UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

WASTE REDUCTION ON CONSTRUCTION SITES IN GHANA- CASE STUDY OF SELECTED CONSTRUCTION COMPANIES IN KWAHU EAST DISTRICT.

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A Dissertation in the Department of **CONSTRUCTION**, Faculty of **CONSTRUCTION TECHNOLOGY EDUCATION**, submitted to the School of Graduate Studies, University of Education, Winneba, in partial fulfilment of the requirements for award of the Master of Technology (Construction) degree.

NOVEMBER, 2017

DECLARATION

STUDENT'S DECLARATION

I, AMAKYE OWUSU, declare that this dissertation, with the exception of the quotations and references contained in published works which have all been identified and acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere

SIGNATURE: ………………………………….

DATE: ………………………………………….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this dissertation were supervised by me in accordance with the guidelines on supervision of dissertation as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: MR. M.K. TSORGALI

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DATE: ……………………………………………………

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DEDICATION

This research is dedicated to my children, Owusu Agyapong Rhoila, Audrey Owusu and Ester Owusu Adwenpa.

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ABSTRACT

The main objective of the study was to assess waste reduction on construction sites in Ghana- case study of selected construction companies in the Kwahu East District. The mixed research design was used for the study (quantitative and qualitative research design). The population for the study was one hundred and twenty five (125). The population of the study was made up of Managers and Supervisors of the Building construction companies in the Kwahu Municipality. Census sampling technique was used to select all the 125 Managers and Supervisors in the selected construction sites for the study. The data collection techniques used for the study involved questionnaires, interview and observation. Primary data was collected through a field survey of Managers and Site Supervisors at the selected Construction industries in the Kwahu Municipality. The questionnaire data was coded to enable the respondents to be grouped into limited number of categories. The SPSS version 18 was used to analyse data. The study findings concluded that most of the construction sites do not have waste management and recycling system in place. Moreover, 86 supervisors representing 69.9% agreed that an unskilled labourer can mismanage construction resources and create waste at the construction sites. Also, 80 supervisors representing 65% agreed that overdesign of building plans can create waste at the construction sites. Also, 84 supervisors representing 68.3% agreed that inadequate storage facilities can create waste at the construction sites. Moreover, lack of markets for recyclable materials also generated waste at the construction sites. The study concluded that to reduce waste at the construction sites there is the need to focus on quality and performance and provide safe transportation from the point of sale to the construction sites. The study recommended that the Supervisors' of the construction companies in the Kwahu East District should reduce construction waste generation by promoting the recycling of construction waste. Again, management of the firms should employ competent and skilled labourers to work effectively and professionally to minimise the generation of construction wastes. This initiative is important because unskilled labourer can mismanage construction resources and create waste at the construction sites.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The construction industry is now becoming aware that it has an important role to play in the minimising of waste production (Osmani, 2012). The level of waste produced needs to be reduced for environmental and economic reasons (Coelho & de Brito, 2011). The positive impacts of construction are well publicised but the negative environmental consequences receive a lot less attention. It is now realised that waste produced has a value and that the contractor can either save money from producing less waste or recycle the waste to generate an income (Dhir et al., 2014).

The motivation for this dissertation is due to the emphasis on environmental issues in the last number of years and the need for the construction industry to realise that it also has negative impacts on the environment and that these impacts need to be avoided where possible. The key players need to understand and implement waste management and minimisation strategies in order to reduce waste generation. If a company can reduce its waste and thus benefit from lower construction costs and higher productivity, it can then become more competitive in the construction industry (Cheol et al., 2010; Damnjanovic et al., 2008).

Construction activities consume large amounts of natural resources, energy and materials but it also generates a large amount of waste. Kulatunga *et al.,* (2016) states that the construction industry consumes 25 per cent of virgin wood and 40 per cent of raw stone and sand used each year globally. The production and manufacturing process required for the construction industry involves the extraction of billions of tonnes of materials annually.

Faced with this large amount of waste the industry has carried out continuous research to investigate how to minimise the generation of waste so that the adverse impacts of construction and demolition waste can be reduced. Waste legislation goes back as far as 1975 in the EU and previous studies such as Symonds et al. (2014) and Teo and Loosemore (2011) have covered a wide range of topics ranging from waste production recycling and reuse to waste minimisation and attitudes towards construction waste.

Research into waste management measures to reduce waste at project level has also been carried out. Previous studies have shown that there are a number of variables that affect waste production including design changes, investment in waste management, government regulations, space constraints on site, construction technology and the waste management culture in the organisation. Changing the design during the construction phase is seen as a large producer of waste. Up to 33 per cent of construction waste could be related to the project design (Osmani et al., 2008). Studies carried out by Jaillon et al., (2009) and Esin and Cosgun (2007) have shown that the use of low waste construction techniques such as off-site fabrication and modularisation can significantly reduce on site waste production. This study therefore assessed waste reduction on construction sites in Ghana- using selected construction companies in the Kwahu East District.

1.2 Statement of the Problem

The problem of the study is that in the Kwahu East District waste on construction sites creates a lot congestion and wastage of construction materials. Inadequate recycle plants in the District have contributed to the inability to reuse construction waste thereby creating a lot of waste on construction sites. Waste from construction may contain solvents and chemicals that result in soil and water pollution. There is a solution to this problem as many of the materials discarded can be recycled into the same product or into other usable products. Unfortunately reprocessing materials for recycling is not always economically viable unless the facility that is recycling the materials is located close to the waste production source. The production and manufacturing process required for the construction industry involves the extraction of billions of tonnes of materials annually. Faced with this large amount of waste the industry has carried out continuous research to investigate how to minimise the generation of waste so that the adverse impacts of construction and demolition waste can be reduced.

1.3 Purpose of the Study

The purpose of the study is to ensure an effective waste reduction on construction sites using selected construction companies in the Kwahu East District as a case study.

1.4 Objectives of the study

The following objectives of the the study are to;

1. examine wastage issues on construction sites in the Kwahu East District.
2. identify the causes of construction materials waste on construction sites
3. devises strategies to ensure effective waste reduction on construction sites.

1.5 Research Questions

The following research questions will be used for the study,

1. What are the waste management issues on construction sites in the Kwahu East District?
2. What are the causes of construction materials waste on construction sites?
3. What are the strategies to ensure effective waste reduction on construction sites?

1.6 Significance of the Study

- The study would help Construction firms with regards to creating awareness about effective waste management practices that could minimize waste on construction sites.
- Moreover, minimising waste on construction sites increases the profitability of the construction firm.
- Also, the study outcome would help the stakeholders to develop policies and practices that could minimize material wastage.
- Furthermore, the recommendations from the study could also help construction firms adopt the best practices and standards at the construction sites and enforce contractors to take keen interest in training their employees on material handling and waste management on construction sites.

1.7 Scope of the Study

The study is focused on construction professionals working on projects in the Kwahu East District in the Eastern Region of Ghana. This study is geographically limited in scope to Kwahu East District in the Eastern Region of Ghana. However, the study is conceptually, theoretically and empirically limited in scope to effective waste management practices and its benefits in minimising waste in the construction firms, ascertaining and maintaining the flow and supply of materials, and waste minimization management in the construction industry. Moreover, the researcher gathered literature to cover the following scope including; the overview of the Ghanaian construction industry, construction waste management in the global perspectives, management of construction waste, causes of construction materials waste, waste management framework in Europe, European community strategy for waste management, waste framework directive, construction waste minimisation in Ghana, the importance of minimising construction waste, financial benefits, environmental benefits, current states of recycling construction waste, practices of reuse, recycle and reduction, and types of construction wastes generated.

1.8 Organization of the Study

This dissertation consists of five chapters. Chapter one deals with the background to the study, the statement of the problem, research questions and objectives of the study, significance and organization of the study. In chapter two the researcher reviewed related literature whiles chapter three deals with the research methodology used in the study. Other aspects of chapter three describes the research design, the population sample and sample procedures, data gathering instruments and data collection procedures of the study, methods of data analysis. Chapter four describes the research findings and the discussion of the main findings and chapter five presents the summary of the findings, conclusions and recommendations and suggestions for further research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter covers the following subheadings; Overview of the Ghanaian construction industry, construction waste management in the global perspectives, management of construction waste, causes of construction materials waste, waste management framework in Europe, European community strategy for waste management, waste framework directive, construction waste minimisation in Ghana, the importance of minimising construction waste, financial benefits, environmental benefits, current states of recycling construction waste, practices of reuse, recycle and reduction, and types of construction wastes generated.

2.1 Overview of the Ghanaian Construction Industry

The construction industry in Ghana, as in other parts of the world, is huge and a crucial segment in economic development. No matter what one does, there is construction, as it cuts across all sectors. Being among the top drivers of the Ghanaian economy, including agriculture, manufacturing and mining, its importance cannot be over emphasized, especially as the country is one of the most active economically in West Africa. From a low point in the1970s and 1980s the share of construction in the GDP has moved up from 4.5% in 1975 to 8.5% by the turn of the century and has been doing about the same levels since. The sector grew by 10% in 2008 but registered a negative growth rate of 1% in 2009 due to the global economic recession (Gyadu-Asiedu, 2009). The key stakeholders in the construction industry in Ghana are clients, professional consultants and contractors (Gyadu-Asiedu, 2009).

In Ghana four main clients are distinguishable: the Government (being the major client), Real Estate Developers, Investors and Owner occupiers. Between 2000 and 2008 the government of Ghana identified construction as a priority sector for foreign and private investment as part of its vision to promote the private sector as the engine of growth. According to World Bank (2013) as provided by Anvuur and Kumaraswamy (2006), an approximate annual value of public procurement for goods, works and consultant services amount to US$600 million. This represent about 10% of the country's GDP. This amount forms part of the bulk of the expenditure of all government agencies, namely, the Ministries, the Assemblies, Departments, Institutions and other agencies. The government as a client is represented by the Ministry of Road and Transport (for road works) and the Ministry of Water Resources, Works and Housing in giving out projects. The Real Estate developers are also the other group of clients who undertake large investment in building. Usually, these take loans and undertake speculative buildings for sale. Their performance is usually influenced by the lending situations in the country.

Professional consultants who are regularly engaged by the government and other clients are Architects, the Quantity Surveyors (QS), Geodetic Engineers (GE), Structural Engineers (St.E), Electrical Engineers (EE) and Services Engineers (SE). Geodetic Engineers are often called when it is about roads construction. All these professionals are regulated by their professional institution (Gyadu-Asiedu, 2009). Contractors in Ghana are grouped into eight categories (A, B, C, S, D, K, E and G) according to the type of works they undertake. These are (i) Roads, Airports, and Related Structures (A); (ii)

Bridges, Culverts and other Structures (B); (iii) Labour based road works (C); (iv) Steel bridges and structures: construction rehabilitation and maintenance (S); (v) General building works (D); (vi) General civil works (K); (vii) Electrical works (E); and (viii) Plumbing works (G). In each category, they are grouped into 4, 3, 2 and 1 financial classes in increasing order (Vulink, 2014). In addition, Dansoh (2015) notes a combined category of AB for road contractors. According to Dansoh (2015) Class 4 contractors can tender for contracts up to $75,000; class 3 up to $200,000; class 2 up to $500,000. Class 1 takes contracts of all amounts. Categories E and G contractors act as main contractors when the work is of a specialized nature.

The industry is dominated by large number of small- and medium-sized firms. This is mainly because such firms are able to register with as little equipment as possible. Mostly, they are sole proprietors, (few cases of partnerships), and are characterized by high attrition rate. This is because they are highly influenced by the boom and slum nature of the industry in Ghana. They are the least organized and because they lack the resources to employ and retain very skillful labour, their performance is usually below expectation and they have often been accused of producing shoddy works. Because there are often more jobs within their financial class than those above their limits, and because they form the largest group, their performance impacts greatly on the performance of the industry. Because of this, the classification by the Ministry has been criticized as being too general and obsolete with the registration criteria, list of contractors and monetary thresholds not regularly updated (Eyiah and Cook, 2013; World Bank, 2013). The two upper classes (D1 and D2) are more organized and hence more stable, taking on both bigger and smaller works. However, these firms (especially the D2 firms) do not always employ the very qualified workers. The Ghanaian-based foreign contractors are able to do this and hence perform better. Vulink (2014) notes that because of the poor performance of Ghanaian local contractors most of the nation's major projects are usually awarded to foreign contractors. Assibey-Mensah (2008) attributes this to the "non-businesslike culture" with which indigenous firms operate in Ghana.

2.1.1 Construction waste management in the global perspectives

The construction industry plays a vital role in meeting the needs of society and enhancing quality of life (Shen & Tam, 2012; Tse, 2011). However, the responsibility of ensuring that construction activities and products are consistent with environmental policies needs to be defined, and good environmental practices improved (Environmental Protection Department, 2012; Shen et al., 2012). Compared with other industries, construction generates fairly large amount of pollutants, including solid waste, noise, dust and water (Ball, 2012; Morledge & Jackson, 2011). Since construction has a major and direct influence on many other industries by means of both purchasing the inputs from other industries and providing products to almost all other industries, eliminating or reducing waste could yield great cost savings to society (Polat & Ballard, 2014).

The construction industry has been encouraged to re-use built assets, minimize waste, recycle materials, minimize energy in construction and use of buildings, use environmental management systems to reduce pollution, enhance bio-diversity, conserve water, respect people and their local environment, measure performance and set targets for the environment and sustainability (Ofori et al., 2010). Environmental protection has recently become an important issue all over the world. It is, however, regrettable that although stakeholders are now questioning the traditional routes of waste disposal in favour of sustainable waste management strategies, the majority of construction companies have placed waste reduction at the bottom of their agenda because of complexities over re-use and recycling. Construction waste has caused serious environmental problems in many large cities (Begum et al., 2016; Chen et al., 2012; Teo & Loosemore, 2011). Polat and Ballard (2014) defined waste simply as “that which can be eliminated without reducing customer value”. In a study on methods for waste control in the building industry in Brazil, Formoso et al. (2009) classified waste into unavoidable waste (or natural waste), in which the investment necessary for its reduction is higher than the economic benefit, and avoidable waste in which the cost of waste is higher than the cost to prevent it. The percentage of unavoidable waste depends on the technological development level of the company (Polat & Ballard, 2014; Formoso et al., 2009; Womack & Jones, 2016).

Waste can be categorized according to its source - the stage in which the root causes of waste occurs. Bossink and Brouwers (2016) in a study on waste rates in the Dutch construction industry identified the main sources of waste in construction as design, procurement, material handling, operation and residual. Sources of waste are also identified from the processing preceding construction such as materials manufacturing, design, material supply, and planning, as well as from the construction stage (Formoso et al., 2009). In a study on construction material waste source evaluation in Singapore, Ekanayake and Ofori (2010) divided construction waste into three major categories: material, labour and machinery waste. The current study, however, focuses on material wastage since most of the raw materials from which construction inputs are derived come from non-renewable resources and once wasted, becomes very difficult to replace them (Ekanayake & Ofori, 2010).

The Environmental Protection Department of Hong Kong (2010) defines materials waste as comprising of unwanted materials generated during construction, including rejected structures and materials, materials which have been over-ordered or are surplus to requirements, and materials which have been used and discarded. Furthermore, materials waste can be defined as "any material, apart from earth materials, which needs to be transported elsewhere from the construction site or used within the construction site itself for the purpose of landfilling, incineration, recycling, re-using or composting, other than the intended specific purpose of the project due to materials damage, excess, non-use, or non-compliance with the specifications or being a by-product of the construction process" (Ekanayake & Ofori, 2010). In a study on dominant causes of waste generation in Egyptian construction, Garas et al. (2011) categorized material wastes by activity, to include over-ordering, overproduction, wrong handling, wrong storage, manufacturing defects and theft or vandalism.

Begum *et al.,* (2016) conducted a study on implementation of waste management and minimization in the Malaysian construction industry and categorized waste minimization into source reduction and recycling. Source reduction is defined as any activity that reduces or eliminates the generation of waste at source, usually within a process, and recycling as the recovery and/or re-use of what would otherwise be a waste material. Poon *et al.,* (2014) also studied how to reduce building waste at construction sites in Hong Kong, and defined waste minimization as "any technique, process or activity which avoids, eliminates or reduces waste at its source or allows re-use or recycling of the waste.

The Environmental Protection Agency of USA (2010) defines waste minimization as "any method that reduces the volume or toxicity of a waste that requires disposal". Different measures for minimizing materials waste have been reported (Begum *et al.,* 2016; Faniran & Caban, 2008). In a study on application of Lean Construction to reduce waste in Turkish construction, Polat and Ballard (2014) emphasized that reduction is the best and most efficient method for minimizing the generation of waste and eliminating many of the waste disposal problems. Coffey (2009) studied cost-effective systems for solid waste management and pointed out that solid construction waste management is generally seen as a low priority when financial constraints are present and suggested that considerable waste reduction can be achieved if waste management is implemented as part of project management functions. Ayarkwa and Adinyira (n.d) report of a wide variation in wastage rates of between 5% and 27% of total materials purchased for construction projects in Ghana. As construction is a locomotive sector of the national economy, waste in the construction industry affects the overall national economy. It is important therefore to explore measures contributing to construction material waste minimization and assess the level of practice of such measures in the construction industry since cost reduction arising from minimization of materials waste is of direct benefit to all stakeholders.

2.2 Management of Construction Waste

During the construction process, construction managers have to deal with different factors that can negatively affect the performance of the production process, and producing different type of wastes. Wastes can include mistakes, rework, working out of sequence, redundant activity and movement, delayed or premature inputs and products or services that do not meet customer needs (Construction Industry Board, 2008).

Waste in construction has been defined in different ways by different studies. According to the new production philosophy, waste should be understood as any inefficiency that results in the use of equipment, materials, labour, or capital in larger quantities than those considered as necessary in the production of a building. Waste includes both the incidence of material losses and the execution of unnecessary work, which generates additional costs but do not add value to the product (Polat & Ballard, 2014). Waste should be defined as any losses produced by activities that generate direct or indirect costs, but do not add any value to the product from the point of view of the client (Alwi *et al.,* 2012; Formoso *et al.*, 2009).

According to Polat and Ballard (2014), a simple way to define waste is "that which can be eliminated without reducing customer value". It can be activities, resources, rules, etc. Macomber and Howell (2014), add that, the common sense understanding of waste is anything of no value. More precisely, waste is the expenditure of effort or the using-up of resources without producing value. After categorizing waste to seven types by Ohno (2014), Womack and Jones (2016) defined waste as any activity that absorbs sources and does not have any value adding. Waste in construction can be classified into three main types; waste of materials, waste of time and waste of machinery (Al-Moghany, 2016; Ekanayake and Ofori, 2010). However, this research focuses on materials waste. Construction material wastes refer to materials from construction sites that are unusable for the purpose of construction and have to be discarded for whatever reason (Yahya &

Boussabaine, 2016). According to Ekanayake and Ofori (2010), construction material waste is defined as any material apart from earth materials, which needs to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project due to damage, excess or non-use or which cannot be used due to non-compliance with the specifications, or which is a by-product of the construction process. Bossink and Brouwers (2016) conducted a research in The Netherlands that was concerned with the measurement and prevention of construction waste with regard to meeting sustainability requirements stated by Dutch environmental policies. Waste from seven materials was monitored in five house-building projects between April 1993 and June 1994. During the study, all material waste was sorted and weighed. The amount of direct waste by weight ranged between 1 and 10% in weight of the purchased amount of materials. Further, it was concluded that an average 9% (by weight) of the total purchased construction materials end up as site waste in the Netherlands.

According to Datta (2010), about 20-25% of materials are wasted on construction sites in Tanzania, Zambia, Zimbabwe and Botswana. Fatta *et al.,* (2013) also stated that in Greece, each 1000m^2 of building activity entail the generation of 50m^3 of waste. Ayarkwa and Adinyira (n.d.) reports of a wide variation in wastage rates of between 5% and 27% of total materials purchased for construction projects in Ghana.

2.3 Causes of Construction Materials Waste

Many factors contribute to construction waste generation on site. Waste may occur due to one or a combination of many causes. According to Poon *et al.* (2011), research in Hong Kong indicates there are many contributory factors to the generation of waste; these include both human and mechanical activities. Bossink and Brouwers (2015) classified the main waste causes in construction into six sources, which are design, procurement, material handling, operation, residual, and others. Also Gavilan and Bernold (2009) used the same six categories. Waste production on construction sites is often due to inadequate storage and protection, poor or multiple handling, poor site control, over ordering of material, bad stock control, lack of training, and damage to material during delivery (2014). Other researchers categorized these causes into four categories, according to Lingard et al. (2013), procurement, handling, operation, and culture, while Ekanayake and Ofori (2008) grouped factors generating material waste into design, procurement, handling of material, and operation. Muhwezi et al. (2010) classified materials wastage on building construction projects into 9 groups. These are design and documentations, site management and practices, procurement, materials handling, storage, transportation, operation, and environmental and other conditions. Table 2.2 is a summary of the major causes of materials waste in Hong- Kong.

Table 2.1 Causes of Construction Site Waste

	Causes of Building Waste on Site	**Examples**
SITE MANAGEMENT PRACTICES	Lack of a quality management system aimed at waste minimization	lack of waste management plan
	Untidy construction sites	waste materials are not segregated from useful materials
	Poor handling	breakage, damage, losses
	Over-sized foundations and other elements	over design leads to excess excavation and cut-offs
	Inadequate protection to finished work	finished concrete staircases are not protected by boarding
	Limited visibility on site resulting in damage	inadequate lighting in covered storage area
	Poor storage	pallet is not used to protect cement bags from contamination by ground water
	Poor workmanship	poor workmanship of formwork
	Waste generation inherited with traditional construction method	e.g. timber formwork, wet trade
DELIVERY OF PRODUCTS	Over-ordering	over ordering of concrete becomes waste
	Method of packaging	inadequate protection to the materials
	Method of transport	materials drop from forklift
	Inadequate data regarding time and method of delivery	lack of records concerning materials delivery

(Source: Poon *et al.,* 2001)

Bossink and Brouwers (1996), in their study in The Netherlands indicated the main sources and causes of construction waste as shown in Table 2.3.

Table 2.2 Sources and Causes of Construction Materials Waste

SOURCE	CAUSE
Design	Error in contract documents
Design	Contract documents incomplete at commencement of construction
Design	Changes to design
Design	Choices about specifications of products
Design	Choices of low quality to sizes of used products
Design	Designer is not familiar with possibilities of different products
Design	Lack of influence of contractors and lack of knowledge about construction
Procurement	Ordering error, over ordering, under ordering, and so on
Procurement	Lake of possibilities to order small quantities
Procurement	Use of products that do not fit
Materials handling	Damage during transportation to site/on site
Materials handling	Inappropriate storage leading to damage or deterioration
Materials handling	Unpacked supply
Materials handling	Throwaway packaging
Operation	Error by tradesmen or operatives
Operation	Equipment malfunction

Operation	Inclement weather
Operation	accidents
Operation	Damage caused by subsequent trades
Operation	Use of incorrect material, requiring replacement
Operation	Method to lay the foundation
Operation	Required quantity of product unknown due to imperfect planning
Operation	Information about types and sizes of products that will be used arrived too late on the construction site
Residual	Conversion waste from cutting uneconomical shapes
Residual	Off cuts from cutting material to length
Residual	Over mixing of materials for wet trades due to a lack of knowledge of requirements
Residual	Waste from application process
Residual	Packaging
Other	Criminal waste due to damage or theft
Other	Lack of onsite materials control and waste management plans

(Source: Bossink and Brouwers, 1996)

Similarly in Singapore, Ekanayake and Ofori (2010) organized the sources of construction waste under four categories: (1) design; (2) operational; (3) material handling; (4) procurement as shown in Table 2.4.

Table 2.3 Sources of Construction Materials Waste

Design	Operational	Material handling	Procurement
Lack of attention paid to dimensional coordination of products	Errors by tradesmen or operatives	Damages during transportation	Ordering errors (eg., ordering significantly more or less)
Changes made to the design while construction is in progress	Accidents due to negligence	Inappropriate storage leading to damage or deterioration	Lack of possibilities to order small quantities
Designers inexperience in method and sequence of construction	Damage to work done caused by subsequent trades	Materials supplied in loose form	Purchased products that do not comply with specification
Lack of attention paid to standard sizes available on the market	Use of incorrect material, thus requiring replacement	Use of whatever material close to working place	
Designers unfamiliarity with alternative products	Required quantity unclear due to improper planning	Unfriendly attitudes of project team and operatives	
Complexity of detailing in the drawings	Delays in passing information to the contractor on types and sizes of products to be used		
Errors in contract documents	Equipment malfunctioning		
Incomplete contract documents at commencement of project	Inclement weather		
Selection of low quality products			

(Source: Ekanayake and Ofori, 2000)

According to Alwi *et al.* (2002), the most significant causes of waste during the construction process in a comparative study of Indonesia and Australia construction projects are summarized in Table 2.5.

Table 2.4 Causes of Construction Materials Waste in Indonesia and Australia

Indonesia	Australia
Design changes	Design changes
Lack of trades" skill	Poor design
Slow in making decisions	Poor quality site documentation
Poor coordination among project participants	Slow drawing revision and distribution
Poor planning and scheduling	Unclear site drawing supplied
Delay of material delivery to site	Unclear specifications
Inappropriate construction methods	Weather

(Source: Alwi *et al.,* 2002).

Other studies (Arnold 2008; Formoso *et al.,* 2009; Polat and Ballard 2014) trace materials waste to sources including; overproduction, substitution,, waiting time, transportation, processing, inventories, movement and production of defective products. Many of the root causes and sources of materials in the aforementioned studies can be traced to supply chain issues such as but not limited to; poor supplier relationship management, poor customer relationship and poor flow of information. Arguably, effective SCM can lead to prevention or reduction in levels of materials waste on most projects as observed in many of the aforementioned studies.

2.3.1 Waste management framework in Europe

2.3.1.1 European community strategy for waste management 2009

The European Commission initially set out its waste policy in the European Community Strategy for Waste Management of 2009 (SEC (89) 934 Final 2009). This document forms the cornerstone of European waste policy. As well as many detailed measures, the strategy contains the following points:

Confirmation of the 'Proximity Principle'. This requires that waste is dealt with as near as possible to its source. The establishment of a waste management hierarchy. The waste hierarchy sets out the most favored options of waste management in a pyramid shape showing the most favored option (prevention) at the top and the least favored option (disposal) at the bottom.

The European Union Waste Framework Directive in 1975 first introduced the concept of the waste hierarchy and in the European Commission's Community Strategy for Waste Management in 1989 it was formed into a hierarchy of waste management options. Further to this the hierarchy was endorsed in the Commissions review of this strategy in 1996. This traditional waste hierarchy prioritises the prevention and reduction of waste, and then followed by reuse and recycling and the final option being disposal.

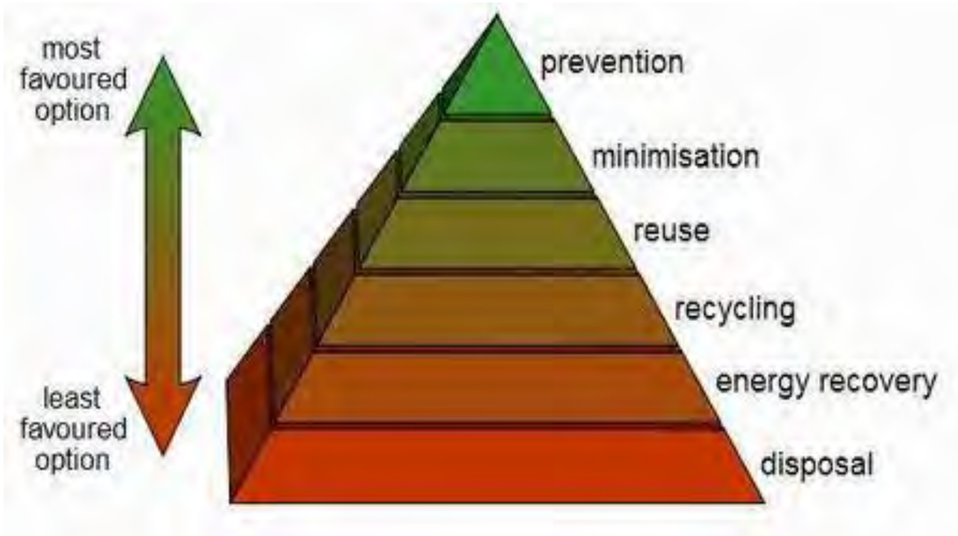

Figure 2.1 Waste hierarchy (Source: European commission, 2009)

If the waste hierarchy is followed then waste should be reduced at source and where waste cannot be prevented the waste materials should be reused or recycled. If this is not possible the next option is to recover the energy content from the materials. Only if none of these options are available should waste be sent for disposal and this disposal should be done in a controlled and authorised way. Applying the waste hierarchy to construction waste means that waste materials should be managed in a way that protects both people and the environment. Human health, safety and security should be considered along with any environmental decision making. When undertaking waste management it is important that the contamination of waste streams with hazardous waste is prevented.

During the past the waste hierarchy has taken different forms but the most basic concept is still the basis for most waste minimisation strategies. The main aim of the hierarchy is to extract the maximum benefits from products and to generate the minimum amount of waste possible. Price and Joseph (2010) state that the reality of the waste hierarchy is that it is a prescriptive approach and that the hierarchy does very little to alleviate the over reliance on end of the line solutions. They believe that if more regard was given to the development of efficient processes and demand management that it would reduce resource and energy usage and impact directly on waste generated. The waste hierarchy was initially developed to focus on high population areas such as the core of the EU. Barrett and Lawlor (2010) found that the application of the waste hierarchy in areas of low population density may place an unnecessary economic burden on that region. The study found that landfill is significantly cheaper in these low population industries and consequently cheaper than the alternative methods. In conclusion they found that landfill should not be excluded as a disposal option in areas of low population density. This scenario is applicable to certain areas of rural Ireland where the waste recovery facilities are a considerable distance from the waste source.

Subsequent to the establishment of the European Union in 1993, a revised version of the strategy was adopted by the commission in July 1996. This strategy included the following amended points:

Energy recovery may in some cases be environmentally superior to recycling within the hierarchy.

The EU will investigate possible actions on incineration and the implications of using waste as a fuel at installations not originally designed for this.

The Commission will introduce targets to substantially reduce the amount of waste generated and to generally achieve high waste recovery objectives.

The principle of producer responsibility will be incorporated in all future measures.

The Commission will come forward with proposals to control landfill (European Commission, 2009)

2.4 Waste framework directive 2008 98/2008 EC

The waste framework directive repeals the previous 2006 directive on waste as well as Directives 75/439/EEC and 91/689/EEC regarding waste oils and hazardous waste respectively. The revised waste framework directive sets out provisions to boost waste prevention and clarifies the key concepts and definitions.

The waste framework directive 2008 was entered into Irish law in March 2011. The directive sets out the concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. It also explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products.

The Directive lays down some basic waste management principles, these include:

It requires that waste be managed without endangering human health and harming the environment.

Waste legislation and policy of the EU member states shall apply the waste management hierarchy.

The directive introduces the polluter pays principle and the extended producer responsibility. Extended producer responsibility might include an acceptance of returned products and of the waste that remains after those products have been used, as well as the management of the waste and financial burden for such activities.

It includes a new target for re-use, recycling and other recovery of 70 per cent of construction and demolition waste by 2020.

The directive requires that member states adopt waste management plans and waste prevention programs.

A new waste hierarchy was set out in Article four of the Waste Framework Directive and is, as before, the priority order for waste management. The hierarchy lists five ways of dealing with waste (although prevention is technically not a waste management method because it concerns objects before they become waste). The following figure illustrates the new waste hierarchy;

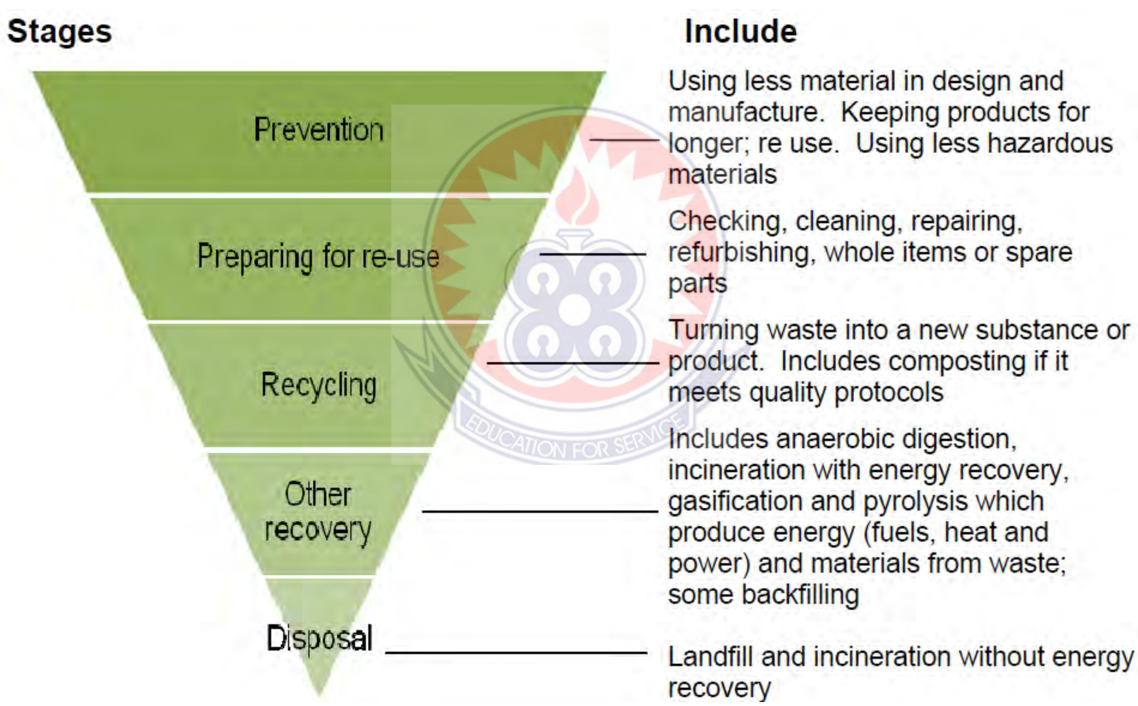

Figure 2.2 Waste Hierarchy WFD (Source: Defra.gov.uk)

There are a number of changes in comparison to the previous waste hierarchy as laid out in the 2006/12/EC Directive. The former waste hierarchy was expanded to five steps and 'preparing for reuse' was added as a new concept. The previous legislation ranked preparation for reuse, recycling and recovery as equal but this new hierarchy distinguishes between these and now ranks preparing for reuse above recycling and recovery. It is now mandatory for Member States to apply the waste hierarchy and the options that deliver the best environmental outcome must be considered. In the third paragraph of Article 4(2) of the WFD it states that;

"*Member States shall take into account the general environmental protection principles of precaution and sustainability, technical feasibility and economic viability, protection of resources as well as the overall environmental, human health, economic and social impacts when applying the waste hierarchy."* (European Parliament, 2008).

As well as this Articles 28(1) and 29(1) of the WFD emphasise that waste management plans and waste prevention should be established in accordance with the waste hierarchy. (European Parliament, 2008) Although the concept of the waste hierarchy is nothing new, in the past there was no obligation on Member States to encourage it, now under the Waste Framework Directive 2008 it has become mandatory.

2.5 Construction waste minimisation in Ghana

Ayarkwa and Adinyira (n.d), studied the perceptions of contractors and consultants on the major causes of materials wastage on construction sites in Ghana. The results are shown in the Figures 2.3 and 2.4 respectively.

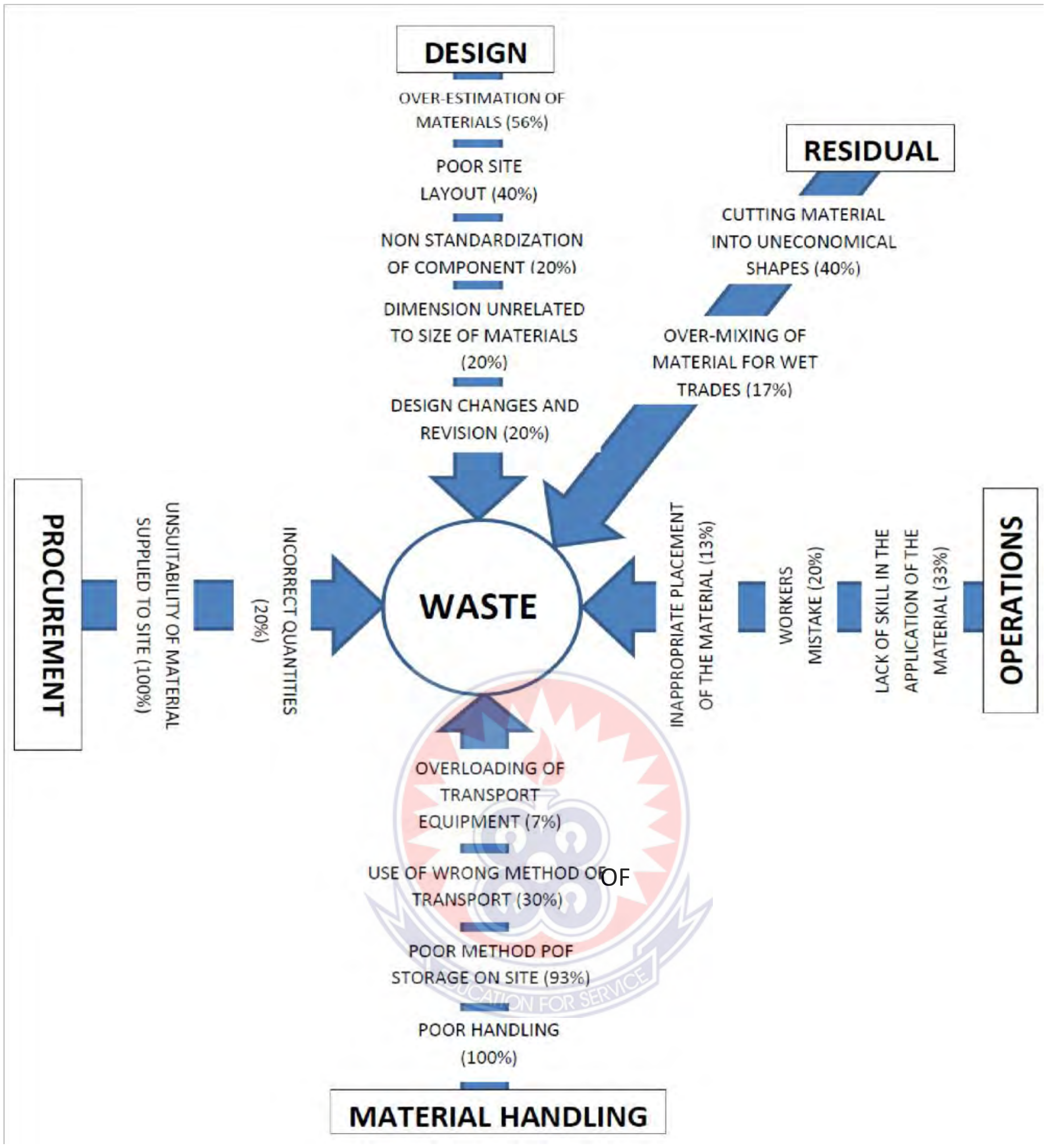

Figure 2.3 Contractors‟ perceptions of the main causes of material waste in construction in Ghana

(Source: Ayarkwa and Adinyira, n.d.)

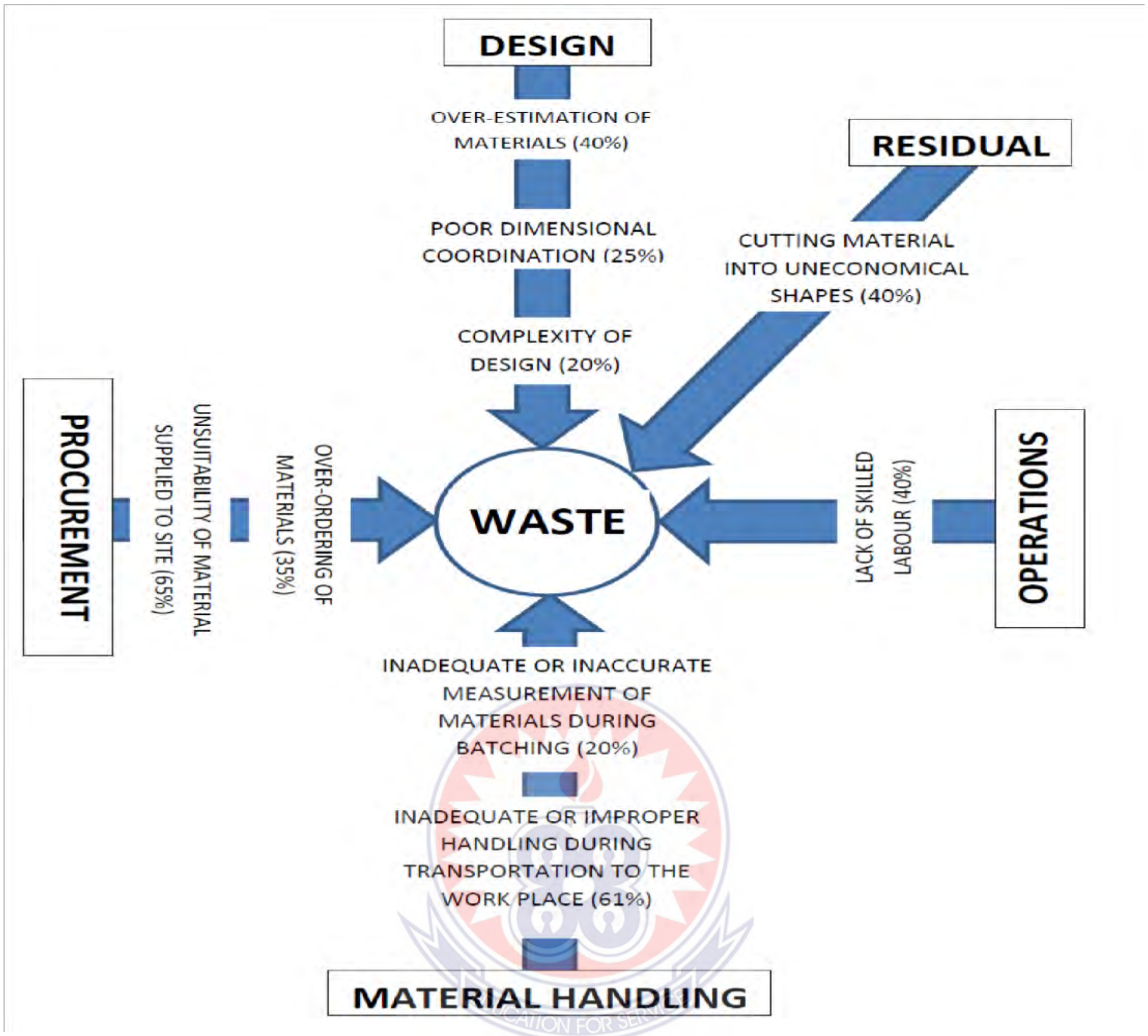

Figure 2.4 Consultants" perception of the main causes of material waste in construction in Ghana (Source: Ayarkwa and Adinyira, 2011)

According to Ayarkwa and Adinyira (2011), in order to reduce the amount of waste generated in construction, the main causes of waste generation must be identified. The study asked respondents to identify the main causes of material waste in their construction operations. The frequencies of the causes were calculated following a classification proposed by Bossink and Brouwers (2016). The main causes of material waste and their percentage frequencies are presented in Figure 2.3 and 2.4 respectively.

Waste occurs at every stage in the construction life cycle. All contractors and 65% of consultants considered the ordering of unsuitable materials for a project (in terms of quality, type and dimensions) to result in material waste. This situation may arise from wrong information flow, deliberate choice of low quality materials in order to reduce cost, or wrong/ inadequate specification by project consultant. Bossink and Brouwers (2016) and Polat and Ballard (2014), realized that the choice of low quality products and products that do not fit are two main causes of material waste. All contractors and 61% of consultants were of the opinion that poor handling of materials results in material waste. This may occur during transportation to the workplace, within the store, or during application. Poor handling may result from lack of knowledge on proper handling of sensitive material or lack of skill in job performance on the part of site workers. Poor storage method was also considered by 93% of contractors to cause material waste. Poor storage can result in breakage or damage to materials, especially fragile ones like ceramic tiles and glass. Overestimation, over-ordering, and poor site layout were also considered by significant percentages of contractors and consultants to result in material waste. Overestimation leads to over-ordering of materials which will bring more materials than necessary for a job. Improper site layout resulting from improper planning, which affects the flow or sequence of activities on site, creates problems with transportation of materials and movement of site workers, and results in poor handling and resultant damage to materials. Lack of standardization of component dimension, dimensions unrelated to sizes of materials or poor dimensional coordination, which are design issues, may result in cutting, shaping, sawing etc., causing material waste in construction.

Most of the causes of construction materials waste identified by Ayarkwah and Adinyira (2011) confirm the findings of similar other studies (Garas *et al.,* 2011; Bossink and Brouwers, 2016, Gavilan and Bernold, 2014; Craven *et al.,* 2014; Polat and Ballard, 2014). Twenty percent of contractors indicated that workers‟ mistakes cause material waste on site. Fourty percent (40%) of consultants also think lack of skilled labour cause material waste. In a study of dominant causes of waste generation in Egyptian construction Garas *et al.* (2011) is reported to have found that untrained labourers make mistakes frequently. The results again showed that the reduction of construction waste is not only a responsibility of the construction company. The client and the designer can make environmentally-friendly choices in the programme of demands and the design. Sources of material waste have been traced to the design, procurement, material handling, operation and residual activities. Also worth noting is that effective SCM has the potential to address some causes of materials wastes thereby substantially reducing levels of materials waste on construction sites and consequently resulting cost savings to both contractor and clients of the construction industry.

2.6 The Importance of Minimising Construction waste

Construction and demolition projects pose unique challenges in the area of waste minimization (Hoe, 2016; Milward, 2015). Since each project is different, generating its own unique combination of wastes, the contractor must be flexible and creative in finding ways to reduce, reuse, or recycle the various types of wastes (Hoe, 2016). According to Hoe (2016), managing construction and demolition waste can constitute a significant cost to the business. Some wastes require careful and perhaps expensive handling techniques during the construction process. A company can thus benefit in a number of ways from reducing the amount of waste it needs to dispose of. The consideration of waste minimization can generate advantages such as financial and environmental benefits (Al-Moghany, 2016; Poon and Jailon, 2012).

2.6.1 Financial benefits

Waste minimization can provide financial benefits, and in some cases can even save cost and time. The financial benefits can be appreciated over a short term or long-term period. But overall, cost benefits can be appreciated throughout the whole building process by carrying out an analysis of the life cycle costs. Financial benefits include:

- Reduced transportation costs for waste materials (less transportation because of less material wasted). This includes transportation to and from the site and disposal.
- Reduced disposal costs of waste materials.
- Reduced purchase quantity and price of raw materials by waste minimization.
- Reduced purchase price of new materials when considering reuse and recycling (depending on materials).
- Increased returns can be achieved by selling waste materials to be reused and recycled.

Long term benefits through optimizing the building life concept, by avoiding expenses from demolition and construction of new buildings (Al-Moghany, 2016; Poon and Jailon, 2012). Use of recycled materials has reduced waste storage costs and minimized the dereliction of land (Al-Moghany, 2016; Lnyang, 2013). Sometimes, reuse and recycling may not always be financially viable, hence other considerations should be considered such as environmental benefits (Al-Moghany, 2016).

2.6.2 Environmental benefits

Waste minimization can provide environmental benefits, which are important to be considered due to the alarming situation of materials waste on construction sites (Al-Moghany, 2016; Poon and Jailon, 2012). These environmental benefits are:

- Reduced quantity of waste generated.
- Efficient use of waste generated.
- Reduced environmental effects as a result of disposal, e.g. noise, pollution.
- Reduced transportation of waste to be disposed of (hence less noise, vehicle emission pollution, and energy used).

2.7 Current States of Recycling Construction Waste

The economic and environmental benefits to be gained from waste minimization and recycling are enormous (Guthrie *et al*., 2009), since it will benefit both the environment and the construction firms in terms of cost reduction. The economic benefits of waste minimization and recycling include the possibilities of selling specific waste materials and the removal from site of other waste at no charge or reduced cost, with a subsequent reduction in materials going to landfill at a higher cost (Snook *et al*., 2015). Therefore, it can increase competitiveness through lower production costs and a better public image.

However, very few contractors have spent efforts in considering the environment and developing the concept of recycling building materials (Lam, 2007). Because contractors rank timing as their top priority, their effort is always focused on completing the project in the shortest time, rather than the environment (Poon *et al*., 2011). Their account books cannot reveal the potential savings resulted from reduction in construction waste. Managing building material waste can in fact achieve higher construction productivity, save in time and improvement in safety (Chan and Ma, 2008; Gavilan and Bernold, 2014; Skoyles and Skoyles, 2007) while extra waste take extra time and resources for disposal that may slow down the construction progress.

There are many possibilities for disposing of waste from construction and demolition activities, from recycling to incineration and land filling. Five waste management actions had been recommended by Waste Reduction Framework Plan (WRFP, 2008): (1) Waste avoidance: waste should not be produced in the first place, for example, packaging should not be used unless essential; (2) Waste minimization: if waste production is unavoidable, the quantities should be minimized. Essential packaging, for example, should be designed to minimize the materials used; (3) Waste recovery, recycling and reuse: the recovery, recycling and reuse of suitable waste materials should be maximized; for example, using a producer responsibility scheme to recover waste packaging for reusing; (4) Waste bulk reduction: if it is not possible to recover, recycle or reuse the waste materials, the volume of residual waste should be reduced before final disposal, this might involves incineration or composting; and (5) Waste disposal: wherever possible the residue left after bulk reduction will be used for construction purposes or reclamation in preference to being dumped in the landfills.

Normally, three main waste minimization strategies identified were reusing, recycling and reducing construction materials, collectively called the '3Rs' and these are presented in the order or preference, representing a hierarchy of environmental benefit and potential for economic savings (Shen and Tam, 2012). To reduce the waste generated on site, coordination among all those involved in the design and construction process is essential and so meetings that being together all of these parties should occur on a regular basis to address waste issues.

2.8 Practices of Reuse, Recycle and Reduction

Furthermore, according to the research conducted in Hong Kong by Shen and Tam, (2012), the interviewees suggested the possibility of current practices of reuse, recycling and reduction of the construction material in on-site construction activities. Five types of construction materials are under discussions with the practitioners, namely, ferrous and non ferrousmetals, glass, timber, compostables, and other materials. The following summarized the suggested methods for reuse, recycle and reduction on those five materials:

(1) *Ferrous and non-ferrous metals* includes steel re-bar, aluminum siding, plumbing fixtures, piping, metal bending, roofing cladding and brass. It should be noted that individuals attitude towards the reuse of metals depends primarily on metal prices in the world market. Most of the interviewees explained that very little of the ferrous and non-ferrous metals is taken to waste because it is considered to be the most profitable waste materials for recycling. The high costs of virgin metals have resulted in the establishment

of a highly efficient recycling business that has been operating in the industry for some time.

(2) *Glass* has already being separated in many overseas countries and the Hong Kong government is looking into this matter seriously. One of the interviewed contractors pointed out that glass can be reused several times and that they have managed to substitute glass with other materials on some occasions. In addition, one contractor explored the opportunity for recycling glass into other products such as aggregate, windows and glass fibres. Glass bottle recycling is a mature industry; however, the recycling of glass in the construction industry has only recently gained popularity.

(3) *Timber* can be chopped and sold as landscaping mulch. One contractor pointed out that they are already recycling timber on one of their projects in Japan. One of the interviewees also suggested that it can be reused in the form of interior fixture and furniture and act as organic-bonded or cement-bonded boards for whole timber or timber fragments in the future. Although timber formwork is the most usual form for formwork making, one contractor is encouraging and recommending to use other durable materials, such as steel or aluminum. The advantage to employing the latter formwork materials is that they can be reused a larger number of times than timber.

(4) *Compostable materials* can be crushed into gravel for using in paving materials and as aggregates for the new concretes (Tam *et al.*, 2005). The Hong Kong government is proposing to make it a contractual requirement to adopt recycled aggregate (HKHA, 2015).

(5) *Other materials* should also be considered for reuse, recycling and reduced consumption. Education and training is a key enabler for achieving environmental

awareness and ensuring that any opportunities for reuse, recycling and reduction of any type of material are not missed (Shen & Tam, 2002).

2.8 Types of construction wastes generated

Concrete

With the present technology, concrete cannot be made 100 percent by recycling old concrete. This is because new cement is always required for new concrete, as well the existing regulations and strict demand on physical properties for some structural concrete make this unpractical (WBCSD, 2009). It should also be noted that concrete is typically crushed to produce recycled concrete aggregate. In Sweden, it is estimated to realize 70% production of Recycled Concrete Aggregate by 2010. In turn it would be used as: 3% on the bound applications as aggregate for new concrete, 92% on the unbound applications below ground such as road base, backfill etc. and 5% to be used above ground for unbound uses such as road surface (Engelsen, 2015).

Figure 2.5: Waste concrete

Wood

Most of the used wooden material in the EU are used for energy recovery or used as virgin material in manufacturing primary materials. In Sweden, 90% of recovered wood is used for energy recovery while in France most of recovered wood is used as virgin material for processing new wooden products such as fiber boards (Muthu, 2015). There is no accurate data on wood waste fraction in C&D sector. According to the total market volume of wood, the recovery rate is estimated at 22.3% in the EUs which is 9.2% on material recovery and 12.1% on energy recovery (Mantau, 2012).

Figure 2.6: Wood waste

Steel wastes

With regard to steel however, typically the greatest amount of recovered materials are used as scrap in new steel production process. Krogh et al. (2011) states that in Sweden scrap steel are a base material in new concrete reinforcement bars production. The Green Building Council of Australia in 2010 reported a 90% recycling rate on steel scraps generated from C&D (Muthu, 2015).

Figure 2.7: Scrap dealer crushing waste pillars for waste iron rods

Figure 2.8 Waste steel from unwanted crushed pillars

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The chapter presents the methods used in the collection of data for the study. It also includes research design, population of the study, sampling and sample size determination, data collection and analysis of data.

3.2 Research Design

Research designs can be classified into three main types. These are qualitative research method, quantitative research method and the mixed research method. The researcher used both qualitative and quantitative research methods. This research required the use of the mixed method. Burns and Grove (2013), describes qualitative research method as identifying and exploring factors like assessing waste reduction on construction sites in Ghana. It is an approach used to describe life experiences and situations to create meanings out of it (Burns and Grove, 2003). Qualitative research methods are usually related to inductive approaches which are based on empirical evidence (Anon n.d.).

However, quantitative research method can be identified as testing pre-determined hypotheses and produced generalized result by the use of statistical methods. It is characterised by collecting information which can be analysed numerically and presenting the results by using statistics, tables and graphs (Burns and Grove, 2013). Quantitative research methods are also usually related to deductive approaches which are based on logic. From above the mixed method approach was used.

The mixed method can also be described as collecting or analysing both quantitative and qualitative data in a single study in which the data are collected sequentially and given a priority which involve the integration of the data at one or more stages in the research process. The use of both quantitative and qualitative data helps to enhance the results of a research (Hanson *et al.,* 2015). This study employed the mixed method through the use of questionnaires and interview guides and observations in collecting data from the field. Specific views and opinions will be sampled from the managers, and supervisors on the construction sites in the Kwahu Municipality.

3.3 Population

The population for the study is one hundred and twenty five (125). The population of the study was made up of Managers and Supervisors of the Building construction companies in the Kwahu East Municipality.

3.4 Sampling Procedures and Sample Size

Sampling is the collection of information about some group of people in order to answer the research questions. Census method refers to the complete enumeration of a universe. A universe may be a place, a group of people or a specific locality through which we collect the data. Census method is necessary in some cases like population census, for gaining vast knowledge. But in contrary this & method is not applicable as well as needed to some social problems because it is costly and time consuming. It is difficult to study the whole universe because financially aid requires for it to complete the study. For this purpose we use sampling method to pick up a simple from the whole universe. Census method is perplexed and takes more time in data collection.

3.4.2 Sample size

Census sampling technique will be used to select all the 125 Managers and Supervisors in the selected construction sites for the study.

3.5 Data Collection Instruments

The data collection Instruments used for the study involved questionnaires, interview and observation.

3.5.1 Questionnaire

Questionnaires were designed and distributed to the respondents. Closed and open ended questionnaire items were designed to collect primary data; this is because it has proven to be consistent and popular method of data collection. Questionnaires were designed for the Managers and Supervisors of the selected construction firms. The questionnaire covered items which helped the researcher to get information regarding the management of waste on construction sites. The study questionnaire consisted of five sections, section one consists of the demographic information of the respondents, including the respondents' gender, age and current year of study. Section two evaluated waste reduction techniques on construction sites in the Kwahu East District. Section three identified the causes of construction materials waste on construction sites. Section four assessed the types of construction wastes generated on construction sites and section five assessed the importance of minimising construction waste on construction sites. The analysis of the study was based on these issues.

3.5.2 Interview

The study obtained information from the 125 respondents using face to face interview; this was aimed at finding out certain information needed, of which satisfactory response may not be obtained through written questionnaire. The interview guide contains information regarding waste management on the construction sites in the Kwahu East Municipality. The interview examined wastage issues on construction sites in the Kwahu East District. Secondly, the interview identified the causes of construction materials waste on construction sites and finally devised strategies to ensure effective waste reduction on construction sites.

3.5.3 Observation

The researcher visited El Shaddai Construction Company and Obodai Construction company in the Kwahu East District and critically observed how the managers and supervisors of the construction firms dispose of waste, recycling opportunities and effective waste management techniques used. Moreover, at El Shaddai Construction Company the researcher observed an abandoned construction work containing a lot of concrete, wood and steel wastes at the construction site. Finally, at Obodai Construction Company the researcher observed waste cement blocks and concrete abandoned at the construction sites.

3.6 Pilot Testing

The pilot questionnaire were given to 10 Managers to answer to correct errors which could take the form of repetition of questions and typographical mistakes and the avoidance of double questions. The pilot testing took place at the selected construction sites in the Kwahu Municipality.

3.7 Data Collection Procedure

Primary data were collected through a field survey of Managers and Site Supervisors at the selected Construction industries in the Kwahu Municipality. Data were collected through the use of a designed questionnaire and interview guides administered to participants in their construction sites. Questionnaires were filled out by participants and the researcher had to go for the questionnaires on the same day.

3.8 Data Analysis

Raw data obtained from a study is useless unless it is transformed into information for the purpose of decision making (Emery & Couper, 2013). The data analysis involved reducing the raw data into a manageable size, developing summaries and applying statistical inferences. Consequently, the following steps were taken to analyze the data for the study. The questionnaire data was then be coded to enable the respondents to be grouped into limited number of categories. The SPSS version 18 was be used to analyse data. Data were presented in tabular form, graphical and narrative forms. In analyzing the quantitative data, descriptive statistical tools such as Tables, frequencies and charts were used.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Introduction

The chapter presents the results and discussion obtained from the questionnaires, interviews and observation.

Response rate of the respondents

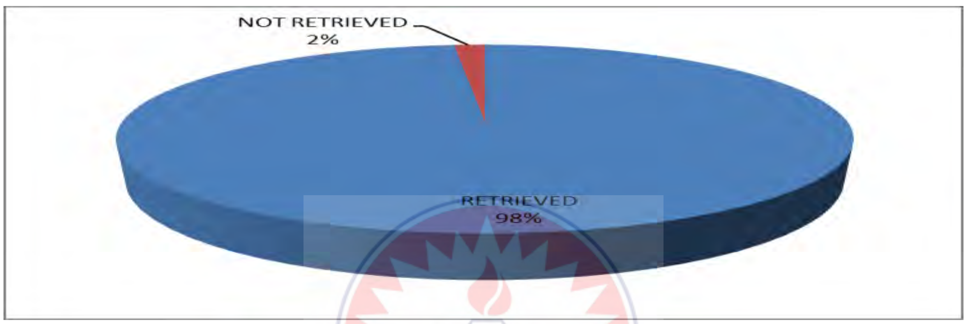

Figure 4.1: Response rate

Source: Field survey, 2017

4.2 Results of the Questionnaire

This section analysed the results of the questionnaire received from Supervisors of the construction firms.

4.2.1 Results of the Questionnaire from the Supervisors

Table 4.1 showed the demographic information of the respondents.

Table 4.1 Demographic characteristics of the respondents

Gender	Frequency	Percent (%)
Male	116	94.3
Female	7	5.7
Total	123	100
Age ranges of the respondents		
Below 25 years	14	11.4
26-35 years	30	24.4
36-45 years	37	30.1
46-55 years	23	18.7
56-65 years	19	15.4
Total	123	100
Educational qualification of the respondents		
SSSCE/WASSCE/NVTI	28	22.8
Higher National Diploma (HND)	42	34.1
Bachelors' degree	42	34.1
Masters' degree	11	8.9
Total	123	100
Working experience		
1-5 years	6	4.9
5-10 years	26	21.1
10-15 years	42	34.1
15-20 years	32	26
20 years and above	17	13.8
Total	123	100

Source: Field survey, 2017

Table 4.1 indicates that 116 supervisors representing 94.3% were males while 7 supervisors representing 5.7% were females. Moreover, 37 supervisors representing 30.1% were in the age ranges 36-45 years, 30 supervisors representing 24.4% were in the age ranges 26-35 years, 23 supervisors representing 18.7% were in the age ranges 46-55 years, 19supervisors representing 15.4% were in the age ranges 56-65 years while 14 supervisors representing 11.4% were below 25 years. Furthermore, 42 supervisors representing 34.1% of the respondents were holding HND and Bachelors' degrees respectively, 28 supervisors representing 22.8% were SSSCE/WASSCE/NVTI certificate holders while 11 supervisors representing 8.9% were holding Masters' degrees. The study results shows that 42 supervisors representing 34.1% affirmed that they have worked for 10-15 years, 32 supervisors representing 26% have worked for 15-20 years, 26supervisors representing 21.1% have worked for 5-10 years, 17 supervisors representing 13.8% have worked for more than 20 years while 6 supervisors representing 4.9% have worked for 1-5 years.

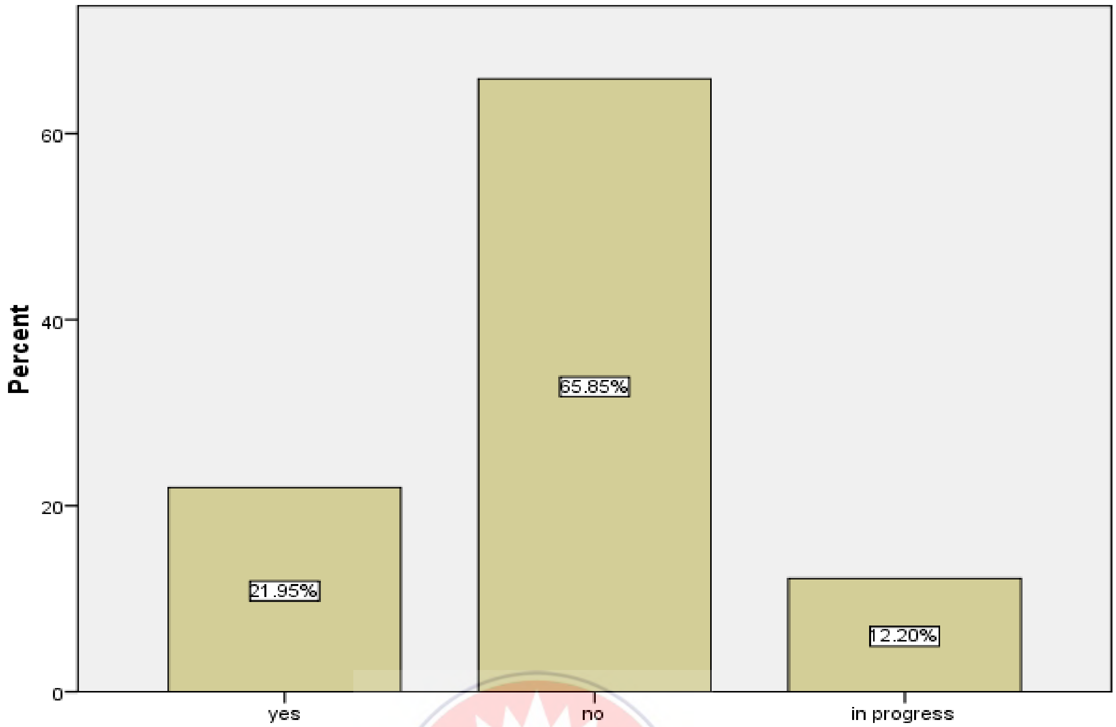

Figure 4.2: Availability of waste management system

Figure 4.2 indicated that on the availability of waste management system in the construction company, 81 supervisors representing 65.9% said that waste management system is not in place, 27 supervisors representing 22% said that currently the company have waste management system in place, while 15 supervisors representing 12.2% said that the introduction of waste management system is in progress. This result is in disagreement with Price and Joseph (2010), who believe that if more regard was given to the development of efficient processes and demand management that it would reduce resource and energy usage and impact directly on waste generated.

Evaluating waste reduction techniques on construction sites in the Kwahu East District.

Table 4.2 showed waste reduction techniques used on construction sites in the Kwahu East District.

Table 4.2: Evaluating waste reduction techniques on construction sites

Waste reduction Techniques	Agree f(%)	Neutral f(%)	Disagree f(%)	Total f(%)
Focus on quality and performance.	84 (68.3)	26 (21.1)	13 (10.6)	123 (100)
Safe transportation	88 (71.5)	25 (20.3)	10 (8.1)	123 (100)
Initiative, tendering, design and procurement	92 (74.8)	14 (11.4)	17 (13.8)	123 (100)
Just-In-Time delivery (JIT) and logistics management.	96 (78)	6 (4.9)	21 (17.1)	123 (100)
Pipeline mapping, Supply chain modelling and logistics performance measurement.	86 (69.9)	18 (14.6)	19 (15.4)	123 (100)
Analysing stock levels across the supply chain.	87 (70.7)	13 (10.6)	23 (18.7)	123 (100)
Supply chain costing and value stream mapping	83 (67.5)	11 (8.9)	29 (23.6)	123 (100)
Packaging reduction or modifications	92 (74.8)	11 (8.9)	10 (16.3)	123 (100)
Recycling of waste	85 (69.1)	28 (22.8)	10 (8.1)	123 (100)

Source: Field survey, 2017

Table 4.2 showed that 84 supervisors representing 68.3% of the respondents agreed that to reduce waste at the construction sites there is the need to focus on quality and performance, 26 supervisors representing 21.1% were neutral while 13 supervisors representing 10.6% disagreed. The study further indicates that 88 supervisors representing 71.5% agreed that safe transportation from the point of sale to the construction sites can reduce waste, 25 supervisors representing 20.3% were neutral while 10 supervisors representing 8.1% disagreed. Moreover, 92 supervisors representing 74.8% agreed that effective initiative, tendering, design and procurement can reduce waste at the construction site, 17 supervisors representing 13.8% disagreed while 14 supervisors representing 11.4% were neutral. To add more, 96 supervisors representing 78% agreed that Just-In-Time delivery (JIT) and logistics management can reduce waste at the construction sites, 21 supervisors representing 17.1% disagreed, while 6 supervisors representing 4.9% were neutral. The study indicates that 86 supervisors representing 69.9% agreed that pipeline mapping, supply chain modelling and logistics performance measurement can reduce waste at the construction site, 18 supervisors representing 14.6% were neutral, while 19 supervisors representing 15.4% disagreed. Moreover, 87 supervisors representing 70.7% agreed that analysing stock levels across the supply chain can reduce waste at the construction sites, 23 supervisors representing 18.7% disagreed while 13 supervisors representing 10.6% were neutral. Also, 83 supervisors representing 67.5% agreed that supply chain costing and value stream mapping is a technique that can reduce waste generation on the construction sites, 29 supervisors representing 23.6% disagreed, while 11 supervisors representing 8.9% were neutral. The study result indicates that 92 supervisors representing74.8% agreed that packaging reduction or modifications can minimise waste at the construction sites, 20 supervisors representing16.3% disagreed while 11 supervisors representing 8.9% were neutral. Furthermore, 85 supervisors representing 69.1% agreed that recycling of waste is a technique to reduce construction waste, 28 supervisors representing 22.8% were neutral, 10 supervisors representing 8.1% disagreed.

These findings agree with Hoe, (2006), who opined that construction and demolition projects pose unique challenges in the area of waste minimization. Since each project is different, generating its own unique combination of wastes, the contractor must be flexible and creative in finding ways to reduce, reuse, or recycle the various types of wastes. According to Hoe (2006), managing construction and demolition waste can constitute a significant cost to the business. Some wastes require careful and perhaps expensive handling techniques during the construction process. A company can thus benefit in a number of ways from reducing the amount of waste it needs to dispose of. The consideration of waste minimization can generate advantages such as financial and environmental benefits.

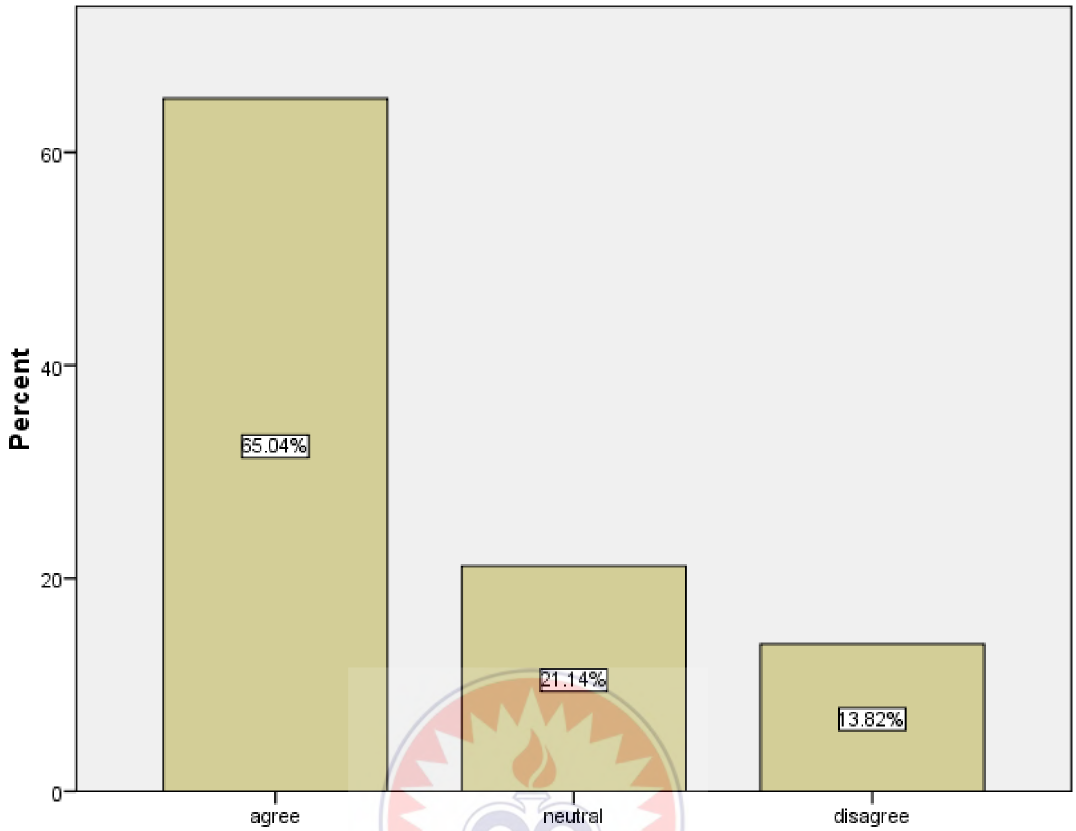

Figure 4.3: Waste management planning

Figure 4.3 indicated that, 80 supervisors representing 65% agreed that effective waste management planning can minimise construction waste, 26 supervisors representing 21.1% were neutral while 17 supervisors representing 13.8% disagreed.

The causes of construction materials waste on construction sites

Table 4.3 assessed the causes of construction materials waste on construction sites

Table 4.3: The causes of construction materials waste on construction sites

ITEM	Agree	Neutral	Disagree	Total
Unskilled labourer	86	23	14	123
	(69.9)	(18.7)	(11.4)	(100)
Overdesign	80	19	24	123
	(65)	(15.4)	(19.5)	(100)
Inadequate storage facilities	84	12	27	123
	(68.3)	(9.8)	(22)	(100)
Improper handling	90	18	15	123
	(73.2)	(14.6)	(12.2)	(100)
Health and safety hazards	81	21	21	123
	(65.9)	(17.1)	(17.1)	(100)
Transportation system	92	18	13	123
	(74.8)	(14.6)	(10.6)	(100)
Misunderstanding of the blueprint	90	20	13	123
	(73.2)	(16.3)	(10.6)	(100)
Vibration/light/heat	94	16	13	123
	(76.4)	(13)	(10.6)	(100)
Lack of markets for recyclable materials	86	20	17	123
	(69.9)	(16.3)	(13.8)	(100)

Source: Field survey, 2017

Table 4.3 showed that 86 supervisors representing 69.9% agreed that an unskilled labourer can mismanage construction resources and create waste at the construction sites, 23 supervisors representing 18.7% were neutral while 14 supervisors representing 11.4% disagreed. Moreover, 80 supervisors representing 65% agreed that overdesign of building plans can create waste at the construction sites, 24 supervisors representing 19.5% disagreed while 19 supervisors representing 15.4% were neutral. The study further showed that 84 supervisors representing 68.3% agreed that inadequate storage facilities can create waste at the construction sites, 27 supervisors representing 22% disagreed, while 12 supervisors representing 9.8% were neutral. Moreover, 90 supervisors representing 73.2% agreed that improper handling of construction materials can create waste at the construction sites, 18 14.6% were neutral, while 15 supervisors representing 12.2% disagreed. To add more, 81 supervisors representing 65.9% agreed that health and safety hazards or accidents can generate construction waste, while 21 supervisors representing 17.1% disagreed and were neutral respectively. The study finding indicated that ineffective transportation system can generate waste at the construction site, 18 supervisors representing 14.6% were neutral while 13 supervisors representing 10.6% disagreed. The study revealed that 90 supervisors representing 73.2% agreed that misunderstanding of the blueprint can cause waste at the construction sites, 20 supervisors representing 16.3% were neutral, while 13 supervisors representing 10.6% disagreed. Moreover, 94 supervisors representing 76.4% agreed that vibration/light/heat can destroy construction materials and cause waste at the construction sites, 16 supervisors representing 13% were neutral, 13 supervisors representing 10.6% disagreed.

These results agree with Poon *et al.* (2011), they said that many factors contribute to construction waste generation on site. Waste may occur due to one or a combination of many causes. According to Poon *et al.* (2011), research in Hong Kong indicates there are many contributory factors to the generation of waste; these include both human and mechanical activities. Bossink and Brouwers (2015) classified the main waste causes in construction into six sources, which are design, procurement, material handling, operation, residual, and others. Also Gavilan and Bernold (2009) used the same six categories. Waste production on construction sites is often due to inadequate storage and protection, poor or multiple handling, poor site control, over ordering of material, bad stock control, lack of training, and damage to material during delivery (2014). Other researchers categorized these causes into four categories, according to Lingard et al. (2013), procurement, handling, operation, and culture, while Ekanayake and Ofori (2008) grouped factors generating material waste into design, procurement, handling of material, and operation. Muhwezi et al. (2010) classified materials wastage on building construction projects into 9 groups. These are design and documentations, site management and practices, procurement, materials handling, storage, transportation, operation, and environmental and other conditions.

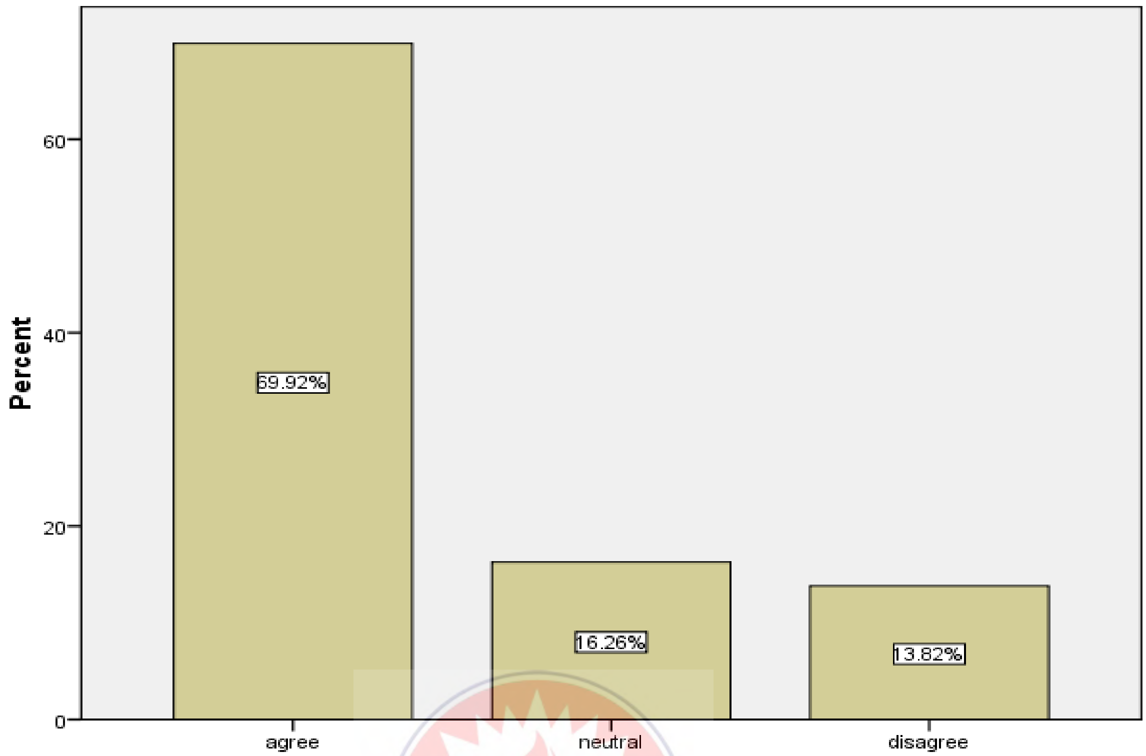

Figure 4.4: Lack of markets for recyclable materials

Figure 4.4 indicated that 86 supervisors representing 69.9% agreed that lack of markets for recyclable materials can generate waste at the construction sites, 20 supervisors representing 16.3% were neutral, while 17 supervisors representing 13.8% disagreed. This results concord with Shen and Tam, (2012), they revealed that normally, three main waste minimization strategies identified were reusing, recycling and reducing construction materials, collectively called the '3Rs' and these are presented in the order or preference, representing a hierarchy of environmental benefit and potential for economic savings.

The Types of construction wastes generated on construction sites.

Table 4.4 revealed the types of construction wastes generated on construction sites.

Table 4.4: The Types of construction wastes generated on construction sites

The Types of construction wastes	Agree f(%)	Neutral f(%)	Disagree f(%)	Total f(%)
Concrete waste	89 (72.4)	16 (13)	18 (14.6)	123 (100)
Wood waste	94 (76.4)	13 (10.6)	16 (13)	123 (100)
Steel wastes	83 (67.5)	26 (21.1)	14 (11.4)	123 (100)
Ceramics waste	85 (69.1)	31 (25.2)	7 (5.7)	123 (100)
Plastic waste	90 (73.2)	21 (17.1)	12 (9.8)	123 (100)
Ferrous and non ferrous metals	78 (63.4)	35 (28.5)	10 (8.1)	123 (100)
Glass waste	93 (75.6)	20 (16.3)	10 (8.1)	123 (100)

Source: Field survey, 2017

The study indicates that 89 supervisors representing 72.4% agreed that concrete waste is a type of waste generated in the construction site, 18 supervisors representing 14.6% disagreed, while 16 supervisors representing 13% were neutral. This agrees with Engelsen, (2015), who indicated that with the present technology, concrete cannot be made 100 percent by recycling old concrete. This is because new cement is always required for new concrete, as well the existing regulations and strict demand on physical properties for some structural concrete make this unpractical. It should also be noted that concrete is typically crushed to produce recycled concrete aggregate. In Sweden, it is estimated to realize 70% production of Recycled Concrete Aggregate by 2010. In turn it would be used as: 3% on the bound applications as aggregate for new concrete, 92% on the unbound applications below ground such as road base, backfill etc. and 5% to be used above ground for unbound uses such as road surface.

Moreover, 94 supervisors representing 76.4% agreed that wood waste a type of waste generated at the site, 16 supervisors representing 13% disagreed, while 13 supervisors representing 10.6% were neutral. This is in agreement with Muthu, (2015), who revealed that most of the used wooden material in the EU are used for energy recovery or used as virgin material in manufacturing primary materials. In Sweden, 90% of recovered wood is used for energy recovery while in France most of recovered wood is used as virgin material for processing new wooden products such as fiber boards. There is no accurate data on wood waste fraction in C&D sector. According to the total market volume of wood, the recovery rate is estimated at 22.3% in the EUs which is 9.2% on material recovery and 12.1% on energy recovery.

Also, 83 supervisors representing 67.5% agreed that steel wastes are generated at the construction site, 26 supervisors representing 21.1% were neutral, while 14 supervisors representing 11.4% disagreed. This agrees with Krogh et al. (2011), with regard to steel however, typically the greatest amount of recovered materials and used as scrap in new steel production process. Krogh et al. (2011) states that in Sweden scrap steel are a base material in new concrete reinforcement bars production. The Green Building Council of Australia in 2010 reported a 90% recycling rate on steel scraps generated from C&D (Muthu, 2015).

Moreover, 85 supervisors representing 69.1% agreed that ceramics wastes are generated at the construction site, 31 supervisors representing 25.2% were neutral, while 7 supervisors representing 5.7% disagreed. The study revealed that 90 supervisors representing 73.2% agreed that plastic waste is generated at the construction site, 21 supervisors representing 17.1% were neutral, 12 supervisors representing 9.8% disagreed.

Moreover, 78 supervisors representing 63.4% agreed that ferrous and non-ferrous metals were generated at the construction site, 35 supervisors representing 28.5% were neutral, while 10 supervisors representing 8.1% disagreed. *Ferrous and non-ferrous metals* includes steel re-bar, aluminum siding, plumbing fixtures, piping, metal bending, roofing cladding and brass. It should be noted that individuals attitude towards the reuse of metals depends primarily on metal prices in the world market. Most of the respondents explained that very little of the ferrous and non-ferrous metals is taken to waste because it is considered to be the most profitable waste materials for recycling. The high costs of virgin metals have resulted in the establishment of a highly efficient recycling business that has been operating in the industry for some time.

The study result further indicate that 93 supervisors representing 75.6% agreed that glass wastes are generated at the construction site, 20 supervisors representing 16.3% were neutral, while 10 supervisors representing 8.1% disagreed. This agrees with Muthu, (2015), who opined that g*lass* has already being separated in many overseas countries and the Hong Kong government is looking into this matter seriously. One of the interviewed contractors pointed out that glass can be reused several times and that they have managed to substitute glass with other materials on some occasions. In addition, one contractor explored the opportunity for recycling glass into other products such as aggregate, windows and glass fibres. Glass bottle recycling is a mature industry; however, the recycling of glass in the construction industry has only recently gained popularity.

The Importance of minimising construction waste on construction sites.

Table 4.5 identified the importance of minimising construction waste

Table 4.5 The Importance of Minimising Construction waste

Financial benefits	Agree f(%)	Neutral f(%)	Disagree f(%)	Total f(%)
Reduced transportation costs for waste materials (less transportation because of less material wasted).	85 (69.1)	20 (16.3)	18 (14.6)	123 (100)
Reduced disposal costs of waste materials.	93 (73.6)	18 (14.6)	12 (9.8)	123 (100)
Reduced purchase quantity and price of raw materials by waste minimization.	91 (74)	12 (9.8)	20 (16.3)	123 (100)
Reduced purchase price of new materials when considering reuse and recycling (depending on materials).	73 (59.3)	17 (13.8)	33 (26.8)	123 (100)
Increased returns can be achieved by selling waste materials to be reused and recycled.	87 (70.7)	17 (13.8)	19 (15.4)	123 (100)
Environmental benefits				
Reduced quantity of waste generated.	86 (69.9)	22 (17.9)	15 (12.2)	123 (100)
Efficient use of waste generated.	80 (65)	34 (27.6)	9 (7.3)	123 (100)
Reduced transportation of waste to be disposed of (hence less noise, vehicle emission pollution, and energy used).	80 (65)	34 (27.6)	9 (7.3)	123 (100)

Source: Field survey, 2017

The study result held that 85 supervisors representing 69.1% agreed that the benefit of minimising construction waste is reduced transportation costs for waste materials (less transportation because of less material wasted). This includes transportation to and from the site and disposal, 20 supervisors representing 16.3% were neutral, while 18 supervisors representing 14.6% disagreed. Moreover, 91 supervisors representing 74% agreed that minimising waste at the construction sites can reduce purchase quantity and price of raw materials by waste minimization, 20 supervisors representing 16.3% disagree, while 12 supervisors representing 9.8% were neutral. Also, 93 supervisors representing 75.6% agreed that the significance of minimising construction waste is reduced disposal costs of waste materials, 18 supervisors representing 14.6% were neutral, while 12 supervisors representing 9.8% disagreed. To add more, 73 supervisors representing 59.3% agreed that minimising waste at the construction site can reduce purchase price of new materials when considering reuse and recycling (depending on materials), 33 supervisors representing 26.8% disagreed, while 17 supervisors representing 13.8% were neutral. The study further revealed that 87 supervisors representing 70.7% agreed that Increased returns can be achieved by selling waste materials to be reused and recycled, 19 supervisors representing 15.4% disagreed, 17 supervisors representing 13.8% were neutral. These findings agrees with Al-Moghany, (2016), who revealed that waste minimization can provide financial benefits, and in some cases can even save cost and time. The financial benefits can be appreciated over a short term or long-term period. But overall, cost benefits can be appreciated throughout the whole building process by carrying out an analysis of the life cycle costs. Financial benefits include:

- Reduced transportation costs for waste materials (less transportation because of less material wasted). This includes transportation to and from the site and disposal.
- Reduced disposal costs of waste materials.
- Reduced purchase quantity and price of raw materials by waste minimization.
- Reduced purchase price of new materials when considering reuse and recycling (depending on materials).
- Increased returns can be achieved by selling waste materials to be reused and recycled.

Furthermore, 86 supervisors representing 69.9% agreed that the quantity of waste generated is reduced, 22 supervisors representing 17.9% were neutral, while 15 supervisors representing 12.2% disagreed. The study result revealed that 80 supervisors representing 65% agreed that generated construction waste is efficiently reused, 34 supervisors representing 27.6% were neutral, while 9 supervisors representing 7.3% disagreed. The study indicates that 80 supervisors representing 65% agreed that minimising construction waste reduced transportation of waste to be disposed of (hence less noise, vehicle emission pollution, and energy used), 34 supervisors representing 27.6% were neutral, while 9 supervisors representing 7.3% disagreed.

These findings are in agreement with Poon and Jailon, (2012), who indicated that waste minimization can provide environmental benefits, which are important to be considered due to the alarming situation of materials waste on construction sites. These environmental benefits are:

- Reduced quantity of waste generated.
- Efficient use of waste generated.
- Reduced environmental effects as a result of disposal, e.g. noise, pollution.
- Reduced transportation of waste to be disposed of (hence less noise, vehicle emission pollution, and energy used).

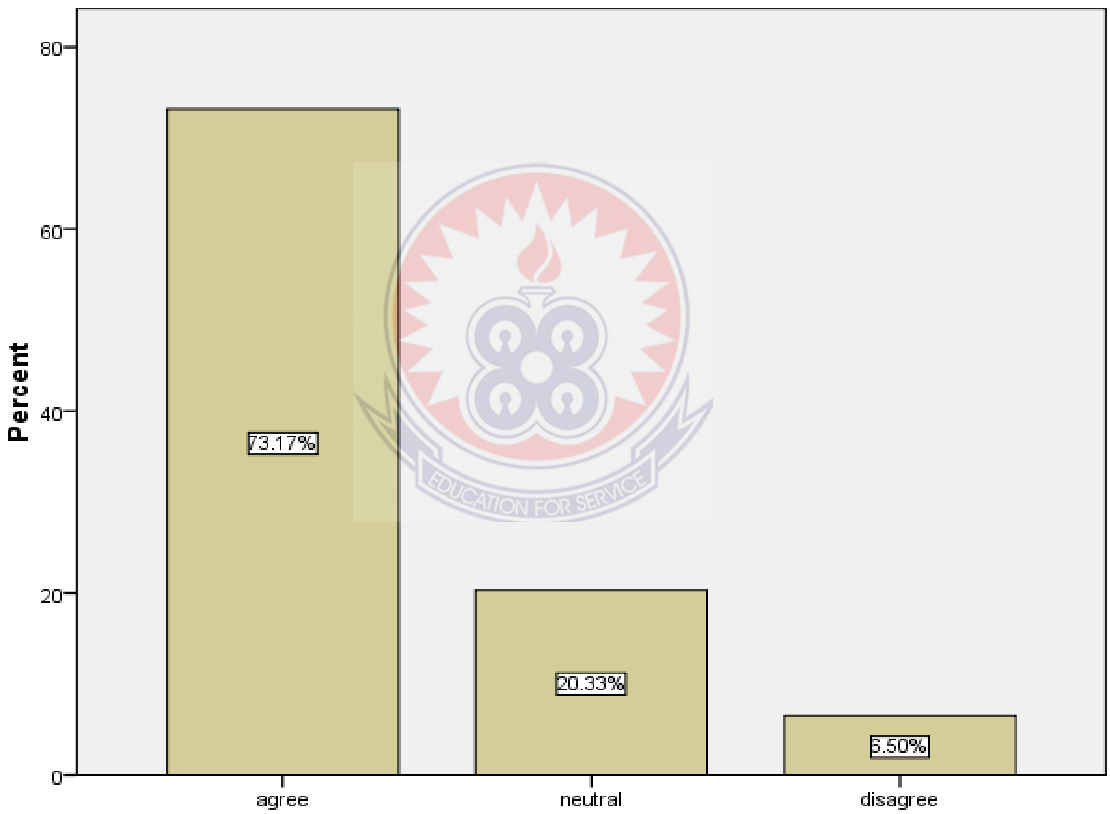

Figure 4.5: Reduced environmental effects as a result of disposal, e.g. noise, pollution.

Figure 4.5 showed that 90 supervisors representing 73.2% agreed that minimising construction waste reduced environmental effects as a result of disposal, e.g. noise, pollution, 25 supervisors representing 20.3% were neutral, while 8 supervisors representing 6.5% disagreed.

4.3 Results of the interview

The researcher interviewed the 10 Managers of the selected construction firms in the Kwahu East District. The outcome of the Managers interview guide is analysed below;

4.3.1 Results of the interview from Managers

The managers of the construction firms were asked about the waste reduction techniques that were used to minimise waste on construction sites in the Kwahu East District. Most of the Managers said '*that safe transportation from the point of sale to the construction sites can reduce waste. Moreover, Just-In-Time delivery (JIT) and logistics management also reduced waste at the construction sites'*. Another Manager called Mr Takyi said that, '*they recycle of waste and applied effective waste management planning techniques to minimise waste at the construction site'*.

When the Managers were asked regarding the causes of construction materials waste on construction sites, '*they said that the causes of construction materials waste were unskilled labourer, overdesign of architectural building designs, inadequate storage facilities, improper handling of construction materials, accidents, and ineffective transportation system can generate waste at the construction site'*. Another Manager called Andrews indicated that '*misunderstanding of the blueprint can cause waste at the construction* *sites, vibration/light/heat can destroy construction materials and cause waste at the construction sites, and lack of markets for recyclable materials can also generate waste at the construction sites'*.

The Managers of the construction companies revealed that the types of wastes generated on the construction sites are '*concrete waste, wood waste, steel wastes, ceramics wastes, plastic waste, ferrous and non-ferrous metals, and glass wastes are generated at the construction site'*.

The Managers of the construction companies were asked regarding the importance of minimising construction waste on construction sites. They indicated that '*the benefits of minimising construction waste are reduced transportation costs for waste materials, reduced disposal costs of waste materials, reduction of purchase price of new materials when considering reuse and recycling (depending on materials), and increased returns can be achieved by selling waste materials to be reused and recycled.* Furthermore, another Manager called Mr. Oduro revealed that *'agreed that generated construction waste is efficiently reused, reduced transportation of waste to be disposed of (hence less noise, vehicle emission pollution, and energy used), and reduced environmental effects as a result of disposal, e.g. noise, pollution'*.

4.4 Results of Observation

This section demonstrated the results of the observations at the selected construction companies in the Kwahu East District.

4.4.1 Results of Observation at El Shaddai Constriction Company

The researcher visited El Shaddai Construction firm and observed how blocks were crushed and abandoned at the mercy of the sun, and rain.

Figure 4.6: an abandoned construction work containing a lot of concrete, wood and steel waste s at the construction sites.

4.4.2: Observations at Obodai Construction Company

At Obodai Construction Company, the researcher observed that waste concrete blocks were abandoned at the site. Moreover, concrete pillars were totally abandoned. The researcher also observed that there were no recycling plants at the construction site and this created more waste at the site.

Figure 4.7: Waste cement blocks and concrete abandoned at the construction sites of Obodai Construction Company.

Figure 4.8: An abandoned dilapidated building at Kwahu Nteso

CHAPTER FIVE

5.0 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of findings, conclusion and recommendation of the study.

5.2 Summary of Findings

1. The study revealed that most of the construction sites do not have waste management and recycling system in place.
2. The study showed that unskilled labourers causes a lot of waste at the construction sites through misuse of construction resources.
3. The study also revealed that, over design of building plans, inadequate storage facilities cause wastage at the construction site, improper handling of construction materials has also created wastage at the construction sites.
4. Misunderstanding of the blueprint has led to a lot of waste at the construction sites.
5. Also vibration/light/heat has destroyed construction materials and caused wastage at the construction sites.
6. The types of construction wastes on construction sites were concrete waste, wood waste, steel wastes, ceramics wastes, plastic waste, ferrous and non-ferrous metals, and glass wastes.
7. The study further revealed that the sale of construction site waste for reuse and recycle has generated some income for the firms and thereby reduced the effects of pollution on the environment.

5.2 Conclusions

The study findings concluded that unskilled labour at the construction sites eventually caused mismanagement of construction materials and created waste at the construction sites. Overdesign of architectural building plans and inadequate storage facilities to store building materials created waste at the construction sites. Improper handling of construction materials and ineffective transportation system created waste at the construction site. Moreover, lack of markets for recyclable materials also generated waste at the construction sites.

The study concluded that the construction sites do not have waste management and recycling system in place. The study further concluded that to reduce waste at the construction sites there is the need to focus on quality and performance and provide safe transportation from the point of sale to the construction sites. Finally, recycling and effective waste management planning minimised construction waste.

5.3 Recommendations

The following recommendations are made to address the findings:

- There is the need for provision of waste management and recycling system at all construction sites to process the waste materials into viable ones.
- There should be waste management expertise to manage waste at the construction sites. Also, the avoidance of over designing of building plans, and provision of adequate storage facilities should be a priority to minimise waste on sites. Also, there should be effective training of staff for proper handling of construction materials to prevent waste on sites.

- The study recommended that proper understanding of blueprint is necessary for the personnel to minimise waste at the construction site. Also standard temperature should be used in the storing of the materials at construction sites.
- The researcher recommended that concrete, wood, steel, ceramics, plastics, non-ferrous metals, glasses should be recycled after use in construction site to reduced waste.
- The study further recommended that the waste in construction site should be reduced and recycle to minimize the effect of environmental pollution.

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Appendix 1

Questionnaire for the Respondents

The researcher is a Post graduate student of University of Education Winneba, Kumasi Campus conducting a piece of research on the assessment of waste reduction on construction sites in Ghana- case study of selected construction companies in the Kwahu East District. I respectively request that you form part of this research by completing the attached questionnaire. Anonymity and non-traceability are assured. It is my fervent hope that you participate in the study. May I thank you for your valuable cooperation.

The sections 1: Demographic Information of the Respondents

Please tick [√] in the box where appropriate

1. What is your Gender? Please tick [√]

[ ] Male

[ ] Female

2. What is the age category you belong? Please tick [√]

[ ] Below 25 years

[ ] 26-35 years

[ ] 36-45 years

[ ] 46-55 years

[ ] 56-65 years

[ ] More than 66 years

3. What is your highest level of educational qualification?

[ ] Senior High School Certificate/NVTI

[ ] Higher National Diploma (HND)

[ ] Bachelor's degree

[ ] Master's degree

[ ] PhD

Other (please state)……………………………………………………………………

4. How long have you been a manager of your construction firm?

[ ] 1-5 years

[ ] 5-10 years

[ ] 10-15 years

[ ] 15-20 years

[ ] 20 years and above

5. Is there currently a waste management System in place? Please tick [√] in the box where appropriate

[ ] Yes

[ ] No

[ ] In progress

SECTION 2: Evaluating waste reduction techniques on construction sites in the Kwahu East District. Please tick [√] in the box where appropriate

To what extent do you agree on the following waste reduction techniques on construction sites in the Kwahu East District? Please rate using a scale of 1-5 where 1 represents strongly disagree, 2 represent disagree, 3 represents uncertain, 4 represents agree, 5 represents strongly agree.

Waste reduction Techniques	**1**	**2**	**3**	**4**	**5**
6. Focus on quality and performance.					
7. Safe transportation					
8. Initiative, tendering, design and procurement					
9. Just-In-Time delivery (JIT) and logistics management.					
10. Pipeline mapping, Supply chain modelling and logistics performance measurement.					
11. Analysing stock levels across the supply chain.					
12. Supply chain costing and value stream mapping					
13. Packaging reduction or modifications					
14. Recycling of waste					
15. Waste management planning					

Section 3: The causes of construction materials waste on construction sites

To what extent do you agree on the causes of construction waste on construction sites? Please rate using a scale of 1-5 where 1 represents strongly disagree, 2 represent disagree, 3 represents uncertain, 4 represents agree, 5 represents strongly agree.Please tick as appropriate.

	1	2	3	4	5
Causes of waste reduction					
16. Unskilled labourer					
17. Overdesign					
18. Inadequate storage facilities					
19. Improper handling					
20. Health and safety hazards					
21. Transportation system					
22. Misunderstanding of the blueprint					
23. Vibration/light/heat					
24. Lack of markets for recyclable materials					

Section 4: The types of construction wastes generated on construction sites.

To what extent do you agree on the following tyoes of construction wastes generated on the construction sites? Please rate using a scale of 1-5 where 1 represents strongly disagree, 2 represent disagree, 3 represents uncertain, 4 represents agree, 5 represents strongly agree.

Ranking

	1	2	3	4	5
The types of construction wastes generated on construction sites.					
25. Concrete waste					
26. Wood waste					
27. Steel wastes					
28. Ceramics waste					
29. Plastic waste					
30. Ferrous and non ferrous metals					
31. Glass waste					
32. Timber waste					
33. Compostables waste					
Other materials waste					

Section 5: The importance of minimising construction waste on construction sites.

Please use the following likert scale to identify the importance of minimising construction waste on construction sites? Please rate using a scale of 1-5 where 1 represents strongly disagree, 2 represent disagree, 3 represents uncertain, 4 represents agree, 5 represents strongly agree.

The Importance of Minimising Construction waste

Financial benefits	1	2	3	4	5
35. Reduced transportation costs for waste materials (less transportation because of less material wasted). This includes transportation to and from the site and disposal.					
36. Reduced disposal costs of waste materials.					
37. Reduced purchase quantity and price of raw materials by waste minimization.					
38. Reduced purchase price of new materials when considering reuse and recycling (depending on materials).					
39. Increased returns can be achieved by selling waste materials to be reused and recycled.					

Environmental benefits	**1**	**2**	**3**	**4**	**5**
40. Reduced quantity of waste generated.					
41. Efficient use of waste generated.					
42. Reduced environmental effects as a result of disposal, e.g. noise, pollution.					
43. Reduced transportation of waste to be disposed of (hence less noise, vehicle emission pollution, and energy used).					

Thank you very much for completing this questionnaire

Appendix 2: Interview Guide for the Managers

What are the waste reduction techniques on construction sites in the Kwahu East District?

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What are the causes of construction materials waste on construction sites?

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What are the types of construction wastes generated on construction sites?

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What is the importance of minimising construction waste on construction sites?

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