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ASSESSMENT OF CONSTRUCTION WASTE MANAGEMENT IN THE GREATER ACCRA REGION CONSTRUCTION INDUSTRY, - GHANA

by

SETOFIA KWADJO AGBOZO

A DISSERTATION

SUBMITTED IN PRELIMINARY FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

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IN CONSTRUCTION MANAGEMENT

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FACULTY OF ENGINEERING AND BUILT ENVIRONMENT

DEPARTMENT OF CONSTRUCTION MANAGEMENT & QUANTITY SURVEYING

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ASSESSMENT OF CONSTRUCTION WASTE MANAGEMENT IN THE GREATER ACCRA REGION CONSTRUCTION INDUSTRY - GHANA

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A DISSERTATION submitted in fulfilment of the requirements for the award of the degree Magister Technologiae in Construction Management in the Faculty of Engineering and the Built Environment, Department of Construction Management and Quantity Surveying at the University of Johannesburg, Republic of South Africa.

JOHANNESBURG, MARCH 2017
DECLARATION

I, SETSOFIA KWADJO AGBOZO, do hereby declare that this dissertation is the result of my own investigation and research, except to the extent indicated in the references and by comments included in the body of the report and that it has not been presented elsewhere for a similar purpose. It was submitted to the University of Johannesburg (Department of Quantity Surveying and Construction Management), as a requirement to obtain a MAGISTER TECHNOLOGIAE degree in Construction Management.

Signature

Date

University of Johannesburg,
Doornfontein Campus
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DEDICATION

I dedicate this dissertation to the blessed memory of my parents, Theophilus Kwame Agbozo and Rejoice Yawa Depke.
ABSTRACT

The construction industry is a key sector in the development and economic growth of Ghana. However, the industry has not escaped the challenges facing other countries worldwide in terms of construction waste management in the industry. This study assesses the factors, effects, and measures of minimising construction waste, the extent of material wastage, and the environmental impact of construction waste in the construction industry of the Greater Accra Region Ghana.

The data used in this study were derived from both primary and secondary sources. The secondary data were collected via a detailed review of related literature. The primary data was collected through a questionnaire which was distributed to construction professionals. Out of the 200 questionnaires sent out, 132 were received, representing a 66% response rate. Findings revealed that project complexity, site conflicts among construction parties, challenges with transportation, and adverse weather conditions were the major factors of waste generation. Furthermore, the study also showed that the extension of time, idling resources, disputes, and the resignation of skilled employees are the effects of construction waste. The study also revealed that proper project planning and scheduling, the availability of clear information and communication channels, frequent coordination between the construction team, complete and proper design at the right time, and frequent progress meetings were the major ways of minimising construction waste. It was also revealed that water pollution, high energy consumed during extraction, and land consumption were the environmental impacts of construction waste. Finally, the findings revealed that paints, plywood, roofing tiles, electrical wires, roofing sheets, and conduit pipes (electrical) were the materials that are observed as being the highest wastage materials in the construction industry.

Keywords: Construction waste, Management, Greater Accra Region, Construction industry, Ghana
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LIST OF ABBREVIATIONS

C&DW - Construction and demolition waste

USEPA – United States Environmental Protection Agency

EPA - Environmental Protection Agency

GAR - Greater Accra Region

CI - Construction industry

UK – United Kingdom

IWM - Integrated waste management

WMS - Waste management system

WMP - Waste management plan
CHAPTER ONE

INTRODUCTION

1.1 Background of the study

The construction industry plays an important role in meeting the needs of society and enhancing the quality of life (Shen & Tam, 2002; Tse, 2001). However, the responsibility of ensuring that construction products are consistent with environmental policies needs to be defined as well as good environmental practices (Environmental Protection Department [EPD], 2002; Shen et al., 2002). Compared with other industries, construction generates a considerable amount of pollutants, including solid waste, noise, dust, and water (Ball, 2002; Morledge & Jackson, 2001). Since construction has a major and direct influence on many other industries, purchasing the inputs from other industries and providing products to almost all other industries, eliminating or reducing waste could be great cost savings to society (Polat & Ballard, 2004). The construction industry has been encouraged to re-use built assets, minimise waste, recycle materials, and minimise energy in construction and use of buildings.

Use environmental management systems to reduce pollution, enhance biodiversity, conserve water, respect people and their local environment, measure performance and set targets for the environment and sustainability (Ofori et al., 2000). 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 for 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., 2006; Chen et al.,
Polat and Ballard (2004) defined waste simply as “…that which can eliminate without reducing customer value.” In a study on methods for waste control in the building industry in Brazil, Formoso et al. (1999) classified waste into unavoidable waste (or natural waste).

The percentage of unavoidable waste depends on the technological development level of the company (Polat & Ballard, 2004; Formoso et al., 1999; Womack & Jones, 1996). Waste can be categorised according to its source - the stage in which the root causes of waste occur. Bossink and Brouwers (1996), 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., 1999) in a study, “Construction material waste evaluation” in Singapore.

Ekanayake and Ofori (2000) 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, become very difficult to replace (Ekanayake & Ofori, 2000).

The Environmental Protection Department of Hong Kong (2000) defines materials waste as comprising 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 on the construction site itself for the purpose of landfilling.
Incineration, recycling, reusing 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, (2000). In a study on the dominant causes of waste generation in Egyptian construction, Garas et al. (2001) categorised material wastes by activity to include over-ordering, over-production, wrong handling, wrong storage, manufacturing defects and theft or vandalism. Begum et al. (2006) conducted a study on the implementation of waste management and minimisation in the Malaysian construction industry and categorised waste minimisation into source reduction and recycling. Begum et al. (2006) again defined Source reduction as any activity that reduces or eliminates the generation of waste at source, usually within a process, and recycling as the recovery and reuse of what would otherwise be a waste material. Poon et al. (2004) also studied how to reduce building waste at construction sites in Hong Kong, and defined waste minimisation 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 (2000) defines waste minimisation as “…any method that reduces the volume or toxicity of waste that requires disposal.” Different measures for minimising materials waste have been reported (Begum et al., 2006; Faniran & Caban, 1998). In a study on the application of lean construction to reduce waste in Turkish construction, Polat and Ballard (2004) emphasised that reduction is the best and most efficient method for minimising the generation of waste and eliminating many of the waste disposal problems.

The construction and demolition (C&D) waste can be defined as waste material produced in the process of construction, renovation or demolition of structures (Statistics Canada, 2000). The C&D is often a significant component, representing 20–30 % and sometimes more than 50 % of
the total municipal solid waste. C&D waste is composed mainly of wood products, asphalt, drywall, concrete, and masonry. Other components often present in significant quantities include metals, plastics, earth, shingles, insulation and paper and cardboard (USEPA, 1995).

Construction waste is normally combined with demolition waste and described as "construction and demolition" (C&D). There are many definitions for C&D. Virtually every country has a slightly different definition of C&D waste. The United State Environmental Protection Agency’s categorization of building-related construction and demolition debris in the United States contains a list of these varied definitions for C & D. For the purpose of this study, C&D waste is defined as the waste resulting from new construction, remodelling, or the demolition of a structure.

Waste reduction in the construction industry is important, not only from the perspective of efficiency, but also because concern has been growing in recent years about the adverse effect of the waste of building materials on the environment. It is alleged that construction waste accounts for between 15 - 30% of urban waste (Brooks et al., 1994; Bossink & Brouwers, 1996; Forsythe & Marsden, 1999). Building materials waste is difficult to recycle owing to high levels of contamination and a large degree of heterogeneity (Bossink & Brouwers, 1996), and often there is insufficient space for its disposal in large cities (Bossink & Brouwers, 1996). Rapid, uncontrolled urbanisation in Ghana has saddled the country’s cities with problems of a physical, socio-economic and environmental nature. Besides the physical problems of poor infrastructure, inadequate housing, congestion and poor accessibility, major cities in the country such as the Greater Accra are confronted by socio-economic challenges including increasing levels of unemployment and poverty, social exclusion and rising crime and violence (Songsore, 2003).
Many urban residents, therefore, live in health- and life-threatening conditions and Ghana cannot take comfort in the (Hardoy et al., 2001) United Nation’s observation that urbanisation is a positive feature and cities offer the best opportunity to escape poverty. On the other hand, Tamakloe (2006) attributes the poor environmental conditions in the cities to low institutional capacity for urban management, poor physical planning and the lack of enforcement of development laws, poor provision of infrastructure and services for environmental maintenance, and low public awareness of environmental hygiene. It is against this background that the study seeks to investigate the management of construction waste in the Greater Accra Region construction industry of Ghana. Effectively, minimization of waste contributes to profit maximization, which is the primary reason for the existence of most companies. Despite the serious threat wastage of construction materials poses to the profit objective of most construction firms, no serious attention has been paid to identifying factors that contribute to the increase of waste in the GAR construction industry.

1.2 AIM OF THE STUDY

The aim of this study is to gain insight into the management of construction waste in the Ghanaian construction industry, as in the case of the Greater Accra Region (GAR). The study further adds to the body of knowledge on the effects of construction waste management in the Greater Accra Region construction industry of Ghana and the measures of minimizing construction waste in the construction industry. Furthermore, the study would contribute to the reduction of the environmental impacts by the waste from construction activities and also create employment through the recycling of waste materials for reuse as a means of construction waste reduction while tackling the source of the generation of waste via construction using education into account.
1.3 PROBLEM STATEMENT

Effective minimization of construction waste contributes to profit maximisation, which is the primary reason for the existence of most companies. Despite the serious threat wastage of construction materials poses to the profit objective of most construction firms, no serious attention has been paid to identifying factors that contribute to the increase of waste in the GAR construction industry.

The buildup of the cost of these projects significantly includes the cost of waste. Unfortunately, most contractors have failed to initiate measures to reduce the cost of waste and in turns reduce the burden they inflict on their clients in the form of exorbitant charges. Consequently, prospective clients aggravate the situation by engaging non-professionals and sometimes are unable to state their designs. Without a reduction in waste, companies produce at high costs, incur high debts and soon face bankruptcy. The situation is exacerbated when those in production do not have any idea about operations management. It is not to say that non-operations managers cannot reduce waste but it believed that professionals could do it better than non-professionals. These studies will, therefore, assessed the management of waste in the Greater Accra Region’s construction industry in Ghana.

1.4 RESEARCH QUESTIONS

Based on the above problem stated, the following research questions have been designed for this study:

1. What are the factors that contribute to waste generation in the construction industry of the Greater Accra Region?
2. What are the effects of construction waste on the performance of the Greater Accra Region’s construction industry?

3. What are the ways of minimising construction waste in the Greater Accra Region?

4. What are the environmental impacts of construction waste on the Greater Accra Region?

5. What is the extent of construction materials wastage in the Greater Accra Region Construction Industry?

1.5 OBJECTIVES OF THE STUDY

The following research objectives are formulated to respond to the defined research questions as stated above:

1. To identify factors that contribute to waste generation in the Greater Accra Region construction industry;

2. To examine the effects of construction waste on the performance of the Greater Accra Region’s construction industry;

3. To identify the ways of minimising construction waste in the Greater Accra Region;

4. To identify the environmental impacts of construction waste on the Greater Accra Region; and

5. To examine the extent of construction materials wastage in the Greater Accra Region Construction Industry.
1.6 MOTIVATION FOR THE STUDY

The motivation for conducting this research is to improve the knowledge base of construction waste management in the Greater Accra Region construction industry. The results of this study will contribute towards a better understanding of the causes, effects, and measures of minimising construction waste by construction professionals. Furthermore, this study will help construction professionals in Ghana to better understand the different factors that cause waste during the construction processes.

1.7 PURPOSE OF THE STUDY

The purpose of this study is to provide a decision support tool for construction professionals engaged in C&D waste management. This study is meant to draw the attention of construction companies to factors that contribute to materials wastage and the understanding of construction waste management through the application of some important but neglected principles such as waste minimisation and planning in the GAR construction industry of Ghana.

1.8 RESEARCH METHODOLOGY AND DESIGN

1.8.1 Research methodology

Research methodology explains the method used in carrying out the research. This section outlines the geographical area where the research was conducted, the study design and the population sample. The instruments used in collecting data and methods implemented to maintain validity and reliability of the instruments are also described.
1.8.2. Approach design

The quantitative approach was adopted in this research. A descriptive survey design was adopted in the current study. Thus, questionnaires were the research instrument used for sourcing information from the respondents for the study. Cohen, Manion and Morrison (2000) referred to questionnaires as a widely and useful instrument for collecting survey information, providing structured and often numerical data, being able to be administered without the presence of the researcher and often straightforward to analyse. The questionnaire made use of open-ended and close-ended questions. The open-ended questions sought to get the subjective views of the respondents.

A survey approach was adopted for this study. The survey design was adopted based on the explanation Creswell (2003) gave as “…it provides a quantitative or numeric description of trends, attitudes or opinions of a population by studying a sample of that population.” According to Veal (2006), quantitative methods refer to the regular empirical investigation of quantitative properties, phenomena, and relationships. The objective of the quantitative method is to gather quantitative data which deals with numbers and anything that is measurable. Statistics, tables, and graphs are often used to present the results.

1.8.3 Research area and targeted respondents

The Greater Accra Region (GAR) of Ghana was formerly part of the Ghana Eastern Region and created in the year 1982; and it is the smallest region with its administration capital at Accra Metropolitan Assembly that forms part of the ten (10) regions in Ghana. The Region is currently the administration capital of the country.
The core vision of the Region is to improve livelihoods and provide adequate socio-economic infrastructure in an equitable and sustainable manner for the people of the region through effective stakeholder collaboration within a secure, decentralised system of governance and sound environmental management. The Region shares boundaries with the Volta Region to the east, the Eastern Region to the north, the Central Region to the west, and to the south with the Gulf of Guinea. (www.ghana.gov.gh/index.php).

Alan et al. (2000) defined a population as a set of all measurements (generally about a group of people or objects) that are of interest and possess at least one common characteristic. According to Neuman (2006), a target population is made up of a group of cases from which a researcher studies a sample and then generalizations are made from the results of the sample. Two (200) hundred architects, quantity surveyors, civil engineers, construction managers, construction project managers, project managers and other professionals who are involved in construction projects were targeted in the GAR construction industry.

1.8.4 Sample and data collection

This study adopted a random sampling method; hence all the participants had an equal chance of being selected. A questionnaire was developed as a tool for collecting data from the respondents by the reviewed literature. Architects, quantity surveyors, civil engineers, construction managers, construction project managers, and project managers who are involved in construction project were sampled for the study owing to the vast nature of the study area and considering the time frame within which the study needed to be completed.
The questionnaires were distributed to the respondents. They were guided as to how to answer the questions, especially those who could not read. Though much time was involved, it facilitated the collection of all questionnaires and accuracy of information needed for the study.

1.8.5 Delimitations

This research assessment involved construction professionals in the Greater Accra Region, with the respondents being architects, quantity surveyors, civil engineers, construction managers, construction project managers, project managers and other professionals who are involved in construction projects in the province. This study investigates the factors causing construction waste and their effects. In addition, it establishes the measures that will be employed to minimise construction waste in the Greater Accra Region construction industry of Ghana.

1.8.6 ETHICAL CONSIDERATIONS

The current study did not encounter or identify any ethical issues. However, the ethical considerations in this research involved acknowledging professionals in the industry whose work had been cited and therefore contributed to the literature. The obligation to the participants who responded to the research questionnaire was that their input would be kept confidential and only used for academic purposes. Respondents to the questionnaire had the right not to answer questions that they felt were not appropriate, without any coercion.
1.9 OVERVIEW OF CHAPTERS

CHAPTER 1

Introduction

This chapter defines the problem that the researcher investigated and shows how the investigation of the problem was conducted. The introduction gives an overview of the problem and the research questions. This chapter, therefore, provides a framework for the whole study.

CHAPTER 2

OVERVIEW OF THE FACTORS, EFFECTS, MEASURES OF MINIMIZING AND IMPACT OF CONSTRUCTION WASTE

This chapter reviews the literature on the same topic by scholars and researchers in the field of construction management. Literature review gives the readers information and ideas that have been put forward by other researchers on the topic. Hence this chapter gives the readers an understanding of the causes of construction waste, its effects and measures of minimising waste in the construction industry.

CHAPTER 3

INTERNATIONAL LITERATURE: CONSTRUCTION WASTE MANAGEMENT IN CHINA AND UNITED KINGDOM (UK)

This chapter reviews the literature on the topic by accredited scholars and researchers in China and the United Kingdom. Hence this chapter gives the reader an understanding of construction
waste, their effects and measures of minimising waste in the Chinese and UK construction industry.

CHAPTER 4

AFRICA LITERATURE: CONSTRUCTION WASTE MANAGEMENT IN NIGERIA AND SOUTH AFRICA

This chapter reviews the literature on the topic by scholars and researchers in Nigeria and South Africa. Hence this chapter gives the reader an understanding of construction waste, their effects and measures of minimising in the construction industry.

CHAPTER 5

Research methodology

This chapter shows the methods that the researcher used to obtain participants and further collect information from them. In this study, the researcher focused on a literature review and a questionnaire survey targeted at construction professionals in the Greater Accra Region. Furthermore, statistical methods were used to analyse the data collected from the questionnaire survey described in this chapter.

CHAPTER 6
Questionnaire survey results

Once an appropriate design and suitable means of measuring relevant variables had been identified and adopted, the findings were analysed using an appropriate procedure. Statistical techniques were adopted to analyse data and drew up findings. The analysed results then provided feedback on the originally formulated questions.

CHAPTER 7

Discussion of findings, conclusions, and recommendations

In Chapter 7 the findings analyzed in Chapter 6 were discussed and linked to the literature reviewed to establish whether the research objectives were achieved and all the research questions answered. This chapter further concludes the study and gives recommendations on how to minimise construction waste and its management.

1.10 Conclusion

In this chapter, the various components of the study were introduced. The research problem, rationale, research questions and the structure of the study were discussed. It is against this background that an understanding of the present research was attained. This chapter also highlighted the importance of construction waste minimisation and management. The next chapter reviewed literature related to construction waste management in developed and developing countries presented.
CHAPTER TWO

LITERATURE REVIEW

OVERVIEW OF THE FACTORS/CAUSES, EFFECTS, MEASURES OF MINIMISING
AND ENVIRONMENTAL IMPACT OF CONSTRUCTION WASTE

2 Introduction

Waste reduction in the construction industry is important, not only from the perspective of efficiency, but also because concern has been growing in recent years about the adverse effect of the waste of building materials on the environment. This kind of waste typically accounts for between 15 to 30% of urban waste. A successful project requires careful planning, organisation, and control throughout to achieve the correct result for the client. Administration of construction works is difficult, as a result of which some clients or owners engage a construction manager or construction programme manager to act as the owner’s authorising agent and project overseer. The reasons for the complexity of construction administration can be seen from an examination of the owner’s role before and during construction. Wyatt as early as (1978) stressed the consequences of high levels of waste, both in reducing the future availability of materials and energy and in creating unnecessary demands on the transportation system. In fact, some construction materials and components use large amounts of non-renewable sources of energy, as well as resources that are in danger of depletion, such as timber, sand, and crushed stone. Human activities generate waste materials that are often discarded because they are considered useless. These wastes are normally solid, and the word ‘waste’ suggests that the material is
useless and unwanted. However, many of these waste materials can be reused, and thus they can become a resource for industrial production or energy generation if managed well. This applies to new commercial and residential buildings, schools, renovations, and core and shell construction. The buildings and other construction works that we undertake have a very significant impact on our natural environment, economy, productivity, health, and the quality of our lives as well as the overall well-being of our planet. Construction also transforms the land into an urban environment with an impact on the overall ecology.

2.1 Examining the concept of waste

Waste is the unnecessary depletion of the natural resources, unnecessary costs and environmental damage which can be avoided through improved waste ethics. The Waste Framework Directive (European Directive 2006/12/EC) has defined waste as “…any substance or object the holder discards, intend to discard or required to discard.”

Once a material falls within this definition, it will remain waste until it is fully recovered and is no longer a threat to the environment and human health.

Building Research Establishment (1981 cited in Ofori, 2004) define waste as “…any materials apart from earth materials which needed to be transported elsewhere from the construction site itself other than the intended specific purpose of the project due to damage, excess or non-use or which cannot use due to noncompliance with the specification.

Waste is defined by Formoso et al., (1999) cited in Yara and Boussabaine (2006) as “…any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the client.” Mohanty and Deshmukh (1998) cited in Mohanty and Deshmukh (1999) state that “…any non-value adding activity carried out in any work system at any time
can be defined as waste.” According to Mohanty and Deshmukh, (1998) “…any resource deployed in the work process which does not create utility for the stakeholders can conceive as waste”. According to Chen et al. (2002), construction waste can be defined as debris of construction and demolition. Specifically, construction waste refers to solid waste containing no liquids and hazardous substances; largely inert waste, resulting from the process of construction of structures, including the building of all types (both residential and non-residential), as well as roads and bridges. Construction waste does not include clean-up materials, land waste, solvent sealers, adhesive living garbage, furniture appliances or similar materials.

Koskela (1992), Alarcon (1993), and Sepell et al. (1995) cited in Boussabaine (2006), have defined construction waste as “…quality costs, lack of safety, rework, unnecessary transportation trips, long distances, improper choice of management, methods or equipment and poor constructability.” Gilpin (1996) provides a more elaborate definition of the term ‘waste’. According to him, the concept of waste embraces “…all unwanted and economically unusable by-products or residuals at any given place and time, and any other matter that may be discarded accidentally or otherwise into the environment” (Gilpin, 1996:228). Gilpin also suggests that what constitutes waste must “…occur in such a volume, concentration, constituency or manner as to cause a significant alteration in the environment.” Thus, apart from waste being an unwanted substance that is discarded, the amount of it and the impact it makes on the environment also become important considerations in defining waste.

McLaren (1993: https://www.scribd.com>doc>Management online) has also referred to waste as the “…unwanted materials arising entirely from human activities which discarded into the environment.” This notion that waste results entirely from human activities is corroborated by
Jessen (2002: online) who has noted that “waste is human creation” and “there is no such thing as waste in nature where cut-offs of one species become food for another”.

On his part, Palmer (1998) argues that “…there is no constellation of properties inherent in any lump, object or material which will serve to identify it as waste: an item becomes waste when the holder or owner does not wish to take further responsibility for it.” As a default definition, Palmer (1998) suggests that “…any substance that is without an owner is a waste.” Davies (2008) also describes wastes as “…unwanted or unusable materials that emanate from numerous sources from industry and agriculture as well as businesses and households and can be liquid, solid or gaseous in nature, and hazardous or non-hazardous depending on its (their?) location and concentration” (Davies, 2008:4).

Davies (2008:5) further notes that “…what some people consider to be waste materials or substances are considered a source of value by others.” This relative attribute of waste can be compared with the concept of ‘resource’ which has also been defined as material that has use-value. As noted by Jessen (2002: online), “…our waste stream is full of resources going in the wrong direction.” Drawing from the views expressed above, the definition of waste to use in this study is any substance (liquid, solid, gaseous or even radioactive) discarded into the environment because it is unwanted, which poses a significant nuisance to or has an adverse impact on the environment.

2.2 Classification of waste
Maryam Zafar Ansari and Kritika Verma (1988) classified waste in their project titled, “Waste Management” as waste resources, origin of waste, property of waste, and recoverability of waste. V. S. Rama Rao (2009) explained the above classifications as follows:

Waste tesources: Material resources such as solids, liquids, and gasses can be waste. Energy resources such as physical, human and solar energy can be waste. Time resources can be wasted. Includes idle time that workers spend on waiting for machines to complete operations and that managers spend on waiting for information to make decisions.

Capital in the form of capacity, equipment, machine hours and inventory can be wasted. Once again, in the case of inventory, in traditional assembling operations, complete elimination for in-progress inventories are still impossible, but regarding lean production, these extra inventories are deemed one of the root causes for manufacturing problems. Services like communication, transport, health, etc. can waste. Life or human resources data and information may also suffer wastages.

Origin of waste: It could be industrial, residential, commercial, office, municipal, construction, and demolition, or agricultural. Property: Materials wasted are either hazardous or non-hazardous.

Recoverable: Wastes can be recovered into some useful material. Non-recoverable wastes are lost with time. Some criteria are usually employed to classify wastes into types, including their sources, physical state, material composition and the level of risk associated with waste substances (See Table 2.1). Such classification of waste provides a basis for the development of appropriate waste management practices.
Table 2.1: Classification of waste

<table>
<thead>
<tr>
<th>Criteria for waste classification</th>
<th>Examples of waste types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources or premises of generation</td>
<td>Residential, commercial, industrial, municipal services, building, and construction, agricultural.</td>
</tr>
<tr>
<td>Physical state of waste materials</td>
<td>Liquid, solid, gaseous, radioactive</td>
</tr>
<tr>
<td>Material composition of waste</td>
<td>Organic food waste, paper, and card, plastic, inert, metal, glass, textile</td>
</tr>
<tr>
<td>Level of risk</td>
<td>Hazardous, non-hazardous</td>
</tr>
</tbody>
</table>


The source classification of waste is based on the fact that waste emanates from different sectors of society such as residential, commercial and industrial sources. A good example of the source classification is provided by the World Bank (1999) in a study in Asia which identified the sources of waste as residential, commercial, industrial, municipal services, construction and demolition, processing and agricultural sources.

In the Stakeholders’ Guide: Sustainable Waste Management, the UK Environment Council (2000) also employed source classification to identify the major sources of waste as municipal sources, commerce and industry, agricultural sources, demolition and construction.
activities, dredged spoils, sewage sludge and mining and quarrying operations. Classifying wastes by their sources is a useful way of determining the relative contributions of the different sectors of society to the waste stream and how to plan for their collection and disposal.

2.3 Factors of waste/ Causes of waste?

Rao (2009) mentions various causes responsible for waste. The highest waste causing factors are considered to be critical.

1) Faulty planning and policies systems and procedures; 2) Project complexity; 3) Environmental pressures; 4) Tardiness (slow to act); 5) Lack of accountability; 6) Site conflict among construction parties; 7) Non-responsiveness to automation /computerisation; 8).


2.3.1 Material causes of waste in construction

Formoso et al. (2002) list the following causes of waste in the construction industry:
• **Industry steel reinforcement**

Controlling the use of steel reinforcement in building sites is relatively difficult because it is cumbersome to handle due to its weight and shape. Also, this material is sold by weight, and most building sites in Brazil cannot afford to have a scale for weighing steel reinforcement.

For that reason, most companies use a conversion table to calculate the weight of each lot delivered to or withdrawn from the site. Three main reasons can be pointed out for steel reinforcement waste: some short unusable pieces produced when bars cut; some bars may have an excessively large diameter due to fabrication problems; and trespassing. The worst performing sites were usually the ones in which the structural design was poor regarding standardisation and detailing, causing waste due to the non-optimised cutting of bars. Many problems related to poor handling of materials were also observed, resulting in largely disorganized stocks, which often caused waste for substitution — that is, unnecessary replacement of some bars by others of larger diameter. In recent years many companies in Brazil have opted to purchase off-site preassembled steel reinforcement. One of the advantages of this alternative is that it drastically reduces waste, mainly by optimising the cutting of bars, although no systematic study on the extent of this economy has published so far.

• **Premixed concrete**

Despite having one of the lowest waste indices among all materials, the relatively poor performance of premixed concrete was fairly surprising, due to the relatively high cost of this material. In contrast, most construction companies in Brazil assume that the waste of premixed concrete is negligible. Site managers often complain about the difficulty of controlling the
amount of premixed concrete deliveries. In fact, in the 1996–1998 study, as many as 64% of the sites in which the waste of this material investigated had no control of this kind. In the same study, the research team monitored the difference between the purchased amount of concrete and the amount delivered at 12 sites. An average difference of 3.6% was found — this means that some suppliers often deliver quantities of material smaller than what the construction firms pay for.

The obvious solution seems to be the installation of a site scale to control the delivery of materials or to place an inspector in the concrete plant. However; this might not be economically feasible for small companies. One alternative adopted by some Brazilian companies was to establish a deal with the suppliers whereby the premixed concrete paid for based on the quantity of the concrete required to be placed in the formwork. Deviations in the dimensions of cast-in-place structural elements (slabs, beams, and columns) are an important source of indirect concrete waste. Based on the analysis of 30 sites, the slab and thickness were on average 5.4% larger than specified in the design (Formoso et al.; 2002).

Beams also had similar problems; their width was on average 2.7% larger, considering a sample of 29 sites. The excessive thickness of slabs seems to be the most serious problem because of shape, and also due to the relatively high percentage of this element in the volume of the whole structure, usually around 50 to 60%. The main causes for this problem were a lack of constructability of some structural elements, poor design of the concrete formwork system, imprecision of the measuring device, and flaws in the formwork assembling process. Fairly often, some waste of concrete was also observed during the handling and transportation operations on site, mostly related to site layout problems and the use of inadequate equipment, although it was difficult to quantify its magnitude due to the relatively high cost of measurement.
At a few sites, the excessive dimensions of concrete foundation piles and curtain walls also caused unexpected waste. This problem was mainly related to the lack of precision in excavation methods. Finally, due to uncertainty related to material consumption, site managers often order an additional allowance of concrete to avoid interruptions in the concrete-pouring process. Sometimes this results in a surplus of concrete that is not used.

• Cement

Analysing the waste of cement is relatively complex because this material is used as a component of mortar in different processes, such as brickwork, plastering, and floor screed. This is a relatively expensive material that has high levels of waste in Brazil. Its main sources of waste are as follows:

1. In situ production of mortar: Much waste of cement was observed in the production of mortar on site. Cement and other materials are usually loaded manually in the mixer using inadequate equipment. For instance, in the 1992–1993 study, 14 different combinations of equipment and tools, including shovels and buckets. It also indicates the lack of process standardisation. Another typical cause of waste in this stage is the lack of information available to construction labour for producing different mixes of mortar.

2. Handling and transportation of mortar: waste of mortar was observed on most sites during the handling and transportation operations, although no quantification was possible. Multiple handling of the same batch of mortar, due to intermediate stocks along the process flow, is also fairly common. Such waste was mostly related to site layout problems, lack of properly maintained pathways, and use of inadequate equipment.
3. Brickwork joints: The production of brickwork was also responsible for some waste of cement, due to the excessive consumption of mortar in joints. In the 1992–1993, the average thickness was 19.1% greater in the vertical joints and 35.6% in the horizontal joints.

In the 1996–1998 study, in a larger sample of sites, the average deviation in thickness was 52% for horizontal joints (20 sites) and 56% for vertical joints (21 sites). There is usually a combination of reasons for the excessive thickness of joints, which may include a lack of modular coordination between concrete structure and brick walls, inadequate training of labour, insufficient information available about process standards, inadequate supervision, variations in the size of blocks, and lack of process standardisation.

4. Plaster thickness: The excessive thickness of plaster was identified as a major cause of cement waste. In the 1992–1993 study, the actual thickness exceeded the designed one by, on average, 17.8% for ceilings, 76% in internal walls, and 93.3% for facades. In the 1996–1998 study, this waste was on average 46.8% for internal plaster (15 sites) and 32.7% for external plaster (6 sites). Pinto ~1989. The main causes for this problem are deviations in the dimensions of structural elements, flaws in the integration between different designs, lack of modular coordination in design, and omissions in the design regarding defining the exact sizes of components, such as door frames and blocks.

5. Floor screed: Excessive thickness for concrete floor screed was also detected in the 1996–1998 study. On average, the actual thickness of this element exceeded the designed one by 47%, based on a sample of seven sites. The main causes for this problem were deviations in the concrete slab level and the need to inlay pipes in the floor.
• Sand, lime, and premixed mortar

The waste of mortar used in brickwork and plastering has already discussed in the previous section. The main causes of cement waste can also explain most of the problems related to sand, lime, and premixed lime and sand mortar. Sand and mortar are usually delivered in trucks, and so there may be additional losses related to the lack of control in the delivery operation and the necessary handling it demands. In recent years, some companies in Brazil have started using packed ready-to-use mortar mix, which tends to eliminate many of the problems related to delivery control, handling, and transportation. Although not enough data are available, there are indications that such changes have reduced the waste of mortar, in comparison to the traditional method of producing mortar on site.

• Bricks and blocks

In most poorly performing sites, a combination of causes related to the waste of bricks and blocks. At several sites, there were problems related to the delivery of materials, such as the lack of control of bricks or blocks delivered and the damage of bricks or blocks during the unloading operation. Poor handling and transportation were the major sources of waste for bricks and blocks. As in the case of mortar, multiple handling of the same batch of bricks, due to intermediate stocks along the process flow, was observed at many sites. Insufficient planning of the site layout, lack of properly maintained pathways, and the use of inadequate equipment were among the main causes of waste. It seems that most of the problems related to delivery, handling, and transportation could be eliminated by supplying bricks and blocks on pallets. In fact, some of the sites in the 1996–1998 study adopted this strategy and were able to reduce waste to some extent. However, it was also observed in the same study that the use of pallets does not improve
performance on its own. They have a positive impact only if other measures related to flow management are also implemented, such as planning the layout, keeping pathways unobstructed and minimising inventories. Another source of waste was the need to cut blocks and bricks due to the lack of modular coordination in design. Indeed, the percentage of cut pieces at some sites was relatively high— considering a sample of 40 sites, the percentage of cut ceramic blocks about the total number of blocks was, on average, nearly 18%. In this context, the waste tends to be higher if the cutting operation is not planned and needs to execute at the installation locale.

• Ceramic tiles

The poor performance of ceramic tiles in the 1996–1998 study was unexpected, considering the relatively high cost of this material. The main source of waste was the need to cut tiles— on average, 35% of the pieces on floors (15 sites) and 27.4% of the pieces on walls (23 sites) had to be cut. Lack of modular coordination and flaws in the integration between architectural and structural design were the main causes of the cuts. At some of the sites, it was also observed that the lack of planning in the distribution of materials contributed to increased waste. In most instances, whole packages of ceramic tiles (typically 1.5 m² each) were sent to the installation places, based on the demand by the work crews. When necessary, pieces are cut, and some are left as debris when the crew moves to the next work face. In contrast, a few companies adopt the strategy of sending to the work face the exact amount of tiles in a kit, including all necessary precut pieces. It allows the operation of cutting tiles to be centralised and thereby optimised and avoids unnecessary handling of wasted parts (Formoso et al., 2002).
• Pipes and wires

Keeping track of the causes of a waste of electrical pipes, electrical wires, and hydraulic and sewage pipes is a fairly complex task. Both electrical and plumbing services are usually subcontracted, and the materials sometimes provided by the specialist subcontractor. As this activity tends to be very fragmented on site, such materials are often moved into and out of the site. Another difficulty related to the measurement of waste is the fact that both plumbing and electrical service designs are often poorly detailed, and many changes in the routines of pipes made during the installation. The most important causes of waste for these materials are short unusable pieces produced when pipes cut; poor planning in the distribution of materials, which does not encourage cutting optimization; and replacement of elements by others that have superior performance (Formoso et al., 2002).

2.4 Measuring and ranking of construction waste

According to Urio and Brent (2006: 21), Table 2.2 summarises the ranking value of the causes of construction waste by project managers, contractors, site representatives and waste management supervisors.

Table 2.2: Ranking of the causes of construction waste

<table>
<thead>
<tr>
<th>Causes of construction waste</th>
<th>Overall ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of onsite waste management plan</td>
<td>1</td>
</tr>
<tr>
<td>Waste from application process e.g. during plastering</td>
<td>2</td>
</tr>
<tr>
<td>Error Description</td>
<td>Number</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Over–mixing of material due to the lack of knowledge of the requirement</td>
<td>3</td>
</tr>
<tr>
<td>Errors by tradespersons and labourers</td>
<td>4</td>
</tr>
<tr>
<td>Cutting of uneconomical shape/length</td>
<td>5</td>
</tr>
<tr>
<td>Damages by subsequent trades</td>
<td>6</td>
</tr>
<tr>
<td>Changes in design</td>
<td>7</td>
</tr>
<tr>
<td>Use of incorrect material</td>
<td>8</td>
</tr>
<tr>
<td>Damage during transportation on site</td>
<td>9</td>
</tr>
<tr>
<td>Inclement of weather</td>
<td>10</td>
</tr>
<tr>
<td>Other errors</td>
<td>11</td>
</tr>
<tr>
<td>Contract document incomplete at time of construction commencement</td>
<td>12</td>
</tr>
<tr>
<td>Error in contract document</td>
<td>13</td>
</tr>
<tr>
<td>Over ordering</td>
<td>14</td>
</tr>
<tr>
<td>Inappropriate storage</td>
<td>15</td>
</tr>
<tr>
<td>Damage during transportation to site</td>
<td>16</td>
</tr>
<tr>
<td>Accidents</td>
<td>17</td>
</tr>
<tr>
<td>Supplier error</td>
<td>18</td>
</tr>
<tr>
<td>Criminal waste due to damage or theft</td>
<td>19</td>
</tr>
<tr>
<td>Equipment malfunction</td>
<td>20</td>
</tr>
</tbody>
</table>

Source: Urio & Brent, 2006:21
2.5 Classification of construction waste

Waste in construction can culminate as a result of different causes and situations. Construction waste falls into different categories, which are elaborated on below:

2.5.1 Waste according to the type of resources consumed

According to Castelo Branco (2007:13), construction waste can be categorised into physical and financial waste. This classification includes the following:

- Physical waste of materials: The additional amount of materials about those specified in the project;
- Physical waste of person-hours: Man hours increased by delay in the arrival of materials and overproduction; and
- Physical waste of equipment: Equipment hours increased in shortage of material required quoted for the workforce;

2.5.2 Waste according to its nature

Skoyles and Skoyles (1987:18-24) categorise waste into four principal types, namely “natural direct,” “indirect” and “consequential waste.” Waste is, to a certain extent, inevitable on building sites and this recognised by everybody in the construction industry. Skoyles and Skoyles (1987:19) refer to this acceptable level of waste as “natural waste.” “Indirect waste” is distinguished from “direct waste” in that the materials are not usually lost physically, but the payment for part or whole of the value lost. Table 2.3 summarises the various forms in which direct and indirect waste can occur.
### Table 2.3: Types of waste

<table>
<thead>
<tr>
<th>Principal types</th>
<th>Forms of the principal types</th>
</tr>
</thead>
</table>
| **Indirect waste** | • Substitution, where materials used for purposes other than those specified.  
• Production waste, where the material used more than those indicated or not clearly defined in contract documents, e.g. additional concrete in trenches, which extracted wider than designed because no appropriately sized digger bucket was available.  
• Operational waste, where materials used for temporary site work for which no quantity or other allowances have made in the contract documentation, e.g. tower crane bases, site paths, temporary protection.  
• Negrete waste, where materials used in addition to the amount required by the physical waste, financial waste, equipment material purchase due to physical waste, waste according to the type of resource consumed contract, owing to the construction contractor’s negligence. |
| **Direct waste** | • Deliveries waste comprises all losses in transit to the site, unloading and placing into the initial storage.  
• Site storage and internal site transit waste comprise losses due to bad stacking and initial storage, including movement and unloading around the site, to stack at the workplace or placing into position. |
| Conversion waste comprises losses due to cutting uneconomical shapes, e.g. timber, sheeted goods. |
| Fixing waste comprises materials dropped, spoiled or discarded during the fixing operation. |
| Cutting waste includes losses caused by cutting materials to size or irregular shapes. |
| Application waste includes materials such as mortar for brickwork and paint spilled or dropped during application, similarly, materials left in containers or cans which are not sealed and mixed materials like mortar and plaster left to harden at the end of the day. |
| Waste due to the uneconomical use of the plant. It covers plant running when not in use, or not employed to its optimal use. |
| Management waste includes losses arising from an incorrect decision and not related to anything other than a poor organisation or lack of supervision. |
| Waste caused by other trades. It includes losses arising from events such as “borrowing” by trades for purposes other than work, and not returning the plant or material or damage by succeeding trades. |
| Criminal waste covers pilfering, theft from the site and vandalism. |
| Waste due to incorrect type or quality of materials. It includes waste stemming from materials wrongly specified and waste due to errors, particularly in the bills of quantities and specification. |
• Waste that is usually caused by apprentices, unskilled tradespeople, and tradespeople on new operations.

Source: Skoyles and Skoyles (1987:19)

2.6 The concept of waste management

The business of keeping our environment free from the contaminating effects of waste materials is termed waste management. Gbekor (2003), for instance, has referred to waste management as involving “…the collection, transport, treatment and disposal of waste including after-care of disposal sites.” Similarly, Gilpin (1996) has defined waste management as “…purposeful, systematic control of the generation, storage, collection, transportation, separation, processing, recycling, recovery and disposal of solid waste in a sanitary, aesthetically acceptable and economical manner.” It can be deduced from these definitions that waste management is the practice of protecting the environment from the polluting effects of waste materials to protect public health and the natural environment. Thus, the priority of a waste management system must always be the provision of a cleaning service which helps to maintain the health and safety of citizens and their environment (Cooper, 1999). Furthermore, Gilpin (1996) regards the business of waste management as a professional practice which goes beyond the physical aspects of handling waste. It also “…involves preparing policies, determining the environmental standards, fixing emission rates, enforcing regulations, monitoring air, water and soil quality and offering advice to government, industry and land developers, planners and the public” (Gilpin, 1996).
Waste management, therefore, involves a wide range of stakeholders who perform various functions to help maintain a clean, safe and pleasant physical environment in human settlements to protect the health and well-being of the population and the environment. Effective waste management is, however, a growing challenge to all municipal governments, especially in developing countries.

2.7 The principles of waste management

The principles of waste management, as identified by Schubeller et al. (1996), are “…to minimize waste generation, maximize waste recycling and reuse, and ensure the safe and environmentally sound disposal of waste.” It means that waste management should be approached from the perspective of the entire cycle of material use which includes production, distribution, and consumption as well as waste collection and disposal. While immediate priority must give to effective collection and disposal, waste reduction and recycling should be pursued as equally important longer term objectives (Schubeller et al., 1996).

2.8 Strategies for waste reduction

Environmental stresses are escalating due to the consumer culture that relies heavily on resource extraction, production, consumption and disposal (Barr, 2004; Entwistle, 1999; Pongracz & Phojola, 2004). Sources of production are often distant from places of consumption and disposal, making the interconnectedness of resource cycling difficult to ascertain. It must be emphasised how the conditions experienced by one group of people can undermine the existence of another (Hartwick, 2000). To link the spaces of production to the places of consumption and disposal, one must “…follow the path of a commodity back from the point of consumption, marketing, distribution, and processing, along with the transport network, to the point of production, and
beyond” (Hartwick, 2000). It is also important to follow the commodity forward through consumption, second-handedness, deconstruction, transformation, or disposal. Hernandez and Martin-Cejas (2005) reinforce that “…the integral management of solid waste requires a global perspective of the flow of materials circulating in the ecosystem.” Taking account of the full environmental, social and economic costs of products and waste management policies is a step towards regarding the future consequences of today’s actions (Powell, Craighill, Parfitt, & Turner, 1996). These costs must be considered in a long-term context as sustainable waste management “…raises concerns not only about the inter-generational but also the inter-generational implications of cradle-to-grave control where the potential environmental impacts may last hundreds of years” (Petts, 2005).

Recent investigations into waste management strategies are challenging the idea that production-consumption-disposal follow an inevitable sequence from the cradle-to-the-grave. Production and consumption processes can be imagined as being part of a cycle, referred to as a “cradle-to-cradle” model by McDonough and Braungart (2002), where materials are continuously utilised throughout multiple lifecycles, never being downgraded to lesser products. The emphasis is on durable, long-lived products over single-use items, thereby minimising waste, conserving raw resources, reducing pollution and offering the consumer a sustainable option. Consumer waste is highly variable, typically unsorted, and contains multiple materials from an array of production sources. The true economic costs of solid waste management are far removed from consumers’ decisions, thus violating the ‘polluter pays’ principle (Michaelis, 1995). Waste management on a global scale should enforce the notion that individuals, governments, and industry have a role in reducing and reusing materials. Individuals have a responsibility to reduce environmental impacts from waste through participation in environmentally-conscious consumer practices;
governments have a responsibility to monitor and enforce best practices for waste reduction, including the implementation of policies and incentive programmes; and industry has the responsibility for reducing energy and resource consumption by producing packaging that is recyclable or reusable.

2.9 EFFECTS OF CONSTRUCTION WASTE ON PERFORMANCE

Effects of construction waste are the consequences that will occur when the project deadlines are not achieved. The major effects of time overruns on construction projects in Nigeria are the following: time overrun, cost overrun, dispute, arbitration, litigation and total abandonment (Aibinu and Jagboro, 2002:595). These results were in general agreement with the study done by Jonathan (2013:6). Akinsiku and Akinsulire (2012:29) identified several effects of construction waste and ranked them as follows: extension of time on the project; wastage and under-utilization of manpower resources; idling resources; claims on the disturbance of regular progress work by the main contractor; loss of confidence in the contract, thereby jeopardising the reputation of contractor in case of future tendering chances; late returns of income for private developers; reduction in employment opportunities; dispute between the parties involved; a decrease in the tempo of economic activities in the nation; additional insurance charges; extra taxes and dues due to delay; insolvency of the contractor; inability to meet the minimum living standard; arbitration and litigation; and total abandonment of projects (Akinsiku and Akinsulire, 2012:29).

2.10 Environmental impact of construction waste

The large volume of waste in the construction industry contributes to the rapid depletion of natural resources and the production of high volumes of air pollution caused during processing. Water pollution will also result from the processing of materials. When material ends up as waste, it has the potential to be reused or recycled, thereby minimising its impact on the environment through less processing. The construction industry is the biggest consumer of raw
material in the UK: 90% of non-energy minerals extracted in Great Britain are used to supply the construction industry.

The waste contains embodied energy which, according to Boustead and Hancock (1979), cited in Treloar et al. (2003), is “…the energy consumed during extraction, processing, manufacture and transportation at all stages.” When the material is recycled, the embodied energy within that material means there will be less energy needed in its processing.

According to the National Waste Strategy Scotland (1999), simple changes to the management and production processes aided by the use of innovations can make big savings to the amount of waste generated and the amount of energy used. The construction of buildings, their materials and the occupant’s use of services is responsible for 50% of the UK CO2 emissions. A push for a more sustainable construction is required as the UK government has targets for a 60% reduction in emissions by 2050 below the 1990 levels. Metal, glass, and hardwood timber have a high embodied energy. Their re-use and recycling should be given high priority towards waste minimisation. By using reclaimed and recycled materials, 70% of embodied energy can be saved. It could potentially result in cost savings of 40% of the building price.

Gypsum causes harm at landfill due to the leaching of sulfates into the ground; this is harmful to humans if it contaminates the water supply. Gypsum accounts for the largest portion of the non-inert waste in the UK, at 36%, of the waste stream at construction sites. According to Mussink gypsum (calcium sulfate) when mixed in a landfill with anaerobic bacteria, organic matter and high levels of moisture, will release sulfate ions, producing hydrogen sulfate (H2S) and metallic sulfide leachates which are toxic to fish. This gas is also harmful to humans at levels higher than 1000ppm.
At UK one landfill levels of 5000ppm were recorded. The gas will reach maximum emissions 15 years after it is first placed in a landfill. When plasterboard is mixed with biodegradable waste such as food, it can produce hydrogen sulfide which is a major contributor to acid rain. In the UK, if a skip contains more than 10% of plasterboard, then this material needs to be segregated out and put in special ‘mono’ cells in a landfill. The demands that developed nations are putting on the world’s resources are several times larger than our share of the planet. By 2050 we are expected to have four times the environmental impact compared to what we have today (Edwards, 2005). The ecological footprint of the UK is growing and so too is that of developing nations whose consumption of consumer goods is rising by 10-20% in rapidly developing economies. The UK economy will be competing with these developing nations for resources which are beginning to become scarce.

2.11 Attitude and perceptions of the construction workforce

The construction industry is labour intensive, with the attitudes and perceptions of workers influencing its growth. It argued that the causes of construction waste are directly or indirectly affected by the attributes and perceptions of the personnel involved in the construction industry. Kulatunga et all (2006:57-72) identify workers involvement during the pre-contract stage as a major influence on the prevention of waste.

Worker involvement during the post-contract stage influences the minimisation of waste by ordering materials according to correct quantities and quality, the use of proper storage facilities, and proper handling of materials. Research has also shown that the attitudes of construction labourers towards waste minimisation activities are negative. The attitude of the workforce is
important to management as it determines people’s behaviour and provides an insight into their motivating values and beliefs. An attitude can be defined as a “...psychological tendency to evaluate a particular object or situation in a favorable or unfavorable way, which causes someone to behave in a certain way towards it” (Ajzen, 1993:41-57, cited in Teo & Loosemore, 2003:345-76). Attitude is difficult to grasp because of the interaction between beliefs and attitude, as well as the interaction between people’s underlying values and opinions. In this respect, to measure attitude, people must be assessed during work, either because the project is intended to change people’s attitude or because people need to increase some measure of their appreciation.

Teo and Loosemore (2001:741-9) find that attitudes towards waste reduction have become one of the reasons behind the difficulties encountered in the management of waste in the construction industry. Loosemore, Lingard and Theo (2002:256-76) highlight the importance of human factors in the minimisation of waste and argue that waste can be prevented by changing people’s attitudes. According to Skoyles and Skoyles (1987:86-90), cited in Teo and Loosemore (2001:741-9), the involvement of people is ignored in the waste management equation. The attitudes on waste also differ from one organisation to the next, based on their culture and waste management policies. Another contributing factor to high levels of construction waste is the high level of non-conforming work experienced from sub-contractors.

2.12 Consultants’ perspectives on materials waste reduction in Ghana

The construction industry plays a vital role in meeting the needs of society and enhancing the quality of life (Shen & Tam, 2002; Tse, 2001). 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, 2002; Shen et al., 2002). Compared with other industries, construction generates a fairly large amount of pollutants, including solid waste, noise, dust and water (Ball, 2002; Morledge & Jackson, 2001). Since construction has a major and direct influence on many other industries using 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, 2004). The construction industry has been encouraged to re-use built assets, minimise waste, recycle materials, minimise energy in construction and use of buildings, and use environmental management systems to reduce pollution, and enhance biodiversity.

Ofori et al., (2000). 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 for 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., 2006; Chen et al., 2002; Teo & Loosemore, 2001).

Polat and Ballard (2004) defined waste simply as “…that which can eliminate without reducing customer value.” Formoso et al. (1999) 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, 2004; Formoso et al., 1999; Womack & Jones, 1996). Waste can be categorised according to its source - the stage in which the root causes of waste occurs. Bossink and
Brouwers (1996), 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.

2.13 Extent of construction material wastage

Ekanayake and Ofori (2000) 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, become very difficult to replace (Ekanayake & Ofori, 2000). The Environmental Protection Department of Hong Kong (2000) 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 such as, timber, nails, shipboard, paint, asbestos sheet, roofing tiles, plywood, electrical wire, roofing sheet, conduit pipe (electrical), sand, and stone.

Incineration, recycling, reusing 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, 2000).

In a study on the predominant causes of waste generation in Egyptian construction, Garas et al. (2001) categorised material wastes by activity, to include over-ordering, overproduction, wrong handling, wrong storage, manufacturing defects and theft or vandalism. Begum et al. (2006)
conducted a study on the implementation of waste management and minimisation in the Malaysian construction industry and categorised waste minimisation 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 reuse of what would otherwise be a waste material. Poon et al. (2004) also studied how to reduce building waste at construction sites in Hong Kong, and defined waste minimisation 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 (2000) defines waste minimisation as “…any method that reduces the volume or toxicity of waste that requires disposal.” Different measures for minimising materials waste have been reported (Begum et al., 2006; Faniran & Caban, 1998). In a study on the application of lean construction to reduce waste in Turkish construction, Polat and Ballard (2004) emphasised that reduction is the best and most efficient method for minimising the generation of waste and eliminating many of the waste disposal problems. Coffey (1999) studied cost-effective systems for solid waste management and pointed out that solid construction waste management is 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 minimisation and assess the level of practice of such measures in the construction industry since
cost reduction arising from the minimisation of materials waste is of direct benefit to all stakeholders.

2.14 Integrated waste management

George et al. (2002). Integrated waste management (IWM) can be defined as the selection and application of suitable techniques, technologies, and management programmes to achieve specific waste management objectives and goals. Because numerous state and federal laws have adopted, IWM is also evolving in response to the regulations developed to implement the various laws. The U.S. Environmental Protection Agency (EPA) has identified four basic management options (strategies) for IWM: (1) source reduction, (2) recycling and composting, (3) combustion (waste-to-energy facilities), and (4) landfills. As proposed by the U.S. EPA, these strategies are meant to be interactive, as illustrated in Figures 2.1(a) and 2.1(b) below. It should be noted that the State of California has chosen to consider the management options in a hierarchical order. For example, recycling can be considered after all that can be done to reduce the quantity of waste at the source has been done. Similarly, the waste transformation is considered only after the maximum amount of recycling has been achieved. Further, the combustion (waste-to-energy) option has replaced by waste transformation in California and other states. Interpretation of the IWM hierarchy will, most likely, continue to vary by state. The process of integrated waste management options considered are below.
2.15 Framework for decisionmaking

According to George et al. (2002), the preceding sections present information on the four waste management options: source reduction, recycling, waste-to-energy, and landfilling. With that material as a background, it must map out a framework for making decisions. In a world without economic constraints, the tools for waste management could be ordered by their degree of apparent environmental desirability. Source reduction would clearly be at the top, as it prevents waste from having to be managed at all. Recycling, including composting, would be the next-best management tool because it can return resources to commerce after the original product no longer serves its intended purpose. Waste-to-energy follows because it can retrieve energy that otherwise would be buried and wasted. Finally, landfilling, while often listed last, is not any
better or worse than incineration, as it too can recover energy. Moreover, waste-to-energy facilities still require landfills to manage their cash.

In reality, every community and region will have to customise its integrated management system to suit its environmental situation and its economic constraints. A small, remote community such as Nome, Alaska, has little choice but to rely solely on a well-designed and -operated landfill. At the other extreme, New York City can easily and effectively draw on some combination of all the elements of the waste management hierarchy. Communities that rely heavily on groundwater that is vulnerable, such as Long Island, New York, and many Florida communities, usually need to minimise landfilling and look at incineration, recycling, and residual disposal in regions where groundwater is less vulnerable. Communities that have problems with air quality usually avoid incineration to minimise more atmospheric pollutants. Sometimes these communities can take extra steps to ensure that incineration is acceptable by first removing metals and other bad actors out of the waste stream. In all communities, the viability of recycling certain components of the waste stream linked to volumes, collection costs, available markets, and the environmental consequences of the recycling and the reuse operations.

Liv H. (2008). Shows how one type of material can get recycled and save energy and transportation costs for many different groups. It is a pile of crushed concrete from the demolition of a dormitory at the University of South Carolina. It was hauled only a few miles away to an asphalt plant where it was stockpiled for reuse in many ways.
Fig.2: A stockpile

A stockpile of crushed concrete at the Sloan Construction asphalt plant in Columbia, S.C., ready for reuse. The concrete comes from the demolition of dormitories at the University of South Carolina, only a few miles away. (Photograph taken, August 2007). Source?

2.16 LESSONS LEARNT

The literature reviewed in this chapter showed that the major causes of construction waste include the following: Technical incompetence, poor organisational structure, failures of the enterprise, lack of waste reports during the construction stage, and inadequate project preparation, planning and implementation.

Delays in issuing information to the contractor during the construction stage, lack of coordination at the design phase, change in the scope of the project.
In government policies, some tendering maneuvers by contractors, such as front-loading of rates, incomplete design at the time of tender, bad allocation of labour inside the site, delays in decisions making by government, and failure of specific coordinating were the top five identified causes of construction waste. The effects of construction waste also identified in the literature, and they include the following: delays of supplementary agreement, adversarial relationship between participants of the project, poor quality artistry, dissatisfaction by project owners and consequently by end users. The literature reviewed revealed that there are four waste management options: source reduction, recycling, waste-to-energy, and landfilling. The study further identified the following as the measures that can be used to minimise construction waste: Perfect design, adequacy of plans and specifications, constructability, owner’s involvement and frequent feedback, prevention of double handling, project manager competency and experience, workforce attitudinal change, realistic obligations and clear objectives, and risk identification of management.

The literature further revealed that the causes of construction waste could be categorised into seven groups, namely owner related, contractor related, consultant related, material related, equipment related, labour-related and causes by external factors. Finally, the following were noticed to be the top ten measures of minimising construction waste: Site management and supervision, effective strategic planning, clear information and communication channels, frequent progress meeting,

Collaborative working in construction, proper project planning, and scheduling, frequent coordination between the parties involved, complete and proper design at the right time, use appropriate construction methods, accurate initial cost estimates, and proper material procurement.
2.17 CHAPTER SUMMARY

From the review of literature in this section, it was found that construction waste impacts negatively on the construction industry and the economy of any country with devastating implications such as an extension of time, disputes, and claims and can eventually lead to total abandonment of construction projects. The next chapter reviews literature related to construction waste management in China and the United Kingdom (UK).
CHAPTER 3

INTERNATIONAL LITERATURE: CONSTRUCTION WASTE MANAGEMENT IN CHINA AND THE UNITED KINGDOM (UK)

3.0 INTRODUCTION

This chapter gives a theoretical review and conceptual perspective of construction waste management in the construction industry of China and the UK. The theories of construction waste in China and the UK, such as causes, effects, factors, measures of minimising and environmental impact of C&D waste in the Chinese and UK’s construction industry are discussed in this chapter.

CONSTRUCTION AND DEMOLISHING (C&D) WASTE MANAGEMENT IN CHINA

3.1 The Chinese construction industry

The management of construction waste is an important part of the sustainable construction process, which is also a popular research field (Deng et al., 2008; Wimalasena et al., 2010). In recent years, China’s urban construction has developed at a rapid speed; the total new building area is 1.6 billion-2 billion square meters each year (Zhou, 2010), and annually more than 100 million tons construction waste is produced (Yu et al., 2006). China’s construction waste makes up 30-40% of the urban waste. Most of this waste is directly transported to suburban or villages without any treatment, and disposed of by air storage or burying (Liu 2010). To regulate the management of construction waste and reduce pollution, the China Ministry of Construction promulgated the Regulations on the Management of City Construction Waste in 1996. However, the regulations are only limited to the regulation on the damage the waste can do to the
environment, but ignore the recycling of construction waste (Gao, et al. 2010). At present, China’s construction waste recycling rate is as low as 5% (Zhou et al., 2009).

In recent years China has carried out management methods on the construction waste on-site, including (1) reducing construction waste through the materials selection via taking full account of purchasing plan, transportation, and construction conditions Wang, (2010); (2) Investigating and analysing the waste source, carrying out a strict environmental management system and strengthening the government's leading role.

Yu et al. 2006; (3) Industrialising the construction waste, forming an integration chain of waste collection, sorting, recycling, storage, processing, reusing, and operating (Yu et al., 2006). However, these methods were introduced in a few cities, enormous quantities of construction waste are not dealt with effectively (Wang, 2010). Construction waste is a worldwide issue. If appropriately treated, many benefits can be obtained, such as reduced cost, accelerated construction speed, improved quality of the building and making people more comfortable (Llozor, 2009). Effectively control of construction waste, much consideration must be given to China’s cultural and resource situation, this paper tries to explore the situation of China’s management of construction waste on-site using interviews, and then put forward a mode of construction waste management that applies to China so as to promote the sustainable development of construction industry.

According to Zhao W. et al. (2008), the Chinese government has made a clear commitment to achieve a minimum of 15.5 m² of living space per person by 2010 for improving the standard of living after the post-reforms initiated in the early 1980s. To achieve this goal, since the early 1980s, urban China has been changing rapidly with a massive housing development programme
together with a heavy infrastructure construction schedule. The fastigium of C&DW generation will be coming after 30–40 years, which is the lifetime of current buildings. In recent years, civil engineering wastes have reached 30–40% of the total city waste because of the large-scale construction and buildings demolition, which results from the accelerating urbanisation and city rebuilding. The large quantity of C&DW has placed a great burden on the finite landfill space and environmental protection. In the current recycling market in China only small amounts of valuable materials like copper and steel are reused or recycled, whereas large amounts of materials like concrete are directly transported to the C&D landfills because no profit can be made. The current market is a significant obstacle for C&DW management in China.

3.2 Problems of C&DW management in China

Government have the facilities to manage C&D flow in China, meanwhile the related problems are discussed from a view of economics because the problems of the actors normally attribute to “money.”

3.2.1 Consumers

For most consumers, the costs of waste processing are normally less than one per cent of their total expenditure. For contractors, especially public contractors, the problems of waste reduction are divided into the following four aspects:

The architectural design: The special phenomenon in China is a concurrence of design and construction. In half of 12 track survey projects, the delay from redesign results in reworking that produces a large amount of construction waste.
The management on the construction site: Due to the low price of raw materials and disposal, most managers do not pay attention to improving the level of management on site and establish the standardisation of operation for avoiding waste generation.

The environmental awareness: The contractors consider environmental management as a non-profitable activity. Investigation on a construction site in Shenzhen and Hong Kong has found 90% of the respondents think they have no relationship with waste management and only 10% of the respondents think strengthening waste management is significant work.

Recycling and reuse on site: Especially for contractors of demolition, it is not worth recycling and reuse if the recycling cost exceeds the recyclable value of waste. Mixed waste will be directly transported to C&DW landfill for saving cost in the case of low tipping fees of the landfill.

3.2.2 Recyclers

The recycling market lacks a central and stable medium to transform the waste into wealth in China. Unprofessional collection and sorting by waste pickers are difficult for manufacturers’ to find suitable recyclers considering quality and quantity insurance. The current recycling market-oriented economy gets a few profit on materials like steel are reused or recycled, whereas large and nonprofit materials like concrete are directly transported to the C&D landfills. Weak recycling chains are maintained by spontaneous recycling and reuse of contractors and waste pickers.
3.2.3 Investors

Insufficient investment in disposal facilities does not indicate that private investors are not interested in the waste recycling industry. It is difficult for investors to afford the high investment costs of facilities, equipment, land and labour in a current recycling environment and market. Changes or ordination in legislation and technical regulation might make the recovery process more expensive. These dynamics make it difficult for the investors to find the right timing and the right level of investments. Finally, low benefits from recycling aggregates and long payback periods stop investment into recycling industry.

3.2.4 Manufacturers

The recycled materials are still difficult to be accepted by manufacturers with the consideration of non-quality assurance. An attractive price will make manufacturers change their minds. Nevertheless, consequent low selling revenue will inevitably place a great burden on recyclers in the case of high recycling cost. The competition in price will ultimately make the recycling chain disappear.

3.2.5 Owners of landfills

Although a lot of private landfills exist, public C&D landfills take the dominant capacity of disposal. According to regional regulation like “Commodity Prices issued documents” in some cities, disposal fees of urban C&DW are only 0.2-0.5 EUR per ton excluding transportation. Low disposal fees of landfill lead the waste flow into landfill without recycling. The reasons for low tipping fees are not only non-internal costs from landfill leachate and the gas collection system but also neglected external cost containing land loss and health loss of workers and residents.
3.2.6 Government

The Chinese government as two-tier actors (policy maker and investor) plays an essential role in the improvement of waste chain and even determination of the future of waste management. The technical and treatment regulations are not distinctly defined. The conservation of resources, minimisation of C&DW from “Construction Law” and “Urban construction waste management” and other regulations are a guideline.

For example, recycling C&DW refers to the standardised utilisation of original building materials. Furthermore, the regulations and legislations related to environmental matters are too liberal. Waste producers are to implement the high-investment environmental management measures. Limited financial support will further constrain the development of waste management. Also, “government” is defined as a cooperative administration for C&DW at national and local levels, since three current responsible governmental agencies (Construction Committee, Municipal Administration Commission, and Environmental Protection Administration) are responsible for waste management on site, waste transportation, and waste disposal respectively.

3.3 The causes of waste generation

3.3.1 Amount of C&D waste

There are numerous reports concerning the amount of C&D waste generated in various countries and regions. For example, In Hong Kong, about 38% of the solid waste comes from the construction industry (Tarn, 2008a), and between 1993 and 2004 the annual generation of C&D waste in Hong Kong more than doubled.
According to (Poon, 2007). Tarn (2008a) reported that C&D waste forms 14% - 19% of the waste disposed of. The above statistics provide an indication of the proportion of C&D waste as a percentage of total solid waste generated in some typical economies. However, when the waste generated from new construction and the waste generated from demolition are considered separately, it is evident that the volume of waste generated from demolition activities is more than that from construction activities. Without accurate and timely data on C&D waste generation, the general public would not realise the situation facing societies and the industry could not be persuaded of the pressing need to manage C&D waste. Over the past few decades, C&D waste and its adverse impact on the environment have attracted widespread attention from researchers and industry practitioners. However, some countries, notably China (Wang et al., 2008), Malaysia (Begum et al., 2007a), Turkey (Esin and Cosgun, 2007) and Thailand (Kofoworola and Gheewala, 2009), are lagging behind in reporting the amount of C&D waste that they generate.

3.3.2 Origins/Causes of C&D waste

C&D waste originates from various sources throughout the lifecycle of construction projects, from inception through to construction and demolition (Shen et al., 2004). According to previous studies, the origins of C&D waste can classified into the following four categories: contractual, design, procurement, and transportation.

On-site management and planning, material storage, material handling, site operations, residual, and other causes (Osmani et al., 2008; Kulatunga et al., 2006; Gavilan and Bernold, 1994). These origins/causes are shown in Table 3.1 below.
Table 3.1: Origins and causes of C&D waste

<table>
<thead>
<tr>
<th>Origins</th>
<th>Causes of construction waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractual</td>
<td>Errors in contract documents, contract documents incomplete at commencement.</td>
</tr>
<tr>
<td>Design</td>
<td>Design changes, design, and detailing complexity, design and construction detail errors, unclear/unsuitable specification, poor construction and communication (late information/last minute client requirement, slow drawing revision and distribution) Remove these internal lines – confusing – see Contractual</td>
</tr>
<tr>
<td></td>
<td>Selection of low-quality product, lack of attention to standard size</td>
</tr>
<tr>
<td></td>
<td>Available in the market, designers’ unfamiliarity with alternative products. Is this a separate item or does it follow on from the previous? Unclear</td>
</tr>
<tr>
<td>Procurement</td>
<td>Ordering errors i.e.; ordering items not in compliance with specification</td>
</tr>
<tr>
<td></td>
<td>Over allowances i.e. difficulties to order small quantities, suppliers errors, purchased products that do not comply with specification</td>
</tr>
<tr>
<td>Transportation</td>
<td>Damage during transportation, difficulties for delivery vehicles accessing contract sites, insufficient protection during unloading, insufficient methods of unloading</td>
</tr>
<tr>
<td>On-site Management and</td>
<td>Lack of on-site waste management plans, improper planning for required quantities, delays in passing information on type and sizes of materials And components to be used, lack of on-site material control</td>
</tr>
<tr>
<td>planning</td>
<td></td>
</tr>
</tbody>
</table>
Amongst these categories, origins such as contractual, design, and procurement will cause indirect C&D waste because their effects will only be observed during the construction stage. It is suggested that to effectively reduce C&D waste at source, C&D waste management strategies should embrace lifecycle thinking rather than merely concentrating on the construction stage. Design changes occurring during construction are widely recognised as the most significant source of C&D waste (Ekanayake and Ofori, 2004; Faniran and Caban, 1998). It concurs with the finding from the study of Osmani et al. (2008) that approximately 33% of on-site waste is related, either directly or indirectly, to project design. Changes to the original project design can cause waste in two ways. Firstly, if the construction materials have been purchased according to the original design, waste could be caused if the material cannot be resold or returned to the

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material storage</td>
<td>Inappropriate site storage space leading to damage or deterioration</td>
</tr>
<tr>
<td></td>
<td>Materials stored far away from the point of application</td>
</tr>
<tr>
<td>Material handling</td>
<td>On-site transportation methods from storage to the point of application,</td>
</tr>
<tr>
<td></td>
<td>Damages during transportation, materials supplied in loose form</td>
</tr>
<tr>
<td>Site operation</td>
<td>Accidents due to negligence, unused materials, and products,</td>
</tr>
<tr>
<td></td>
<td>Equipment malfunction, poor craftsmanship, poor work ethics,</td>
</tr>
<tr>
<td></td>
<td>Use of wrong materials resulting in their disposal, time pressure</td>
</tr>
<tr>
<td>Residual</td>
<td>Waste from application processes (i.e., over-preparation of mortar)</td>
</tr>
<tr>
<td></td>
<td>Off-cuts from cutting materials to length, packaging</td>
</tr>
<tr>
<td></td>
<td>Waste from cutting uneconomical shapes</td>
</tr>
<tr>
<td>other</td>
<td>Weather, vandalism, theft.</td>
</tr>
</tbody>
</table>
supplier and has to disposed of. Secondly, a design change in part of a structure that has already been built might result in that part having to be dismantled with a subsequent waste of the material that cannot be salvaged for reuse (Faniran and Caban, 1998). Project design associated with C&D waste generation is complex owing to the usage of a wide variety of materials and the involvement of stakeholders other than the designers, such as clients and contractors (Osmani et al., 2008). Such complexity results in very few attempts to find solutions for minimising C&D waste during project design (Osmani et al., 2006), and is probably the main barrier to effective C&D waste minimisation at the project design stage.

3.3.3 Measuring C&D waste

Efforts have been made to report C&D waste as a percentage of total MSW so that comparisons can make order to discover the reasons for high or low waste generation rates (WGR). For example, Tam (2008a) found that C&D waste formed 19% and 14% of the waste disposed of at landfills in Germany and Finland respectively, while in Hong Kong, it was about 38%. However, these comparisons should be treated with caution because the percentages are influenced not only by construction activities but also by the size of a country/region's economy and population, as well as its social behaviour. Researchers consider WGR to be a good comparism.

The first extensive investigation of WGR in Hong Kong was carried out by Poon et al. (2001a) who, between June 1992 and February 1993, investigated 32 construction sites. The report revealed that the rate of packaging waste was as high as 5% of the volume of materials and that
WGR of premixed concrete ranged from 2.4% to 26.5%. A series of studies was led by Poon et al. (2004a, 2004b, 2004c) to investigate WGR of various construction materials in Hong Kong.

3.4 Strategies for C&D waste management in China

C&D waste management research and practices have been guided by a '3Rs' principle, which is also known as the hierarchy of C&D waste management (see Figure 3.1). The principle refers to the 3Rs of reduction, reuse, and recycling, which classify waste management strategies according to their desirability (Peng et al., 1997). The 3Rs are meant to be a hierarchy, arranged in ascending order of their adverse impacts on the environment from low to high.

![Figure 1: Hierarchy of C&D waste management](image)
3.4.1 Measures of Minimising/Reduction of C&D Waste in China

Reduction considered as the most effective and efficient method for managing C&D waste. It not only minimises the generation of C&D waste but also cuts the cost of waste transporting, recycling and disposal (Poon, 2007; Esin and Cosgun, 2007). As the highest priority for managing C&D waste, it is not surprising to see that C&D waste reduction has been examined extensively by previous researchers. Various approaches have employed by studies about C&D waste reduction, including survey, case study, descriptive models, and deployment of mathematical models and information technology. (Begum et al, 2007b; Baldwin et al., 2007; Poon et al., 2004b, 2004c; Faniran and Caban, 1998). A case study serves a similar purpose as survey method (Poon et al., 2004c; Seydel et al., 2002), but results from limited cases are not reliable and cannot therefore applied to other projects. The waste flow process can be depicted by descriptive models (e.g. Lu et al., 2006; Shen et al., 2004). By mapping the waste handling processes, different waste management practices can be presented as a tool to assist in planning on-site waste management procedures and enable the comparison of different waste management practices. It helps to identify both good practices and weak areas in C&D waste management (Shen et al., 2004). With the aid of mathematical models and information technology, the waste handling process can optimised (Lu et al., 2006),

Workers can motivated to reduce waste (Li et al., 2005; Chen et al., 2002), and a better understanding of the dynamic interactions of key areas of the C&D waste management process can be facilitated (Hao et al., 2007b). In summary, the survey and descriptive models are helpful in acquiring a qualitative understanding of C&D waste reduction, while the case study and mathematical models are useful for quantitatively improving the performance of C&D waste management.
The measures for effectively reducing C&D waste can be summarised into five categories: (1) reducing waste through governmental legislations, (2) reducing waste by project design, (3) developing an effective waste management system (WMS), (4) adopting low-waste construction technologies, and (5) improving major stakeholders’ attitudes toward waste reduction. The effectiveness of legislation for reducing C&D waste has attracted significant attention. For example, the effectiveness of implementing a waste management plan proposed by the Hong Kong government was investigated by Tam (2008a), and Hao et al. (2008a) who conducted a study on the effectiveness of Hong Kong's Construction Waste Disposal Charging Scheme. The results showed that C&D waste was reduced by approximately 60% in landfills, by approximately 23% in public fills, and by approximately 65% in total waste generation between 2005 and 2006. This, to a large extent, demonstrated that governmental legislation has an important role to play in C&D waste reduction. Solutions arising from project design are also important, since waste caused by design changes has been found to be the most significant source of C&D waste. A WMS generally comprises five key elements: (1) waste management policy, (2) planning, (3) implementation and operation, (4) checking and corrective action, and (5) management review. As the key component of a WMS, the importance of a waste management plan (WMP) has been highly emphasised by some studies (e.g. Poon et al., 2001b). A WMP contains a set of waste prevention strategies involving the effective coordination of material management, the use of materials to minimise loss, maximising reuse, preventing undoing and redoing, and reducing packaging waste (Chen et al., 2002). It is considered proper to evaluate the effectiveness of a WMP from a perspective of integrating society, the environment and the economy. However, how to develop a scheme which is economically competitive has attracted the most attention from researchers (Begum et al., 2006; Chen et al.,
This is probably because major stakeholders are more likely to be motivated if they are rewarded according to the amounts and values of materials saved (Li et al., 2005; Chen et al., 2002). In addition, cost is commonly a much higher priority than the environment amongst the objectives of construction projects (Shen et al., 2006). Previous studies have recognised the potential of low-waste construction technologies, such as prefabrication and modular structure in buildings, for minimising C&D waste (Jaillon et al., 2009; Jaillon and Poon, 2008; Esin and Cosgun, 2007; Tam et al., 2007b; Poon et al., 2004a). Baldwin et al. (2007, 2008) argued that for high-rise residential buildings, the main opportunities for waste minimisation are related to the adoption of pre-fabrication techniques, while Jaillon et al. (2009) suggested that waste reduction is one of the major advantages of using prefabrication. This was supported by a finding from Tam et al. (2007b) that adoption of prefabrication in concreting could achieve a 90% waste reduction compared with cast-in-situ. The implication of the foregoing is that a wider use of low-waste construction technologies could considerably reduce C&D waste. Recognition by major stakeholders of the need to reduce waste has also been perceived as an effective solution to C&D waste reduction. Lingard et al. (2000) revealed the understanding of both managers and site workers of the need for waste reduction, while the attitudes of site workers toward waste management were investigated by Teo and Loosemore (2001) and Chen et al. (2002) and Osmani et al. (2006) conducted a study in the UK to assess architects' views on the origins of design waste, as well as barriers to waste reduction. Findings of these studies suggest that it is crucial to take the attitudes of major stakeholders into account when exploring possible solutions to C&D waste reduction. The findings also indicate that attitudes toward C&D waste reduction differ between various groups of stakeholders.
The discussions above testify to the fact that measures for C&D waste reduction are well developed. Nevertheless, how to apply them effectively to different practices remains a challenge. The investigation by Tam et al. (2008a) showed that schemes from the Hong Kong government have been criticised by industry participants because the productivity of these schemes is largely affected when implemented in practice. Similarly, despite the consensus in the literature that C&D waste can be greatly reduced by focusing on design waste, findings from Osmani et al. (2006) revealed that waste management is not a priority in the design process and that architects typically hold the view that waste is mainly produced by site operations. Another study on architects' attitudes toward waste management showed that they are reluctant to adopt waste reduction strategies at the design stage (Osmani et al., 2008), probably because of the belief that C&D waste management is out of their control and is not cost effective (Lingard et al., 2000). Furthermore, Tam et al. (2007b) identified drawbacks of prefabrication, including inflexibility for design changes and higher initial construction cost. This was supported by Jaillon et al. (2009), who identified key obstacles to a wider use of prefabrication in residential buildings that included the need for specification change, conflict with traditional design process, lack of incentives, lack of on-site cast yard areas, and conflict with construction practice.
3.4.2 Construction & demolition waste reuse and recycling

Reuse means using the same material more than once. This might be for the same function, such as formwork (Ling and Leo, 2000) or for a new function, such as using cut-corner steel bars for shelving (Duran et al., 2006). The waste materials that cannot be reused will either be recycled for new construction use or disposed of at landfills. Reuse is therefore the most desirable option after reduction because of the minimum processing and energy involved (Peng et al., 1997). When reduction and reuse become difficult, recycling is the next best option. Through recycling, some new materials can be made out of the C&D waste. Tam (2008a) and Kartam et al. (2004) suggested that recycling could offer five major benefits: (1) reducing the demand for new resources, (2) cutting down transport and energy production cost, (3) utilising waste that would otherwise be lost to landfill sites, (4) preserving areas of land for future urban development, and (5) improving the quality of the environment. By comparison with reduction and recycling, relatively fewer studies have been conducted on reuse of C&D waste. A study by Ling and Leo (2000) found that there are three sub-factors of importance affecting the reuse of timber formwork, namely, the workers' attitudes, the workers' efficiency, and the formwork stripping process. It is reasonable to conclude that effective solutions to waste reuse depend largely on the stakeholders involved, rather than the wasted material itself.

On the other hand, waste recycling is attracting considerable attention. A study by Lauritzen (1998) showed that recycled materials would normally be competitive where there is a shortage of both raw materials and suitable deposit sites. Additionally, two determinants for using recycled materials in construction projects exist. One determinant is transportation facilities, such as roadways, railways and pipelines. Since virgin materials usually have to be transported from distant sources, it might be more cost efficient to use recycled materials in close proximity.
The other determinant is high population density, particularly for countries and regions with large populations and scarce space for disposal (Inyang, 2003). These determinants are supported by the findings of Peng et al. (1997) and Tam and Tam (2006a), both of whom concluded that from a purely economic point of view, recycled materials are only attractive when they are competitive with virgin materials in terms of cost and quality. Clearly then, cost and quality are the major considerations when adopting recycled materials. A number of studies have been launched to deal with the two major concerns over waste recycling: the economic viability and acceptability of recycled materials (e.g. Tam, 2008b; Rao et al., 2007; Tam and Tam, 2006b; Bianchini et al., 2005). Studies have also evaluated the financial feasibility of investing in recycling centres with Nunes et al. (2007) showing that recycling centres could be economically viable for public authorities providing there is continuity and sufficient production volume.

3.4.3 C&D Waste disposal

In accordance with the hierarchy of C&D waste management as shown in Figure 3.1, when C&D waste cannot be effectively minimised based on the 3Rs principle, it should be disposed of at landfills and/or public fills to avoid polluting the environment. However, uncontrolled and illegal dumping of C&D waste has been occurring widely in many economies (Zygouras et al., 2009; Esin and Cosgun, 2007). Generally, there are two ways to reduce uncontrolled and illegal dumping: one is by polluters' (such as contractors, sub-contractors and waste contractors) willingness to dispose of waste at landfills and the other is through government regulations (Hao et al., 2008a; Tam et al., 2007a). Unfortunately, studies indicate that voluntarily disposing of C&D waste at landfills and/or public fills does not work effectively in many economies. The major barrier is that polluters will spend extra costs for waste disposal under the polluters-pay principle (Begum et al., 2007a). This to some extent implies that the reduction of illegal
dumplings can only be effective by regulating the disposal behaviour, and these regulations must be enforced by the government. Although many countries/regions have legislation aimed at regulating C&D waste disposal, the outcomes are far from effective (Kofoworola and Gheewala, 2009; Tam, 2008a; Wang et al., 2008). How to effectively implement legislation related to C&D waste is the subject of much research. For example, through a questionnaire survey, Tam et al. (2007c) found that the reason for the limited effectiveness of regulatory measures in Hong Kong is that these measures allow for skewed distribution of commitments and responsibilities among key project participants. A major focus of studies relating to regulatory measures for C&D waste management is the waste charging scheme (WCS). A WCS imposes a levy on those who dispose of their C&D waste into public landfills. Therefore it is also called a landfill charging scheme or waste disposal charging scheme. The scheme is not only intended to provide an economic incentive for key stakeholders to reduce waste but also to encourage reuse and recycling of wasted material in order to slow down the depletion of limited landfill and public fill capacities (Hao et al., 2008a). To deal with the challenge of limited landfills for C&D waste, the cost of disposing of C&D waste has increased significantly worldwide (Peng et al., 1997). For instance, in Southeast Queensland, Australia, a levy reflecting the environmental and social costs of landfilling was imposed to encourage the diversion of waste from landfills (Tam et al., 2009). In Hong Kong, a charge for C&D waste disposal, initially at HK$55/t (US$7/t), has been increased to HK$120/t (US$15.2/t) and is thought to have reduced the amount of inert C&D waste entering landfills (Poon et al., 2001b).

Measures to improve the effectiveness of WCSs have also been developed in previous studies. Based on daily C&D waste records from landfills and public fill facilities, Hao et al. (2008a) found that C&D waste dumped at landfills and public fills was reduced by approximately 65%
after implementing a WCS. This can lead to further improvement in reducing waste by embodying WCSs to waste reduction guidelines, providing thresholds for the amount of waste sent to landfills or public fills, using waste dumping charge as an incentive, encouraging the recycling of different type of C&D waste, and promoting the use of recycled materials. Waste disposal charges are an important component of a WCS and greatly influence the effectiveness of implementing a WCS in a given country. The majority of studies tend to suggest that disposal charge should be higher than they already are. However, an overly-high waste disposal charge might alienate major stakeholders, such as clients and contractors, and thereby lose their active participation and support. Economists give waste disposal charges a theoretical explanation: the low cost of C&D waste dumping generally leads polluters (C&D waste producers) to dispose of most of their waste in landfills, where society has to incur the environmental cost. By using a WCS, policy makers are attempting to internalise the costs by ensuring that the polluters themselves and not society incur the costs.

3.5 Environmental impact

It has been widely acknowledged that C&D waste handling and processing by nature is not environmentally friendly owing to its enormous adverse impacts on the environment. Fundamentally, C&D waste management can harmfully affect the total environment in many ways, such as exhausting a large amount of land resources for waste landfilling (Poon et al., 2003), harming the surroundings by hazardous pollution, and wasting natural resources (Esin and Cosgun, 2007). A synthesis of previous studies, government legislations and reports determined that five indicators are critical to the environmental performance of C&D waste management: (1) land consumption due to waste landfilling, (2) water pollution, (3) noise emission, (4) air pollution, and (5) environmental impacts of illegal waste dumping on public living environment.
• Land consumption due to waste landfilling

Significant amounts of C&D waste are annually generated globally (Bell, 1998). In Hong Kong, according to the report by the Environment Protection Department (EPD), about 2900 tons of C&D waste was received at landfills per day in 2007 (HKEPD, 2007). In addition, it was estimated that China generated about 90 million tons of C&D waste in 2005 and the average amount of C&D waste generation during 2003–2006 was around 120 million tons.

• Water pollution

The inappropriate management of C&D waste is causing a wide range of environmental problems, among which a typical one is water pollution. C&D waste would enter waterways through various channels such as storm-water drains, and may be a major reason for water pollution. Any leak of suspended solid materials and/or waste leachate to a watercourse may have very damaging environmental effects. Therefore, effective C&D waste management should avoid discharging water-borne pollution. Water pollution can also result from C&D waste from sources such as solvents or chemically treated wood.

• Noise emission and air pollution

C&D waste management can change the nearby air quality considerably by releasing pollutants (including noise and air pollution) into the air. Firstly, C&D waste generation, collection and separation influence the air quality of construction sites by causing noise emission and dust discharges. Secondly, transporting aggregates, whether by road or rail, generates further impacts in the form of noise, vibration, dust and air pollution, and contributes to the visual impacts associated with existing infrastructure.
Environmental impacts of illegal waste dumping on public living environment

Illegal C&D waste dumping is the unlawful deposit of C&D waste onto land. In this illegal action, waste materials have been dumped, tipped or otherwise deposited onto land where no license or approval exists to accept such waste. Illegal C&D dumping varies from small bags of rubbish in an urban environment, such as street side, to larger scale dumping of waste materials in isolated areas, such as rivers and mountains. Illegally dumped C&D waste can adversely affect the public living environment in many aspects. As was mentioned by Yuan (2008), the living surroundings were substantially affected, such as polluting municipal rivers with illegally dumped waste and hindering the city subway construction activities by disposing of C&D waste illegally. More importantly, illegally dumped C&D waste generates hazardous wastes. It is a threat to rivers, lakes, air, land, oceans and ultimately to the public health.

3.6 LESSONS LEARNT

The literature reviewed in this chapter showed that the major problem of construction waste management in China includes the following: For most consumers, the costs of waste processing are normally less than one per cent of their total expenditure. For contractors, especially public contractors, the problems of waste reduction are divided into the following four aspects and the architectural design is the first most: The special phenomenon in China is concurrence of design and construction. Furthermore recyclers, investors, manufacturers, owners of landfills, and government are also some of the problems. The literature also reviews the causes of construction waste as follows: the origins of C&D waste can be classified into the following ten categories: contractual, design, procurement, transportation, on-site management and planning, material storage, material handling, site operations, residual, and other causes. Damage during
transportation, difficulties for delivery vehicles accessing Contract sites, insufficient protection during unloading, insufficient Methods of unloading, Lack of on-site waste management plans, improper planning for required Quantities, delays in passing information on type and sizes of materials And components to be used, Lack of on-site material control, Lack of supervision.

Inappropriate site storage space leading to damage or deterioration, Materials stored far away from point of application, On-site transportation methods from storage to the point of Application, Damages during transportation, materials supplied in loose form, Accidents due to negligence, Unused materials and products, Equipment malfunction, Poor craftsmanship, Poor work ethics, Use of wrong materials resulting in their disposal, Time pressure Waste from application processes (i.e., over-preparation of mortar), Off-cuts from cutting materials to length, Packaging, Waste from cutting uneconomical shapes, Weather, Vandalism, and Theft.

The literature review the measures of minimizing/reduction of C&D waste as, The measures for effectively reducing C&D waste can be summarised into five categories: (1) reducing waste through governmental legislations, (2) reducing waste by project design, (3) developing an effective waste management system (WMS), (4) adoption of low-waste construction technologies, and (5) improving major stakeholders’ attitudes toward waste reduction. The effectiveness of legislation for reducing C&D waste has attracted significant attention. And a WMS generally comprises five key elements: (1) waste management policy, (2) planning, (3) implementation and operation, (4) checking and corrective action, and (5) management review, and also recycling could offer five major benefits: (1) reducing the demand for new resources, (2) cutting down transport and energy production cost, (3) utilizing waste that would otherwise be lost to landfill sites, (4) preserving areas of land for future urban development, and (5) improving the quality of the environment. The literature review finally highlighted the
environmental impact of C&D waste as a synthesis of previous studies, government legislations and reports determined that five indicators are critical to the environmental performance of C&D waste management, which are (1) land consumption due to waste landfilling, (2) water pollution, (3) noise emission, (4) air pollution, and (5) environmental impacts of illegal waste dumping on public living environment.

CONSTRUCTION AND DEMOLISHING (C&D) WASTE MANAGEMENT IN UNITED KINGDOM (UK)

3.7 UNITED KINGDOM (UK) CONSTRUCTION INDUSTRY

The UK produces about 330 million tonnes of waste each year. A third of waste produced each year is from the construction industry. The waste produced is growing by about 3% every year. This is more than the growth in GDP (2-2.5%) and one of the fastest European growth rates for waste (www.sustainablebuild.co.uk). With the UK being the second most land-filled country in the EU, producing over 330 million tonnes every year, new methods of disposal are essential. The case study of Kamikatsu, a village in Japan which aims at becoming a zero-waste village by 2020 is a good example, revealing that WM does not necessarily need the input of large amounts of money. In Kamikatsu, the community was brought together where each person living in the village volunteers to help out and has a specific job to achieve this sustainability. This example shows that the key to sustainability is time and effort.

The UK‘s construction output is the second largest in the EU and contributes 8.2% of the UK‘s gross value added. Each year 400 million tons of solid materials are used in the UK construction industry but only two-thirds is added to the building stock and the rest is sent directly to landfill
According to Khairulzan and Boussabaine (2006), 13% of all the solid materials delivered to a construction site do not get used. Current methods used in the UK to dispose of all types of waste are landfill, incineration, and recycling. Spivey (1974) proposed a specific construction WMS based on the collection, transportation and disposal of construction waste. Spivey (1974) classified the components of construction waste as demolition materials, packaging materials, wood, waste concrete and asphalt, scrap metal products, rubber, plastic, and glass. Gavilan and Bernold (1994), on the other hand, categorised and evaluated construction waste according to the following sources: design, procurement, materials handling, and operation. Gavilan and Bernold (1994) found that most of the construction waste came from residual material. According to Hao et al. (2007), there are two ways to handle the waste, namely to transport directly to sorting facilities with high charges or to adopt the on-site sorting process before disposal at landfills or public fillings. Hao et al. (2007) showed that the most effective means of WM is on-site sorting of construction waste which involves inert and non-inert wastes. By separating these two types of waste, the inert waste can be used for land reclamation, and the non-inert waste can be disposed of in landfills. On-site sorting is an effective means to reduce the quantities of construction waste to be disposed of in landfills.

However, about 70% of the contractors would not perform on-site construction waste sorting unless it is specified in the contract (Poon et al, 2001). On-site sorting is not yet a common measure in the industry because there is not enough site space, skilled workers or equipment to operate on site. Furthermore, the normal construction may be disturbed by the sorting work. The on-site sorting process involves a vast amount of containers which are difficult to store when constructing in the city centre.
3.8 Measures of minimising / reducing C&D waste in the UK construction industry

According to Defra (2008), the government’s key objectives are to decrease waste growth (in all sectors) from economic growth and put more emphasis on waste prevention and re-use; meet and exceed the Landfill Directive diversion targets for biodegradable municipal waste in 2010, 2013 and 2020; increase diversion from landfill of non-municipal waste and secure better integration of treatment for municipal and non-municipal waste; secure the investment in infrastructure needed to divert waste from landfill and for the management of hazardous waste; get the most environmental benefits from investment through increased recycling of resources and recovery of energy from residual waste using a mix of technologies; recycle and compost household waste to at least 50% by 2020; and recover 75% of municipal waste by 2020.

The government published the Waste Strategy 2007 for England and Wales. The objectives of the Waste Strategy for the construction sector include to provide the drivers for the sector to improve its economic efficiency by creating less waste from design to demolition; treat waste as a resource, re-using and recycling more and asking contractors for greater use of recovered material; and improve the economics of the re-use and recycling sector by increasing demand and securing investment in the treatment of waste. The government has a major impact on WM through taxes and directives. New regulations in 2008 made site waste management plans (SWMP) compulsory for all construction projects in England. The regulations aim to increase the amount of construction waste that is recovered, re-used and recycled and improve material resource efficiency, and prevent illegal waste activity by requiring that waste is disposed of appropriately, in accordance with the waste duty of care provisions (Defra 2008). The Landfill Directive (1999/31/EC) adopted by the European Union in 1999 was brought into force in the
The Landfill Directive (1999/31/EC) targets were to reduce biodegradable municipal waste sent to landfill by 65% by 2015; ban landfill of hazardous and non-hazardous wastes together from 2002; ban liquid waste, and certain hazardous wastes from 2002; and ban landfill of whole tyres by 2003 and shredded tyres by 2006. Landfill tax was first introduced at £7 per ton in 1996. The standard rate increased to £10 per ton in April 1999 (Lets recycle website). The landfill tax will increase up to a level of at least £48 per ton. Her Majesty's Revenue and Customs states that the aim of the tax is to encourage less disposal of waste and to recover more value from waste through recycling and composting, and to stimulate moves to more environmentally friendly WM methods. The WM methods used in the UK construction industry are briefly explained below:

- **Reuse**: By creating markets for recovered materials and encouraging voluntary cooperation by promoting awareness of disposal problems, the governments targets by 2020 may be possible. At present around 2000 companies (www.sustainablebuild.co.uk) specialised in architectural salvage are in operation in the UK.

- **Recycling**: In the construction industry waste is generally bulky and low in value. Waste produced from demolition is a mixture of concrete, masonry, metal, timber, plastics, and plasterboard. The decision to recycle depends on the availability of the raw materials, the energy used to collect and process the material and the effect of their release to land, water and air. Some environmental and economic constraints to recycle are energy consumed and pollution created by haulage, transport costs of the material, and technical standards and specification of the use of secondary aggregates. Jones and Greenwood
(2005) suggested that the construction waste is built up of around ten main materials: hardcore (23%); plasterboard (36%); electric cable (1%); plastic (1%); rubber (1%); chipboard (2%); canteen waste (2%); timber (4%); insulation (10%); and cardboard (20%). Concrete can be crushed and recycled for fill and road material. Metals and bricks can be sold. Concrete and masonry can be reused as fill material, sub-base or base material for roads is an attractive option on suitable sites. Recycled concrete needs to comply with grading limits, contain minimum levels of contaminants and meet requirements of stability and durability. The use of wood waste particles can be used to create MDF, chipboard and fibreboards. Al-Nageim et al (2006) suggested that another potential source of alternative aggregate can be formed from waste plastic.

- **BREEAM**: The BREEAM scheme was produced by the British Research Establishment (BRE) with a number of private sector sponsors (Prior, 1992). This scheme identifies the performance of the building against a defined set of environmental criteria so that clients and users can easily differentiate —greener— buildings from other designs. BRE developed the SMART Waste Plan which is free to use from the Internet and takes the contractor through stages for preparing and writing a waste management plan (WMP). The website includes a waste measurement tool which can calculate the amount of money saved per site along with waste benchmarks to help companies to improve their performance.
3.8.1 Means of sorting C&D waste

According to Begun S. et al. (2012), before a project is due to start, the WMP is thoroughly read and analysed. Contractors and sub-contractors receive a copy when tendering for a new project where they hold certain responsibilities for waste on site. Most contractors and sub-contractors are responsible for their waste and must dispose of this before they leave the site. A colour-coded skip system is used where yellow skips are used for cardboard, red for bricks and blue for metals. All soil is left in a heap at the rear of the site which the company comes and collects free of charge. All wooden pallets are stacked in a pile and sent back to the manufacturer for reimbursement. In order to make sure that these bins are used, when employees first arrive on-site and fill out health and safety forms, they also read a document concerning the WMS. All documents are signed to show they have fully understood what is required.

Government should have more input into the construction waste control and possibly help finance new methods. The site manager thinks that if the government created stricter laws then more companies may take this issue more seriously and start to do more about their levels of waste. The WM approach for all of these materials has been analysed and the following approaches have been proposed (Begun et al., 2012):

- Metal: The company has no need to throw away scrap metal in general waste skips. Some skip companies charge a much reduced rate of the skip and then weigh in the scrap and send the company a cheque. The company also has a tipper truck that can be used to clear away scrap from local sites to be weighted in. If there are only small volumes of
more expensive scrap e.g. lead, copper and aluminum, those with vans would be allowed to take it directly to the scrap yard.

- **Timber**: The company should use timber recycling skips as there is no ideal way of getting rid of timber. Any good lengths/sheets of timber left could be put onto the beam surplus materials list and reused on a different site. Previously company’s had had some success with local timber collection services; these are people that used recycled timber to make furniture and such like. This needs to be looked into at the start of each job to check whether a service like this is available in the area.

- **Plasterboard**: Depending on the costs and space available, plasterboard skips or general waste skips should be used.

- **Glass**: Company’s rarely gets contracts with large amounts of glass to dispose of. However at Banbury it has proven to work well getting in touch with Pilkington and getting them to take the glass away for recycling free.

- **Aggregates**: Aggregates can be seen as a commodity and company’s should try to avoid throwing it away. Company always uses Type 1 hardcore, sand and ballast. If there is spare topsoil available or other less useful aggregates, the company can take it to Elliott and Sons old pit on Shurdington Road or the new one at Bishops Cleeve and tip for free.

- **General waste skips**: General waste skips are still the most practical way for getting rid of general waste. However, if segregation is implemented, the number of skips used can be reduced dramatically.
The percentages of material on site have been taken from the study of Jones and Greenwood (2005) according to which a typical site is built up of 20% cardboard, 36% plasterboard, 23% hardcore, 10% metal, 6% wood, and 5% other.

3.8.2 The waste hierarchy

In England, the waste hierarchy is both a guide to sustainable waste management and a legal requirement, enshrined in law through the Waste (England and Wales) Regulations 2011. The hierarchy gives top priority to waste prevention, followed by preparing for reuse, then recycling, other types of recovery (including energy recovery), and last of all, disposal (e.g. landfill). The dividends of applying the waste hierarchy will not just be environmental. Money can be saved by making products with fewer natural resources, and reduce the costs of waste treatment and disposal.

The 2011 Regulations require everyone involved in waste management and waste producers in England to take, on the transfer of waste, all reasonable measures to apply the waste hierarchy except where, for specific waste streams, departing from the hierarchy is justified by lifecycle thinking on the overall effects of generating and managing the waste. Regulators under the Environmental Permitting (England and Wales) Regulations 2010 must exercise functions (such as granting environmental permits) for the purpose of ensuring that the waste hierarchy is applied to the generation of waste by a waste operation.
3.8.3 Prevention

The government’s aim is to reduce the amount of waste produced across the economy whilst supporting economic growth. To measure the total amount of raw materials used and waste produced alongside the commercial, industrial and household waste produced per unit of gross value added (GVA). This shows how quickly things are moving along a pathway to a zero waste economy. Although information on waste arising is available for England, information on use of materials is currently only available at a UK level. The most current statistics (2010) providing this information can be found at https://www.gov.uk/government/organisations/department-for-environment-food-ruralaffairs/series/waste-and-recycling-statistics.

This will continue the progress towards a zero waste economy by setting out detailed actions to:

- Help businesses recognise and act upon the savings possible through better resource efficiency and preventing waste, to contribute to a greener economy;
- Make it easier for people to find out how to reduce their waste, and how to reuse items they no longer want; and
- Support action by local government, businesses and the civic society to capitalise on these opportunities.

3.8.4 Preparing for reuse

Government is currently developing re-use and repair policies alongside the development of the waste prevention programme. The Government’s Call for Evidence for the Waste Prevention Programme provides information on current reuse, remanufacture and repair activities in England.
3.8.5 Recycling

The most recent statistics show that the rate of recycling for waste from households in England continues to increase, with current policy measures, towards the EU target of recycling 50% of household waste. It is also already exceeding the 70% target for recovering construction and demolition waste. Commercial and industrial waste reached a recycling rate of 52% in 2010. This Plan sets out a number of other initiatives that are under way to boost recycling. Based on current trends and with the action already planned in mind, no policies additional to those in hand or planned are currently considered necessary.

Statistics on recycling are available at: -


3.8.6 Disposal

Landfill is the last resort for biodegradable waste. The landfill tax is the key driver to divert waste from landfill to ensure that it’s meet EU targets under the Landfill Directive. That does not mean that all wastes will be diverted from landfill by 2020. There are some wastes for which landfill remains the best or least worst option. The Waste Review 2011 suggested that such materials are likely to include:

- some hazardous wastes – such as asbestos;
- some inert‘ materials and wastes, to restore quarries and mineral workings;
- certain process residues, such as pre-treated industrial wastes from which no further resources can be recovered; and
• waste for which the alternatives to landfill are not justified on cost or environmental
• And resource efficiency grounds.

3.9 LESSONS LEARNT

The literature reviewed in this chapter showed how C&D waste is managed in the United Kingdom and it was revealed that current methods used in the UK to dispose of all types of waste are landfill; incineration, and recycling. Spivey (1974) proposed a specific construction WMS based on the collection, transportation and disposal of construction waste. Spivey (1974) classified the components of construction waste as demolition materials; packaging materials; wood; waste concrete and asphalt; scrap metal products; rubber, plastic, and glass. On the other hand, categories of construction waste according to the following sources: design; procurement; materials handling; and operation. It was noted that on-site sorting is an effective means to reduce the quantities of construction waste to be disposed of in landfills. However, the normal construction may be disturbed by the sorting work. The on-site sorting process involves a vast amount of containers difficult to store when constructing in the city centre. However construction waste is built up of around ten main materials, namely hardcore (23%); plasterboard (36%); electric cable (1%); plastic (1%); rubber (1%); chipboard (2%); canteen waste (2%); timber (4%); insulation (10%); and cardboard (20%). Concrete can be crushed and recycled for fill and road material. Metals and bricks can be sold. Concrete and masonry can be reused as fill material, sub-base or base material for roads is an attractive option on suitable sites.
3.10 CHAPTER SUMMARY

From the review of literature in this section, it was found that construction waste can be reduced to its minimum if appropriate measures are put in place, such as waste management policy, planning, implementation and operation, checking and corrective action, and also reducing waste through governmental legislations, reducing waste by project design, developing an effective waste management system (WMS), adoption of low-waste construction technologies, and improving major stakeholders' attitudes toward waste reduction. Finally, the adoption of the 3R’s principle of C&D waste management. The next section reviews literature related to the Nigerian and South African construction industry.
CHAPTER 4

CONSTRUCTION WASTE MANAGEMENT IN NIGERIA AND SOUTH AFRICA

4 INTRODUCTION

This chapter reviews literature on asseccement of construction waste management by scholars and researchers in Nigeria and South Africa. Hence, this chapter gives the reader an understanding of construction waste, its causes and effects, the environmental impact and further suggests measures of minimising waste in the Nigerian and South African’s construction industry.

4.1 Nigerian construction industry

The structure of a business firm, including the construction firms, is a function of its performance and output. Therefore, the level of waste generated by a construction firm may be the reflection of its organisational structure, culture, practices, policies and size. Basically, industries could be classified on the basis of various parameters of the scope of operation, ownership, management control and the like. Like other nations of the world, construction firms could be classified as small, medium and large (Odediran et al., 2012). In Nigeria, large firms are dominated by expatriates with very few indigenous firms that could be categorised as medium while most are categorised as small size firms. For example, Olaleye and Abdullahi (2014) categorized the construction industry into three (3) layers: small, medium, and large construction firms based on the number of persons employed on a permanent basis but Odediran et al. (2012) based their classification on the annual turnover, staff strength and equipment capacity. In the UK, construction companies employing 1-59 employees are categorised as small-scale construction firms Williams et al. (2011). This study adopts the categorisation style of Ujene et
al. (2013) regarding construction firms with 1-49, 50-249, and 250 and above permanent employees as small, medium and large construction organisations respectively.

Construction waste management is an aspect of sustainable development, which is fuelled by the growing concern for the effect of man’s activities on the environment. The management of construction processes to reduce, reuse, recycle and effectively dispose of wastes has a serious bearing on the final cost, quality, time and impact of the project on the environment. This research studied the practice of construction material waste management by firms in Nigeria.

According to Henry et al. (2009), the construction sector represents one of the most dynamic and complex industrial developments the world over. The construction activities in the context of the Nigeria economy cannot be treated with a wave of hand. Obadan and Uga (1996) claimed that the construction industry contributes between 3% and 6% of the gross development product (GDP) in developing countries and records from the Federal Office of Statistics specifically indicate that the contribution of the construction industry to Nigeria’s gross development product (GDP) has hovered around 2% for the past 15 years and this accounts for about 69% of the nation’s gross fixed capital formation (FOS, 1997). Empirical studies have also reinforced the fact that a 1% increase in the stock of infrastructure generates a 1% increase in the GDP across all countries. Ilesanmi (1986) pointed out that the cost of materials accounted for 50% to 60% of the total cost of construction of any project, while Skoyles (2000) came out with the information that the cost of material alone in the building construction project is 55% to 65%. To reduce waste in construction projects, optimum material control on site should be therefore adopted. Construction waste is a growing problem in many countries.
4.2 Causes and effects of C&D waste

According to Skoyles (2000), the construction industry in particular and the built environment in general have been found to be among the main consumers of resources and energy. Moreover, the construction sector is reported to be generating unacceptable levels of material and manpower waste. Generally, construction activities which produce wastage can be grouped into off-site and on-site operational activities. Off-site activities include prefabrication, project design (architectural, structural, mechanical and electrical design), manufacturing and transporting of materials and components. On-site construction activities relate to the construction of a physical facility which consists of the substructure and superstructure of the building. Some degrees of waste materials are inevitable in the construction process. All estimators allow for wastage factors in pricing a bill of quantities.

Waste normally emanates during different stages of construction which can be during the planning, estimating or construction stage, while Skoyles (2000) came out with the information that in Nigeria, not all the materials procured are used during construction and this indicates that the left-overs may remain as waste that may not be accounted for. Over the years, there has been an increase in the rate of construction activities in the country. This has inevitably led to the generation of waste at different stages of projects. Currently in Nigeria, little consideration has been paid to the control of generation of construction and demolition waste (C & D) in the last decade. This can be attributed to the availability of relatively low means of waste disposal and the generally, low environmental awareness of the construction industry wastes in the country.

The critical path method is primarily useful in addressing the second of these conditions and in some cases can be used to assist in determining at least a portion of the monetary awards (Ahmed et al, 2002:12). The main causes of disputes are slow or late payments for completed or
ongoing work, client interference, neighbour issues, change in requirements, distribution of work, less communication within parties, and subcontractor issues (Haseeb et al., 2011:34).

4.3 Environmental impact

It has been widely acknowledged that C&D waste handling and processing by nature is not environmentally friendly owing to its enormous adverse impacts on the environment. Fundamentally, C&D waste management can harmfully affect the total environment in many ways, such as exhausting a large amount of land resources for waste landfilling. Al-Hajj and Hamani (2011) found that the main driver of material waste minimisation is the immediate financial benefits and cleaner and safer site conditions, not legislations or care for the environment, though the latter factors impact some influence. According to Oladiran (2009), the dividends of materials waste minimisation in the firms that adopt the techniques are expressed in increased profits, reduced materials shortage, reduced delay on projects’ completion and final cost. Furthermore, a good practice of material waste minimisation, according to WRAP (2009) produces a range of benefits which include reduced material and disposal costs, increased competitive differentiation, increased performance against corporate sustainability responsibility (CSR) objectives, lower carbon oxide (CO2) emissions, meeting planning requirements, complementing other aspects of sustainable design, and responding to and pre-empting public policy, in addition to improvements in materials resource efficiency. The drivers for waste minimisation were summarised into four main groups by Osmani et al. (2006) and include environmental, industry, and economic issues and legislation while the key drivers from these groups were explained by Al-Hajj and Hamani (2011) to consist of government policies and contractual terms; environmental standards and assessment tools; and financial benefits. In Spain, a national decree to regulate the production and management of construction and
demolition (C&D) waste was promulgated in 2008 and a framework of the Sixth Environment Action Programmed advocated for effective management of C&D in the European Union Skoyles and Skoyles (1987). A waste management plan (WMP) is a standard requirement for most significant development in the majority of Australian local government areas (Hardie et al., 2007). Dainty and Broke (2004) reported that there is an increase use of off-site prefabrication to control waste and damage on site in the UK. While most developed nations and some developing ones have incorporated some of these drivers, the Nigerian construction industry is yet to either adopt any or come to terms on this issue (Dania et al., 2007).

4.4 Measures of minimizing C&D waste

Adewuyi et al. (2010) established that the actual material waste generated on site is significantly in excess of the allowable provided in estimate through an empirical study and, as such, suggested that there is either the need to adjust the allowable value to mitigate its effect on project cost or contractors should explore control measures to minimise waste. The practice of purchasing extra materials to make up for wastage during construction will lead to cost and time overruns, sub-standard works, disputes, and abandonment of projects Adafin et al. (2010), Teoh et al. (2009). Shen and Tam (2002) are of the opinion that since additional materials are usually purchased because of a lack of consideration given to material waste reduction during the planning and design stages, the competitive edge of contractors is usually affected, thus making their survival more difficult in a competitive environment.

In a study conducted on Turkish construction sites, Polat and Ballard [2004] emphasised that minimisation is the best and most effective method of reducing the generation of waste and eliminating many of the waste generation problems. Greenwood et al. (2003) noted that the top
priority in minimising waste is to avoid waste through designing out or reducing waste at the source and proposed three key project stages where waste minimisation initiative should be introduced, namely the contractual, design and site execution stages. Agapiou et al. (1998) recommended that waste minimisation should start at the design stage. Greenwood et al.(2003) noted that waste minimisation is one way of improving the efficiency of the construction industry. Keys et al. (2000) and Ekanayake and Ofori (2004) agreed with Agapiou (1998), that waste minimisation should start at the design stage. According to Ene (1997), construction firms must develop or adopt effective waste minimisation strategies in order to solve the problem of material wastage on construction projects. Ayarkwa et al. (2011) stated that for wastage to be reduced or eliminated, construction firms should introduce material waste minimisation strategies.

4.5 LESSONS LEARNT

The literature reviewed in this chapter showed that the major problem of construction waste management in Nigeria includes the following: The management of construction processes to reduce, reuse, recycle and effectively dispose of wastes has a serious bearing on the final cost, quality, time and impact of the project on the environment. The literature also reviews the causes of construction waste as follows: construction activities which produce wastage can be grouped into off-site and on-site operational activities. Off-site activities include prefabrication, project design (architectural, structural, mechanical and electrical design), manufacturing and transporting of materials and components. On-site construction activities relate to construction of
a physical facility which consists of the substructure and superstructure of the building. Some degrees of waste materials are inevitable in the construction process. Furthermore, the top priority in minimising waste is to avoid waste through designing out or reducing waste at the source and proposed three key project stages where waste minimisation initiatives should be introduced, namely the contractual, design and site execution stages.

CONSTRUCTION AND DEMOLISHING (C&D) WASTE MANAGEMENT IN SOUTH AFRICA

4.6 South Africa construction industry

A review of the South African construction industry, according to the CSIR (2004), indicates that the industry is capable of delivering the most innovative and complex projects at times. It is also acknowledged that the industry is underachieving in, amongst others, quality and efficiency, and that the industry needs to radically improve the practice through which it delivers its projects. Improvements to the delivery process will require building professionals to review their current practices and through innovation, their own products and processes. Improved construction industry performance will require vigorous and energetic professional leadership. The construction industry is considered a wasteful sector. The industry consumes an estimated 12-16% of fresh water and 40% of energy, and added to this an estimated 15% of purchased materials end up as waste. According to the research of Mocozoma (2002), the South African construction industry has been in recession for more than two decades. The deterioration in capital investment and activity in infrastructure delivery in the late 70s and a lack of efficiency in construction processes have all contributed to this. Inefficiencies in the construction practice occur in three areas: acquisition and use of equipment and machinery, labour practices, and
procurement and use of materials. Construction waste management has become essential to improve the performance of the industry in terms of economic quality and sustainability. One way of achieving this target is by reducing waste at all stages of the construction process.

Managing building material waste can result in higher construction productivity, saving time and assisting sustainability. Hardly any data from previous projects are available on how to avoid the causes of waste generation during construction projects. This research aims to identify how, where and when waste in construction projects is generated, the environmental impact, measures of minimising it, as well as the dominant causes as identified according to South African current practices. Skoyles and Skoyles (1987) support the opinion of Ekanayaka and Ofori (2000) that construction waste has become a burden to clients as they have to bear the costs of waste. This is a major problem for contractors as well, because it leads to a loss of profits and may even contribute to bankruptcy. According to De Silva and Vithana (2008), many countries are experiencing an increase in construction waste, which has created growing tensions for authorities, especially as the search for new landfill sites has become an increasing priority.

4.6.1 Constitutional and legal framework

The Constitution of South Africa, 1996 provides the foundation for environmental regulation and policy in South Africa. The right to environmental protection and to live in an environment that is not harmful to health or well-being is set out in the Bill of Rights (section 24 of Chapter 2). This fundamental right underpins environmental policy and law, in particular the framework environmental legislation established by the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA).
The Waste Act fundamentally reforms the law regulating waste management, and for the first time provides a coherent and integrated legislative framework addressing all the steps in the waste management hierarchy. The waste management hierarchy provides a systematic and hierarchical approach to integrated waste management, addressing in turn waste avoidance, reduction, re-use, recycling, recovery, treatment, and safe disposal as a last resort.

4.7 Causes/Sources of C&D waste

Gauteng, as the economic hub of South Africa, is undergoing rapid development and construction. This invariably leads to the generation of excess building and demolition waste.

Building and demolition waste is the excess material produced during construction, renovation, and demolition of buildings and structures. Building and demolition waste is generated when new structures have to be erected to replace existing ones, when there are alterations to be made to structures, or when existing structures collapse owing to natural causes such as ground movement or unnatural causes such as explosions. Fittings such as partitions, frames, light fittings, and ceilings are included in the classification of building and demolition waste, as is the soil aggregate displaced from building foundations and tunneling activities.

Building and demolition waste streams include the following:

   a) aluminium
   b) asbestos
   c) asphalt
   d) brick
   e) concrete
   f) corrugated cardboard
g) drywall (interior wall paneling)

h) glass

i) lumber (or timber)

j) insulation

k) masonry

l) plastics

m) rocks

n) roofing materials

o) soil, and

p) steel.

An increasing component nowadays is building and demolition waste from the maintenance of roadways. These are made of asphalt and reinforced concrete. Although it mainly finds its way to landfills, enterprising entrepreneurs are increasingly re-processing it for use again in roadways construction and maintenance.

4.8 Environmental impact of C&D waste

The Gauteng Provincial Government (GPG), through the Department of Agriculture Conservation and Environment (GDACE), initiated a General Waste Minimisation Plan (GWMP) for the Province. The GWMP identified in its report, entitled “General Waste Minimisation Plan Status Quo Report” that on average, 20 % of waste in the Gauteng province was due to building and demolition waste.

The 2004 Gauteng Provincial State of the Environment Report (SoER) has identified building and demolition waste as a major contributor to the rapid loss of air space within the Gauteng
Province’s landfill sites. Gauteng, as the province with the greatest industrial and population density, inherently generates the greatest amount of waste (approximately 42% of the waste generated in South Africa is produced in Gauteng Province). It states, *inter alia*, that approximately 25% of waste entering landfills is building and demolition waste.

The GPG has therefore concluded that building and demolition waste is a major contributor to the rapid loss of air space within the Province’s landfills. It is, therefore, taking appropriate steps to address this problem, amongst which is the development and publication of this document.

This Guidelines Document has been developed by the GPG to assist all players to minimise and/or divert the building and demolition waste away from landfills for other potential and practical re-use options which also make economic sense for the user. The environmental costs associated with the disposal of building and demolition waste, a potentially recyclable material, include:

a) Loss of land for housing development;

b) Potential loss of habitat for indigenous species when large tracts of land are utilized for landfill space;

c) Increased extraction of raw materials for *inter alia* new construction products;

d) Social costs such as loss of available land for recreation facilities; and

e) Increase in illegal dumping and the accompanying cleanup costs.

The scale and extent of the problem demands a comprehensive solution, especially since the majority of the building and demolition waste can be recovered, reused and / or recycled and can serve as a resource to limit the amount of non-renewable natural resources utilized. The GDACE
has therefore targeted this area for strategic intervention in order to minimise unnecessary
disposal of building and demolition waste on landfills.

This document aim is to facilitate Greater Accra Region waste minimisation processes through
practical guidelines to assist the construction and demolition industry. It is based on the use of
best practice, where applicable, for waste reduction in building and demolition projects at all
scales of operation. It also aim to promote better waste management practices for a wide range
of stakeholders including *developers, design professionals, suppliers, waste contractors, and
collectors.*

The purpose of this Building and Demolishing Waste Guideline Document is to encourage
efficient waste minimisation, good environmental citizenship and resource recovery from
building and demolition waste. Role-players targeted for the use of this Guideline Document
include (but are not restricted to):

a) Landfill operators and managers,
b) Municipal managers,
c) Design engineers and architects,
d) Construction engineers and managers,
e) Property owners and developers,
f) Building and demolition contractors, and
g) Other professionals involved in the design, construction, maintenance and demolition
cycle of buildings and infrastructure.
h) The overall objective being to optimise and maximise the efficiency of waste
management whilst minimising any negative impacts on the environment.
One of the environmental management principles outlined in the National Environmental Management Act 107 of 1998 (NEMA), the framework statute governing the environment in South Africa, underpins the philosophy of IWM. It holds that sustainable development requires that “…waste is avoided, or where is cannot be altogether avoided, minimized and reused or recycled where possible and otherwise disposed of in a responsible manner.

Thus, IWM requires the following processes to be considered when managing waste, listed in order of preference:

a) Waste Avoidance, i.e. the prevention and avoidance of the production of waste;

b) Minimisation, i.e. when used in relation to waste, means the avoidance of the amount and toxicity of waste that is generated and, in the event where waste is generated, the reduction of the amount and toxicity of waste that is disposed of;

c) Waste Recycling, i.e. a process where waste is reclaimed for further use, and includes the separation of a waste stream for further use and the processing of that separated material as a product or a raw material;

d) Re-use, i.e. means to utilise articles from the waste stream again for a similar or different purpose without changing the form or properties of the article;

e) Waste treatment, i.e. means any method, technique or process that is designed to

i. change the physical, biological or chemical character or composition of a waste;

or

ii. remove, separate, concentrate or recover a hazardous or toxic component of a waste; or

iii. destroy or reduce the toxicity of a waste, in order to minimise the impact of the waste on the environment prior to further use or disposal; and
f) Waste disposal, i.e., the environmentally safe and legal deposit or placing of waste onto land.

Essentially, IWM involves the reduction of the amount and environmental impact of waste generated, and can be achieved by, *inter alia*, reducing the quantities of materials used (and therefore potential for wastage) or by reusing existing materials. Ideally, prevention of waste is the target, but this is not always realistic, nor achievable. Waste prevention, also called source reduction, involves the reduction of the amount or toxicity of the relevant waste streams.

**4.9 Measures of minimising C&D waste**

It is widely acknowledged that the construction industry has a major impact on the environment, both in terms of the resources it consumes and the waste it produces. The industry produces significant building and demolition waste that ends up in landfills or at times is illegally dumped. The reality though is that the construction industry is crucial to the development required in all countries including South Africa and the Gauteng Province. It is also responsible for producing a wide range of waste products, the amount and type of which depend on factors such as the stage of construction, the type of construction work being undertaken and the practices adopted on the construction site.

As the majority of building and demolition waste is being disposed of either illegally or to landfill, the actual and/or potential environmental impact of such practices includes the following:

a) Piles of building and demolition waste found on open spaces which aesthetically degrade the landscape and invite further dumping. The fines imposed in terms of
local bylaws for illegal dumping are generally not considered adequate to act as a
deterrent to this practice but the new Waste Act is likely to change this;
b) Seepage from building and demolition waste that contains hazardous materials can
transport hazardous substances which has the potential to contaminate the soil and as well as pollute groundwater;
c) Failure to recycle building- and demolition-related waste directly affects the volume of natural resources depleted. Using recycled aggregates reduces the amount of natural resources needed;
d) Landfilling of building and demolition waste uses up expensive land and continuance of this practice in place of reusing or recycling will put a heavy burden on scarce land resources.

Worldwide, the problem of building and demolition waste is being addressed by comprehensive strategies to reduce waste through more efficient planning and use of new materials, while promoting reuse and recycling of building and demolition waste, thus adhering to and promoting the principles of IWM. In some cases, these strategies are being developed through partnerships amongst government, the construction industry, project planners and architects. The following, based in part on the waste management hierarchy, illustrates basic strategies for dealing with waste in which the management and minimisation of building and demolition waste should be based, namely reduction, deconstruction for reuse, and recycling.

4.9.1 Minimisation of building and demolition waste through reduction

In terms of the Waste Management Hierarchy, waste prevention is the ideal, and this can be addressed firstly by identifying possible waste streams earlier on in the building process by planning and designing for waste minimisation.
Many waste reduction issues are addressed prior to the commencement of construction activities. In planning, components and quantities of waste stream are typically projected, and goals will be set and methods and recycling markets identified. The design stage will provide plans and specify materials that are prefabricated, recyclable, recycled-content and/or non-hazardous, when feasible. Education of contractors also contributes to waste reduction and therefore minimisation.

4.9.2 Benefits of reduction

Reduction is the most important waste minimisation option. It keeps materials out of the waste stream. Methods to reduce waste include changing packaging, substituting disposable items for reusable ones and developing products that are more durable or at least repairable, for example, long-life light bulbs as opposed to traditional incandescent light bulbs, and longer lasting washable paints. A change in packaging might be the removal of unnecessary packaging, for example, cement bags for certain applications, or a complete switch to biodegradable packaging.

The benefits of minimising waste through reduction include the following:

a) Reducing demand for landfill space,

b) Saving resources and energy,

c) Reducing pollution increasing the efficiency of production, and

d) Reduction in illegal dumping

4.9.3 Minimisation of building and demolition waste through deconstruction

Deconstruction is a process of building disassembly and material salvage, for reuse, as per the waste management. This process is not new but has increased in popularity overseas owing to the benefits that it offers. Deconstruction literally means taking apart a building and removing
some or all of the contents for recovery. Materials such as equipment and appliances, metals, wood timber and flooring, architectural features such as mouldings, masonry, and more may be salvaged from a building. Depending on the nature and condition of the materials, deconstruction may be a small part of the demolition process or may replace the demolition activities entirely.

With careful planning, deconstruction projects can be cost competitive and show valuable returns. However, the work is labour intensive, but generally does not require specialised technology as many tools used in the deconstruction process are the same as those used in the construction of the building. Deconstruction has the potential to provide benefits to the Gauteng market, particularly in respect of the need for low income housing.

4.9.4 Benefits of deconstruction

Overall, the advantages and benefits of the deconstruction as a means of minimising building and demolition waste present great opportunities for job creation and economic development in Gauteng. These include the following:

a) The stimulation of growth in a local economy by creating businesses to support both the actual deconstruction of structures and the marketing of the recovered materials;

b) Opportunities to increase the skill level of the local workforce by training workers for jobs in construction. Internationally, project managers work alongside non-profit organisations dedicated to training the local workforce to reduce the cost of the deconstruction and to support the local economy; and
c) A higher cost for deconstruction is perceived because of the longer time and care required.

4.9.5 Limiting factors for the deconstruction of waste to reduce building and demolition waste

Dismantling a building takes considerably longer than demolition. Additionally, materials that are bound for reuse require more care in storing and processing than those bound for recycling or disposal. Items also need to be carefully evaluated and separated so they can be properly matched with markets.

4.9.6 Minimisation of building and demolition waste through reuse and recycling

The reuse and recycling of building and demolition waste are practicable options and a large portion of the waste stream can be reused within the building industry. The capacity for recycling the majority of the waste stream has been proven in many countries. Recycling, as a minimisation strategy, generally requires more technological innovation than those of reduction and reuse through deconstruction, as the process typically requires the modification of materials through re-manufacture (Leigh and Patterson, 2004).

Some materials can be recycled directly into the same product for re-use, as discussed above. Others can be reconstituted into other usable products. Standard building and demolition waste recycling generally involves the following three types of recycling:

a) Direct use of materials, as discussed above.

b) Physical alteration of materials, e.g. the use of crushed concrete for granular sub-base layers in road pavement construction or drainage and excavation fill applications. Crushed brick and concrete may be used as fill on construction sites.
c) Remanufacture of products, e.g. recycled wood can be used to produce composite lumber and plastic, glass can be transformed into fiberglass or extruded into glass beads.

Internationally, and to a certain extent locally, the reuse and recycling of building and demolition waste has a long tradition in the construction industry. A high proportion of conventional building and demolition waste, and particularly the components derived from materials such as concrete, bricks and tiles, are well suited to being crushed and recycled as a substitute for newly quarried aggregates in certain lower grade applications, such as engineering fill and road sub-base. It is important to note, however, that with entrepreneurial activity, the number and types of construction materials provide the potential for more reuse and recycling of the waste stream.

4.9.7 Benefits of the recycling of building and demolition waste

Overall, the advantages and benefits of the recycling of building and demolition waste, through international experience have been identified as including the following:

a) Recycling of building and demolition waste reduces the illegal and unauthorised dumping of materials;

b) Costs associated with the transportation of waste, disposal fees and wastage of materials can be recovered when the building and demolition waste is recycled or reused;

c) The recycling of materials ensures that waste materials are returned into the materials recycle, thereby contributing to the conservation of natural resources;

d) Reduction of waste disposed at landfill sites thereby elongating landfill life span;

e) The amount of energy needed to produce recycled materials is less than the energy used to produce virgin materials, and

f) Recycling activities can translate into employment and business creation opportunities for communities.
4.9.8 Limiting factors for the reuse and recycling of building and demolition waste

Although there are more materials emanating from the building and demolition industry than those listed in Section 4.9.7 above that are suitable for recycling, there are external factors that influence the spread of such recycling. These include the value of recycled and salvaged goods in the market place, the labour costs for the removal, sorting and processing of such materials and the relative disposal costs. It is imperative that recycled and salvaged goods are price competitive. Incentives (such as tax or rebates), subsidies and market demand all impact on pricing. In addition, the minimisation and recycling of the waste stream is limited by the following factors:

a) Technology is quickly developing for recycling of materials into reconstituted building materials. However, this technology is not readily available locally and requires initial capital / financial investment;

b) There are currently no incentives to recycle. This, coupled with the relatively low disposal costs, reduces the incentive to invest in recycling initiatives;

c) Lack of industry standards and acceptance of recycling of building materials, coupled with a lack of testing to ensure recycled content construction materials meet the strict performance specifications demanded in the construction industry;

d) The more complex processes, i.e. remanufacturing processes, require more labour and capital;

e) The space, cost, timing and training required for separation of materials on site;

f) When not sorted on site, special facilities are required for the separation and processing of the material. Such facilities are not widely accessible in many markets, and in order to develop and invest in them, investors will require certain market conditions;
g) Many countries, including South Africa, have immature recycling markets;

h) Inadequate information on safety and acceptable use limits the recyclability of some building and demolition waste. Those building and demolition associated businesses that are operating generally demonstrate that the innovators are either using government support and/or private entrepreneurship to use the material, rather than sending it to landfill; and

i) Lack of markets for a wide variety of products and a lack of guaranteed supply of recovered building (and demolition) materials, coupled with the difficulty in breaking into established markets dominated by virgin materials.

3.10 LESSONS LEARNT

The literature reviewed in this chapter showed that the major problems of construction waste management in South Africa include the following: The management of construction processes to reduce, reuse, recycle and effectively dispose of wastes has a serious bearing on the final cost, quality, time and impact of the project on the environment. The literature reviewed also highlights the causes of construction waste as follows: Off-site activities include prefabrication, project design (architectural, structural, mechanical and electrical design), manufacturing and transporting of materials and components. On-site construction activities relate to construction of a physical facility which consists of the substructure and superstructure of the building. Some degrees of waste materials are inevitable in the construction process. Furthermore, the top priority in minimising waste is to avoid waste through designing out or reducing waste at the source and the three key project stages where waste minimisation initiative should be introduced. The recycling of materials ensures that waste materials are returned into the materials recycle, thereby contributing to the conservation of natural resources.
4.11 CHAPTER SUMMARY

From the review of literature in this section, it was found that construction waste impacts negatively on the construction industry and the economy of any country with devastating implications such as extension on time, disputes and claims and can eventually lead to the total abandonment of construction projects. The next chapter will discuss the research methodology and the procedure followed during the study in order to achieve the goal of the study.
CHAPTER FIVE

RESEARCH METHODOLOGY AND DESIGN

5 Chapter introduction

This chapter explains the research methodology used in carrying out this study. The geographical area where the study was conducted, the study design and population sample are also described. Furthermore, the instrument used in collecting the data, are also described, including methods implemented to maintain validity and reliability of the instruments in order to carry out the evaluation of the causes, effects, measures of minimising construction waste, the environmental impact of C&D waste, and the extent of construction materials wastage in the Greater Accra Region construction industry of Ghana.

5.1 Rational of the study

The rationale of the current study is to contribute to the body of knowledge on the subject of construction waste management using the Greater Accra Region construction industry of Ghana as a case study.

5.2. Research approach and design

Questionnaires were the research instrument used for sourcing information from the respondents for the study. Cohen, Manion and Morrison (2000) referred to questionnaires...”as a widely and useful instrument for collecting survey information, providing structured and often numerical data, being able to be administered without the presence of the researcher and often straightforward to analyse. The questionnaire made use of open-ended and closed-ended questions. The open ended questions sought to gain the subjective views of the respondents.
A survey approach was adopted for this study. The survey design was adopted based on the explanation Creswell (2003) gave as “…it provides a quantitative or numeric description of trends, attitudes or opinions of a population by studying a sample of that population”. According to Veal (2006), quantitative methods refer to the regular empirical investigation of quantitative properties, phenomena and relationships. The objective of the quantitative method is to gather quantitative data which deals with numbers and anything that is measurable. Statistics, tables, charts and graphs are often used to present the results. This method was chosen to meet the objectives of this study, namely to identify the causes of C&D waste, and further, to identify the effects of these waste and eventually establish the measures that can be taken to minimise construction waste, and the environmental impact of C&D waste. Furthermore, the extent of construction materials wastage in the GAR construction industry, Ghana.

5.3 Research area

The Greater Accra Region (GAR) was formally part of the Eastern Region and was created in 1982. It is the smallest region with its administrative capital at Accra Metropolitan assembly form part of the Ten (10) Region in Ghana. The region is currently the administrative capital of the country.

The core vision of the Region is to improve livelihoods and provide adequate socio-economic infrastructure in an equitable and sustainable manner for the people of the Region through effective stakeholder collaboration within a secure, decentralised system of governance and sound environmental management.

The Region shares boundaries with the Volta Region to the east, Eastern Region to the north, Central Region to the west, and to the south with the Gulf of Guinea. The Region has sixteen

Some of the key departments and units of interest in the Region are the following:

- General Administration
- The Finance Department
- Regional Planning Co-coordinating Unit
- Waste Management Department
- Urban Roads Department
- Regional Works Department
- Budget and Rating Department
- Town and Country Planning Department

5.4 Targeted respondents

Alan et al. (2000) defined a population as a set of all measurements (generally pertaining to a group of people or objects) that are of interest and possess at least one common characteristic. According to Neuman (2006), a target population is made of group of cases from which a researcher studies a sample and then generalisations are made from the results of the sample. The target populations for the current study were architects, quantity surveyors, civil engineers, construction managers, construction project managers, project managers and other professionals who are involved in construction projects in the GAR Construction industry. This yardstick was
considered vital for the survey in order to have a true reflection of the causes, effects and measures of minimising construction waste.

5.5 Sample

This study adopted a random sampling method; hence all the participants had an equal chance of being selected. A questionnaire was developed as a tool of collecting data from the respondents in accordance with the reviewed literature. Architects, quantity surveyors, civil engineers, construction managers, construction project managers, project managers and other professionals who are involved in construction project were sampled for the study due to the vast nature of the study area considering the time frame within which the study needed to be completed.

5.6 Data collection

Upon contacting the respondents, the questionnaires were distributed to them. After their responses, the questionnaires were taken back. Though much time was involved, it facilitated the collection of all questionnaires and accuracy of information needed for the study.

Data collection took approximately one month as the respondents were free to take their time when filling in the questionnaires without any coercion. It took an average of twenty-five minutes to complete one questionnaire in the respect of the literate. A total of 150 questionnaires were received back from the respondents.
5.7 Instrument of data collection

A questionnaire was chosen for this research as a data collection instrument. Burns and Grove (1993:368) define a questionnaire as a printed self-report form designed to draw information that can be obtained through the written responses of the subject. Burns and Grove (1993:368) further state that information obtained through a questionnaire is similar to that obtained through an interview, but the questions tend to have less depth.

Data was collected with the aid of a questionnaire to evaluate the causes, effects and measures of minimising construction waste and management in the GAR construction industry in Ghana. There are two types of questionnaires, namely closed-ended and the open-ended questionnaires. In the open-ended questionnaires the respondents are required to respond in writing in their own words and providing more details as they wish, whereas in the closed-ended questionnaires, the respondents are given options related to the research topic which are determined by the researcher (Burns and Grove, 1993:370). Therefore, a closed-ended questionnaire was used in this research because it is easier to administer and analyse.

The questionnaire was designed in English though all the respondents may not be highly educated construction professionals. The respondents were assured of the anonymity of their responses. The questionnaire consisted of six sections, namely A, B, C, D, E, and F. Section A was aimed at gaining demographic data such as gender, age, level of education and the like. This information would assist the researcher when interpreting the results. Section B was aimed at evaluating the causes of construction waste, Section C was aimed at evaluating the environmental impact of construction waste, Section D aimed at assessing the effects of construction waste, Section E aimed at assessing the measures of minimising/reducing
construction waste, and Section F of the questionnaire explored the extent of construction materials wastage in the Greater Accra Region construction industry in Ghana. Instructions and guidelines were attached to the questionnaires to guide the respondents on how to answer the questionnaires.

Out of the two hundred copies of the questionnaire sent out, one hundred and fifty were received back which represents a 75% response rate. These formed the basis of this study as summarised in Table 5.1 below. This was considered adequate for analysis based on the assertion by Moser and Kalton (1971) that the result of a survey could be considered as biased and of little value if the return rate was lower than 30 to 40%.

Table 5.1: Questionnaire survey

<table>
<thead>
<tr>
<th>Survey responses</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaire sent out</td>
<td>200</td>
</tr>
<tr>
<td>Questionnaire received back</td>
<td>150</td>
</tr>
<tr>
<td>Useable questionnaires</td>
<td>150</td>
</tr>
<tr>
<td>Useable response rate %</td>
<td>75%</td>
</tr>
</tbody>
</table>

Source: Author’s own compilation

The collected data from the respondents was then cleaned and screened before analysis could take place. Frequency analysis of the raw data was then done using the Statistical Package for Social Sciences (SPSS).

5.8.1 Period of collection

The data was collected by the researcher in the month of May, 2016.
5.9 Mean item score (MIS)

A five-point Likert scale was used to determine the causes, effects, measures of minimising, environmental impact of C&D waste and the extent of construction waste in the GAR construction industry in Ghana with respect to the identified factors from the reviewed literature. The adopted scales were as follows:

1. = Strongly disagree
2. = Disagree
3. = Neutral
4. = Agree
5. = Strongly agree

The other scale used was as follows:

1. = Extremely unlikely
2. = Unlikely
3. = Neutral
4. = Likely
5. = Extremely likely
The five-point scale was transformed to a mean item score (MIS) for each of the factors of causes, effects, measures of minimising C&D waste, environmental impact, and the extent of construction materials wastage in the construction industry as assessed by the respondents. The indices were then used to determine the rank of each item. The ranking made it possible to cross-reference the relative importance of the items as perceived by the respondents. This method was used to analyse the data collected from the questionnaires survey.

The computation of the relative mean item score (MIS) was calculated from the total of all weighted responses and then relating it to the total responses on a particular aspect. This was based on the principle that respondents’ scores on all the selected criteria, considered together, are the empirically determined indices of relative importance. The index of MIS of a particular factor is the sum of the respondents’ actual scores (on the five-point scale) given by all the respondents as a proportion of the sum of all maximum possible scores on the five-point scale that all the respondents could give to that criterion. A weighting was assigned to each response ranging from one to five for the responses of ‘Strongly disagree’ to ‘Strongly agree’ and ‘Extremely unlikely’ to ‘Extremely likely’. This is expressed mathematically below. The mean item score (MIS) was calculated for each item as follows:

\[
\text{MIS} = \frac{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{\sum N}
\]  

\text{Equation 1.0}

where

\[
\begin{align*}
  n_1 & = \text{Number of respondents for ’Extremely unlikely’ or ‘Strongly disagree’}, \\
  n_2 & = \text{Number of respondents for ’Unlikely’ or ‘Disagree’}, \\
  n_3 & = \text{Number of respondents for ’Neutral’}, \\
  n_4 & = \text{Number of respondents for ’Likely’ or ‘Agree’}, \\
  n_5 & = \text{Number of respondents for ’Extremely likely’ or ‘Strongly agree’}, \\
  N & = \text{Total number of respondents}
\end{align*}
\]

After mathematical computations, the criteria are then ranked in descending order of their mean item score (from the highest to the lowest).
5.10 Data analysis

Data collected from the respondents was cleaned and screened before analysis could take place. Raw data was then entered onto a Statistical Package for Social Sciences (SPSS) for frequency analysis. Data presentation and analysis made use of frequency distributions and percentages of all the respondents. Frequency tables were drawn and from there the data was presented in pie chart diagrams, bar graphs and tables.

5.11 Limitation of the study

This research assessment was only based on the construction professionals in the Greater Accra Region in Ghana, with the respondents being architects, quantity surveyors, civil engineers, construction managers, construction project managers, project managers and other professionals who are involved in construction projects. This study only determined factors causing construction waste, effects of construction waste, the environmental impact of C&D waste, and measures of minimising construction waste and further explored the extent of construction materials wastage in the GAR construction industry in Ghana.

5.12 Ethical consideration

The current study did not encounter or identify any ethical issues. However, the ethical considerations in this research took into account the obligations to the professionals in the industry whose work had contributed to the literature was properly cited and acknowledged. The obligation to the participants in the research questionnaire was that their input was to be kept confidential and only used for academic purposes. Respondents to the questionnaire had the right not to answer questions that they felt were not appropriate, without any coercion.
A written cover letter of permission to carry out this research study was obtained from the University of Johannesburg, Faculty of Engineering and Build Environment, Department of Construction Management and Quantity Surveying, Doornfontein Campus and was affixed to the questionnaires sent out. Anonymity and confidentiality were maintained throughout the study. Anonymity is a situation where the respondents cannot be linked, even by the researcher, to their individual responses (Burns and Grove, 1993:762).

5.13 Chapter summary

In this chapter, the research methodology used for the study was described, including the population, sample, data collection instruments, strategies used to ensure ethical standards as well as why questionnaires were adopted for the research. The next chapter of this study presents the data analysis and discussion.
CHAPTER SIX
QUESTIONNAIRE SURVEY RESULTS

6.1 Introduction

This chapter presents the result of the study. It starts with an overview of the descriptive statistics, analysis of reliability and validity of the instrument as well as the analysis on the main objectives.

6.2 Descriptive statistics

The descriptive statistics give a general idea of the demographic presentation of the respondents with respect to gender, age, names of the various profession, years of industrial experience, educational background of the respondents, sectors at work, current undertaking projects as well as categories of project undertaking.

6.3 DATA ANALYSIS

6.3.1 Section A: Gender distribution of the respondents

Figure 6.1: Respondents’ gender
The gender of the respondents in the study’s survey revealed that 76% were male respondents while 24% were females. This shows that male respondents outnumbered females. It demonstrates that the Ghanaian construction environment is male dominated.

**Age distribution of the respondents**

![Age distribution chart](image)

**Figure 6.2: Respondents' age group**

Regarding the age distribution of the respondents, those between the ages of 36 - 45 years of age recorded the highest with 34%, followed by those with ages between 46 - 55 years recording 30%. Those aged between 26 - 35 years recorded 19%; those above 55 years recorded 9%, while ages between 18 - 25 recorded the least with 8%. It is worth noting that the majority of the respondents in the construction industries in Ghana were between the ages of 36 - 45.
Professions of respondents

![Professional types chart]

**Figure 6.3: Professions of respondents**

In assessing the categories of professionals within Ghana’s construction industry it was revealed that quantity surveyors recorded the highest with 33.7%, followed by civil engineers with 29.2%, architects and project managers both recorded 9%, other newly created categories recorded 6.8%, and construction project managers recorded 6.7%, while construction managers recorded the least with 5.6%.
Years of experience in the industry

The above figure shows the experience level of respondents in years. It was observed that respondents with experience levels above ten years recorded the highest with 49%, those between six and ten years recorded 28%, respondents with two to five years’ experience recorded 17% while those with experience level below one year recorded the least with 5%. It demonstrates that respondents with more than ten years’ experience recorded the highest number of years in the construction industry.

Figure 6.4: Experience in years
Regarding the educational level of the respondents, those who hold degrees as their highest qualification in the industry constituted a majority with 42%, followed by those with national diplomas 25%; a master’s degree, 23%; technician certificate, 5%; diploma certificate 4%, and those with doctoral degrees constituted 1%. It is worth noting that the majority of the respondents in the construction industry in Ghana hold degrees as their highest qualifications.
In assessing the various sectors the respondents represented, it was observed that respondents who were in the public sectors in the industry constituted the majority with 44%, followed by the private sector with 28%, consultants with 16%, while contractors constituted the least, with 12%. The results showed that respondents within the public sectors in the construction industries constituted the majority in the study.
Construction projects undertaken

Figure 6.7: Projects undertaken

In assessing the number of projects currently undertaken by the respondents, it was revealed that respondents handling 1 - 2 projects recorded the highest with 27%, those with 3 - 4 projects followed with 23%, those above eight projects recorded 17%, while respondents who had not handle, 5 - 6 projects as well as 7 - 8 projects recorded the least respectively in that order. The results then indicate that respondents working on one or two projects recorded the highest per the result from the study.
Figure 6.8: Category of projects

The categories of specified projects were also assessed and the findings were the following: housing estate projects recorded the highest with 19.2%, renovation of residential and civil recorded 17%., schools recorded 16.2%, road construction followed with 14%, government offices with 12.5%, hospitals with 10.2%, shopping complexes with 4.5%, civil works like the construction of dams recorded 4.2%, while the construction of stadia and others constituted the least, with both recording 1.1%.

6.3.1 Assessment of reliability and validity

Reliability and validity of the instrument were assessed before the data was finally analysed so as to ensure strong internal consistencies and the actual information needed for the study. The reliability was assessed using Cronbach alpha coefficient values and they were presented as follows:
6.3.2 Reliability

Cronbach’s coefficient alpha was used to assess the measurement scale in the study to confirm the internal consistency so as to evaluate the reliability of the measurements. According to Kipkebut (2010), values for Cronbach alpha range between 0 and 1. Hair et al. (2009) also opined that values higher than 0.7 were considered as being reliable. In the current study, the lowest Cronbach alpha value was 0.776 while the highest value was 0.908. It was then clear that the Cronbach alpha values of the study all exceeded the recommended threshold of 0.6 and 0.7, authenticating that the measures that were used in the study were all reliable. The reliability statistics of each of the variables in the study are given below:

<table>
<thead>
<tr>
<th>Measurement instrument</th>
<th>Number of items</th>
<th>Cronbach alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contribution to waste generation (BTW)</td>
<td>19</td>
<td>0.869</td>
</tr>
<tr>
<td>Effects of construction waste (CTE)</td>
<td>12</td>
<td>0.773</td>
</tr>
<tr>
<td>Ways of minimising construction waste (DTW)</td>
<td>16</td>
<td>0.854</td>
</tr>
<tr>
<td>Environmental impacts of const. waste (ETI)</td>
<td>11</td>
<td>0.819</td>
</tr>
<tr>
<td>Extent of construction materials wastage (FTM)</td>
<td>25</td>
<td>0.901</td>
</tr>
</tbody>
</table>

Source: Researcher’s own compilation

6.3.3 Validity

Validity refers to the degree to which a survey instrument actually measures what it purports to measure. In this research, validity was checked with the help of factor analysis. The KMO (Kaiser-Meyer-Olkin) measure values for all the variables were greater than 0.7 which indicated that the factor analysis was good for further analysis because it exceeded the minimum requirement of 0.50 for overall measure of sampling adequacy. It was also determined that the result of the Bartlett’s test of sphericity and the Kaiser-Meyer-Olkin (KMO) test were also
significant for all the variables employed in the study where the probability values were all less than $p < 0.05$. The items that were extracted have all been explained in the subsequent chapters.

**Contribution to waste generation as a variable**

<table>
<thead>
<tr>
<th>KMO and Bartlett's test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaiser-Meyer-Olkin measure of sampling adequacy.</td>
<td>.765</td>
</tr>
<tr>
<td>Bartlett's test of sphericity</td>
<td></td>
</tr>
<tr>
<td>Approx. Chi-square</td>
<td>670.294</td>
</tr>
<tr>
<td>Df</td>
<td>171</td>
</tr>
<tr>
<td>Sig.</td>
<td>.000</td>
</tr>
</tbody>
</table>

The results of the test of sphericity and the measure of sampling adequacy helped in determining factors that were appropriate for the dataset. The KMO value was 0.765 while the significance level was also at 0.000 which all meet the threshold for a successful factor analysis to be carried out in a study. Nineteen questions were validated after which five of the questions were retained. They were: Project complexity; Site conflicts among construction parties; Challenges with transportation; Adverse weather conditions as well as Lack of motivation - which all represented question numbers 6,8,9,14 and 18 respectively as provided explicitly in the appendix column.

**Effects of construction waste (CTE)**

<table>
<thead>
<tr>
<th>KMO and Bartlett's test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaiser-Meyer-Olkin measure of sampling adequacy</td>
<td>.784</td>
</tr>
<tr>
<td>Bartlett's test of sphericity</td>
<td></td>
</tr>
<tr>
<td>Approx. Chi-square</td>
<td>363.378</td>
</tr>
<tr>
<td>Df</td>
<td>66</td>
</tr>
<tr>
<td>Sig.</td>
<td>.000</td>
</tr>
</tbody>
</table>

In validating the effects of construction waste, the test of sphericity and the measure of sampling adequacy were 0.784 and 0.000 respectively which were satisfactory results to continue with factor analysis. Twelve questions were subjected to the reduction test, out of which four were extracted to be adequate for further analysis. They were ‘Extension of Time’, ‘Idling
resources’, ‘Disputes’, and ‘Resignation of skilled employees’, representing question numbers: 1, 3, 6 and 9.

**Ways of minimising construction waste (DTW)**

<table>
<thead>
<tr>
<th>KMO and Bartlett's test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaiser-Meyer-Olkin</td>
<td>.803</td>
</tr>
<tr>
<td>measure of sampling</td>
<td></td>
</tr>
<tr>
<td>adequacy</td>
<td></td>
</tr>
<tr>
<td>Bartlett's test of</td>
<td>672.081</td>
</tr>
<tr>
<td>sphericity</td>
<td>120</td>
</tr>
<tr>
<td>Approx. Chi-square</td>
<td>.000</td>
</tr>
<tr>
<td>Df</td>
<td></td>
</tr>
<tr>
<td>Sig.</td>
<td></td>
</tr>
</tbody>
</table>

In validating ways of minimising construction waste, the test of sphericity and the measure of sampling adequacy were 0.803 and 0.000 respectively, which were acceptable results to continue with factor analysis. Sixteen questions were subjected to the reduction test, out of which five were extracted to be passable for further analysis. They were: ‘Proper project planning and scheduling’ as question number 3, ‘Availability of clear information and communication channels’ as number 5, ‘Challenges with transportation’ as number 6, ‘Adverse weather conditions’ as number 7, while ‘Lack of motivation’ was number 12.

**Environmental effects of construction waste**

<table>
<thead>
<tr>
<th>KMO and Bartlett's test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaiser-Meyer-Olkin</td>
<td>.820</td>
</tr>
<tr>
<td>measure of sampling</td>
<td></td>
</tr>
<tr>
<td>adequacy</td>
<td></td>
</tr>
<tr>
<td>Bartlett's test of</td>
<td>363.683</td>
</tr>
<tr>
<td>sphericity</td>
<td>55</td>
</tr>
<tr>
<td>Approx. Chi-square</td>
<td>.000</td>
</tr>
<tr>
<td>Df</td>
<td></td>
</tr>
<tr>
<td>Sig.</td>
<td></td>
</tr>
</tbody>
</table>

The variable ‘Environmental effects of construction waste’ was also validated: it was evident that the test of sphericity and the measure of sampling adequacy were 0.820 while the probability value was less than the recommended threshold of 0.000, which were good enough results to
continue with factor analysis. In all, eleven questions were taking through the component analysis and three of the questions were extracted to be sufficient for further analysis. They were ‘Water pollution’, ‘High energy consumed during extraction’ as well as ‘Land consumption’ in questions 3, 4 and 6 respectively.

**Extent of construction material waste**

<table>
<thead>
<tr>
<th>KMO and Bartlett’s test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaiser-Meyer-Olkin measure of sampling adequacy</td>
<td>.789</td>
</tr>
<tr>
<td>Bartlett's test of sphericity</td>
<td></td>
</tr>
<tr>
<td>Approx. Chi-square</td>
<td>1300.833</td>
</tr>
<tr>
<td>Df</td>
<td>300</td>
</tr>
<tr>
<td>Sig.</td>
<td>.000</td>
</tr>
</tbody>
</table>

The results of the test of sphericity and the measure of sampling adequacy for the extent of construction material waste were 0.789 and at a significant level of 0.000. Twenty-five questions were validated, after which six questions were retained for further analysis. They were ‘Paint’s’, ‘Plywood’, ‘Roofing tiles’, ‘Electrical wires’, ‘Roofing sheets’ and ‘Conduit pipes’ (electrical), which represented question numbers 12, 15, 16, 18, 19 and 20 respectively as provided explicitly in the appendix column.

### 6.4 SECTION B: FACTORS THAT CONTRIBUTE TO WASTE GENERATION IN GHANA

The table below reveals the respondents’ ranking of factors that contribute to waste generation in Ghana according to the findings from the study after nineteen questions were subjected to component factor analysis to extract the adequate questions for the final analysis. Five factors were extracted and these were revealed as follows: ‘project complexity’ was ranked first with a mean score of 3.68 and standard deviation (SD) = 1.162, ‘Site conflicts among construction parties’ was ranked second with a mean score of 3.61 and SD = 1.154, ‘Challenges with
transportation’ was ranked third with a mean score of 3.45 and SD = 1.158, ‘Adverse weather conditions’ was ranked fourth with a mean score of 3.44 and SD = 0.998, while ‘Lack of motivation’ was ranked last with a mean score of 3.42 and SD = 1.130

Factors that contribute to waste generation in Ghana

Table 6.1 Factors contributing to waste generation

<table>
<thead>
<tr>
<th>Factors contributing to waste generation</th>
<th>ΣX</th>
<th>x</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project complexity</td>
<td>1.162</td>
<td>3.68</td>
<td>1</td>
</tr>
<tr>
<td>Site conflicts among construction parties</td>
<td>1.154</td>
<td>3.61</td>
<td>2</td>
</tr>
<tr>
<td>Challenges with transportation</td>
<td>1.158</td>
<td>3.45</td>
<td>3</td>
</tr>
<tr>
<td>Adverse weather conditions</td>
<td>0.998</td>
<td>3.44</td>
<td>4</td>
</tr>
<tr>
<td>Lack of motivation</td>
<td>1.130</td>
<td>3.42</td>
<td>5</td>
</tr>
</tbody>
</table>

σX = Standard deviation, x = Mean item score, R = Rank

Source: Researcher’s own compilation

6.5 SECTION C: EFFECTS OF CONSTRUCTION WASTE

Table 6.2 depicts the effects of construction waste on performance. The study subjected twelve constructs or questions into exploratory factor analysis, out of which four were extracted as part of the sample adequacy to perform the final analysis. They were ‘Extension of time’ which was ranked first with a mean and standard deviation values of 3.92 and 1.05, which was followed by ‘Idling resources’ with a mean score of 3.83 and SD = 0.888, ‘Disputes’ was ranked third with a mean score of 3.70 and SD = 0.927 and ‘Resignation of skilled employees’ was ranked last with a mean score of 3.28 and SD = 0.996.
Table 6.2 Effects of construction waste on performance

<table>
<thead>
<tr>
<th>Effects of construction waste on performance</th>
<th>ΣX</th>
<th>ë</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension of time</td>
<td>1.051</td>
<td>3.92</td>
<td>1</td>
</tr>
<tr>
<td>Idling resources</td>
<td>0.888</td>
<td>3.83</td>
<td>2</td>
</tr>
<tr>
<td>Disputes</td>
<td>0.927</td>
<td>3.70</td>
<td>3</td>
</tr>
<tr>
<td>Resignation of skilled employees</td>
<td>0.996</td>
<td>3.28</td>
<td>4</td>
</tr>
</tbody>
</table>

σX = Standard deviation, ë = Mean item score, R = Rank

Source: Researcher’s own compilation

Table 6.2 Effects of construction waste on performance

6.6 SECTION D: WAYS OF MINIMISING CONSTRUCTION WASTE

In assessing ways in which construction waste was minimised, sixteen questions were validated through a component factor analysis out of which five were extracted. They are presented as follows: ‘Proper project planning and scheduling’ was ranked first with a mean score of 4.54 and standard deviation (SD) = 0.610, ‘Availability of clear information and communication channels’ was ranked second with a mean score of 4.40 and SD = 0.682, ‘Challenges with transportation’ was ranked third with a mean score of 4.39 and SD = 0.634, ‘Adverse weather conditions’ was ranked fourth with a mean score of 4.26 and SD = 0.848 while ‘Lack of motivation’ was also ranked last with a mean score of 4.12 and SD = 0.832.

Table 6.3 Ways of minimising construction waste

<table>
<thead>
<tr>
<th>Ways of minimising construction waste</th>
<th>ΣX</th>
<th>ë</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proper project planning and scheduling</td>
<td>0.610</td>
<td>4.54</td>
<td>1</td>
</tr>
<tr>
<td>Availability of clear information and communication channels</td>
<td>0.682</td>
<td>4.40</td>
<td>2</td>
</tr>
<tr>
<td>Challenges with transportation</td>
<td>0.634</td>
<td>4.39</td>
<td>3</td>
</tr>
<tr>
<td>Adverse weather conditions</td>
<td>0.848</td>
<td>4.26</td>
<td>4</td>
</tr>
<tr>
<td>Lack of motivation</td>
<td>0.832</td>
<td>4.12</td>
<td>5</td>
</tr>
</tbody>
</table>

σX = Standard deviation, ë = Mean item score, R = Rank
Table 6.3: Ways of minimising construction waste

6.7 SECTION E: ENVIRONMENTAL IMPACT OF CONSTRUCTION WASTE

The respondents were further asked to rank causes of environmental impact of construction waste in Ghana. It became evident that ‘Water pollution’ was ranked first with a mean score of 4.30 and standard deviation (SD) = 0.759, ‘High energy consumed during extraction’ was ranked second with a mean score of 4.09 and SD = 0.780, while ‘Land consumption’ recorded the least with with a mean score of 4.08 and SD = 0.946.

Table 6.4 Environmental impact of the construction of waste

<table>
<thead>
<tr>
<th>Impact of the construction of waste</th>
<th>σX</th>
<th>x</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water pollution</td>
<td>0.759</td>
<td>4.30</td>
<td>1</td>
</tr>
<tr>
<td>High energy consumed during extraction</td>
<td>0.780</td>
<td>4.09</td>
<td>2</td>
</tr>
<tr>
<td>Land consumption</td>
<td>0.946</td>
<td>4.08</td>
<td>3</td>
</tr>
</tbody>
</table>

σX = Standard deviation, x = Mean item score, R = Rank

Table 6.4 Impact of the construction of waste

6.8 SECTION F: EXTENT OF CONSTRUCTION MATERIAL WASTE

The respondents were furthermore asked to rank the extent of construction material waste related to the study area. The findings revealed that ‘Paints’ was ranked first with a mean score of 2.58 and standard deviation (SD) = 1.121, ‘Plywood’ was ranked second with a mean score of 2.50 and SD = 1.078, ‘Roofing tiles’ was ranked third with a mean score 2.47 and SD = 1.105, ‘Electrical wires’ was ranked fourth with a mean score of 2.46 and SD = 1.096, ‘Roofing sheets’ was ranked fifth with a mean score of 2.22 and SD = 1.168, and ‘Conduit pipes (electrical)’ was ranked last with a mean score of 2.16 and SD = 0.940.
Extent of construction material waste

<table>
<thead>
<tr>
<th>Extent of construction material waste</th>
<th>σX</th>
<th>x</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paints</td>
<td>1.121</td>
<td>2.58</td>
<td>1</td>
</tr>
<tr>
<td>Plywood</td>
<td>1.078</td>
<td>2.50</td>
<td>2</td>
</tr>
<tr>
<td>Roofing tiles</td>
<td>1.105</td>
<td>2.47</td>
<td>3</td>
</tr>
<tr>
<td>Electrical wires</td>
<td>1.096</td>
<td>2.46</td>
<td>4</td>
</tr>
<tr>
<td>Roofing sheets</td>
<td>1.168</td>
<td>2.22</td>
<td>5</td>
</tr>
<tr>
<td>Conduit pipes (electrical)</td>
<td>0.940</td>
<td>2.16</td>
<td>6</td>
</tr>
</tbody>
</table>

σX = Standard deviation, x = Mean item score, R = Rank

Table 6.5 Extent of construction material waste

6.9 T - test analysis

An independent sample t-test was also employed to test whether there was factors that contribute to waste generation scores for male and female respondents.

<table>
<thead>
<tr>
<th>Group statistics</th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Std. error mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTW Male</td>
<td>76</td>
<td>3.6898</td>
<td>.52404</td>
<td>.06011</td>
</tr>
<tr>
<td>Female</td>
<td>23</td>
<td>4.0961</td>
<td>.57429</td>
<td>.11975</td>
</tr>
</tbody>
</table>

An independent t-test was also conducted to compare factors that contribute to waste generation scores for both males and females in the study. There was a significant difference in the scores for males (M = 3.6898, SD = 0.52404) and females (M = 4.0961, SD = 0.57429); t (100) = -3.187, p = 0.002 which is less than 0.05 two-tailed. The magnitude of the difference in the mean values shows that female respondents in the study were more aware of the factors that generate waste in the study area than their male counterparts, even though the females constituted the minority in the study.
Independent samples test

<table>
<thead>
<tr>
<th></th>
<th>Levene's test for equality of variances</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>Sig.</td>
<td>t</td>
<td>Df</td>
</tr>
<tr>
<td>BTW</td>
<td>Equal variances assumed</td>
<td>1.065</td>
<td>.305</td>
<td>-3.187</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
<td></td>
<td></td>
<td>-3.033</td>
<td>33.854</td>
</tr>
</tbody>
</table>

The significant level is shown at the sig. (2--tailed) in the above table (number?)

A simple linear regression

A simple linear regression was also conducted to test the relationship between factors that contribute to waste generation, the effects of construction waste as well as the environmental impact of construction waste with a model equation as:

**The model equation:** \( Y = \beta_0 + \text{BTW}\beta_1 + \text{CTE}\text{PD}\beta_2 + \text{ETI}\beta_3 + \varepsilon \)

<table>
<thead>
<tr>
<th>BTW</th>
<th>factors that contribute to waste generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTE</td>
<td>effects of construction waste</td>
</tr>
<tr>
<td>ETI</td>
<td>environmental impact of construction waste</td>
</tr>
</tbody>
</table>

\( Y = \text{DTW} = \) ways of minimising construction waste with a model equation

\( \beta_0 = \) Constant

\( \varepsilon = \) the error term.
Model Summary of the regression

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R square</th>
<th>Std. error of the estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.712a</td>
<td>.508</td>
<td>.492</td>
<td>.30231</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), ETI, BTW, CTE  
b. Dependent variable: DTW

From the above table, it is clear that the R square value of 0.712 of the variance elucidates the factors that contribute to waste, the effects of waste as well as the environmental impact of waste construction explained 71.2% on the ways by which waste is minimised, showing a greater impact of the independent variable on the dependant variable.

(Analysis of variance )ANOVA

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>9.041</td>
<td>3</td>
<td>3.014</td>
<td>32.977</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>8.774</td>
<td>96</td>
<td>.091</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>17.815</td>
<td>99</td>
<td>.091</td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent variable: DTW  
b. Predictors: (Constant), ETI, BTW, CTE

The table above explains the ANOVA with a statistical significance result of the model at sig = .000 which is less than p < .005 which also demonstrated that there was a strong relationship between the independent variable and the dependent variable.

Coefficients of the regression

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardised coefficients</th>
<th>Standardised coefficients</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. error</td>
<td>Beta</td>
<td>t</td>
<td>Sig.</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td>1.674</td>
<td>.273</td>
<td>6.128</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>BTW</td>
<td>.180</td>
<td>.065</td>
<td>.237</td>
<td>2.792</td>
</tr>
<tr>
<td></td>
<td>CTE</td>
<td>.376</td>
<td>.076</td>
<td>.471</td>
<td>4.968</td>
</tr>
<tr>
<td></td>
<td>ETI</td>
<td>.108</td>
<td>.081</td>
<td>.127</td>
<td>1.347</td>
</tr>
</tbody>
</table>

a. Dependent variable: DTW
The table above (Number?) explains the coefficient values of the independent variables that were included in the model for the regression analysis. In comparing the contribution of each variable, the beta values under the standardised coefficients were used. A value with a greater number was considered first as part of the ranking of their effectiveness. In that case the largest beta coefficient was .471 which was "CTE” thus ‘the effects of construction waste’ was the variable that makes the strongest unique contribution to explaining the dependant variable. This is followed by “BTW” – ‘factors that contribute to waste generation’ with .237 while ‘environmental impact of construction waste’ with .127 recorded the least. It demonstrates that the effects of construction waste on performances impacts greatly on the idea of minimising construction waste, followed by the factors that contribute to the waste and environmental impact of the construction waste. The various effects of the construction waste ought to be checked and monitored carefully since they have a greater influence in limiting the idea of minimising construction waste.

6.10 Normal probability plot of the regression standardised residual

A normality test was carried out to determine the linear regression model which was normal so that the best linear unbiased estimators were achieved. The linear regression model had a dependent variable, namely ‘ways of minimising construction waste’ while the independent variables, ‘factors that contribute to waste generation’, ‘effects of construction waste’ as well as ‘environmental impact of construction waste’ were normally distributed. A quantile-quantile plot (Q-Q plot) was used to test normality of the data which resulted in points lining in a straight diagonal line from bottom left to top right which signified that there was no major deviation from the normality with a very high positive relationship as shown in the figure (Number?) below.
6.11 CHAPTER SUMMARY

Data obtained from the structured questionnaire sent out and completed by the architects, quantity surveyors, civil engineers, construction managers, construction project managers, project managers and other professionals who are involved in construction projects in Ghana was presented and analysed in this chapter. The next chapter will focus on the discussion of the findings from the research analysis in relation to the research questions and the research objectives that were formulated in Chapter One. The purpose of this is to establish whether the research objectives were met.
CHAPTER SEVEN

DISCUSSION OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

7.1 CHAPTER INTRODUCTION

Chapter Seven discusses the findings from the research analysis in relation to the research questions. The findings are further discussed in relation to the reviewed literature in Chapters 2, 3, and 4. This is with a view to ascertaining whether the defined research problems have been answered from the findings’ analysis in Chapter Six. Results have been presented in relation to the research questions and the relevant data as required. This chapter also presents conclusions based on the research objectives and finally gives a general research recommendations.

7.2 RESEARCH QUESTION 1

What are the factors that contribute to waste generation in the Greater Accra Region construction industry?

7.2.1 Findings

Based on the ranking (R) and using the calculated standard deviation (SD) and mean scores (x̄) for the listed factors that contribute to waste generation, it was revealed that the most dominant factors include ‘Project complexity’ which was ranked first with a mean score of 3.68 and standard deviation (SD) = 1.162, Site conflicts among construction parties’ which was ranked second with a mean score of 3.61 and SD = 1.154, ‘Challenges with transportation’ which was ranked third with a mean score of 3.45 and SD = 1.158, ‘Adverse weather conditions’ which was ranked fourth with a mean score of 3.44 and SD = 0.998, while ‘Lack of motivation’ was ranked last with a mean score of 3.42 and SD = 1.130. These findings were in agreement with the study by Rao (2009) except for ‘lack of motivation’. The findings also agreed to a certain extent with the findings of a study by Osmani et al. (2008), Kulatunga et al. (2006), and Gavilan and Bernold (1994) where ‘Project complexity’, ‘Site conflicts among construction parties’, ‘Challenges with transportation’, and ‘Adverse weather conditions’ were the major factors of waste generation.
7.3 RESEARCH QUESTION 2

What are the effects of construction waste on the performance of the Greater Accra Region construction industry?

7.3.1 Findings

The study subjected twelve constructs or questions to exploratory factor analysis, out of which four were extracted as part of the sample adequacy to perform the final analysis. They were ‘Extension of time’ which ranked first with a mean and standard deviation values of 3.92 and 1.05; which was followed by ‘Idling resources’ with a mean score of 3.83 and SD = 0.888, ‘Disputes’ was ranked third with a mean score of 3.70 and SD = 0.927, and ‘Resignation of skilled employees’ was ranked fourth as the least with a mean score of 3.28 and SD = 0.996. The findings were in agreement with those of Ahmed et al. (2002:12) where ‘Time’ and ‘Dispute among others’ are the effects of construction waste.

7.4 RESEARCH QUESTION 3

What are the ways of minimising construction waste in the Greater Accra Region?

7.4.1 Findings

In assessing ways in which construction waste was minimised, sixteen questions were validated through a component factor analysis out of which five were extracted and they are presented as follows: ‘Proper project planning and scheduling’ was ranked first with a mean score of 4.54 and standard deviation (SD) = 0.610, ‘Availability of clear information and communication channels’ was ranked second with a mean score of 4.40 and SD = 0.682, ‘Frequent coordination between the construction teams’ was ranked third with a mean score of 4.39 and SD = 0.634, ‘Complete and proper design at the right time’ was ranked last with a mean score of 4.26 and SD = 0.848, while ‘Frequent progress meetings’ was also ranked last with a mean score of 4.12 and SD = 0.832. These findings were in agreement with those of Hao et al. (2007b), Rao (2009), Osmani et al. (2008), Kulatunga et al. (2006) and Gavilan and Bernold (1994) where all the variables are ways of minimising waste.
7.5  RESEARCH QUESTION 4

What are the environmental impacts of construction waste on the Greater Accra Region?

7.5.1 Findings

The respondents were further asked to rank the environmental impact of construction waste in Ghana. It became evident that ‘Water pollution’ was ranked first with a mean score of 4.30 and standard deviation (SD) = 0.759, ‘High energy consumed during extraction’ was ranked second with a mean score of 4.09 and SD = 0.780, while ‘Land consumption’ recorded the least with a mean score of 4.08 and SD = 0.946. These findings were in agreement with the study by Esin and Cosgun (2007) where water pollution and land consumption were the environmental impact that agreed, meanwhile high energy consumed during extraction disagreed and agreed with the study by Boustead and Hancock (1979), cited in Treloar et al (2003).

7.6  RESEARCH QUESTION 5

What is the extent of construction materials wastage in the Greater Accra Region CI?

7.6.1 Findings

Based on the ranking (R) and using the calculated standard deviation (SD) and mean scores (\(\bar{x}\)) for the listed extent of construction materials wastage in the Greater Accra Region CI, the findings revealed that ‘Paints’ was ranked first with a mean score of 2.58 and standard deviation (SD) = 1.121, ‘Plywood’ was ranked second with a mean score of 2.50 and SD = 1.107, ‘Roofing tiles’ was ranked third with a mean score 2.47 and SD = 1.105, ‘Electrical wires’ was ranked fourth with a mean score of 2.46 and SD = 1.096, ‘Roofing sheets’ was ranked fifth with a mean score of 2.22 and SD = 1.168, and ‘Conduit pipes (electrical)’ was ranked last with a mean score of 2.16 and SD = 0.940. Findings were in agreement with the study by Ekanayake and Ofori (2000) where ‘Paints’, ‘Plywood’, ‘Roofing tiles’, ‘Electrical wires’, ‘Roofing sheets’, and ‘Conduit pipes (electrical)’ were the materials that were observed as the materials recording the greatest amounts of wastage in the construction industry.
7.7 CONCLUSIONS

The aim of the current research study was to explore the factors/causes, effects, methods of minimising construction waste, extent of material wastage, and environmental impact of construction waste in Greater Accra Region in Ghana. In this chapter the conclusions and recommendations of the research study are presented and discussed in relation to the objectives of the study. In order to accomplish this purpose, the specific objectives of the study were the following:

1. To identify factors that contribute to waste generation in the Greater Accra Region construction industry;

2. To examine the effects of construction waste on the performance of the Greater Accra Region construction industry;

3. To identify the ways of minimising construction waste in the Greater Accra Region;

4. To identify the environmental impacts of construction waste on the Greater Accra Region; and

5. To examine the extent of construction materials wastage in the Greater Accra Region CI.

Below the researcher demonstrates how the current study objectives were answered:

7.7.1 RESEARCH OBJECTIVE 1

The first research objective was to determine the factors that contribute to waste generation in the Greater Accra Region construction industry.

Literature revealed that the major factors that contribute to construction waste generation are

1) Faulty planning and policies systems and procedures, 2) Project complexity, 3) Environmental pressures, 4) Tardiness (slow to act), 5) Lack of accountability, 6) Site conflict among construction parties, 7) Non-responsiveness to automation /computerisation, 8) Wrong specifications, standard, codes, 9) Wrong raw materials, 10) Lack of inventory control, 11) Challenges with transportation, 12)

Findings from the questionnaire survey results obtained from the respondents showed that ‘Project complexity’; ‘Site conflict among construction parties’; ‘Challenges with transportation’; ‘Adverse weather conditions’; and ‘Lack of motivation/incentives for the work force. Hence the research objective was achieved from both the literature review and from a well-structured questionnaire.

7.7.2 RESEARCH OBJECTIVE 2

The second research objective was to examine the effects of construction waste on the performance of the Greater Accra Region construction industry.

Literature revealed that the major effects of construction waste on the performance of the effects of construction waste to the performance are extension of time on the project, wastage and under-utilisation of manpower resources, idling resources, claims on the disturbance of regular progress work by the main contractor, loss of confidence in the contract thereby jeopardising the reputation of contractor in case of future tendering chances, late returns of income for private developers, reduction in employment opportunities, dispute between the parties involved, the decrease in tempo of economic activities in the nation, additional insurance charges, extra taxes and dues due to delay.

Findings from the questionnaire survey results obtained from the respondents showed that extension of time on the project, idling resources, dispute between the parties involved, and reduction in employment opportunities. Therefore, it can be inferred that the research objective was met based on the findings from the structured questionnaire survey.

7.7.3 RESEARCH OBJECTIVE 3

The third objective of the study was to identify the ways of minimising construction waste in the Greater Accra Region.
Literature revealed that the major ways of minimising construction waste in the Greater Accra Region are site management and supervision, effective strategic planning, clear information and communication channels, frequent progress meeting, collaborative working in construction, proper project planning, and scheduling, frequent coordination between the parties involved, complete and proper design at the right time, use of appropriate construction methods, accurate initial cost estimates, and proper material procurement.

Findings from the questionnaire survey revealed that construction waste can be minimised by proper project planning, and scheduling, clear information and communication channels, frequent progress meetings, frequent coordination among the parties involved, and complete and proper design at the right time. Hence the objective of the study was achieved from both literature review and from the structured questionnaire.

7.7.4 RESEARCH OBJECTIVE 4

The fourth research objective was to identify the environmental impacts of construction waste on the Greater Accra Region.

Literature revealed that the major environmental impacts of construction waste on the Greater Accra Region are (1) land consumption due to waste landfilling, (2) water pollution, (3) noise emission, (4) air pollution, (5) environmental impacts of illegal waste dumping on public living environment, and (6) high energy consumption.

From the questionnaire survey obtained from the respondents, it was revealed that water pollution, high energy consumption, and land consumption due to waste landfilling, were the major environmental impacts. Therefore, the research objective was achieved in the current study.
7.7.5 RESEARCH OBJECTIVE 5

The research objective was to examine the extent of construction materials wastage in the Greater Accra Region CI.

Literature revealed that materials wastage in the Greater Accra Region CI comprises timber, nails, chipboard, paint, asbestos sheet, roofing tiles, plywood, electrical wire, roofing sheet, conduit pipe (electrical), sand, and stone.

From the survey results obtained from respondents it was observed that paint, plywood, roofing tiles, electrical wires, roofing sheet, and conduit pipe (electrical) were the highest wastage materials. Therefore it can be concluded that the research objective was achieved from both literature review and from a well-structured questionnaire.

7.8 GENERAL RESEARCH CONCLUSION

Literature review revealed that there are a number of factors that causes construction waste. The causes identified from the literature were similar to those identified in the current study. Furthermore, the literature review showed that the causes of construction waste are found at different levels, ranging from those caused by the client or owner to those that are caused by other external factors. The literature showed that each category of the causes of construction waste generation included different factors that could lead to profit minimisation. This study examined factors that contribute to construction waste generation from the several identified categories as compiled from an extensive literature review. Findings from the study supported work done by previous researchers and scholars shows that most of the factors are responsible for causing construction waste.

Furthermore, findings revealed that there are corresponding negative effects of construction waste in Greater Accra construction industry in Ghana. However, the study identified measures that can be taken by construction professionals to avoid and eventually reduce construction waste. The empirical study indicate findings of the factors, effects, ways of minimising, extent of material wastage, and the environmental impact of construction waste in Greater Accra construction industry in Ghana. Therefore, the results revealed in this study contribute to the
body of knowledge and give guidelines on running construction waste management in way that minimizes construction waste generation.

7.9 RECOMMENDATIONS

Construction waste usually occurs during post-construction and construction phases and it is mostly caused by inadequate planning, change in project design, project complexity, site conflict among construction teams, lack of motivation, and adverse weather conditions. Therefore,

- It is recommended that all members of construction teams should be trained and educated on the factors that contribute to construction waste in order to minimise its generation.
- It is also recommended that frequent site co-ordination meetings should be held in order to flag possible construction material wastage.
- It is further recommended that clients should appoint experienced contractors and consultants in order to minimise site conflicts which lead to construction waste generation.
- Members of construction teams should practise the identified measures of reducing construction waste such as adequate project planning and scheduling, clear information and proper communication channels, frequent coordination among the construction teams, complete and proper project designing, and frequent progress meetings, among other identified measures.

7.10 AREAS FOR FURTHER STUDIES

The study further recommends the following as areas of possible research:

- Further study should be conducted to evaluate how experienced professionals are always appointed.
- Research should be conducted to evaluate how good project management can minimise construction waste in Ghana.
- The current study revealed that site conflicts among construction parties are major causes of construction waste generation. A study should therefore be conducted on effective conflict management.
• Further research should be conducted to evaluate which on-site construction waste management method that would reduce virgin land consumption by construction waste dumping.
REFERENCES


UNDP/UNCHS (Habitat/World Bank/SDC Collaborative Programme on Municipal Solid Waste Management in Low- Income Countries. St, Galen, SKAT


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**APPENDIX 1: Cover Letter**

University of Johannesburg
Dear Sir/Madam,

**LETTER OF INVITATION FOR RESEARCH SURVEY**

The Department of Construction Management and Quantity Surveying at the University of Johannesburg is undertaking a research project, namely *ASSESSMENT OF CONSTRUCTION WASTE MANAGEMENT IN THE GREATER ACCRA REGION CONSTRUCTION INDUSTRY - GHANA*. To this end, we kindly request that you complete the following short questionnaire. It should take no longer than 15 minutes of your time. Your response is of the utmost importance to us.

To protect your anonymity, please do not enter your name or contact details on the questionnaire.

Summary of the results of this research will be available at the Department of Construction Management and Quantity Surveying in September, 2016.

Should you wish to know the findings of the research, you are welcome to contact S.K. Agbozo telephonically at: +233243531286 or at: assetsofia@yahoo.com

Thanking you in advance

AGBOZO S.K.

**APPENDIX 2: Questionnaire**

**QUESTIONNAIRE ON ASSESSMENT OF CONSTRUCTION WASTE MANAGEMENT IN THE GREATER ACCRA REGION CONSTRUCTION INDUSTRY – GHANA**

**INSTRUCTIONS:**
PLEASE ANSWER THE FOLLOWING QUESTIONS BY CROSSING (X) ON THE RELEVANT BLOCK OR WRITTING DOWN YOUR ANSWER IN THE SPACE PROVIDED.

EXAMPLE of how to answer this questionnaire:

Your gender? If you are female:

<table>
<thead>
<tr>
<th>Male</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>x</td>
</tr>
</tbody>
</table>

SECTION A - BACKGROUND INFORMATION

This section of the questionnaire refers to background or biographical information. Although we are aware of the sensitivity of the questions in this section, the information will allow us to compare groups of respondents. Once again, we assure you that your response will remain anonymous. Your cooperation is appreciated.

1. Gender

<table>
<thead>
<tr>
<th>Male</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>x</td>
</tr>
</tbody>
</table>

2. What is your age? (in complete years)

3. What is your profession?

| Architect | 1 |
| Quantity Surveyor | 2 |
| Civil Engineer | 3 |
| Project Manager | 4 |
| Construction Manager | 5 |
| Construction Project Manager | 6 |
| Other: Please specify... | 7 |

4. How many years of experience do you have in the construction industry? (in complete years)

5. State your highest educational qualification.

| Technician certificate | 1 |
| Diploma | 2 |
National diploma 3
Bachelor’s degree 4
Master’s degree 5
Doctorate 6

6. For which of the following do you currently work?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Public sector</td>
<td>1</td>
</tr>
<tr>
<td>Private sector</td>
<td>2</td>
</tr>
<tr>
<td>Contractor</td>
<td>3</td>
</tr>
<tr>
<td>Consultant</td>
<td>4</td>
</tr>
<tr>
<td>Other: Please specify</td>
<td>5</td>
</tr>
</tbody>
</table>

7. State the number of construction projects you have been involved in during the past two (2) years.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td>1–2 projects</td>
<td>2</td>
</tr>
<tr>
<td>3–4 projects</td>
<td>3</td>
</tr>
<tr>
<td>5–6 projects</td>
<td>4</td>
</tr>
<tr>
<td>7–8 projects</td>
<td>5</td>
</tr>
<tr>
<td>More than 8 projects</td>
<td>6</td>
</tr>
</tbody>
</table>

8. What type of construction projects do you frequently work on? (you can select more than one option)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Schools</td>
<td>1</td>
</tr>
<tr>
<td>Hospitals</td>
<td>2</td>
</tr>
<tr>
<td>Housing estates</td>
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</tr>
<tr>
<td>Road construction</td>
<td>4</td>
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<tr>
<td>Other civil works (Dams etc.)</td>
<td>5</td>
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<tr>
<td>Government offices</td>
<td>6</td>
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<tr>
<td>Renovations (Residential, civil etc.)</td>
<td>7</td>
</tr>
<tr>
<td>Stadia</td>
<td>8</td>
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<td>Shopping complexes</td>
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<tr>
<td>Other: Please specify</td>
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</table>

SECTION B: FACTORS THAT CONTRIBUTE TO WASTE GENERATION.

This section of the questionnaire explores the factors that contribute to constructions waste generation in Greater Accra Region construction industry – Ghana.
Please indicate your answers using the following 5-point scale where 

1 = Strongly disagree (SD), 2 = Disagree (D), 3 = Neutral (N), 4 = Agree (A), and 5 = Strongly agree (SA)

9. To what extent do you agree that the following factors are contributing to construction waste generation in GAR construction industry -- Ghana?

<table>
<thead>
<tr>
<th>CODE</th>
<th>FACTORS OF WASTE GENERATION</th>
<th>Strongly disagrees</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>CWG1</td>
<td>Contractors’ inexperience</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG2</td>
<td>Inadequate planning</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG3</td>
<td>Rework or correction</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG4</td>
<td>Double handling of materials</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG5</td>
<td>Change in project design</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG6</td>
<td>Project complexity</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG7</td>
<td>Incorrect raw materials</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG8</td>
<td>Lack of motivation</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG9</td>
<td>Challenges with transportation</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG10</td>
<td>Shortage of skilled site workers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG11</td>
<td>Poor project management assistance (Professionals/Consultants)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG12</td>
<td>Lack of proper storage</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>CWG13</td>
<td>Communication gap</td>
<td>1</td>
<td>2</td>
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<td>5</td>
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<tr>
<td>CWG14</td>
<td>Site conflicts among construction parties</td>
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<td>2</td>
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<td>5</td>
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<tr>
<td>CWG15</td>
<td>Poor workmanship</td>
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<td>2</td>
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<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG16</td>
<td>Unsafe practices</td>
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<td>2</td>
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<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG17</td>
<td>Unsteady material supply</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG18</td>
<td>Adverse weather conditions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>CWG19</td>
<td>Breach of local regulations</td>
<td>1</td>
<td>2</td>
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</table>

SECTION C: EFFECTS OF CONSTRUCTION WASTE

This section of the questionnaire examines the effects of construction waste on the performance of the construction industry in Ghana.

10. To what extent do you agree that the following effects of construction waste influence the performance of the construction industry in Ghana?
SECTION D: WAYS OF MINIMISING CONSTRUCTION WASTE

This section of the questionnaire identifies the ways of minimizing construction waste in the Greater Accra Region – Ghana.

11. To What extent do you agree that the following measures can be taken to minimise construction waste in the Ghanaian construction industry?
<table>
<thead>
<tr>
<th>CODE</th>
<th>WAYS OF MINIMISING CONSTRUCTION WASTE</th>
<th>Strongly disagrees</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>WMCW1</td>
<td>Separate site management and supervision</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>WMCW2</td>
<td>Effective strategic planning</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>WMCW3</td>
<td>Availability of clear information and communication channels</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>WMCW4</td>
<td>Collaboration between the entire construction team</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>WMCW5</td>
<td>Proper project planning and scheduling</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>WMCW6</td>
<td>Frequent coordination between the construction team</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>WMCW7</td>
<td>Complete and proper design at the right time</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>WMCW8</td>
<td>Appropriate construction methods</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
</tr>
<tr>
<td>WMCW9</td>
<td>Accurate initial cost estimates</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>WMCW10</td>
<td>Proper material procurement</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>WMCW11</td>
<td>Building according to the construction drawings</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>WMCW12</td>
<td>Frequent progress meetings</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>WMCW13</td>
<td>Fast-tracking construction</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>WMCW14</td>
<td>Use of modern construction equipment</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
</tr>
<tr>
<td>WMCW15</td>
<td>Up-to-date technology utilisation</td>
<td>1</td>
<td>2</td>
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<td>5</td>
</tr>
<tr>
<td>WMCW16</td>
<td>Adherence to construction specifications</td>
<td>1</td>
<td>2</td>
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</tbody>
</table>

**SECTION E: ENVIRONMENTAL IMPACTS OF CONSTRUCTION WASTE**

This section of the questionnaire identifies the environmental impacts of construction waste on the Greater Accra Region -- Ghana.
12. To what extent do you agree with the following environmental impacts of construction waste in Greater Accra Region -- Ghana?

<table>
<thead>
<tr>
<th>CODE</th>
<th>ENVIRONMENTAL IMPACTS OF CONSTRUCTION WASTE</th>
<th>Strongly disagrees</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>EICW1</td>
<td>Rapid depletion of natural resources</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>EICW2</td>
<td>High volumes of air pollution</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>EICW3</td>
<td>Water pollution</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
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<tr>
<td>EICW4</td>
<td>High energy consumed during extraction</td>
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<td>2</td>
<td>3</td>
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<td>5</td>
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<tr>
<td>EICW5</td>
<td>Noise emission</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>EICW6</td>
<td>Land consumption</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>EICW7</td>
<td>Illegal waste dumping on public living environment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>EICW8</td>
<td>Heavy duty vehicles transporting waste materials causes road surfaces to wear off</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>EICW9</td>
<td>Contributes to the visual impacts associated with existing infrastructure</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>EICW10</td>
<td>Loss of building lands to landfills</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
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</tbody>
</table>

SECTION F: EXTENT OF CONSTRUCTION MATERIALS WASTAGE

This section of the questionnaire examines the extent of construction materials wastage in the Greater Accra Region -- Ghana. Please indicate your answers using the following percentages (%) where 1 = 5%, 2 = 10%, 3 = 15%, 4 = 20% and 5 = 25%:
13. To What extent are the following construction materials wasted in the Greater Accra Region construction industry (GARCI)?

<table>
<thead>
<tr>
<th>CODE</th>
<th>EXTENT OF CONSTRUCTION MATERIALS WASTAGE</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
<th>25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECMW1</td>
<td>Cement</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ECMW2</td>
<td>Timber</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ECMW3</td>
<td>Premix concrete</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ECMW4</td>
<td>Sand</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>ECMW5</td>
<td>Iron rods (Steel reinforcement)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>ECMW6</td>
<td>Ceramic tiles</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ECMW7</td>
<td>Nails</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ECMW8</td>
<td>Mortar</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ECMW9</td>
<td>Paving bricks</td>
<td>1</td>
<td>2</td>
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<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ECMW10</td>
<td>Blocks</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ECMW11</td>
<td>PVC pipes (plumbing)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>ECMW12</td>
<td>Paints</td>
<td>1</td>
<td>2</td>
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<tr>
<td>ECMW13</td>
<td>Plaster board</td>
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<td>2</td>
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<td>ECMW14</td>
<td>Water</td>
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<td>2</td>
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<td>5</td>
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<tr>
<td>ECMW15</td>
<td>Electrical wires</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>ECMW16</td>
<td>Conduit pipes (electrical)</td>
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<td>2</td>
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<tr>
<td>ECMW17</td>
<td>Glass</td>
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<td>2</td>
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<tr>
<td>ECMW18</td>
<td>Roofing sheets</td>
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<td>5</td>
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<tr>
<td>ECMW19</td>
<td>Roofing tiles</td>
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<tr>
<td>ECMW20</td>
<td>Plywood</td>
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<td>ECMW21</td>
<td>Roofing timbers</td>
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<td>ECMW22</td>
<td>Ceramic tiles</td>
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<td>Stone</td>
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<td>ECMW25</td>
<td>PVC tiles</td>
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</tr>
</tbody>
</table>

Thank you for your co-operation in completing this questionnaire. May God bless you.