MANAGING WASTE AND COST IN THE CONSTRUCTION INDUSTRY:

A CASE STUDY OF THE ROAD CONSTRUCTION INDUSTRY

by

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A thesis submitted to the Institute of Distance Learning, Kwame Nkrumah University of Science and Technology in partial fulfilment of the requirements for the degree of

COMMONWEALTH EXECUTIVE MASTER OF BUSINESS ADMINISTRATION

OCTOBER 2011

Declaration

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

Augustine Sagoe

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Certified by

Name of supervisor	Signature	Date

Certified by

Head of Dept.	Signature	Date

DEDICATION

This work is dedicated to my wife and our two lovely children.

I owe this lovely family of mine a debt of gratitude for the love, motivation, support and encouragement they gave me while I carried out my research.

Acknowledgement

First of all, I would like to express my gratitude to my supervisor, Mr. Kwesi Enninful, for guiding me in writing this thesis. His scholarly guidance, constructive comments and critical revision of the drafts made it possible for me to complete this thesis.

I want to appreciate the management and staff of KAMSAD Construction company and PMC construction Ltd all in Accra for their cooperation and assistance during my field observation and questionnaire administration.

My sincere thanks go to Mr. Bernard Ribeiro for his immerse assistance during this research work.

Abstract

Construction is a vital connection to the infrastructure and growth of industry in Ghana. Building roads, bridges and other constructed facilities play an important role in shaping society's future. Consequently, the construction Industry produces a vast quantity of waste which is environmentally unfriendly, and costly to project budgets. This thesis aimed to find out how much construction waste is costing construction project budgets, and attempted to make recommendations to the industry on how profits can be maximized and how the waste can be minimized. For the empirical investigation, a mixed methodology was used which combined questionnaire and interview data from stakeholders in the road construction sector, together with documentary and observational data, to examine the issue of construction waste and cost management. The research revealed that a number of construction companies in Ghana do not adhere to international best practices and standards. Practices such as site waste management plan, waste minimization strategies were found to be non- existent in these companies. A number of recommendations were made to improve the practices of the construction firms in Ghana. For example, the need to train every construction employee on waste management, the need of government agencies to monitor and enforce rule of waste management in the construction industry.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the study

In general, a very high level of waste is assumed to exist in construction. Although it is difficult to systematically measure all wastes in construction, various studies from various countries have confirmed that waste represents a relatively large percentage of production costs. For example, the construction and demolition industry annually produces three times the amount of waste generated by all UK households combined. The industry produced 91 million tonnes of inert waste in England and Wales in 2003. Of this, 40 million tonnes (44%) was used as recycled aggregate and a further six million tonnes (6.5%) as recycled soil for landfill engineering or restoration. The remaining 45million tonnes were either spread on registered exempt sites, used to backfill quarry voids or disposed of at landfill sites. WRAP estimate that there is 15 – 20 million tonnes of non-inert and mixed construction and demolition waste in addition to the 91 million tonnes of inert waste (Dti Sustainable Construction review, 2006).

A further 13 million tonnes of waste is created through material waste i.e. materials delivered to the site, unused and then sent away for disposal. BRE will publish The Construction Resources & Waste Roadmap shortly which will be linked to the Defra Waste Strategy and will detail the waste scenarios of today set against the potential to improve in the future, and actions that could be taken to realise those improvements (Dti Sustainable Construction review, 2006).

A wide range of measures have been used for monitoring waste, such as excess consumption of materials (Skoyles 1976; Bossink and Brouwers 1996), quality failure costs (Cnudde 1991), and maintenance and repair costs, accidents, and non productive time (Oglesby et al. 1989).

Waste reduction in the construction industry is important not only from the perspective of efficiency, but also concern has been growing in recent years about the adverse effect of the waste of building materials on the environment. This kind of waste typically accounts for between 15 and 30% of urban waste (Brooks et al.1994; Bossink and Brouwers 1996; Forsythe and Marsden 1999) Building materials waste is difficult to recycle due to high levels of contamination and a large degree of heterogeneity (Bossink and Brouwers 1996), and often there is insufficient space for its disposal in large cities. Wyatt (1978) stressed the consequences of high levels of waste, both in reducing the future availability of materials and energy and in creating unnecessary demands on the transportation system. In fact, some building materials and components use large amounts of non renewable sources of energy, as well as resources that are in danger of depletion, such as timber, sand, and crushed stone (Bossink and Brouwers 1996).

Measuring waste is an effective way to assess the performance of production systems because it usually allows areas of potential improvement to be pointed out and the main causes of inefficiency to be identified. Compared to traditional financial measures, waste measures are more effective to support process management, since they enable some operational costs to be properly modelled and generate information that is usually meaningful for the employees, creating conditions to implement decentralized control.

In fact, waste elimination is a major focus for process improvement in the Lean Production paradigm. Originated in Japan in the 1950s, this is an important development trend in manufacturing, based on both the Total Quality Management (TQM) and Just in Time (JIT) production philosophies. The most prominent application of Lean Production so far is the Toyota Production System (Monden 1983) , but in recent years its principles and concepts have been disseminated in other industries, including the construction industry (Koskela 2000).

Rapid, uncontrolled urbanization in Ghana has saddled the country's cities with problems of physical, socio-economic and environmental nature. Besides the physical problems of poor infrastructure, inadequate housing, congestion and poor accessibility, major cities in the country are confronted by socio-economic challenges including increasing levels of unemployment and poverty, social exclusion and rising crime and violence (Songsore, 2003).

Furthermore, environmental conditions in the cities are appalling due to inadequate provision for services such as water supply, sanitation and waste disposal. These problems, and many others, constitute obstacles to the socio-economic development of the country and, therefore, hinder improvements in the lives of the population. The situation is aptly captured by Songsore (2004:5) when he observes that "in virtually every urban centre in Ghana, from regional capitals to district centres and small towns, many people live in neighbourhoods with little or no provision of infrastructure, services and facilities that are essential to good health".

Many urban residents, therefore, live in health and life threatening conditions (Hardoy *et al.*, 2001) and Ghana cannot take comfort in the United Nation's observation that urbanization is a positive feature and cities offer the best opportunity to escape poverty (UNFPA, 2007). Nabila (1993) has blamed the worsening environmental conditions in the cities on the rapidly growing urban population in an unfavourable economic environment whereby city governments lack the resources to provide basic infrastructure and services for environmental management. On the other hand, Tamakloe (2006) attributes the poor environmental conditions in the cities to low institutional capacity for urban management, poor physical planning and the lack of enforcement of development laws, poor provision of infrastructure and services for environmental maintenance and low public awareness of environmental hygiene.

Thus, while it is true that rapid population growth is the source of pressure on urban infrastructure and services (Nabila, 1993), the lack of institutional capacity to plan and manage urban settlements and to confront the challenges that accompany urbanization is also a major contributor to the chaotic urban development and poor environmental conditions in Ghanaian cities (Tamakloe, 2006).

Among the many problems that confront cities in Ghana, solid and material waste disposal is a particularly worrying issue that seems to overwhelm the authorities. In fact, the problem appears intractable and can be likened to a 'monster' staring the authorities in the face while they look on helplessly (Kironde, 1999). Tamakloe (2006) has referred to it as "a nightmare" and it would seem that many of the Millennium Development Goals (MDGs) are far from achievable by the target year of 2015 in the waste-laden city environments since solid waste disposal affects most of the issues to be addressed by the MDGs including child health and mortality (Goal 4) maternal health (Goal 5) the incidence of malaria and other diseases (Goal 7) and environmental sustainability (Goal 7).

1.2 Statement of the problem

Effective minimization of waste contributes to profit maximization which is the reason for the existence of most companies. Despite the serious threat waste poses to the profit objective of most firms no serious attention is paid to identifying factors that contribute to the increase of waste in the construction industry.

The construction of roads, houses, bridges or anything for individuals or the government, involves many resources. The build up of the cost of these projects significantly includes the cost of waste. Unfortunately, most contractors have failed to initiate measures to reduce the cost of waste and in turns reduce the burden they inflict on their clients in the form of exorbitant charges. Consequently, prospective clients aggravate the situation by engaging non-professionals and sometimes are unable to clearly state their designs.

Without reduction in waste, companies produce at high cost, incur high debts and soon folds up. Reducing waste is not limited to small or big business but also to the newly established companies be it multinational or local. The situation is again worsening when those in production do not have any idea about operations management. This is not to say that non operations managers cannot reduce waste but it is believed that the professional can do better that the non-professional.

This study was therefore undertaken in order to gain understanding of the challenges and issues involved in the generation of waste in the construction industry in Ghana and how cost can be minimized if best practices are upheld in the industry and to pave the way towards finding a solution to the waste menace.

1.3 Research objectives

The general objective is to examine the factors that contribute to waste in the road construction industry.

1.3.1 Specific objectives

But specifically the research has the following objectives:

1. To identify the critical sources and causes of construction waste.
2. To assess the environment and social concerns of operations management.
3. To review ways of reducing or minimising cost related to waste in the construction industry.

1.4 Research questions

The following questions were put forward to help the achievement of the objectives set above:

1. What factors contribute to waste generation in the construction industry?
2. What is the environmental impact of construction waste?
3. How can waste related cost be reduced or managed in the construction industry?

1.5 Brief methodology

A multi-method approach is used in this study. Information used was obtained by using available literature, this included books and articles in libraries. The main instruments employed at the fieldwork were questionnaire, interviews and observation. A well-prepared and structured questionnaire, arranged in sequence and designed to be self-administered were sent out. As a result, two structured questionnaires were used to solicit information regarding the research topic. The first questionnaire was designed for operation managers. It contains twenty one questions of varied nature. The second questionnaire was designed for foremen and it also contains nineteen questions. Furthermore, random interviews were conducted. Close ended and open ended question formats were adopted by the researcher.

Participant observation used consisted of observation of interactions, actions and reactions,

1.6 Significance of the study

This work is meant to draw attention for those in the construction companies to know some of the factors that shoots up the cost of construction so that they can reduce the waste level and as such improve on productivity.

The study also intends to make some contributions to the understanding of construction waste management through the application of some important but neglected principles.

Also this study intends to provide some framework for the development of policies and rules in the management of construction waste.

1.7 Scope and limitations

This research was conducted on examining the factors of waste and cost management in the construction industry with specific focus on two companies namely KAMSAD constructions and PMC construction Ltd in Accra. In such a research there is bound to be several constraints to be encountered. First, there are several construction firms in the country hence the study might not be necessarily representative of all the overall population.

Secondly, the study is also constrained in terms of time. We are also constrained by the limitedness of time in which this project is supposed to be presented. This may not allow us to critically assess large numbers of the construction work force. Cost is another issue that limited how widespread our data can be collected, as more data would have been necessary to have a better assessment of clients.

Nevertheless, in the face of all of these limitations, it is believed that the core objective of assessing the contributing factors to waste and how to manage the related cost can be achieved with a high amount of confidence.

1.8 **Outline of the research**

This research has been organised in five chapters. The first chapter gave an introduction to the entire thesis, and it covers the background to the study, statement to the research problem, the objectives of the study and the significance of the study. The chapter two was devoted to presenting a review of the literature related to conceptual issues addressed in this thesis. The chapter three covered the methodological approach employed and the method used to collect data for the research. The chapter four covered analysis of the data gathered and also provided a solid interpretation to these data. The final chapter assessed the findings of this study, drew the conclusion and important recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The literature review involves researching what others have written in the subject area of construction waste management. Insights and background knowledge obtained from the literature review was used to bring something new to the subject area.

2.2Examining the concept of waste

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

Once a material falls within this definition it will remain waste until it is fully recovered and is no longer a threat to the environment and human health. After this point, it will no longer be subjected to the controls of the directive.

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

Waste is defined by Formoso et al. (1999 Cited in Yara and Boussabaine 2006) as "any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client". Mohanty and Deshmukh (1998 cited in Mohanty and Deshmukh 1999), state that "any non value adding activity carried out in any work system at any time can be defined as waste". According to Mohanty and Deshmukh "any resource deployed in the work process which does not create utility for the stakeholders can be conceived as waste.

According to Chen et al (2002) construction waste can be closely defined as debris of construction and demolition. Specifically, construction waste refers to solid waste containing no liquids and hazardous substances, largely inert waste, resulting from the process of construction of structures, including building of all types (both residential and non-residential) as well as roads and bridges. Construction waste does not include clean-up materials; lend waste, solvent sealers, adhesive living garbage, furniture appliances or similar materials.

Koskela (1992), Alarcon (1993), Sepell et al. (1995 cited in Yara and Boussabaine 2006) , have defined construction waste as "quality costs, lack of safety, rework, unnecessary transportation trips, long distances, improper choice of management, methods or equipment and poor constructability".

Gilpin (1996) provides a more elaborate definition of the term waste. According to him, the concept of waste embraces "all unwanted and economically unusable by products or residuals at any given place and time, and any other matter that may be discarded accidentally or otherwise into the environment" (Gilpin, 1996:228). Gilpin also suggests that what constitutes waste must "occur in such a volume, concentration, constituency or manner as to cause a significant alteration in the environment". Thus, apart from waste being an unwanted substance that is discarded, the amount of it and the impact it makes on the environment also become important considerations in defining waste.

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

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

Davies (2008:5) further notes that "what some people consider to be waste materials or substances are considered a source of value by others" This relative attribute of waste can be compared with the concept of 'resource' which has also been defined as material that has use-value (Jones and Hollier, 1977:20) and "a reflection of human appraisal" (Zimmermann, cited in Jones and Hollier, 1977:20). Just as a material becomes a resource when it gains use-value, it also becomes waste when it loses its use-value. Like resources, waste is also a relative concept or human appraisal because what constitutes waste can vary from one person to another, one society to another and over time. As noted by Jessen (2002:online) "our waste stream is actually full of resources going in the wrong direction".

Drawing from the views expressed above, the definition of waste to be used in this study is any substance (liquid, solid, gaseous or even radioactive) discarded into the environment because it is unwanted, which causes significant nuisance or adverse impact in the environment.

2.3 Classification of waste

Maryam Zafar Ansari and Kritika Verma (1988) classified waste in their project titled, "*Waste Managemen*t" on the basis of: Waste resources, Origin of waste, Property of waste, Recoverability. V. S. Rama Rao (2009) explained the above classifications as follows:

*Waste Resources***:** Material resources like solids, liquids, and gases can be wasted. Energy resources like physical, human and solar energy can be wasted. Time resource can be wasted. Time resource can be considered as Waste of waiting. This includes idle time that workers spend on waiting for machines to complete operations and that managers spend on waiting for information to make decisions.

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

*Origin of waste***:** It could be industrial, residential, commercial, office, municipal, construction and demolition, agriculture etc.

Property: materials wasted are either hazardous or non-hazardous

Recoverable: Wastes can be recovered into some useful resources, material waste recycled. Non- recoverable wastes are lost with time.

A number of criteria are usually employed to classify wastes into types including their sources, physical state, material composition and the level of risk associated with waste substances (Table 1). Such classification of waste provides a basis for the development of appropriate waste management practice.

Table 1: classification of waste

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

Source: **World Bank/IBRD, 1999. What A Waste: Solid Waste Management in Asia**

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

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

2.4 Background to the construction industry (A South Africa assessment)

A review of the South African construction industry, according to CSIR (2004:3), states that the industry is capable of delivering the most innovative and complex projects at times. It is also acknowledged that the industry is underachieving in, amongst others, quality and efficiency, and that the industry needs to radically improve the practice through which it delivers its projects. Improvements to the delivery process will require building professionals to review their current practices and through innovation, their own products and processes. Improved construction industry performance will require vigorous and energetic professional leadership.

The construction industry is considered a wasteful sector. The industry consumes an estimated 12-16% of fresh water and 40% of energy, and added to this an estimated 15% of purchased materials end up as waste. According to the research of Mocozoma (2002:1), the

South African construction industry has been in recession for more than two decades. The deterioration in capital investment and activity in infrastructure delivery in the late 70s and a lack of efficiency in construction processes, have all contributed to this.

Inefficiencies in the construction practice occur in three areas: acquisition and use of equipment and machinery, labour practices, and procurement and use of materials.

Construction waste management has become essential to improve the performance of the industry in terms of economic quality and sustainability. One way of achieving this target is by reducing waste at all stages of the construction process. Managing building material waste can result in higher construction productivity, save time and assist sustainability. Hardly any data from previous projects are available on how to avoid the causes of waste generation during construction projects.

This research aims to identify how, where and when waste in construction projects is generated, as well as the dominant causes as identified according to South African current practices. Skoyles and Skoyles (1987:11), support Ekanayaka and Ofori (2000:1-6), in stating that construction waste has become a burden to clients, as they have to bear the costs of waste. This is a major problem for contractors as well, because it leads to loss of profits and may even contribute to bankruptcy. According to De Silva and Vithana (2008:188-198), many countries are experiencing an increase in construction waste, which has created growing tension for authorities, especially as the search for new landfill sites has become an increasing priority.

2.5 Causes of waste

Rao (2009) mentions various causes responsible for wastes. An illustrative list is given below. The highest waste causing factors are considered to be critical.

1) Faulty planning and policies systems and procedures; 2) Faulty organization structure; 3) Environmental pressures ; 4) Tardiness(slow to act); 5) Lack of accountability; 6) Unawareness of technological advances; 7) Non-responsiveness to automation / computerization; 8) Wrong specifications, standard, codes; 9) Wrong raw materials 10) Lack of inventory control; 11) Lack of proper storage, layout of facilities, handling of material; 12) Communication gaps; 13) Faulty work method; 14) Less emphasis on PPC 15) Lax supervision and control; 16) Wrong recruitment /selection policies; 17) Lack of motivation / incentives; 18) Poor working conditions; 19) Unsafe practices; 20) Poor IR: Industrial Relations; 21) Maintenance failure; 22) Power failure; 23) Distribution problems; 24) Less attention to waste segregation and collection; 25) Technological obsolescence; 26) Miscellaneous causes; 27)information asymmetry

2.5.1 Material causes of waste in the construction

Formoso et al.; (2002) list the following causes of waste in the construction industry;

- **industry Steel Reinforcement**

Controlling the use of steel reinforcement in building sites is relatively difficult because it is cumbersome to handle due to its weight and shape. Also, this material is sold by weight, and most building sites in Brazil cannot afford to have a scale for weighing steel reinforcement. For that reason, most companies use a conversion table to calculate the weight of each lot delivered to or withdrawn from the site.

Three main reasons can be pointed out for steel reinforcement waste: some short unusable pieces are produced when bars are cut; some bars may have an excessively large diameter due to fabrication problems; and trespassing. In both studies, the worst performing sites were usually the ones in which the structural design was poor in terms of standardization and detailing, causing waste due to non optimized cutting of bars. Many problems related to poor handling of materials were also observed, resulting in large disorganized stocks, which often caused waste for substitution—that is, unnecessary replacement of some bars by others of larger diameter.

In recent years many companies in Brazil have opted to purchase off-site preassembled steel reinforcement. One of the advantages of this alternative is that it drastically reduces waste mainly by optimizing the cutting of bars, although no systematic study on the extent of this economy has been published so far.

- **Premixed Concrete**

Despite having one of the lowest waste indices among all materials, the relatively poor performance of premixed concrete in both studies was fairly surprising, due to the relatively high cost of this material. In contrast, most construction companies in Brazil assume that the waste of premixed concrete is negligible.

Site managers often complain about the difficulty of controlling the amount of premixed concrete deliveries. In fact, in the 1996–1998 study, as many as 64% of the sites in which the waste of this material was investigated had no control of this kind. In the same study, the research team monitored the difference between the purchased amount of concrete and the amount actually delivered at 12 sites. An average difference of 3.6% was found— this means that indeed some suppliers often deliver quantities of material smaller than what the construction firms are actually paying for.

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

Beams also had similar problems—their width was on average 2.7% larger, considering a sample of 29 sites. The excessive thickness of slabs seems to be the most serious problem because of shape, and also due to the relatively high percentage of this element in the volume of the whole structure—usually around 50 to 60%. The main causes for this problem were lack of constructability of some structural elements, poor design of the concrete formwork system, imprecision of the measuring device, and flaws in the formwork assembling process.

Fairly often, some waste of concrete was also observed during the handling and transportation operations on site, mostly related to site layout problems and to the use of inadequate equipment, although it was difficult to quantify its magnitude due to the relatively high cost of measurement. At a few sites, the excessive dimensions of concrete foundation piles and curtain walls also caused unexpected waste. This problem was mainly related to the lack of precision in excavation methods. Finally, due to uncertainty related to material consumption, site managers often order an additional allowance of concrete in order to avoid interruptions in the concrete-pouring process. Sometimes this results in a surplus of concrete that is not used.

- **Cement**

Analyzing the waste of cement is relatively complex due to the fact that this material is used as a component of mortar and casting place concrete in several different processes, such as brick- work, plastering, and floor screed. By contrast this is a relatively expensive material that has high levels of waste in Brazil, according to both studies.

Its main sources of waste are as follows:

1. In situ production of mortar: much waste of cement was observed in the production of mortar on site. Cement and other materials are usually loaded manually in the mixer using inadequate equipment. For instance, in the 1992–1993 study, 14 different combinations of equipment and tools, including shovels and buckets, were found at only five sites during the data collection period. This also indicates the lack of process standardization. Another typical cause of waste in this stage is the lack of information available to construction labor for producing different mixes of mortar.

2. Handling and transportation of mortar: in both studies, waste of mortar was observed in most sites during the handling and transportation operations, although no quantification was possible. Multiple handling of the same batch of mortar, due to intermediate stocks along the process flow, is also fairly common. Such waste was mostly related to site layout problems, lack of properly maintained pathways, and use of inadequate equipment.

3. Brickwork joints: the production of brickwork was also responsible for some waste of cement, due to the excessive consumption of mortar in joints. In the 1992–1993 study, the average thickness was 19.1% greater in the vertical joints and 35.6% in the horizontal joints. In the 1996–1998 study, in a larger sample of sites, the average deviation in thickness was 52% for horizontal joints (20 sites) and 56% for vertical joints (21 sites). There is usually a combination of reasons for the excessive thickness of joints, which may include lack of modular coordination between concrete structure and brick walls, inadequate training of labour, insufficient information available about process standards, inadequate supervision, variations in the size of blocks, and lack of process standardization.

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

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

- **Sand, Lime, and Premixed Mortar**

The waste of mortar used in brickwork and plastering has already been discussed in the previous section. The main causes of cement waste can also explain most of the problems related to sand, lime, and premixed lime and sand mortar. Sand and mortar are usually delivered in trucks, and so there may be additional losses related to the lack of control in the delivery operation and the necessary handling it demands.

In recent years, some companies in Brazil have started using packed ready-to-use mortar mix, which tends to eliminate many of the problems related to delivery control, handling, and transportation. Although not enough data are available, there are indications that such changes have reduced the waste of mortar, in comparison to the traditional method of producing mortar on site.

- **Bricks and Blocks**

In most poorly performing sites, a combination of causes was related to the waste of bricks and blocks. At several sites, there were problems related to the delivery of materials, such as the lack of control in the amount of bricks or blocks actually delivered and the damage of bricks or blocks during the unloading operation. In both studies, poor handling and transportation were the major sources of waste for bricks and blocks. As in the case of mortar, multiple handling of the same batch of bricks, due to intermediate stocks along the process flow, was observed at many sites.

Insufficient planning of the site layout, lack of properly maintained pathways, and the use of inadequate equipment were among the main causes of waste. It seems that most of the problems related to delivery, handling, and transportation could be eliminated by supplying bricks and blocks on pallets. In fact, some of the sites in the 1996–1998 study adopted this strategy and were able to reduce waste to some extent. However, it was also observed in the same study that the use of pallets does not improve performance on its own. They have a positive impact only if other measures related to flow management are also implemented, such as planning the layout, keeping pathways unobstructed and minimizing inventories.

Another source of waste was the need to cut blocks and bricks, due to the lack of modular coordination in design. Indeed, the percentage of cut pieces at some sites was relatively high— considering a sample of 40 sites, the percentage of cut ceramic blocks in relation to the total number of blocks was, on average, nearly 18%. In this context, the waste tends to be higher if the cutting operation is not planned and needs to be executed at the installation locale.

- **Ceramic Tiles**

The poor performance of ceramic tiles in the 1996–1998 study was unexpected, considering the relatively high cost of this material. The main source of waste was the need to cut tiles—on average, 35% of the pieces on floors (15 sites) and 27.4% of the pieces on walls (23 sites) had to be cut. Lack of modular coordination and flaws in the integration between architectural and structural design were the main causes of the cuts.

At some of the sites, it was also observed that the lack of planning in the distribution of materials contributed to increased waste. In most instances, whole packages of ceramic tiles (typically 1.5 m2 each) are sent to the installation places, based on the demand by the work crews. When necessary, pieces are cut, and some are left as debris when the crew moves to the next work face. In contrast, a few companies adopt the strategy of sending to the work face the exact amount of tiles in a kit, including all necessary pre cut pieces. This allows the operation of cutting tiles to be centralized and thereby optimized and avoids unnecessary handling of wasted parts.

- **Pipes and Wires**

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

2.6 Framework of waste in construction industry

Formoso, et al. (1999) in their earlier research paper entitled "Method for Waste Control in Building Industry" had significantly grouped some researches and studies done by other researchers around the world on the wastes in construction into two main aspects based on the impacts of the construction waste:

1. Researches and studies mostly focused on the impacts on environmental damage that result from the generation of material waste. For example:

2.6.1 The research on construction waste conducted by The Hong Kong Polytechnic and the Hong Kong Construction Association Ltd. in 1993 aimed to reduce the generation of waste at source, and to proposed alternative methods for treatment of construction waste in order to reduce the demand for final disposal areas.

2.6.2 The research project conducted by Brossik and Brouwers in the Netherlands in 1996, concerned with the measurement and prevention of construction waste, regarding sustainability requirements stated by Dutch environmental policies.

2. ***Researches and studies mostly concerned with the economic impacts of waste in the construction industry.*** For example

2.6.3 The most extensive studies on this theme was carried out by Skoyles in UK year 1976 whereby he actually monitored material wastes in 114 building sites, and concluded that there was a considerable amount of waste that can be avoided by adopting relatively simple prevention procedures. Some other findings from Skoyles' researches also pointed out that storage and handling was a major cause of waste while most of the problems concerning waste on building sites are related to flaws in the management system, and have very little to do with the lack of qualification of workers.

Besides that, Formosa and his co-authors have also documented some extensive studies and surveys done in Brazil, which the concentration of those studies were more towards identifying the types of material wastes in construction. For example,

2.6.4 Pinto developed a study in 1989 based on one site only; pointing out for the fact that indirect waste (materials unnecessarily incorporated in the building) can be higher than direct waste (rubbish that should be disposed in other areas).

2.6.5 The first research project on construction waste developed at the Federal University of Rio Grande do Sul (UFRGS) started in April 1992. The main objective of that study was to analyse the main causes of material waste in the building industry in order to propose guidelines for controlling it in small sized firms. Seven building materials were monitored in five different sites during a period ranging from five to six months.

2.6.6 The Brazilian Institute for Technology and Quality in Construction (ITQC) more recently coordinated a much more ambitious research project on material waste measurement, which was developed for the Brazilian construction industry, involving 15 universities (including UFRGS) and more than one hundred building sites. For over 2 years, eighteen materials had their waste monitored by using a data collection method similar to the projects carried out at the Federal University of Rio Grande do Sul (UFRGS) in 1992.

Some conclusions that were drawn from those conventional construction waste studies above such as:

1. The waste of building materials is occasionally far higher than the nominal figures assumed by the companies in their cost estimates.

2. There is a very high variability of waste indices from site to site. Furthermore, similar sites might present different levels of wastes for the same material. This indicates that a considerable portion of this wastage can be avoided.

3. Some companies do not seem to be concerned about material waste, since they do not apply relatively simple procedures to avoid waste on site. None of them had a well-defined material management policy, neither a systematic control of material usage.

4. The lack of knowledge was an important cause of waste. Most building firms did not know the amount of waste they had.

5. Most causes of waste are related to flaws in the management system, and have very little to do with the lack of qualification and motivation of workers. Also, waste is usually the result of a combination of factors, rather than originated by an isolated incident.

6. A significant portion of waste is caused by problems, which occur in stages that precede production, such as inadequate design, lack of planning, flaws in the material supply system, etc.

2.7 Measuring and Ranking of construction waste

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

Table 2: Ranking of the causes of construction waste

Causes of construction waste	Overall Ranking
Lack of onsite waste management plan	1
Waste from application process; e.g. during plastering	2
Over –mixing of material due to the lack of knowledge of the requirement	3
Errors by tradesperson and labourer	4
Cutting of uneconomical shape/length	5
Damages by subsequent trades	6
Changes in design	7
Use of incorrect material	8

Damage during transportation on site	9
Inclement of weather	10
Other errors	11
Contract document incomplete at time of construction commencement	12
Error in contract document	13
Over ordering	14
Inappropriate storage	15
Damage during transportation to site	16
Accidents	17
Supplier error	18
Criminal waste due to damage or theft	19
Equipment malfunction	20

Source: Urio & Brent, 2006:21

2.8 Classification of construction waste

Waste in construction can culminate as a result of different causes and situations.

Construction waste falls into different categories, which are elaborated on below:

2.8.1 Waste according to the type of resources consumed

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

- **Physical waste of materials:** Additional amount of materials relative to those specified in the project.
- **Physical waste of man-hours:** Man hours increased by delay in the arrival of materials and overproduction.
- **Physical waste of equipment:** Equipment hours increased in function of the problem quoted for the man power.
- **Financial waste as a result of physical waste:** Determine the costs associated with physical waste.

- **Financial waste in result of material purchase:** Relative additional cost for the use of a material with superior value to the specified one.

2.8.2 Waste according to its nature

Skoyles and Skoyles (1987:18-24), categorise waste into four principal types, namely "natural direct", "indirect" and "consequential waste". Waste is, to a certain extent, inevitable on building sites and this is generally recognised by everybody in the construction industry. Skoyles and Skoyles (1987:19), refer to this acceptable level of waste as "natural waste". "Indirect waste" is distinguished from "direct waste" in that the materials are not usually lost physically, but the payment for part or whole of the value is lost. This is the waste, which can be prevented, and involves the actual loss. Table three (3) summarises the various forms in which direct and indirect waste can occur.

Table 3: Types of waste

Principal types	Forms of the principal types
Indirect waste	• Substitution, where materials are used for purposes other than those specified. • Production waste, where materials are used in excess of those indicated or not clearly defined in contract documents, e.g. additional concrete in trenches, which are extracted wider than designed because no appropriately sized digger bucket was available. • Operational waste, where materials are used for temporary site work for which no quantity or other allowances have been made in the contract documentation, e.g. tower crane bases, site paths, temporary protection. • Negligent waste, where materials are used in addition to the amount required by the physical waste financial waste materials man-hour Equipment material purchase Due physical waste. Waste according to the type of resource consumed contract, owing to the construction contractor's own negligence.

Direct waste	• Deliveries waste comprises all losses in transit to the site, unloading and placing into the initial storage. • Site storage and internal site transit waste comprise losses due to bad stacking and initial storage, including movement and unloading around the site, to stack at the workplace or placing into position. • Conversion waste comprises losses due to cutting uneconomical shapes, e.g. timber, sheeted goods. • Fixing waste comprises materials dropped, spoiled or discarded during the fixing operation. • Cutting waste includes losses caused by cutting materials to size or irregular shapes. • Application waste includes materials such as mortar for brickwork and paint spilled or • dropped during application, similarly, materials left in containers or cans which are not • Sealed and mixed materials like mortar and plaster left to harden at the end of the day. • Waste due to the uneconomical use of the plant. This covers plant running when not in use, or not employed to its optimal use. • Management waste includes losses arising from an incorrect decision and not related to anything other than poor organization or lack of supervision. • Waste caused by other trades. This includes losses arising from events such as "borrowing" by trades for purposes other than work, and not returning the plant or material or damage by succeeding trades. • Criminal waste covers pilfering, theft from the site and vandalism. • Waste due to incorrect type or quality of materials. This includes waste stemming from materials wrongly specified and waste due to errors, particularly in the bills of quantities and specification. • Waste that is usually caused by apprentices, unskilled tradesmen, and tradesmen on new operations.

Source: Skoyles and Skoyles (1987:19),

2.9 Examining the concept of waste and value

In Koksela's research paper (1992), he has been looking for the evidences of waste and value loss due to quality of works, material management, non-productive time, safety and constructability.

2.9.1 Waste and value loss due to quality of works

The first element of waste and value loss was compiled in term of quality costs, the subsequent findings from 3 different projects are stated as follow:

1. In numerous studies from different countries done in 1991, the cost of poor quality (no-conformance) as measured on site has turned out to be 10 - 20% of total project costs. In a Belgian study, it has also recorded the causes of these quality problems are 46% design-related, 22% construction-related and 15% are related to material supply

2. In a very detailed Swedish study on a design-construct project carried out in 1991, the costs of quality failures for a construction company were found to be 6%. In Sweden and Germany, it was found out that external quality costs or the loss of value (understood as exceptional maintenance) to owners during facility use are estimated to be 3% of the value of annual construction production. In the case of Sweden, 51% of these costs are associated with design problems, 36% with construction problems and 9% with use problems.

3. In an American study of several industrial projects, deviation costs averaged 12.4% of the total installed project cost. The researchers of the study also recorded the causes of these quality problems are 78% design-related, 17% construction-related and 20% are related to material supply quality problems are 46% design-related, 22% construction-related and 15% are related to material supply

2.9.2 Waste and value loss due to constructability

The second factor that contributed to waste and value loss as compiled by Koskela is the factor of constructability. Constructability is the capability of a design to be constructed, or in a more elaborated word, constructability of a design depends on the consideration of construction constraints and possibilities. It was found from a constructability report in 1986 stated that projects where constructability has been specifically addressed have reported 6 - 10% savings of construction costs.

2.9.3. Waste and value loss due to material management

Materials management in construction site was generally being neglected. Some researchers such as Bell & Stukhart have estimated that 10 - 12% savings in labour costs could be produced by materials-management systems. Furthermore, a reduction of the bulk material surplus from 5 - 10% to 1 - 3% would result from a better material management practice. Besides that, some researchers also reported that savings of 10% in materials costs can be achieved from vendor cooperation in streamlining the material flow.

2.9.4. Waste and value loss due to non-productive time

As for work flow processes, It has been found that construction work flow consists of a lot of non value-adding activities where they consume a high percentage of overall working time. All the estimation given from the researches compiled by Koskela, the average distribution of working time used in value-adding activities ranging around 30% to 40%. Oglesby and his co-author estimated around 36% in 1989 while Levy in 1991 claimed that the average share of working time is 31.9 % in the United States.

There are similar figures from other countries but some other researches did show a greater variance in percentage. For example, the average distribution of working time of the 17 observed building projects survey in Chile conducted by Serpell, et al. (1995) during 1990 and 1994 shows that the minimum value of productive work was 35% and the maximum was 55%.

2.9.5 Waste and value loss due to safety issues

Another waste factor is lack of safety. In the United States, safety-related costs are estimated to be 6 percent of total project costs as reported by Levitt & Samelson in 1988.

Thus, there is strong empirical evidence showing that a considerable amount of waste and loss of value exists in construction apart from the conventional understanding of physical waste or material waste. A large part of these wastes has been hidden, and it has not been perceived as actionable.

2.10 Productivity theories in relation to waste management

Several productivity enhancement techniques and theories have emerged over the last five decades with the clear objective of minimizing waste. These techniques have been revolutionary in some industries and have also improved the level of efficiency in others. It is therefore relevant to discuss briefly these techniques since the cornerstone of these productivity tools has been the desire to eliminate waste.

2.10.1 Just In Time (JIT)

The starting point of this new production philosophy was in industrial engineering oriented developments initiated by Ohno and Shingo at Toyota car factories in the 1950's. The driving idea in the approach was reduction or elimination of inventories (work in progress). This, in turn, led to other techniques that were forced responses to coping with fewer inventories: lot size reduction, layout reconfiguration, supplier co- operation, and set-up time reduction. The pull type production control method, where production is initiated by actual demand rather than by plans based on forecasts, was introduced.

The concept of waste is one cornerstone of JIT. The following 7 wastes were recognised by Shingo as (1) Overproduction, (2) Waiting, (3) Transporting, (4) Too much machining (over processing), (5) Inventories, (6) Moving, (7) Making defective parts and products. Elimination of waste through continuous improvement of operations, equipment and processes is another cornerstone of JIT.

2.10.2 Total Quality Control (TQC)

The starting point of the quality movement was the inspection of raw materials and products using statistical methods. The quality movement in Japan has evolved from mere inspection of products to total quality control. The term total refers to three extensions:

1. Expanding quality control from production to all departments,
2. Expanding quality control from workers to management, and
3. Expanding the notion of quality to cover all operations in the company.

The quality methodologies have developed in correspondence with the evolution of the concept of quality. The focus has changed from an inspection orientation (sampling theory), through process control (statistical process control and the old seven tools -

2.10.3 Total Productive Maintenance (TPM)

Total Productive Maintenance is a comprehensive program to maximise equipment availability in which production operators are trained to perform routine maintenance tasks on a regular basis, while technicians and engineers handle more specialised tasks. The scope of TPM programs includes maintenance prevention (through design or selection of easy-to-service equipment), equipment improvements, preventive maintenance, and predictive maintenance (determining when to replace components before they fail).

2.10.4 Concurrent engineering

Concurrent engineering is a cross-functional, team-based approach in which the product and the production process are designed and configured within the same time frame, rather than sequentially. Ease and cost of constructability, as well as customer needs, quality issues, and product life cycle costs are taken into account earlier in the development cycle.

The main ideas about concurrent engineering is to achieve an improved design process characterized by rigorous up-front requirements analysis, incorporating the constraints of subsequent phases into the conceptual phase, and tightening of change control towards the end of the design process.

2.10.5Continuous improvement

Continuous improvement is a never-ending effort to expose and eliminate root causes of problems; small-step improvement as opposed to big-step or radical improvement. A Continuous Improvement strategy involves everyone from the very bottom to the very top, the basic premise being that small regular improvements lead to a significant positive improvement over time. The main goal of the continuous improvements is to affect the mindset as well as achieve the improvements of the techniques. In this case, everyone pitches in and receives training in the appropriate skills; responsible for their own efforts, areas and progress of their teams and the employees will continuously suggest improvements to meet quality, cost and delivery target improvements. The key idea of continuous improvement is to maintain and improve the working standards through small, gradual improvements.

2.10.6 Visual management

Visual management is an orientation towards visual control in production, quality and workplace organisation. The core principal of visual management is the ability to understand that, with a quick look at the shop floor what orders are being done, if production is ahead, on par or behind and what needs to be done next. No orders are missed or lost and everyone knows if they are behind or ahead on the day's production. Shop floor staff will take on more self-managing responsibility with this method as day-to-day decisions are handled on the shop floor.

Generally this method is implemented on large boards next to particular areas on the shop floor, and as much information is shared as is feasible, ranging from maintenance to production targets and production output to injuries.

2.10.7 Re-engineering

Re-engineering is the radical reconfiguration of processes and tasks, especially with respect to implementation of information technology. The key issue in re- engineering is in recognising and breaking away from outdated rules and fundamental assumptions in order to establish a radical change to the processes and tasks for improvement.

2.10.8 Value based strategy (or management)

Value based strategy (or management) is a customer-oriented, in contrast to competitor-oriented approach toward overall production process. It is a continuous improvement to increase customer by conceptualizing and articulating value as the basis for competing.

In various subfields of the new production philosophy, a number of heuristic principles for flow process design, control and improvement have evolved. It is important to note that the understanding of these principles is of very recent origin. It is presumed that knowledge of these principles will rapidly grow and be systematised. The principles of new production are further breakdown as follows (Koskela, 1992)

2.10.9 Reduce the share of non value-adding activities

Reducing the share of non value-adding activities is regarded as the most fundamental principle of new production philosophy or lean production where it is the center of idea for new production philosophy, which differentiates it from conventional production thinking.

There are 3 main sources of non value-adding activities:

1. Non value-adding activities exist by design in hierarchical organisations. Every time a task is divided into two subtasks executed by different specialists, non value-adding activities increase: inspecting, moving and waiting. In this way, traditional organisational design contributes to an expansion of non value- adding activities.

2. Ignorance is another source of non value-adding activities. Especially in the administrative sphere of production, many processes have not been designed in an orderly fashion, but instead just evolved in an ad hoc fashion to their present form. The volume of non value-adding activities is not measured, so there is no drive to curb them.

3. Non value-adding activities exist also due to the nature of the production: work- in-process has to be moved from one conversion to the next, defects emerge, accidents happen.

With respect to all three causes for non value-adding activities, it is possible to eliminate or reduce the amount of these activities. However, this principle cannot be used simplistically. This is because some of the non value-adding activities produce value for internal customers, like planning, accounting and accident prevention. Such activities should not be suppressed without considering whether more non value-adding activities would result in other parts of the process. However, accidents and defects, for example, have no value to anybody and should be eliminated without any hesitation.

Most of the principles presented below address suppression of non value-adding activities. However, it is possible to directly attack the most visible waste just by flowcharting the process, then pinpointing and measuring non value-adding activities.

2.10.10 Increase output value through systematic consideration of customer requirements

This is another fundamental principle. Value is generated through fulfilling customer requirements, not as an inherent merit of conversion. The organisational and control principles of the conventional production philosophy have tended to diminish the role of customer requirements. In many processes, customers have never been identified nor their requirements clarified. The dominant control principle has been to minimise costs in each stage; this has not allowed for optimisation of cross-functional flows in the organisation.

The practical approach to this principle is to carry out a systematic flow design, where customers are defined for each stage, and their requirements analysed. Other principles, especially enhanced transparency and continuous improvement, also contribute to this principle.

2.10.11 Reduce variability

Production processes are variable. There are differences in any two items, even though they are the same product, and the resources needed to produce them (time, raw material, labor) vary from time to time. From the customer point of view a uniform product is better. Thus, reduction of variability should go beyond mere conformance to given specifications and reduction of variability within processes must be considered an intrinsic goal.

2.10. 12 ISO 9001 as a quality improvement methodology

According to Delgado-Hernandez and Aspinwall (2005:965), the use of quality improvement tools has proven to be an important aspect of continuous improvement. Following a comprehensive literature review, various quality improvement tools are available. ISO 9001 as a Quality Management System was investigated. It was found that certified companies made more use of and placed higher levels of importance on these tools than companies, which were not certified. ISO 9001 was developed as a standard for business quality systems.

To be certified, businesses need to document their Quality Management System and ensure adherence to it with frequent reviews and audits. According to Lakshy Management Consultants (2010: **Online**), ISO 9001 certification is considered a strategic growth tool for the construction industry. The ISO 9001 Quality Management System is the best tool available to increase productivity, streamline operations, increase customer satisfaction and improve profit margins through superior quality of product, process and service. ISO 9001 offers a variety of benefits to the construction industry. These benefits range from better resource planning to effective monitoring, and control of the project from improved employee efficiency to reduced customer complaints, and from increased productivity to enhanced market image. The ISO 9001 standard places greater emphasis on customer needs and expectations and improving business performance. A well-established ISO 9001 Quality Management System delivers the following benefits to the construction industry:

- Consistent and effective control of key processes and project management.
- Promotion and standardisation of good working practices.
- Provision of a vehicle for training new employees.
- Effective management of risk and improved crisis management.
- More effective data analysis, generation of key performance matrix and continual improvement objectives.

- Greater emphasis on communication, leadership, change management and adequacy of training.
- A planning and review process which ensures that the system in place remains suitable, effective and capable of identifying new opportunities.
- Effective remote site management, accountability and contractual control.
- Promoting control of suppliers and subcontractors and the development of effective supply chain management.
- World-wide recognition and improved market image.

Besides the fact that ISO 9001 is used as a great marketing selling point, cost education is probably the biggest significant aspect. Regardless of the methodology implemented, managers need to have a better understanding of the impact that poor quality and good quality may have on their investments and on their products/services (Delgado-Hernandez & Aspinwall, 2005:965).

ISO 9001 does not specify quality improvement methodologies. Therefore the implementation of an effective non-conformance system is essential for the success of the system. The development of a formal documented complaint process outlined in the Quality Management System supports continuous improvement ideals (Delgado-Hernandez & Aspinwall, 2005:965).

2.10. 13 Six Sigma as a quality improvement methodology

According to Andersson, Eriksson and Torstensson (2006:282-296), Six Sigma, a methodology pioneered by Motorola and made famous by General Electric, focuses on variance reduction through a problem-solving approach that will improve output quality. Six Sigma is acknowledged as a quality technique and a business improvement strategy implemented to reduce variation/defects within a process and thus improve productivity. The main objective of the programme is to reduce defects and costs related to poor quality and render a product or service of exceptional quality when compared with those produced by an organisation's competitors. The methodology of Six Sigma aims at integrating all operations throughout the processes to make them produce their desired results (Andersson, Eriksson & Torstensson, 2006:282 -296).

Six Sigma (DMAIC) is defined as a method for improvement and is a popular approach. It has basic quality tools that provide inflexibility and repeatability in quality improvement efforts. The basic quality tools can be used to handle 90% of quality problems. Only 10% requires advanced training and analytical techniques and 1% requires outside specialists not found in a company. The focus on profits is one of the strengths of this approach.

2.11 New concept of waste in production activities – Lean Production

In new production philosophy, "waste" has been given a broader concept and definition as compared to its usual narrow meaning. According to the new production philosophy, waste should be understood as any inefficiency that results in the use of equipment, materials, labour, or capital in larger quantities than those considered as necessary in the production of a building.

Waste includes both the incidence of material losses and the execution of unnecessary work, which generate additional costs but do not add value to the product (Koskela 1992).

Therefore, waste should be defined as any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client.

Two other definitions below as quoted by Alarcon (1995) expressed the broaden dimension of wastes as seen by new production paradigm.

Toyota defines waste as: "Anything that is different from the minimum quantity of equipment, material, parts and labour time that is absolutely essential for production." A western definition for waste would be following: "Anything different from the absolute minimum amount of resources of materials, equipment, and manpower necessary to add value to the product."

In this lean production paradigm, the concept of waste is directly associated with the use of resources that do not add value to the final product. This is very much different from the conventional conversion view of production processes where not significant attempts to separate the activities into value-adding or non value-adding activities.

The conventional view sees all activities combined as a whole and therefore waste is being monitored and evaluated as a whole conglomerated additional cost to the production and mainly it only captured costs for the material wastes. The new production philosophy intend to look into and detail out the dimension of waste by identifying non value-adding activities and introduce new measures to wastes such as additional costs or opportunity costs especially due to time waste and value loss which very much invisible in conversion model.

There are 2 approaches to improving processes for new production philosophy compared to conventional conversion view. One is to improve the efficiency of both value-adding and non value-adding work, and the other is to eliminate waste by removing non value-adding activities. Therefore, waste should be defined as any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client.

The ideal outcomes that can be pictured by adopting new production philosophy or lean production will be production will be managed in the way that actions are aligned to produce unique value for the client. Project duration and cost are considered in “project- as-production system” terms making concern for project total cost and duration more important than the cost or duration of any activity. Coordination is accomplished in general by the central schedule while the details of work flow are managed throughout the organisation by people who are aware of and support project goals performance. The primary objectives for this new movement will be looking at value to the client and throughput, the movement of information or materials to completion. Improvement results from reducing waste that is the difference between the current situation and perfection, i.e., meeting customer unique requirements in zero time with nothing in store.

2.12 The concept of waste management

The business of keeping our environment free from the contaminating effects of waste materials is generally termed waste management. Gbekor (2003), for instance, has referred to waste management as involving “the collection, transport, treatment and disposal of waste including after care of disposal sites”. Similarly, Gilpin (1996) has defined waste management as “purposeful, systematic control of the generation, storage, collection, transportation, separation, processing, recycling, recovery and disposal of solid waste in a sanitary, aesthetically acceptable and economical manner”.

It can be deduced from these definitions that waste management is the practice of protecting the environment from the polluting effects of waste materials in order to protect public health and the natural environment. Thus, the priority of a waste management system must always be the provision of a cleansing service which helps to maintain the health and safety of citizens and their environment (Cooper, 1999).

Further, Gilpin (1996) regards the business of waste management as a professional practice which goes beyond the physical aspects of handling waste. It also "involves preparing policies, determining the environmental standards, fixing emission rates, enforcing regulations, monitoring air, water and soil quality and offering advice to government, industry and land developers, planners and the public" (Gilpin, 1996).

Waste management, therefore, involves a wide range of stakeholders who perform various functions to help maintain a clean, safe and pleasant physical environment in human settlements in order to protect the health and well-being of the population and the environment. Effective waste management is, however, a growing challenge to all municipal governments, especially in developing countries.

2.13 The principles of waste management

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

2. 14 Strategies for waste reduction

Environmental stresses are escalating due to the consumer culture that relies heavily on resource extraction, production, consumption and disposal (Barr, 2004; Entwistle, 1999; Pongracz & Phojola, 2004). Sources of production are often distant from places of consumption and disposal, making the interconnectedness of resource cycling difficult to ascertain. It must be emphasized how the conditions experienced by one group of people can undermine the existence of another (Hartwick, 2000).

To link the spaces of production to the places of consumption and disposal, one must "follow the path of a commodity back from the point of consumption, marketing, distribution, and processing, along the transport network, to the point of production, and beyond" (Hartwick, 2000). It is also important to follow the commodity forward through consumption, second-handedness, deconstruction, transformation, or disposal. Hernandez and Martin-Cejas (2005) reinforce that "the integral management of solid waste requires a global perspective of the flow of materials circulating in the ecosystem."

Taking account of the full environmental, social and economic costs of products and waste management policies is a step towards regarding the future consequences of today's actions (Powell, Craighill, Parfitt, & Turner, 1996). These costs must be considered in a long-term context as sustainable waste management "raises concerns not only about the intragenerational but also the inter-generational implications of cradle-to-grave control where the potential environmental impacts may last hundreds of years" (Petts, 2005). Recent investigations into waste management strategies are challenging the idea that production-consumption-disposal follow an inevitable sequence from cradle to grave. Production and consumption processes can be imagined as being part of a cycle, referred to as a 'cradle-to-cradle' model by McDonough and Braungart (2002), where materials are continuously utilized throughout multiple lifecycles, never being downgraded to lesser products. The emphasis is on durable, long-lived products over single-use items, thereby minimizing waste, conserving raw resources, reducing pollution and offering the consumer a sustainable option.

Consumer waste is highly variable, typically unsorted, and contains multiple materials from an array of production sources. The true economic costs of solid waste management are far removed from consumers' decisions thus violating the 'polluter pays' principle (Michaelis, 1995). Waste management on a global scale should enforce the notion that individuals, governments and industry have a role in reducing and reusing materials. Individuals have a responsibility to reduce environmental impacts from waste through participation in environmentally conscious consumer practices; governments have a responsibility to monitor and enforce best-practices for waste reduction, including the implementation of policies and incentive programs; and industry has a responsibility for reducing energy and resource consumption by producing packaging that is recyclable or reusable.

2.15 Integrated waste management and the waste hierarchy

In recent years, the concept of integrated waste management (IWM) has become popular as a new approach to waste management. As defined by the World Resource Foundation (WRF, cited in Environment Council, 2000:23), IWM refers to "the use of a range of different waste management options rather than using a single option". In other words, IWM is an approach which relies not only on technical solutions to the waste problem, but on a wide range of complementary techniques in a holistic approach. The approach involves the selection and application of appropriate technologies, techniques and management practices to design a programme that achieves the objectives of waste management (Tchobanoglous *et al.*, 1993).

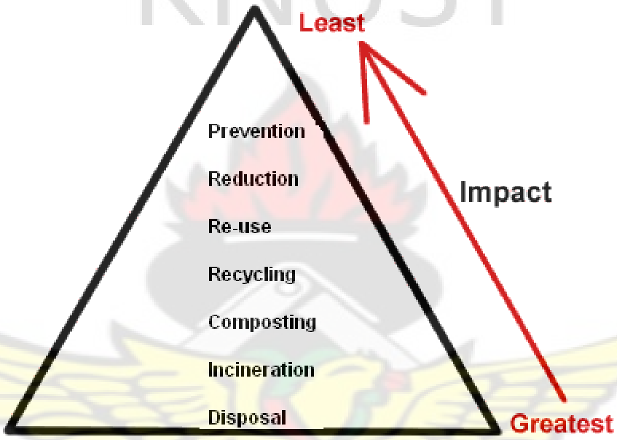
The concept of IWM seems to have emerged from the realization that technical solutions alone do not adequately address the complex issue of waste management and that there is the need to employ a more holistic approach to waste management. As argued by Rhyner *et al.* (1995:17), "a single choice of methods for waste management is frequently unsatisfactory, inadequate, and not economical". Use of an integrated approach to managing solid waste has therefore evolved in response to the need for a more holistic approach to the waste problem. In this approach, all stakeholders participating in and affected by the waste management regime are brought on board to participate in waste management. Furthermore, issues such as social, cultural, economic and environmental factors are considered in the design of an IWM project (Tchobanoglous *et al.*, 1993; Rhyner *et al.*, 1995; Schubeller *et al.*, 1996).

These elements most commonly associated with integrated solid waste management are waste prevention, waste reduction/minimization, re-use of materials and products, material recovery from waste streams, recycling of materials, composting to produce manures, incineration with energy recovery, incineration without energy recovery and disposal in landfills in that order of priority (Durham County Council, 2007)

These elements of IWM are frequently formulated into a waste hierarchy model which Girling (2005) has described as "a penny-plain piece of common sense that places the various strategies for waste management in order of environmental friendliness, from best to worst".

As shown in the model (Figure 1), waste prevention and reduction are placed at the top to show that the best way to deal with waste is to prevent its production and, where this is not possible, to produce less of it. At the other extreme, disposal is placed at the bottom to show that it should be the last resort among the strategies for waste management.

Figure 1: The waste hierarchy



Source: Adopted from: Lancashire CPRE: http://www.lancashire.gov.uk/environment/lmwlp/pdf/

The waste hierarchy was originally set out in the EC Framework Directive on Waste (Girling, 2005) and is a useful guiding principle for waste management planning.

Intergraded waste management and the waste hierarchy both inspire sustainable waste management and can reduce the environmental hazards associated with waste disposal. It is therefore important for stakeholders in the waste sector to realize that an integrated approach which constantly strives to move up the waste hierarchy can be a useful tool for sustainable waste management. In spite of efforts by municipal authorities to improve waste management, most countries in the world still resort to strategies at the bottom of the waste hierarchy. In both developed and developing countries the bulk of solid waste collected by municipalities is still disposed of in landfills.

Other instruments that encourage good practice in waste management are the proximity principle (PP) and the best practicable environmental option (BPEO) (Environment Council, 2000). The proximity principles calls for the disposal of waste as close to its source as possible. Among other advantages, this practice reduces the time, energy and an expense involved in the transportation of waste to disposal sites, and also minimizes the possibility of accidents associated with the transportation of waste. With regard to the BPEO, it encourages the use of waste management strategies that achieve the most benefits in terms of cost, energy and time, and that also cause the least damage to the environment.

2.16 Sustainable waste management

Another important concept of waste management is 'sustainable waste management' (SWM). SWM is an integral part of sustainable development (the Brundtland Commission's approach) to development which seeks to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987) because the amount of waste generated and how it is managed has profound implications for the quality of the environment and for the prospects of future generations. Thus, in keeping with the objectives of sustainable development, sustainable waste management can be regarded as an approach to waste management that, in addition to protecting human health and the environment, ensures that the scarce resources of the earth are conserved for both present and future generations of humanity.

It therefore becomes important to minimize natural resource extraction and consumption by recycling waste materials, and conduct waste management efficiently to curtail the environmental impacts of waste disposal and protect ecosystem services for both current and future generations (Millennium Assessment Report, 2005). In line with the waste hierarchy, the best way to achieve sustainable waste management is to reduce the amounts of waste we produce (Girling, 2005). Where waste is unavoidable a sustainable approach is to encourage re-use and recycling of products to prevent them from getting into the waste stream. Finally, where waste prevention/reduction, re-use and recycling are economically impossible, waste is processed to recover their intrinsic values such as energy. Sustainable waste management also seeks to increase co-ordination between the producers of goods, retailers, manufacturers, the public, local authorities and all concerned with the management of waste and reusable materials and equipment (London Waste Action, 2007).

2.17 Partnerships and governance arrangements in waste management

The uneven distribution of waste service provision between wealthy and poor, and rural and urban neighbourhoods has been noted in many cases (Johnson & Wilson, 2000; Miraftab, 2004; Morrissey, 1992; Petts, 2005). Currently, most local governments "follow a top-down process of producing compliance with waste management, rather than seeking to identify citizens' needs and concerns" (Johnson & Wilson, 2000, p. 306). Entwistle (1999) argues that the structure of conventional waste management systems is fundamentally unsuited to the definition and delivery of sustainable waste management. This view suggests that solutions are best framed at the local level where governance issues can be addressed. Therefore, the option of forming partnerships between multiple stakeholders to address waste problems is being investigated to find alternatives to conventional waste programs (Beall, 1997; Blake, 1999; Forsyth, 2005; Hernandez & Martin-Cejas, 2005; Kironde & Yhdego, 1997; Massoud & El-Fadel, 2002; Seldon & Wilkinson, 2001).

The concept of partnerships has emerged as a contemporary system of local governance (Southern, 2002). Inherent to partnerships is power dynamics between partners and, although voluntary groups are usually well represented in partnership structures, it has been suggested that they often lack any real power (Southern, 2002). Conventional waste management arrangements do not consult local actors and provide no provision for participation by the public in deceision-making. Kironde and Yhdego (1997) examine community-based waste management in Tanzania from a governance perspective and emphasize the formation of partnerships between non profit organizations and local governments to provide effective, integrated waste management solutions, as the services rendered by private companies do not address the sustainable management of waste. By involving citizens in the management of solid waste, employment, social cohesion and civic engagement should result (Kironde & Yhdego, 1997). Their conclusion is based on assessments of participation in decision-making, transparency and accountability, financial efficiency, and sustainability (Kironde & Yhdego, 1997).

Forsyth (2005) explores case studies of waste management that attempt deliberative forms of environmental governance. He highlights how participation and governance are not uniform processes, and political conditions are not always open to partnership possibilities. Robbins and Rowe (2002) also caution that being co-opted into formal partnerships may make activists and leaders less effective. Marginal populations can become subject to political co-option at national and international scales, thus calling into question accountability and legitimacy of collaboration.

Miraftab (2004) suggests that community partnerships in South Africa also promoted the "casualization of labour and differential levels of service" that reemphasize social hierarchies. Governments have often failed to acknowledge the services of informal recycling groups and have declined to provide financial incentives to recycling micro enterprises (Hernandez, Rawlins, & Schwartz, 1999). However, in Quito, Ecuador, a pilot recycling program incorporated micro-enterprises and informal recycling groups to operate municipal recycling services; the revenue was then used towards local development projects (Hernandez, Rawlins, & Schwartz, 1999).

Partnerships are an increasingly popular arrangement where new political arenas involving diverse stakeholders are formulated. Environmental and developmental policies can thereby be acknowledged through new deliberative platforms of governance (Forsyth, 2005; Hoque, 2006).

Waste management fundamentally requires partnerships to succeed. Cooperation between industry, consumers, governments and community groups is essential to maintain the movement of commodities through the waste stream. More recently, local stakeholders and individuals have had less of a stake in this process as dominant companies have taken control over the waste management economy. Without local level involvement, tendencies for disengagement increase resulting in decreased levels of resource recovery and consequent environmental degradation.

2.18 Evaluating the concept of waste minimization

According to Crittenden and Kolaczkowski (1992) waste minimisation is "any technique, process or activity which avoids, eliminates or reduces waste at its source or allows reuse or recycling of the waste". Waste minimisation is described by Osmani, Glass and Price as reducing waste at the source.

2.18.1 Waste Minimisation Projects

The first waste minimisation demonstration projects in the UK were set up in the early 1990s with the aim of demonstrating the financial benefits of waste minimisation in order that the approach would be copied through out industry. The principle normally involves using a technique based on a hierarchy of options; preventing waste by reduction at source, re-use, internal recycling, external recycling or treatment, and dumping only as a last resort.

Waste minimisation projects are based on the development of inter-organisational networks of companies. However, the extent of networking and sharing of good practice varies widely from project to project. There is a risk that participation in a waste minimisation project, which has been largely promoted on its capacity to produce easy financial savings can result in only single loop learning, and therefore does not lead companies to make the radical changes needed to move towards the scale of environmental improvement needed to achieve sustainable development

Despite the proliferation of projects, their impact still appears to be limited. Cheeseman and Phillips (2001) point to the limited impact of the projects in terms of a small minority of companies participating. There is great variation the impact of the project, notably regional disparities (Phillips, Read, Green and Bates 1999). Envirowise data shows that some regions have been much more active than others in terms both of numbers of projects and the impact of the projects (Envirowise 2001).

2.18.2 Barriers to Waste Minimisation

The difference between traditional industrial waste minimisation and the application of the same principles to construction is that the final data for a development, in terms of materials used, waste generated etc. are not available until the development is complete. This means that any cost saving measures identified in one project can only be applied in the next project. Since no two construction projects are exactly alike, the application of waste minimisation to the construction process is therefore not as precise as it is in an industrial context.

For waste minimisation in construction to be widely adopted, it is necessary to answer definitively one simple question: is it worth it? For example, if you are in charge of a building project with a budget of £1million and you suspect that you can save 2-3% of this cost through waste minimisation, you obviously have £20-30,000 to spend on waste minimisation. If you add up the total cost of segregating, double handling, measuring and managing raw materials, energy, fuels and waste and maybe having a general labourer on site to keep things tidy and it comes to less than the amount you stand to save, then it is worthwhile. The difficulty faced by developers in deciding whether or not to pursue waste minimisation is that the value of neither figure is known: for a given project, it cannot be stated at the outset how much can be saved or how much it will cost to save it.

This leaves developers in the situation we see at the moment: any cost saving measures which are apparently effective will be used and those that may seem a bit more far-fetched may be tried but will not be adopted unless they are clearly working. This principle applies to waste minimisation throughout the design and construction of a project.

2.19 The True Cost of Waste

The true cost of waste consists of direct and indirect costs which could be 10 – 20 times the direct costs of disposal. Direct costs consist of landfill tax and the fee charged by the waste management company for transporting the waste offsite and rental cost of skip.

Indirect costs consist of:

(i) Purchase price of the material that ended up as waste.

(ii) Cost of transportation from suppliers to the site of material that ends up as waste.

(iii) Missed opportunity of not reclaiming reusable and recyclable material.

(iv) Lost time in terms of labour and management time.

(iv) Loss of ability to win contracts based on bad waste history; it is a requirement from organisations with a strong environmental policy, such as local authorities and FTSE100 companies to engage contractors with a good waste history.

2.20 Financial benefits of waste minimisation and Recycling

According to DETR (2000 cited in Andrew et al. 2004) "25% of waste produced on construction sites could be minimised relatively easily, which could increase profits by up to 2%". Very often construction projects are competitively priced, allowing for very little profit margins. With the introduction of environmentally friendly approaches to minimise and divert waste from land fill it will mean that these extra profits will be very noticeable in the contractor's balance sheet.

On demonstration projects used to indicate the cost of waste it was shown that average disposal costs using waste minimisation initiatives accounted for 0.3% of the project value due to wastage being halved. Quantities of waste were as low as one third of normal wastage rates on some of the sites. According to Osmani et al. (2006), construction projects usually allow 4% as an allowance for waste, and savings of 1% can be achieved through a waste minimisation programme.

According to the Hendry, Envirowise business manager Scotland, waste costs businesses 4.5% of turnover; however this may include other non-value adding activities. Begum et al. (2006) found that net financial gains of reusing and recycling construction site waste were 2.5% of the project budget. By maximising resource efficiency through reduce, reuse and recycle it will reduce operational costs and improve environmental performance of companies.

2.21 Environmental Impact of Construction waste

The large volume of waste in the construction industry contributes to the rapid depletion of natural resources and production of high volumes of air pollution caused during processing. Water pollution will also result from the processing of materials. When material ends up as waste it has the potential to be reused or recycled thereby minimising its impact on the environment through less processing. The construction industry is the biggest consumer of raw material in the UK , 90% of non-energy minerals extracted in Great Britain are used to supply the construction industry with materials 260m tonnes of material are extracted for use as aggregate and other construction material.

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

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

Gypsum causes harm at landfill due to leaching of sulphates into the ground, this is harmful to humans if it contaminates the water supply. Gypsum accounts for largest portion of the non-inert waste in the UK, at 36%, of the waste stream at construction sites. According to Musick gypsum (Calcium sulphate) when mixed in landfill with "anaerobic bacteria, organic matter and high levels of moisture, will release sulphate ions, producing hydrogen sulphate (H2S) and metallic sulphide leachates which are toxic to fish. This gas is also harmful to humans at levels higher than 1000ppm.

At one landfill levels of 5000ppm were recorded. The gas will reach maximum emissions 15 years after it was first placed in landfill. When plasterboard is mixed with biodegradable waste such as food it can produce hydrogen sulphide which is a Major contributor to acid rain. In the UK if a skip contains more than 10% plasterboard then this material needs to be segregated out and put in special ‘mono’cells in landfill.

The demands that developed nations are putting on the Worlds resources are several times larger than our share of the planet. By 2050 we are expected to have 4 times the environmental impact compared to what we have today, (Edwards 2005).

The ecological footprint of the UK is growing and so too is that of developing Nations who’s consumption of consumer goods is rising 10-20% in rapidly developing economies. The UK economy will be competing with these developing Nations for resources which are beginning to become scarce.

2.22 Attitude and perceptions of the construction workforce

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

Worker involvement during the post-contract stage influences the minimization of waste by ordering materials according to correct quantities and quality, the use of proper storage facilities, and proper handling of materials. Research has also shown that the attitudes of construction laborers towards waste minimization activities are negative. The attitude of the workforce is important to management as it determines people’s behavior and provides an insight into their motivating values and beliefs. An attitude can be defined as a “psychological tendency to evaluate a particular object or situation in a favorable or unfavorable way, which causes someone to behave in a certain way towards it" (Ajzen, 1993:41-57, cited in Teo & Loosemore, 2003:345-76).

Attitude is difficult to grasp because of the interaction between beliefs and attitude, as well as the interaction between people's underlying values and opinions. See Figure 3.13 in this respect. To measure attitude, people must be assessed during work, either because the project is intended to change people's attitude or because people need to increase some measure of their appreciation.

Hussey and Skoyles (1974:91-4), believe that "a change in this attitude rather than a change in techniques is likely to have most effect overall". Teo and Loosemore (2001:741-9), find that attitudes towards waste reduction have become one of the reasons behind the difficulties encountered in the management of waste in the construction industry. Loosemore, Lingard and Theo (2002:256-76), and Skoyles and Skoyles (1987:86-90), highlight the importance of human factors in the minimization of waste, and argue that waste can be prevented by changing people' s attitudes. According to Skoyles and Skoyles (1987:86-90) (cited in Teo and Loosemore 2001:741-9), the involvement of people is being ignored in the waste management equation. The attitudes on waste also differ from one organization to the next, based on their culture and waste management policies. Another contributing factor to high levels of construction waste is the high level of non-conforming work experienced from sub-contractors.

2.23 Conclusion

A thorough evaluation was done regarding the concept of waste. Several definitions from different angles were considered. It was finally established that waste is any substance (liquid, solid, gaseous or even radioactive) discarded into the environment because it is unwanted.

Subsequently, a review of the various models of waste classification was considered and the framework adopted for this research was that of Castelo Branco (2007). Also a number of productivity theories that were developed to combat waste and enhance increased production were analyzed. For example the Just in Time, Total quality control, Continuous improvement, ISO 9001, Lean production.

Aspect of this review discussed waste management issues, such as strategies applied and their related principles. Strategies such as waste minimization plan, was further considered as it related to reducing the cost of waste management. In the final segment the impact of waste on the environment and the attitude of construction labour force were evaluated.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter presents the general approach and specific techniques adopted to address the objectives for the research. It begins with a discussion of the ontological and epistemological underpinnings of quantitative and qualitative research and the arguments for and against combining the two approaches in a single research. The strengths and weaknesses of the two opposing approaches are briefly pointed out and the rationale for combining them in a single study is further explained. The chapter also presents the research design and the methods used in the selection of the research participants and for data collection. How the data was analysed and interpreted are also briefly presented after which issues relating to position and reflexivity are discussed. The chapter concludes with a look at the limitations of the methodology employed in the conduct of the study.

3.1. Research design

Collis and Hussey (2003:60-66), express the opinion that "if research is to be conducted in an efficient manner and make the best of opportunities and resources available, it must be organised. Furthermore, if it is to provide a coherent and logical route to a reliable outcome, it must be conducted systematically using appropriate methods to collect and analyse the data". A survey should be designed in accordance with the following stages:

- **Stage one:** Identify the topic and set some objectives.
- **Stage two:** Pilot a questionnaire to find out what people know and what they see as the important issues.

- **Stage three:** List the areas of information needed and refine the objectives.
- **Stage four:** Review the responses to the pilot.
- **Stage five:** Finalise the objectives.
- **Stage six:** Write the questionnaire.
- **Stage seven:** Re-pilot the questionnaire.
- **Stage eight:** Finalise the questionnaire.
- **Stage nine:** Code the questionnaire.

The survey design to be used in this instance is both the quantitative and qualitative methods.

3.2 Methodological approach

As stated in chapter one, the purpose of this study was to investigate the phenomenon of waste and cost reduction in the road construction industry, using some companies in Accra as a case study. The varied nature of the data required and different sources from which they had to be gathered made the mixed methods approach appropriate. In line with this methodological approach, research tools associated with both quantitative and qualitative approaches were combined to collect the data. These were interviews, questionnaires, field observation and documentary analysis. The choice of the mixed methods approach was informed by a number of reasons.

First, it was meant to achieve the 'logic of triangulation' Denzin (1989:13) since no single method (such as questionnaire, interviewing of documentary analysis) could completely capture all the relevant features of the study. Furthermore, the combination of qualitative and quantitative methods enabled me to crosscheck the data gathered by different methods, thereby, making the results of the study valid and credible. As observed by Bryman (2004:131) "combining different methodologies in a single study enhances the researcher's claim for the validity of his or her conclusions if they can be shown to provide mutual confirmation".

The decision to combine quantitative and qualitative methods in this study can also be justified on the grounds that it made it possible to explore the research questions from different perspectives which would lead to broader understanding of the issues connected with waste and cost reduction in Ghanaian context. Bryman (2004) has argued that while quantitative research is associated with the researcher's perspective, qualitative research is concerned with seeing the object of study through the eyes of the people being studied. Thus, combining qualitative and quantitative methods in the present study made it possible for the issues relating to waste and cost reduction in the Ghanaian context to be captured from the perspectives of key stakeholders in the construction sector as well as from my own perspective.

Furthermore, combining different methods of data collection and analysis provided me with the opportunity to obtain in-depth information from the different categories of participants including construction companies, clients for the service, public institutions involved in waste management in one way or the other and communities. Without this mixed methodological approach, reliance on any single approach to data gathering could lead to loss of valuable information.

3.3 Selecting the construction companies and area of study

Collis and Hussey (2003:56), define a population as “any precisely defined set of people or collection of items which is under consideration”. Collis and Hussey (2003:155-160), define a sample as made up of the members of a population” (the target population), the latter referring to a body of people, or to any other collection of items, under consideration for the research purpose. For this survey, the population is building construction companies.

KAMSAD Construction Company and PMC Constructions were the two companies selected for this study. These companies are SMEs in nature and will relate significantly to the study, especially the idea of reducing cost by employing waste minimisation tools.

Accra which is the first urban agglomeration in Ghana formed the area for this study. I was motivated to focus on Accra because it represented a large city in the Ghanaian context and so provided an opportunity to investigate the problem of waste because of the numerous ongoing road construction projects.

3.4 The research population and sample

For the purpose of the fieldwork, a total of twenty people were interviewed as well as responded to a set of questionnaires. The responded included the Operation Managers, Foremen and Labourers.

Table 4: Sample population

Categories of stakeholders	Actual participants selected for the study
Road construction companies	• PMC • KAMSAD Construction Company Ltd
Officers of the construction companies	• Operation Managers • Foremen • Labourers

Source: Field data 2011

3.5 Sampling Techniques

In order to obtain a representative sample for the study, various sampling techniques were used to select the companies and the respondents for the study. Purposive sampling technique was used to select KAMSAD Construction Company and PMC. This was based on it wide range of employees from different background and also extensiveness of its service provision for a long period of time for the nation. Quota sampling technique was used to assign quota to each of the departments from which the respondents were selected. The respondents were selected through purposive sampling based on their experience on the culture of the organization and work performance.

3.6 Research Instruments

Questionnaires, interviews, observations and question guides were the main tools used in generating the data for this study. Cohen, Manion and Morrison (2000) described questionnaires 'as a widely and useful instrument for collecting survey information, providing structured and often numerical data, being able to be administered without the presence of the researcher and often straightforward to analyze. The questionnaire made use of open-ended and close ended questions. Questionnaires were self administered except in the instance where the employees could read and understand the questions properly. The uses of the questionnaires allow both subjective and objective views of respondents to be sourced. It allows the respondent an ample time to answer the questions. Interviews, allow the researcher to have direct communication with respondents. It gives the respondent to express his/her view freely with the researcher and go the understanding of whatever was not understood. It also served the researcher from spending extra time of following up for questionnaires. With the observation the researcher was able to see and document sensitive things that there is likelihood that the respondents may not like to comment on. The question guide helped in leading to issues that might not be answered if asked directly.

3.7 Methods of data collection

After carefully considering the research questions, the nature of the data needed for the analysis and the prevailing conditions on the research field, it became evident that the best way to collect adequate data for the research would be a combination of the methods of both quantitative and qualitative approaches. This is because some of the data required were qualitative in nature and could best be obtained through interviews while others were quantitative and thus, could be elicited by means of questionnaires.

Furthermore, aspects of the data were physically observable and could be gathered through direct field inspection or observation. There was also a range of published information including newspaper articles and other publications that could yield useful data for the study. In view of this, I became convinced of the usefulness of combining different methods from both qualitative and quantitative approaches in my attempt to gather the data needed for this investigation. The study, therefore, employed interviews, semi-structured questionnaires, field observation and documentary analysis, drawing upon the strengths of these different methods to improve the quality or validity of the data.

3.8 Data analysis

Both quantitative and qualitative data were gathered for the study using questionnaires, interviews, field observation and documentary sources. After cleaning up the data from the household questionnaire survey and correcting the few mistakes that were detected in the filling of the questionnaires, the data were coded and fed into SPSS 14.0. for Windows. Analysis was undertaken to generate a descriptive picture of the data gathered. Simple percentages and means (central tendencies) were used to analyse the quantitative data obtained from the household questionnaire administration.

The qualitative data from interviews conducted with all other categories of respondents were analysed manually by making summaries of the views of the respondents and supporting these with relevant quotations that captured these views, supported with data from documentary sources and my own field observations of the waste situations in the two case-study firms. The analysis (presented in the next chapters) is organised under themes derived from the data and the research questions that guided the entire investigation.

CHAPTER FOUR

ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter aims to display the research results of this study. The researcher interpreted and analyzed data and highlighted certain relation between the results. The quantitative research findings are outlined both in table form and text form. Each result was discussed concisely by the researcher. Certain results were however followed by a more in-depth discussion.

The total number of respondents who participated in this study consisted of forty individuals but collected responses were only twenty. The questionnaires comprised of twenty one and nineteen questions respectively as the researcher aimed to do a thorough research investigation.

4.2 Outline of research result

Two different questionnaires were administered, one for operation managers and the other for site foremen. The research result first considered the result of the operation managers' questionnaires then that of the site foremen.

4.2.1 Enterprise profiles

The two companies selected for this study are KAMSAD Construction and PMC Construction which are both located in Accra. They have a total of ninety nine workers covering different categories. KAMSAD considers its construction works as a labour based whereas PMC describes theirs as equipment based.

Table 4.1: Classification of employees of the companies

Categories of staff	KAMSAD	PMC
Civil Engineer	2	-
Geodetic Engineer	1	3
Surveyor	2	2
Site Foremen	5	2
Administrators	2	2
Labourers	38	40
Total	**50**	**49**

Source: Field data 2011

The table above shows the composition of the workforce of two researched companies. Both companies failed to state the actual required number of workers per each category. The researcher could not ascertain whether the responses gathered reflect industry best practices and benchmarks.

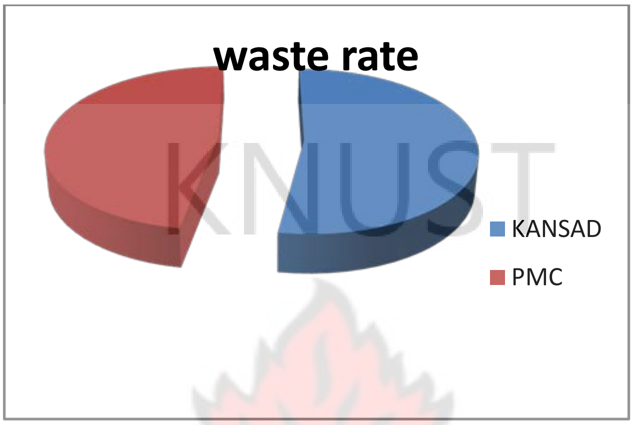
Both companies do not operate site waste management plan (SWMPs) on any of their construction sites. The failure to operate waste management plan means that recycling is not practiced and therefore waste is created without any attempt to curtail it. This obviously affects the cost of projects and may even impact negatively into the profit margin of the firms.

4.2.2 Company practices

1. Waste detection and waste rate

Although both companies don’t have any waste detection mechanisms, they seem to have an idea of their current rates of waste. KAMSAD estimated their waste rate at 10% while PMC valued their waste as 9%. Both firms believe that their acceptable waste rate is 5%.

Figure 2: waste rate



Source: Filed data 2011

The researcher has difficulty in the reliability of this statistics because the firms’ evaluation of their current rate of waste is arbitrary since they have no waste detection mechanism in place. The absence of a clear waste rate and the lack of detection systems indicate the problems of the accuracy of most project costs. It is an accepted practice that certain percentage of the cost is allocated to waste but since there is not system of measuring waste the proposed allocations could either be less than the actual waste produced or could be more than the waste produced.

2. Waste minimization plan

The two firms agreed that more productive work can be done if waste minimization plans are introduced. They also hold they view that the cost of waste during construction is one of the main contributors to an increased project budgets. Project budgets are inflated most often with a percentage of the total cost allocated to waste.

The researcher finds this practice unacceptable, especially when no clear methods of detecting waste exist and calculating the acceptable cost of waste per project is capricious.

Moreover, there is no strategy in place in both firms on how to minimize waste.

3. Cost of Projects and Cost reduction

The respondents acknowledged that many factors are considered before arriving at the cost of a road per kilometer. For example, the location of the project to be executed, the presence of an old road to be demolished or rehabilitation, asphalt or gravel for the surfacing.

According to KAMSAD, constructing one kilometre of asphalt road costs US$ 800,000 but according to PMC constructing the same length of asphalt road costs US$ 1,020,000. Below is a table which provides the components of this cost build up.

Table 4.2: Components of 1km asphalt road

Components of the cost	KAMSAD Labor based US$/KM	PMC Equipment based US$/KM

Surveying		
Clearing and pilling		
Earthwork		
Grading		
Surfacing		
Re-routing traffic		
Total	**800,000**	**1,020,000**

Source: Field data 2011

From the table is can clearly be seen that the difference between the two contracts is 30%. It can be seen that the labour based contract has a lower cost per kilometre as compared to the equipment based contract. This study could not assess the reasons for the differentials in the cost.

The percentage cost of the waste in the above cost build for a kilometre of asphalt road varies, according to KAMSAD the total cost include a five percent allocated for waste, whereas PMC allocated about eight percent to waste.

The result analyzed below is derived from the foremen' questionnaires.

4.2.3 Personal data

Ten questionnaires were administered to foremen from each company. The average age of foremen in KAMSAD is thirty six years (36) and the average year of experience is seven years (7). On the other hand, the average age of foremen in PMC is thirty three years (33) coupled with an average of three years (3) work experience.

Table 4.3: Personal data of labourers

Name of companies	Average age of labourers	Average work experience
KAMSAD	36	7
PMC	33	3

Source: Field data 2011

4.2.4 Company practices

After a careful evaluation of the responses from the questionnaires, the researcher observed similarity in the responses gathered therefore the analysis will not show a comparison between the two firms.

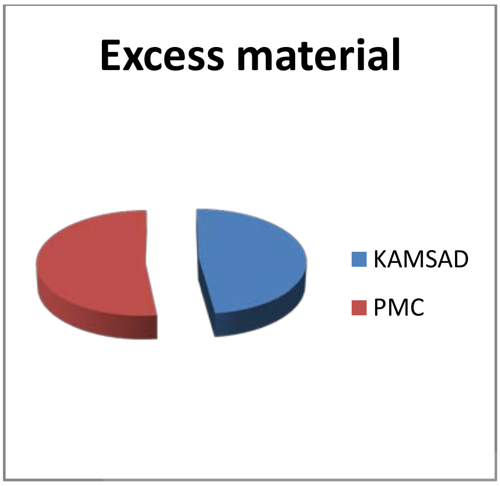
1. **The forms waste take in these firms**

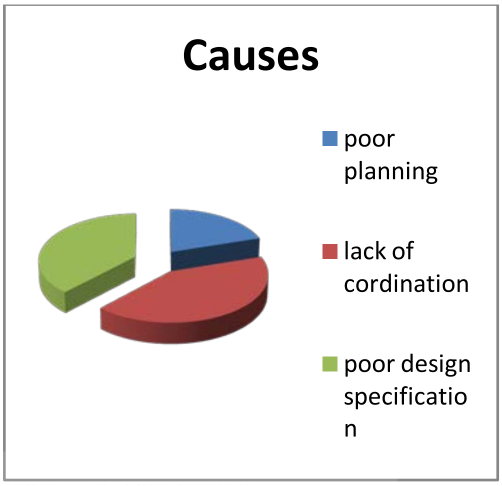
The respondents were asked to identify the three most prevalent forms of waste in their operations. The three recorded waste forms are;

- **Excess material**

Figure 3: excess material

figure 4: Cause of excess material





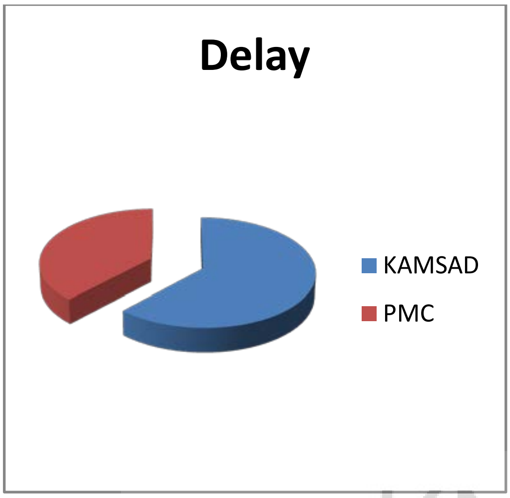
Source: Field data2011

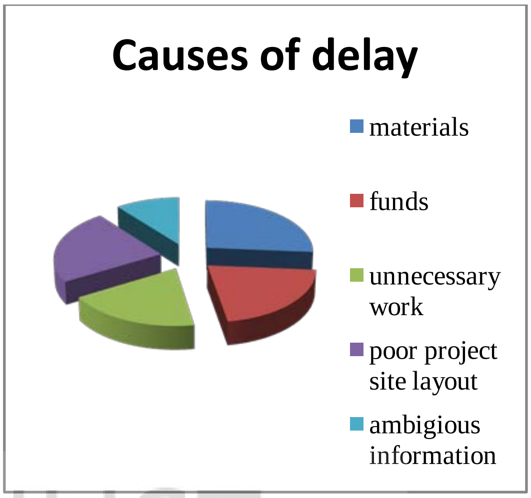
48% of KAMSAD labourers and 52% of PMC believed that waste is generated through excess material. According to the labourer this form of waste is cause by poor planning (20%), lack of coordination between production and the design teams (42%) and poor design specification (38%).

These results show that this form of waste is avoidable if there effective coordination between the various departments in the management team. This form is waste is created due to management's lack of harmony.

- **Delay**

Figure 5: Delay **Figure 6: causes of delay**





Source:Field data 2011

The respondents noted delay as another form of waste they are confronted with. This assertion was noted by 62% of KAMSAD labourers and 38% of PMC labourers. It is not clear to the researcher why the high percentage of KAMSAD labourers held this view as compared to the PMC labourers. One can only infer that the experiences of the companies are varied. While a lot of delay occurs at KAMSAD, less of delay seems to occur at PMC. Figure 6 displays the causes of this form of waste. Each cause was allotted various percentages by the respondents. Particularly;

i. late arrival of materials 20%

ii. The erratic release of fund 25%

iii. Unnecessary work 18%

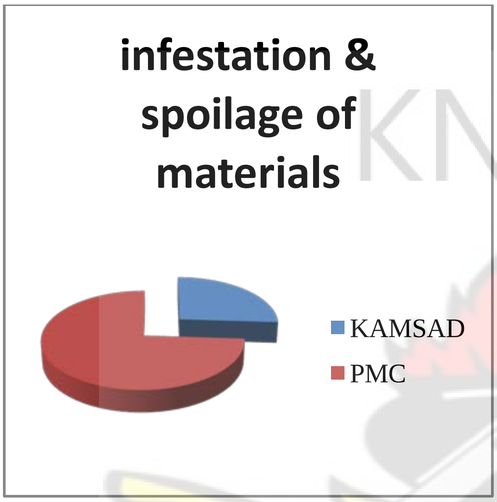
iv. Poor project site layout 22%

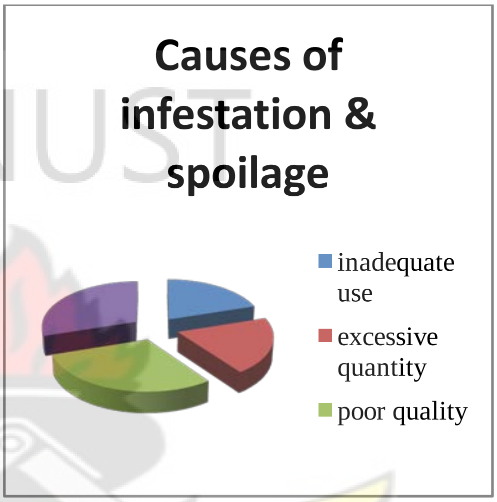
v. Ambiguous information 10%

These acknowledged causes are legitimate in causing delay in an operation. Leading the list is the erratic release of funds. This cause emanates from the customer and not from management. This result shows that the customer or the client of a project can contribute indirectly to waste. The erratic release of waste potentially may lead to the late arrival and supply of materials. This finding confirms a perceived notion that most government contracts are delayed because funds are not release in time and most often are released in pieces thereby increasing the production costs of the contractors.

- **Insects infestation and spoilage of materials (timber/ cement)**

Figure 7: infestation &spoilage of material **figure 8: causes of infestation & spoilage**





Source:Field data 2011

The third form of waste identified by the respondents is infestation and spoilage of materials, especially timber and cements. This claim is made by 26 % of KAMSAD labourers and 74% of PMC labourers. The researcher could not ascertain whether this phenomenon is a continuous occurrence mostly because the causes are preventable.

Various factors were noted for this waste form. The following shows the various factors and their respective percentage allocations.

i. Inadequate use of the materials 20%

ii. Excessive quality 20%

iii. Poor quality 30%

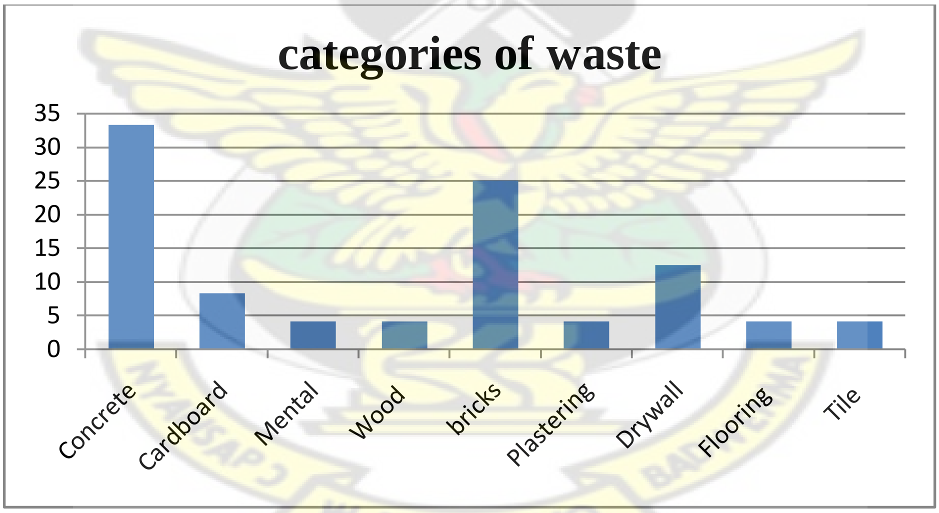
iv. Inadequate storage 30%

As noted earlier, these causes of this waste form are all avoidable or preventable. If this phenomenon of waste is a recurrent issue then the problem comes from management's failure to improve their methods of operation over a period of time. However, the labourers can also be held accountable for their lack of responsibility in complementing the work of management.

2. **Major categories of waste**

The respondents from the two companies acknowledged the following as the categories of waste they generate. The table (8) indicates the aggregate percentages of the various waste categories.

Figure 9: categories of waste



Source:Field data 2011

From this diagram the waste categories that were mostly represented were concrete and masonry (33.3%), cardboard (8.3%), mental (4.7%), wood (4.0%), brick (25.0%), plastering (4.0%), drywall (13%), flooring (4.0%) and tile (4.0%).

The various categories of waste noted here are consistent with the industry. As observed from the table the three most prevalent waste categories are, leading the list is concrete, followed by bricks which is caused by faulty design or breakage due to low quality and drywall which arises from faulty erections.

3. **Waste rate detection**

   All the foremen noted that they have no mechanism in place by management to determine the rate waste. This assertion corroborated the claim of the operation managers. These two companies can identify waste but cannot measure the rate due to a lack of a mechanism. The lack of mechanism is also caused by the companies' lack of interest or ignorance of the existence of the mechanism or system.

Table 4.4: waste rate detection

Question : Does your company have a system of determining the rate of waste			
KAMSAD		PMC	
Yes	No	Yes	No
-	10	-	10

Source: Field data 2011

4. **Current rate of waste**

   There was significant disparity in the percentage of the current rate of waste. However, an average percentage is 6%. Additionally, the foremen differ in the percentage of waste their companies consider acceptable. The average figure is 5%. This disparity is because these companies do not have a formal and known acceptable rate of waste.

Table 4.5: current rate of waste

Variable	Aggregate	Average
What is the company's current rate of waste	13%	6.5%

Source: Field data 2011

5. **Waste minimization plan**

All the foremen underscored the need to implement waste minimization plans in their companies. They noted that they would be motivated to reduce waste by the implementation of this program. They also reckon that the program will help improve their performances.

6. **Reuse of waste**

A greater portion (75%) of the foremen believes the waste generated can be reuse. A small number (25%) also disagree. Those that disagree stated the nature of the waste generated as the reason why the waste cannot be reuse. They observed that most of these wastes are mixed or sometimes caked as well as cut in slices. Those that agreed explained that the reuse may be difficult but possible.

Source: Field data 2011

7.**Ways of minimizing or reducing waste**

They listed the following ways of reducing waste;

Table 4.6: ways of minimizing waste

Suggestions	**Companies**	
	KAMSAD %	**PMC %**
➢ Buying qualitative materials	**36**	**64**
➢ Performing to specification	**52**	**48**
➢ Sell the generated waste	**45**	**55**
➢ Proper storage	**60**	**40**
➢ Employ experienced workers	**63**	**37**
➢ Effective supervision	**46**	**54**
➢ Discourage stealing	**51**	**49**

Source: Field data 2011

8.Attitude of workforce towards waste management

This last section assessed the perception of the labourers about the waste management. The significance of this is to measure the difference between perception and reality.

Respondents were asked to grade a statement with a score to express the point of view. The score ranges from 1 to 5, where 1 means strongly agree; 2 means agree; 3 undecided, 4 disagree and 5 means disagree strongly. An aggregate is found for each perception for the purposes of analysis

Table 4.7: perception 1

No.	Variable	Scale					Total
1	Construction companies perform well in the area of construction waste management	**1**	**2**	**3**	**4**	**5**	
	KAMSAD	2	2	2	2	2	**10**
	PMC	1	2	2	4	1	**10**
	Aggregate	**3**	**4**	**4**	**4**	**3**	**20**

Source: Field data 2011

The result above indicates various perceptions without any particular leading perceptions. For example, 3 responded agree strongly that construction companies did well in waste management, while the same number of respondent disagrees strongly with this assertion. The rest of the points are shared by the other scale. This means that there is no clear of perception about the management of waste in the construction industry. In order words, there is a mixed perception.

Table 4.8: perception 2

No.	Variable	Scale					Total
2	Construction companies have a waste management strategies	**1**	**2**	**3**	**4**	**5**	

	KAMSAD	1	4	1	2	2	**10**
	PMC	-	5	1	3	1	**10**
	Aggregate	**1**	**9**	**2**	**5**	**3**	**20**

Source: Field data 2011

The above table demonstrates that most of the respondents (9) agree that construction companies have waste management strategies. This is closely followed respondents (5) who disagree with the assertion. The assertion of the respondents who agree is contrary to the evidence gathered from their own firms. In both firms waste management strategies were no existent. This may mean the labourers knew this from other companies that had these strategies. This may be true especially when most of the labourers are short time workers. Those that disagree may purely be reflecting the position of their firms.

Table 4.9: perception 3

No.	**Variable**	**Scale**					**Total**
3	Cost of waste does not have much effect on project	**1**	**2**	**3**	**4**	**5**	
	KAMSAD	1	3	1	4	1	**10**
	PMC				6	4	**10**
	Aggregate	**1**	**3**	**1**	**10**	**5**	**20**

Source: Field data 2011

From the above table, 10 of the respondents disagreed with the statement. Five of the respondents also strongly disagreed. The inference is that the respondent believed that the cost of waste affect the project. This result confirms the claim made earlier by the operation managers of the two firms.

Table 4.10: perception 4

No.	Variable	Scale					Total
4	Waste management is as important as other functions of construction management.	**1**	**2**	**3**	**4**	**5**	
	KAMSAD	4	3	1	1	1	**10**
	PMC	6	1	1	1	1	**10**
	Aggregate	**10**	**4**	**2**	**2**	**2**	**20**

Source: Field data 2011

A total of 14 respondents strongly agreed with this assertion, that is, waste management is an important function. This result implies some consciousness of waste management among the labourer. The lack of this practice by these firms is the product of unwillingness and not ignorance.

Table 4.11: perception 5

No.	Variable	Scale					Total
5	Attention of waste management in actual practice is not sufficient.	**1**	**2**	**3**	**4**	**5**	
	KAMSAD	2	4	1	2	1	**10**

	PMC	1	5	2	2	-	**10**
	Aggregate	**3**	**9**	**3**	**4**	**1**	**20**

Source: Field data 2011

About 12 respondents agreed with the above claim. In theory there is a believe and understanding of the important of waste management but in practice there is however an unwillingness to practice waste management. It seems to me that lack of motivation accounts for the lack of practice.

Table 4.12: perception 6

No.	**Variable**	**Scale**					**Total**
6	Waste management is worthwhile irrespective of the cost gains.	**1**	**2**	**3**	**4**	**5**	
	KAMSAD	3	3	2	2	-	**10**
	PMC	2	6	-	2	-	**10**
	Aggregate	**5**	**9**	**2**	**4**	**0**	**20**

Source: Field data 2011

Again, 14 respondents favour the above claim.

The perception among the labourers about the practice of waste management is unambiguous. Waste management is construction industry is important and worthwhile. The challenge is the lack of practice. We can infer that this lack of practice results from management lack of motivation for the practice.

CHAPTER FIVE

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter will present a conclusion outlining the main findings as well as possible recommendations for further research. It will focus on proposing practical steps that the government and the entrepreneurs could use to enhance the development of the Ghanaian society.

5.2 Findings from literature review

In line with the objectives of this research, the findings this study from the literature has proven that the construction industry remains an important economic sector that has a vital role to play in ensuring economic development in the formal and informal sectors of the Ghanaian economy. It is commonly acknowledged that a very high level of waste exists in construction. Construction waste reduction has become an important issue to improve the performance of the construction industry in terms of economy, quality and sustainability.

Many countries are experiencing an increase in construction waste, which creates growing tension for authorities, especially as the search for new landfill sites becomes an increasing priority (De Silva & Vithana 2008:188-198). Ekanayaka and Ofori (2000:1-6), explain that construction waste can be divided into three principal categories, namely material, labour and machinery waste. The origin of waste was depicted as coming from all stages of the construction process and is identified throughout the production phase (Keys *et al*, 1994:4).

Various stages of the construction process create physical waste. Owing to complex and difficult construction projects currently undertaken, the constraints of time, resources and performance must be managed effectively. According to Ekanayaka and Ofori (2000:2), economic development has resulted in an increase in volume of construction and demolition activities. This results in serious problems both locally and globally.

Construction waste at project level directly affects the contractor's profit. Waste classification and quantities may vary in type, size, method, material, and location of projects (CSIR 2008:**Online**). Waste weakens the efficiency, effectiveness, value and profitability of construction activities, calling for the need to identify the causes of waste and to control them within reasonable limits (Urio & Brent 2006:20). Waste in construction can culminate as a result of different causes and situations, and construction waste falls into different categories. Castelo Branco (2007:13), divides waste according to the type of resources consumed, according to its nature, and according to its control. According to Urio and Brent (2006:21), the ranking value of the causes of construction waste by project managers, contractors, site representatives and waste management supervisors is explained.

5.3 Finding from data analysis

The data gathered from the questionnaires administered to the two construction companies in Accra reveals several disturbing issues in the construction industry. If the findings of this research are to be extrapolated to the entire local construction industry then there is the need to be awakened.

Several international best practices and benchmarks for dealing with construction waste are non available and non- implemented in these companies. For example;

There are no clear mechanism put in place to detect waste

Officials from the two firms studied admitted it was regrettable that they have no clear guidelines on detecting waste and that having a system to determine waste is important since this will help in minimizing waste as well as discouraging the generation of waste by employees.

There are no system to measure waste

The non existence of waste measurement is an indictment on these companies. This would certainly affect clients because arbitrary measurement of waste has been use in computing costs of projects. On the other hand, the companies themselves are at a risk of loosing part of their profit in cases where the waste generated is more than what was factored in the project cost.

There are no acceptable and approve rate of waste

The lack of industry acceptable rate of waste shows the lack of commitment in dealing with the menace of waste in our society. Even if there is, the lack of monitoring and enforcement by the state agencies has culminated in the current trend of indifference by the industry.

There are no waste minimization plan and strategies

Waste minimization plan is to encourage operators to be conscious of the threat of waste to the society and rise to the challenge by being responsible. The lack of it accentuates the indifference. Moreover, it is not part of the necessary requirement for securing a contract. As a result, no attention is given to waste minimization by both the regulators and industry operators.

The lack of implementing waste management plan on construction sites

Waste management plan defines how waste minimization plan is discharged. Operators must be challenged by best practices of the industry to chart a path of professionalism that will help them gain contracts beyond the shores of Ghana. It is out of order to say that the limitedness or the lack of expansion experienced by most local construction firms can be traced to their non compliance with international best practices.

No recycling and reuse policies

Although the technology for recycling is not fully available and fully operational here in Ghana, the lack of clear policies is regrettable. There is the need for regulators to put guidelines in place and make it a mandatory requirement for securing government contracts. This will gradually influence the attitude of the operators to become more concern of their role in dealing with the waste menace.

There is a total lack of knowledge and understanding of the concept of waste and its implication to cost and profitability among most workers of the firms researched.

5.4 Conclusion and Recommendations

The following conclusions and recommendations result from the data analysis:

Conclusion 1: 82% of the workforces agreed that waste management is worthwhile irrespective of cost. However, the behaviour of the construction workforce in the actual workplace indicates a lack of a positive attitude and behaviour towards waste minimization. This lack of practice of waste management principles was found to be caused by other priorities during pre and post-construction stages, such as profit, time, cost, etc.

Recommendation 1: Waste can only be reduced once all employees and contractors are fully aware of the extent of the problem in the company. Each construction employee must be trained on waste management. This training may include for example waste management induction training to reinforce the importance of waste minimization practices. Adequate communication strategies from the top to the bottom levels of organizations, the use of reliable practices (work studies) to establish waste allowances and the introduction of incentives for better waste management practices would help to develop and implement waste management applications in the construction industry and thereby improve their performance.

Conclusion 2: A number of causes were identified as the major causes of most types of waste.

Recommendation 2: Implement a waste management plan to address the identified causes of waste. It is critical that the first efforts be met with success; otherwise employees will be discouraged and lose motivation and enthusiasm for this initiative. Secondly, a waste Quality

Control Plan (QCP) can be implemented by main contractors to define the activities required for waste management.

The following key elements are essential for the success of the waste management plan implementation:

- Train all employees on the Waste Management Plan.
- Ensure appropriate and adequate container placement.
- Identify the reporting procedure.
- Identify the procedure for correcting any disposal errors.
- Recognition strategies for employees and their sites that meet their goals.
- Strategies for continued visibility and awareness.

The objective of the implementation plan is to get the word out about the waste management plan by making exciting communication channels available which can include (but is not limited to) the following:

- Newsletters.
- E-mails.
- Management meetings.
- Bulletin boards.
- Pay slip inserts.

The preparation of a waste management plan at the early stages of a project is essential to facilitate suitable arrangements for proper management of waste and a sequence of operations to sort and segregate materials. Transportation associated with the movement of materials and waste should also be considered.

Deconstruction and salvage opportunities must be identified for the most critical materials. Re-cycling of materials is essential. Bricks and other materials will be purchased and stored on site, palletized and the waste must be re-used or re-sold as a product to outside sources. Prior to starting construction, a listing of quantities and types of materials that will be generated on site, must be formulated by site management.

Conclusion 3: Government's lack of supervision and monitoring of these companies is a reason for their non-compliance to international best practices and standards.

Recommendation 3: Each contractor must be clearly notified of their duties and responsibilities in respect to waste management. This must be incorporated into their contractual obligations. Sites need to present a waste totals to date on a monthly basis. On-site supervision of the waste management plan must be examined frequently.

Management must be made to show budget it has allocated to waste management and be actively involved in the program to ensure its success. Regular waste management audits must be conducted to ensure that corrective actions bring about waste reduction. A tracking system should indicate the success or failures of corrective actions.

5.5 Recommendations for future studies

1. **JIT productivity and ISO 9001 for construction industry development**

This research will examine compliance to these practices in the industry in Ghana and set the tone for clear regulations regarding the adherence to best practices in Ghana.

2. **A comparison of attitudes between Ghanaian construction companies and foreign construction companies in Ghana in relation to waste.**

This research will examine perceptions and attitude in both types of companies and which ones have the best attitudes and how it impact the productivity and profitability

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APPENDIX I

QUESTIONNAIRE

FOR THE ROAD CONSTRUCTION INDUSTRY

EXAMINING THE FACTORS OF WASTE AND COST MANAGEMENT- A CASE STUDY OF THE ROAD CONSTRUCTION INDUSTRY

Dear respondent, thank you for taking the time to complete this questionnaire; your co-operation is appreciated. Please ensure that you read the following before answering the questionnaire:

INSTRUCTIONS

• Please do not leave out any questions. If you have difficulty understanding questions please ask the researcher or volunteer for assistance.

• Please answer questions honestly. Even if your answers are negative in nature, this survey will only be able to assist the entrepreneurs and the government if you are upfront and forthright with your answers.

• Questionnaires should be administered by the researcher or volunteers.

SECTION A –PERSONAL DATA

1. **State your age:**	2. **Gender:** M ☐ F ☐
3. **State your position:**	4. **Educational Background** Graduate (MBA/MSC/MPHIL) ☐ Undergraduate (BA/BSC/BBA ☐ Diploma ☐ Senior high Certificate ☐ Junior high Certificate ☐ Vocational training ☐

Section B – ENTERPRISE PROFILE

5. State the name of your Company : ____

____

6. what is the company's labour force: [ ]

7. what categories of staff work in your company/ (eg. Engineers, labourers ,etc)

Categories of staff	Number employed	Number required

8. Does your company operate SWMPs (site waste management plan) on all their sites?
   Yes [ ] No [ ]
9. Can you describe the nature of your SWMPs

____
____
____
____

Section C – COMPANY'S PRACTICES

10. What are the success or inhibiting factors of SWMPs in your company

Success factors	Inhibiting factors

11. Does your company have a waste detection mechanism? __________
12. Can you describe the mechanism briefly

____
____
____
____

13. What is the company’s current rate of waste? ____________________

14. What is the acceptable waste rate by product of construction in your opinion ________
Comment
____
____
____
____

15. In your opinion would there be less productive work done if/when a waste minimization plan is introduced. (eg. Will it lengthen the contract program?) ________
Comment
____
____
____
____

16. Do you believe the amount of unnecessary waste during construction is one of the main contributors to an increased project budgets? ________ Comment.
____
____
____

17. How would you describe your construction works? Labour based { } Equipment based { }

18. How much does it cost to construct 1km of road
Labour based ____________________ Equipment based ____________________

19. What are the components of this cost?

Labour based roads	Equipment based roads

20. Can the amount be reduced if waste minimization plan is introduced? Yes { } No { }

21. What is the percentage cost of waste in this cost build-up? ____________________

APPENDIX II

QUESTIONNAIRE

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• Questionnaires should be administered by the researcher or volunteers.

SECTION A – PERSONAL DATA

1. Name of company ……………………………………………………………………………….
2. Designation of officer: ……………………………………..………………………………...
3. Gender of the officer:……………………………………………………………………..........
4. Age of the officer:…………………………………………………………………………….
5. How long have you worked with the company……………………………….........................
6. How many labourers do you supervise……………………………………………………….

SECTION B – COMPANY PRACTICES

7. What form(s) does waste take at your sites

____
____
____

8. Do you have a system to detect waste? Yes { } No { }
   Can you describe the system if there any?

____
____
____

9. What is the company's current rate of waste? [ ]

10. What % do you consider acceptable? [ ]

11. In your opinion will you get less productive work achieved in a day if a waste minimization plan is introduced? Yes { } No { } explain below

____
____
____

12. Would you feel better about your company and become more motivated about the work you do if waste minimization plan is introduced? Yes { } No { } explain

____
____
____

13. Do think the waste you generate can be reuse on site? Yes { } No { } explain

____
____
____

14. Can you suggest ways of minimizing or reducing waste?

1.	3.
2.	4.

15. How would you describe your construction works? Labour based { } Equipment based { }
16. Do you know how much it cost to construct a Km of road in your company? Yes { }

No { } if yes how much

17. Do consider the price of constructing a 1km of road in your company fair? Yes{ }
No { } explain

18. Do you think waste contributes to the cost of construction? Yes { }
No { } if yes what is the % cost of waste in your opinion?

19. How do you think the cost of construction can be reduced?