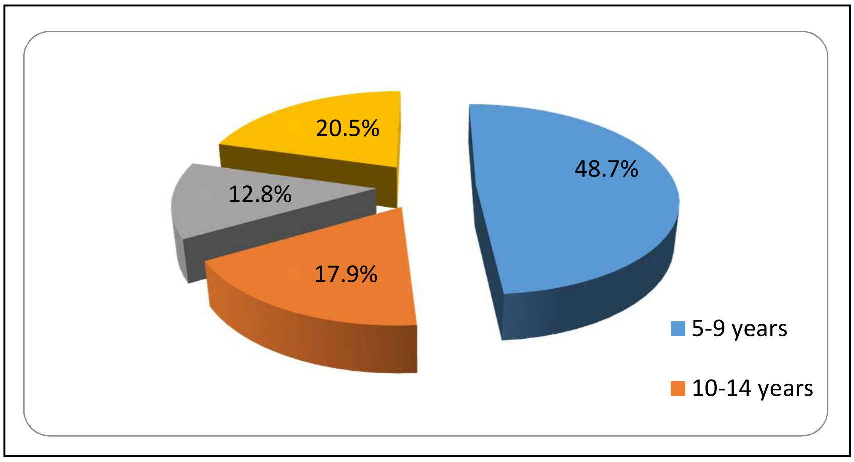
From the 39 respondents, Table 4.2 below indicates their position within the organization. The years of the respondent's experience within the construction industry are as illustrated in figure 4.1 below.

Table 4.2: Years of Work in Current Organization

		Frequency	%	Valid %	Cumulative %
Valid	below one year	8	20.5	20.5	20.5
	1-10 years	23	59.0	59.0	79.5
	11-20 years	2	5.1	5.1	84.6
	over 20 years	6	15.4	15.4	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

Figure 4.1 Years of Work in the Construction Industry



Source; Field Survey, 2016

Table 4.3: Years of Experience at Management Level

		Frequency	%	Valid %	Cumulative %
Valid	below 1 year	9	23.1	23.1	23.1
	1-5 years	16	41.0	41.0	64.1
	6-10 years	5	12.8	12.8	76.9
	over 10 years	8	20.5	20.5	97.4
	23	1	2.6	2.6	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

The information of the respondents indicates that they had been in practice for not less than a year within the construction industry, in the same organisation and in management for a period and hence have an understanding on the issues concerning excavation waste generated in their construction sites.

4.4 EXCAVATED WASTE VOLUMES

From the study findings, the excavated waste volumes from the construction sites was mainly ranging from 1.5 to 3.0 meter depth as was indicated by 38.5% of the respondents. The depth of below 1.5 meter was indicated by 17.9% of the respondents. The depth of 3.1 to 4.5 meter was noted by 28.2% of the respondents. The depth of 4.6 to 6.0 meter was 5.1%.

From the analysis of the findings, it was noted that the depths of excavation in meters and the volumes of waste in tonnage generated was highly determined by the types excavation experienced on the different construction sites. Type A soils (mainly clay, silty clay, sandy clay, and clay loam) were noted by 43.6% of the respondents as requiring of depth of 1.5 to 3.0 meters.

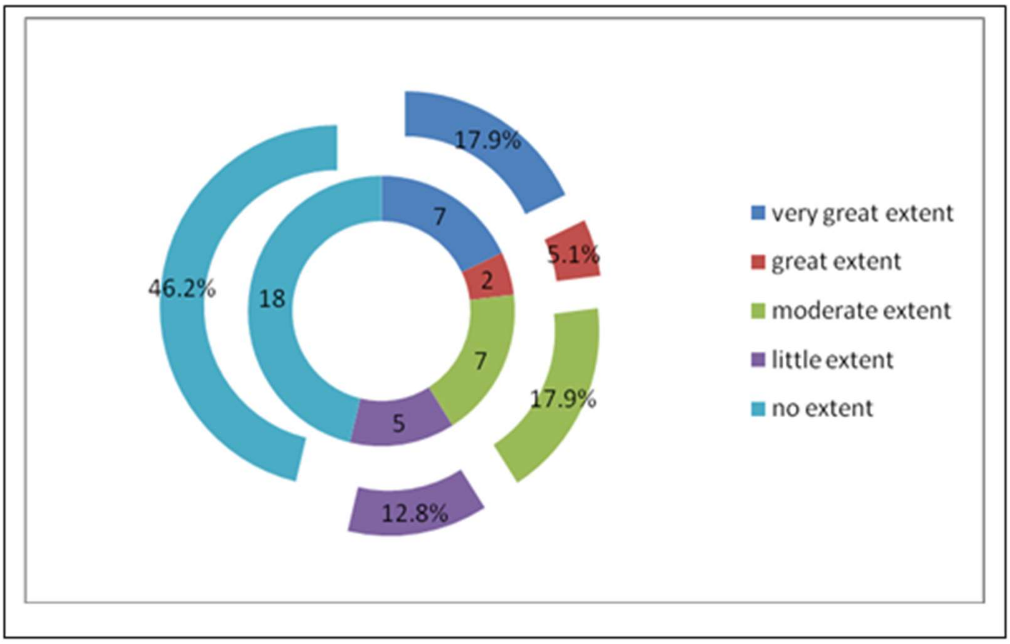
Hyder (2011) noted that this is the more complicated and problematic material in Construction and Demolition waste especially due to the volume as it becomes a significant contaminant to the environment.

4.5 EXCAVATED WASTE MANAGEMENT TECHNIQUES

4.5.1 EXCAVATED WASTE REMOVAL METHODS

According to the research, soil removal method by manual means was not preferable as indicated in figure 4.2.

Figure 4.2: Manual Removal



Source; Field Survey, 2016

This method is not preferred by the NCA 1 contractors in their projects due to its labour intensive nature and eventual cost on the project.

Table 4.4: Use of Bucket and Lifting by Crane

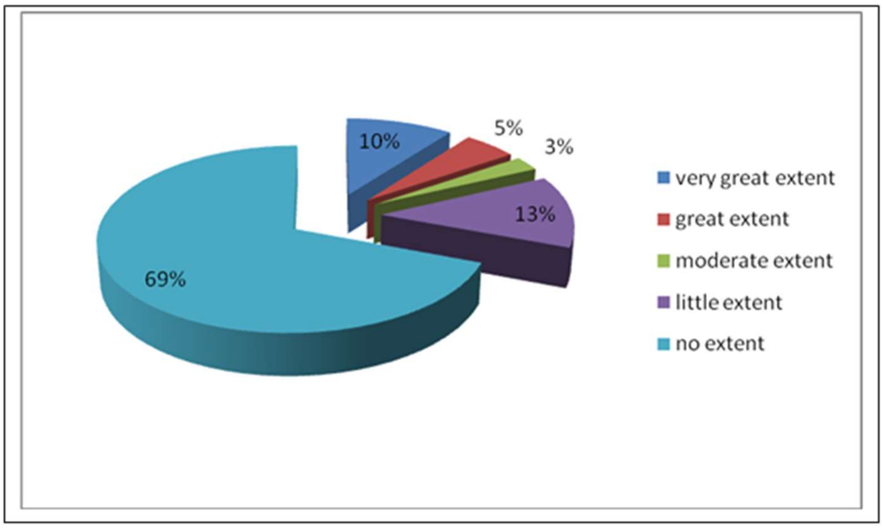
		Frequency	%	Valid %	Cumulative %
Valid	very great extent	8	20.5	20.5	20.5
	great extent	3	7.7	7.7	28.2
	moderate extent	4	10.3	10.3	38.5
	little extent	3	7.7	7.7	46.2
	no extent	21	53.8	53.8	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

Excavated materials removal using bucket and lift by use of crane, is used to a very great extent of up to 20.5% and to no extent at 53.8%. This method is preferred to the manual method as it is less labour intensive.

The use of the hoist racks depends on the no. of trips per day, which varies based on material being hoisted. However, results show that it's been used to no extent of up to 69.2% as seen in figure 4.3. This is due to the expertise required to make and operate the hoist racks.

Figure 4.3: Use of Hoist Racks



Source; Field Survey, 2016

In determining waste excavation by use of gantry crane, the respondents noted that only 2.6% of this method is used to a very great extent while 79.5% of complete no use of this method in projects. This is illustrated in the table 4.5 below.

Table 4.5: Use of Gantry Crane

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	1	2.6	2.6	2.6
	moderate extent	2	5.1	5.1	7.7
	little extent	5	12.8	12.8	20.5
	no extent	31	79.5	79.5	100.0

Source; Field Survey, 2016

In the analysis of the respondent's perception on excavation of waste using the conveyor belts, they indicated no extent of 79.5%. This is indicated in the following table 4.6.

Table 4.6: Use of Conveyor Belt

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	3	7.7	7.7	7.7
	great extent	1	2.6	2.6	10.3
	little extent	4	10.3	10.3	20.5
	no extent	31	79.5	79.5	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

The use of excavation machines and dump trucks as excavation waste management on construction sites was embraced by the respondents to a very great extent by 82.1%. This method was noted to be the mostly used as seen in table 4.7.

Table 4.7: Use of Excavation Machine and Dump Truck

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	32	82.1	82.1	82.1
	great extent	5	12.8	12.8	94.9
	moderate extent	1	2.6	2.6	97.4
	no extent	1	2.6	2.6	100.0
	Total	39	100.0	100.0	

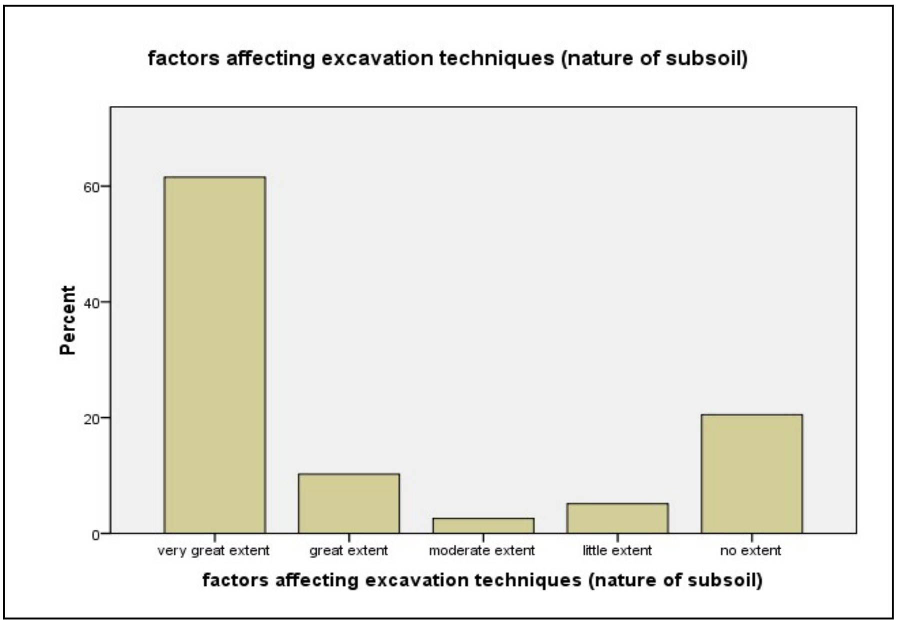
Source; Field Survey, 2016

The excavated soil removal method most preferred by the NCA 1 contractors was the use of excavation machine and dump truck to the volumes and size of the projects. The least preferred soil removal methods in order of use were the manual removal, use of hoist racks, use of conveyor belts and the use of the gantry crane. The contractors preferred mechanical removal of the excavated waste using the excavators and dump trucks at their disposal (either owned or hired) as it was easier to use due to the nature of the excavation works.

4.5.2 FACTORS AFFECTING EXCAVATION TECHNIQUES

In trying to evaluate methods to be used in excavation, respondents' acknowledged factors that could affect the techniques discussed above. Soft ground is easier to dig whereas soil that is hard and stony makes excavation process more complex. Therefore, the respondents noted that the nature of subsoil influences the technique to be used to a very great extent as illustrated in the figure 4.4 below.

Figure 4.4: Nature of Subsoil



Source; Field Survey, 2016

The respondents indicated size/volume affects these techniques as shown in table 4.7 to a very great extent.

Table 4.7: Size/Volume of Excavation

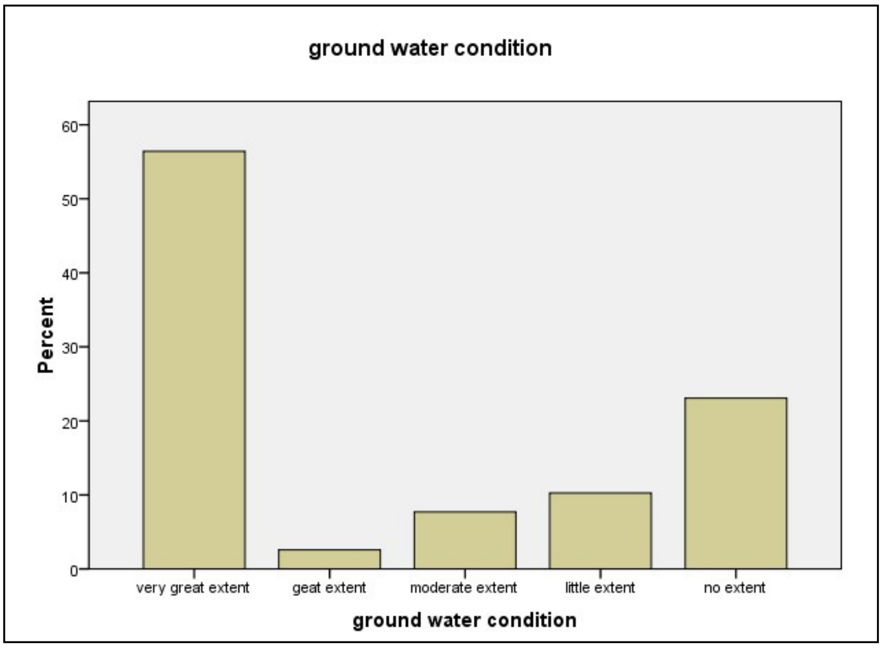
		Frequency	%	Valid %	Cumulative %
Valid	very great extent	28	71.8	71.8	71.8
	great extent	4	10.3	10.3	82.1
	moderate extent	1	2.6	2.6	84.6
	no extent	6	15.4	15.4	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

The scale of work or the complexity of the excavation would affect the technique to be used during this process. The respondents acknowledged that the scale of work would affect the process to a very great extent by 74.4% whereas some thought it would affect it to a great extent by 5.1%. In addition, it would affect excavation to a moderate extent by 10.3%, by 2.6% to little extent and by 7.7% no extent. This is because the more complex the design of the project is, the more complex the excavation works are.

Ground water conditon can be a significant problem when excavating for basement constructions. As noted in the bar graph below, the respondents reported that this may affect excavation process to a very great extent by 56.4%. This is because it affects workability safety on the site and thus requires attention having realised it attracts a higher percentage of effect.

Figure 4.6: Ground water Condition



Source; Field Survey, 2016

The surrounding conditions of the site ought to be favourable for any excavation method to be used. Following the existing land use, illustrating activities and movements in the site is important. The respondents therefore noted that this would affect the whole process to a very great extent by 43.6%. The table below illustrates the responses.

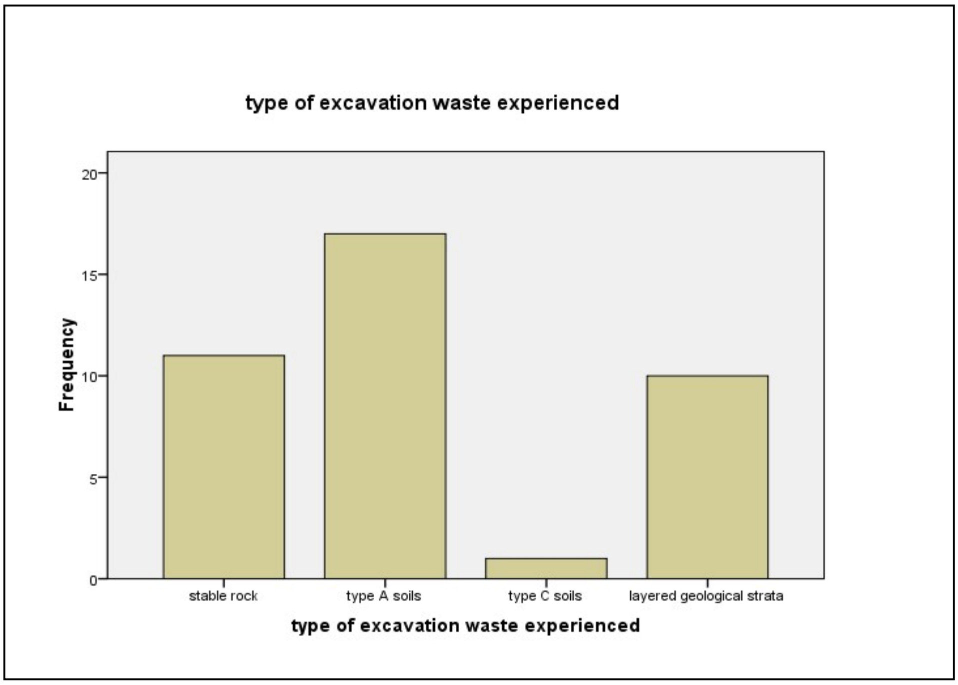
Table 4.8: Surrounding Condition/Abutting Site Conditions

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	17	43.6	43.6	43.6
	great extent	4	10.3	10.3	53.8
	moderate extent	7	17.9	17.9	71.8
	little extent	2	5.1	5.1	76.9
	no extent	9	23.1	23.1	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

The type of excavation waste experienced is a factor to be considered before excavation begins. The respondents acknowledged that it is made up of stable rock of up to 28.2%, type A soils at 43.6%, type B soils at 2.6% and layered geological strata at 25.6%. The table below indicates the type of excavation experienced in construction.

Figure 4.7: Type of excavation waste experienced



Source; Field Survey, 2016

The respondents reported that the danger concerning contacts with utility lines on the site is by 30.8% to a very great extent. In addition, by 10.3% to a great extent, moderate extent by 5.1%, to a little extent by 15.4% and to no extent by 38.5%. This indicates there is not much risks related to utility risk.

4.6 SUSTAINABLE EXCAVATION WASTE MANAGEMENT TECHNIQUES

To find sustainable excavation waste management techniques, it is prudent to know causes of excavation waste on the sites.

The type of foundation will gives an indication of the amount of waste generated as shown in the table 4.9. The type of foundation will determine how the excavation is to be carried out and thus determines the amount of waste generated.

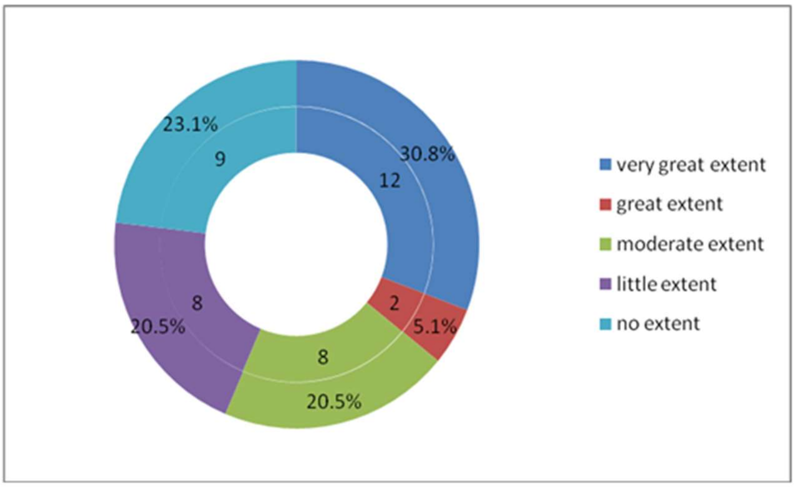
Table 4.9: Type of Foundation

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	23	59.0	59.0	59.0
	great extent	3	7.7	7.7	66.7
	moderate extent	2	5.1	5.1	71.8
	little extent	3	7.7	7.7	79.5
	no extent	8	20.5	20.5	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

The soil type as a cause of excavation construction waste on the site is represented by 66.7% to a very great extent while 23.1% to no extent. The response indicates that excavation waste is greatly determined by the soil type generated from the excavation.

Figure 4.8: Excavation Method/Technique

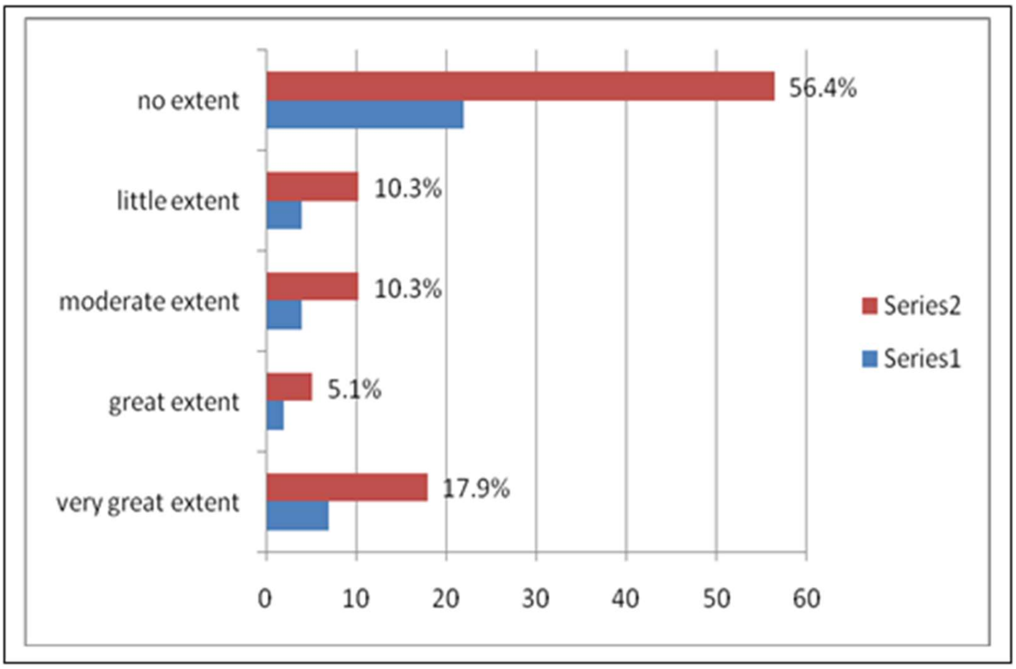


Source; Field Survey, 2016

The respondents' perception was that building complexity is a cause of excavation waste in the site to a very great extent by 41.0%. It follows to a great extent by 12.8%, moderate extent by the same percentage, by 17.9% to a little extent and by 15.4% no extent. The more complex the building design is the more complex the excavation works are and waste will be experienced.

Lack of understanding of site management coordination and communication often causes excavation waste in construction sites. This is evident as illustrated in fig. 4.9 below. The response indicates that communication and proper site management does affect the waste generated from an excavation.

Figure 4.9: Site Management/Communication



Source; Field Survey, 2016

On the basis of yes/no, 28.2% of the respondents' recognized toxic waste requiring professional handling. 71.8% did not acknowledge waste that would require professional handling as indicated in table 4.10.

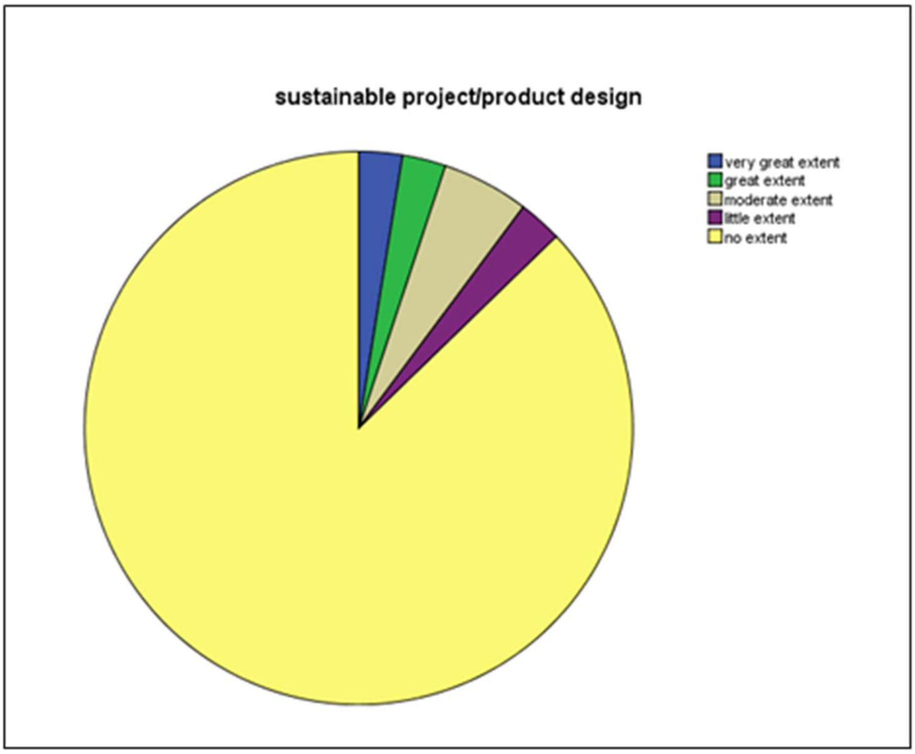
Table 4.10: Contaminated/Toxic Waste Requiring Professional Handling

		Frequency	%	Valid %	Cumulative %
Valid	Yes	11	28.2	28.2	28.2
	No	28	71.8	71.8	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

Sustainable project as a technique applied in construction excavation waste management is used by 2.6% to a very great extent while to no extent by 87.2%. The pie chart below gives pictorial representation.

Figure 4.10: Sustainable Project /Product Design

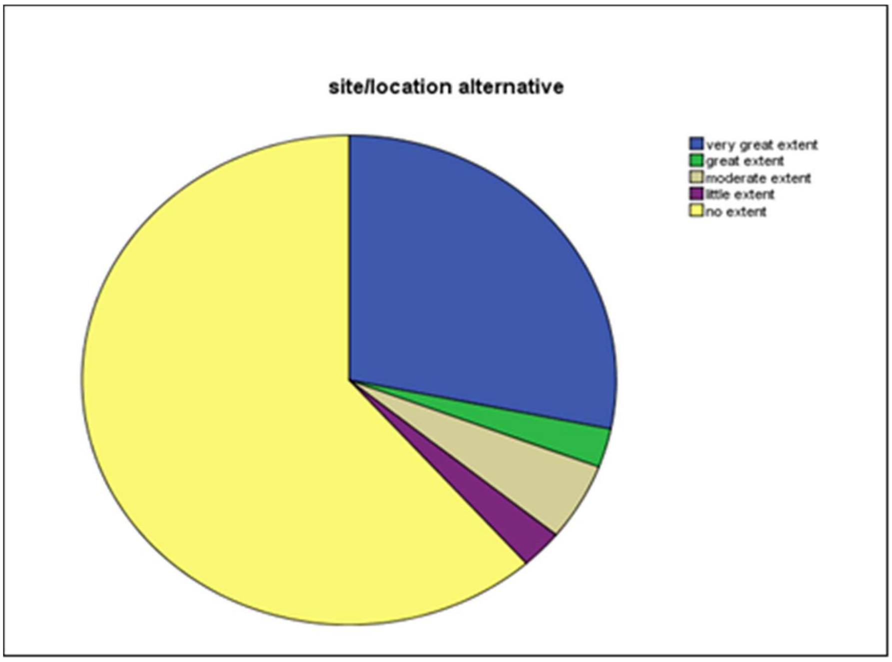


Source; Field Survey, 2016

According to Keys et al (2000) "*The best management approach to waste is to manage the process so that there is no waste to manage*". The data indicates that this is not being practiced by the respondents.

Location alternative is used to a very great extent by 28.2%, to a great extent by 2.6%, to moderate extent by 5.1%, to a little extent by 2.6%, (purple), and by 61.5% to no extent represented by figure below.

Figure 4.11: Site/Location Alternative



Source; Field Survey, 2016

Site waste management plan seemed to be embraced by the majority of the respondents as seen in table 4.12 below.

Table 4.12: Site Waste Management Plan

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	31	79.5	79.5	79.5
	great extent	4	10.3	10.3	89.7
	little extent	1	2.6	2.6	92.3
	no extent	3	7.7	7.7	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

Just as in developed countries of which "*Construction waste management plans have been gaining popularity as an important tool to minimise the adverse impacts of the construction industry*" (Papargyropoulou et al, 2001), the data indicates that the same is being embraced by the construction industry in Kenya.

In the analysis of the respondents' perception on the benefits of using sustainable excavation waste management techniques, it was reported that there are lots of environmental benefits of up to 82.1% to a very great extent as seen in Table 4.13 below. The respondents responded showed that they understood the importance of waste management techniques to the environment.

Table 4.13: Environmental Benefits

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	32	82.1	82.1	82.1
	great extent	4	10.3	10.3	92.3
	moderate extent	1	2.6	2.6	94.9
	little extent	2	5.1	5.1	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

The table 4.14 below shows the benefits to human health. The respondents related the sustainable excavation waste techniques to the good health of those on the sites.

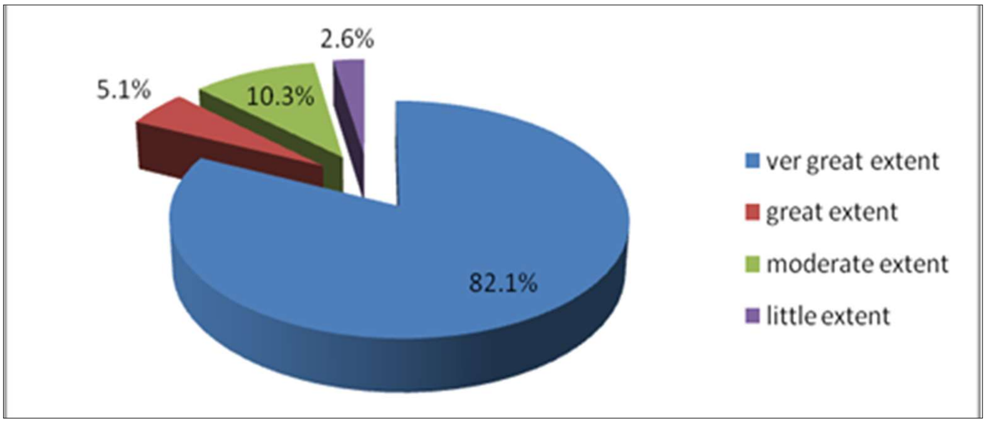
Table 4.14: Human Health

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	29	74.4	74.4	74.4
	great extent	3	7.7	7.7	82.1
	moderate extent	4	10.3	10.3	92.3
	little extent	3	7.7	7.7	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

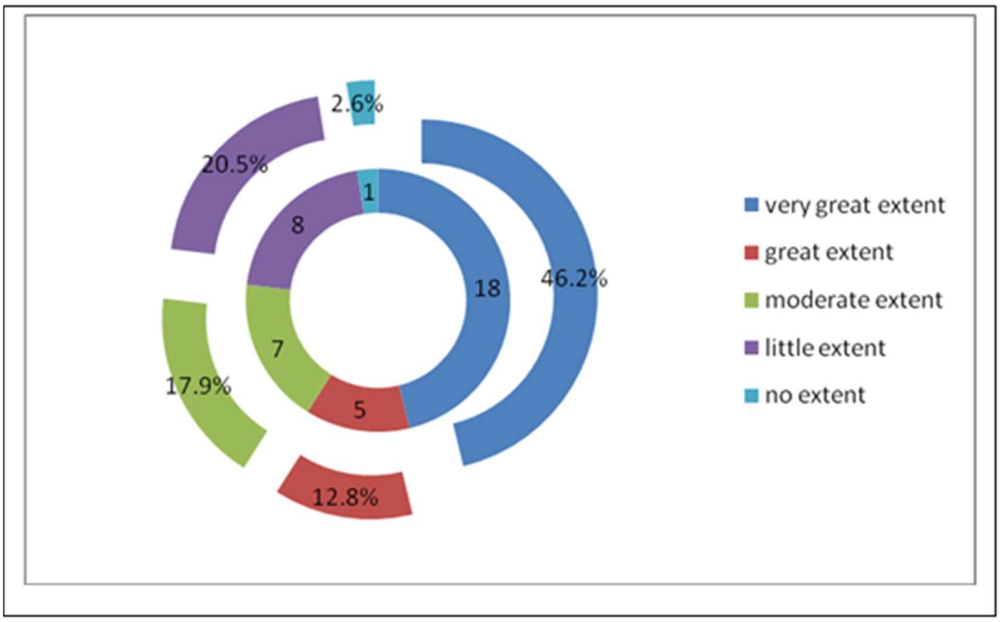
Economic benefits was to very great extent by 82.1% (see figure 4.14) while social benefits to very great extent by 46.2% as seen in figure 4.15.

Figure 4.14: Economic Benefits



Source; Field Survey, 2016

Figure 4.15: Social Benefits



Source; Field Survey, 2016

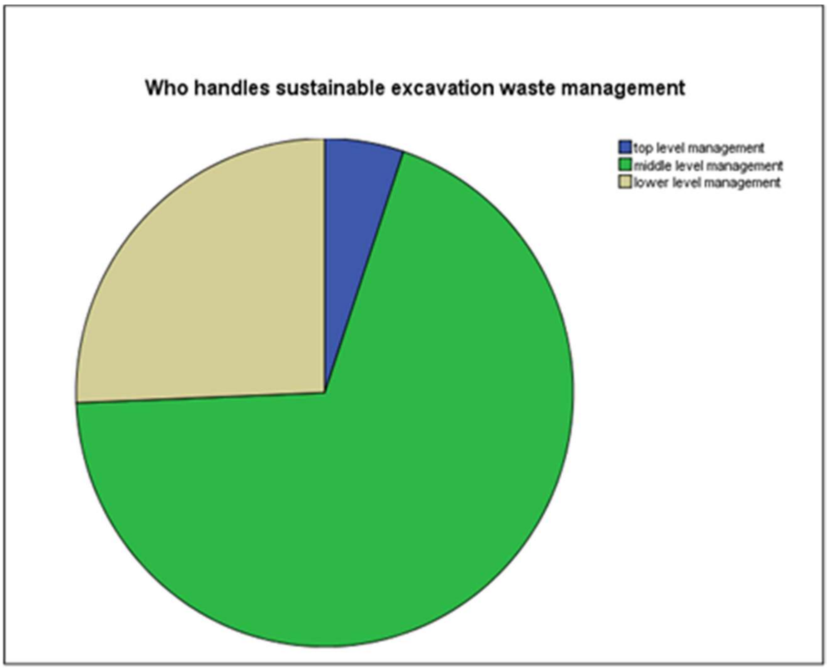
Table 4.15: Sustainable Excavation Waste Management

		Frequency	%	Valid %	Cumulative %
Valid	top level management	2	5.1	5.1	5.1
	middle level management	27	69.2	69.2	74.4
	lower level management	10	25.6	25.6	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

Middle level management shoulders the most responsibility for sustainable excavation waste management according to the respondents by 69.2% as indicated in table 4.15 above.

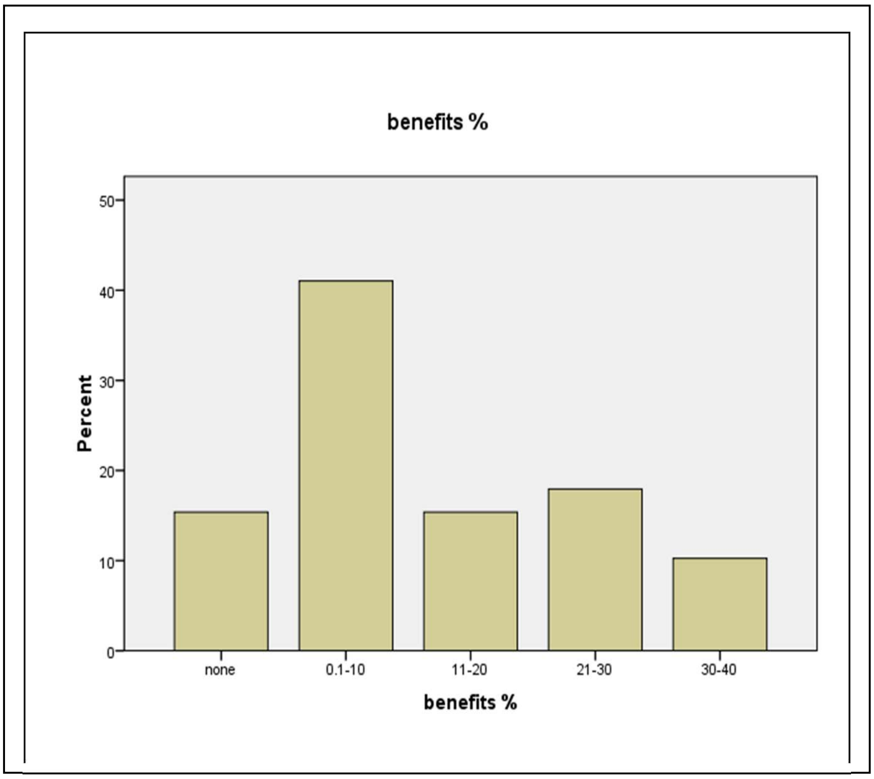
Figure 4.16: Responsibility for Excavation Waste Management



Source; Field Survey, 2016

Inspection to ensure sustainable excavation waste is carried out at the construction sites as indicated by 61.5% of the respondents while 38.5% indicated otherwise as shown in figure 4.16.

Figure 4.17: Percentage Benefits



Source; Field Survey, 2016

The percentage of estimated profits on application of sustainable excavation waste management techniques during construction is as distributed in figure 4.17.

7.7% of the respondents indicated that there are incentives for application of sustainable excavation waste management techniques while 92.3% indicated the contrary. The incentives were tax incentives at 2.6% and recognition and awards at 2.6%.

4.6.1 Limitations for Effecting Sustainable Excavation Waste Management Techniques

The limiting factors for effecting sustainable excavation waste management techniques were management to a very great extent by 17.9%, great extent by 7.7%, moderate by 12.8% and little extent by 10.3% and no extent by 51.3%, cost to a very great extent by 59.0%, great extent by 15.4%, moderate extent by 10.3% and little extent by 7.7% and no extent by 7.7%, laws to very a great extent by 41.0%, great extent by 10.3%, moderate extent by 28.2%, little extent by 7.7% and no extent by 12.5%, Time to A very great extent by 28.2%, great extent by 10.3%, moderate extent by 33.3%, little extent by 12.8% and no extent by 15.4%, technical expertise and skills to a very great extent by 38.8%, great extent by 5.1%, moderate extent by 12.8%, little extent by 20.5% and no extent by 30.8%, type of waste to a very great extent by 69.2%, great extent by 12.8%, moderate extent by 8.3% and no extent by 7.7% and volume to very great extent by 59.0%, great extent by 17.9%, moderate extent by 5.1%, little extent by 7.7% and no extent by 10.3%.

4.7 CHALLENGES EXPERIENCED IN THE MANAGEMENT OF EXCAVATED WASTE

4.7.1 Excavation Hazards

Table 4.16: Contacts with Utility Lines on Site

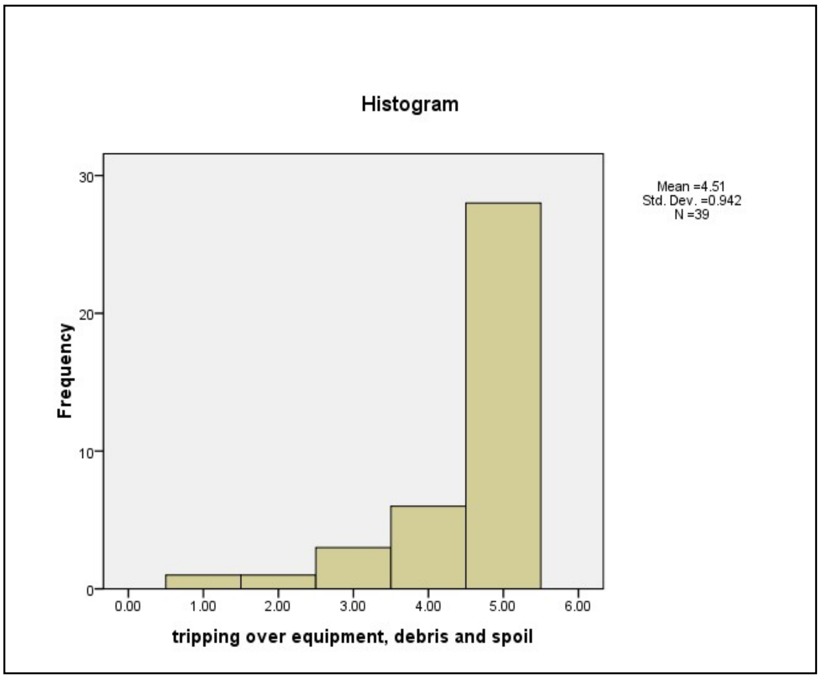
		Frequency	%	Valid %	Cumulative %
Valid	very great extent	12	30.8	30.8	30.8
	great extent	4	10.3	10.3	41.0
	moderate extent	2	5.1	5.1	46.2
	little extent	6	15.4	15.4	61.5
	no extent	15	38.5	38.5	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

As seen in table 4.16 above, contacts with utility lines was considered to be not a hazard by 38.5% of the respondents however 30.8 % considered it as so.

Considering tripping over equipment, debris and spoil, the danger is well illustrated in by the histogram. The respondent shows that it's a risk to a very great extent by 2.6% also to a great extent at the same percentage as seen in figure 4.18 below.

Figure 4.18: Tripping of Equipment



Source; Field Survey, 2016

Excavation materials or objects falling on workers seems to be minor hazard in many constructions sites as seen in table 4.17 below.

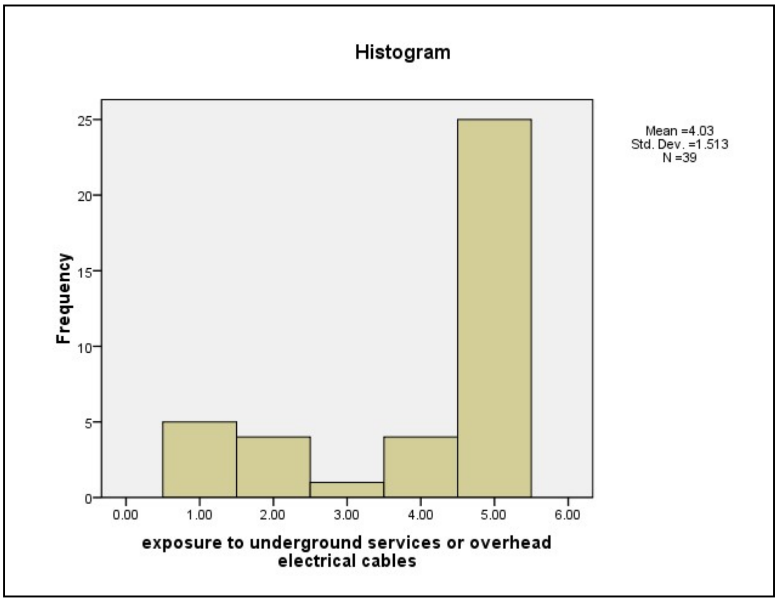
Table 4.17: Excavated Material or Other Objects Falling on Workers

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	1	2.6	2.6	2.6
	moderate extent	1	2.6	2.6	5.1
	little extent	5	12.8	12.8	17.9
	no extent	32	82.1	82.1	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

Underground services or overhead electrical cables was perceived as an excavation hazard to a very great extent by 12.8%, great extent by 10.3%, moderate extent by 2.6%, little extent by 10.3% and to no extent by 64.1% as illustrated by the histogram below.

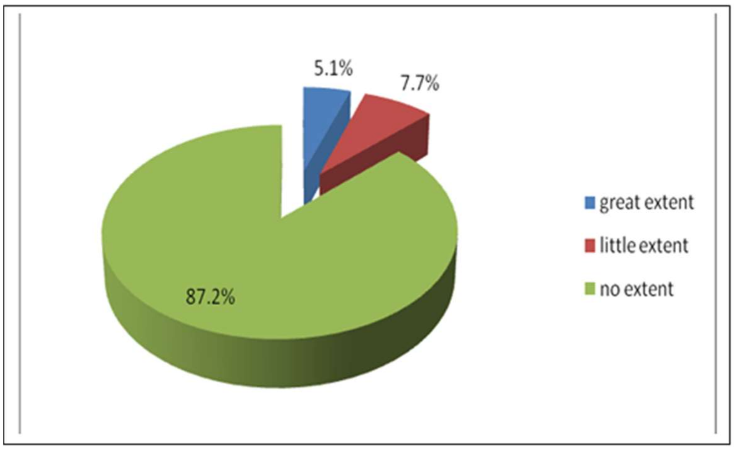
Figure 4.19: Underground Services or Overhead Electrical Cables



Source; Field Survey, 2016

The Figure 4.20 below illustrates how unstable adjacent structures may be a hazard in the sites.

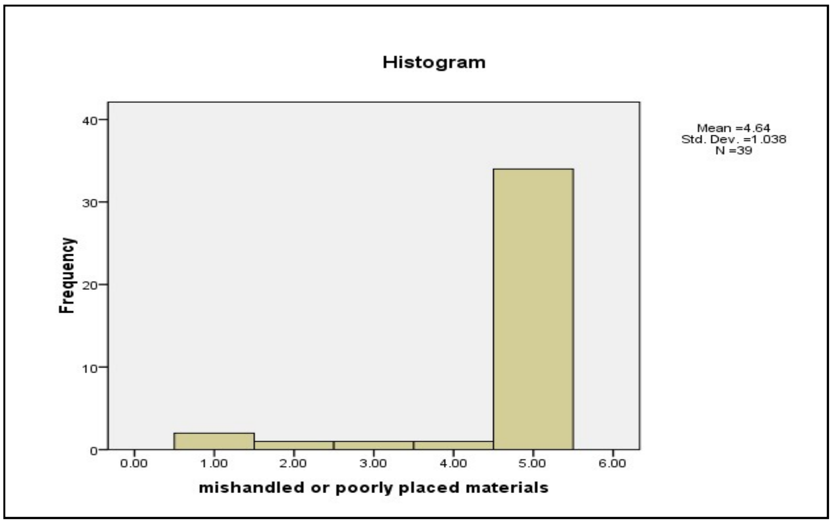
Figure 4.20: Unstable Adjacent structures



Source; Field Survey, 2016

The figure 4.21 below shows results by the respondent concerning mishandled or poorly placed materials. It indicates 5.1% to a very great extent, 2.6% to great extent, moderate extent and to a little extent, followed by 87.2% no extent.

Figure 4.21: Mishandled or Poorly Placed Materials



Source; Field Survey, 2016

Considering the atmosphere, things posing immediate threat to life or could affect with a person's ability to escape unaided from a confined space posed little threat at 89.7% to no extent (see table 4.18 below).

Table 4.18: Hazardous Atmosphere

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	1	2.6	2.6	2.6
	moderate extent	1	2.6	2.6	5.1
	little extent	2	5.1	5.1	10.3
	no extent	35	89.7	89.7	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

The respondents acknowledged that incidents involving vehicles and other mobile equipments may pose some challenge but to no extent of up to 82.1%. They indicated 2.6% to a very great extent, 10.3% to a little extent and up to 5.1% moderate extent.

84.6% of the respondents are aware of state/county legislations on sustainable excavation waste management and 15.4% are not aware of any. The legislations are mainly implemented by the National Construction Authority. 87.2% of the respondents acknowledged that there are standards for sustainable excavation waste which are mainly determined by NEMA as indicated by 87.2% of the respondents.

4.7.2 Limitations for Effecting Sustainable Excavation Waste Management

The respondents perceived that the management to a very great extent only limited the effective of sustainable excavation by 17.9%. Most respondents perceived that management did not limit the effecting of the same as seen in table 4.19 below.

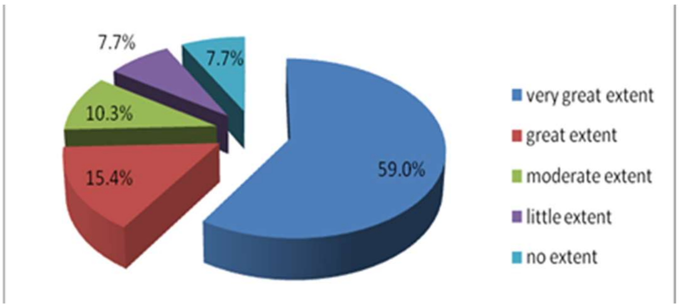
Table 4.19: Management

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	7	17.9	17.9	17.9
	great extent	3	7.7	7.7	25.6
	moderate extent	5	12.8	12.8	38.5
	little extent	4	10.3	10.3	48.7
	no extent	20	51.3	51.3	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

As seen below in figure 4.22, cost was a major limitation according to the respondents to the effecting of sustainable techniques during excavation.

Figure 4.22: Cost



Source; Field Survey, 2016

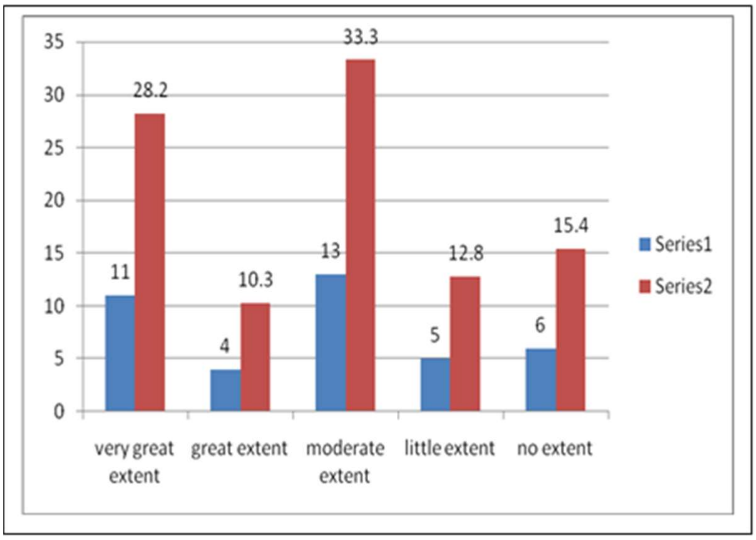
Table 4.20 shows that respondents perceived that the existing laws governing waste management impeded to a great extent the effecting of sustainable excavation waste management. The laws do not offer incentives to practice sustainable waste management.

Table 4.20: Existing Laws and by-laws

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	16	41.0	41.0	41.0
	great extent	4	10.3	10.3	51.3
	moderate extent	11	28.2	28.2	79.5
	little extent	3	7.7	7.7	87.2
	no extent	5	12.8	12.8	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

Figure 4.23: Time



Source; Field Survey, 2016

As seen below in figure 4.23, time was a moderate limitation according to the respondents to the effecting of sustainable techniques during excavation. Only 28.2 % of respondents thought that time affected to a very great extent.

Technical expertise and skills to handle the excavated waste neither limited nor encouraged sustainable practices on the site. Table 4.21 shows that 30.8% of the respondents noted that the expertise limited to a very great extent and similarly to no extent the implementation of the techniques.

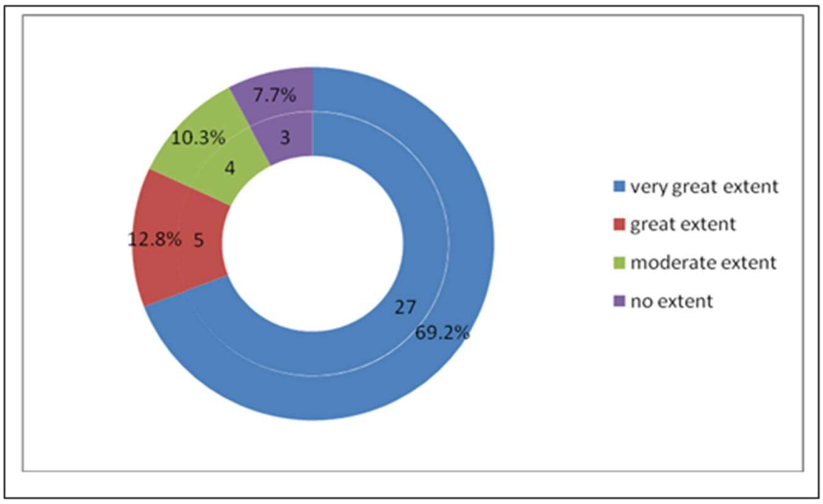
Table 4.21: Technical Expertise and Skills

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	12	30.8	30.8	30.8
	great extent	2	5.1	5.1	35.9
	moderate extent	5	12.8	12.8	48.7
	little extent	8	20.5	20.5	69.2
	no extent	12	30.8	30.8	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

Figure 4.24 below shows that 69.2% of the respondents noted that the type of waste emanating from the excavations impeded the implementation of sustainable techniques of handling it. The waste could impede the reuse on the same site or on other sites depending on the type.

Figure 4.24: Type of Waste



Source; Field Survey, 2016

The volumes experienced on the sites limited the sustainable waste management techniques by up to 59%. This was since only so much could be recycled on the same sites or on other sites.

Table 4.22: Volume

		Frequency	%	Valid %	Cumulative %
Valid	very great extent	23	59.0	59.0	59.0
	great extent	7	17.9	17.9	76.9
	moderate extent	2	5.1	5.1	82.1
	little extent	3	7.7	7.7	89.7
	no extent	4	10.3	10.3	100.0
	Total	39	100.0	100.0	

Source; Field Survey, 2016

4.8 SUMMARY

A total of 39 respondents representing a response rate of 86.67%, showed a knowledgeable understanding of excavation waste issues. The contractors preferred using mechanical means as opposed manual methods to carry out the works and the excavated material did not require professional handling as it was not toxic. The causes of construction waste were investigated and the soil type was deemed to be the greatest factor followed by the type of foundation at 66.7 % and 59% respectively.

The 79.5% of contractors used SWMPs to manage waste on site and informed the study of the benefits of sustainable waste management as being environmental and economy each at 82.1%. Management of the SWMPs was mainly carried out by middle level management on the sites as indicated by 69.2% of the respondents.

The main limitations experienced by the respondents effecting sustainable excavation waste management techniques were they type of waste to very great extent by 69.2%, volume to very great extent by 59.0%.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

The purpose of this study was to investigate into sustainable excavation waste management on construction sites the case of Nairobi, Kenya. The objectives of the study were fourfold and included; To examine the excavation waste volumes on construction sites of office blocks in Nairobi County, to identify the excavation waste management techniques applied by NCA 1 building contractors on these sites, to examine challenges experienced by NCA 1 building contractors in effecting sustainable excavation waste management techniques and to evaluate the sustainability of excavation waste management techniques to NCA 1 building contractors. Consequently, research questions were formulated in accordance to the research objectives, which the researcher set out to look for answers.

A sample size of 45 NCA 1 construction sites located within Nairobi County were randomly selected from the registered list of NCA 1 building contractors in 2016 and have handled buildings constructions for the period of the between 2011-2016. The study findings were analysed, presented and interpreted. This chapter therefore presents discussions of the study findings, conclusion and recommendations on important issues that arose from the study and ends by recommending areas for further research work.

5.2 DISCUSSION OF STUDY FINDINGS

5.2.1 Volumes of excavated waste on construction sites in Nairobi County.

Excavated waste was mainly of type A soils (clay, silty clay, sandy clay, and clay loam). This is attributed to the geographical characteristic of Nairobi County. These soils were mostly non-contaminated and did not need professional handling. The nature of these soils affected the choice of the excavation techniques, of which the contractors showed preference to mechanical means, mainly using excavation machines and dump trucks. The volumes experienced were significant to cause environmental pollution. However, proper recording by the contractors of the amount of waste and its handling was lacking.

5.2.2 Excavation waste management techniques applied by NCA 1 contractors

The NCA 1 contractors were keen on using Site Waste Management Plans in the construction process including while handling excavation waste. They were aware of the benefits of sustainably handling the excavation waste and were keen on the environmental benefits and the economic benefits.

This can be attributed to the fact that the contractors are keen on maintaining good public relations by having their companies known for good corporate responsibility. On the other hand, fines and clean-up costs attributed to mishandling of excavation waste can affect their bottom line profits.

5.2.3 Sustainability of excavation waste management techniques

Middle level management takes responsibility for sustainable excavation waste, are aware of state legislations on sustainable excavation waste management. The use of Sustainable project design was not embraced by the respondents (87.2%) yet the practical approach of handling waste sustainably is to design the project to have no waste (Keys et al., 2000). The respondents would rather change the site location. The effecting of site waste management plans on the site indicated the sustainability of the techniques carried out by the contractors.

5.2.4 Challenges experienced by NCA 1 building contractors in effecting sustainable excavation waste management techniques.

In determination of the main limitations effecting sustainable excavation waste management techniques, the study found that the type of waste was the greatest challenge. This was followed by the volume of waste emanating from the sites and the cost of handling and disposing the excavated waste. The contractors noted that technical expertise of handling the waste was also a significant challenge. These challenges can be attributed to the gap in training the middle level management on how to handle excavation waste and the proper implementation of waste management plans. In addition, there are very little incentives for the application of sustainable excavation waste management techniques of which majority of the respondents (92.3%) being aware of none.

5.3 CONCLUSION

The study concluded that excavation waste volumes on construction sites of office blocks in Nairobi is significant and does pose a challenge to the construction projects. The study also concludes that proper recording and reporting of excavated waste is not done by contractors in their sites.

The study noted that sustainable excavation waste management techniques were employed by the NCA 1 construction firms with the most used being the site waste management plan. The study noted that the construction firms embraced this technique and were enlightened on the benefits of using it. The main benefit of using sustainable excavation waste management techniques was mainly environmental benefits.

The study concludes that main limitation in effecting sustainable excavation waste management techniques is the type of soil to be excavated that determines the type of waste. The volumes experienced and the cost of sustainable waste management also paused a high limitations.

5.4 RECOMMENDATION

In line with the findings and conclusion of the study, the researcher made the following recommendations: there is need to have proper recording of excavation waste activities on construction sites through proper implementation of the SWMP as a management tool. This should include but not limited to the type, volume, handling, disposal or reuse.

The middle level management and all involved in handling of the excavation waste need to be trained on SWMP as a management tool so as to sustainably handle all waste. It is also recommended that construction companies be encouraged to reuse the excavation waste generated for a sustainable industry. Government and policy makers should focus on setting legislation and incentives on sustainable handling of excavation waste.

5.5 AREAS OF FURTHER RESEARCH

Further research can be done on the role of SWMP on health and safety performance of construction companies in Kenya. Another area of further research could be the role and influence of clients and designers in effective preparations and implementation of SWMPs during the construction process.

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APPENDICES

Appendix I: Introduction Letter

Kathy Chebet Kibowen,
University of Nairobi,
Dept. of Real Estate and Construction Management
P. O. Box 67174-00200,
Nairobi, Kenya.

Date: …………………………

Dear Sir/Madam,

RE: INTRODUCTION

I am a student at the University of Nairobi undertaking a Master of Arsts degree in Construction Management. I am currently undertaking a research study entitled **'Sustainable Excavation Waste Management on Construction Sites, Case of Nairobi, Kenya'**

The study is expected to provide useful information that will be beneficial for practitioners in the construction industry in relation to the care of the environment.

You have been identified as one of the respondents to provide information for the study. This is therefore to request you to complete the questionnaire attached as honestly as possible. All information that you provide will be treated with utmost confidence and will be used for the purpose of this study only.

Thank you for your co-operation.

Yours faithfully,

Kathy Chebet Kibowen,

M.A. Candidate in Construction Management,

University of Nairobi.

Appendix II: Questionnaire

UNIVERSITY OF NAIROBI

DEPARTMENT OF REAL ESTATE AND CONSTRUCTION MANAGEMENT

RESEARCH QUESTIONNAIRE

SUSTAINABLE EXCAVATION WASTE MANAGEMENT ON CONSTRUCTION SITES; CASE OF NAIROBI, KENYA

Name of organization: ______________________________ Questionnaire No: ________

Date of Interview: __________________________ Location: _______________________

Part I: General information

1. What is your rank/position in the organization?
   - I. Top level manager – (e.g. CEO, Director, Board member, etc). [ ]
   - II. Middle level manager – (e.g. Functional/head unit, Contracts manager, etc) [ ]
2. How many years have you been in your current organization?
   1) Below one year [ ]
   2) 1 – 10 [ ]
   3) 11 – 20 [ ]
   4) Over 20 years [ ]

3. How many years' experience do you have in the construction industry?
   1) 5 – 9 years [ ]
   2) 10 – 14 years [ ]
   3) 15 – 19 years [ ]
   4) Over 20 years [ ]

4. How many years' experience do you have at management level in construction?

1) Below 1 year [ ]
2) 1 – 5 years [ ]
3) 6 – 10 years [ ]
4) Over 10 years [ ]

Part II: Excavation waste

5. Kindly rank the following soil removal methods in order of their use in your site.

Use a scale of 1-5 where 1 where great extent, 2 great extent, 3 moderate, 4 little and 5

Soil removal methods	**1**	**2**	**3**	**4**	**5**
Manual e.g. by wheelbarrow					
Bucket and lift by use of crane					
Use of hoist rack					
Use of gantry crane					
Use of conveyor belt					
Use of excavation machine and dump truck					

6. Kindly rank the following factors that affect the excavation techniques you use;

(Use a scale of 1-5 where 1 where great extent, 2 great extent, 3 moderate, 4 little and 5 no extent.)

Factors affecting excavation techniques	**1**	**2**	**3**	**4**	**5**
Nature of subsoil					
Size/volume of excavation					
Scale of work/Complexity of excavation					
Ground water condition					
Surrounding condition/abutting site conditions					

7. What is the type of excavation waste experienced?

1) Stable rock (natural solid mineral matter e.g. granite, sandstone etc.) **[ ]**
2) Type A soils (e.g. clay, silty clay, sandy clay, clay loam) **[ ]**
3) Type B soils (e.g. angular gravel, silt, silt loam, previously disturbed soils, dry unstable rock) **[ ]**
4) Type C soils (e.g. gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable.) **[ ]**
5) Layered Geological strata (where soils are configured in layers e.g. type c soil rests on top of stable rock) **[ ]**

8. Kindly rank from natural ground level, the depths and volumes (tonne) of the excavation works on your site.

Depths (Meters)	**Volume (Tonnes)**
Below 1.5	
1.5 to 3	
3.1 to 4.5	
4.6 to 6.0	
Above 6.0	

9. Kindly rank the following dangers experienced during excavation on your sites.

(Use a scale of 1-5 where 1 where great extent, 2 great extent, 3 moderate, 4 little and 5 no extent.)

Excavation hazards	**1**	**2**	**3**	**4**	**5**
Accidental contact with utility lines					
Tripping over equipment, debris and spoil					
Excavated material or other objects falling on workers					
Exposure to underground services or overhead electrical cables					
Unstable adjacent structures					
Mishandled or poorly placed materials					
Hazardous atmosphere (noxious gases/lack of oxygen) Toxic, irritating or flammable and explosive gases					
Incidents involving vehicles and other mobile equipment					

Part III: Sustainable Excavation Waste Management Techniques

10. Kindly rank the following causes of excavation construction waste on your sites.

(Use a scale of 1-5 where 1 where great extent, 2 great extent, 3 moderate, 4 little and 5 no extent.)

Causes of construction of Waste	**1**	**2**	**3**	**4**	**5**
Type of foundation					
Soil type					
Excavation methods/techniques					
Building Complexity					
Site management/Co-ordination/communication					

11. Did you experience contaminated/ toxic waste that will need professional handling?

1) Yes [ ]

2) No [ ]

If yes which ones?

………………………………………………………………………………………………

………………………………………………………………………………………………

12. Which techniques do you apply in construction excavation waste management and how would you rank the extent of its use?

(Use a scale of 1-5 where 1 where great extent, 2 great extent, 3 moderate, 4 little and 5 no extent.)

Technique Used	**1**	**2**	**3**	**4**	**5**
1. Sustainable Project/Product Design					
2. Development/Project					
3. Site/Location Alternative					
4. Site Waste Management Plan					
5. Others……………………………………					

13. In your opinion, what makes the waste management technique sustainable?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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……………………………………………………………………………………………………

14. Kindly rate the following benefits of use of sustainable excavation waste management techniques during construction. (Use a scale of 1-5 where; 1 Very great extent, 2 Great extent, 3 Moderate extent, 4 Little extent, 5 No extent.)

Building Performances	**1**	**2**	**3**	**4**	**5**
Environmental					
Human Health					
Economic					
Social Benefits					

15. Who takes responsibility for sustainable excavation waste management during construction?
    1) Top level manager – (e.g. CEO, Director, Board member, etc). [ ]
    2) Middle level manager – (e.g. Functional/head unit, Contracts manager, structural engineer etc) [ ]
    3) Consultant [ ]
    4) Others (Specify) ……………………………………………………………………………

16. Are you aware of any county or state legislation related to sustainable construction?

    1) Yes [ ]   2) No [ ]

17. And if yes for number 16 above, which are they.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………

18. Are there standards for sustainable excavation waste management during construction in Kenya?

    1. Yes [ ]   2) No [ ]

19. If yes, which are they?

………

……

20. Is excavation waste disposal inspected /implemented/ regulated?

    1. Yes [ ]   2) No [ ]

21. What are the estimated benefits (% of profits) in application of sustainable excavation waste management techniques during construction?

    1) None [ ]
    2) 0.1-10 [ ]
    3) 11-20 [ ]
    4) 21-30 [ ]
    5) 30-40 [ ]

22. Are there incentives for use of sustainable waste management techniques during construction in Kenya?

    1. Yes [ ]   2) No [ ]

23. If 'yes' what are the incentives? Give examples.

Tax incentives

………

Recognitions/Awards

………

Others

……………………………………………………………………………………………………

….……………………………………………………………………………………

24. What are the main limitations for effecting sustainable excavation waste management techniques?

(Use a scale of 1-5 where; 1 Very great extent, 2 Great extent, 3 Moderate extent, 4 little extent, 5 No extent.)

Indicators	**1**	**2**	**3**	**4**	**5**
Management					
Cost					
Laws					
Time					
Technical expertise and skills					
Type of waste					
Volume					

25. Are there any other available and affordable techniques not being used?

……………………………………………………………………………………………………

Appendix III: Random sampling table

Table of Random Numbers

36518	36777	89116	05542	29705	83775	21564	81639	27973	62413	85652	62817	57881
46132	81380	75635	19428	88048	08747	20092	12615	35046	67753	69630	10883	13683
31841	77367	40791	97402	27569	90184	02338	39318	54936	34641	95525	86316	87384
84180	93793	64953	51472	65358	23701	75230	47200	78176	85248	90589	74567	22633
78435	37586	07015	98729	76703	16224	97661	79907	06611	26501	93389	92725	68158
41859	94198	37182	61345	88857	53204	86721	59613	67494	17292	94457	89520	77771
13019	07274	51068	93129	40386	51731	44254	66685	72835	01270	42523	45323	63481
82448	72430	29041	59208	95266	33978	70958	60017	39723	00606	17956	19024	15819
25432	96593	83112	96997	55340	80312	78839	09815	16887	22228	06206	54272	83516
69226	38655	03811	08342	47863	02743	11547	38250	58140	98470	24364	99797	73498
25837	68821	66426	20496	84843	18360	91252	99134	48931	99538	21160	09411	44659
38914	82707	24769	72026	56813	49336	71767	04474	32909	74162	50404	68562	14088
04070	60681	64290	26905	65617	76039	91657	71362	32246	49595	50663	47459	57072
01674	14751	28637	86980	11951	10479	41454	48527	53868	37846	85912	15156	00865
70294	35450	39982	79503	34382	43186	69890	63222	30110	56004	04879	05138	57476
73903	98066	52136	89925	50000	96334	30773	80571	31178	52799	41050	76298	43995
87789	56408	77107	88452	80975	03406	36114	64549	79244	82044	00202	45727	35709
92320	95929	58545	70699	07679	23296	03002	63885	54677	55745	52540	62154	33314
46391	60276	92061	43591	42118	73094	53608	58949	42927	90993	46795	05947	01934
67090	45063	84584	66022	48268	74971	94861	61749	61085	81758	89640	39437	90044
11666	99916	35165	29420	73213	15275	62532	47319	39842	62273	94980	23415	64668
40910	59068	04594	94576	51187	54796	17411	56123	66545	82163	61868	22752	40101
41169	37965	47578	92180	05257	19143	77486	02457	00985	31960	39033	44374	28352
76418												