UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION - KUMASI

EFFICIENT UTILIZATION OF CONSTRUCTION MATERIALS ON SITES IN GHANA: A CASE STUDY OF AFADZATO SOUTH DISTRICT IN THE VOLTA REGION

NICHOLAS KUDZO MODZRO

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A Dissertation in the Department of CONSTRUCTION AND WOOD TECHNOLOGY, Faculty of TECHNICAL EDUCATION submitted to the school of Graduate Studies, University of Education, Winneba- Kumasi in partial fulfillment of the requirements for award of Master of Technology Degree in Construction Technology

DECEMBER, 2020

DECLARATION

STUDENTS' DECLARATION

Nicholas Kodzo Modzro, declare that this dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledge, is entirely my own original work and it has not been submitted either in part or whole for another degree elsewhere.

SIGNATURE:……

DATE:……

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of the work was supervised in accordance with guidelines for supervision of dissertation laid down by the University of Education, Winneba

MR. MICHAEL TSORGALI

SIGNATURE:……

DATE:……

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DEDICATION

I dedicate this work to my family most especially to my wife Vivian Modzro and to all my loved ones, your support keeps me blazing for more.

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LIST OF ABBREVIATION

MDGs	Millennium Development Goals
C &DW	Construction and Demolition Waste
EPA	Environmental Protection Agency
WTE	Waste to Energy Technologies
MSW	Municipal Solid Waste
MLGRD	Ministry of Local Government and Rural Development
NREB	Natural Resources Environmental Board
DANIDA	Danish International Development Agency
UK	United Kingdom
MMDAs	Metropolitan Municipal and District Assemblies
WMDs	Waste Management Department
EHSD	Environmental Health and Sanitation Department
MWRWH	Ministry of Water Resources Works and Housing
EPD	Environmental Protection Department of Hong Kong
JTI	Just-In-Time Delivery
GPS	Global Positioning System
GIS	Geographical Information System
IRP	Incentive Reward Program
CIDB	Construction Industry Development Board
IBS	Industrialized Building Systems
SMEs	Small and Medium Enterprises
SPSS	Statistical Package for Social Sciences

ABSTRACT

In the world over, the critical role of the construction industry cannot be downplayed. It plays the vital role of infrastructural and economic development in all nations. The specific objectives of the study were to examine issues of materials wastage in construction; to identify factors contributing to waste of construction materials; and to devise strategies to minimize construction waste on construction sites in the Afadzato South District. The study adopted a descriptive survey approach. A questionnaire was developed and administered to site managers, supervisors and workers of construction firms. A simple random sample of 56 site managers working with the Afadzato South District were selected out of a total population one hundred and sixty eight (168). A response rate of ninety four (94%) percent was achieved from the survey questionnaires administered. Results of the study indicate that minimizing waste at source of origin only; combination of re-using waste and minimizing waste at source of origin; and a combination of re-using waste, recycling waste and minimizing waste at the source of origin were the waste minimization strategies. Further results also indicate that unavailability of properly engineered disposal sites and waste management plants; high disposal/tipping cost; lack of planning for waste management; high cost of waste recycling; lack of funds for equipment and training; lack of legal knowledge and environmental regulation and programmes on waste; no attention on waste reduction at the planning and design stage; lack of proper policies and administrative systems by government for construction waste management; insufficient incentives for private projects to implement waste reduction measures; lack of space within site for separation and recycling; and lack of well-developed recycling industry and market for recycled products were the challenges of construction waste management. The study made some recommendations.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Construction industry globally plays a very important role in every nation's development both in infrastructure and economical development. As the standards of living and disposable incomes increase; consumption of goods and services increases, which results in corresponding increase in the amount of waste generated (Hoomweg & Bhada-Jata, 2012). Although solid waste is generated by different housing and economic activities, the construction industry has always been considered as one of a major producer of waste (Al-Haj & Hamani, 2011). This has become a serious problem for every nation. Industry player and researchers pointed that waste emanates during design, procurement and construction stage. The waste also influences economical dynamics of society and has an important effect on the environment (Kraly, 2011).

Waste emanating from construction can be classified into two groups, namely; physical and non physical waste. Physical waste is generated in the form of material loss and contributes to a significant part of land fill. Studies show that construction industry produce large amount of waste and more than 50% of waste material is deposited in landfill/Hwang and Yeo 2011). The Natural Resources and Environmental Board (NREB) and Danish International Development Agency (DANIDA), it is estimated that about 50% of the construction waste does not leave the site. It's either left on site or openly burnt.

The influx of both foreign and indigenous firms into the construction industry (Ogunblyi 1998), as the years roll by hence the more generation of waste. Waste produce as a result to cut reinforcement rods scrap is usually collected for recycling due to it high selling value at present date (Tang and Larson 2004). As a result only little quantity of construction waste was legally dumped into public disposal unit or landfills. A practice that impacted negatively on the environment against the regulation that ensures safety of public and healthy environment.

All the waste generated leads to decrease in production efficiency as industrialization of construction waste can lead to high productivity, save time and unpose safety on worksite thus increasing the probability of success of a construction project. Therefore construction waste management is a vita aspect of achieving project success. In Chile Construction Company are applying several actions to improve the performance of their project minimize the waste produced during construction process.

In Ghana the past decade have says great improvement thereby increasing productivity. A major factor in this achievement was the implementation of the new production techniques which provides a continuous improvement in the production process by removing various types of waste (Wang and Lee (2011) while manufacturing attained great result, the construction industry still encounters several problem resulting from huge amount of waste and its disposal. however very few contractors have made the effort to develop and implement strategies to reduce waste, contractors very often try to complete a project within the stipulated possible time rather than applying sustainable concept (Kulatuga et al, 2006). In doing so the neglect the significant of waste management and sustainable construction.

In fact anecdotal evidence show practices such as poor storage system, poor material control and wrong material specification which general waste and increase construction cost. Apart of overburdening the limited landfill site as Gray (2013) reveal material wastes result to unnecessary high construction cost great impediment to affordability of good house to the citizen (Oladian, 2009).

It is acknowledged that high level of waste exist in construction works. However construction has a major and direct influence on many other industries worldwide by means of both purchasing from other industries and providing the product to at most all other industries, elimination or reducing waste, could yield great cost saving to the society. The Government of Ghana through Ministry of work water resources works and hosing (MWRWH 2011) is determined to bridge this gab securing funding for various affordable housing program in Accra and other Regional and District Capital (MOIC 2010). These projects obviously will generate tones of waste that is likely to compound the already solid waste problems in the cities. Government has established institution and structures that are to cater for waste minimization and disposal. these regulatory agencies are enable to track and quantify the amount of construction and demolition C& D waste accurately which then limit their ability to make adequate regulation and enforce them property .

It is therefore imperative to raise awareness and there by revising previous practices that will eliminate and reduce waste within the construction industry. Various methods such as lean construction sustainable construction among many other have been raised as means to dealing waste challenges.

It is on the background that minimization and elimination of construction waste has been brought to the forefront as an important issue. All these waste generation leads to decrease in production efficiency and indicated by many researchers.

Ghana as a developing country can safely be estimated to be above 30%. Considering that the cost of material forms 50-60% of the project cost, and can be said that thousands of Ghana cedis are lost to waste in construction industry in Ghana.

In some areas, all part of C & D was is unlawfully deposited on lands, or in natural drainages including water contrary to regulations to protect human health, and the environment (Tom Napier, 2012). This in its own rights has contributed to some floods and sanitation challenges in parts of the country.

It is on this background that this research has been conducted to discuss the important of waste management and identify the causes and effects on construction as to develop strategies to effectively reduce its generation on construction industries.

1.2 Statement of the problem

The building of roads, houses, bridges in the District for individual or the government involves many resources. The issue of landfill site has been of strenuous negotiation with rising population pressure continuing to impact on waste generation and management. This in its own rights has contributed to some flood and sanitation challenges in that part of the region. A research show that the buildup of construction and demolition of bridges houses during the construction of the Eastern corridor road through the afadzato South District have over the recent years causes flood as a result of disposal of waste into the water ways and non adherent to good waste management practices. Explaining at the 3 days tour by the President in the Volta Region, Amoaku Atta the Minister of Roads and Highways, said COCOBOD is funding Eastern

Corridor roads through Afadzato District to Hohoe lot 1& 2 (51.3km) stretch of the road.

1.3 The aim of the study

The aim of this study was to ensure that wastage of construction materials are minimized in construction sites in the Afadzato South District in the Volta Region.

1.4 Objectives

The following are the objectives of the study:

- To examine issues of materials wastage in construction sites in Afadzato South District in the Volta Region.
- To identify factors contributing to waste of construction materials
- Devise strategies to minimize construction waste on the sites Afadzato South District in the Volta Region.

1. 5Research questions

The following research questions guided the study

- What are the waste minimization strategies of construction firms on project site?
- What are the challenges encountered in construction waste management?
- What effective measures can be put in place for managing construction waste on project sites?

1.6 Significance of the study

- The investigation into waste management is meant to draw attention for those in the construction industry on how waste is managed on project site so as to

reduce the volume of waste produced and eliminate many disposal challenges associated with this type of waste. Impliedly, contractors could benefit immensely from the study's findings and recommendations.

- The study also intends to identify the challenges construction firm go through in their attempt to manage waste and how these can be handle to minimize waste generation and increase productivity. Site managers could benefit through interventions designed to overcome the challenges to be identified.
- The study is to contribute to knowledge by identifying constrains to waste management of construction site in the Afadzato South District Assembly

1.7 Scope of the study

The study was restricted to construction companies in the Afadzato South with construction classification of D2-K2, D1-K1 Certificate. These categories of construction firms were chosen because of their technical knowhow and are well equipped with various types of equipment's and work ongoing who are capable of providing adequate information for this study. The study was limited to Afadzato South District environs because of wide range of construction work ongoing such as school block, administration blocks and roads. As a new District couple with wide range of experienced construction expect with modern facilities and improvement in the construction industry. This was to bring to the study more diverse and accurate responses that made the final report more detailed. The choice of Afadzato South District was also influence by the proximity to the researcher.

1.8 Organization of the Study

This research provides an overview of the current situation of the construction and demolition waste management in Ghana by gathering information and opinions from the construction firm managers. Findings and recommendations of the study may be used to improve waste management in the construction industry. Chapter 2 provides an overview of the current situation and practice on construction waste management in Ghana. It also provides literature on strategies adopted in dealing with the waste menace in the Ghanaian construction industry.

Chapter 3 describes the methodology adopted in the research. Chapter 4 summarizes the results of the research. It includes the constraints in implementing waste reduction strategies and some measures viewed by industry participants as effective in managing waste. Chapter 5 discusses the summary of the findings, conclusion and recommendations of the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter assesses the current status of waste generated by construction activities from residential construction site. The chapter focuses in the concept in waste management, classification of waste, Quantification of waste, waste minimization strategies on construction project. Others are challenges in construction waste management, and the most efficient ways of managing construction waste will be extensively discussed in others to minimize the generation of this type of waste and find solution to many disposal problems.

2.2 Concept of Waste

There are number of definition of waste. Waste could be understood as any inefficiency that results in the uses of equipment, materials, labour or capital in larger quantities than those considered as necessary in the production of a building. Waste includes both the incidence of material losses and the execution of unnecessary work, which generates additional costs but do not add value to the product (Koskela, 1992). Waste is more easily recognized than defined. Something can become waste when it is no longer useful to the owner or it is used and fails to fulfill its purpose (Gourlay, 1992 cited by Freduah, 2004). According to Formoso et al (1999), waste can be classified as unavoidable waste or natural waste, in which investment necessary to its reduction is higher than the economy produced, and avoidable waste, in which the cost of waste is higher than the cost to prevent it. The cost of unavoidable waste depends on the technological development level of the company (Womack & Jones,

1996, Fomoso er al, 1996). A simple way to define waste is "that which can be eliminated without reducing customer value". It can be activities, resources, rules, etc. (Polat and Ballard, 2004). The common sense understanding of waste is anything which is not valued.

More precisely, waste is the expenditure of effort or the using up of resources without producing value. (Macomber and Howell, 2004). Waste means anything other than the minimum amount of equipment, material, parts, space and workers' time absolutely necessary to add value to the product (Anold, 1991).

Therefore, waste should be defined as any losses in material, time and monetary result by activities but do not add value or progress to the product, which can be eliminated without reducing customer value.

2.2.1Construction and demolition waste

Waste has been considered to be a major problem in the construction industry. Waste in construction is not only focused on the quality of waste of materials on site, but also related to time waste. Waste in the construction industry has been the subject of several research projects around the world in recent times. Some of them have focused on the environmental damage that result from the generation of material waste. On the other hand, there have been a number of studies mostly concerned with the economic aspect of waste in the construction industry (Formoso et al 1999a). waste in construction is defined as "the difference between the value of those materials delivered and accepted on site and those used properly as specified and accurately measured in the work, after the deducing cost saving of substituted

materials and those transfer elsewhere" (Pheng & Tan,1998). Lee et al. (1999) classified construction waste in 8 groups, namely: delay times, quality cost, lack of safety, rework, unnecessary transportation trips, long distances, improper choice or management of methods or equipment, and poor constructability. Garas, Anis and El Gammal, (2001) grouped construction waste into two principal components;

- Time waste including waiting periods, stoppages, clarification, variation in information, rework, ineffective work, interaction between various specialists, delays in plan activities, and abnormal wear of equipment, and
- Material waste comprising over ordering, overproduction, wrong handling, wrong storage, manufacturing defects, and theft or vandalism.

Waste in the construction industry is important not only form the perspective of efficiency, but also this concern has been growing in recent years about the adverse effect of the waste of building materials on the environment (Formoso, et al, (1999a). The definition of construction waste varies and depends significantly on the type of construction waste May be defined as "The by-products generated and removed from construction, renovation and demolition workplaces or sites of building and civil engineering structures". In environmental terms the latter definition provides the better description as it identifies clearly materials that must be either recycled or re-used or disposed of (McDonald and Smithers, 1998).

Construction waste defined by the Environmental Protection Department (EPD) of Hong Kong (2000) as; Construction waste comprises of unwanted materials generated during construction, including rejected structures and materials, materials which have been over ordered or are surplus to requirements, and materials which have been used

and discarded. Furthermore, materials waste can be defined as " any materials, apart from earth materials, which needs to be transported elsewhere from the construction site or used within the construction site itself for the purpose of land filling, incineration, recycling, re-using or composting, other than the intended specific purpose of the project due to materials damage, excess, non-use, or non-compliance with the specifications or being a by-product of the construction process" (Ekanyayake and Ofori, 2000)

2.3The Concept of Waste Management

The business of keeping our environment free from contaminating effects of waste materials is generally 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 site". 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 derived from these definitions that waste management is the practice of protecting the environment from the polluting effects of waste materials in order to protect public health and the natural environment. The priority of 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). Further Gilpin (1996) regards the business of waste management as a professional practice which goes beyond the physical aspects of handing 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 settlement in order to protect the health and well-being of the population and the environment. Effective waste

Management is, however, a growing challenge to all District/Municipal, especially in developing countries.

2.4 Classification of Waste

Construction waste can culminate as a result of different causes and situations. Construction waste falls into different categories namely: physical non physical waste as shown in **Fig. 2.1.**In common, physical waste is generated in the form of material loss. Material loss occurs in two forms, namely: Direct and Indirect waste. Direct waste consists of complete loss of materials, due to the fact that they are irreparably damaged or simply lost. In this case, the wastage usually needs to be removed from the site. (Formosco et al. 2002). Shen, Tam, Chan, and Kong, 2003), defined direct waste as the loss of those materials, which were damaged and could not be repaired and subsequently used, or which were lost during the building process whilst indirect waste occurs when materials are not physically lost; causing only a monetary loss for example, waste due to concrete slab thickness larger than specified by the structural design (Formosco et al. 2002). Indirect waste arises principally from substitution of materials, from use of materials in excess of quantities allowable under the contract, and from errors as sometime demolished and rebuilt (Shen et al, 2002).

These forms of wastes contribute to a significant part of landfill. Studies show that construction industry produces large amount of waste and more than 50% of waste material is deposited in landfill (Hwang, and Yeo, 2011). Bossink and Brouwers, (1996), reported that almost 26% of landfill occupied with construction waste.

Table (2.1) summaries the various forms in which direct and indirect waste can occur.

Table 2.1: Classification of waste

Principal Types	Forms of the Principal Types
	▪ Substitution, where materials are used for purposes other than those specified. ▪ Production waste, where materials are used in excess of those indicated or not clearly defined in contract documents, e.g. additional concrete in trenches, which are extracted wider than designed because no appropriately sized digger bucket was available ▪ Operational waste, where materials are used for temporary site work for which no quantity or other allowances have been made in the contract documentation, e.g. tower crane bases, site paths, temporary protection. ▪ Negligent waste, where materials are used in addition to the amount required by the physical waste financial waste materials man-hour. Equipment material purchase. Due to physical waste. Waste according to the type of resource consumed contract, owing to the construction contractor's own 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 material 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 stilled 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 plants. This covers plants running when not in use, or not employed to its optimal use. ▪ Management waste includes losses arising form an uneconomical decision and not related to anything other than poor organization lack of supervision. ▪ Waste caused by other trades. This 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. This includes waste

	stemming from materials wrongly specified and waste due to errors, particularly in the bill of quantities and specification. ▪ Waste that is usually caused by apprentices, unskilled tradesmen, and tradesmen on new operation.

Source: Skeyles (1987:19)

2.5 Quantifying Waste

The amount of C & D waste produced depends on several variables. Donovan (1992) suggests that the amount of C & D waste generated at the national levels depends on:

- ❖ The extent of growth and overall economic development that drives the level of construction, renovation, and demolition.
- ❖ Periodic special projects, such as urban renewal, road construction and bridge repair and unplanned events, such as natural disasters.
- ❖ Availability and cost of hauling and disposal options.
- ❖ Local State and Federal regulations concerning separation, reuse, and recycling of C & D waste.
- ❖ Availabilities of recycling facilities and the extent of end-use markets.

There are few comprehensive estimates of C & D waste generation rates at the national level. It has been either historically aggregated into the municipal solid waste data, or not accounted for since there are so many non regulated disposal options. Bruckner (1997) estimates that the quantity of C & D debris generated are over 100 million tons per year. This equates to almost 35 to 40 percent of the total amount of Municipal/District solid waste.

According to Shen et al (2004) the lack of standard guidance for setting up proper waste management procedures on site and lack of contractors imitative for engaging in proper waste management practices account the high level of material waste during construction phase of projects. According to Ekanyake and Ofori (2000), a study about waste arising from materials storage and handling reveals that the four key materials which are wasted most on construction site are timber, cement/mortar, concrete and blocks (Table 2.2). Means scores of all the key materials evaluated are significantly greater than the neutral score of 3.00 (p=0.05) when the

t-test was applied. Thus, the respondents agree that timber, cement/mortar, concrete, blocks, steel, quarry chippings, paint, sand pipes all contribute to the generation of waste on construction site.

Tables 2.2 Level of Contribution of key Construction Materials 'to Wastage on Construction site

Materials	Mean	Standard deviation	T-Value	Sig	Ranking
Timber	4.289	0.860	26.462	0.000	1
Cement mortar	4.205	0.902	23.607	0.000	2
Concrete	3.888	0.880	17.812	0.000	3
Blocks	3.843	1,087	13.701	0.000	4
Steel	3.721	0.940	13.553	0.000	5
Quarry chippings	3.612	0.860	12.572	0.000	6

Paint	3.561	8.854	11.601	0.000	7
Sand	3.471	1,054	7.893	0.000	8
Tiles	3.337	0.760	7.821	0.000	9
Pipes	3.093	1,031	1, 593	0.000	10

Ekanyake and Ofori, (2000)

These results confirm findings in the literature which list concrete, cement/mortar, timber, blocks and steel as the major materials wastage on construction sites (Wang et al, 2008; Shen et al, 2002; Formoso et al, 2001, Garat et al, 2001, Ayarkwa and Adinyira, nd)

2.6Waste minimization strategies on construction projects

The Environmental Protection Agency (EPA) of United State (2000) as' any system that reduces the volume of toxicity of a waste that requires disposal. In a practical sense, it is any method that reduces the amount of waste. Government regulations, as well as internal cost effectiveness, require that the production and therefore the disposal of all wastes, and particularly hazardous waste be kept to a minimum.

Waste minimization is defined by Poon et al, (2004) any technique, process or activity which avoids, eliminates or reduces waste at source or allows reuse or recycling of the waste, any practice or process that avoids, eliminates or minimizes waste at source.

Practitioners in the waste and environmental pollution fields recommend that minimization of waste at source should be given the at most priority when developing

strategies for waste minimization. This is because, conceptually, it makes more sense to avoid or minimize the generation of waste than to develop extensive schemes for treating waste.

The Environmental Protection Agency of UK describes waste minimization as the reduction of waste at source by understanding and changing processes to reduce and prevent waste.

(Hoe, 2006), Also known as process or resource efficiency, waste minimization includes the substitution of less environmentally harmful materials in the production process (Hoe, 2006). The waste minimization process involves systematic prevention or reduction of raw material, water and energy consumption and the reuse and recycle of waste on site. It focuses on the term. Reduce, Reuse, and Recycle" with disposal of waste being a last resort. This has financial benefits for businesses by reducing operating costs and minimizing the environmental impact (Hoe, 2006), waste minimization, a generic term in preferred hierarchy of waste management, is often the preferred method of managing waste to achieve the broader environmental objectives of the environmental management system (Hoe, 2006). This system can involve changes to the raw material input, the production process and/ or the final product. It can be achieved through simple procedural alterations, or through major changes that may involve or often justify significant capital expenditure the benefits of minimizing waste include (Hoe, 2006).

- Reduce demand for landfill space
- Saving resources and energy
- Reducing pollution, and
- Increasing the efficiency of production.

The main resources for managing C & D wastes are divided into four categories, namely; recycling, reusing or salvaging; source reduction/waste minimization' and incineration. Incineration, or waste to energy (WTE) technologies, provide waste disposal option as some C & D waste are simply burned with most other types of municipal solid wastes (MSW) to provide energy.

Tam and Tam (2006) call three basic waste minimization strategies, reduce, recycle and reuse" as "3Rs". Within these three, reduction of waste is seen as the most desired strategy by most authorities. For example, Gavilan and Bernold (2004) denote it as the best and most economical option that requires: cause and effect relationship: understanding. Begum et al, (2006), also call reduction as the most efficient solution that minimizes most problems related to waste.

Reduction option includes strategies existing in the supply chain management and material management practices. Within these strategies, just –in-time (JIT) delivery, controlling storage levels to stay away from excessive ordering, managing design to avoid over specification, increasing off-site prefabrication usage, providing supplier flexibility in procuring smaller amounts of materials, education workers and developing waste consciousness among them can be counted (Dainty and Brooke, 2004. Being a recent concept, JIT delivery is one of most attractive measures among these. JIT is a synonym of "stockless production" (Tersine, (1994), it aims is to improve productivity and minimize waste. The main idea is procuring just the right quantity at the time of production. This, according to Tersine (1994), this strategy considers stock materials as the amount that is planned for waste, and as the quantity of material on site decreases, there will be less for waste. However, it has some

disadvantages. For example, in order to modify JIT concept according to uncertain nature of construction industry, a buffer level of time should be included, which can only be achieved by effective management (Pheng and Chuan, 2001). In addition, applying this concept only to single project will cause problems due to temporary nature of the construction industry, thus it should be adopted as an organizational philosophy (Mc George and Palmer, 2002).

Recycling and reusing, considered as the other waste minimization strategies, are highly effective in developed countries. Recycling involves extracting, processing and reincorporating materials back into original or new products. Reusing or salvaging is a similar process except that instead of reprocessing and reincorporating material into products, the waste materials are extracted and reused with little or no processing. Reusing and recycling waste refers to the re-using and recycling of waste materials, thereby reducing the volume of waste material to be disposed of and discharged into the environment (Faniran and Caban, 1998), According to Australian Blue Book – Australian Waste Industry (2008) within 2006-2007 data from National Waste Report 2010 showed that 22,707,000 tones or 52 percent of Australian's waste was recyclined out of which 42 percent was from C & D waste stream.

In 2004-2005 C & D waste generation in Australia was 15.1 million tones, of which 7.6 million tones was recycled materials (timber, steel, concrete, rubble and soil) and 7.5 million tones was residual waste to landfill. In 2006-2007, 43, 777.000 tons of waste was generated, 38 percent of which was form the C & D steam. Researchers and reality show that it is possible to recycle 90% of C & D waste (Begum et al, 2006).

In other words, reusing and recycling may give an advantage of 2.5% of total construction cost as Begum et al (2006), indicate. Needless to say, these strategies play important role

environmentally, too.

There are several other strategies such as bar-code system application. "Global Positioning. System (GPS)" and "Geographical Information System (GIS)" technologies. As Chen et al, 2002) indicate, the bar-code system not only tracks the flow of material and within the site, but also measures the worker's performance in terms of amount of materials they wasted. The system helps in quantifying the materials taken and returned by each working group. On the other hand, li et al, (2005), point out another technology that combines this bar-code system with GPS and GIS to let the personnel on site and in headquarters track the materials during transportation and get concurrent information about its arrival time.

As they indicate, both bar-code system and GPS and GIS technologies are based on "incentive reward program (IRP)", which encourages the workers to reduce material waste and prizes them according to the quantity of the materials they saved.

The contribution that the source reduction, re-use and recycling industry can make to lower the embodied impacts of waste in building is significant. Communicating the benefits of re-use and recycling and highlighting how barriers have been overcome will help to address the misperception that reuse of C& D wastes in infrastructure is novel, difficult and risky. This will stimulate greater re-use and recycling of C & D waste across the supply chain. Effective waste management is of growing significance for the construction industry. Adding the cost of storing and transporting construction

waste, along with the loss of revenue from not reclaiming waste materials, it makes financial sense for construction companies take action to minimize waste.

Figure 2.1 and 2.2 illustrate the proposed waste management and minimization hierarchy respectively.

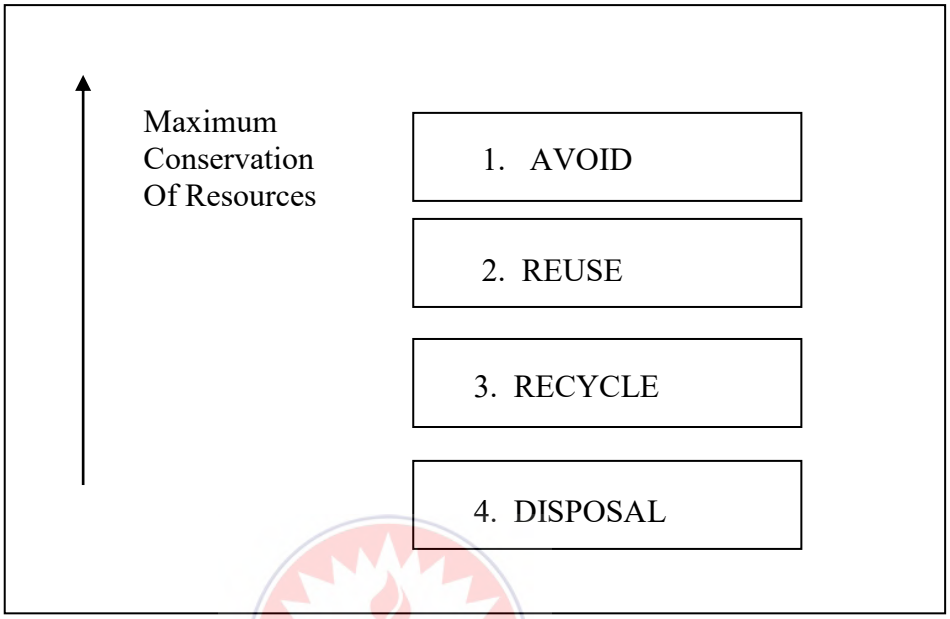

Fig. 2.1 Waste Management Hierarchy (Faniran and Caban, 1998)

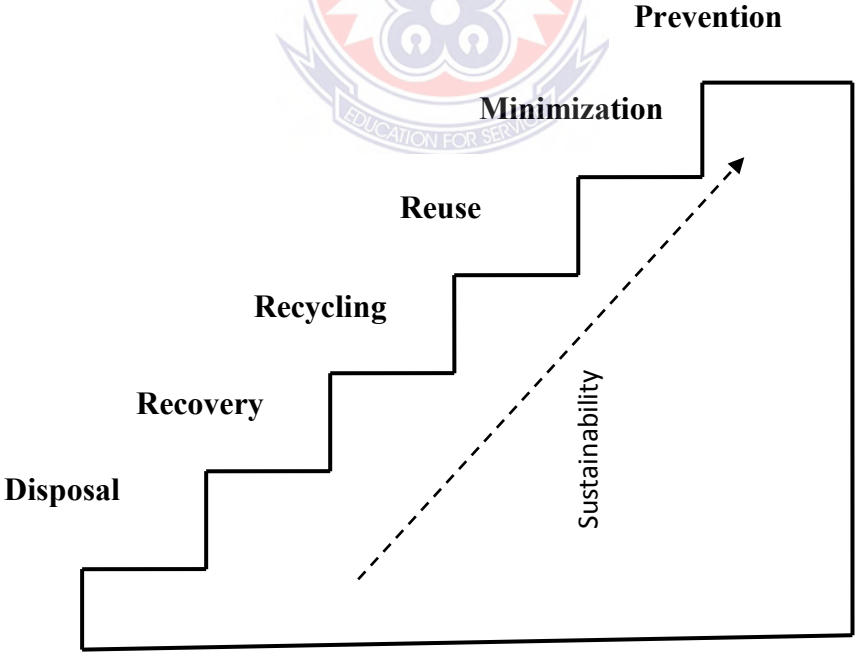

Fig.2.2 sustainability Waste minimization hierarchy in 1998 (Poon et al,2004)

2.6.1 Prevention

According to Ekanayeke and Ofori (2000), prevention is also referred to avoid, which is the best way to manage waste. This is the highest level in the need for sustainability. Nevertheless, these are a few challenges which have to be tackled by practitioners mainly during pre-construction stage. Designers need to take into account the technical information about construction process during the design stage to avoid construction waste (Poon et al, 2006). It can help in preventing construction waste, as studies show that error and frequent change in design will always be the waste generating factors (Faniran and Caban 1998). In Hong Kong and Malaysia the prefabrication technique has been used as a solution to prevent waste generation during design phase. However, prevention of wastes requires a fine coordination among all those involved in construction process.

Thus it is paramount to have a very good rapport and communication with and within the construction community, i.e. the contractors, consultants and clients, to avoid any miscommunication or untoward happenings. Lack of communication and discussion could lead to misunderstanding and the generation of more waste. Therefore, various improvement methods should be implemented frequently to experience the benefits of the approach on excellent management toward sustainability in construction waste.

2.6.2. Minimization

Reduction was ranked as the second most preferable way in managing construction waste. These steps reduce destruction on environment and reduce construction cost. However, minimization from beginning of projects will reduce resources usage and reduce transportation works (Wang and Li 2011). Hence, minimization talent needs to

embark and practice for reducing the waste at source of generation. Due to the running out of reclamation sites and landfill space in Hong Kong, researchers urge to have site inspection regularly and a waste management plane for the reduction of waste. (Wong and Cheung 2004). Therefore, waste minimization is obviously important for sustainable practice. The authorities in the country's construction field, taking minimization manner for achieving sustainability and lessen the usage of land (Ekanayeke et al 2004). However, the need is for the contractors to support and land (Ekanayeke et al, 2004).

It is now prudent and good practice to develop a construction waste management plan. The key objective of any construction waste management plan should be to:

- Minimize the amount of waste generated as part of the project.
- Maximize the amount of material which is sent for reuse, recycling or processing
- Minimum the amount of material sent to land still.

However the need is for the contractors to support and play their utmost role for the enhancement of this sustainable step.

2.6.3 Reuse

Apart from prevention and minimization, most countries use this approach to reduce construction waste at site before disposing them to landfills. In Germany, a very advanced waste handing technology was developed to reuse construction materials. The technology used by Siemens Company is a three step process which includes drying, distillation and burning of waste technique to enable the waste material to be reused as cited in Economist reference paper. In Hong Kong, the materials at site in

promoting the reuse approach in waste management. These sorting actions enable the reuse of some of the generated waste (Poon et al 2004). Equally, another study stated that a trip-ticket scheme in Hong Kong encouraged separating inert waste for possible reuse. (Lam et al, 2011) consequently, there are many types of reuse technique in constructions. Some of the construction used broken bricks and stones as a sub-grade of access road to the construction site (Wang and Li, 2011). They also used construction materials such as timber or plywood to build their temporary shed at site.

2.6.4 Recycle

The number one reason for recycling in any sector is the positive impact it has on the environment. By reducing the use of virgin resources, construction companies can lowest their carbon foot print tremendously. Some developed countries such as Germany and Hong Kong obtain these steps to reduce disposal waste in landfills. In Germany, the government supported the recycle activity very well. Study on raw material of light weight concrete shows commitment of the country in sustainability. Moreover the country is committed to collect a million tons of glass every year for recycling purpose. This shows the country is fully gear to become a green nation (Krali, 2011). Meanwhile, in the case of Hong Kong, recycle aggregates for concrete and paving blocks have been promoted by the government (Lam et al 2011). Wang and Li have reported that Holland government has utilized legislative power construction players in recycling process. This is in accordance with the findings as in Yuan (2012, which states that waste land filling charge is an effective instrument for forcing contractors and developers to reduce waste.

2.6.5 Recovery

In the hierarchy of construction waste management, recovery ranked fifth in its priority. Recovery which is defined as the removal of materials or components form the waste stream in a manner to keep its original form for reuse in the similar form as it was produced. With recovery, the volume of waste ending up in a landfill can be reduced. In Germany, the incineration technology has assisted the recovery of metal waste. This recovery tools will cut off to 3 kilogram harmful heavy metal in 1 ton waste after distillation and burring process. Thus, this method resolved the problem effectively from taking space to the landfill. Moreover, gas produced during the handling process is used to generate electricity. The recovery steps also have been practiced in many countries. However, government has to support this process because the setting up of the recovery factory may require huge capital.

2.6.6 Disposal

This is the last option and can be labeled as the lowest criterion towards achieving sustainability in waste management. However many countries dispose their construction waste in landfills. For example in Malaysia, the Department of National Solid Waste Management revealed that about 289 landfills exist in the country (Nagapan et al, 2012). Furthermore, the study also stated that contractors' perception on direct disposal of construction waste to landfills has become a culture. Despite strong influence in the disposal of waste to landfill, Solid Waste Management and Public Cleansing Corporation (PPSPPA) and Construction Industry Development Board (CIDB) keep promoting recycling and Industrialized Building Systems (IBS) to reduce the amount of waste in landfills. Disposal method however, is not a favorable choice because the role of sustainable waste management is to reduce the amount of waste that is discharged into the environment.

2.7 Challenges in construction waste management

Increasing of population alongside rapid urbanization has come with challenges to waste management. These challenges are many and include unavailability of properly engineered disposal sites and waste treatment plants, inadequate haulage equipment and the lack train of expertise and appropriate technical knowhow.

According to Moses and Mensah (2015) Result show that rate of waste generation in Ghana was 0.47kg per day which translates into about 12,710 tons of waste per day. Ghana generates annually about 3.0 million tones of solid waste. Anomanyo (2004) and Boateng and Nkrumah (2006) specify that solid waste generated daily in Accra between 1500-1800 tones and was attributed to the rate of population growth in the Metropolis/Districts which stood at 3.5 per cent. However, the amount of waste contributed by construction companies is not known.

In recent studies conducted regarding the breakdown of waste in the central and southern region of Malaysia, 28 -34% of the total waste generated was contributed by construction and industrial waste-stream (Begum et al, 2006), whilst in the United States, Construction and Demolition waste have been estimated to make up 15-20% of all municipal solid waste (Brickner, 1994).

In Ghana, Boadi and Kuitunen (2004) pointed out some of the challenges affecting solid waste management. These include weak institutional capacity and lack of resources, both human and capital. Furthermore, a document from the Ministries of Local Government and Rural Development MLGRD (2004) summaries the challenges of solid waste management in Ghana as follows: poor planning for waste management programmes, inadequate equipment and operational funds to support

waste management activities, inadequate sites and facilities for waste management operations, inadequate skills and capacity of waste management staff, and negative attitudes of the general public towards the environment in general.

Therefore, it can be said that the main challenges facing solid waste management in developing countries and for that matter Ghana include: inadequate funds to support waste management, inadequate equipment to support waste storage, collection and disposal, low collection coverage and irregular collection services, crude open dumping and burring without air and water pollution control. Lack of enforcement, not embracing waste to energy.

Perhaps the biggest challenge of construction waste management is disposal cost. The construction of a single family home in the United States typically produces between two and four tons of debris (Jones 1993, Donnelly, 1995). Home construction activities generate a large amount of waste that is becoming increasingly expensive to discard. The strain caused by increasing waste disposal costs for builders is seen in the rise in average tipping fees across the country: from $4.90 per ton in 1976 to $34.00 per ton in 2002 (Yost, 1995, Chart well Information, 2003). In a study of home construction firms, 65% of survey respondents indicated that the costs for disposing of construction debris negatively affect the economic health of their companies (Austin, 1991).

In addition, from the perspective of home buyers, these costs also have negative impacts on the affordability of homes. Aside the costs of disposal, questions related to

the squandering of resources and declining availability of landfill space require that this situation be addressed systematically, in both new construction and rehabilitation.

Another study conducted by Tang et al, (2003) to investigate the collection and transport of construction waste in Kuching City, Sarawak, identify the disposal of construction waste generated from construction activities is the responsibility of the developer or contractor. In most cases, construction waste is normally transported by private contractors,, in which the construction waste usually ends up at their own premises or re-allocated within the construction site for land filling or future construction purposes. However, the waste transported from small scale construction or renovation works is believed to be disposed of at illegal dump sites. This statement is supported by illegal dump site field surveys (Tang et al, 2003).

Based on the survey conducted by Natural Resources and Environmental Board (NREB) and Danish International Development Agency (DANIDA), it is estimated that about 50% of the construction waste does not leave the site.

It is either used for the preparation of site-works, left on site, or even openly burnt. The remainder is fly-tipped at informal dumpsites on private land and illegally dumped at road reserves or idle land. Scrap metal is usually collected for recycling due to its high resell value of present date (Tang and Larsen 2004). Thus only a small amount of construction waste was actually legally dumped into public landfills. Currently, there are no official facilities in Kuching City for the treatment of construction waste. Based on the surveys, it can be concluded that a majority of the construction waste generated is 'informally' land filled, with significant quantities

being dumped illegally in rural areas, road reserves or land filled on private land (Tang et al, 2003).

Research conducted by Jonathan et al, (2003), in Hong Kong identified some hurdles preventing construction firms from adopting sustainable waste management programs. One of the most important issues regarding sustainability is waste management following a project's completion. The study revealed that while small subcontracting firms have almost no means to properly manage waste, larger construction firms do have some means available to them. One inhibitor for smaller firms compared to larger firms is the lack of funds for equipment and training in sustainable means of waste management.

According to an industry professional the costs of an environmentally-friendly business plan for construction over its lifetime were far less than the costs of current practices (Tang et al, 2012). It further states that if subcontractors are trained to sort waste on site, then recyclable can be removed from the waste to be disposed of. The cost of construction waste disposal, per the charging schemes by weight, is then reduced in all future projects. The industry is loosely organized due to the size of the firms, so information may not spread too efficiently.

Many companies also lack legal knowledge so they are unaware of environmental regulations and programs. Finally, depending on the size of projects, a smaller plot can also mean very limited space for waste.

Therefore immediate disposal would be necessary and time would be too short to waste on separation for recycling. Better practices need to be identified, and implemented, so that SMEs can overcome the hurdles of sustainable waste management. Another study conducted by Mou (2008) in Hong Kong outlined lack of strong government will, No-Error mindset embedded in government culture, insufficient legislative procedure and administrative system, insufficient incentives to stakeholders. Others are insufficient incentives for private projects to implement waste reduction measures, no attention on waste reduction at the planning and design stage, lack of a well developed recycling industry and market for recycled products and finally conflicting objectives and confusion of jurisdiction across government departments, are some barriers of construction waste management in Hong Kong.

2.8 Effective Measures of Managing C & D Waste

In order to manage C and D waste effectively, it is important to identify the sources or causes of its generation. It is necessary to state that most of these sources of waste generation about half of solid waste generated World Wide are from building materials. There is an environmental impact of building materials at every step of building process are due to human errors occurring at different stages of a construction process (Chung and Lo, 2003). Gavilan and Bernold (1994) identify the reasons of waste as “design, procurement, handling of materials, operation, residual waste and others,. On the other hand, building Research Establishment (BRE) divides it into four as design, take off or specification, delivery and site waste” (Williams, 2004). Shah (1988) also classifies these sources under six different headings as “planning and design, purchasing, transportation and handling, storage, production or repairs and consumption: all relate to the attitude and waste awareness of workers.

There are other classifications found in literature. However, there is a great commonality within these descriptions of the reason of C and D waste generation. Almost every source considers "design" as the major source of materials waste.

A research conducted in UK construction industry by Saunders and Wynn (2004) shows that site management quality, poor material handling and storage, poor design, lack of care by operatives and lack of education about waste awareness are the main factors affecting the level of waste in construction. They add that, these results put forward the important of worker's talent and approach in the generation of waste. The worker's inclination and desire to work collectively together with their awareness highly affect the waste.

Rework may be another reason as accepted by many researchers. It is simply defined by Love and Sohal (2003) as, "doing something at least one extra time due to non-conformance to requirement". Researchers showed that 50% of these rework were due to design and 40% were due to construction errors; and according to Karim et al, (2006), these construction error were causes of carelessness and negligence of the workers. It is also stated that cost of rework may vary between 3 and 15% of total construction cost (Love and Edwards, 2004). These findings prove the effectiveness of design in waste generation.

Packaging is also included in construction waste and considered as a big problem by some researchers and writers (Gavilan and Bernold, 1994). However, taking into account that packaging of construction materials is an indirect waste of construction process, it will not be taken into consideration within the scope of the study. The

sources of waste generation discussed above brought to the fall that, effective construction waste management could not be tackled at one point but must be looked at holistically.

The adoption of Waste Management hierarchy may be one of the best methods of effectively managing construction waste. Waste management hierarchy is a hierarchy of waste management options for waste management. The waste hierarchy prioritized the prevention and reduction of waste, then its reuse and recycling and lastly the optimization of its final disposal. It is because end-of-pipe management could only recover waste or reduces waste bulk after the waste has been produced, where changes in product design and consumption patterns could prevent and reduce the overall waste production. The concept is described by the "3Rs". Reduce, Reuse and Recycle – followed by unavoidable disposal (Eco Recycle, 2000; SITA UK, 2004.

The Department of Environment and Climate Change, 2008) 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"

According to Poon and Jaillon (2002) any techniques, process or activity which avoids eliminate or reduces waste at its source or allows reuse or recycling of the waste is an effective measure of dealing with waste. However, re-using and recycling do not avoid the generation of waste (although these approaches serve to reduce the quantity of waste to be ultimately disposed of and treated) Faniran and Caban, 1998).

Ekanayake and Ofori (2000) and Polat and Bollard (2004) examined architects approach towards construction waste management in UK and found out that waste could essentially arise from design decisions. The authors therefore emphasized the need for waste management in the design process. Begum et al (2006) studied waste minimization measures in the implementation of waste management in the Malaysian construction industry and reported on highly practiced measures to reduce waste in Malaysia. Al-Moghany (2006) identifies the main waste causes in Gaza Strip construction industry in order to develop methods for prevention and elimination of develop of waste causes inherent in the construction process. The recommendations of the study was to ask designers to pay attention to detailing and dimensioning of materials and components during design and contractors should assign qualify personnel to construction projects and prepare waste management plans Polat and Ballard (2004). In the Turkish Construction Industry, a study conducted by Shen et al (2002)) about material wastage on public, private and commercial projects. The results proposed measures for waste minimization on site including good construction management practices, provision of waste reduction training to on-site staff and adoption of proper site management techniques.

A study conducted by Poon et al (2001) on on-site sorting of construction and demolition waste on public building sites and recommended a number of measures for effective waste minimization including adoption of proper site management techniques, training of construction personnel, on-site sorting of materials, re-use and recycling.

According to Teo and Loosemore (2001) the significant contribution to waste reduction in the construction industry is through people changing their wasteful behaviour. Waste is an inevitable by-product of construction activity; its management is a low project priority with an absence of appropriate resource and incentives to support it (Teo and Loosemore, 2001). Their findings complement Lingard et al's (2000) study which identified the availability of local infrastructure and top management supportiveness as the most critical determinant of waste reduction behaviour on projects. Their recommendations to help managers improve operative attitudes towards waste include clear communication of waste management policies, provision of necessary waste infrastructure, the cooperation of and promotion of sense of cooperation responsibility among the workforce. Table 2.3 determines and enumerates the causes of material waste in construction from the one having the highest frequency to the one with lowest frequency.

Table 2.3 Main causes or sources of material waste in Turkish Construction

SOURCE	CAUSES OF MATERIAL WASTE	FREQYEBCT (%)
Design	Lack of information about types and sizes of material on design document	13
	Design changes and revisions	12
	Error in information about types sizes of materials on design documentations	10
	Determination of types and dimensions of material without considering waste	3
	Ordering of materials that do not fulfill project requirement defined on design documents	86
	Over ordering or under ordering due to mistake in	

Procurement	quantity surveys	8
	Over ordering or under ordering due to lack of coordination between warehouse and construction crews	4
Material Handling	Damage of materials due to deficient stockpiling and handling of materials	16
Operation	Imperfection planning of construction	61
	Worker\s mistakes	32
	Damage caused by subsequent trades	3
Residual	Conversion waste form cutting uneconomical shapes	22
Others	Lack of onsite material control	23
	Lack of waste management plan	10

Source: (Polat and Ballard, 2004).

2.9 Regulation in Construction Waste Management

According to the Ministry of Local Government and Rural Development (MLGRD, 2004), general waste management in Ghana is the responsibility of the MLGRD, which supervises the decentralized Metropolitan, Municipal and District Assemblies (MMDAs). However, the ministry indicates that, regulatory author is vested in the Environmental Protection Agency (EPA) under the auspices of the Ministry of Environment and Science. The MMDAs are responsible for the collection and final disposal of solid waste through their Waste Management Departments (WMDs) and their Environmental Health and Sanitation Departments (EHSD).

Regulations for disposal of construction and demolition wastes (C&D) wastes have not been stringent as those of Municipal solid waste (MSW). In many cases, C & D

landfills, sometimes called clean fills, demo fills, or rubble fills, are separated from the (MSW) landfills and do not receive the same scrutiny as MSW waste (Brickner, 1994). Without the ability to specifically identify C & D waste going to landfills, government agencies such as EPA are unable to track, monitor, and quantify the total amount of waste accurately.

Whilst there are a number of provisions deemed available to regulate the management of construction waste in Sarawak, they are somewhat ineffective. According to surveys performed by Natural Resources and Environment Board. Sarawak (NREB), the existing provisions are currently not put into good use due to the fact that no consistent strategy or system of management is in place (Tang & Larsen 2004, Cheng et al 2001).

CHAPTER THREE

RESEARCH METHODLOGY

3.1 Introduction

This chapter outlines the methodology used in this research and provides information about the research design, population, sample and sampling techniques. It also identifies the instruments employed, developing and distribution of questionnaires and data analysis.

3.2 Research Design

The research design is the overall plan for obtaining answers to the question being studied and for handling some of the difficulties encountered during the research process (Polit and Hungler, 1999). Research design is an action plan for getting from 'here' to 'there' where 'here' may be defined as the initial set of questions to be answered, and there is some set of conclusion (answers) about these questions. Between here and 'there' may be found a number of major steps, including the collection and analysis of relevant data (Naoum, 1998). The design normally specifics which of the various types of research approach will be adopted and how the researcher plans to implement scientific controls to enhance the interpretability of the results (Polit and Hungler, 1999). To find the real fact and describe the conditions that exist concerning construction waste management practices, the research design adopted was descriptive survey.

Survey in statistics, is a method of collecting data in which people are asked to answer a number of questions usually in a form of questionnaire (Redmond.2006). Survey design was chosen in order to present documentary evidence that gives explicitly

statements about the research provide analyzed data for the guidance of future course of action. However, it is not without any weakness as the researcher has no control over the answers given by the contractors and the authenticity of some answers could be questionable.

3.3 Population

The population of the present study consists of Building Construction Firm operating within Ghana Registered with the Ministry of Water Resources Works and Housing (MWRWH) in four categories: D, K, E and G, based on the nature of work the firms engaged in building civil engineering, electrical and plumbing work respectively. There are four financial classifications within these categories - Class I, 2, 3, and 4 – which set the limitations for firms in respect of their assets, plants and labour holdings, and the nature and size of the projects they can undertake. Class 1 has the highest resource base, decreasing through 2 and 3, to class 4 having the least resource base (MWRWH, 2011). Site managers, supervisors and workers of D1 and D2 building construction firms who are registered with the MWRWH were involved in the study. Afadjato South was selected for the study because of its accessibility coupled with the fact that a wider courage could be achieved. Records in the Afadjato South Assembly revealed that the number of contractors registered stands at 84 as at September 14, 2020. This number was used as the study's population as the Afadjato South Assembly keeps an up to date record of contractors (The list of contractors is revised annually by the Assembly).

3.4 Sampling Techniques and Sample Size

The list of 84 constructors formed the sampling frame of the study. Site managers of D1 K1 and D2 K2 firms were the focus of the study mainly because such firms have the capacity to employ most of the waste minimization measures identified from the literature and confirm through the interviews as applicable to the Ghanaian construction industry. A sample size of 70 site managers of supervisors and workers D1 K1 and D2 K2studies by Israel (1992).

n=N/1+N (e) 2

Where is the sample size, N is the population size and e is the desired level of precision (5%).

3.5 **Data Collection Instrument**

Base on the research questions and literature gathered, questionnaire was designed to collect the data. A structured questionnaire was designed and the response categories were mutually exclusive and exhaustive (O'Rourke, 2002). This is to make questionnaires simple and easy. To make analysis easy the questionnaire was divided into sections that correspond to each research question. Respondents were to supply answers by ticking the appropriate rectangular box that corresponded to their opinion on a particular item they deemed correct. The accuracy of responses of respondents was checked using follow up questions and interview for further clarification and site visit.

3.5.1 Questionnaires

The researcher administered questionnaires to site managers, supervisors and workers. Questionnaires administered to each of the group was 56 totalling 168.

Among the issues raised in the questionnaire are delivery of materials, storage facilities environment regulation of materials, challenges of materials management on sites and cost of construction material. It also involved the impact of materials waste on the project cost and ways of ensuring materials waste on construction site are minimized.

3.5.2 Interview

The interview was conducted for site managers, supervisors and other workers of various construction companies in the Afadzato South District for the study. Areas covered in the interview were waste minimization strategies, effective measures put in place to managing waste on project site and challenges in construction waste management.

3.5.3 Observation

The researcher visited various construction site to carry out observation exercise on both public and private ongoing projects in the Afadzato South District. At the Afadzoto District Assembly Compound where Administration complex is being built, the researcher observed the handling and storage of materials and the minimization of waste of materials.

A visit to Golokwati basic school where a classroom block is under construction, the researcher observed the mixing of mortar, concrete and its utilization.

At the Easting Corridor road through have to Hohoe currently under construction, the researcher observed the demolition of existing structures, preparation of formworks and casting of concrete.

Another visit to have Technical Institute premises where renovation works are being carried out, observation was made on the removal of the savageable item and handling and storage of timber members. Attached is some pictures of issues associated with waste reduction observed during the visit

3.6 Data Analysis

The data gathered using the designed questionnaire was coded and analyzed with the aid of Statistics Package for Social Sciences (SPSS) Version 17. The software was used to generate frequencies and percentages. Also bar charts and graph produced out of the data gathered helped to analyze and compare the responses of respondents via drawing of conclusions. Record of observation was also collated and evidence of waste reduction, elimination and reuse of waste and methods of disposal of waste took centre stage.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter present the result and the analysis of the data gathered from questionnaires, interviews and observation.

4.2 Result and Discussion of Questionnaires

The results were obtain from the questionnaires that were distributed. Fifty six (56) questionnaires were sent to site managers and eighteen (18) was retrieved after a lot of follow up.

4.2.1 Results and Discussion of questionnaires from site managers

The result of questionnaire from the site managers are presented in this section of the study

Demographic of respondents

The characteristics of the respondents covered area of specialization, education, year in construction and position in the company. Table 4.1 present the background information of respondents area of specialization, education and position in the company.

Table 4.1: Descriptive Analysis of Demographic Characteristics of Respondents

Managers

Variable	Details	Frequency	Percent
Classification of Construction Company	D1K1	8	44.4
	D2K2	5	27.8
	D3K3	4	22.2
	D4K4	1	5.6
Area of Specialization	Building Construction works	11	61.1
	Civil Engineering Construction works	1	5.6
	Electrical Installation works	1	5.6
	Building and Civil Engineering works	4	22.2
	Plumbing Installation works	1	5.6
Education in Management	Yes	17	94.4
	No	1	5.6
Years in Construction	2 – 5 years	3	16.7
	6 – 10 years	8	44.4
	11 - 15 years	2	11.1

	16 years and above	5	27.8
Position in Company	General Manager	5	27.8
	Site Manager	7	38.9
	Building Manager	6	33.3

The sample size for the study was a total of 48 respondents, involving managers, supervisors and workers of construction firms considered under the present study. Specifically, there were eighteen (18) of the respondents who were managers of construction firms; eleven (11) of the respondents were supervisors of construction firms; and nineteen (19) of the respondents were workers of construction firms.

Among the respondents, 17 managers representing 94.4% had education in management and 1 representing 5.6% had no education in management.

In the context of classification of construction firms, 8 respondents representing (44.4%) managed D1K1 classified construction firm; 5 managers representing (27.8%) managed D2K2 classified construction firm; 4 representing (22.2%) managed D3K3 classified construction firm; 1 respondent representing (5.6%) managed D4K4 classified construction firm. In terms of area of specialization, 11 managers representing (61.1%) of the managers were building construction specialists,1 respondent representing (5.6%) of the managers were civil engineering specialists; 1 respondents representing (5.6%) of the managers were electrical installation specialists; 1 managers representing (5.6%) of the managers were plumbing installation specialists; and 4 representing (22.2%) of the managers were both building and civil engineering specialists. For the number of years spent in

construction work, 3 respondents representing (16.7%) of the managers had spent between 2-5 years in construction field; 11 representing (44.4%) of the managers had spent between 6 -10 years in construction field; 2 representing (11.1%) of the managers had spent between 11 -15 years in construction field; and twenty seven point eight percent (27.8%) of the managers had spent between 16 years above in construction field.

In the context of position held in company, 5 representing (27.8%) of the managers held the position of general managers; 7 representing (38.9%) of the managers held the position of site managers; and 6 representing (33.3%) of the managers held the position of building managers.

4. 2.2 Result and discussion of questionnaire from site supervisors

Supervisors plays vital role sin supervision of construction projects due to technical knowhow and field of specialization their views were sought and discussed. Out of a total of fifty six (56) supervisors sampled for the study, only eleven (11) were retrieved.

Table 4.2 Demographic information of the site supervisors.

Supervisors of Construction Company

Variable	Details	Frequency	Percent
Area of Specialization	Building Construction works	5	45.4
	Civil Engineering Construction works	3	27.3
	Building and Civil Engineering works	3	27.3
Education in Management	Yes	7	63.6
	No	4	36.4
Years in Construction	Less than 2 years	1	9.1
	2 – 5 years	3	27.3
	6 – 10 years	3	27.3
	11 – 15 years	3	27.3
	16 years and above	1	9.1
Position in Company	Project Supervisor	9	81.8
	Site Foreman	2	18.2

Table 4.2 showed that, among the supervisors, 6 representing (63.6%) had education in management and 4 representing (36.4%) had no education in management.

In terms of area of specialization, 5 representing (45.4%) of the supervisors were building construction specialists; 3 representing (27.3%) of the supervisors were civil engineering specialists; and 3 representing (27.3%) of the supervisors were both building and civil engineering specialists. For the number of years spent in construction work, 1 representing (9.1%) of the supervisors had spent less than 2 years in the construction field; 3representing (27.3%) of the supervisors had spent between 2-5 years in construction field; 3 representing (27.3%) of the supervisors had spent between 6-10 years in construction field; 3 representing (27.3%) of the supervisors had spent between 11-15 years in construction field; and 1 representing (9.1%) of the supervisors had spent 16 years or more in the construction field. In the context of position held in company, 9 representing (81.8%) of the supervisors were project supervisors; and 2 respondents representing 18.2%) of the supervisors were site foreman.

4.2.3 Result and discussion of questionnaires from the workers

Workers of different field of specialization were sample in the study. Fifty six (56) questionnaires were sent to the workers, Nineteen (19) were retrieved.

Table 4.3 shows Demographic information of the workers.

Workers of Construction Company			
Variable	**Details**	**Frequency**	**Percent**
Area of Specialization	Building Construction	3	15.8

	works		
	Electrical Installation works	1	5.3
	Building and Civil Engineering works	13	68.4
	Mechanical Installation	1	5.3
	Plumbing Installation works	1	5.3
Years in Construction	Less than 2 years	1	5.3
	2 – 5 years	10	52.6
	6 – 10 years	6	31.6
	11 – 15 years	2	10.5

Position in Company	Carpenter	4	21.1
	Mechanic	1	5.3
	Mason	7	36.8
	Electrician	2	10.5
	Painter	2	10.5
	Plumber	1	5.3
	Laborer	1	5.3
	Foreman	1	5.3

Source: Author's computation based on survey data

Among the workers, 3 respondents representing (15.8%) of the workers were building construction specialists; 1 representing (5.3%) of the workers were electrical installation specialist; 1 representing (5.3%) of the workers were mechanical installation 1 representing (5.3%) of the workers were plumbing installation specialist; and 13 representing (68.4%) of the workers were both building and civil engineering specialists. For the number of years spent in construction work, 1 representing (5.3%) of the workers had spent less than 2 years in the construction field; 10 representing (52.6%) of the workers had spent between 2-5 years in construction field; 6 representing (31.6%) of the workers had spent between 6-10 years in construction field; and 2 representing (10.5%) of the workers had spent between 11-15 years in construction field.

In the context of position held in company, 4 representing (21.1%) of the workers were carpenters; 1 representing (5.3%) of the workers were mechanics; 7 respondents representing (36.8%) of the workers were masons; 2 representing (10.5%) of the workers were electricians; 2 representing (10.5%) of the workers were painters; 1

representing (5.3%) of the workers were plumbers, 1 representing (5.3%) of the workers were laborers; and 1 representing (5.3%) of the workers were foremen.

Components of Key Construction Waste Materials

Figure 4.1 captures the ranking of frequency of wood as a construction wastes are produced. From the figure 6 representing (31.3%) of the respondents produces construction waste in the form of wood very often; 4 representing (20.8%) of the respondents produces construction waste in the form of wood often; and 6 representing (47.9%) of the respondents produces construction waste in the form of wood not often

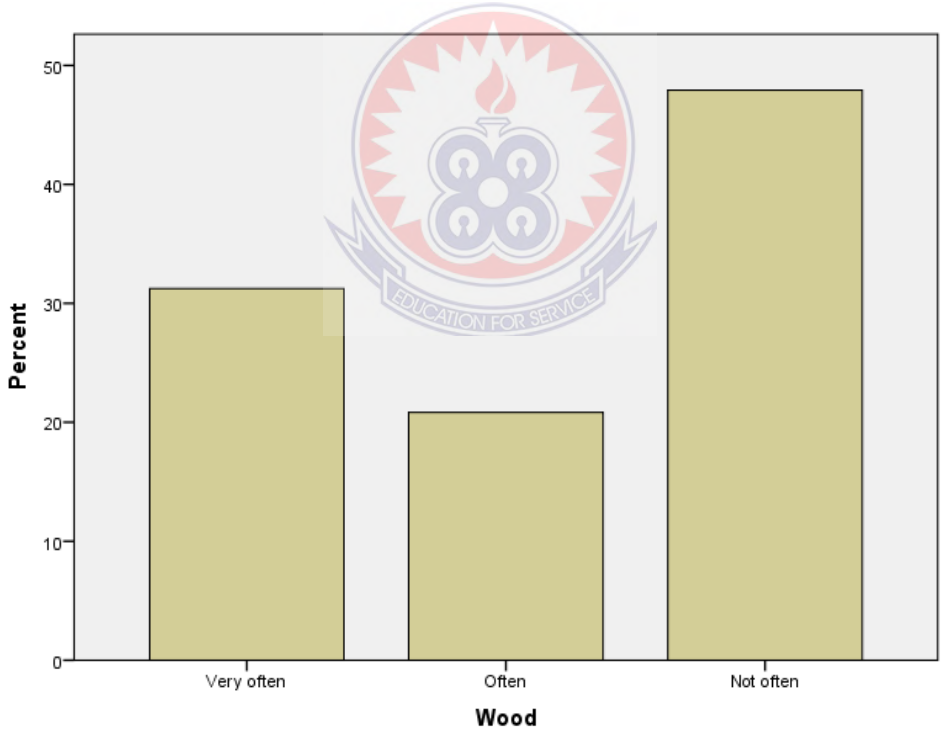

Figure 4.1: Ranks of Frequency of Construction Waste (Wood) Produced

Figure 4.2 revealed the ranking of frequency of metal as a construction wastes are produced. From the figure 3 representing (16.7%) of the respondents produces

construction waste in the form of metal very often; 4 representing (25%) of the respondents produces construction waste in the form of metal often; and 10 representing (58.3%) of the respondents produces construction waste in the form of metal not often.

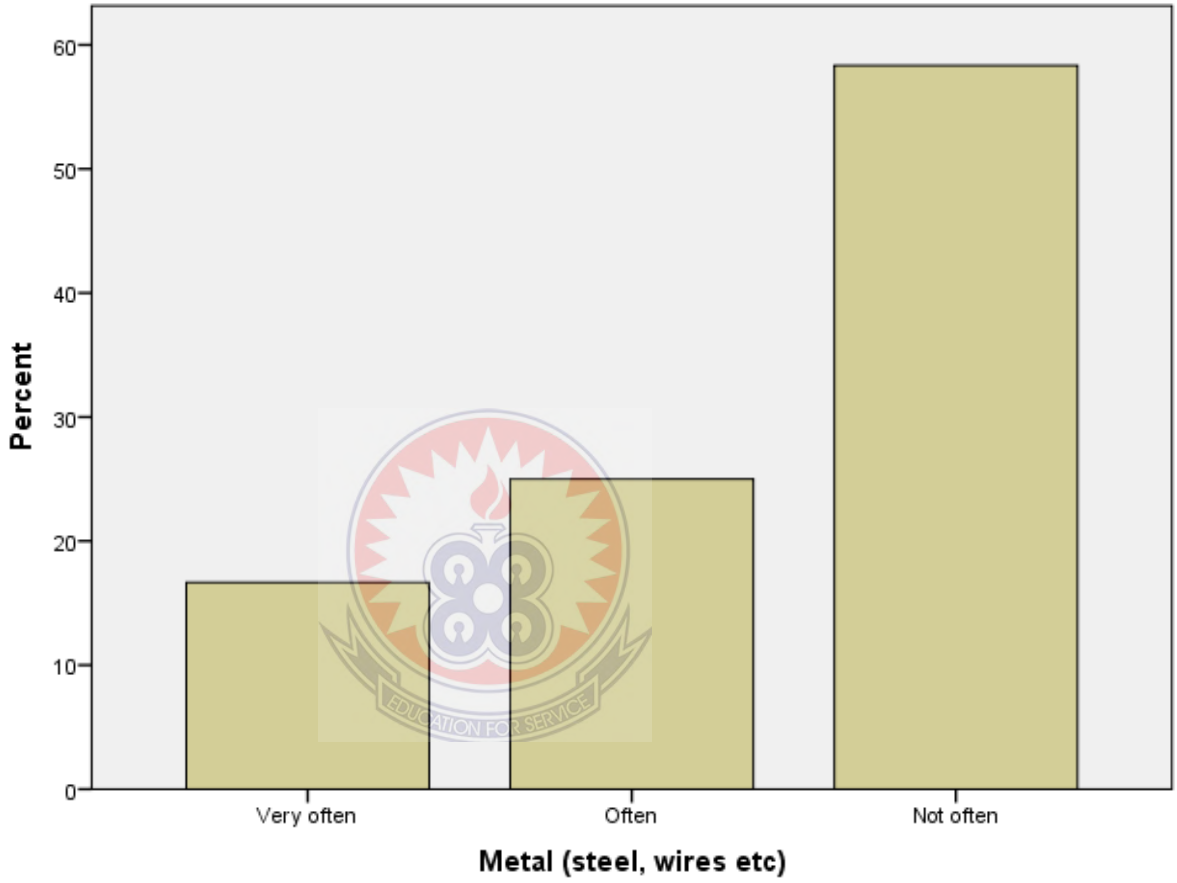

Figure 4.2: Ranks of Frequency of Construction Waste (Metal) Produced

Figure 4.3 showed the ranking of frequency of plastics as a construction wastes are produced. From the figure 6 representing (33.3%) of the respondents produces construction waste in the form of plastics very often; 5 representing (27.1%) of the respondents produces construction waste in the form of plastics often; and 8 representing (39.6%) of the respondents produces construction waste in the form of plastics not often.

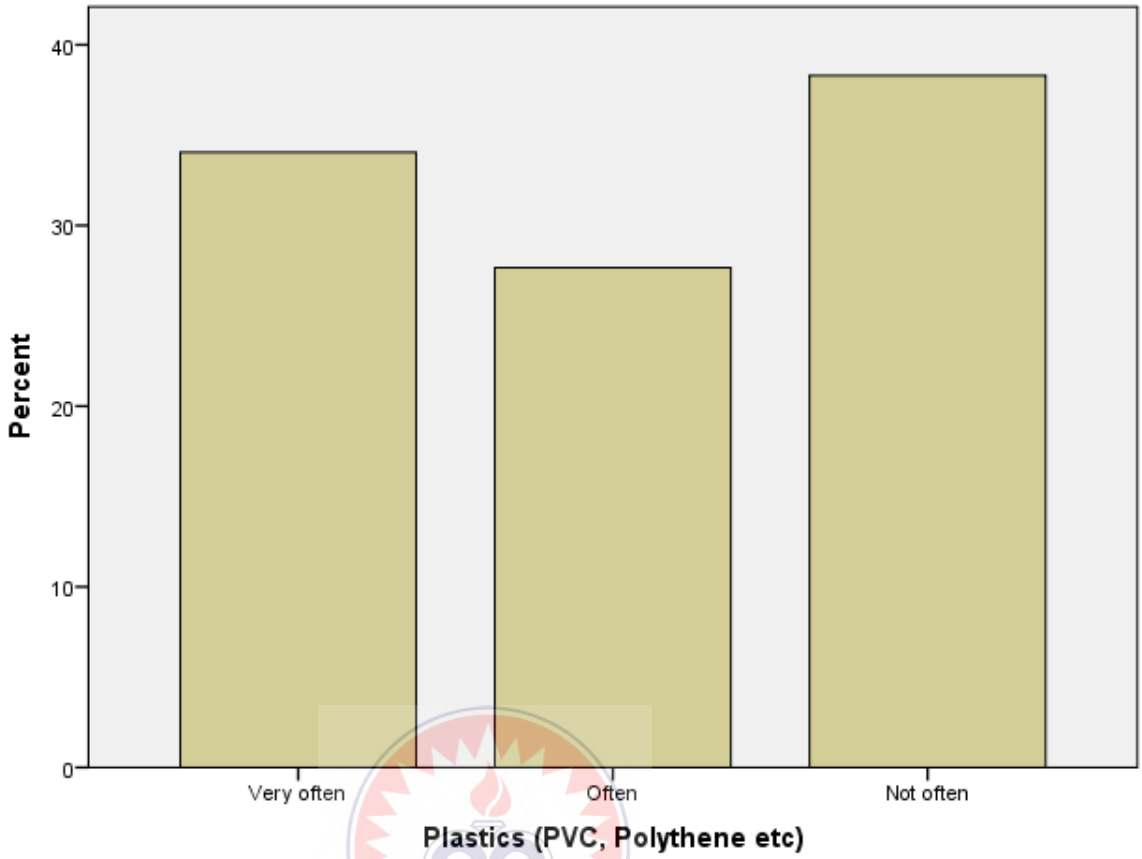

Figure 4.3: Ranks of Frequency of Construction Waste (Plastics) Produced

Figure 4.4 indicated the ranking of frequency of concrete/block/mortar as a construction wastes are produced. From the figure 4.4 thirty three point three percent (33.3%) of the respondents produces construction waste in the form of concrete/block/mortar very often; 6 representing (33.3%) of the respondents produces construction waste in the form of concrete/block/mortar often; 5 representing (27.1%) of the respondents produces construction waste in the form of concrete/block/mortar not often; and 2 representing (6.3%) of the respondents never produces construction waste in the form of concrete/block/mortar.

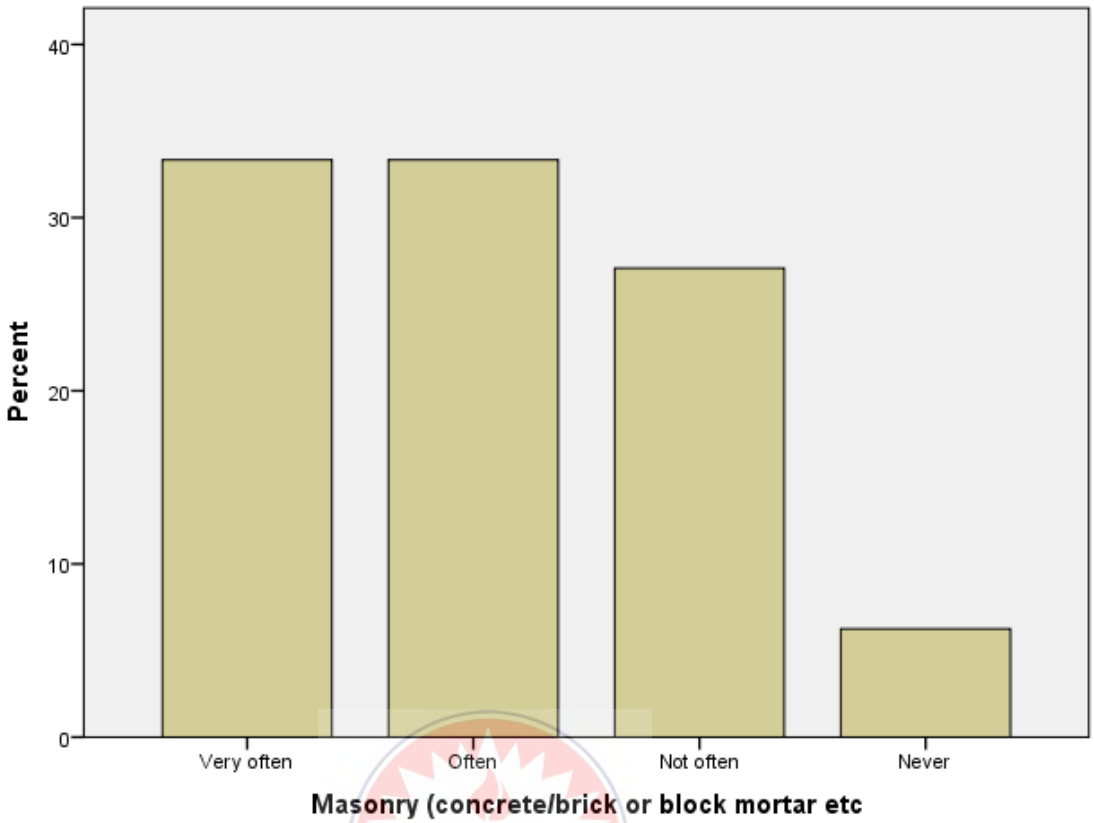

Figure 4.4: Ranks of Frequency of Construction Waste (Masonry) Produced

Figure 4.5 indicated the ranking of frequency of packaging materials as a construction wastes are produced. From the figure 1 representing (2.1%) of the respondents produces construction waste in the form of packaging materials very often; 12 representing (56.3%) of the respondents produces construction waste in the form of packaging materials often; 5 representing (27.1%) of the respondents produces construction waste in the form of packaging materials not often; and 2 representing (14.6%) of the respondents never produces construction waste in the form of packaging materials.

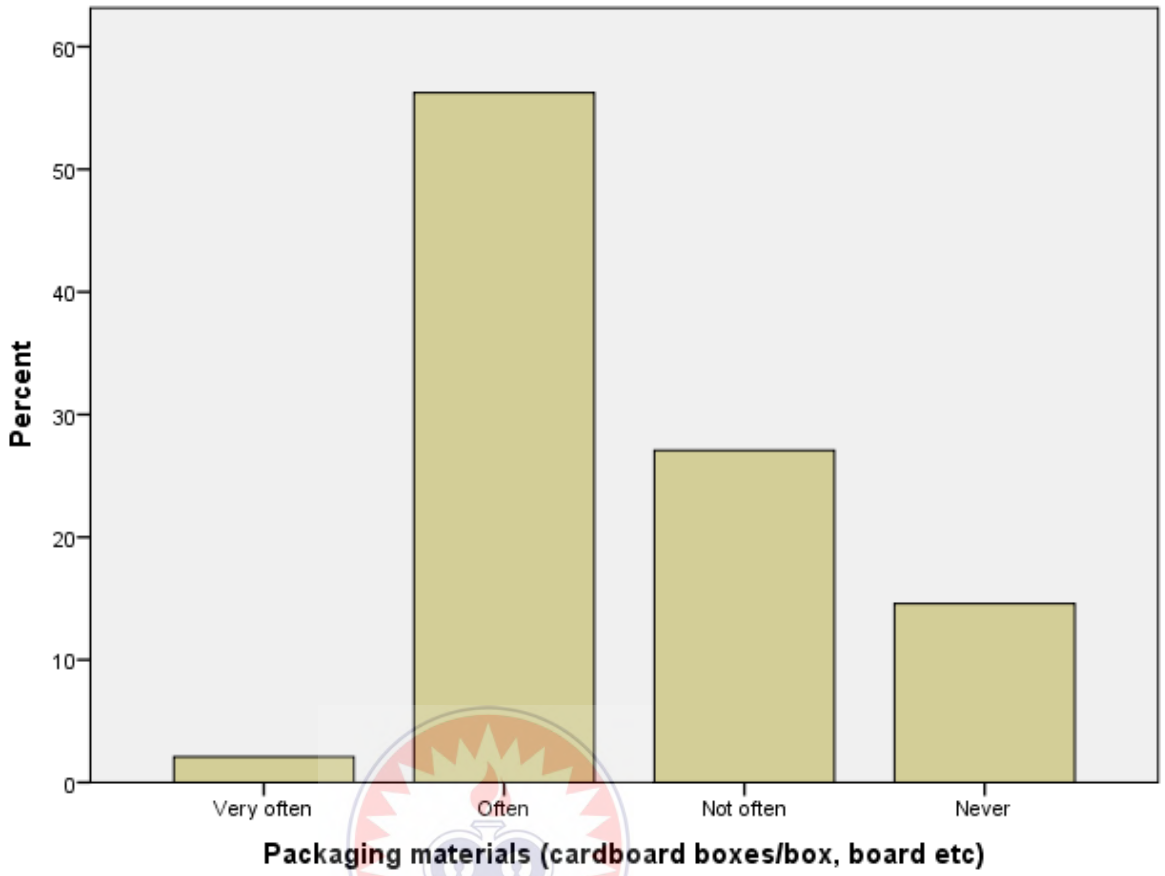

Figure 4.5: Ranks of Frequency of Construction Waste (Packaging Materials) Produced

Figure 4.6 presented the ranking of frequency of drywall as a construction wastes are produced. From the figure 6 representing (6.3%) of the respondents produces construction waste in the form of drywall very often; 5 representing (31.3%) of the respondents produces construction waste in the form of drywall often; 12 representing (54.2%) of the respondents produces construction waste in the form of drywall not often; and eight point three percent (8.3%) of the respondents never produces construction waste in the form of drywall.

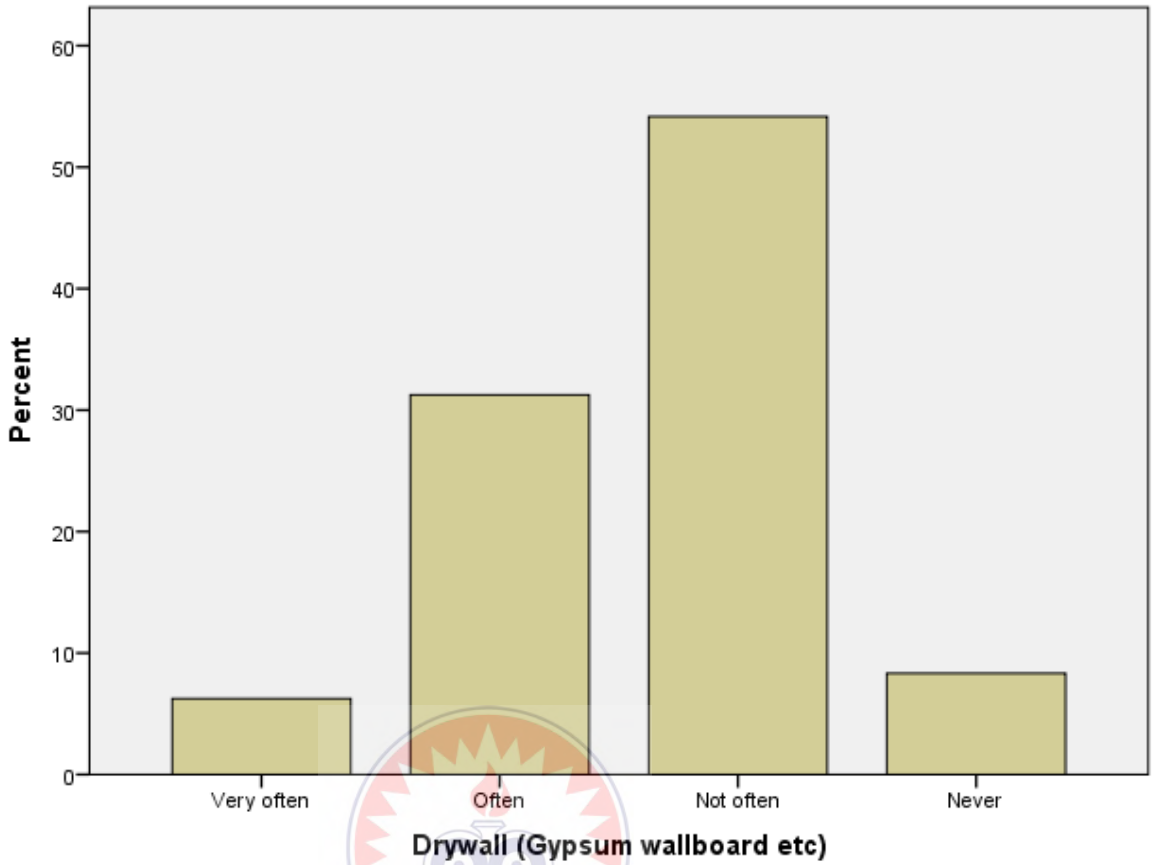

Figure 4.6: Ranks of Frequency of Construction Waste (Drywall) Produced

Figure 4.7 presented the ranking of frequency of glass as a construction wastes are produced. From the figure 6 representing (64.6%) of the respondents produces construction waste in the form of glass very often; eighteen point eight percent (18.8%) of the respondents produces construction waste in the form of glass often; and sixteen point seven percent (16.7%) of the respondents produces construction waste in the form of glass not often.

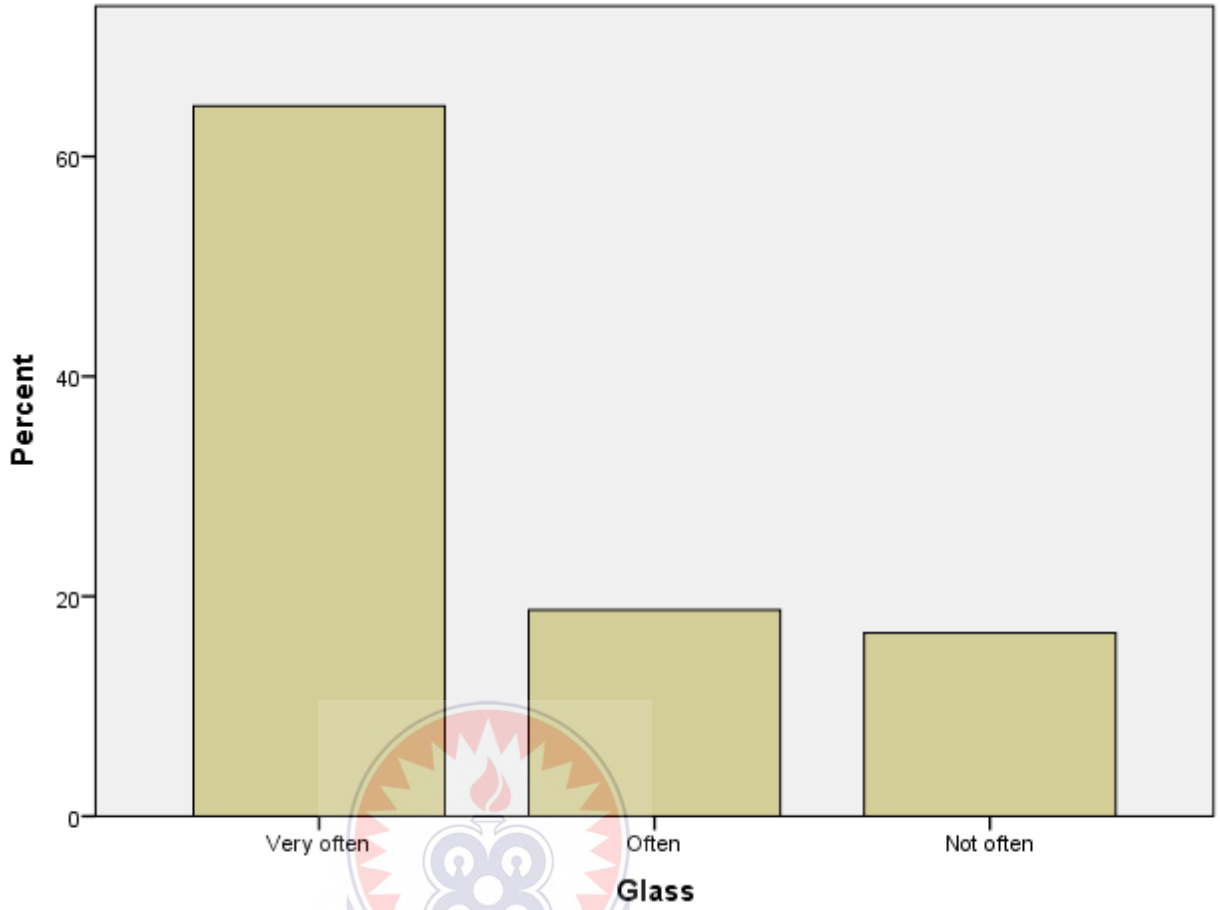

Figure 4.7: Ranks of Frequency of Construction Waste (Glass) Produced

Construction Waste Reduction Strategies

The values or scores from the Likert scale items for this study were treated as continuous variable as done by previous studies (Johnson & Creech, 1983; Norman, 2010; Sullivan & Artino Jr., 2013; Zumbo & Zimmerman, 1993).

Table 4.2 captures the scores assigned by respondents for waste minimization strategies. Clearly from the table, a median response score of 2.00, a minimum response score of 1.00 and a standard deviation of 0.46 suggest that majority of the

respondents for this study disagree to the fact that re-using waste only is a waste minimization strategy.

Likewise a median response score of 2.00, a minimum response score of 1.00 and a standard deviation of 0.44 suggest that majority of the respondents for this study disagree to the fact that recycling waste only is a waste minimization strategy.

In the context of minimizing waste at source of origin only as strategy of minimizing waste, a median response score of 1.00, a minimum response score of 1.00 and a standard deviation of 0.43 suggest that majority of the respondents for this study agree to the fact that minimizing waste at source of origin only is a waste minimization strategy.

With regards to combination of re-using waste and minimizing waste at source of origin as strategy of minimizing waste, a median response score of 1.00, a minimum response score of 1.00 and a standard deviation of 0.45 suggest that majority of the respondents for this study agree to the fact that combination of re-using waste and minimizing waste at source of origin is a waste minimization strategy. Likewise combination of re-using waste, recycling waste and minimizing waste at the source of origin as strategy of minimizing waste, a minimum response score of 1.00 and a standard deviation of 0.51 suggest that majority of the respondents for this study agree to the fact that combination of re-using waste, recycling waste and minimizing waste at the source of origin is a waste minimization strategy.

Table 4.2: Waste Minimization Strategies

Waste Reduction Strategy	Min	Max	Mean	Std. Dev.
1. Re-using waste only.	1	2	2.0	0.46
2. Recycling waste only	1	2	2.0	0.44
3. Minimizing waste at source of origin only	1	2	1.0	0.43
4. Combination of re-using waste and minimizing waste at source of origin	1	2	1.0	0.45
5. Combination of re-using waste, recycling waste and minimizing waste at the source of origin	1	2	1.0	0.51

Note. Scale: 1 =Agree; 2 =Disagree.

Responses on Waste Minimization Policy, Impact of Waste Generated on Construction Site and Waste Disposal Facilities.

Table 4.3 captures responses on waste reduction policy, impact and waste disposal facilities. From the table, 17 representing (35.4%) of the respondents stated that their firms had specific policy for minimizing waste and 31 representing (64.6%) had no specific policy for minimizing waste. In the context of effect or impact of waste generated on construction site, 12 representing (25.0%) of the respondents stated that

waste generated on site makes site congested; 27 representing (56.3%) of the respondents stated that waste generated on site inhibit free movement of humans, materials and equipment; and 9 representing (18.8%) of the respondents stated that waste generated on site makes site prone to accidents.

With regards to incorporation of waste disposal in pricing of projects, 25 representing (52.1%) of the respondents stated that their firms incorporate waste disposal in pricing of projects and 23 representing (47.9%) of the respondents stated that their firms do not incorporate waste disposal in pricing of projects.

In the context of waste facilities, 7 representing (14.6%) of the respondents stated that rubbish disposal bins were the waste facilities used on site; 22 representing (45.8%) of the respondents responded that a combination of sorting waste materials into types on site was the waste facility used on site; and 19 representing (39.6%) of the respondents stated that waste chutes were the waste facilities used on site.

Table 4.3: Waste Reduction Policy, Impact and Waste Disposal Facilities

Variables	Details	Frequency	Percent
Waste Minimization Policy	Yes	17	35.4
	No	31	64.6
Impact of Waste Generated on Construction Site	Makes site congested	12	25.0
	Inhibit free movement of human, materials and equipment	27	56.3
	Makes site prone to accidents	9	18.8
Incorporation of Waste Disposal in Pricing of Projects	Yes	25	52.1
	No	23	47.9
Waste Facilities on Site	Rubbish disposal bins	7	14.6
	Combination for sorting waste materials into types on site	22	45.8
	Waste chutes	19	39.6

Challenges of Construction Waste Management

Table 4.3 captures the scores assigned by respondents for challenges of construction waste management. Clearly from the table, a median response score of 2.00, a minimum response score of 1.00 and their corresponding standard deviation (ranging from 0.82 to 1.00) suggest that majority of the respondents for this study assert that, unavailability of properly engineered disposal sites and waste management plants; high disposal/tipping cost; lack of planning for waste management; high cost of waste recycling; lack of funds for equipment and training; loose organized determination of information on waste with the firm; lack of legal knowledge and environmental regulation and programmes on waste; no attention on waste reduction at the planning and design stage; lack of proper policies and administrative systems by government for construction waste management; and insufficient incentives for private projects to implement waste reduction measures are often the challenges of construction waste management. Also lack of space within site for separation and recycling; and lack of well-developed recycling industry and market for recycled products were some of the challenges of construction waste management but not very often.

Table 4.4: Challenges of Construction Waste Management

Challenges of Waste Management	Min	Max	Mean	Std. Dev.
1. Unavailability of properly engineered disposal sites and waste management plants	1	3	2.0	0.82
2. High disposal/tipping cost	1	4	2.0	0.84
3. Lack of planning for waste management	1	4	2.0	0.94

4. High cost of waste recycling	1	4	2.0	0.94
5. Lack of funds for equipment and training	1	4	2.0	0.98
6. Loose organized determination of information on waste with the firm	1	4	2.0	0.96
7. Lack of legal knowledge and environmental regulation and programmes on waste	1	4	2.0	0.82
8. No attention on waste reduction at the planning and design stage	1	4	2.0	1.00
9. Lack of proper policies and administrative systems by government for construction waste management	1	4	2.0	0.98
10. Insufficient incentives for private projects to implement waste reduction measures	1	4	2.0	0.98
11. Lack of space within site for separation and recycling	1	4	3.0	0.89
12. Lack of well-developed recycling industry and market for recycled products	1	4	3.0	0.99
13. Insufficient incentive to stakeholders	1	4	4.0	0.89

Note. Scale: 1 =Very Often; 2 =Often; 3=Not Often; 4=Never.

Responses on Effective Waste Management Measures

Table 4.5 showed the scores assigned by respondents for effective construction waste management measures. Clearly from the table, a median response score of 4.00, a minimum response score of 1.00 and their corresponding standard deviation (ranging from 1.08 to 1.37) suggest that majority of the respondents for this study assert that, compliance with regulations to waste disposal; complying with contract provisions on waste management; integration of waste management in design and construction of projects; use of quality materials on construction sites; use of competent site personal on construction sites; careful planning of procurement of materials; and employing the right methods in the execution of construction activities are the effective measures in construction waste management.

Also majority of the respondent disagree and uncertain that timely and effective communication of design changes to all parties concerned; careful dimensioning of materials and components to avoid cutting-to-fit; thorough review of projects specification by the contractor at the construction stage to detect design, detailing on other errors; detailed planning of construction process requirement and material storage facilities; overproduction/production of a quantity greater than required or earlier than necessary; lack of strategy to waste minimization; and lack of quality management system aimed at waste minimizations were effective measures for construction waste management.

Table 4.5: Effective Waste Management Measures

1. Measures	Min	Max	Mean	Std. Dev.
2. Compliance with regulations to waste disposal	1	5	4.0	1.08
3. Complying with contract provisions on waste management	1	5	4.0	1.22
4. Integration of waste management in design and construction of projects	1	5	4.0	1.30
5. Use of quality materials on construction sites	1	5	4.0	1.26
6. Use of competent site personal on construction sites	1	5	4.0	1.37
7. Careful planning of procurement of materials	1	5	4.0	1.15
8. Employing the right methods in the execution of construction activities	1	5	4.0	1.27
9. Timely and effective communication of design changes to all parties concerned	1	5	3.0	1.24
10. Careful dimensioning of materials and components to avoid cutting-to-fit	1	5	2.0	1.54
11. Thorough review of projects specification by the contractor at the construction stage to detect design, detailing on other errors	1	5	1.0	1.51
12. Detailed planning of construction process requirement and material storage facilities	1	5	2.0	1.54

13. Overproduction/production of a quantity greater than required or earlier than necessary	1	5	3.0	1.38
14. Lack of strategy to waste minimization	1	5	2.0	0.96
15. Lack of quality management system aimed at waste minimizations	1	5	2.0	1.07

Note. Scale: 1 =strongly disagree; 2 =Disagree; 3=Uncertain; 4=Agree; 5=strongly agree.

Responses on Construction Waste Management Regulation and Dump Site Treatment of Construction Waste

Table 4.6 showed responses on construction waste management regulations and dump site treatment of construction waste. From the table, 30 representing (62.5%) of the respondents were aware of construction waste management regulations and 18 representing (37.2%) of the respondents were not aware of the construction waste management regulations. In the context of effectiveness construction waste management regulations, 30 representing (62.5%) of the respondents stated that the construction waste management regulations were effective and 18 representing (37.2%) of the respondents stated that the construction waste management regulations were not effective.

With regards to visits by environmental health and sanitation directorate, 27 representing (56.3%) of the respondents stated that their construction sites were visited by environmental health and sanitation directorate and 21 representing (43.7%) of the respondents stated that their construction sites were not visited by environmental health and sanitation directorate.

In the context of number of visits by environmental health and sanitation directorate, 32 representing (66.7%) of the respondents stated that their construction sites were not visited by environmental health and sanitation directorate; 7 representing (14.6%) of the respondents responded that their construction sites were visited once a week by environmental health and sanitation directorate; 5 representing (10.4%) of the respondents stated that their construction sites were visited once a month by environmental health and sanitation directorate; and 4 representing (8.3%) of the respondents stated that their construction sites were visited at the various stage of the projects by environmental health and sanitation directorate.

With regards to sanctions and the types slapped on respondents for non-compliance to waste management regulations, 9 representing (18.8%) of the respondents were sanctioned for non-compliance to waste management regulations whilst 39 representing (81.2%) of the respondents were not sanctioned for non-compliance to waste management regulations. For the kinds or types of sanctions, 6 representing (12.5%) of the respondents paid fines for non-compliance to waste management regulations; 14 representing (29.1%) of the respondents had their project or work suspended for non-compliance to waste management regulations; and 28 representing (58.4%) of the respondents were not sanctioned at all for non-compliance to waste management regulations.

In the context of landfill site for waste disposal and treatment of construction waste at dump site, 9 representing (18.8%) of the respondents had landfill site for waste disposal in their area whilst eighty one point two percent of the respondents did not have landfill site for waste disposal in their area. For the treatment of construction waste at dump site, 10 representing (20.8%) of the respondents burnt their construction waste generated at the dump sites; 10 representing (20.8%) of the

respondents sold their construction waste generated at the dump sites; 3 representing (6.3%) of the respondents buried their construction waste generated at the dump sites; and 25 representing (52.1%) of the respondents do not have any idea of how their construction waste generated are treated at dump sites.

Table 4.6: Waste Management Regulation and Dump Site Treatment of Construction Waste

Variables	Details	Frequency	Percent
Knowledge of regulation for Construction waste	Yes	30	62.5
	No	18	37.5
Effectiveness of Regulation	Yes	30	62.5
	No	18	37.5
Visits by Environmental Health and Sanitation Directorate	Yes	27	56.3
	No	21	43.7
Number of visits by Environmental Health and Sanitation Directorate	No visits	32	66.7
	Once a week	7	14.6
	Once a month	5	10.4
	At various stage of the project	4	8.3
Sanctions	Yes	9	18.8
	No	39	81.2
Type of Sanctions	Fine	6	12.5

	Suspension of work	14	29.1
	No sanctions	28	58.4
Landfill Site for Construction Waste Disposal	Yes	9	18.8
	No	39	81.2
Treatment of Waste at Dump Site	Burnt	10	20.8
	Do not have any idea	25	52.1
	Sold	10	20.8
	Buried	3	6.3

The analyses of responses from managers, supervisors and workers of the various construction firms or companies considered under the present study are vital for the efficient utilization of construction materials on sites in Ghana. Findings from this study indicated that the components of waste mostly generated by the construction companies/firms considered for the study were wood, plastics (PVC, polythene, etc.), metal (steel, wires etc.), concrete/brick or block mortar, packaging materials (cardboard boxes/box, board etc.), drywall (gypsum wall board etc.), and glass(Bilitewski et al., 1997; Nakajima & Russell, 2014).

In the context of challenges of waste management, findings indicate that, unavailability of properly engineered disposal sites and waste management plants; high disposal/tipping cost; lack of planning for waste management; high cost of waste recycling; lack of funds for equipment and training; loose organized determination of information on waste with the firm; lack of legal knowledge and environmental regulation and programmes on waste; no attention on waste reduction at the planning and design stage; lack of proper policies and administrative systems by government

for construction waste management; insufficient incentives for private projects to implement waste reduction measures; lack of space within site for separation and recycling; and lack of well-developed recycling industry and market for recycled products were the challenges of construction waste management (Kumar et al., 2017; Yoada et al., 2014).

In the context of waste minimization strategies, findings of the study indicate that minimizing waste at source of origin only; combination of re-using waste and minimizing waste at source of origin; and a combination of re-using waste, recycling waste and minimizing waste at the source of origin were the waste minimization strategies ("Chapter three Sources, characteristics, and management of wastes," 1998; Faniran & Caban, 1998; Yoada et al., 2014).

In the context of effective waste management measures, findings of the study indicate that, compliance with regulations to waste disposal; complying with contract provisions on waste management; integration of waste management in design and construction of projects; use of quality materials on construction sites; use of competent site personal on construction sites; careful planning of procurement of materials; and employing the right methods in the execution of construction activities were the effective measures in construction waste management.

4.3 Result and Discussion of Interview

The researcher conducted interview for site managers, supervisors and workers of various construction group of categories that is D1k1, D2k2, D3k3 to solicit their views on the waste management issues prevailing in public and private construction

sites. The researcher conducted interview base on the fact that some of the managers and supervisor do not manage one site, therefore will influence retrieval of the questionnaires. Also, it was noted that some workers cannot read and write. The following section present the discussion of these issues below.

4.3.1 Results and Discussion of Interview from site Managers.

The result of interview were obtained from site management of both public and private construction managers sites. Six (6) managers were interviewed on some of the waste management processes.

All the managers interview said lack of planning for waste management, contribute to high production of waste on sites. Some managers are of the views that recycling or proper disposal reduces waste on site. Also most private developers leave waste materials on site unattendent causing accident.

4.3.2 Results and Discussion of interview from Supervisors

From the interview of supervisors, it was revealed that adequate education should be given to workers on waste management. It was also realized that no attention is paid on the part of the supervisors to monitor material usage.

Another cause is lack of space within the site for separation and recycling of waste materials. The interview conducted also revealed that there is lack of legal knowledge and environment regulation on waste.

4.3.3 Result and Discussion of Interview from workers

The interview of workers, it was learnt that not all construction company or firms that comply with regulations relating to waste disposal.

Another cause the worker revealed is the uses of sub quality materials in construction resulting to a lot of waste generation. They are also the view that proper storage facilitate be provided.

Again interview conducted revealed the following as problem related to lack of management system, lack of visit of environmental health and sanitation officers.

Another cause is lack of qualified tradesmen in the construction industry.

4.4 Result of observation

A guide of the observation was prepared based on the utilization of construction materials, minimization of waste and other. This was used as checklist against whatever observation was made during the process interview, administering of questionnaires and some few round made by the researcher.

The observation carried out revealed that most of the public site visited use quality material and competent site personnel therefore reduces amount of waste.

The observation also revealed that most of the private site developers paid little or no attention of waste management as compared to the public construction companies.

During visual inspection on the project sites, under study pictures were taken that show some of the issues during the observations.

Fig 4.1 shows bally stored aggregates along easting corridor road –Have Afadzato South

Fig 4.2 Unattendent waste materials lying on site Afadzato District Assembly, Golokwati

Fig 4.3 Disposal of concrete waste materials logba – Alapeti Secondary School Afadzato South

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter constitute the summary of research findings from the analysis and discussions.

5.1 Summary of Findings

The following are the summary of the findings from the study:

- The study show that most respondents agree to the combination of re-using waste and minimizing waste at source, combining recycling waste and minimizing and Re- using recycling and minimizing waste at source.
- The study showed that there are no environmental health and sanitation directorate to visit the activities of construction companies.
- Also there is lack of legal knowledge and environmental regulation and programmes on waste management
- The study also revealed that, there are no properly engineered disposal site and waste management plants for construction industries.

5.2 Conclusion

The specific objectives of the study were to examine issues of materials wastage in construction; to identify factors contributing to waste of construction materials; and to devise strategies to minimize construction waste on construction sites.

In order to achieve these specific objectives spelt out in the foregoing paragraph, review of both theoretical and empirical literature was conducted. With regards to the

review, the study concentrated on a critical review of some empirical studies done in the area of waste management with emphasis on construction waste management.

Research methodology which included study design, population and sampling techniques, data collection techniques and methods of data analyses were also employed in order to fulfill the objectives of the study.

Statistical analysis such as the descriptive statistical methods employed by the study aided in achieving all the three (3) objectives of the present study.

5.3 Recommendations

Based on the research findings, the study recommends the following:

- Environmental Health and Sanitation Directorate should pay regular visits to construction sites within their locality to ensure construction waste management regulations and practices are adhered to by construction firms.
- Punitive measures in form of sanctions should be enforced for non-compliance to construction waste management regulations by Environmental Health and Sanitation Directorate.
- Construction firms should have policies for construction waste minimization.

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DEPARTMENT OF TECHNICAL EDUCATION

QUESTIONNAIRE FOR MANAGERS

PREAMBLE: Construction and Demolition waste is becoming a major concern to the construction industry players, and the government because of indiscriminate disposal and negative impact if not properly disposed. With increased activities of Real Estate Developers and Government of Ghana Affordable Housing Projects, this type of waste is expected to rise. As a student of Master of Construction Technology Education, the study is designed to investigate how construction firms mange waste on project sites with the view to ensure efficient management of waste which intend positively affect the economic health of buildings.

You are requested to please contribute to the study by answering the questions that follow by ticking the appropriate option and give any further information in written. All information given would be treated with outmost confidentiality. Thank you for participation in the study.

INSTRUCITONS: Please choose the options that apply

SECTION A

PART I:*BACKGROUNDINFORMATION OF RESPONDENT*

1. Name of company:…….
2. What is the classification of the construction company you are working for?
    a. DIKI ☐
    b. D2K2 ☐
    c. D3K3 ☐
    d. D4K4 ☐
    e. Other please state:……..
3. What is the area of specialization of the construction company you are working for?
    a. Building construction works
    b. Civil engineering construction works
    c. Electrical installation works
    d. Mechanical installation works
    e. Building and Civil engineering works
    f. Plumbing installation work
    g. Others Please specify:…….
4. What position do you hold in the company you are working for?
    a. General Manager ☐
    b. Site Manager ☐
    c. Building Engineer ☐
5. How long have you been working in the construction industry?

    Please tick the category of number of years below:

a. Less than 2 years

b. 2 -5 years

c. 6 – 10 years

d. 11 -15 years

e. 16 years and above

6. Do you have any formal education in management

a. Yes ☐

b. No ☐

PART II:*COMPONENTS OF KEY CONSTRUCTION MATERIALS TO WASTAGE*

This section seeks your expert opinion on types of waste produced within your company

and in general.

7. Rank the frequency of the following type of construction waste produced on project site

[Tick [√] where appropriate]

Material component	Very Often	Often	Not Often	Never
a. Wood				
b. Metal (steel, wires etc)				
c. Plastics (PVC, Polythene etc)				
d. Masonry (concrete/brick or block mortar etc)				
e. Packaging materials (cardboard boxes/box board etc)				
f. Drywall (Gypsum wallboard etc.)				
g. Glass				
h. Others Please Specify ……..				

PART III: ***CONSTRUCTION WASTE MINIMIZATION STRATEGIES***

This ***section seeks your expert opinion on waste minimization strategies of construction companies***

8. Does your firm have a specific policy for minimizing construction waste?

☐ YES ☐ NO

If yes determine the strategy

Waste reduction strategy	Agree	Not agree
Re-using waste only		
Recycling waste only		
Minimizing waste at source of origin only		
Combination of re-using waste and minimizing waste at source of origin		
Combination of re-using waste, recycling waste and minimizing waste at the source of origin.		

9. How does the waste generated affect construction work on site?

√ [Tick where appropriate]

☐ Makes site congested

☐ Inhibit free movement of human, materials and equipment

☐ Make site prone to accidents

10. Is waste disposal taken into account in pricing of projects

√ [Please tick]

☐ Yes

☐ No

11. What waste facilities do you provide on your site? [Please tick as many options that are applicable]

☐ Rubbish disposal bins

☐ Combination for sorting waste materials into types on site

☐ Waste chutes

PART IV:*CHALLENGES OF CONSTRUCTION WASTE MANAGEMENT*

12. How often do you face the following challenges in construction waste management on project sites?

√ Please tick where appropriate

Challenges of waste management	Very Often	Often	Not Often	Never
Unavailability of properly engineered disposal sites and waste management plants				
High disposal/tipping cost				
Lack of planning for waste management				
High cost of waste recycling				
Lacks of funds for equipment and training				
Loose organized determination of information on waste with the firm				
Lack of legal knowledge and environmental regulation and programmes on waste				
No attention on waste reduction at the planning and design stage				
Lack of proper policies and administratively systems by government for construction waste manage				
Insufficient incentives for private projects to implement waste reduction measures				
Lack of space within site for separation and				

recycling				
Lack of well-developed recycling industry and market for recycled products				
Insufficient incentive to stakeholders				

PART V: *MANAGING WASTE EFFECTIVELY*

13. To what extend do you agree with the following measures for effectively managing waste of project sites. Please tick 1 to 5 where 1 = strongly disagree, 2= disagree, 3= uncertain, 4 = agree and 5= strong agree.

Measures in effectively managing waste	**Response**				
	1	2	3	4	5
Compliance with regulations relating to waste disposal					
Complying with contract provisions on waste management					
Integration of waste management in design and construction of projects					
Use of quality materials on construction sites					
Use of competent site personal on construction sites					
Careful planning of procurement of materials					
Employing the right methods in the execution of construction activities					

Timely and effective communication of design changes to all parties concerned					
Careful dimensioning of materials and components to avoid cutting-to-fit					
Thorough review of project specifications by the contractor at construction stage to detect design, detailing on other errors					
Detailed planning of construction process requirements and material storage facilities					
Overproduction/ Production of a quantity greater than required or earlier than necessary					
Lack of strategy to waste minimization					
Lack of quality management system aimed at waste minimizations					
Others Please Sate……					

PART VI: ***CONSTRUCTIONWASTE MANAGEMENT REGULATION***

14. Are you aware of any regulation governing construction and demolition waste?
    a. Yes
    b. No
15. If yes, it effective?
    a. Yes
    b. No

16. Do you have personnel from the Environmental Health and Sanitation Directorate of your Municipality visiting and inspecting activities on your site?
    a. Yes
    b. No

17. How often do such inspectors visit the site
    a. No visits
    b. Once a week
    c. Once a month
    d. At various stages of the project
    e. Others please specify:…….

18. Do the local authority sanction for non-compliance to waste management regulation?
    a. Yes
    b. No

19. What kind of sanction is given?
    a. Fine
    b. Suspension of work
    c. Imprisonment
    d. Others please specify?.....

20. Do you have a landfill site for construction waste disposal and treatment in your area?
    a. Yes
    b. No

21. If yes, do you pay any toll for dumping?

    a. Yes

    b. No

22. How much do you pay for dumping construction waste?

    a. Below GH¢20.00

    b. GH¢21.00 –GH¢50.00

    c. GH¢50.00 –GH¢75.00

    d. GH¢76.00 –GH¢100.00

    e. Above GH¢100.00

23. If No for Question 16, how do you dispose of waste on site?

    a. Yes

    b. No

    c. Fly-tipped at illegal dump sites

    d. Others please specify:…….

24. How is construction waste treated at the dump site?

    ☐ Burnt

    ☐ Do not have any idea

    ☐ Recycled

    ☐ Sold

    ☐ Buried

    ☐ Others please specify:…….

Thank you for your contribution to this study

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DEPARTMENT OF TECHNICAL EDUCATION

QUESTIONNAIRE FOR SUPERVISORS

PREAMBLE: Construction and Demolition waste is becoming a major concern to the construction industry players, and the government because of indiscriminate disposal and negative 78 if not properly disposed. With increased activities of Real Estate Developers and Government of Ghana Affordable Housing Projects, this type of waste is expected to rise. As a student of Master of Construction Technology Education, the study is designed to investigate how construction firms mange waste on project sites with the view to ensure efficient management of waste which intend positively affect the economic health of buildings.

You are requested to please contribute to the study by answering the questions that follow by ticking the appropriate option and give any further information in written. All information given would be treated with outmost confidentiality. Thank you for participation in the study.

INSTRUCITONS: Please choose the options that apply

SECTION B

PART I:*BACKGROUNDINFORMATION OF RESPONDENT*

1. Name of company:…… …….

2. What is the area of specialization of the construction company you are working for?

   a. Building construction works

   b. Civil engineering construction works

   c. Electrical installation works

   d. Mechanical installation works

   e. Building and Civil engineering works

   f. Plumbing installation work

   g. Others Please specify:…….

3. What position do you hold in the company you are working for?

   a. Project Supervisor ☐

   b. Site Foreman ☐

4. How long have you been working in the construction industry?

   Please tick the category of number of years below:

   a. Less than 2 years

   b. 2 -5 years

   c. 6 – 10 years

   d. 11 -15 years

   e. 16 years and above

5. Do you have any formal education in management
   a. Yes
   b. No

PART II: *COMPONENTS OF KEY CONSTRUCTION MATERIALS TO WASTAGE*

This section seeks your expert opinion on types of waste produced within your company and in general.

6. Rank the frequency of the following type of construction waste produced on project site

[Tick [√] where appropriate]

Material component	Very Often	Often	Not Often	Never
a. Wood				
b. Metal (steel, wires etc)				
c. Plastics (PVC, Polythene etc)				
d. Masonry (concrete/brick or block mortar etc)				
e. Packaging materials (cardboard boxes/box board etc)				
f. Drywall (Gypsum wallboard etc.)				
g. Glass				
h. Others Please Specify ……..				

PART III: ***CONSTRUCTION WASTE MINIMIZATION STRATEGIES***

This ***section seeks your expert opinion on waste minimization strategies of construction companies***

7. Does your firm have a specific policy for minimizing construction waste?

☐ YES ☐ NO

If yes determine the strategy

Waste reduction strategy	Agree	Not agree
Re-using waste only		
Recycling waste only		
Minimizing waste at source of origin only		
Combination of re-using waste and minimizing waste at source of origin		
Combination of re-using waste, recycling waste and minimizing waste at the source of origin.		

8. How does the waste generated affect construction work on site?

√ [Tick where appropriate]

☐ Makes site congested

☐ Inhibit free movement of human, materials and equipment

☐ Make site prone to accidents

9. What waste facilities do you provide on your site? [Please tick as many options that are applicable]

☐ Rubbish disposal bins

☐

Combination for sorting waste materials into types on site

☐ Waste chutes

PART IV: *CHALLENGES OF CONSTRUCTION WASTE MANAGEMENT*

10. How often do you face the following challenges in construction waste management on project sites?

√ Please tick where appropriate

Challenges of waste management	Very Often	Often	Not Often	Never
Unavailability of properly engineered disposal sites and waste management plants				
High disposal/tipping cost				
Lack of planning for waste management				
High cost of waste recycling				
Lacks of funds for equipment and training				
Loose organized determination of information on waste with the firm				
Lack of legal knowledge and environmental regulation and programmes on waste				
No attention on waste reduction at the planning and design stage				

Lack of proper policies and administratively systems by government for construction waste manage				
Insufficient incentives for private projects to implement waste reduction measures				
Lack of space within site for separation and recycling				
Lack of well-developed recycling industry and market for recycled products				
Insufficient incentive to stakeholders				

PART V: ***MANAGING WASTE EFFECTIVELY***

11. To what extend do you agree with the following measures for effectively managing waste of project sites. Please tick 1 to 5 where 1 = strongly disagree, 2= disagree, 3= uncertain, 4 = agree and 5= strong agree.

Measures in effectively managing waste	**Response**				
	1	2	3	4	5
Compliance with regulations relating to waste disposal					
Complying with contract provisions on waste management					
Integration of waste management in design and construction of projects					
Use of quality materials on construction sites					
Use of competent site personal on construction sites					
Careful planning of procurement of materials					

Employing the right methods in the execution of construction activities					
Timely and effective communication of design changes to all parties concerned					
Careful dimensioning of materials and components to avoid cutting-to-fit					
Thorough review of project specifications by the contractor at construction stage to detect design, detailing on other errors					
Detailed planning of construction process requirements and material storage facilities					
Overproduction/ Production of a quantity greater than required or earlier than necessary					
Lack of strategy to waste minimization					
Lack of quality management system aimed at waste minimizations					
Others Please Sate……					

PART VI: ***CONSTRUCTIONWASTE MANAGEMENT REGULATION***

12. Are you aware of any regulation governing construction and demolition waste?
    a. Yes
    b. No

13. If yes, it effective?
    a. Yes
    b. No

14. Do you have personnel from the Environmental Health and Sanitation Directorate of your Municipality visiting and inspecting activities on your site?
    a. Yes
    b. No

15. How often do such inspectors visit the site
    a. No visits
    b. Once a week
    c. Once a month
    d. At various stages of the project
    e. Others please specify:…….

16. Do the local authority sanction for non-compliance to waste management regulation?
    a. Yes
    b. No

17. What kind of sanction is given?
    a. Fine
    b. Suspension of work
    c. Imprisonment
    d. Others please specify?.....

18. Do you have a landfill site for construction waste disposal and treatment in your area?
    a. Yes
    b. No

19. If yes, do you pay any toll for dumping?
    a. Yes
    b. No

20. If No for Question 14, how do you dispose of waste on site?
    a. Yes
    b. No
    c. Fly-tipped at illegal dump sites
    d. Others please specify:…….

21. How is construction waste treated at the dump site?
    ☐ Burnt
    ☐ Do not have any idea
    ☐ Recycled
    ☐ Sold
    ☐ Buried
    ☐ Others please specify:…….

Thank you for your contribution to this study

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QUESTIONNAIRE FOR WORKERS

PREAMBLE: Construction and Demolition waste is becoming a major concern to the construction industry players, and the government because of indiscriminate disposal and negative impact if not properly disposed. With increased activities of Real Estate Developers and Government of Ghana Affordable Housing Projects, this type of waste is expected to rise. As a student of Master of Construction Technology Education, the study is designed to investigate how construction firms mange waste on project sites with the view to ensure efficient management of waste which intend positively affect the economic health of buildings.

You are requested to please contribute to the study by answering the questions that follow by ticking the appropriate option and give any further information in written. All information given would be treated with outmost confidentiality. Thank you for participation in the study.

INSTRUCITONS: Please choose the options that apply

SECTION C

PART I:*BACKGROUNDINFORMATION OF RESPONDENT*

1. Name of company:…….

2. What is the area of specialization of the construction company you are working for?

   a. Building construction works
   b. Civil engineering construction works
   c. Electrical installation works
   d. Mechanical installation works
   e. Building and Civil engineering works
   f. Plumbing installation work
   g. Others Please specify:……..

3. What position do you hold in the company you are working for? …….

4. How long have you been working in the construction industry?

   Please tick the category of number of years below:

   a. Less than 2 years
   b. 2 -5 years
   c. 6 – 10 years
   d. 11 -15 years
   e. 16 years and above

5. Please indicate your Age

   a. 20 -30 years

   b. 31 – 40 years

   c. 41 – 50 years

   d. 51 years and above

PART II: *COMPONENTS OF KEY CONSTRUCTION MATERIALS TO WASTAGE*

This section seeks your expert opinion on types of waste produced within your company and in general.

6. Rank the frequency of the following type of construction waste produced on project site

[Tick [√] where appropriate]

Material component	Very Often	Often	Not Often	Never
a. Wood				
b. Metal (steel, wires etc)				
c. Plastics (PVC, Polythene etc)				
d. Masonry (concrete/brick or block mortar etc)				
e. Packaging materials (cardboard boxes/box board etc)				
f. Drywall (Gypsum wallboard etc.)				
g. Glass				
h. Others Please Specify ……..				

PART III: ***CONSTRUCTION WASTE MINIMIZATION STRATEGIES***

This ***section seeks your expert opinion on waste minimization strategies of construction companies***

7. Does your firm have a specific policy for minimizing construction waste?

☐ YES ☐ NO

If yes determine the strategy

Waste reduction strategy	Agree	Not agree
Re-using waste only		
Recycling waste only		
Minimizing waste at source of origin only		
Combination of re-using waste and minimizing waste at source of origin		
Combination of re-using waste, recycling waste and minimizing waste at the source of origin.		

8. How does the waste generated affect construction work on site?

√ [Tick where appropriate]

☐ Makes site congested

☐ Inhibit free movement of human, materials and equipment

☐ Make site prone to accidents

9. What waste facilities do you provide on your site? [Please tick as many options that are applicable]

☐

☐ Rubbish disposal bins

Combination for sorting waste materials into types on site

☐ Waste chutes

PART IV: *CHALLENGES OF CONSTRUCTION WASTE MANAGEMENT*

10. How often do you face the following challenges in construction waste management on project sites?

√ Please tick where appropriate

Challenges of waste management	Very Often	Often	Not Often	Never
Unavailability of properly engineered disposal sites and waste management plants				
High disposal/tipping cost				
Lack of planning for waste management				
High cost of waste recycling				
Lacks of funds for equipment and training				
Loose organized determination of information on waste with the firm				
Lack of legal knowledge and environmental regulation and programmes on waste				
No attention on waste reduction at the planning and design stage				
Insufficient incentives for private projects to implement waste reduction measures				
Lack of space within site for separation and recycling				
Lack of well-developed recycling industry and market for recycled products				

PART V:*MANAGING WASTE EFFECTIVELY*

11. To what extend do you agree with the following measures for effectively managing waste of project sites. Please tick 1 to 5 where 1 = strongly disagree, 2= disagree, 3= uncertain, 4 = agree and 5= strong agree.

Measures in effectively managing waste	Response				
	1	2	3	4	5
Compliance with regulations relating to waste disposal					
Complying with contract provisions on waste management					
Integration of waste management in design and construction of projects					
Use of quality materials on construction sites					
Use of competent site personal on construction sites					
Careful planning of procurement of materials					
Employing the right methods in the execution of construction activities					
Careful dimensioning of materials and components to avoid cutting-to-fit					
Detailed planning of construction process requirements and material storage facilities					
Overproduction/ Production of a quantity greater than required or earlier than necessary					
Lack of strategy to waste minimization					
Lack of quality management system aimed at waste minimizations					
Others Please Sate……					

PART VI: ***CONSTRUCTIONWASTE MANAGEMENT REGULATION***

12. Are you aware of any regulation governing construction and demolition waste?
    a. Yes
    b. No

13. If yes, it effective?
    a. Yes
    b. No

14. Do you have personnel from the Environmental Health and Sanitation Directorate of your Municipality visiting and inspecting activities on your site?
    a. Yes
    b. No

15. How often do such inspectors visit the site
    a. No visits
    b. Once a week
    c. Once a month
    d. At various stages of the project
    e. Others please specify:…….

16. Do the local authority sanction for non-compliance to waste management regulation?
    a. Yes
    b. No

17. What kind of sanction is given?

    a. Fine

    b. Suspension of work

    c. Imprisonment

    d. Others please specify?.....

18. Do you have a landfill site for construction waste disposal and treatment in your area?

    a. Yes

    b. No

19. If yes, do you pay any toll for dumping?

    a. Yes

    b. No

20. How is construction waste treated at the dump site?

    ☐ Burnt

    ☐ Do not have any idea

    ☐ Recycled

    ☐ Sold

    ☐ Buried

    ☐ Others please specify:…….

Thank you for your contribution to this study