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Waste reduction strategies on construction projects: the case of Accra metropolis

by

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DECLARATION

I hereby declare that this submission is my own work towards the MSc construction management and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

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ABSTRACT

According to Ghana Statistics Service (GSS), the Ghanaian construction industry has contributed significantly to the gross domestic product of the country with it being the highest contributor in 2011 and therefore it can be said that the country's construction industry is directly linked to our economy. Unfortunately, the local contractors cannot compete effectively with foreign operatives due to the lack or inadequacies of vital capabilities like capital, plants and managerial know-how which are required for reduction of wastage (effective use of materials, labour and plant). In view of the above, this project was conducted with the main aim of exploring strategies adopted by construction firms in reducing waste generation on construction sites within the Accra metropolis. Three (3) distinct but related objectives were set in order to achieve this aim which where to identify the causes of material wastage on construction sites; to identify materials predominantly wasted on construction sites; and to identify strategic ways to reduce the generation of excessive waste on construction sites in the Accra metropolis. In achieving these objectives, pre-existing theories were used as a means of building an evidence of the importance of the construction industry on the economy and challenges it faces with regards to construction waste and the distribution of questionnaires. The Kish formulae was used to calculate the sample size of fifty-six (56) from a population of one hundred and thirty-two (132) construction firms in the Accra metropolis. Fifty-Six (56) questionnaires were distributed and fifty (50) were retrieved representing a response rate of 89.29%. The data was analyzed using the Relative Importance Index formulae and mean score ranking method. The results demonstrated that, poor site management is a major cause of waste generation on-site. Also, the results demonstrated that concrete is the most wasted construction material on-site. Lastly, it was identified that, proper supervision of works on site is the best strategy to adopt in order to reduce waste generation on site. With regards to the findings, it was recommended that, there should be proper supervision on construction sites to expedite operatives work execution on construction site. Also, the project manager should pay more attention in planning his/her construction process so as to reduce or eliminate any wasteful activity on-site and bidders should submit their methods of minimizing waste as part of bid requirements and any bidder who fails to do so can be deemed not responsive.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AMA	Accra Metropolitan Area
GDP	Gross Domestic Product
HND	Higher National Diploma
Km^2	Kilometers Square
MWRW&H	Ministry of Water Resources Works and Housing
RII	Relative Importance Index
SCC	State Construction Corporation
SPSS	Statistical Packages for Social Sciences
UK	United Kingdom
USA	United State of America

DEDICATION

This thesis is dedicated to God Almighty and my family especially my wife who has been a great support.

ACKNOWLEDGMENT

I want to thank the Almighty God for His grace, goodness, provision, protection and favor to complete this work. I would like to thank my supervisor, Dr. Kofi Agyekum for sharing very useful knowledge and his supervisory role. I am very grateful to lecturers of the Building Technology Department. In addition I want to extend my appreciation to Project Managers and Consultants of the various sites who provided responses to my questionnaire and helped in reaching this conclusion.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

The construction industry is a key part of the economy in every country (Ofori, 2012). It creates revenue for the Government and also generates employment. According to Langford et al. (1997) 87% of the Ghanaian construction industry is labor intensive. According to Ghana Statistics Service (GSS, 2012), the construction industry has contributed significantly to the gross domestic product of the country with it being the highest contributor in 2011. According to Agyakwa-Baah, (2007), the Ghanaian construction industry is directly linked to our economy because the Government of Ghana is the biggest client in the industry. The industry has experienced steady growth over the past years which is clearly depicted in the domestic construction sector. This sector happens to be among the quickest developing sector with about 7-8% average growth per year (Agyakwa-Baah, 2007). To be able to achieve an even faster development, there must be an effective and efficient infrastructural development which can be realized through waste reduction.

According to Abernethy's (1988), local contractors cannot compete effectively with foreign operatives due to the lack or inadequacies of vital capabilities like capital, plants and managerial know-how which are required for effective and successful project tendering and execution. The construction industry is widely recognized as an environmentally unfriendly industry (Lu et al., 2011). The same author stated that, the industry generates unacceptable level of waste because of its extreme consumption rate

of huge amount of energy and physical and non-physical material resources. In United State of America (USA) only, manufacturing and production components of building construction engage extraction and transportation of over 6 billion tons of construction materials (Kibert and Ries, 2009). In China, the construction activities consume approximately 40% of natural resources (Lu et al., 2011). This consumption rate directly generates billions of metric tons of waste. In USA, Chini (2007) estimated demolition and construction of buildings to be 143 million metric tons. The sector is incredibly a key contributor to waste generation across countries and Ghana is not exempted.

All these waste generation leads to decrease in production efficiency as indicated by many researchers. For instance, according to Gavilan and Bernold (1994), minimization of construction waste can lead to higher productivity, save time and improve safety on work sites thus increasing the probability of success of a construction project. Therefore, construction waste management is a vital aspect of achieving project success. In Chile, construction companies are applying several actions to improve the performance of their project by minimizing the various waste produced during construction process (Serpell et al., 2000). This means, waste minimization advances project performance. Therefore, construction waste management is a vital aspect of achieving project success. Waste management can save up to 30% of construction cost (Tam et al., 2007). 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 shortest possible time rather than apply sustainability concepts (Kulatunga et al., 2006). In doing so, they neglect the significance of waste management and sustainable construction.

In view of this background, this research is been conducted to vividly discuss the importance of waste management and identify the causes and effects of its generation so as to correctly develop strategies to effectively reduce waste generation on construction sites.

1.2 STATEMENT OF PROBLEM

Numerous studies conducted in developed nations identified that generation of waste in urban centers is much more severe (Nazech et al., 2008). Researches in United States and Europe identified the main cause of generation of the waste and revealed that substantial amount of the waste generated lies in the flow of construction process (Serpell et al., 2000). According to Wahab and Lawal (2011), waste can be generated at various stages of the construction process like the planning stage, estimating or construction stage. Rameezdeen (2014), stipulated that, construction waste originates from various sources, generally from the inception of construction through to the completion of a building project. Research have shown that a substantial amount of material waste is generated in any construction project (Lu et al., 2011).

Material waste causes a lot of financial loss to the contractor which is most of the time transferred to the client sometimes leading to litigation. According to Wang et al., (2008) construction waste is a very serious environmental canker in many large cities in China. The authors estimated that, in 1998, an average of 7,030 tonnes (42%) of waste from demolition and construction were disposed as landfill in Hong Kong. This increasing volume of waste have created a bad image for the construction industry (Rameezdeen, 2014). It is not surprising that research studies on construction waste are gaining significance and more public concerns (Yuan and Shen, 2011). It is very

difficult to systematically measure all wastes in construction as it exists in many forms in a typical construction project.

Generally, waste forms a large quantum of production cost therefore is very necessary to identify ways to minimize waste generation in construction. Waste generation has become a nuisance to the industry to the extent that, extra construction materials has to be estimated for to make-up for waste (Begum et al., 2006). This depicts clearly the lack of considerations given to waste reduction during pre-contract and contract execution stage of a project to minimize the generation of waste. According to the same author, the extreme wastage of raw materials, improper waste management and low awareness of the need for waste reduction are common in the local construction sites and Ghana is no exception.

Construction waste despite its effect on construction cost and construction projects as a whole, it also affects the environment negatively many authors have attested to that fact. According to Craven *et al.* (1994), construction activity constitute about 20-30% of all waste deposited in Australian landfills. Ferguson *et al.* (1995) in one of his research identified that, more than 50% of the waste deposited in a typical landfill in the UK is construction waste. Rogoff and Williams (1994) reported that 29% of the solid-waste stream in the USA consisted of construction waste. Research studies have also reported that construction waste constitutes 19% of the total waste deposited in landfills in Germany (Brooks *et al.* 1994) and 13-15% of the total waste deposited in landfills in Helsinki, Finland (Heino 1994).

These findings brings out the need to strategically manage construction waste not only to save our environment but to give constructions stakeholders and clients in particular the optimum best value for money.

1.3 RESEARCH AIM AND OBJECTIVES

1.3.1 Specific Aim

The purpose of the study is to explore strategies adopted by construction firms in reducing waste generation on construction sites within the Accra metropolis.

1.3.2 Objectives

The objectives of this research are:

- To identify the causes of material wastage on construction sites;
- To identify materials predominantly wasted on construction sites; and
- Identify strategic ways to reduce the generation of excessive waste on construction sites in the Accra metropolis.

1.4 RESEARCH QUESTIONS

The study sought to provide answers to the following questions:

1. What are the causes of material wastage on construction sites?
2. Which materials are predominantly wasted on construction sites?
3. What are the strategies adopted by construction firms to minimize the wastage of materials on construction?

1.5 SIGNIFICANCE OF STUDY

The construction industry is one of the most important components of every economy. However, with the scientific and technological advancement in the industry, it is still popular for its client dissatisfaction, project delays, cost overruns and excessive waste (Morledge et al, 2009). Therefore this study will create awareness among construction engineers, developers, professional builders/contractors, and the general public about construction waste

and mitigation measures. This will help decrease the occurrence of client dissatisfaction, project delays and cost overrun.

Wastage in construction may come in different forms like waste associated with human resource but the most common form of waste in the construction industry is material wastage. According to Formoso et al., (2002), material waste is known as the main set-back in the building industry and has significant implication on the efficiency of industry in terms of time and cost. Waste management can save up to 30% of construction cost (Tam et al. 2007). This study will aid in the realization of this savings by developing practical strategies that can be adopted in that respect.

Lastly, this study will add to the body of knowledge with regards to waste generation and it minimization strategies.

1.6 METHODOLOGY

The methodology adopted for this research involved the gathering and critically reviewing the literature relevant to construction waste and strategies to reduce the quantum of waste generated. This served as a guide to identify previous works undertaken, contributions made, criticisms, limitations, current findings and their effective applications in the Ghanaian construction environment.

Quantitative research methods were adopted to gather information concerned with the study. The quantitative approach is chosen because it helps in collection of thoughtful data from a randomly large sample. The use of semi-structured questionnaires was exercised to gather information on the study. Details of the methodology were discussed in chapter three of this research work.

1.7 SCOPE

Basically, the study was restricted to construction firms with D1 and D2 certificates from MWRW&H in Accra Metropolis. These categories of construction firms were chosen because they are well equipped with various equipment's and with different construction activities on going on the project and are capable of providing adequate information for successful completion of this study.

The study was executed within the environs of Accra Metropolis because of the concentration of wide range of experienced construction professionals in the Metropolis; attributed to the rising modern facilities and improvements in the construction business. This was envisaged to bring to the study more diverse and accurate responses that made the final report more detailed with general practicality. Also, the choice of Accra was due to its proximity to the research. This reduced the problems that the research faced in terms of data collection, making it easier and faster to retrieve the questionnaires.

1.8 THESIS STRUCTURE

This research study was categorized into five independent but interrelated chapters, as discussed below.

Chapter one entailed the introduction which was subdivided into seven sections: background of the study, problem statement, research questions, aim and objectives, significance of the study and scope of study. Chapter two contained the literature review followed by the chapter three which consisted of the methodological approaches, namely: research methods, research design, sample and sampling procedural techniques, and data collection process. Chapter four

consisted of the data analysis and discussion of results. The last was chapter five which presented the summary of the major findings, conclusion, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

In this section, an in-depth literature review on the causes of excessive wastage on construction sites is conducted followed by the identification of materials predominantly wasted on construction site. The last aspect of this chapter identifies the strategic ways to reduce the occurrence of excessive generation of waste on construction site.

2.2 THE CONCEPT OF CONSTRUCTION WASTE

Alarcón (1997) defines waste as all other materials different from the absolute minimum quantity of resources of materials, equipment, and manpower necessary to add value to the product. Thus, waste is resources that do not add value to a product. This is not far from the description of construction waste. Rameezdeen (2014) defines construction waste as unused and unviable materials left on site. In the view of Westerveld (2003), construction waste is an unwanted material from construction activities. People make this assumption probably because looking at waste from that perspective makes it relatively easy to see and quantify. Unfortunately, regardless of the easy quantification of waste from that definition, this viewpoint has been heavily criticized. According to Gudigar, et al., (2014), at every stage of construction the inputs gets deformed, discarded, discouraged, discounted, disgraced, diseased, disfigured, disintegrated and hence categorized and termed as waste.

According to Wahab and Lawal (2011), waste can be generated at various stages of the construction process like the planning stage, estimating or construction stage.

Rameezdeen (2014), stipulated that, construction waste originates from various sources, generally from the inception of construction through to the completion of a building project. Research have shown that a substantial amount of material waste is generated in any construction project (Lu et al., 2011).

Material waste causes a lot of financial loss to the contractor which is most of the time transferred to the client sometimes leading to litigation.

2.3 CAUSES OF WASTAGE ON CONSTRUCTION SITES

Many contractors and other construction personnel engage in many activities during construction process that does not add value to the construction project (Ekanayake and Ofori, 2000). These non-value adding activities can be termed as waste.

2.3.1 Poor site management

Poor site management and supervision is a significant casual factor of waste generation which affects the general progress of construction. This was elaborated in Wang et al. (2008) research in China. The authors stipulated that, lack of management skills and lack of supervision is a key reason of substantial amount of waste generation on construction sites. Furthermore, in Chile, it was identified by Serpell et al. (2000) that poor or lack of supervision causes waste generation in the construction industry mainly on-site. A more recent study conducted by Lu et al. (2011) stated that waste also occurs due to the poor construction management on all construction projects executed. Moreover, a pilot study conducted in Sri Lanka stipulated that a considerable amount of construction waste is mostly due to improper management and supervision of sites (Jayawardane, 1998). The findings stated above shows that, poor site supervision is a major contributor of waste in the construction industry which affects cost management.

2.4.2 Lack of experience

Lack of experience on the side of both consultants and contractors is also a significant cause of waste which affects cost in the construction industry. This assertion was buttressed by researchers in South China who studied the work of steel benders. They mentioned that reinforcement works handled by inexperienced steel benders is the main cause of reinforcement waste (Lu et al., 2011).The substantial amount of waste they cause also have significant effect on the productivity and progress of work. Lee and Sivananthiran (1996) also agreed on the assertion and they stated that a substantial percentage of foreign contract labour has little or no experience in construction. Furthermore, inexperienced foremen add to more defective works in Hong Kong construction industry (Wan et al., 2009). Nazech et al. (2008) also believed that a lot of waste generated is due to the inexperience field supervisor.

2.4.3 Inadequate planning and scheduling

Due to the risk nature of construction, planning of activities is very key as it indicates the required input at various stages of a construction project. Inadequate planning and scheduling is another major construction waste generator is inadequate planning and scheduling. A number of researchers attested to the same fact stating that poor planning and scheduling is a key variable causing waste. For example, a study conducted by Ekanayake and Ofori in 2000 identified improper planning as the most imperative operational contributors to waste generation. Material wastage can also occur as a result of improper planning. Furthermore, imperfect planning of construction results in material waste (Polat and Ballard 2004).

2.4.4 Variations during construction

Variation of construction works can also lead to construction waste generation as major changes may result in demolition and reconstruction. According to Wan et. al. 2009 variations result in a high volume of construction waste. Errors and mistakes in design may lead to variations during construction and may include a misplaced column in the design. Australian researchers identified a similar result from their research and grouped typical construction debris cause into design change and design error (Faniran and Caban, 2007). Also, a research conducted in China by Zhao and Chua (2003) identified that reworks caused by the variations is another form of significant waste generator. Rework involves demolition and re-construction which may involve additional materials and labor and disposal of damaged materials on landfills as a result of demolition.

2.4.5 Mistakes during construction

Mistakes during construction are also a major cause of wastes in construction. It occurs as a result of default from construction procedure (Wang et al., 2008). Lack of ability to build a project can increase cost of a project from around 6-10% of total of project cost in United Stated (Koskela 1992) which is also a factor in construction waste. According to Pheng and Tan (1998), mistakes during construction can significantly cause huge waste generation on site.

2.4.6 Unnecessary movement of workers and goods

Unnecessary movement of people is a major source of waste that affects cost and its management. This type of waste is dependent on work by employees. Ohno (1988) categories movement of operatives into waste and work. Waste is a movement that does

not add value. Again, unnecessary transports of goods on site which may arise due to improper site layout have significant effect on time and cost.

2.4.7 Overproduction

Overproduction is also a different type of waste which can be associated with over-use of materials and excess input of energy by employees into production. Ohno (1988) categorize this type of waste as indirect waste where materials are not physically lost but causing only a monetary loss and increasing cost of production. For example, waste due to concrete slab thickness larger than specified by the structural design. This over-design structurally does not have any impact on the structure but can have significant impact on cost.

2.4.8 Other causes of waste generation

There are other various causes of waste generation on site and these may include; wrong construction method, defects and poor optimization in performing tasks.

2.5 MATERIALS PREDOMINANTLY WASTED ON CONSTRUCTION SITES

The construction industry is well noted for its diverse waste generation. It is necessary to determine which materials are predominantly generated as waste so as to know how it can be avoided or managed (Gudigar et al., 2014). Li et al., (2016) explained that waste from construction activities are of distinct levels, which are derived on the basis of the waste produced.

According to Wang et al., (2008) the construction industry generates various types of waste which may include aluminium, concrete, timber, cement, tile, brick and steel waste. Agyekum et al. (2012) assessed the magnitude of generation of some waste, measures of waste reduction and how these measures are put to use. The authors asserted

that, waste on construction sites can be grouped according to its source. In addition, Li et al. (2016) classified these waste materials into: (1) waste from an element, which equates waste from every sub-element of construction materials (packaging materials, extracted materials, and building element); (2) waste from components; (3) waste from systems; and (4) waste from building construction projects. To Bossink and Brouwers (1996) as cited in (Agyekum et al., 2012), the sources upon which they rated waste materials are operation, residual, material handling, procurement and design.

Ameh and Itodo (2013) conducted a study on material wastage on construction sites and identified most wasteful building materials during project operation as mortar from plastering (rendering). Chini (2007) conducted a study in Hong Kong and identified the following: concrete, blocks, plastering and waste from screeding, as waste materials generated on construction sites. Napier (2012) identified numerous waste materials according to their percentage contribution and these are concrete 5%, wood 30%, dry wall 3%, gravels, aggregate and fines, 20%, Asphalt roofing 5%, plastic 1%, ferrous and non-ferrous metals 9%, disposal as refuse 5% and cardboard and paper 3%. Looking at the percentages, it means wood is the predominant material wasted on project sites. In support of this, Tam et al., (2007) identified the following percentage wastage of materials: block/brick 8.9%, concrete 8.99%, formwork 20%, reinforcement 7.7%, and tiles 15.58%. The author concluded that, of all these wasted materials wood is the highest generated waste material. Waste from brick is the highest waste by weight generated on domestic construction site in Australia (Ameh and Itodo, 2013). It is of this that Agyekum et al. (2012) stated that the construction industry is highly responsible for producing numerous varieties of wastage owing to its factors of production, stages of

construction, the kind of construction task and practices on project site. Based on this, Li et al. (2016) concluded in their report that construction waste is the amalgamation of waste from all work packages at site. The five (5) major building materials associated with excessive waste generation are concrete, reinforcement, brick and block, formwork and tile (Tam et al., 2007). These are further discussed below.

2.5.1 Concrete

Concrete is the most used material on construction projects (Bossink and Brouwers 1996). Concrete is generally a mixture of fine aggregates, coarse aggregate and cement. According to Tam et al., (2007), waste in concrete basically results from excess quantity of ready mix concrete which result from changes and mistakes in quantifying the needed amount of concrete due to inadequate planning or ineffective communication. He also identified a quantum of concrete waste generation during transportation. He stated that, concrete may settle due to long distance of transportation and therefore will not be suitable for any construction activity. A project manager interviewed in Hong Kong stated that, due to congested traffic in Hong Kong, concrete wastage due to the settlement over long transportation time affects around 1.5% of the total mixed concrete materials. However, just like in Ghana, it is impossible to control the transportation system in Hong Kong. Other causes of wastage in concrete may include poor formwork and concrete handling processes.

2.5.2 Reinforcement

Steel bars are mostly used in construction projects as reinforcements. According to Tam et al., (2007), steel wastage mostly results from cutting. Damages and rusting during storage also form a major part of steel wastage.

2.5.3 Formwork

Timber boards used for formwork is another major material used on construction sites. The major causes of wastage in timber are rots and cutting waste and are very difficult to avoid (Tam et al., 2007). According to Li et al. (2016), timber materials wastage can be as high as 20 percent of the total materials during substructure works. Thus, timber wastage can be significant without proper management.

2.5.4 Brick and block

Bricks and blocks are the most common materials used in walling. Cutting of bricks and blocks for joints or small spaces is the main cause of their wastage. Due to the fragile nature of bricks and blocks, they can be damaged during transportation and unloading (Tam et al. 2007). Unused bricks and blocks can also go waste and such wastes can be imperative in projects where material planning is poor.

2.5.5 Tile

Tiles are normally wasted in a non-consequent process, affected by different stages of construction sequence (Tam et al., 2007). The sizes of the materials may not match specifications in the design because of poor coordination and communication. In some cases, wastes have to occur in the application to these specific sized areas. Also, during transportation, tiles can be easily cracked.

2.6 STRATEGIES IN REDUCING WASTAGE

A number of literature has identified numerous ways and strategies to reduce construction waste. According to Gudigar et al. (2014), developing of a construction waste management plan, which can be generally categorized into four major groups. These are contract language, design issues and construction techniques; building

materials specification; and education. All these categories falls under the design stage of a project. According to Osmani et al. (2008), waste minimization strategies implemented right at the design stage are more efficient and effective because bidders are aware even before the project starts. In view of this, a number of researchers like; Coventry and Guthrie (1998), Greenwood (2003), Poon et al. (2004), and Baldwin et al. (2006), have demonstrated that the architect has a very vital role to play in construction waste minimization and reduction because they are the most active stakeholders in the design stage of a project.

Therefore, Coventry and Guthrie (1998) suggested three key duties the architects should play in ensuring waste minimization in the construction industry and they included; giving advice to clients, improving design practices etc.

2.6.1 Advising of Client

This is done by educating the client on the impact of waste production and highlighting benefits including cost savings. According to Dainty and Brooke (2004) many clients do not have adequate information about the severity of construction waste. Waste minimization could be a very significant initiative by both the client and consultants when they know, identify and analyze the merits of waste reduction at various stages of a construction process. In view of this, Innes (2004) concluded in his study that savings of about 3% can be made without significant investment outlay.

2.6.2 Improvement of design practices

Waste can also be minimized by improving design practices by addressing the key causes of design waste. According to Coventry and Guthrie (1998), design waste could be handled by addressing the various problems encountered during the design process

which will facilitate better coordination at project level. This will eliminate a number of causal agents of waste and save construction cost without any investment outlay. Proper design will eliminate frequent design and detailing changes so as to avoid abortive work during site operations, design for deconstruction, planning to minimize wastage through off-cuts, the use of reclaimed building materials; and appropriate specification of design performance and products and improve design.

2.6.3 Contract and contractual agreement

At the contract and contractual agreement stage, a number of measures can be put in place which could play a very critical role in reducing waste. This could be done by making room for specifically waste minimization oriented contract tender clauses (CRiBE 1999). A typical example was identified by Dainty and Brooke (2004) who suggested the use of contractual clauses to penalize poor waste performance contractors. Greenwood literature in 2003 put forward similar recommendation and went further to suggest the incorporation of a fully integrated waste minimization strategy at the contractual stage. This strategy that was set forth by Greenwood identify and communicate the responsibilities for waste minimization between all the construction project stakeholders.

2.6.4 Standardization of design

Literature shows that, a huge volume of waste which directly affects construction cost is generated as a result of late changes during construction site operations. These amendments may change the type or quantity of building materials required at a specific stage of a project (Coventry et al., 2001). The author stated that standardization of design as a construction method improves the ease of building and reduces the quantity

of waste generated. Hylands (2004) had similar findings in his study and the authors argued that standardization of both building layouts and components result in less waste generation. Baldwin et al. (2006) agreed with the fact that standardization is a major way of reducing waste generation and he went further to state that pre-casting and prefabrication offer significant avenues to reduce waste generation. Dainty and Brooke (2004) similarly asserted that the use of off-site prefabrication leads to better control of waste and damage.

2.6.5 Management support

According to Teo and Loosemore (2001), managers ought to show greater commitment to waste management. This will encourage employees to view waste management as a very important aspect of the construction process on site and thus they will strive to reduce waste generation during construction on site. Waste management has a low priority during construction projects and not enough is done to reduce waste generation (Teo and Loosemore, 2001). Management involvement can help raise the importance associated with waste management. Also they can provide recycling facilities to help reduce unavoidable waste generated.

2.6.6 Effective planning of construction process.

Proper planning of construction process is a very important strategy in reducing construction waste generation on site. Planning reduces waste generation at source. Experienced practitioners in the waste and environment pollution fields recommend that reduction of waste at source should be given the highest priority when developing strategies for waste minimization (Crittenden and Kolaczkowski, 1995). This is because, conceptually, it makes more sense to avoid waste generation that to develop extensive ways in treating waste.

2.6.7 Government initiatives

The government also have a role to play in the reduction of waste generation in the Ghanaian construction industry. The government of New South Wales, Australia proposed to achieve a 60% reduction in waste in the year 2000 by making reforms to their existing Waste Disposal Act. Their existing Waste Disposal Act focused on the storage, collection, treatment and disposal of waste (Faniran and Caban, 1998). Similar strategy can be adopted in Ghana to reduce the amount of waste generated in our construction sites drastically.

2.6.8 Incentives

When waste management is done effectively, it brings about cost savings and it is the most attractive benefits to reducing waste (Teo and Loosemore, 2001). Therefore, site staff and other employers should benefit from the potential cost savings of waste reduction in the form of rewards and incentives so as to encourage them to put more effort in waste reduction. This will also create awareness of the economic benefits of waste reduction.

2.6.9 Proper supervision

According to Teo and Loosemore (2001), proper supervision of works on site will expedite operatives work and reduce the quantum of waste generated. Operatives tend to waste more with no or low supervision. Also, proper supervision will reduce the cases of theft and unnecessary material wastage as they also form a portion of waste generated on construction sites.

2.6.10 Construction waste management plan

Drawing a plan for waste management is also a vital tool in waste reduction. According to Gudigar et al. (2014) the plan for the management of construction waste management

should be divided into phases as displayed in figure 2.1. The authors concluded in their study that, waste management needs its due importance in projects and that the management area needs to be developed as any other management knowledge area and the benefits of this area towards environment, sustainability, cost-benefits, speed of construction, and needs distribution (Gudigar et al., 2014)

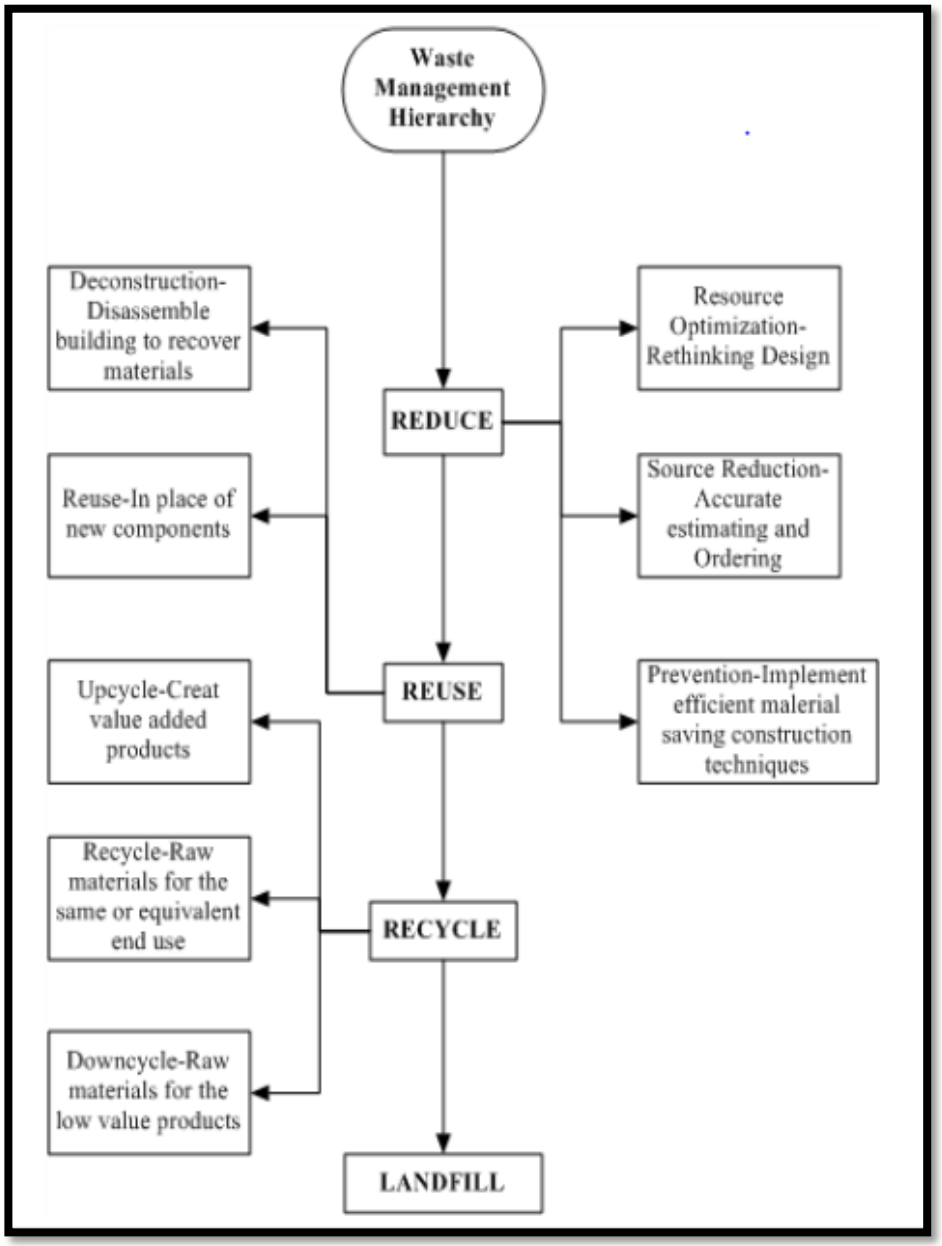

Figure 2.1: Waste Management Hierarchy

Source: *Gudigar et al., (2014).*

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Research methodology details out the philosophical considerations, procedures and methods required to put together the requisite knowledge for the set research questions and by so doing realizing the aim as well as the objectives of the study. This chapter discloses the methodological approaches to this research. It describes how the primary data was collected and handled, and how it was utilized in addressing the issues brought out by the research aim and objectives. It also explained data analysis method that was used in analyzing the acquired primary data, how the sampling population and sample size was determined. In summary, it seeks to describe the entire approach that was adopted to address the research aim, specific objectives and questions.

3.2 RESEARCH DESIGN

Research design fundamentally talks about a collection of guides or rules or data collection (Adams and Schvaneveldt, 1985). Researchers suggest that, research design shows the structure for data collection and analysis. The structure influences the technique for collection and analysis of data and provides the connection between empirical data as well as its conclusions in a logical sequence to the initial research question of the study.

The research adopts a questionnaire survey in the quest to explore the various strategies that can be adopted to reduce waste generation on construction sites in the Accra metropolis. The questionnaire was designed for construction managers and other personnel on site who has influence in waste management in on-going in the Accra metropolis. Questionnaire survey enhances consistency of observations and improves replication due to its inherent standardized measurement and sampling techniques (Oppenheim et al., 2003)

3.3 PROFILE OF THE SETTING

The selected setting within which the study was conducted was Accra Metropolitan Assembly (AMA) in the Greater Accra region of Ghana. Geographically, AMA, with a land surface area of approximately 231km^2, has a total population of 1,848, 614, population density of 69.3 persons per hectare and growth rate of 3.36% (Ghana Statistical Service, 2012). Accra is the most economically active city in Ghana, where lots of local and international construction companies are striving.

The Accra Metropolis was selected because of its proximity to the researcher, and has numerous construction companies, including construction logistics suppliers and those within the supply chain system; all located in several parts of the metropolis. The city is bursting with both completed and on-going constructional activities which involve several building contractors, capable of providing the necessary information for the study.

3.4 POPULATION, SAMPLE, AND SAMPLING TECHNIQUE

The population of a research is the universe of units from which the sample is selected (Bryman, 2004). Sample means a part of a population drawn to reflect the remaining of the population (Naoum, 2003). The targeted group were construction firms with on-going projects in the Accra metropolis. Bryman (2004) defines sampling technique as the process to select a unit or an entity from a sample frame or population that its attribute will reflect.

The population of the study is personnel working in construction companies with classification of D1 and D2 in the Accra Metropolis in the Greater Accra Region of Ghana. The number of registered D1 and D2 building contractors based on the Ministry of Works and Housing in the Accra Metropolis is 128 as at 2014 in the Greater Accra Region. This is as a result of the fact that, these classification of companies are well established and demonstrate satisfactory site layout conditions as well as safety records in the Ghanaian construction industry. Site supervisors and site personnel, including site agents, clerk of work and both skilled as well as unskilled workers gave relevant information to help carry out the research.

In order to obtain a sample, the Kish Formula was used to determine the sample size. Kish Formula states that:

$$n = \frac{n'}{\left(1 + \frac{n'}{N}\right)}$$

$$n' = \frac{s^2}{v^2}$$

Where

v = the standard error of sampling distribution = 0.05

s^2 = the maximum standard deviation of the population

Total error = 0.10 at a confidence interval of 95%

$s^2 = p(1-p)\ where\ p = 0.50$

$= 0.50(1-0.50)$

$= 0.25$

p = the proportion of the population elements that belong to the defined region.

$n' = \frac{s^2}{v^2}$

$= \frac{0.25}{0.05^2} = 100$

N = 128

Therefore

$$n = \frac{100}{\left(1 + \frac{100}{128}\right)} = \frac{100}{(1 + 1.205)} = 56.15 \approx 56$$

This sample size formula provided the minimum number of questionnaires that were to be administered. The sample size was found to be fifty-six (56) D1K1 and D2K2 construction firms. Site supervisors and site personnel, including site agents, clerk of work and both skilled as well as unskilled workers gave relevant information to help carry out the research.

3.5 DATA COLLECTION AND INSTRUMENTATION

This section talks about how data was collected from various respondents.

3.5.1 Questionnaire Design and Development

In order to achieve the aims and objectives of the research an elaborate questionnaire was developed based on the stated objectives of the research. The questionnaire used in this research (Appendix A), consist of two parts, with the first part considering the background of the person answering the questionnaire. The section B of the questionnaire was developed in accordance to the objectives of the study, in relation to the comprehensive literature review conducted on the topic. The opinions and perceptions of the various construction personnel were collected and scaled with scores ranging from 1-5 popularly called the likert scale. The scale was used because the data is primarily ordinal where 1= never, 2= rarely 3=neutral, 4= often and 5 = very often. The questions address issues on the causes of waste generation in the construction industry and the strategies to reduce waste generation in the construction industry.

3.5.2 Instrument Administration

The questionnaires were self-administered by hand delivery by the researcher to personnel in the D1 and D2 construction firms. Some of the questionnaires were retrieved on the spot whiles the rest were retrieved a week or two after their administration. In all, fifty-six (56) questionnaires were administered and 50 were retrieved representing a response rate of 89.29%.

3.6 DATA PREPARATION AND DATA ANALYTICAL TECHNIQUES

This section talks about how the quantitative data collected was processed and analyzed. Oppenheim (2003) prescribed a way of going about analyzing collected data. He proposed that, routines which should be followed has to be set. The individual responses collected were processed and entered into the Statistical Packages for Social Sciences

(SPSS). The analytical technique adopted were mean score ranking and the 'Relative Importance Index' (RII) which was used to rank the identified variables.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODDUCTION

This chapter analyses the data collected from the fifty (50) respondents interviewed from building construction sites with MHRW&H D1 and D2 certificates in the Accra Metropolis of the Greater Accra. Respondents were randomly chosen from various on-going construction sites in Accra. This chapter deals with the analyses and discussion of the materials predominantly wasted on construction sites, the causes of excessive wastage in construction projects and ways to reduce the occurrence of excessive waste in the construction industry.

The analysis is pivoted around the objectives of the study, that is, to identify the materials predominantly wasted on construction sites, to identify the causes of excessive wastage in construction projects and identify ways to reduce the occurrence of excessive waste in the construction industry. The organization of the data presentation, description and analyses were done using Statistical Package for Social Sciences (SPSS) and Microsoft Excel. The statistical tools used for the analysis were the Frequency Index and

Relative Importance Index (RII), which were used to rank the various variables. This chapter also presents the results of the analysis and discussions in the form of texts, figures and tables.

4.2 DEMOGRAPHIC/ BACKGROUND INFORMATION

This section presents background information on various respondents. The background information included the respondent's gender, age, role in the construction industry, the number of years of practice, the level of education of the respondent and the number of clients his firm works on. The respondent was also asked to indicate if his firm practices waste management.

4.2.1 Gender

Table 4.1 show the details of the respondent's gender. (28%) were female and (72%) were males.

4.2.2 Age of the respondents

The age distribution of the respondents was considered. Table 4.1 gives the statistical summary of responses. It demonstrated that, (48%) of respondents were within 40 to 49 years whereas (4%) fell within the ages of 50 and 59. Also 16% were within the 20 to 29 year category and (32%) were found to be within 30 to 39 year category. Most of the respondents on the various construction sites were within the ages of 40 to 49 years.

4.2.3 Role on the construction site

The purpose of this question was to know the respondent's on role on the construction site. Table 4.1 shows a summary of the roles of the respondents in the construction industry. Most of the respondents as seen below were Project Managers (32%) and Project Consultant (28%). With the rest of the respondents, 6% were Quantity

Surveyors, 4% were Maintenance Officers and another (4%) were Site Engineers, respectively. This indicated that majority of the respondents interviewed were Project Consultants and Project Managers. The project consultants were from the clients fold and they included architects, quantity surveyors and other construction professionals.

4.2.4 Number of years of practice of respondents

The main intent of this question was to ascertain how long the respondents have worked in their current profession. This information will give relevance to the quality of answers given out by the respondents. If respondents have experience in their current profession, their responses would authenticate the outcome of this research.

Table 4.1 below represents the respondent's years of service in their current practice. From the results (48%) have been working in the sector for less than 10 years. (44%) have been working in the sector for 10 to 20 years. (8%) have been working in the industry for between (21 – 30) years. In all, (52%) of respondents have more than 10 years working experience. This shows that most respondents have much experience in the construction sector.

4.2.5 Level of education

Table 4.1 shows a summary of the level of education of respondents. The purpose of this background information was to ascertain the respondent's highest level of education which is very significant in terms of the knowledge the respondent will have in waste management.

From table 4.1, (68%) of respondents had Bachelor Degree qualification. Respondents who have post-graduate qualification are (12%). (20%) of the respondents were having Higher National Diploma (HND) qualification.

4.2.6 Waste management practices

The last question under section A was to ascertain whether the respondent's firm had any idea about waste management. This question was posed to determine the credibility of answers given by the respondent in the section B. Out of the 50 who responded, (8%) claimed they do not have any idea about it, 12% claimed they do not have it, however, majority of (80%) asserted they have it as shown in table 4.1

4.3 PRESENTATIONS AND DESCRIPTIVE ANALYSIS OF DATA

This section deals with the analysis of the various responses given by the respondents concerning the various research objectives which included the identification of the causes of material wastage on construction sites, the identification materials predominantly wasted on construction sites and the identification of strategic ways to reduce the generation of excessive waste on construction sites in the Accra metropolis.

The questionnaire sought to give respondents the opportunity to show by indicating on a five point Likert scale, the causes of waste generation on construction sites and indicate strategies adopted by construction personnel in reducing waste generation on site. The respondents were also asked to indicate the type of material wasted most on construction sites.

4.3.1 Materials predominantly wasted on site

Tam et al. (2016), identified five major construction materials wasted most on site which included concrete, reinforcement, bricks and blocks, formwork and tiles. Respondents were asked to indicate the material wasted most on their site.

From table 4.2, it shows that concrete is the material wasted most on site with a respondent percentage of 36. It was followed by tiles which was (22%). Formwork had

18% while bricks and blocks and reinforcements had 14 and 10 percent respectively. According Bossink and Brouwers (1996) concrete is the most widely used material for most construction projects. It is not surprising then that the respondents ranked concrete to be the most waste material on site. Concrete waste basically results from excess quantity of ready mix concrete which result from changes and errors in calculating the quantity of needed concrete due to improper planning or inefficient communication (Tam et al., 2016).

Table 4.1: Background of respondents

Gender	**Percent (%)**	**Cumulative (%)**
Male	*28.00*	*28.00*
Female	*72.00*	*100.00*
Age	**Percent (%)**	**Cumulative (%)**
20-29	*16.00*	*16.00*
30-39	*32.00*	*48.00*
40-49	*48.00*	*96.00*
50-59	*4.00*	*100.00*
60 and above	*0.00*	*100.00*
Role	**Percent (%)**	**Cumulative (%)**
Project manager	*38.00*	*38.00*
Consultant	*32.00*	*70.00*
Quantity surveyors	*10.00*	*80.00*
Maintenance officers	*8.00*	*88.00*
Site engineers	*12.00*	*100.00*
Years of practice	**Percent (%)**	**Cumulative (%)**
Less than 10 years	*48.00*	*48.00*
10-20 years	*44.00*	*92.00*
21-30 years	*8.00*	*100.00*
Above 30 years	*0.00*	*100.00*
Level of education	**Percent (%)**	**Cumulative (%)**
HND	*20.00*	*20.00*
1st Degree	*68.00*	*88.00*
Post graduate	*12.00*	*100.00*
Waste management	**Percent (%)**	**Cumulative (%)**
Yes	*80.00*	*80.00*

No	*12.00*	*92.00*
Don't know	*8.00*	*100.00*

Source: *Field survey, (2016)*

Table 4.2: Materials predominantly wasted on site

Materials wastage on site	Frequency	Percent
Concrete	18	36.00
Reinforcement	5	10.00
Bricks and Blocks	7	14.00
Formwork	9	18.00
Tiles	11	22.00
Total	**50**	**100.0**

Source: Field survey, (2016)

4.3.2 Causes of waste generation on site

Many contractors and other construction personnel commit with many wasteful activities during design and construction process without adding value for the construction progress (Ekanayake and Ofori, 2000). According to (Polat and Ballard, 2004) significant portion of challenges faced by the construction industry are materials wastage. As a result, this research sought to identify the most severe cause of waste generation on Ghanaian construction sites by asking respondents to indicate the severity of the causes of waste generation variables identified in the literature.

The data was analyzed by ranking the causes in other of severity using Relative Importance Index mathematical tool. The (**RII**) values ranges from 0 to 1 with 0 not inclusive. It shows that the higher the value of **RII**, the more significant was the critical

success factor and vice versa. According to Chen et al. (2010), the comparison of RII with the corresponding significance level is measured from the transformation matrixes which are as follows:

High (**H)**	0.8 < RII < 1.0
High-medium (**H-M)**	0.6 < RII < 0.8
Medium (**M)**	0.4 < RII < 0.6
Medium-low (**M-L**)	0.2 < RII < 0.4
Low (**L)**	0.0 < RII < 0.2

Table 4.3 summaries the findings. A critical look at the table shows that poor site management according to the respondents is the most severe cause of wastage on construction sites with an RII value of 0.86 indicating a High significance level. Other factors like inadequate planning and scheduling, mistakes during construction, errors in design and lack of experience all have High significance level and they are discussed below.

4.3.2.1 Poor site management

A number of research have identified poor site management as a major cause of on-site construction waste. For instance, Lu et al., (2011) stated that waste also occurs due to the poor construction management on all construction projects executed. It is not surprising then that the respondents ranked it as the most severe cause of on-site waste generation with RII value of 0.860.

4.3.2.2 Inadequate planning and scheduling

A lot planning goes into the pre-tender stage and construction stage of every construction project. Construction is a very complex activity and involves a lot of workmen and materials. Improper planning for these resources will lead to wastage on-site during construction. A study conducted by Ekanayake and Ofori in 2000 identified that improper planning and scheduling as the most imperative operational contributors to waste generation. The respondents ranked it as the 2nd most severe cause of on-site waste generation factor with RII value of 0.836.

Table 4.3: Ranking of causes of waste generation on construction sites

Causes of waste generation on construction site	**∑W**	**RII**	**Level**	**Rank**
Poor site management	215	0.860	**H**	1ST
Inadequate planning and scheduling	209	0.836	**H**	2ND
Mistakes during construction	208	0.832	**H**	3RD
Errors in design	206	0.824	**H**	4TH
Lack of experience	200	0.800	**H**	5TH
Unnecessary movement of workers and goods	195	0.780	**H-M**	6TH
Changes in materials	191	0.764	**H-M**	7TH
Inadequate monitoring and control	188	0.752	**H-M**	8TH
Overproduction	187	0.748	**H-M**	9TH
Slow flow of information	176	0.704	**H-M**	10TH
Lack of coordination between stakeholders	127	0.508	**M**	11TH

Source: Field survey, (2016)

4.3.2.3 Mistakes during construction

According to Koskela (1992) mistakes during construction and lack of buildability can lead to waste generation on site with can escalate the cost of construction by 6 to 10 percent. Mistakes may include wrong position of column, wrong concrete mix ratio. Mistakes during construction was ranked 3rd by the respondents with RII value of 0.832.

4.3.2.4 Errors in design

Errors in designs which may lead to reworks is another significant cause of waste generation on construction sites. This was supported by Zhao and Chua (2003), because rework is a waste, due to design error and mistakes and can lead to increase in construction cost. This factor was ranked 4th with RII value of 0.824

4.3.2.5 Lack of experience

Nazech et al (2008) believed that a lot of waste generated is due to the inexperience field supervisor. Lack of experience had RII value of 0.800 and was ranked 5th. Experience is vital when it comes to on-site work execution and management. Lack of experience can lead to mistakes which can cause waste generation consequently affecting construction cost and time.

4.3.3 The strategies of reducing waste generation on site

Many contractors and other construction personnel engage in many activities during construction process that does not add value to the construction project (Ekanayake and Ofori, 2000). According to Polat and Ballard (2004) significant portion of challenges faced by the construction industry are materials wastage on construction site. As a result, this research sought to identify the best strategy for mitigating waste generation on construction sites in the Accra metropolis.

From table 4.4, it can be deduced that the best strategy that can be adopted to reduce waste generation on site is proper supervision of works on site. It has a mean score of 4.13. According to Teo and Loosemore (2001), proper supervision of works on site will expedite operatives work and reduce the quantum of waste generated. It is not surprising then that the respondents deemed it as the best strategy in minimizing waste generation. Effective planning of construction process was the second best strategy as ranked by the respondents with a mean score of 3.84. Experienced practitioners in the waste and environment pollution fields recommend that reduction of waste at source by expediting the construction process should be given the highest priority when developing strategies for waste minimization (Crittenden and Kolaczkowski, 1995).

Table 4.4: Ranking of mitigation strategies

Mitigation Strategies	Never	Rarely	Moderately	Often	Very Often	Mean Score	Meaning
Advising of client	2	16	12	8	12	**3.24**	**Often**
Improvement of design practices	0	8	12	24	6	**3.56**	**Often**
Contract and contractual agreement	4	14	18	8	4	**2.88**	**Rarely**
Standardization of design	2	16	14	8	10	**3.16**	**Often**
Management support	2	4	14	12	18	**3.80**	**Often**
Prefabrication of components	10	12	10	14	2	**2.72**	**Rarely**
Re-usage and recycling	6	10	8	14	12	**3.32**	**Often**
Proper supervision	2	4	4	14	24	**4.13**	**Very Often**
Effective planning	2	8	10	6	24	**3.84**	**Often**
Government initiatives	6	10	26	4	4	**2.80**	**Rarely**

***Source**: Field survey, (2016)*

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter summarizes the issues addressed throughout the study. It begins with a summary of how the research objectives were achieved, followed by contributions of this research to knowledge. The chapter concludes with recommendations for further research that can be conducted based on the conclusions

5.2 ACHIEVING THE RESEARCH OBJECTIVES

This research was initiated with the primary aim of identifying strategies of reducing waste generation on construction projects in the Ghanaian construction industry. In order to achieve the stated aim, three (3) research objectives were set in chapter one. Objectives one (1), two (2) and three (3) were achieved through the literature reviews and the survey questionnaires, which were conducted. Below are discussions on how the objectives were achieved.

5.2.1 The first Objective: To identify the causes of excessive wastage in construction projects.

Literature was also reviewed in the third objective which covered the causes of waste generation in construction projects. The review identified that, many contractors and other construction personnel commit with many wasteful activities during design and construction process without adding value for the construction progress. The review also identified eleven (11) causes of waste generation in construction projects.

With the background knowledge in the causes of waste generation on construction projects gained from the literature, a questionnaire was designed to address the third

objective. The respondent's response was analyzed and the Relative Importance Index formulae was applied to ranked the variables and arrange them in order of most severe cause of waste generation on construction projects.

5.2.2 The second objective: To identify materials predominantly wasted on construction sites

Literature was also reviewed in the second objective which covered the various types of construction materials wasted on sites. The review identified that, there are five main construction materials which are wasted in large quantities on construction sites and they included concrete, brick and block, tiles, formwork and reinforcement. Also the review identified the major causes of waste generation of these materials on construction sites. The causes included cutting, transportation, handling etc.

With the background knowledge in materials predominantly waste on construction site gained from the literature, a questionnaire was designed to address the second objective, of which the respondents were ask to indicate among the five construction materials outlined in the literature, the one wasted most on their construction sites.

5.2.3 The third Objective: To identify strategic ways to reduce the occurrence of excessive waste generation in the construction industry.

Literature was also reviewed in the fourth objective which covered the strategies for minimizing waste generation. The review identified that, waste minimization strategies implemented right at the design stage are more efficient and effective because bidders are aware even before the project starts. The literature also demonstrated that the architect has a very vital role to play in construction waste minimization and reduction because they are the mostly the active stakeholders in the design stage of a project. The

review also identified eleven (11) strategies of minimizing waste generation in construction projects.

With the background knowledge in the strategies of minimizing waste generation on construction projects gained from the literature, a questionnaire was designed to address the fourth objective. The respondent's response was analyzed using the average percentile table to identify if the strategies as outlined in the literature can be work effectively and efficiently when applied in our local construction industry.

5.3 SUMMUARY OF FINDINGS

After the reviews and analysis of data collected, a number of findings were identified and is presented below.

5.3.1 Findings on Respondents' Demographic Profile

This section first presents the major findings on the demographic profile of respondents interviewed. It combines the findings on gender, age, educational status, role in construction industry, number of years of working in the construction industry, waste management policy and existence of waste management personnel.

By gender, the study revealed that most respondents were males (72%), which far outnumbered the females (28%). Based on this it was established that in Ghana, males dominate the construction industry. The age structure demonstrated that a proportion of (48%) of Project Managers and Consultants in construction firms in Ghana are within the ages of 40 and 49 whereas the few (4%) fall within the ages of 50 and 59. Also 16% are within 20 and 29 year category and twice of that (32%) are found to be in 30 and 39 year category. Considering the educational status of respondents, it was shown that a greater proportion (68%) of them was with Bachelor Degree qualification. However,

those with post-graduate qualification were (12%). The rest (20%) were having HND qualification. Based on this finding, it was evidenced that in Ghana, most site administrators and Consultants in the construction industry hold higher educational qualification. In terms of the various role or position of respondents, it was established that most of the respondents were Project Managers (32%) and Project Consultants (28%).

Emphasizing on years of work experience, the results as displayed in the Figure 4.5, showed that majority (48%) of respondents interviewed have been working in their various firms for less than 10 years. A little below that, 44% have been working in the construction sector for 11 to 20 years but the few (8%) have been working in the industry for (20 – 30 years). In all, (52%) have more than 10 years working experience.

Much more, the study revealed that most respondents from the firms that were selected have waste management policy. Thus, out of the 50 respondents, majority (80%) claimed they have waste management policy. Only few (8%) claimed they do not have any idea about it, whereas 12% indicated that they do not have it at all. With regards to existence of waste management personnel, it was discovered that a greater number of construction firms have personnel responsible for waste management. This is by virtue of the fact that majority claimed yes, they have; only (12%) claimed they did not know.

5.3.2 Findings on the causes of waste on construction sites

This objective was analyzed using RII to rank the eleven (11) variables identified in the literature. After the analysis of the data concerning the causes of waste on construction sites, poor site management was ranked as the most severe cause of waste on

construction sites. This was followed by inadequate planning and scheduling and mistakes during construction as shown in table 4.2.

5.3.3 Findings on the materials predominantly wasted on Construction Sites

This objective was analyzed using frequencies and percentages on the five (5) variables identified in the literature. After the analysis of the data concerning the materials predominantly wasted on construction sites, concrete was identified as the most wasted material on construction sites followed by reinforcement bars. Bricks and blocks were the third most wasted material on construction sites as shown in table 4.3.

5.3.4 Findings on strategies to reduce waste generation on construction sites

This objective was analyzed using the mean score ranking to identify the best strategy to adopt to reduce waste generation on site. After the analysis of the data concerning the strategies to reduce waste generation on construction sites, proper supervision of works on site was ranked by respondents as the best strategy that can adopted to reduce waste generation on site followed by effective planning of construction process as shown in table 4.4.

5.4 CONCLUSION TO THE RESEARCH

Construction is very vital and beneficial for human development. The sector relies on numerous resources but extensively on capital, human and materials resources, which brings to the sector lots of gains that all and sundry can make prudent use of it. Hence, a sector with such a great impact and multidimensional benefits cannot be devoid of waste, due to its human and material resources. It is of necessity to decrease its menace by seeking the best and reliable mitigation strategies and that was the aim of the study;

to explore strategies adopted by construction firms to control material wastage on construction sites in the Accra Metropolis.

This research identified the causes of waste generation on construction sites and also the materials wasted most on site. The research also came out with strategies that can be adopted to reduce waste generation on site which informed the researcher in making recommendations to reduce or eliminate the challenge of waste generation on site in the Accra metropolis.

5.5 RECOMMENDATIONS

In view of the findings of this research, the following recommendations were made.

- There should be proper supervision on construction sites to expedite operatives work execution on construction site.
- The project manager should pay more attention in planning his/her construction process so as to reduce or eliminate any wasteful activity on-site.
- For public projects, bidders should submit their methods of minimizing waste as part of bid requirements and any bidder who fails to do so can be deemed not responsive.

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APPENDIX

INSTITUTIONAL QUESTIONNARE

I am a student of the Kwame Nkrumah University of Science and Technology (KNUST) conducting a research on '**Construction Waste in Accra Metropolis,'** to find out how construction wastes are managed and the contributory factors with the case of your firm. This is an academic requirement for graduation success hence information provided will strictly not be published but be used for analysis only. It deems much appreciative if you could provide answers to the various questions contained in this questionnaire.

Please tick the boxes **[✓] appropriately.**

SECTION A: BACKGROUND PROFILE OF FIRM AND RESPONDENT

Could you please provide a brief information about the below statements, which concern your background and company's profile?

1) Gender (a) Male [ ] (b) Female [ ]
2) Age (a) 20-29 [ ] (b) 30-39 [ ] (c) 40-49 [ ] (d) 50-59 [ ] (e) 60 and above [ ]
3) What is your highest level of education? (a) HND [ ] (b) 1st Degree [ ] (c) Post graduate [ ] (d) Others (specify), ……
4) Please indicate your role in the construction industry? (a) Project manager [ ] (b) Consultant [ ] (c) Other, state ……

5) How many years have you been in practice? (a) Less than 10 [ ] (b) 11 – 20 [ ] (c) 21 – 30 [ ] (d) Above 30 [ ]

6) Does your firm have waste management policy? (a) Yes [ ] (b) No [ ] (c) Do not know [ ]

7) Does your firm have personnel responsible for waste management? (a) Yes [ ] (b) No [ ] (c) Do not know [ ]

SECTION B: CAUSES OF EXCESSIVE WASTE IN THE GHANAIAN CONSTRUCTION INDUSTRY

8) Using **5-Point Likert Scale of 1-5, where 1 = Never, 2 = Rarely, 3 = Neutral, 4 = Often, 5 = Very Often,** Please indicate the causes of waste generation in your firm on construction (project) sites?

Item	Causes of construction waste generation	1	2	3	4	5
1	Poor site management					
2	Lack of experience					
3	Inadequate planning and scheduling					
4	Errors in design					
5	Mistakes during construction					
6	Unnecessary movement of workers and goods					
7	Overproduction					
8	Slow flow of information					
9	Inadequate monitoring and control					
10	Lack of coordination between stakeholders					
11	Changes in materials					

9) Aside the above listed causes, is there any other cause(s) you have in mind? (a) If Yes [ ], state

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……..…… (b) No [ ]

SECTION C: MATERIALS PREDOMINANTLY WASTED ON CONSTRUCTION SITES

10) Which of these waste materials listed in the below table are predominantly found on your site?

11) Using **5-Point Likert Scale of 1-5, where 1 = Never, 2 = Rarely, 3 = Neutral, 4 = Often, 5 = Very Often,**

Please indicate the causes of waste generation in your firm on construction (project) sites?

Item	Construction waste materials	1	2	3	4	5
1	Fine and Coarse aggregate					
2	Tiles					
3	Concrete and aggregate					
4	Metallic waste (scraps, spare parts, salvages, etc.)					
5	Brick and blocks					
6	Roofing and ceiling materials (sheets, POD)					
7	Wood (broken woods, fire woods, ply woods, etc.)					
8	Liquid waste (paints, contaminated water, fuel, etc.)					
9	Plastic waste					
10	Packaging products					

12) How would you rate the level of waste generation on project sites?

(a) Excessive [ ]	(b) Not really excessive [ ]	(c) Not at all excessive [ ]

SECTION D: STRATEGIES TO REDUCE WASTE ON CONSTRUCTION PROJECTS This section seeks mitigation measures to waste generation in the construction industry.

13) Please indicate the strategies adopted by your firm to reduce waste generation?

Key: 1 = Never, 2 = Rarely, 3 = Neutral, 4 = Often, 5 = Very Often

Item	Construction waste reduction strategy	1	2	3	4	5
1	Advising of client					
2	Improvement of design practices					
3	Contract and contractual agreement					
4	Standardization of design					
5	Management support					
6	Prefabrication of components					
7	Re-usage and recycling					
8	Proper supervision					
9	Effective planning					
10	Government initiative					

14) Aside the above listed causes, is there any other strategy [ies] that can be adopted to reduce the occurrence of waste in the Ghanaian construction industry? (a) If Yes [ ], state

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(b) No [ ]