

KEY COMPETENCIES FOR DRIVING WASTE MINIMIZATION AT THE
CONSTRUCTION STAGE OF PROJECTS

By

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DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma at Kwame Nkrumah University of Science and Technology, Kumasi or any other educational institution, except where due acknowledgement is made in the thesis.

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ABSTRACT

Competency is the knowledge, skills and attributes needed in an organization or area of operation to enhance high productivity. Construction waste could also be defined as an unusable or unwanted material at the construction site. There is low level of awareness on key competencies that drive waste minimization at the construction stage of a project. The awareness and the implementation of the various competencies that drive waste minimization ensure proper collaboration among construction stakeholders as well as a positive attitude towards waste minimization to enhance high productivity. This study was designed with the aim to explore the key competencies that drive material waste minimization at the construction stage of projects. An in-depth literature review and a pilot survey were done. Through that, questionnaires were designed and administered to Public Procurement Authority (PPA) registered construction firms in the Ashanti Region with much focus on Construction Managers. Data generated from the field survey of a sample size of sixty-nine (69) respondents was subjected to Relative Importance Index, Factor Analysis, and Kendall's Coefficient of Concordance. The findings of the study revealed Awareness Competency (AC), Managerial Competency (MC), Personnel Ability Competency (PAC) and Communication Competency (CC) as the key competencies that drive construction material waste minimization. Poor Workmanship, Challenges arising from Transportation of construction materials, and Poor Supervision were highly ranked as the causes of material waste at the construction stage of projects while Increased purchased quantity and price cost, Poor site organization and obstruction of movement due to excessive waste generated, and Lower business patronage were also ranked as the effect of construction material waste variable in undertaking construction projects. A future study is thereby proposed by this study to explore the role of construction professionals in material waste minimization.

KEYWORDS: key competencies, construction material, waste minimization.

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DEDICATION

This dissertation is dedicated to all my friends and my family members.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The Construction sector is a major economic backbone of most countries. In Ghana, it contributes immensely to Gross Domestic Product (GDP) and employs around 320,000 people (Statistical Service, 2015). The Housing and Civil Infrastructure projects are the major components of the construction industry. The Civil sector is regulated by the Ministry of Roads and Highways (MRH) while the Housing sector is regulated by the Ministry of Works and Housing (MWH) (Ofori, 2012). The rapid urbanization and the growing of other sectors of the economy such as the oil and gas has placed a high demand on the construction industry to meet the housing deficits. Nevertheless, the industry is bedevilled with lower output rate, safety issues, inferior working conditions, poor quality delivery and construction waste which do not give value for money (Koskela, 1992a).

Waste, a principal problem in the construction industry was defined by Koskela (1992a), as “any inefficiency that results in the use of equipment, materials or labour in the construction of a building”. Kareem et al. (2015) also defined Waste as an unusable and unwanted material. Serpell and Alarcon (1998) added to the argument by defining waste as “a by-product of human (material) or industrial activity that has no residual value.” In a nutshell, waste could be defined as an activity or material that adds no value. Large amount of waste are generated in the construction sector as compared to the other industries. This is mainly experienced in the purchasing of raw materials (Sand, Quarry, etc) and throughout the construction stages of a

project (Watuka and Aligula, 2003). The United States of America generates about 136 million tonnes of construction waste annually. Germany contributes 30 million tons of construction waste (US Green Building Council, 2001). The Ghanaian construction industry also experiences an enormous range of construction waste (Agyekum et al. 2012). According to Richardson and Springer (2013), waste can be produced from inception, design, construction, and operation of the built facility/ civil engineering structure. Project duration, project size, activities during project delivery as well as worker numbers greatly influence waste generation. According to Saheed et al. (2016), constructability of a project should be considered in the design process to prevent generation of excessive waste. Bakshan et al. (2015) grouped waste from construction field into inert, non-inert and hazardous categories. Formoso et al. (1999) also added to the argument by classifying waste as unavoidable waste (or natural waste) and avoidable waste. Under avoidable waste, the cost of waste is higher than the cost to prevent it. Unavoidable waste too the investment necessary for its reduction is higher than the cost of waste produced.

Construction Industry Board (1998) postulated mistakes, unplanned work delivery, redundant activity and movement, delayed or premature inputs and products or services that do not meet customer needs as the cause of waste on construction sites. Construction waste has negative effects on the environment as well as project costs. High level of waste recorded at construction sites has brought large demand of Construction materials at our construction sites. The stage of construction as well as the method of construction practice influences waste generation in project delivery. This therefore turns to bring devastating effects on the environment (Lee et al. 2013). Construction players has a role to minimize construction waste in order to bring value for money

at the end of construction projects and also protect the environment through the usage of the three (3) 'Rs' (reduction, re-use and recycle) principle of waste minimization.

The Environment Agency (2001) defined waste minimisation as "the understanding and changing processes in order to reduce waste at source". Richardson and Springer (2013) also stated that waste minimization is any process, method or activity that enables recycling or waste reduction from source. It could be understood from the above literature that the concept of waste minimization tackles waste at the initial stages of the construction activity. There has been a lot of literature on waste minimization. Mendis (2011) argued that planning and controlling are the two waste minimisation strategies. Lu and Yuan (2011) postulated minimizing waste by government legislation; reducing waste through design; establishing an effective waste management system and use of low waste technologies and improving practitioner's' viewpoint toward waste reduction as five (5) waste minimization factors at the Construction stage of projects. Despite the existence of these strategies, little impact has been felt on the construction industry as far as waste minimization is concerned. There is low level of awareness on key competencies that drive material waste reduction at the construction stage of a project. Competencies could be defined as knowledge, skills and attributes needed in an organization or area of operation to enhance high productivity (Parry 1998). The awareness and the implementation of the various competencies that drive waste minimization shall ensure proper collaboration among construction stakeholders as well as a positive attitude towards waste minimization. Construction stakeholders such as Client, Construction manager, Architect, Quantity Surveyor and Site Supervisors are the major players of construction waste minimization.

This research seeks to explore key competencies for driving waste minimization at the construction stage of projects in order to deliver high performance sustainable buildings. The Construction Managers perspective as far as waste minimization is concerned shall be focused on in this study. They are the professionals that control most of the activities at the construction stage of a project. Ofori and Ekanayake (2000) propounded Material, Labour and Machinery as the three (3) basic types of Construction Waste. This study shall also focus on Material Waste as they are the major constituent of waste in the construction industry.

1.2 STATEMENT OF THE PROBLEM

The Construction Industry generates a lot of waste during construction process. Wood waste, steel waste, concrete waste, and dirt waste are the major types of waste generated at construction sites. These wastes normally end up in landfills. Most landfill sites are fully occupied with waste (US Green Building Council, 2001). The disposed construction waste poses a negative threat to the environment and the excessive Construction Waste affects the construction project value. The above points create an avenue for a second look at Construction Waste.

There has been numerous literature works on construction waste minimization of which some include the Hierarchical Waste Management Method; reduction, reuse, recycling and disposal (Yuan and Shen, 2011). Proper planning and control of construction waste was also suggested by Mendis (2011) as a waste minimisation strategy. Nevertheless, the issue of Construction Waste has not been solved. Most construction professionals who are major players of construction waste minimization have low knowledge on key competencies that drive waste minimization at the construction stage of a project (Mirabile, 1997). Others too have difficulties in adapting to new practices, thus refused to accept changes in implementing waste minimization

competencies from conventional practices that have been used for long (Sharif et al. 2014). This therefore creates the urgency to explore the pivotal competencies for driving material waste minimization at the construction stage of a project. The key competencies shall ensure effectiveness among waste minimization players in the construction industry (Li, 2012).

1.3 AIM AND OBJECTIVES

1.3.1 Aim of the Study

The aim of the study is to explore key competencies for driving material wastage minimization at the construction stage of a project.

1.3.2 Objectives of the Study

1. To identify the causes of material wastage at the construction stage of projects.
2. To identify the effects of material wastage in undertaking construction projects.
3. To determine key competencies for driving material wastage minimization.

1.4 RESEARCH QUESTIONS

1. What are the causes of material waste at the construction stage of projects?
2. What are the effects of material waste on construction projects?
3. What are the key competencies for driving material waste minimization?

1.5 SIGNIFICANCE OF THE STUDY

In most Countries, the construction industry generates a higher percentage of waste. This is not different in Ghana. Construction Professionals have not given much priority to construction waste despite its negative environmental and economic effects (Kareem et al. 2015). This study shall add to knowledge on the causes and effects of Construction Waste. Construction Professionals will be informed on key competencies that will result in waste minimization. These may include but not limited to collaboration and ease of information flow among project stakeholders. The listed competencies shall culminate in a sustainable construction. That is, Waste Minimization shall improve project performance, enhance value for money and create a positive impact on the national economy.

1.6 RESEARCH METHODOLOGY

A critical literature review which will discover what waste minimization is and the causes, effects and competency strategies in curtailing it was done. Much focus of the study was on key competencies in waste minimization. The quantitative approach was used to collect data. In this vein, a structured survey questionnaire was designed, as the leading primary data used. The population for the project was Public Procurement Authority (PPA) registered construction firms in Ghana. The Sample frame was Public Procurement Authority (PPA) registered construction firms in Ashanti Region. Construction Managers at the various construction sites were involved in the study. The data collected was coded and analysed with the Statistical Package for Social Scientists (SPSS). The causes and effects of construction material waste at the construction stage of a project were analysed using Relative Importance Index and Kendall's Coefficient of concordance. The key competencies for driving Waste Minimization were explored by applying

Principal Component Analysis using SPSS v 21 software. This gave a general overview of results. The research methodology was discussed in detail in the chapter three.

1.7 SCOPE OF RESEARCH

Geographically, the research study captured key competencies in construction waste minimization in Ghana. Contextually, the research study focused on the construction stage of building projects in the Ashanti Region. This research focused on material waste since they form a major share of construction waste. The sub-structures, super-structures, finish and external works forms the construction stage of a construction activity. Questionnaires were distributed to the respondents who undertook projects at the sampled areas. The respondents here were construction professionals; Project / Construction Managers.

1.8 STRUCTURE OF THE STUDY

This study consists of five chapters. The chapter one gave an overview of the research topic. It highlighted the research in terms of the background of the study, statement of the problem as well as the aim and objectives of the study. Significance of the study, research methodology adopted, scope of study and the structure of the research were also catered for in the chapter one. Chapter two covered the review of useful literature related to the study. It guided the construction of questionnaires for the research. The Chapter three dealt with detailed methodology that was used in the study. Chapter four covered data analysis and the chapter five tackled the summary of the findings of the study, conclusion and recommendations.

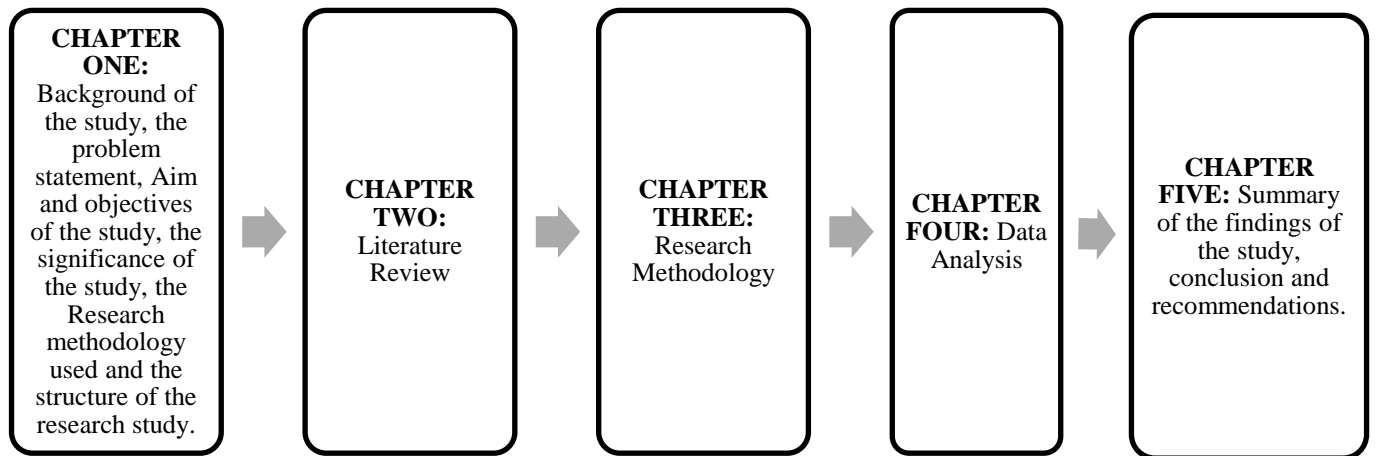


Figure 1.1: Structure of Report

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

According to Hart (1998), literature review expresses certain views on a proposed topic. Ideas, data or information that comprises a literature review could either be published or unpublished. This chapter reviews in detail existing literature works on construction waste; causes, effects and key competencies that drive waste minimization. Insights and background knowledge obtained from the literature review will be used to create the awareness on the key competencies that ensures waste minimization. This shall improve project performance, enhance value for money and create a positive impact on the national economy.

2.2 CONSTRUCTION WASTE

2.2.1 The Concept of Construction Waste

WHO (1984) classified waste generators to be: residential, industrial, commercial, institutional, construction and demolition, municipal services, process and agricultural. Koskela (1992a) postulated construction waste as a major contributor to waste generation as compared to the other waste classifications. The concept of construction waste has been touched by various authors including Ohno (1988) and Womack et al. (1996). Both defined construction waste as an activity or the use of resources that do not bring forth value to the final product. Formoso et al. (2002) also viewed construction waste from the client perspective as “a direct or indirect costs that results from a loss of resources but do not add any value to the final product. In summary, any unwanted material produced intentionally or unintentionally by construction related industries could then be termed as construction waste. Yahya and Boussabaine, 2006;

Rameezdeen and Kulatunga (2004) touched on cement, steel, wood scrap, concrete, asphalt, bricks, blocks and other masonry; plaster and wallboard, roofing materials, plastic scrap, dirt, carpets and padding, glass (window and door) as the various examples of waste generated on construction sites.

Statistical report on waste generation by the United States Environmental Protection Agency (USEPA) stated 154.2 million tonnes as the quantity of construction waste generated in 2003 (United States Environmental Protection Agency, 2003). The US Green Building Council (2001) contributed to the argument that 30 million tons of construction waste is generated by the Germans annually. The Ghanaian construction industry also experiences an enormous range of construction waste; a wide variation in wastage rates of between 5% and 27% of total materials purchased for construction projects (Agyekum et al. 2012).

Marzouk and Azab (2014) postulated that waste from construction activities destroys landfill sites, contributes to greenhouse gas emissions and poses a health hazard. BIS (2010) argued that, with the numerous CO₂ emissions from construction waste, the United Kingdom contributes 250.3mt annually. Construction waste indeed has negative impacts on the environment.

2.2.2 Types of Construction Waste

Diverse literature works have records of construction waste categorization. Skoyles (1976) added to literature review by stating indirect and direct waste as types of construction waste. A direct waste involves serious physical damage leading to material loss while indirect waste only leads to monetary loss. Broken blocks in the process of offloading from truck could be termed as direct waste and an increase in a column thickness despite the structural specifications could also be termed as indirect waste.

Material, Labour and Machinery Waste are the three main types of construction waste according to Ofori and Ekanayake (2000). Material comprises all the raw building constituents; cement, sand, blocks, steel, etc. A major proportion of it are derived from resources that are not renewable hence making it difficult to replace once wasted. Labour also involves the human resource in the industry. Labour on construction sites are mostly categorised as Skilled and Unskilled (Ofori and Ekanayake, 2000). Labour wastes are experienced on construction sites when a worker becomes redundant. Machinery waste also involves using construction materials for an unsuited work, waiting time to be loaded or to load other machineries materials, etc. The focus of this study is on construction material waste since it has a higher percentage of waste generated as compared to labour and machinery (Ofori and Ekanayake, 2000). Most of construction inputs are from non-renewable resources making it difficult to replace them once wasted. A higher amount of energy and monetary value is involved in construction material production creating the urgency to focus on material waste in order to minimize waste.

In terms of activities on construction sites; over-ordering, overproduction, wrong handling, wrong storage, manufacturing defects and theft or vandalism are various categories of construction waste (Garas et al. 2001). Over-ordering is the requesting of materials more than needed, with the supplements not suitable for any works immediately. Overproduction involves producing construction materials more than demanded in the market. Wrong handling is the inappropriate transporting of construction materials within a construction site. This could resort to health implications on the handler and waste of time due to double handling. Construction materials have its rightful place of storage. Highly flammable materials cannot be stored indoors rather an open area. Wrong storage of construction materials could cause damage to the material.

Garas et al. (2001) further stated that construction waste could be minimized by inspecting supplied materials as to any records of defects, secured storage of construction materials to reduce the incident of theft. Formoso et al. (1999) also added to the argument by classifying construction waste as unavoidable waste (or natural waste) and avoidable waste. Under avoidable waste, the cost of waste is higher than the cost to prevent it. Unavoidable waste too the investment necessary for its reduction is higher than the cost of waste produced. Formoso et al. (1999) further stated that the level of unavoidable waste in a company depends on its technological advancement.

The respondents view on various analyses by Koskela, (2000); and Bossink et al. (1996) led to the conclusion on accidents, working under unfavourable conditions, vandalism and theft as categories of construction waste. Bossink and Brouwers (1996) looked at a different angle of waste categorization by focusing on the source. The source is where the root cause of waste occurs. Design, procurement, material handling, operation and residual are the categories of construction waste (Bossink and Brouwers 1996).

2.3 CAUSES OF CONSTRUCTION MATERIAL WASTE AT THE CONSTRUCTION STAGE OF PROJECTS

Each cause of construction waste has a source. Design, procurement, material handling, operation, and residual are the source of construction waste in projects as postulated by Gavailan and Bernold (1994). Excessive waiting period for upstream activities to finish; over-processing; over-production; maintaining excess inventory; unnecessary transport of materials; and unnecessary movement of people are the main causes of construction waste as indicated by Pinch (2005). According to Bakshan (2015) preparation/design stage (Design); pre-construction stage (tendering and contract) and construction stage (construction) are the main stages in a construction project. This study shall focus on the construction stage of a project in terms of construction waste. The causes of construction material waste at the construction stage of a project falls under the umbrella of material procurement, transportation, on site management and planning, material handling and storage, site operations and residual.

2.3.1 Personnel Ordering Errors (Procurement of Construction Materials)

Procurement is one of the major stages in construction. It involves making purchases and order of construction materials. Construction material waste is mostly recorded due to errors on the part of the supplier. A different material other than the requested one could be delivered to site. This then becomes redundant in terms of usage. Osmani et al. (2008) sided with the argument that most construction waste occur because of errors on the part of the supplier. The Procurement department in most construction firms also order for items not in conformity with the specification. This therefore makes it surplus to requirement (Osmani et al. 2008). In a nutshell,

improper procurement of construction materials contributes to construction waste in various ways such as errors on the part of suppliers or the procurement department.

2.3.2 Challenges arising from Transportation of Construction Materials

Transportation greatly affects the success of a construction project. It involves the movement of construction materials from a source to the place of usage or storage. In transporting of construction materials, most of the materials get damaged through accidents, poor weather conditions, etc. There is also no proper protection and methods when offloading of construction materials (Bossink and Brouwers, 1996). Osmani et al. (2008) also stated that vehicles delivering materials to construction sites find difficulties in accessing most construction sites. A lot of construction materials get damaged in the process of offloading. Examples of such include Cement, Blocks, etc. This therefore affects the construction project through shortage of materials requested.

2.3.3 Other Causes of Construction Material Waste at the construction stage of a project.

Other causes of construction waste include; Poor Supervision, Poor Workmanship, Poor Storage Facilities, Improper Handling of Construction Materials, Poor Storage of Construction Materials, Errors and Changes in design, Material Deterioration, No Waste Management, Force Majeure (Ajayi et al. 2016; Lingard et al. 2000).

2.4 EFFECT OF CONSTRUCTION MATERIAL WASTE IN UNDERTAKING CONSTRUCTION PROJECTS

WRAP (2009) postulated that the construction industry strives to enhance sustainable development through minimization of construction waste; reducing the amount of construction waste disposed at landfill sites. However, waste from construction activities has a lot of negative effects on construction projects delivery as well as the environment as a whole. Construction material waste does not encourage cost savings on various projects. It leads to environmental, economic and health issues (Osmani et al. 2008). The economic effects of construction material waste include higher project costs, lower business patronage, and higher risk of litigation regarding wastes. Construction waste contributes about 21-30% to total project cost, leading to the general increase in the total costs of building projects (Ameh and Itodo, 2013). The environmental effects also include an increased risk of immediate and future environmental pollution (Dania et al. 2016). Other effects of construction material waste as indicated by WRAP (2009) include; increased material and disposal costs through an increase in the materials ordered and waste disposed at the landfill; decreased competitive advantage through differentiation; higher Carbon di-oxide emissions; not meeting planning requirements; and poor performance against corporate sustainability responsibility (CSR) objectives.

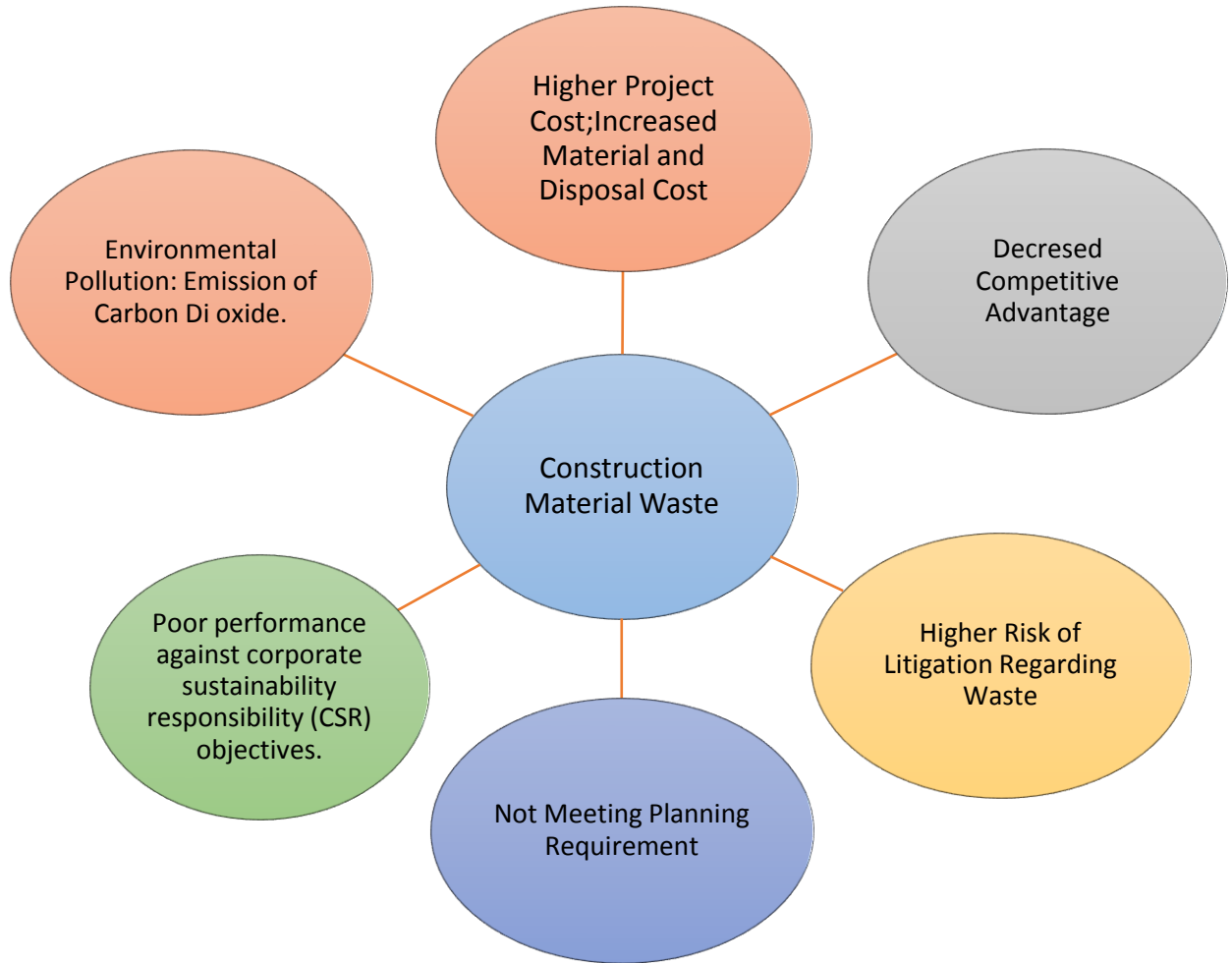


Figure 2.1: Author's Conceptual Module on Effect of Construction Material Waste On Construction Projects

2.5 WASTE MINIMIZATION

2.5.1 Overview

Ajayi (2017) opined that there are a lot of benefits in waste minimization; providing economic benefits and creating environmental friendliness, meeting the global agenda on sustainability. The issue of construction waste minimization has been touched by various journals with much focus on designing out waste; application of methods and techniques in sorting out construction waste on site; development of waste data collection models, including flows of wastes and waste management mapping, development of on-site waste auditing and assessment tools; reuse and recycle of construction waste. Udawatta et al. (2015) argued that, the focus of most construction firms has been on profit maximization despite the lot of literature works as well as government, international and industrial intervention in waste minimization.

Waste minimisation could be defined as “the understanding and changing processes in order to reduce waste at source” (The Environment Agency 2001). Richardson and Springer (2013) also stated that waste minimization is any process, method or activity that enables recycling or waste reduction from source. EPD (2000) buttressed the argument of Richardson and Springer (2013) by saying waste minimization reduces the volume and toxicity of waste that are to be disposed. Poon et al. (2004) also defined waste minimization as, any technique, process or activity which eliminates or reduces waste at its source or allows re-use or recycling of the waste. Also construction waste minimization according to Osmani (2011) is defined as the reduction of waste at source, (i.e. designing out waste) by understanding its root causes and re-engineering current processes and practices to alleviate its generation. Most literature works state that the best period to tackle construction waste should be at the initial stages of the activity. According to Cheng

and Mydin (2014) the concept of waste minimization should be incorporated in the strategic planning of projects.

2.5.2 Waste Minimization Strategies

Waste minimization can occur at various stages of the life cycle of a project. This may include contractual, design and construction stages. The focus of this study shall be on waste minimization at the construction stage of a project. The burden of construction waste minimization is particularly borne by all construction stakeholders; client, designers, contractors and suppliers (Osmani, 2012). Effective waste minimization could improve the performance of the construction industry with cost-saving benefits (Ameh and Itodo, 2013). Two waste minimisation strategies according to Mendis (2011) are effective planning and control of construction activities. Lu and Yuan (2011) also postulated that legislation by the government; designing out waste; effective waste management system, use of low waste technologies and improving construction professionals viewpoint toward waste reduction are also examples of waste minimization strategies at the construction stage of projects. Greenwood et al. (2003) indicated that, tackling construction waste after it is produced is not an appropriate way of minimizing waste rather such need should be prioritized from the source.

2.6 KEY COMPETENCIES FOR DRIVING MATERIAL WASTE MINIMIZATION

2.6.1 The Concept of Competency

The concept of competency has been touched by various literature works with Frederick W. Taylor, McClelland and Boyatzis spearheading it in the 20th century (Mansfield 1996). Competency is the collection of knowledge, skills and attribute that are capable of influencing an individual's performance (Parry 1998). The Iceberg Theory as propounded by Spencer and Spencer (1993) also viewed competency as an iceberg at the sea level depicting a visible part and a hidden part. Knowledge and skill form the visible part while interpersonal, motive/trait/concept and value/moral forms the hidden part. Lee et al. (2003) defined competency as a behaviour that produces successful results through the combination of knowledge, skill, attitude and value. Competency is a series of skills and traits needed by workers for an effective work delivery (Mansfield, 1996).

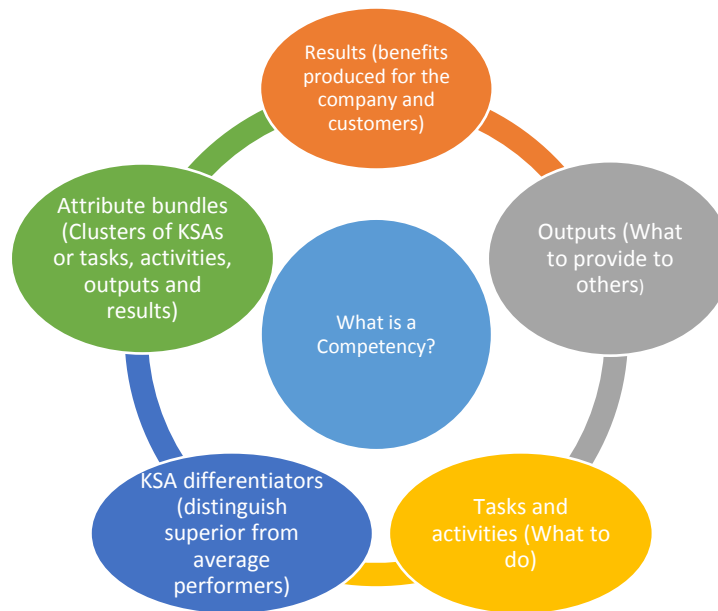


Figure 2.2 : McLagan (1997) Definition of Competency

2.6.2 Components of Waste Minimization Competencies

In order to ensure waste minimization in the construction industry, there is the need to explore the core competencies required by the construction players to ensure effectiveness. Zang (2013) proposed leadership and organization, basic literacy, target management, and emotional intelligence as core competencies that could drive waste minimization. PMI (2008) categorised competency under knowledge, performance, and personal competencies. This study shall focus on skills, and knowledge as the main component of waste minimization competencies. This reiterates the position of Spencer and Spencer (1993) on viewing competency as an iceberg showing forth a visible part (Skills and Knowledge) and a hidden part (Trait).

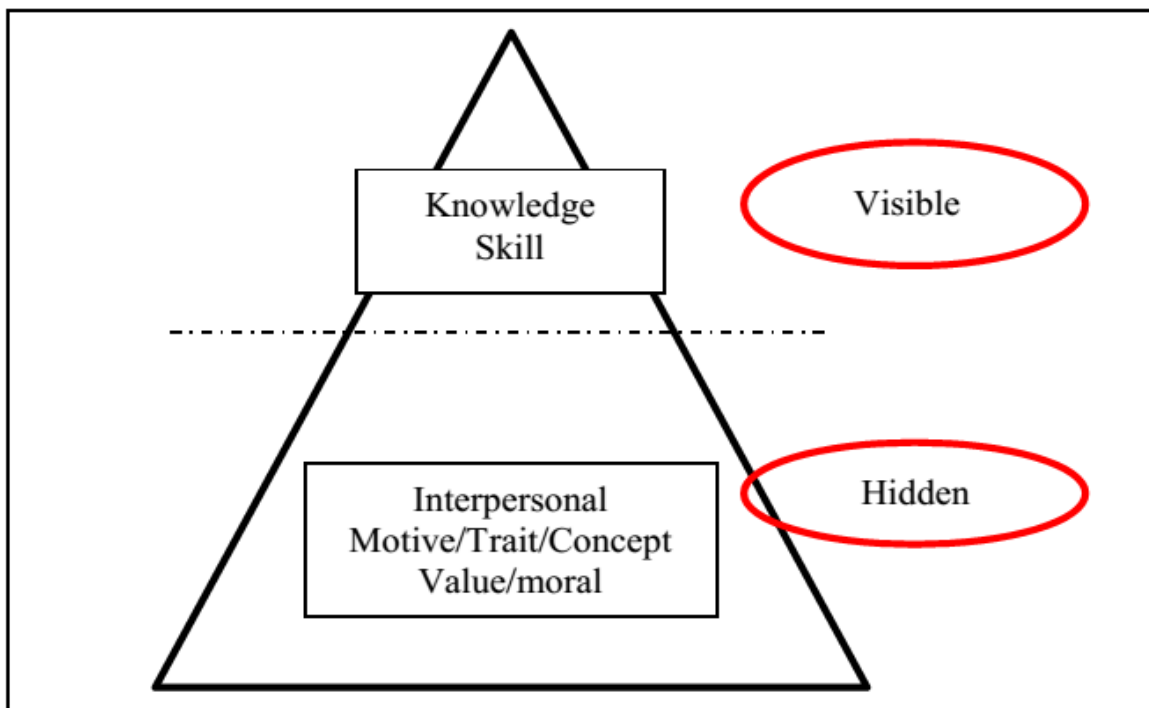


Figure 2.3: Iceberg Theory by Spencer and Spencer (1993)

2.6.2.1 Skills

Marrelli (1998) defined skill as the capacity to perform a task that involves mental or the physical nature in order to have a specified outcome. Skills could be easily identifiable or abstract (Marrelli, 1998). Key skills for minimization of construction waste at the construction stage of a project are expounded in the subsequent paragraphs.

2.6.2.1.1 Leadership

Geoghegan and Dulewiz (2008) asserted that the effectiveness of any project success depends on the leadership role of the construction professionals. Therefore in focusing on key competencies that drive waste minimization at the construction stage of a project, leadership skill was targeted. Leadership skill encompasses self-awareness, emotional resilience, intuitiveness, interpersonal sensitivity, influence, motivation, and conscientiousness (Geoghegan and Dulewiz, 2008) of the construction professional in waste reduction. In managing construction waste, the construction manager is to be able to provide direction to inspire others, track his weaknesses & strength and also show personal commitment to pursuing waste minimization.

2.6.2.1.2 Effective Communication

The Construction manager or the head in charge of waste minimization at the construction site should be able to efficiently communicate with all parties involved in construction waste reduction on policies governing waste management to fulfil sustainability goal. According to Li et al. (2013), effective communication of organizational waste management policy mobilizes supports for the minimization objectives.

2.6.2.1.3 Team Work

According to Hwang and Ng (2013), working cooperatively with others as opposed to separately or competitively is pre-requisite for influencing a team to perform in a desirable manner. This

therefore means teamwork is an important factor when talking about key competencies that drive waste minimization at the construction stage of a project. The construction manager should ensure that effective coordination exist among all project stakeholders (i.e. clients, consultants, and suppliers) in the drive to waste minimization at a construction site (Ajayi, 2017). Effective communication, information sharing, early warning system and early contribution of expertise on construction waste needs to be enhanced to prevent construction errors, reworks and waste (Ajayi, 2017).

2.6.2.1.4 Waste Management Plan Implementation

Developing and the implementation waste management plan contribute immensely to construction waste reduction at the construction stage of a project. It helps identify the forms of waste and their sources, and specifies mitigating measures for them. The plan reflects the peculiarities of the project in terms of the nature and amount of waste anticipated and prescribes ways of managing them (Macozoma and Benting, 1999).

2.6.2.1.5 Supply Chain Management (SCM) Skills

According to Al-Hajj and Hamani (2011) supply chain management skills involves the capacity to obtain suppliers' highest commitment, achieve just-in-time delivery and enable Lean construction in order to avoid waste due to long storage or to ordering unneeded materials. Just-in-time delivery approach enables the usage of a material as and when needed. This reduces double handling and damage that erupts from long storage.

2.6.2.1.6 Material Logistic Plan Implementation

Al-Hajj and Hamani (2011) asserted that implementation of Material Logistics Plan (MLP) at construction sites is an efficient way to reduce construction waste. Logistics management

involves effective planning of materials ordering and purchase, inbound and on-site materials movement, and materials storage (Ajayi et al. 2016). Waste minimization requires adequate estimation of materials required at different stages of projects in an attempt to reduce the likelihood of materials over-ordering and subsequent leftover, which is a key cause of waste generation (Ajayi et al. 2016). Bearing the skills in Logistics management ensures an efficient waste reduction.

2.6.2.1.7 Other Skills

Hwang and Ng (2013) postulated delegation, and problem solving as key skills that could drive construction waste minimization. Shi et al. (2014) also added continuing professional learning, Onsite practical skill, and Personnel quality as skills that should be possessed by construction professionals in waste minimization. Creative thinking, Provision of direction to inspire others, and a personal commitment in pursuing an ethical solution to waste minimization are also skills that that could drive material waste minimization if portrayed by construction site workers (Al-Khawaldah, 2017).

2.6.2.2 Knowledge

Mirabile (1997) defined knowledge as the awareness or the understanding of facts, rules, principles, guidelines, concepts, theories, or processes needed to complete a task. Examples of key competencies driving waste minimization under the component knowledge include;

2.6.2.2.1 Construction Sequencing and Construction Planning

Most waste on construction sites happen due to lack of planning and sequencing of construction activities. Hwang and Ng (2013) asserted that planning and scheduling is a critical factor in the quest to achieve sustainability hence it needs to be well addressed and reflected in construction schedules to avoid any delays and wastage of materials.

2.6.2.2.2 Reuse and recycling of waste

The recycled content as well as the recyclability of a construction material enhances sustainability which eventually contributes to waste reduction. According to Staker Parson Companies, the recycled content of ready mixed concrete makes it sustainable. The concrete might contain a percentage of fly ash, which is a by-product from coal-fired power plants. This creates a concrete that has higher strength and durability. Kim and Rigdon (1998) asserted that Steel can be recycled from construction debris which makes it a commonly recycled building material. Glass is a recyclable construction material but its separation from a construction waste is difficult (Kim and Rigdon, 1998). According to Goh (2014), using materials that can be recycled reduces the use of raw materials and the embodied energy. He further stated that recycling takes less energy than producing a whole new material. Steel formwork can be used instead of any other formwork for efficiency and the preserving of natural resources (Goh, 2014).

Knowledge and the implementation of the above factor drives waste minimization at the construction stage of a project.

2.6.2.2.3 Health and Safety Management

Health and Safety Management is critical when focusing on key competencies that drive waste minimization at the construction stage of a project. The construction manager needs to understand the health impact of construction waste on site workers and the danger improper management of construction waste brings. Accidents which normally happen from poor site waste management could be reduced through proper health and safety management (Hwang and Ng 2013).

2.6.2.2.4 Human Resource Management

Hwang and Ng (2013) postulated that Construction Managers should select parties for construction activities based on their knowledge on construction waste. In human resource management, practices like organizing waste management and materials handling vocational training for operatives, having a dedicated site team or specialist sub-contract package for on-site waste management, the appointment of labour solely for waste management, etc. could enhance the minimization of waste (Ajayi, 2017).

2.6.2.2.5 Modern Construction Methods

Modern construction methods such as the use of prefabricated construction products and modular construction contribute to construction waste minimization at the construction stage of a project. Prefabrication makes use of precast components and modules, modular construction technique and other offsite technologies (Ajayi, 2017). Modular construction also refers to factory produced building units that are delivered and assembled on site as building elements or

volumetric components. The use of precast materials has the potential of reducing the amount of on-site damage and rework thereby contributing to waste reduction output by up to 84% (Ajayi, 2017).

2.6.2.2.6 Standardization and the Implementation of Sustainable Construction Practices

In the construction phase of a project, standard material sizes could be opted for to reduce waste during trimming processes. Mixing of concrete too can be done on site to readily control the amount needed. These points are supported by Kim and Rigdon (1998) with the claim that minimal construction waste during installation reduces the need for landfill space and also provides cost savings. Sustainability is a concept that aims at protecting our environment, ensuring economic profitability and creating social awareness (Parkin et al. 2003). Knowledge on sustainable construction practices ensures effective waste reduction.

2.6.2.2.7 Other Competencies

Other knowledge competencies that drive waste minimization at the construction stage of a project include; adherence to project design/drawings, waste auditing to monitor environmental performance and thorough review of the project specifications by contractors at the construction stage (Osmani et al. 2008).

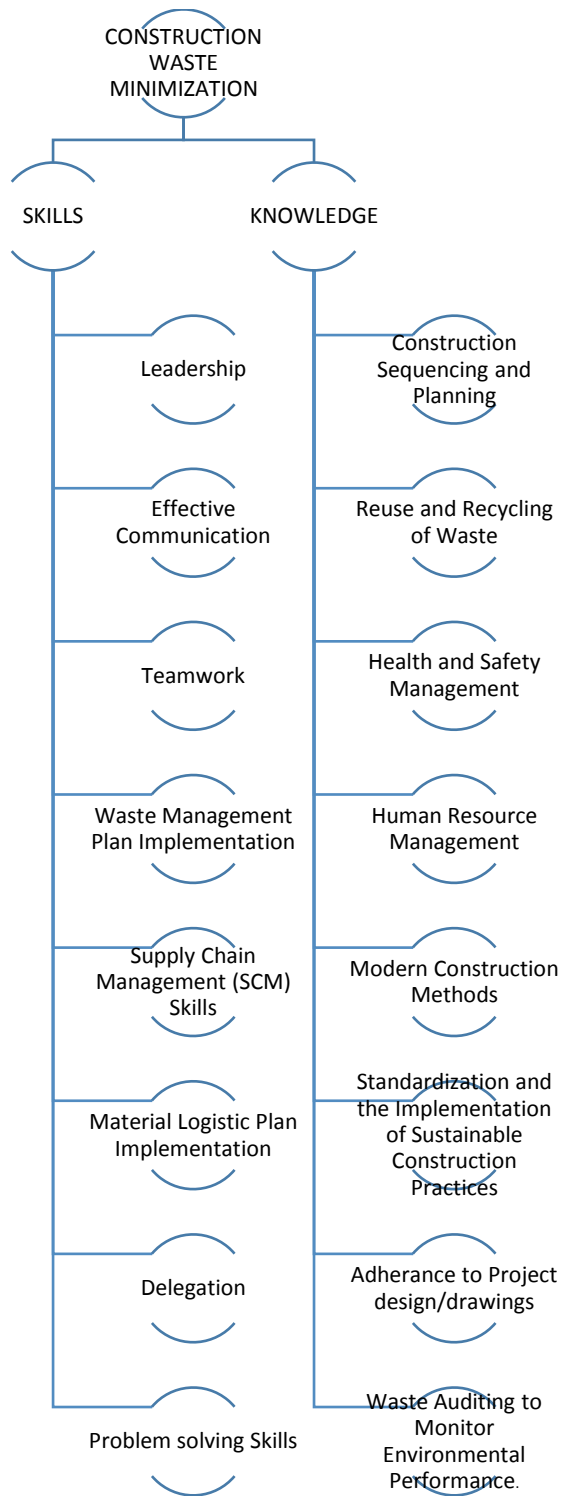


Figure 2.4: Author's Conceptual Module on Key Competencies that Drive Construction Waste Minimization at the Construction Stage of a Project.

2.7 ROLE OF CONSTRUCTION SITE PROFESSIONAL IN CONSTRUCTION

MATERIAL WASTE MINIMIZATION

Key stakeholders of construction projects include; the Owner, their Architectural and Engineering (A/E) services (or Construction Management consultant), the Contractor, and Subcontractors (Gyadu-Asiedu, 2009). They all have a contribution to make in construction waste reduction. In the exhibiting of various competencies by construction site workers (Construction Manager, Site Material Manager, Subcontract Management, Trade workers) in construction waste minimization, the Client and their A/E must first establish waste reduction goals and define what levels of minimization strategies are achievable and reasonable under the project's conditions (Hirpha, 2016). This could be stipulated in the contract document. The Contractor then should incorporate waste minimization & disposal methods in the construction process. The choice of materials should be such that it is not sensitive to damage, contamination, environmental exposure, or spoilage on-site, which increases the potential for jobsite waste (Hirpha, 2016). The design team should observe standard material and product dimensions to reduce cutting and special fitting, which creates scrap. List of Construction Site Workers and their contribution to construction waste minimization as posited by Hirpha (2016) are shown in the table below;

Table 2.1:Role of Construction Site Professional in Construction Material Waste Minimization

Team Member	Role in Materials Management to Minimize Wastage
Site Construction Mgmt.	Applies the materials management plan to the site and oversees management its implementation. Takes into consideration physical space available and ensures subcontractors are familiar with and committed to the plan.
Site material manager	Keeps track of new materials, cuts and used materials Organizes and stores them for availability by the various trades throughout the project in accordance with the materials management plan.
Subcontract management	Communicates with site management and materials management regarding the types of materials they may be able to use for various purposes, even if temporarily. Ensures trades follow the Plan's practices
Trade workers	Use materials properly and Store new materials properly Handle and cut them careful Is for maximum use and minimum waste. Consider using cuts before new pieces.

Source: (Hirpha, 2016)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In order to assemble the requisite knowledge for the research question in realizing the aim as well as the objectives of this study, this chapter makes use of the appropriate methodology to answer the research questions raised. Collis and Hussey (2003) posited that research methodology is the overall approach to the design process from the onset of the work to data collection and analysis adapted for a study. The research methodology therefore expands the procedures, methods and philosophical keystones employed to gather vital knowledge. Chapter three elaborates on the reasons for the selection of the research paradigm. The study population, sample size and how the size was selected are captured under this chapter. The approach to data collection, the data collection instrument and also the data analysis strategies that were adopted for the study are also outlined under this chapter. In summary, the chapter three defines the rationale behind the research method used for this study.

3.2 PHILOSOPHICAL CONSIDERATION

The philosophical position of a research greatly influences its research design (Christou et al. 2008). Ontology and epistemology were highlighted by Bryman (2004) as two key philosophical positions in social research. Denzin and Lincoln (2005) also postulated ontology, epistemology and methodology as three key fundamentals in research paradigm. Christou et al. (2008) opined that philosophical matters such as epistemology, ontology, axiology and methodology suppositions need to be critically looked at since they outline the selection of research instruments.

Epistemology exists to enquire about how knowledge was acquired, the processes of acquisition and the validation of the knowledge thereof (Gall et al. 2003). Saunders et al. (2009) added to the argument that epistemology creates a room for us to know and understand which knowledge is to be accepted in a field of study. **Positivism and interpretivism** forms the two perspectives of epistemology (Saunders et al. 2000). According to Baiden (2006) **positivism** focuses on the application of natural science methods to the study of social reality and beyond while **interpretivism** also looks at the absence of universal truth and emphasizes on realism of context. **Ontology** is concerned with the belief of the researcher about social world's nature and what can be identified of it (Ritchie and Lewis, 2003). **Objectivism and subjectivism** are the two main ontology positions as postulated by Saunders et al. (2000). **Objectivism** holds the view that our influence or behaviours cannot affect the reality while **subjectivism** is mostly based on a social phenomenon: explained as the thoughts and consequence actions of humanistic behaviours about their existence (Christou et al. 2008; Saunders et al. 2009). **Axiology** also determines the appropriateness of either objective criterion (value-free) or subjective criterion (value-laden) in examining a study (Pathirage et al. 2005).

The research philosophy adopted for this study is Pragmatism. It gave the researcher the broad view to explore the methods suitable for the study. Saunders et al. (2009) postulated that a single stance in explaining a subject matter might not be adequate and appropriate. Pragmatism is seen as a midway between the positivist philosophy and the interpretivist philosophy epistemologically. It gives the researcher the opportunity to mix different research methods (Objectivism or subjectivism, value free or value laden criterion) in an effort in getting more

insight in a study (Saunders et al. 2009). However, pragmatists are expected to use the method that are appropriate for the study not necessarily all the methods available at their disposal.

3.3 RESEARCH APPROACHES

Research approach is the stage to stage procedures and general plans adopted for a research from the conception point up to the interpretation of results (Creswell, 2013). Deductive and inductive approach forms the two key areas of research approach. According to Easterby-Smith et al. (2008); research design, research strategies and knowledge in different research conducts influences the choice of research approach for a study. Deductive approach is the testing of patterns identified through observation to confirm its actual occurrence from general to specific (Kwofie, 2015). Data collection for this approach is mostly done using the quantitative method. Ofori-Kuragu (2013) also viewed inductive approach as the study of specific instances of societal issues, through the identification and development of patterns from the analysis of data gathered. The qualitative method is used for data collection under inductive approach. The research approach adopted for this study was the deductive approach. It is objective in nature, and in exploring the key competencies that drive construction waste minimization at the construction stage of projects, it was necessary to allow for experts' views collection through primary data by using structured research questionnaires.

3.4 RESEARCH STRATEGY (QUALITATIVE AND QUANTITATIVE TECHNIQUE)

Research strategy is defined as the enquiry of research objectives (Naoum, 1998). According to Denzin and Lincolns (2005) research strategy provides a pathway for direction from a specific approach, to an appropriate method for collecting and analyzing data. Saunders et al. (2000) postulated quantitative and qualitative techniques as the two main ways by which research

strategy can be conducted. Baiden (2006) agreed to the above views by naming quantitative, qualitative, and triangulation as types of research strategy. The aim, availability of literature works, as well as the type of study, influences the choice of a research strategy (Naoum, 1998; *c.f* Baiden, 2006). This research adapted the quantitative strategy. This enabled the respondents to be asked the same questions with predetermined responses in order to obtain an objective data throughout the study.

3.5 RESEARCH DESIGN

Ogoe (1993) defined research design as a framework or a plan that guides a study. Baiden (2006) viewed research design as; experiment, survey, case study, action research, grounded theory, ethnography, convergent, transformative, explanatory and exploratory sequential research. These according to Baiden (2006) fall under qualitative, quantitative and mixed method research strategy. The research design adopted for this study is questionnaire survey. It was used in the quest to explore key competencies that drive construction material waste minimization at the construction stage of projects. Smaller number of persons was used to represent a bigger group which is mostly and prohibitively expensive and difficult to study at times (Baiden, 2006). According to Oppenheim (2003) questionnaire survey enhances consistency of observations due to its in-built uniform sampling and measurement techniques

3.6 UNIT OF ANALYSIS

In order to understand a theoretic background of a research, data gathering is very important (Bernard, 2002). Considerable care should be taken in data gathering to enhance sound judgement (Bernard et al, 1986). Primary and secondary data was used for this research. Primary data was sourced from construction firms (Construction Managers) in the form of field survey

(questionnaires). Extant literature from scientific journal, technical papers, working papers, conferencing proceedings and the like formed the secondary source of data. These groups of individuals were identified as the unit of analysis.

3.7 POPULATION

Population is described as the composition of all individuals of whom measurement is taken (Baiden, 2006). Polit and Hungler (1993) also said, research population is the totality of a well-defined collection of individuals or objects that have a common, binding characteristics or traits. A population needs to be identified from the said unit of analysis (Bernard, 2002). This study was conducted to explore key competencies for driving waste minimization at the construction stage of projects. The population included all the 3,257 Construction Firms in good standing with the Public Procurement Authority (PPA) in Ghana. Construction Firms registered with PPA are given certificates to prove them valid to transact business with Government of Ghana (PPA, 2019). Such firms were therefore considered to be appropriate if construction material waste minimization is the focus.

Table 3.1: Construction Firms Registered with PPA in Ghana

INSTITUTION	MEMBERS IN GOOD STANDING
Public Procurement Authority (PPA)	3,257

Source: PPA, 2019

3.7.1 Sample Frame

Sampling is the act of taking a part of the entire population to represent that exact population (Strydom et al. 2007). The enormous size of the target population in the study makes it impractical to conduct a survey of the whole target group due to reasons of ‘highly expensive and time consuming’. The sample frame used for this study was the total number of Construction firms registered with PPA in the Ashanti Region as at the year 2019. The table below summarizes the said total number of PPA registered Construction firms in Ashanti Region.

Table 3.2: Construction Firms Registered with PPA in the Ashanti Region

INSTITUTION	MEMBERS IN GOOD STANDING
Public Procurement Authority (PPA)	219

Source: PPA, 2019

3.7.2 Sample Size

According to Naoum (2008), the percentage of the sample size alternates depending on the population. A larger population requires a smaller sample size and vice versa. The sample size was determined in a way to reflect the population. The simplified formula, as suggested by Yamane (1967) was used to calculate the sample sizes in the Table below. A 95% confidence level, $P = 0.5$ and $e = 10\%$ are assumed.

$$\text{Formula: } n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size, and e is the level of precision. P is the estimated population proportion attribute.

Table 3.3: Sample Size for $\pm 5\%$, $\pm 7\%$ and $\pm 10\%$ Precision Levels.

Sample size (n) for precision(e) of ;

Size of Population	$\pm 5\%$	$\pm 7\%$	$\pm 10\%$
100	81	67	51
125	96	78	56
150	110	86	61
175	122	94	64
200	134	101	67
225	144	107	70
250	154	112	72
275	163	117	74
300	172	121	76
325	180	125	77
350	187	129	78
375	194	132	80
400	201	135	81
425	207	138	82
450	212	140	82

Source: Yamane (1967)

The table above was used to determine the sample size for the registered construction firms with PPA in the Ashanti Region. The summary of the population vis-a-vis the sample frame and the sample size is summarized in Table 3.4.

Table 3.4: Summary of the population vis-a-vis the sample frame and the sample size

GROUP	POPULATION	SAMPLE FRAME	SAMPLE SIZE
All Construction Firms	PPA registered construction firms in Ghana (3,257)	219	69

Source: Researcher’s Computation.

3.7.3 Sampling Technique

The simple random sampling approach was employed for this study. The choice for this technique was made based on the purpose of the study as well as the research design. The simple random sampling approach enabled an equal chance of selection among the various units (Hoe, 2006).

3.8 DATA COLLECTION INSTRUMENT

Questionnaires provide an economical way to gather data. Polgar and Thomas (2005); Saunders et al. (2000) agreed to this by saying questionnaire is a data collection instrument with particular set of questions that have been formulated beforehand for which answers are expected from various respondents. The four methods of questionnaire administration include Self-administered questionnaire, mail questionnaire, internet questionnaire (use of emails, survey monkeys etc.) and phone questionnaire (Frazer and Lawley, 2000). Internet questionnaire (use of emails and google forms) were used in this study of which the questions were formulated using mostly

closed ended format. The questionnaires were administered to the respondents (Construction Managers, in PPA registered firms) through email addresses of registered firms on PPA website. The analysis of results revealed the professionals as people who have more than five years' experience in the Ghanaian construction industry. A pilot study was conducted to test the comprehensiveness and relevance of the questionnaire before it was distributed. The pilot study involved three (3) Construction Managers, and a postgraduate researcher who was experienced in this research area. Based on feedbacks from the pilot study, the questionnaire was finalized. In all, sixty-nine (69) questionnaires were administered via google forms. A total of fifty-three (53) responses were achieved. The total number of questionnaires distributed vis-a-vis the number responded to are summarized in the table below.

Table 3.5: Total number of respondents

Respondent's group	Questionnaire distributed	Questionnaire responded
PPA registered construction firms in Ashanti Region	69	53

Source: Researcher's database

3.8.1 Questionnaire Design and Format

The primary data collection tool for this research was the questionnaire. The format of the questionnaire was guided by respondents' ease of reading and supplying the required data required. The questionnaire was also structured to be in line with the main objectives of this study in order to receive answers that would help achieve the research aim. Target respondents for the questionnaire involved professionals (Construction Managers) who work with firms registered with the PPA. The format of the questionnaire used in this research to meet the

objectives is divided into two main sections as can be seen in Appendix A: Section ‘A’, Section ‘B’ and Section ‘C’. Section ‘A’ sought to investigate the biographical data of the respondents. Section ‘B’ sought to identify the causes and effects of construction material waste on projects. Section ‘C’ also looked at the key competencies that drive construction material waste minimization at the construction stage of projects. A Likert scale was employed with various statements to be ranked by the respondents.

3.9 DATA PROCESSING AND ANALYSIS (BASED ON RESEARCH APPROACH)

Strydom et al, (2007) defined data analysis as the interpreting of gathered data in order to find appropriate answers. Reduction of data, presentation of data and drawing of conclusion are the three major activities under data analysis (Saunders et al. 2000). Three major steps were captured in the processing and analysis of the gathered data collected for this study. This was to reduce the data to a clear and understandable form where a conclusion could be drawn. The data collected were arranged and organized in line with the research objectives. In choosing the statistical tool for the study, reference was made to non-parametric statistical test. Descriptive statistics, Relative Importance Index (RII), and the Principal Component Analysis which are non-parametric statistical testing tool were the tools adopted for the analysis. Descriptive statistics involved the use of percentages, frequency tables and the like to present the results. Reasons for the outcome of the analysis were also presented in relation to previous research findings.

3.10 CHAPTER SUMMARY

This chapter presented the methodology as well as the analytical tools adopted for this study. Various research paradigms that extant literature offers were also captured under this chapter. Based on the research agenda the required research strategy was selected. The sample size and

sampling technique for the study were presented. Questionnaire was the primary data collection tool used for the study. Close ended questionnaire was adopted in collecting the primary data.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS DISCUSSION

4.1 INTRODUCTION

This Chapter discusses and expounds the data collected after the field survey. The primary data gathered from the various respondents, composed of construction site professionals; construction managers, who work in Public Procurement Authority (PPA) registered firms. The views of the respondents were analysed in this section. The tools adopted for use in the analyses took the form of the simple descriptive statistics, Kendall's Coefficient of concordance, Principal Component analyses and Relative Importance Index. Systematic analysis format was achieved through the use of statistical package for social sciences (SPSS) and Microsoft excel 2010 software. The results have been tabulated and interpreted accordingly. The analysis is presented in three sections thus i) the demographic variables ii) causes and effects of construction material waste on building projects and iii) key competencies for driving material waste minimization at the construction stage of projects.

4.1.1 Survey Responses

Sixty-nine (69) questionnaires were administered to the various construction firms registered under the Public Procurement Authority (PPA) in Ashanti Region. Fifty-three (53) responses were achieved with a rate of 76.8%. The high response was as a result of the usage of modernised tools in getting respondents views "google forms".

4.2 DESCRIPTIVE ANALYSIS OF DATA (DEMOGRAPHY)

In order to achieve a comprehensive respondent characteristic, the demographic section of the questionnaire is required. This part determines the understanding of the respondents on the study as well as to retrieve basic personal information of the respondent (Adinyira and Anokye, 2013). Adinyira and Anokye (2013) further posited that, having a fair idea of the respondents enables proper situating of the responses within context. This section is of great importance since it establishes and generates confidence in the data collected. Data included in the analysis of the demography were; awareness on construction material waste minimization, ministry of works and housing classification of the respondent firm, professional background of respondent, highest academic qualification, professional experience and material waste minimization integrated building projects undertaken by respondent in the last five years.

4.2.1 Awareness on Construction Material Waste Minimization

Construction material waste minimization contributes immensely to sustainable construction but the inadequate awareness of its relevance is a grave challenge to the construction industry (Kim and Rigdon, 1998). Rydin et al. (2006) added to this assertion by saying that the competence of professionals in various areas of construction falls when material waste minimization issues are addressed. This showed the need to ask about the awareness of the professionals on the concept of material waste minimization before they can proceed to answer the questionnaires.

Table 4.1: Awareness on Construction Material Waste Minimization.

Awareness	Frequency	Percent %	Valid Percent %	Cumulative Percent %
Yes	47	88.7	88.7	88.7
No	0	0	0	0
Somehow	6	11.3	11.3	100.0
Total	53	100.0	100.0	

Source: Field Survey, 2019

From the display of results in table 4.1, Fifty-three (53) respondents completed this section. Out of the total respondents of Fifty-three (53), Forty-seven (47) responded ‘Yes’ and Six (6) responded ‘somehow’ on the awareness on construction material waste minimization. This was represented in percentage as 88.7 % and 11.3 % respectively. None of the respondents responded as having no awareness on sustainable construction practices. It can therefore be deduced that majority of the respondents have awareness on construction material waste minimization.

4.2.2 Ministry of Works and Housing Classification of firm

Table 4.2 represents the Ministry of Works and Housing Classification of the respondent’s firm. The Housing sector of the construction industry is regulated by the Ministry of Works and Housing (MWH) (Ofori, 2012). The inclusion of this section was to know the classification of the firms that took part in the research in order to properly define the project scope.

Table 4.2: Professional background

Background	Frequency	Percent	Valid Percent	Cumulative Percent
D1/K1	42	79.2	79.2	79.2
D2/K2	6	11.3	11.3	90.6
D3/K3	3	5.7	5.7	96.2
D4/K4	2	3.8	3.8	100.0
Total	53	100.0	100.0	

Source: Field survey, 2019

Fifty-three (53) respondents completed this part of the questionnaire. Out of the total number of respondents, forty-two (42) were D1K1 contractors, six (6) were D2K2 contractors, three (3) were D3K3 contractors and two (2) also worked in D4/K4 registered firms. It could be deduced from the table above that the highest numbers of respondents were from D1K1 construction firms, contributing to 79.2% of the total number of Questionnaires distributed.

4.2.3 Role in the Construction Industry

Table 4.3 represents the role the respondent play in the construction industry. This section of the questionnaire created certainty that responses were gotten from right ones.

Table 4.3: Role in the Construction Industry

Background	Frequency	Percent	Valid Percent	Cumulative Percent
Project/Construction Manager	28	52.8	52.8	52.8
Quantity Surveyor	7	13.2	13.2	66.0
Architect	4	7.5	7.5	73.6
Site Supervisor	14	26.4	26.4	100
Total	53	100.0	100.0	

Source: Field survey, 2019

Fifty-three (53) respondents completed this section of the questionnaire. Out of the total number of respondents, Project/construction managers were twenty-eight (28) representing 52.8%, Quantity surveyors were seven (7) representing 13.2 %, Architects were 4 representing 7.5% and site supervisors were also fourteen (14) in number representing 26.4%. Project/construction managers recorded the highest number of respondents.

4.2.4 Highest Academic Qualification

The respondents to the questionnaires were asked of their highest academic qualification. Diploma, Bachelor's Degree, Masters and Doctorate Degree as can be identified in table 4.4 were the options given. Twenty (20) of the total respondents were Bachelor's Degree holders representing 37.7 %. Master's Degree holders had 43.4 % representing twenty-three (23) respondents. Eight (8) out of the total number of respondents were Diploma holders representing 15.1 %. Respondents who were Doctorate degree holders were two (2) representing 3.8%.

Table 4.4: Academic Qualification

Experience	Frequency	Percent	Valid Percent	Cumulative Percent
HND	8	15.1	15.1	15.1
BSC	20	37.7	37.7	52.8
MSC	23	43.4	43.4	96.2
PhD	2	3.8	3.8	100.0
Total	53	100.0	100.0	

Source: Field Survey, 2019

4.2.5 Professional Experience

The professional experience of each respondent in the construction industry was sought after in order to obtain an appropriate result. It could be said that the higher your professional experience, the greater the amount of knowledge gained on the concept of construction material waste minimization.

Table 4.5: Professional experience

Experience	Frequency	Percent	Valid Percent	Cumulative Percent
0-5	21	39.6	39.6	39.6
6-10	13	24.5	24.5	64.2
11-15	4	7.5	7.5	71.7
16-20	6	11.3	11.3	83.0
Above 20	9	17.0	17.0	100.0
Total	53	100.0	100.0	

Source: Field Survey, 2019

A lot of the respondents fall within 0-5 when it comes to professional experience within the construction industry. Twenty-one (21) respondents representing 39.6 % fall within the year range of 0-5 of professional experience. Respondents with years' experience of 6-10 with a total outcome of 13 representing 24.5 % of the entire respondents' number took the second position. 9 respondents fall within the category of 'above 20 years' representing 9.0%, 4 out of the 53 respondents have years' experience of '11-15' representing 7.5%. Finally, 16-20 years' professional experience is represented with a frequency and percentage of 6 and 11.3% respectively.

4.2.6 Material Waste Minimization Integrated Building Projects Undertaken By Respondent.

Table 4.6 represents the number of Material Waste Minimization Integrated building project undertaken by the respondent in the last five years. This section of the data was included in the questionnaire so as to be certain that there exists a practical experience on the concept of Material Waste Minimization among the respondents.

Table 4.6: Material Waste Minimization Integrated Building Project

Projects	Frequency	Percent	Valid Percent	Cumulative Percent
0-5	30	56.6	56.6	56.6
5-10	11	20.8	20.8	77.4
10-15	2	3.8	3.8	81.1
15-20	5	9.4	9.4	90.6
Above 20	5	9.4	9.4	100.0
Total	53	100.0	100.0	

Source: Field Survey, 2019

The Table above shows that out of the total number of respondents, 56.6% representing thirty (30) respondents have undertaken 0-5 material waste minimization integrated projects in the last five years. Eleven (11), two (2), and five (5) respondents have undertaken ‘5-10, 10-15, and 15-20’ waste minimization projects respectively making a cumulative percentage of 34%. Five (5) respondents have undertaken ‘above 20’ projects which involves waste minimization. This is duly represented as 9.4%.

4.3 RESPONDENT’S VIEW ON THE CAUSES AND EFFECT OF CONSTRUCTION MATERIAL WASTE ON BUILDING PROJECTS.

In order to explore the key competencies that drive construction material waste minimization, the causes and effects of these wastes on building projects need to be fully understood. Different research work on the topic was studied to come up with the most prominent factors. In all, ten

(10) and twelve (12) variables were noted under causes and effects of construction material waste on building projects respectively. Respondents were asked to rank the ten (10) causes of construction material waste according to the level of significance through a survey. This was done on a Likert scale 1-5; *1= Not a Waste Cause; 2 = Insignificant Waste Cause; 3 = Neutral; 4 = Significant Waste Cause; 5 = Major Waste Cause.* Per the experience of the respondents, their level of agreement on the ‘effects of construction waste variables’ that could affect building projects was also rated. This was done on a Likert scale 1-5; *1= Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.* The purpose was to determine the dominant ‘causes and effects of construction waste’ variable on building projects.

Respondents view on the factors under causes and effects of construction material waste on building projects were subjected to Kendall’s Coefficient of Concordance test and Relative Importance Index for analysing the data collected from the field. The mean as well as RII scores of all the fifty-three (53) respondents were calculated for each factor and have been indicated on the table below. Kendall’s coefficient of concordance (Kendall’s *W*) is a coefficient index for ascertaining the overall agreement amongst sets of rankings (Chan et al. 2009). This analysis was performed to check whether the experts were consistent or not in ranking the causal and effect of construction material waste on building projects (Siegel and Castellan, 1988). The value of Kendall’s *W* ranges from 0 to +1. This indicates “no agreement” and “complete agreement” respectively within the ranking of a particular set of factors. In this study, the value of Kendall’s *W*; *W*_{causes of construction material waste} and *W*_{effects of construction material waste} were; 0.054, and 0.071 respectively (see Tables 10 and 12). This indicates an appreciable level of agreement amongst the respondents.

According to Siegel and Castellan (1988) when ranked factors in a research study is more than 7 ($N > 7$) with a large sample size (> 20), the significance of an observed W could be determined by referring to the approximate distribution of Chi-Square (X^2) with $N-1$ degrees of freedom (df). X^2 causes of construction material waste = 25.637, df = 9 and X^2 effects of construction material waste = 41.442, df = 11 most of which have probability of occurrence under $p < 0.001$, indicating that there exists a good agreement among the experts regarding the rankings of the causes and effects of construction material waste on building projects. The above Chi-Square (X^2) values also suggest that there exist a high agreement among the experts in ranking the ‘effects of construction material waste’ than ‘causes of construction material waste’ at the construction stage of building projects.

4.3.1 Causes of Material Waste at the Construction Stage of Building Projects

The significant value of 0.002 after the Kendall’s Coefficient of Concordance analysis indicates that all the variables under ‘causes of material waste at the construction stage of building projects’ are very important. After the analysis, Poor *Workmanship* was the critical variable that causes material waste at the construction stage of projects. This variable had an RII of 0.725 and a mean value of 3.623. The mean value is strongly skewed to 4 which stand for higher. This agrees with Ajayi et al. 2016 that numerous wastes experienced on construction sites are as a result of construction artisans not delivering task as expected. *Challenges arising from Transportation of construction materials* were ranked second (2) with an RII and mean value of 0.706 and 3.528 respectively. Bossink and Brouwers (1996) agree that *Challenges arising from Transportation of construction materials* is one the critical causes of construction waste at project sites. Most construction sites do not use the appropriate methods when offloading of

construction materials from Trucks. Also, poor weather conditions, accidents, etc also negatively affect transported construction materials leading to a major proportion of it go waste (Bossink and Brouwers, 1996). The third (3) ranked factor, causing material wastage on project sites was *Poor Supervision*. It had an RII and mean value of 0.706 and 3.528 respectively. Supervisory roles on construction projects are mostly done by site foreman, site supervisors and the construction manager. They meter out professional guidance to construction activities. Negligence on their part could lead to construction waste. Lingard et al. (2000) supports the argument that *Poor supervision* is a major cause of construction waste on project sites. *Improper handling of construction materials* was ranked fourth (4) with an RII and mean value of 0.698 and 3.491 respectively. On Gavailan and Bernold (1994) exposition on causes of construction waste, much focus was dwelt on using the appropriate methods when handling construction materials. That is; lifting of blocks, offloading of cement and carrying of heavy building materials. This in a way could curtail the high amount of waste that comes up from *Improper handling of construction materials*.

Errors and changes in design (RII= 0.683, Mean =3.415), Personnel ordering errors (Procurement of construction materials) (RII= 0.675, Mean =3.377), Poor Storage of construction materials (RII= 0.660, Mean =3.302), No Waste management plan (RII= 0.649, Mean =3.245), Force Majeure (RII= 0.649, Mean =3.245) and Material deterioration (RII= 0.596, Mean =2.981) were ranked 5th, 6th, 7th, 8th, 9th, and 10th variables that cause construction material waste at the construction stage of projects. These factors are supported by Osmani et al. (2008); Lingard et al. (2000); and Bossink & Brouwers (1996). Table 4.7 shows the rankings of

the causes of construction material waste at the construction stage of projects. Table 4.8 also shows the Test of concordance of the causal factors.

Table 4.7: Causes of Material Waste at the Construction Stage of Building Projects

	CAUSES OF CONSTRUCTION MATERIAL WASTE	FREQUENCY					TOTAL	ΣW	MEAN	RII	RANKING
		1	2	3	4	5					
1	Poor Workmanship	0	10	13	17	13	53	192	3.623	0.725	1 st
2	Challenges arising from Transportation of construction materials	0	11	15	15	12	53	187	3.528	0.706	2 nd
3	Poor Supervision	6	2	12	24	9	53	187	3.528	0.706	3 rd
4	Improper handling of construction materials	2	6	17	20	8	53	185	3.491	0.698	4 th
5	Errors and changes in design	4	12	11	10	16	53	181	3.415	0.683	5 th
6	Personnel ordering errors (Procurement of construction materials)	0	8	22	18	5	53	179	3.377	0.675	6 th
7	Poor Storage of construction materials	4	6	13	13	7	43	142	3.302	0.66	7 th
8	No Waste management plan	2	11	17	18	5	53	172	3.245	0.649	8 th
9	Force Majeure	4	13	14	10	12	53	172	3.245	0.649	9 th
10	Material deterioration	0	21	19	6	7	53	158	2.981	0.596	10 th

Source: Field Survey, 2019

Table 4.8: Test of concordance on causes of construction waste.

N	53
Kendall's W ^b	0.054
Chi-Square	25.637
Df	9
Asymp. Sig.	0.002
a. Kendall's Coefficient of Concordance	

Source: Field Survey, 2019

Note: ‘*’ Data with insignificant results of one-sample t-test ($p > 0.05$) (2-tailed); W^b = Kendall's Coefficient of Concordance test on the causes of construction waste among the respondents.

4.3.2 Effect of Construction Material Waste in undertaking Building Projects

The test of concordance on the ‘effect of construction material waste in undertaking building projects’ variables, led to a Kendall’s W , Chi –Square (X^2) and significant value of 0.071, 41.442 and 0.000 respectively. The Kendall’s W and Chi –Square (X^2) value depicts an appreciable amount of agreement amongst the respondents.

Increased purchased quantity and price cost was ranked the highest variable under the effect of construction material waste on building projects with an RII of 0.736 and a mean value of 3.679. The mean value is strongly skewed to 4 which stand for higher. This supports the findings of WRAP (2009) that construction waste increases purchased material quantity and cost. Proper waste minimization strategy includes reuse or recycles. The inability to do this mostly increases the number of construction materials ordered. Cost savings are not achieved in that regard. *Poor site organization and obstruction of movement due to excessive waste* generated was ranked the second (2) critical effect of construction waste in undertaking building projects. It had an RII and mean value of 0.736 and 3.679 respectively. Ideally, construction waste needs to be properly assembled and disposed at the appropriate place. Improper handling of waste leads to *Poor site organization and obstruction of movement*. *Lower business patronage* was also ranked the third effect of construction material waste on building projects. It had an RII and mean value of 0.687 and 3.434 respectively. Ameh and Itodo (2013) posited *Lower business patronage* as an economic effect of construction material waste on building projects. Every client would want to achieve value for money. One way to achieve that is through proper waste management. The

contractor's inability to manage construction waste could then lead to *Lower business patronage*. Ranked fourth (4th) was *Poor performance against corporate sustainability responsibility (CSR) objectives* with 3.415 and 0.683 as its mean and RII value respectively. ISO 15392 (2008) viewed sustainability as "State in which components of the ecosystem and their functions are maintained for the present and future generations". Construction waste minimization is a way through which this objective could be achieved. The inability to reduce material waste at the construction site, leads to a *poor performance against the corporate sustainability responsibility (CSR)*.

Increased disposal cost(RII= 0.679, Mean= 3.396) , Higher project cost(RII= 0.675, Mean= 3.377), Not meeting cost savings on building projects(RII= 0.675, Mean= 3.377), Environmental pollution: vehicular emissions (RII= 0.653, Mean= 3.264), Channelling of productive land into dumping sites (RII= 0.638, Mean= 3.189), Decreased competitive advantage through differentiation (RII= 0.634, Mean= 3.17), Not meeting planning requirements (RII= 0.63, Mean= 3.151, and Higher risk of litigation regarding waste (RII= 0.619, Mean= 3.094) were ranked 5th , 6th ,7th , 8th , 9th , 10th , 11th and 12th respectively as effect of construction material waste on building projects. These variables are supported by Osmani et al. (2008), Ameh & Itodo (2013) and WRAP (2009) as being an effect of material waste on construction projects. Table 4.9 shows the rankings of the effect of construction material waste on building projects. Table 4.10 also shows the Test of concordance of the variables.

Table 4.9: Effect of Construction Material Waste on Building Projects.

	EFFECT OF CONSTRUCTION MATERIAL WASTE	FREQUENCY					TOTAL	ΣW	MEAN	RII	RANKING
		1	2	3	4	5					
1	Increased purchased quantity and price cost	0	3	21	19	10	53	195	3.679	0.736	1st
2	Poor site organization and obstruction of movement due to excessive waste generated.	0	8	14	18	13	53	195	3.679	0.736	2 nd
3	Lower business patronage	1	7	17	24	4	53	182	3.434	0.687	3 rd
4	Poor performance against corporate sustainability responsibility (CSR) objectives	2	11	14	15	11	53	181	3.415	0.683	4 th
5	Increased disposal cost	2	11	12	20	8	53	180	3.396	0.679	5 th
6	Higher project cost	6	6	12	20	9	53	179	3.377	0.675	6 th
7	Not meeting cost savings on building projects	4	9	14	15	11	53	179	3.377	0.675	7 th
8	Environmental pollution: vehicular emissions	2	12	13	22	4	53	173	3.264	0.653	8 th
9	Channelling of productive land into dumping sites	1	10	23	16	3	53	169	3.189	0.638	9 th
10	Decreased competitive advantage through differentiation	0	11	25	14	3	53	168	3.17	0.634	10 th
11	Not meeting planning requirements	0	17	14	19	3	53	167	3.151	0.63	11 th
12	Higher risk of litigation regarding waste	2	17	12	18	4	53	164	3.094	0.619	12 th

Source: Field Survey, 2019

Table 4.10: Test of concordance on effects of construction material waste.

N	53
Kendall's W ^b	0.071
Chi-Square	41.442
Df	11
Asymp. Sig.	0.000

a. Kendall's Coefficient of Concordance

Source: Field Survey, 2019

Note: ‘*’ Data with insignificant results of one-sample t-test ($p > 0.05$) (2-tailed); W^b = Kendall's Coefficient of Concordance test on the Effects of Construction Material Waste on Building Projects.

4.4 RESPONDENT'S VIEW ON THE KEY COMPETENCIES THAT DRIVE MATERIAL WASTE MINIMIZATION AT THE CONSTRUCTION STAGE OF PROJECTS.

Research work on the key competencies that drive construction waste minimization at the construction stage of projects was studied to come up with important competencies that are mostly observed. Respondents were asked to rank twenty-four (24) noted variables (key competencies) according to the level of importance to determine the dominant factor. The statistical tool adopted for this section was the Principal Component Analysis (factor analysis). The choice of this analytical tool for the data analysis was to reduce the large number of variables into a more easily understood framework (Field, 2005).

Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were conducted to determine the adequacy and the reliability of using Principal Component Analysis. This is shown in Table 4.11. KMO determines the appropriateness of Principal Component Analysis as well as and the degree of inter-correlation among the variables (Field, 2005). Correlation among variables is also confirmed by the Bartlett test of sphericity. It provided the probability that correlation matrix has significant correlation among at least, some of the variables as shown in table 4.11 (Field, 2005). KMOs in the range of 0.5-0.6, 0.6-0.7, 0.7-0.8, 0.8-0.9 and above 0.9 are considered poor, average, good, great and superb respectively (Field, 2005). 0.695 was obtained as the KMO for the factors. This, according to Field (2005) signifies average.

Table 4.11: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.695
Bartlett's Test of Sphericity	Approx. Chi-Square	1079.868
	Df	276
	Sig.	0.000

Source: Field Survey, 2019

The extraction for the variables is tabulated below. Few of the variables have extraction value less than 0.5, making it appropriate to be factor analysed (Field, 2005). The validity and essence of the variables are also proven by its significance. “Thorough review of the project specifications by contractors at the construction stage” has 0.817 as its extraction factor. It is the closest to the set initial factor of 1 among the various variables. “Personnel quality” has the least extraction factor of 0.477, which is far skewed from the set initial factor of 1.

4.4.1 Component Detection and Extraction

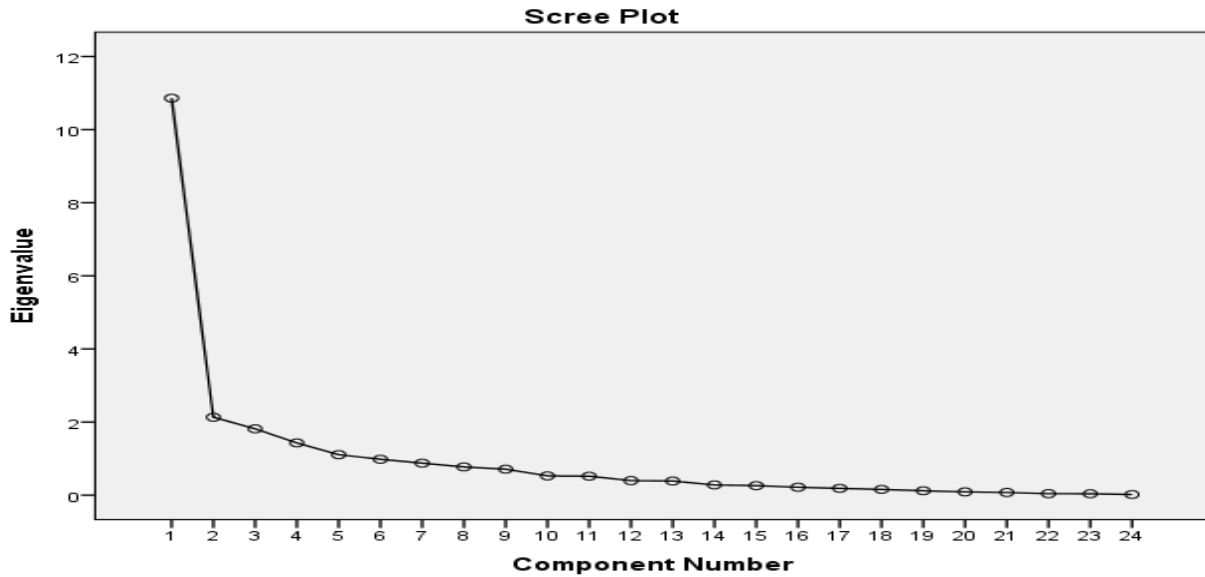
The total variance is explained in Table 4.13 with much emphasis on extraction sums of squared loadings as well as rotation sums of squared loadings. Per the Kaiser criterion, eigenvalues equal to or greater than 1 in Principal Component Analysis ought to be retained. The significance of a variable is determined by the skewness of its eigenvalue towards 1.00. Based on the eigenvalues, four factors were generated encapsulating the 24 variables. 67.7% was the total variance explained by all the extracted components. The Cumulative Proportion of Variance Criterion stipulates that, components extracted should explain at least 50% of the variation in the data set. The test result of 67.7% agrees with the above statement (see Table 4.13). Using the factor loading of 0.50 as the cut-off point, four (4) components with eigenvalues more than 1.0 were extracted. This is indicated on the scree plot in figure 4.1.

Table 4.12: Communalities for Key Competencies that Drive Material Waste Minimization at the Construction Stage of Projects.

	Initial	Extraction
Awareness of construction waste minimization practices	1.000	0.754
Construction sequencing and planning	1.000	0.695
Reuse and recycling of waste	1.000	0.744
Health and Safety Management	1.000	0.645
Human Resource Management	1.000	0.562
Modern Construction Methods	1.000	0.769
Standardization and Implementation of Sustainable Construction Practices	1.000	0.780
Adherence to project design/drawings	1.000	0.697
Waste auditing to monitor environmental performance	1.000	0.650
Thorough review of the project specifications by contractors at the construction stage	1.000	0.817
Effective leadership	1.000	0.800
Effective communication	1.000	0.668
Team work	1.000	0.561
Waste management plan implementation	1.000	0.533
Supply Chain Management (SCM) skills	1.000	0.692
Material logistic plan implementation	1.000	0.579
Delegation	1.000	0.578
Problem solving skills	1.000	0.709
Professional learning	1.000	0.815
Onsite practical skill	1.000	0.725
Personnel quality	1.000	0.477
Creative thinking	1.000	0.816
Personnel commitment to pursuing an ethical solution to waste minimization	1.000	0.500
Provision of direction to inspire others	1.000	0.672

Extraction Method: Principal Component Analysis.

Source: Field Survey, 2019



Source: Field Survey, 2019

Figure 4.1: Scree Plot

Table 4.13: Total Variance Explained

Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.861	45.253	45.253	4.490	18.707	18.707
2	2.132	8.883	54.136	4.417	18.403	37.110
3	1.815	7.562	61.698	3.777	15.737	52.847
4	1.429	5.952	67.650	3.553	14.803	67.650

Extraction Method: Principal Component Analysis.

Source: Field Survey, 2019

Rotation improves the interpretation of results of principal component analysis (Dogbegah et al. 2011). It turns large loading factors in absolute value for the variables to achieve a simple structure. The Rotated component matrix indicating the groupings and the coefficients under each component is tabulated below;

Table 4.14: Rotated Component Matrix on Competencies that Drive Material Waste Minimization at the Construction Stage of Projects.

	Component			
	1	2	3	4
Awareness Competency (AC)				
Awareness of construction waste minimization practices	0.847			
Construction sequencing and planning	0.782			
Standardization and Implementation of Sustainable Construction Practices	0.705			
Modern Construction Methods	0.697			
Waste management plan implementation	0.526			
Team work	0.522			
Managerial Competency (MC)				
Effective leadership		0.805		
Health and Safety Management		0.757		
Reuse and recycling of waste		0.739		
Adherence to project design/drawings		0.599		
Delegation		0.570		
Human Resource Management		0.564		
Waste auditing to monitor environmental performance		0.555		
Personnel Ability Competency (PAC)				
Problem solving skills			0.774	
Creative thinking			0.732	
Professional learning			0.652	
Onsite practical skill			0.591	
Provision of direction to inspire others			0.552	
Personnel quality			0.551	
Personnel commitment to pursuing an ethical solution to waste minimization			0.547	
Communication Competency (CC)				
Supply Chain Management (SCM) skills				0.716
Effective communication				0.679
Material logistic plan implementation				0.646
Thorough review of the project specifications by contractors at the construction stage				0.616
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.				

a. Rotation converged in 22 iterations.

Source: Field Survey, 2019

4.4.2 Findings and Discussion

Four (4) components were retained to represent the 24 listed competencies that drive construction material waste minimization. This is shown in the table above. Each component stands for variables with common attributes. Component 1 accounts for 18.707%, component 2 = 18.403%, up until component 4, which also accounts for 14.803% of the variance. 67.650 % of the variance and the entire data indicate the summation of the four (4) components in the Rotation Sums of Squared Loadings. The four new constructs formed through the factor analysis were labelled as Awareness Competency (AC), Managerial Competency (MC), Personnel Ability Competency (PAC) and Communication Competency (CC).

A. Component 1: Awareness Competency (AC).

Component 1 comprises six (6) variables, which accounted for 18.707% of the total variance. These are: Awareness of construction waste minimization practices (0.847), Construction sequencing and planning (0.782), Standardization and Implementation of Sustainable Construction Practices (0.705), Modern Construction Methods (0.697), Waste management plan implementation (0.526), and Team work (0.522). The figures in the bracket indicate the loading of each variable impact on the component. This component was named as *Awareness Competency (AC)*. *Awareness Competency (AC)* is the understanding or having knowledge on concepts needed to effectively complete an assignment. Per the analysis, much awareness is needed in the area of waste minimization practises, modern construction methods, waste management plan implementation and construction sequencing & planning in the quest to minimize construction waste. Mirabile (1997), Hwang and Ng (2017) and Ajayi (2017) support

AC as a key competency that drive material waste minimization at the construction stage of projects.

B. Component 2: Managerial Competency (MC)

The second component was labelled as ***Managerial Competency (MC)***. It accounted for 18.403% percent of total variance not explained by the first component. The seven (7) variables within (***MC***) include; Effective leadership (0.805), Health and Safety Management (0.757), Reuse and recycling of waste (0.739), Adherence to project design/drawings (0.599), Delegation (0.570), Human Resource Management (0.564), and Waste auditing to monitor environmental performance (0.555). The figures in the bracket indicate the respective eigenvalues. The respondents are of the view that the component, ***Managerial Competency (MC)*** is a critical competency that drives material waste minimization. ***Managerial Competency (MC)*** simply refers to the process of planning, controlling and directing activities to influence individual's performance in order to yield positive results. Per the analysis, ***Managerial Competency (MC)*** is exhibited in the area of leadership, health and safety management, human resource management and the reuse & recycling of construction waste. Geoghegan and Dulewiz (2008), Hwang and Ng (2013) and Osmani et al. (2008) supports the argument that one of the key competencies that drive waste minimization is ***Managerial Competency (MC)***, by focusing more on Effective leadership, Health and Safety Management, Reuse and recycling of waste, Adherence to project design/drawings, Delegation, Human Resource Management, and Waste auditing to monitor environmental performance.

C. Component 3: Personnel Ability Competency (PAC)

This component accounted for 15.737 percent total variance not explained by the former components. It encompasses seven variables: Problem solving skills (0.774), Creative thinking (0.732), Professional learning (0.652), Onsite practical skill (0.591), Provision of direction to inspire others (0.552), Personnel quality (0.551), and Personnel commitment to pursuing an ethical solution to waste minimization (0.547). The figures in the bracket indicate the loading of each variable impact on the component. ***Personnel Ability Competency (PAC)*** refers to the capacity to get things done. It could be inherent or acquired through practice/training. Per the analysis, ***Personnel Ability Competency (PAC)*** as a key competency that drive construction waste minimization is exhibited in problem solving, creative thinking, professional learning, demonstration of practical skill, provision of direction to inspire others, personnel quality and personnel commitment to pursuing an ethical solution to waste minimization. Hwang & Ng (2013) and Shi *et al.* (2014) support the findings that ***Personnel Ability Competency (PAC)*** drive construction waste minimization by focusing on problem solving skills, personnel quality and the demonstration of practical skill.

D. Component 4: Communication Competency (CC)

The final component was labelled as ***Communication Competency (CC)***. It accounted for 14.803 percent total variance with four variables loaded onto it: Supply Chain Management (SCM) skills (0.716), Effective communication (0.679), Material logistic plan implementation (0.646), and Thorough review of the project specifications by contractors at the construction stage (0.616). ***Communication Competency (CC)*** refers to the adequacy and ease of flow of thought (communication) to others through various mediums (drawings, charts, phone calls) for an

effective work delivery. Ajayi et al. (2016) posited that construction waste minimization requires adequate estimation of materials required at different stages of projects in an attempt to reduce the likelihood of materials over-ordering and subsequent leftover, which is a key cause of waste generation. Li et al. (2013) also raised the argument that organizational waste management policy should be communicated to the site workers in order to mobilize support in achieving the minimization objective. *Communication Competency (CC)* is exhibited in the area of proper requisition and supply of construction materials, effective collaboration amongst construction professionals and site workers, and the clearer communication of project specifications. This indeed drives construction material waste minimization.

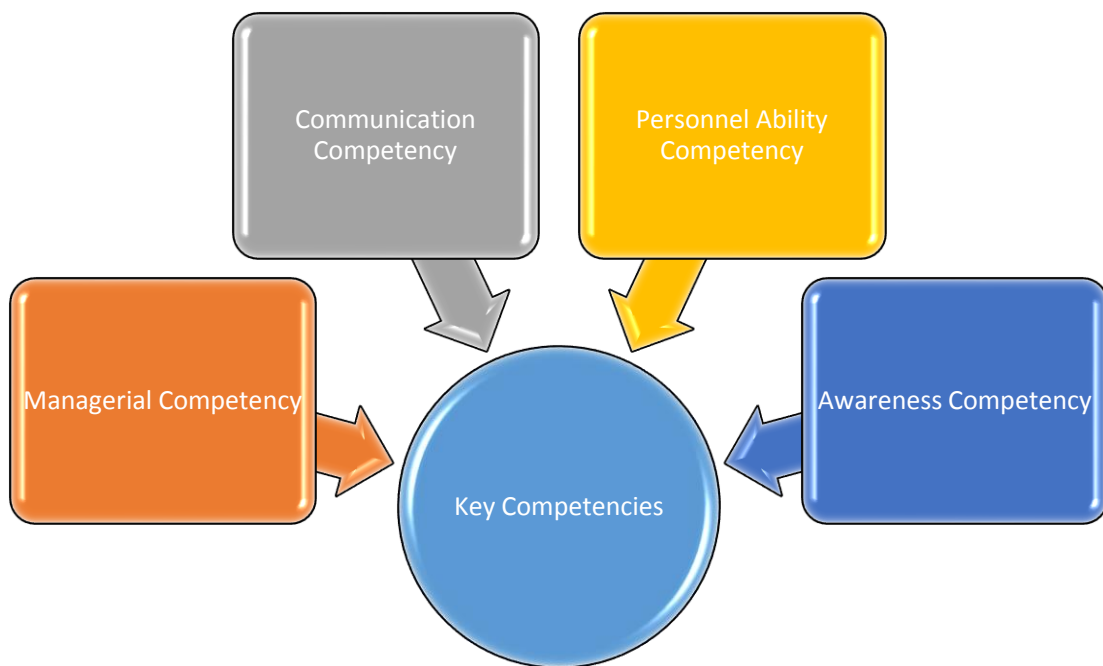


Figure 4.2: Authors Conceptual Module on Key Competencies that Influence Material Waste Minimization at the Construction Stage of Projects.

4.5 CHAPTER SUMMARY

Generally, this chapter discussed the survey results and revealed the actual perception of Ghanaian professionals (Construction Managers) on issues pertaining to key competencies that drive construction waste minimization. Findings obtained are consistent with the research findings of other related studies on construction waste minimization. It commenced with a field survey and discussion of the results retrieved from respondents who are familiar with the concept either through academia or practice. This was followed by descriptive statistics of the field results. Kendall's coefficient of concordance test, Relative Importance Index method, and Principal component analysis were employed to analyse the variables stated in the research; key competencies that drive construction waste minimization.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

Exploring the key competencies that drive construction material waste minimization at the construction stage of projects, has been the topic for this research work. In highlighting the research process; the aim of the research was captured in chapter one, similar works on construction waste minimization as well as competencies that drive its minimization (literature works) were also captured in chapter two. The methodological approach for the study was presented in chapter three. Data were retrieved through Survey questionnaires. The data collected were discussed and analysed in chapter four. This chapter which marks the concluding part of the study summarizes the findings with regards to the research aim and objectives. Based on the research, recommendations were made for future studies whereas the limitations of the study were extensively discussed. The format for chapter five is shown below:

- Review of the research objectives;
- Summary of findings;
- Contribution to knowledge and industry;
- Research Limitation;
- Conclusion;
- Recommendations; and
- Recommendation to future research;

5.2 REVIEW OF RESEARCH OBJECTIVES

The aim of the study was to explore key competencies for driving material waste minimization at the construction stage of a project. Three (3) objectives were established so as to achieve the stated aim. The achievement of each objective is presented below.

5.2.1 Review of Objective One

Objective one sought to *identify the causes of material waste at the construction stage of projects*. This was realized by studying similar research work on the topic to come up with significant factors. Ten (10) variables, representing causes of material waste at the construction stage of projects were assembled through literature enquiry and were ranked by the respondents.. The responses received were analysed using Kendall's Coefficient of Concordance and Relative Importance Index tool. The analysis revealed *Poor Workmanship* as the critical variable that causes material waste at the construction stage of projects. The variable had an RII of 0.725 and a mean value of 3.623. *Challenges arising from Transportation of construction materials* was ranked second (2) with an RII and mean value of 0.706 and 3.528 respectively. The third (3) ranked factor causing material wastage on project sites was *Poor Supervision*. It had an RII and mean value of 0.706 and 3.528 respectively. *Force Majeure* (RII= 0.649, Mean =3.245) and *Material deterioration* (RII= 0.596, Mean =2.981) were lowly ranked by the respondents (9th and 10th respectively) as a cause of construction material waste at the construction stage of projects.

5.2.2 Review of Second Objective

Objective two also sought to *identify the effect of material waste in undertaking construction projects*. Extensive literature works on the objective was done to come up with prominent variables. Twelve (12) variables, representing effect of construction material waste on projects

were ranked to determine the dominant effect. Kendall's Coefficient of Concordance and Relative Importance Index tool were the analytical tools used on the objective. *Increased purchased quantity and price cost* (RII of 0.73, mean value of 3.679), *Poor site organization and obstruction of movement due to excessive waste generated* (RII = 0.736, Mean = 3.679 respectively), and *Lower business patronage* (RII and mean value of 0.687 and 3.434 respectively) were the highest ranked effect of construction material waste variable in undertaking construction projects. Decreased competitive advantage through differentiation (RII= 0.634, Mean= 3.17), Not meeting planning requirements (RII= 0.63, Mean= 3.151), and Higher risk of litigation regarding waste (RII= 0.619, Mean= 3.094) were the least ranked (10th, 11th and 12th) variable with regard to 'effect of construction material waste in undertaking projects'.

5.2.3 Review of Third Objective

The last objective was *to determine key competencies for driving material waste minimization*. Through literature enquiry, twenty-four (24) variables (competencies) that drive material waste minimization were noted. Through a questionnaire survey, the respondents were asked to rank the variables (key competencies) based on the level of importance through a survey. The twenty-four (24) variables were factor analysed to reduce the data into four unique constructs. The four new constructs include; *Awareness Competence (AC)*, *Managerial Competence (MC)*, *Personnel Ability Competence (PAC)* and *Communication Competence (CC)*.

5.3 SUMMARY OF FINDINGS

- Out of the Sixty-nine (69) questionnaires distributed amongst the various construction firms in the Ashanti Region (Ghana) registered with the Public Procurement Authority (PPA), fifty-three (53) were retrieved;
- Out of the total respondents of Sixty-nine (69), forty-seven (47) responded 'Yes' and six (6) responded 'somehow' on the awareness on Construction Material Waste Minimization. This was represented in percentage as 88.7 % and 11.3 % respectively. It can therefore be deduced that majority of the respondents have awareness on construction material waste minimization;
- Majority of the respondents operated in D1K1 firms; 79.2% while the least of the respondents were from D4/K4 construction firms; 3.8 %.
- The highest number of respondents was Project/Construction Managers with a total number of twenty-eight (28). This represented 52.8 %. Site supervisors and others represented 47.2 %;
- Twenty-three (23) of the total respondents were Master's Degree holders representing 43.4 %. Bachelor's Degree holders had 37.7 % representing ten (20) respondents. Eight (8) out of the total number of respondents were Diploma holders representing 15.1 %. Respondents who were Doctorate degree holders were two (2) representing 3.8 %;
- Twenty-one (21) respondents representing 39.6 % fall within the year range of 0-5 of professional experience. Thirteen (13) respondents, representing 24.5 % also has a professional experience of 6-10 years. Nine (9) respondents fall within the category of 'above 20 years' of professional experience representing 17% and 4 out of the 53

respondents have years' experience of 11-15 representing 7.5%. Finally, six (6) of the respondents have professional experience '16-20 years'.

- Thirty (30) respondents have undertaken 0-5 material waste minimization integrated building projects in the last five years. Eleven (11) respondents have undertaken 5-10 projects. Two (2) of the respondents had undertaken 10 – 15 material waste minimization integrated building projects.
- *Poor Workmanship, Challenges arising from Transportation of construction materials, and Poor Supervision* were highly ranked as the causes of material waste at the construction stage of projects.
- *Increased purchased quantity and price cost, Poor site organization and obstruction of movement due to excessive waste generated, and Lower business patronage* were the highest ranked effect of construction material waste variable in undertaking construction projects.
- With regard to the key competencies that drive material waste minimization at the construction stage of projects, twenty-four (24) variables were factor analysed to reduce the data into four unique constructs. The four new constructs include; *Awareness Competence (AC), Managerial Competence (MC), Personnel Ability Competence (PAC) and Communication Competence (CC)*.

5.4 CONTRIBUTION TO KNOWLEDGE AND INDUSTRY

This study has added to knowledge and also contributed to industry in many forms. The Academia and practice have been the major beneficiary from this research. These are outlined below:

- This research has make known the causes and effect of construction material waste on building projects of which its adoption would be of immense benefit to the construction industry; and
- The Study has also make known the key competencies that drive construction waste minimization of which its implementation will ensure success in waste management.

5.5 RESEARCH LIMITATION

Major limitations faced when undertaking this research work was:

- Unwillingness and busy schedules of the respondents in providing the information needed to fill up the questionnaire thereby making its retrieval quite a difficult task.

5.6 CONCLUSION

From the above, it can be concluded that the key competencies that drive construction material waste minimization are; *Awareness Competence (AC)*, *Managerial Competence (MC)*, *Personnel Ability Competence (PAC)* and *Communication Competence (CC)*. Awareness Competency (AC) is the understanding or having knowledge on concepts needed to effectively complete an assignment. Managerial Competency (MC) simply refers to the process of planning, controlling and directing activities to influence individual's performance in order to yield positive results. Personnel Ability Competency (PAC) refers to the capacity to get things done. Communication Competency (CC) refers to the adequacy and ease of flow of thought (communication) to others through various mediums (drawings, charts, phone calls) for an effective work delivery. A deeper understanding of the competencies was obtained by looking at the causes and effect of material waste on construction projects. Poor *Workmanship* was highly ranked as the cause of material waste at the construction stage of projects while *Increased*

purchased quantity and price cost, was also ranked as the major effect of construction material waste in undertaking construction projects. The awareness and the implementation of the various competencies that drive waste minimization shall ensure proper collaboration among construction stakeholders as well as a positive attitude towards waste minimization to enhance high productivity.

5.7 RECOMMENDATIONS

The following recommendations were made based on the study findings to ensure effective construction waste minimization;

- The concept of construction waste should be part of the tertiary education curriculum for the building sector;
- The professionals (Project/Construction Managers) within the building sector need to be fully acquainted with Waste Minimization Competencies through Continuous Professional Development (CPD) such as; seminars, refresher courses and workshops.

5.8 RECOMMENDATION TO FUTURE RESEARCH

A proposed direction of research in the future based on this research study includes;

- Role of construction professionals in material waste minimization; and
- The benefits which could be accrued due to the implementation of waste minimization principles.

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APPENDIX A

QUESTIONNAIRE

Dear Sir/Madam,

Invitation to Participate in a Study

I am Asare, Samuel Senyah, an MSc candidate of the Department of Construction Technology and Management (MSc Construction Management), Kwame Nkrumah University of Science and Technology, Kumasi. This questionnaire is designed for a research study entitled **“EXPLORING KEY COMPETENCIES FOR DRIVING CONSTRUCTION MATERIAL WASTE MINIMIZATION AT THE CONSTRUCTION STAGE OF PROJECTS.**

Lee et al., (2003) defined competency as a behaviour that produces successful results through the combination of knowledge, skill, attitude and value. The key objectives to be achieved by this study are listed below;

1. To identify the causes of material waste at the construction stage of projects.
2. To identify the effects of material waste in undertaking construction projects.
3. To determine key competencies for driving material waste minimization at the construction stage of projects.

Kindly respond to the questions by ticking (✓) and writing the appropriate answers in the options and spaces provided for each item respectively. Information provided will be treated with the highest confidentiality.

I would like to convey my appreciation for your cooperation in completing these questions.

Thank you

Asare, Samuel Senyah, MSc Candidate

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SECTION A : Respondent's Profile

- 1. Do you have any awareness on construction material waste minimization?**
 - a) Yes
 - b) No
 - c) Somehow

- 2. What is the Ministry of Works and Housing (MWH) classification of your firm?**
 - a) D1/K1
 - b) D2/K2
 - c) D3/K3
 - d) D4/K4

- 3. What is your role in the construction industry?**
 - a) Project/Construction Manager
 - b) Quantity Surveyor
 - c) Architect
 - d) Site Supervisor
 - e) Materials Manager
 - f) If Others, Please Specify.....

- 4. What is your highest academic qualification?**
 - a) HND.
 - b) BSc.
 - c) MSc.
 - d) MPhil.
 - e) PhD.
 - f) If Others, Please Specify.....

- 5. How many years of professional experience do you have?**
 - a) 0-5years
 - b) 6-10years
 - c) 11-15years
 - d) 16-20years
 - e) Above 20years

- 6. How many material waste minimization integrated building projects have you undertaken in the last five years?**
 - a) 0-5projects
 - b) 5-10projects
 - c) 10- 15projects
 - d) 15-20projects
 - e) Above 20projects

SECTION B: Causes and Effects of Construction Material Waste on Building Projects.

Section B1.

In your experience, how will you rate the following factors as Causes of Construction Material Waste at the Construction Stage of Building Projects?

Use the following 5-point Likert scale to answer the questions (Please, tick (√)) where:

1 = Not a waste cause; 2 = Insignificant waste cause; 3 = Neutral; 4 = Significant waste cause; 5 = Major waste cause

No	Factors	Rating of Causes				
		1	2	3	4	5
	Waste Causes					
1.	Personnel Ordering Errors (Procurement of Construction Materials)					
2.	Challenges arising from Transportation of Construction Materials					
3.	Poor Supervision					
4.	Poor Workmanship					
5.	Poor Storage of construction materials					
6.	Improper Handling of construction materials					
7.	Errors and Changes in design					
8.	Material Deterioration					
9.	No Waste Management Plan					
10.	Force Majeure					
	<i>If Others, Please Specify</i>					
11.						
12.						
13.						
14.						
15.						
16.						

Section B2.

In your experience, how will you rate the following factors as Effects of Construction Material Waste in undertaking Building Projects?

Use the following 5-point Likert scale to answer the questions (Please, tick (√)) where:

1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree

No	Factors	Level of Agreement				
		1	2	3	4	5
	Effects of Construction Waste					
1.	Higher project costs					
2.	Not meeting cost savings on building projects					
3.	Lower business patronage					
4.	Higher risk of litigation regarding wastes					
5.	Environmental pollution; vehicular emissions, etc					
6.	Increased purchase quantity and price cost					
7.	Increased disposal cost					
8.	Decreased competitive advantage through differentiation					
9.	Channeling of productive land into dumping sites					
10.	Not meeting planning requirements					
11.	Poor performance against corporate sustainability responsibility (CSR) objectives.					
12.	Poor site organization and obstruction of movement due to excessive waste generated					
	<i>If Others, Please Specify</i>					
13.						
14.						
15.						
16.						
17.						
18.						

SECTION C:

In your experience, how will you rate the following factors as key competencies for driving material waste minimization at the construction stage of projects? Please indicate the level of importance of each factor by ticking the appropriate boxes.

Use a scale of *1 = Not Important, 2 = Less Important, 3 = Moderately Important, 4 = Important, 5 = Very Important*

No	Factors	1	2	3	4	5
1.	Awareness of Construction Waste Minimization Practices					
2.	Construction Sequencing and Construction Planning.					
3.	Reuse and recycling of waste					
4.	Health and Safety Management					
5.	Human Resource Management					
6.	Modern Construction Methods					
7.	Standardization and the Implementation of Sustainable Construction Practices.					
8.	Adherence to project design/drawings.					
9.	Waste auditing to monitor environmental performance.					
10.	Thorough review of the project specifications by contractors at the construction stage					
11.	Leadership.					
12.	Effective Communication.					
13.	Team Work.					
14.	Waste Management Plan Implementation.					
15.	Supply Chain Management (SCM) Skills					
16.	Material Logistic Plan Implementation					
17.	Delegation					
18.	Problem solving skills					
19.	Professional learning					
20.	Onsite practical skill					
21.	Personnel quality					
22.	Creative thinking					
23.	Personal commitment to pursuing an ethical solution to waste minimization.					
24.	Provision of direction to inspire others					

Thank you for assisting with this survey.