UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

STRATEGIES FOR MINIMISING REWORK IN THE BUILDING CONSTRUCTION INDUSTRY IN GHANA

DA-COSTA ADOMAH

JULY, 2016

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

STRATEGIES FOR MINIMISING REWORK IN THE BUILDING CONSTRUCTION INDUSTRY IN GHANA

DA-COSTA ADOMAH

(8131760011)

A Dissertation in the Department of CONSTRUCTION AND WOOD TECHNOLOGY EDUCATION, Faculty of TECHNICAL EDUCATION, submitted to the School of Graduate Studies, University of Education, Winneba in partial fulfilment of the requirements for the award of Master of Philosophy (Construction Technology) degree.

JULY, 2016

DECLARATION

STUDENT'S DECLARATION

I, Da-Costa Adomah declare that this Dissertation, with the exception of quotations and references contained in the published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE…………………………………………

DATE…………………………………………………..

SUPERVISOR'S DECLARATION

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

NAME: **DR. NONGIBA A. KHENI**

SIGNATURE……………………………………………..

DATE……………………………………………….…….

ACKNOWLEDGEMENT

Unto the Lord be the glory for great things He has done. I am most grateful to the Almighty God for the knowledge, strength (physical and spiritual), wisdom and also being the lifter of head throughout my educational levels.

My special thanks go to my supervisor Dr. Nongiba A. Kheni who spent his precious time and energy to read over this project work with useful suggestions, constructive criticisms, guidance and above all, his words of encouragement given to me during my thesis writing.

I also wish to render my heart-felt gratitude to Maame Serwaa of University of Education, Winneba-Kumasi campus for her real motherly love shown to me throughout my education in this University and it is my fervent prayer that, the Almighty God will open the windows of heaven and lift her above mountains to the sky.

My sincere thanks also go to my parents; Opanin Atta Kwadwo Kyeremeh (the late) and Maame Afia Kra. Mention must be made of spiritual fathers like the principal of Cape Coast Technical Institute Mr. Albert Adusei and Pastor Emmanuel Ganchie as well as Charles Boateng, a brother from different womb for their unflinching support and assistance.

Great appreciation is also given to all the lecturers at University of Education Winneba-Kumasi Campus especially Dr. S.J Mutchual for their rich fountain of knowledge imparted to me during the course. I pray that, the Lord Almighty God should replenish all the strength and energy lost.

There is a saying that, “to every successful man, there is a good woman” so l wish to express my profound gratitude to my better half, Mercy Akua Kumi and my lovely

daughters Eunice Adoma Kyerekua (Maame) and Julia Adoma Kyeremaa (Lady) for their prayers, materials and financial support, advice and encouragement in times of storms during my two years period of my study. Finally, to all and sundry whose contributions went unnoticed, I say God richly bless you all.

DEDICATION

This research work is dedicated to Adomahs family for their endless support.

TABLE OF CONTENTS

CONTENT **PAGE**

LIST OF TABLES

TABLE **PAGE**

LIST OF FIGURES

FIGURE **PAGE**

ABSTRACT

Rework is an endemic problem in building construction projects and it is an area of research that has received limited attention. Recent research has shown that rework is the primary cause of time and schedule overruns in projects and that rework levels do not significantly differ between current procurement methods despite calls from government for the use of more integrated procurement approaches such as design-and-construct to improve project performance. The study adopted a quantitative research approach involving the administration of survey questionnaires to a simple random sample of 89 architects.The findings revealed eight key factors underlying rework on construction sites. The factors included; high employee turnover and unrealistic schedules, lack of experience and knowledge of design and of the construction process, re-construction due to quality failures, pressure for early completion, on site correction of errors in design, lack of design coordination and integration, inadequacies in contract documentation and client initiated changes in design and execution. Further findings of the study revealed four key effects of rework in construction industry in Ghana as including; increased expenses of labour wages and pay, increased expenditure on building materials, increased time to construct the project and/or correct errors and increased total cost of project. Also, six key strategies for minimizing or preventing rework in the construction industry included; monitoring as the project proceeds, brainstorming in meetings, risk identification, probability analysis, checklist of risk factors and deducing from past experience. Key challenges to minimising or preventing rework included; carelessness of workers, uncertainty about design changes from client, adverse behaviour of some workers, and difficulty in supervision and unclear specification and recruitment problems

in getting the right calibre of workers. Based on the findings, the study recommends that Architects should review newly released working drawings in order to prevent any field inconsistency prior to construction, intensify supervision during the execution stage of the project, liaise with the contractor during recruitment of personnel for the project and there is the need for consensus on a workable mechanism to bring together the client, consultant and the contractor to minimize change orders and introduction of additional works during construction phase.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Construction projects are multi-phased and often involve the synthesis of several ideas and constructs to achieve success in projects. Moreover, effective coordination frameworks and efficient arrangements for information and communication, adequate understanding of the design principles and construction methods by various team players are essential for project success (Love & Smith, 2003; Love et al. 2004).

From this perspective, Aramo-Immonen and Vanharanta (2009) perceive construction projects within the principle of system thinking and maintain that each project phase, which is implemented either simultaneously or sequentially, forms part of a complete system. As a consequence, a defect in any single phase is likely to affect the success of other sections of the project (Howick, 2003). For example, a defect in project design affects the stability of the entire project, as well as the satisfaction of the stakeholders, whose interests also form a major component of the systems perspective of construction. Thus, from the perspective of information symmetry theory, Ceric (2012) asserts that incompleteness of information on the part of any stakeholder in the construction project could lead to poor coordination and eventually, to rework on the project. Ceric (2012) affirms that, in the absence of coordination and thorough understanding of the project design by stakeholders, information asymmetries occur which lead to misinterpretation, implementation error and the need to rework on some sections or the entire project.

Love (2002) maintains that while changes in construction projects may be seen as inevitable, in some perspective, rework is often used to characterise unnecessary redoing/ rectifying efforts of incorrectly implemented processes or activities, which could have been avoided. Therefore, rework in construction can be conceptualised as the need to do work more than once, or to remove and replace work previously installed. On the contrary, Warhoe and Glammalvo (2009) conceive of construction changes as the same as rework, but Love et al. (2004) argue that the general distinction between change and rework in construction lies in the idea that change is unavoidable and uncontrollable, whereas rework can be controlled and eliminated. Thus, Love et al. (2004) often use the concept of rework in connection with wastage, since the factors leading to rework could have been avoided, along with all costs incurred during the rework.

Following this, Diekmann and Nelson (1985) indicate that changes and in essence, rework during construction is underscored by design or construction changes, errors and omissions, unanticipated field conditions, as well as design deficiencies. However, Warhoe and Giammalvo (2009) maintain that several other causes of rework in construction exist which may not easily fit into the broad classifications, and they include changes in contract options, administrative changes, new laws and regulations, currency re-evaluation, unresolved claims and changes in value engineering. Kaminietzky (1991) is however, of the opinion that human errors are the leading causes of defects and rework in construction projects, and thus, Atkinson (1999), as well as Love and Josephson (2004), therefore, emphasise the importance of controlling errors which result from factors, such as poor knowledge or low level of awareness of various phases of the project, excessive workload, excessive budget cuts, and pressure for early completion.

Several studies rationalise the importance of controlling the underlying causes of rework in construction on the basis that rework adversely influences, costs, time and satisfaction of stakeholders (Fayek et al. 2003). In other studies, the impacts of rework on construction projects have been classified as direct and indirect. The direct impacts of rework on project management construction, identified by Barber et al. (2000b), Love and Li (2000), as well as several other studies, such as Egan (1998), Kumaraswanny and Chan (1998), and Planeeswaran et al. (2006) include additional time, costs, materials and labour for rework and related extensions of supervision and manpower.

In terms of costs, Barber et al. (2000a) indicate that rework can increase the cost of projects as high as 25 percent, in the UK. Josephson et al. (2002) also found that the contract value of construction projects in Sweden can increase between 2.3 percent and 9.3 percent. Similarly, Rhodes and Smallwood (2003) found that in South Africa, the cost of rework could be as high as 13 percent of the project value. These percentages can be in thousands or millions in terms of real currency value. For example, in Hong Kong, Cheung and Chau (2005) found that the direct cost overrun of a $60 million project was 16.1 percent and the indirect cost was 4.8 percent which together amounted to over $12 million. The time overrun in construction projects in seven constructions which were due in 277 days was 480 days due to rework. In other study, the time overrun for a 24 month project was an additional two months and additional cost of 2.5 percent of the original value of $290 million dollars (Palaneeswaran, 2006).

Similar incidents have been reported by several studies globally, and thus, it is common knowledge that uncontrolled rework and wastages affect project success (Acharya et al, 2006). Studies have, however, shown that reduction of such damaging items can be targeted by effective management of design (Rounce 1998; Acharya et al. 2006; Palaneeswaran et al. 2007) and construction (Love et al. 1999; Fayek et al. 2003), which can ultimately yield sustainable whole-life values including stakeholder satisfaction. Intangible costs of rework identified by Palaneeswaran et al. (2007) have included adverse effects pertaining to stress, motivation, and relationships with clients, as well reputation in the industry.

In accordance with the effects of construction rework, Zack (2013) maintains that the common strategies to reduce construction rework include early and continuous involvement of stakeholder, finalising and immunising all designs to future changes, providing accurate information to all stakeholders, using Building Information Modelling (BIM) and Virtual Design and Construction (VDC) to simulate the designs for review before the implantation stages, and requesting for delivery of an implemented BIM model at project completion.

In Ghana, Frimpong et al. (2003) observed that 70 percent projects in Ghana were delayed due to costs overrun related to rework. According to Assah-Kissiedu et al.

(2010), one major cause of rework on construction projects in Ghana results from oral instruction and undocumented instructions, with high tendency of misinterpretation, thus leading to human errors in the project implementation. Fugar and Agyakwah-Baah (2010) also found that rework is an underlying cause of avoidable time and cost overrun. This study therefore aims to close the literary gap in rework in construction industry in Ghana and also devise strategies to reduce rework and associated time and overrun costs in Ghana‟s construction sector.

1.2 Statement of the Problem

The global history of the construction industry is full of projects that were completed with significant time and cost overruns resulting from rework on projects (Fayek et al., 2003). The extra costs and time which are allotted to rework on projects, according to Love et al. (2004), are avoidable and thus, there is every justification to find strategies that can reduce or eliminate rework in constructions projects. Although, literature holds several documented strategies to reduce rework in construction, rework remains a major issue in the global construction industry, mainly due to human errors (Zack, 2013).

In Ghana, Frimpong et al. (2003) found in a study that70 percent of all construction overruns cost and times are attributed to errors resulting in rework. However, most of the construction overruns costs and times resulting from rework are not estimated, and as such the total effect of rework on the construction industry in Ghana is not readily known. Similarly, most of the studies on the construction industry in Ghana neither make reference to rework as a problem in the construction industry nor provide in depth discussion on causes, effect and strategies to reduce construction rework in the Ghanaian industry. The aforementioned arguments underscore the need to research into rework to fill this gap in the extant literature. This study therefore aims to explore the adverse effects of and key factors that lead to rework and to develop strategies to minimise the occurrence of rework in construction projects in Ghana.

1.3 Aim and Specific Objectives of the Study

The aim of this study is to examine factors associated with the occurrence of rework in construction projects and to develop a framework for minimising it. The specific objectives of the research are as follows:

- to examine the factors underlying rework in the construction industry in Ghana;
- to assess the effects of rework in the construction industry in Ghana;
- to identify key rework reduction strategies in the construction industry and
- to identify challenges in minimising rework on projects site.

1.4 Research Questions

The following research questions will be answered by the study:

- What factors account for rework in the construction industry in Ghana?
- What are the effects of rework in the construction industry in Ghana?
- What is the various rework reduction strategies used in the construction industry?
- What are the various challenges confronting the construction firms in reducing rework on their projects?

1.5 Significance of the Study

The underlying significance for this study is that, the results could provide a better understanding of the causes and effects of rework in the construction industry in Ghana. It could also form the basis for devising and testing appropriate strategies for the elimination and/or reduction of rework and its associated adverse effects on the construction industry. Specifically, this study will assess direct and indirect effects of construction rework and that instigate tailored strategies that can help to control direct and indirect effects on rework in construction. The existing challenges in controlling rework in construction projects will also be examined and the awareness of these challenges could be a major step in overcoming them.

1.6 Limitation and Delimitation

1.6.1 Delimitations of the Study

Although there are several researchable areas on construction, the study focuses on only strategies for minimising rework in construction industry in Ghana. Geographically, the study only covers architectural consultancy firms in Ghana. The conceptual and theoretical discussions are limited to rework in construction, construction hazards and changes, construction costs and time overruns, and strategies in preventing rework in construction.

1.6.2 Limitation

Every research work is saddled with constraints and this study is not exceptional. The study was constrained by time, money, getting vital information from departments and also getting research topic and so on.

1.7 Organisation of the Thesis

The thesis is sectioned as follows: Chapter one concentrated on the general introduction of the research. Key areas that were addressed included background to the study, statement of the research problem, aim and specific objectives of the study, research questions, significance of the research, limitation and delimitation of the research. Chapter Two reviews theories and concepts, which are related to the study. It presents theoretical and empirical perspectives of rework in the construction industry. The conceptual framework that guides the study is also discussed in the second chapter. Chapter Three focuses on the research methodology, and describes the study organisations, study population and sampling, as well as the data collection and analysis. Chapter Four presents the findings. Chapter Five discusses the results of the study and Chapter Six highlights the summary of the major findings, conclusions and recommendations.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter discusses the theories that are related to rework in the construction industry. The chapter also reviews the differences in the concepts and definitions of rework, the factors leading to rework in the construction industry, the effects of rework and rework reduction strategies in the construction sector. A conceptual framework, which unifies the theories and concepts is discussed and diagrammatically presented to conclude the chapter.

2.2 Theoretical Review

This section proposes a theory that rework occurs because the principal (client) and the agent (contractors) are not often well-informed about each other"s motives and priorities. This information imbalance is referred to as information asymmetry in this section. Thus, the major concerns of this section is that the client entrusts the contractor with a job but it often happens that the client"s perspectives or desires are not implemented because of incompleteness of information or misinterpretation of the contract document.

In terms of the agency theory Jesen and Meckiling (1976) described an agency relationship as "a contract under which one or more persons (the principal(s) engage another person (the agent) to perform a service on their behalf which involves delegating some decision making authority to the agent." The principal-agent relationship is established generally because the agent often possesses a greater or abundance of the needed skills, abilities, and or time to undertake the desired activities. In executing a construction project, within the principal-agent relationship, the agent must choose actions that have either good or bad consequences for both the principal and the agent.

Klimczak (2005) therefore indicates that the agency theory, thus, focuses on the efficiency of contracts between principals and agents, who often pursue different set of goals. According to Ross (1973), the goal of the principal is to secure provision of some product or service, whereas the agent"s preoccupation is to employ some delegated authority to supply the products or services required by the principal. Inherent in the agency theory is a goal conflict between the principal and the agent which results from information asymmetry, as well as profit maximisation and risk-aversion orientation of both parties.

According to Ashworth (2001), information asymmetry represents an information gap which occurs when the principal and the agent have knowledge of different things pertaining to the contract. Wooten (2003) elaborates that in general, principal-agent relationships are undermined by some level of information asymmetry, which creates uncertainty related to the level of an agent"s knowledge, skills and abilities. It also creates some uncertainty about whether the agent"s action will lead to expected outputs and whether or not the agent is acting in the principal"s best interest. This uncertainty, according to Yukon (2010), is the result of knowledge differentials which occur when the agent has knowledge not possessed by the principal about the building project. The principal and the agent, therefore, act on the basis of the knowledge they are privy to. Thus, information asymmetry results in an information gap between the principal and the agent that can encourage deception, misinterpretation, and moral hazard.

The agency theory emphasises principal-agent collaboration such that the principal can verify the activities of the agent (Eisenhardt, 1989). Eisenhardt (1989) discusses the assumptions of the theory and raises the issue of principals learning about the agents when there is a long term relationship, or when there is less need for outcome-based contracts. The theory therefore supports adopting a contractual system where the principal can check and verify implementation processes adopted by the agent.

Another means of guarding against construction rework, in terms of the agency theory is through bonding. Bonding, in this context, refers to voluntary and contractual self-constraints, which are placed on the agent‟s discretion (Adams, 1994). Yukon (2010) explains that bonding may also be termed "sanctions" or "punishment", which indicates a situation where the agent limits its actions to fulfilling the principal‟s ends. In the case where the agent strays or forfeits the bond, it suffers a contractual penalty, a civil liability, or face criminal charges (Yukon, 2010). Thus, the agency theory establishes that effective monitoring and legal sanctions placed on the agent mitigates the occurrence of moral hazard that can be manifested in the form of corruption, misappropriation of funds, and procurement fraud.

The problem with monitoring and bonding, however, lies in the theory"s assumption that "actions and efforts are normally unverifiable, while outcomes are generally known and confirmable" (Dixit, 2002). In terms of construction, the theory suggests that the effort of the contractor is only verified when the project is being implemented, although the actions, such as planning, hiring and staffing, and procurement that led to the project, may not be readily verified by the stakeholders. Moreover, the verification processes often involve monitoring costs, which take the form of agency costs for both parties (Jensen & Meckling, 1976). "According to Jensen and Meckling (1976), agency costs consist of monitoring costs by the principal, bonding/sanctioning expenditures by the agent and residual loss". Monitoring costs, on the other hand, refer to "control mechanisms installed by the principal in order to ensure the agents desired behaviour and to prevent him from moral hazard" (Jensen & Meckling, 1976).

Agency theory acknowledges "residual loss" in any principal-agent relationship, which refers to some residual deviation by the agent from the principal"s interest that cannot be changed or prevented through monitoring or bonding (Yukon, 2010). This occurs as a result of information asymmetry. The information asymmetry theory, thus, stresses that the incompleteness of information on the part of any stakeholder in the construction project could lead to poor coordination and eventually, to rework on the project. For instance, the client may have an intention to change the building plan, which may not be made aware to the contractor. This incompleteness of information can lead to rework on specific sections of the project.

Moreover, the contractor and the client may also not be aware of uncertainties, such as changes in the climate, which may arise in the cause of the project (Chang & Ive, 2007). Information asymmetry may also exist between the contractor and sub-contractors, and also among the various stakeholders, such as the consultant, monitoring teams, workers, and between the government agencies and the project managers (Ceric, 2012). Therefore, within the context of the agency theory, information asymmetry can lead to rework in construction. The information asymmetry theory is that the theory assumes that some signals can be adopted to predict information that has not yet been relayed to the stakeholders (Jager, 2008). For example, the history of contractors can inform the client of their trustworthiness and the quality of their jobs. Thus, the client can select the contractor with more creditability and therefore prevent risk of rework in the process. The critique with this assumption is that signalling does not ensure completeness of information, but may only reduce the risks, to some extent.

2.3 Concept of Rework

According to Fayeket et al. (2003), there are various interpretations of rework in construction management literature, including quality deviations, non-conformance, defects, and quality failures. In this respect, Ashford (1992) defined rework as the process by which an item is made to conform to the original requirement by completion or correction, whereas the Construction Industry Development Agency (CIDA, 1995) also conceptualised rework as doing something at least one extra time due to non-conformance to requirements. Both definitions indicate that a job is considered as rework when a deviation from the construction requirement engenders extra work.

Love et al. (2000) also defined rework as the unnecessary effort of redoing a process or activity that was incorrectly implemented the first time. Josephson et al. (2002) also defined rework as the unnecessary effort of correcting construction error. Thus, rework occurs when efforts that are exerted in changing any phase of the construction process leads to wastage of resources. Similarly, the Construction Industry Institute (CII, 2001) established that rework refers to activities in the field that have to be done more than once in the field, or activities which remove work previously installed as part of the project regardless of source, where no change order has been issued and no change of scope has been identified by the owner. Rogge et al. (2001), however, lump together the issues of change and rework and defined rework as activities in the field that have to be done more than once in the field or activities which remove work previously installed as part of the project.

The aforementioned definitions conceptualise rework as a form of field activity, but the Construction Owners Association of Alberta (COAA, 2001) defined rework in terms of the total direct cost of redoing work in the field regardless of initiating cause. They also state that field rework does not constitute change orders (for new work), off-site fabricator errors, or off-site modular fabrication errors.

The CII (2001) maintains that rework differs from changes in construction. The two concepts are related, but a distinction can be made. They indicate that rework is not synonymous with project scope changes and design changes or errors that do not affect field construction activities. Rework can also be differentiated from additional or missing scope due to designer or constructor errors, although rework covers the cost associated with redoing portions of work that incorporate or interface with additional or missing scope. Thus, the conceptualisation of rework, as either field activity or cost associated with field activity, influence the construction changes that can or cannot be termed as rework. Other changes that cannot be categorised as rework, according to CII (2003), include off-site fabricator errors that are corrected off site, off-site modular fabrication errors that are corrected off site, as well as on-site fabrication errors that do not affect direct field activities.

The differences in the conceptions of rework confirm Love et al.‟s (2004) indication that there has been a lack of uniformity in the way in which rework has been conceptualised. Following this, there is also non-uniformity in the constituents of rework and in the way rework cost data has been collected. They account that terms such as quality deviations (Burati & Farrington, 1987), non-conformances (Abdul-Rahman, 1993), defects (Josephson & Hammarlund, 1999), and quality failures (Barber et al., 2000) are often used, though these definitions vary in scope. Generally, however, rework is not commonly described to include missing scope of work changes and change orders brought about by end users/owners, which are not necessarily considered non-conformance. Rather changes such as these instead stem from a desire to change due to budget constraints or other unrelated circumstances (McDonald, 2013).

For the purpose of this study, rework is conceptualised based on a synthesis of the various literary definitions. Rework is defined as changes in construction, which result from errors and omissions in the various construction phases, leading to deviations from the expected construction quality and schedule requirements, as well as cost overruns. This definition captures the idea of rework from the perspective of field activity and in terms of costs.

2.4 Factors Underlying Rework in the Construction Industry

The Building Research Establishment (BRE, 1982) indicated that rework can occur during different phases of the project life cycle and that errors in building had 50percent of their origin in the design stage and 40percent in the construction stage. O"Conner and Tucker (1986) also identified owner scope change, specification change and design procurement errors that result from poor construction technique or poor construction management processes. Abdul-Rahman"s (1995) study of a highway established that non-conformance and poor management practices as the main causes of rework, which often lead to an overrun cost of five percent of construction costs. Nylen (1996) also confirmed that poor quality management practices used in railway projects led to quality failures, in which quality corrections led to cost overrun of 10percent of the contract value.

In spite of these specific cases, Love and Li (2000) indicate that the general cause of construction rework results from three related concepts, namely, change, errors, and omissions. According to Love and Li (2000), change refers to a directed action altering the currently established requirements; errors are items or activities in a system that is performed incorrectly resulting in a deviation, and omissions are parts of a system including design, construction, and fabrication that have been left out resulting in a deviation.

Love et al. (2002) also indicate that during a project many changes can occur, but changes can be attended or unattended, although both can have positive and negative influences on the project. Attended changes are factored into the construction and predicted, whereas unattended dynamics are not taken into account at the start of the project and might therefore influence the costs of a project. Unattended changes therefore result in uncertainties, which can influence the costs and field construction activities.

Love et al. (2010) noted that these uncertainties can be internal or external.
Internally generated uncertainties have their origin within the project organisation, arising from rules, policies, processes, structures, actions, decisions, behaviours or cultures (Barber, 2005). Love et al. (2004) maintain that internal uncertainties, leading to rework can be project-related, organisation-related, finance-related, interest-related, and human-related. Project-related uncertainties are directly related to the project performance and quality measures that are implemented and expected results. Factors such as location conditions, uncertainties in the contract, uncertain durations for activities, uncertain costs, uncertain technical complexities, and resources availability and limitations directly affect the quality of the project and project requirements.

According to Ceric (2003), multiple forces acting simultaneously create organisational uncertainties. These factors involve the environmental complexity, the wealth of an organisation and the organisational dynamism. Environmental complexity refers to the degree to which an organisation is related the various environmental forces that an organisation deals with, such as suppliers, technology, and customers. Organisation-related uncertainties also arise from the different project stages which require different skills, different contributors and other resources. This refers to the richness or the quality of resources within an organisation"s environment. Project participants vary through the construction process and as such there is the tendency that incongruous processes may be used by the different participants in the project phases. Dynamism on the other hand, refers to the degree of change of the various environmental factors that affect an organisation, such as the availability of raw materials from suppliers.

Finance-related uncertainty explains a company"s financial capability or policies can change (Love et al., 2002). The changed financial status of any party within the project team can affect, or in the extreme even jeopardise the project"s expected outcome. For example, if the client runs out of funds, certain modifications might have to be made to fit within the new budget of the client.

Love et al. (2002) also mention interest-related uncertainties which arise from the interactive constraints and conflicts in interests between disciplines and project participant. This can hinder co-operation in dealing with changes and affect performance, although all project participants may appear to desire realisation of project goals. Human-related uncertainties are generally, more pronounced in rework, as it relates directly to the effectiveness of human resources and possible changes in the competence of human resources.

According to European Commission (2011), the performance by the project management team highly influences the success of a construction project. The EC (2001) also notes that some of the incidental risks associated with poor project management performance, which influence rework include unclear or unattainable project objectives; poor scoping; poor estimation; budget based on incomplete data; contractual problems; insurance problems; delays; quality concerns; and insufficient time for testing.

Love et al. (2009) also make a distinction between internal and external uncertainties that lead to rework. They establish that external uncertainties are originated outside of the project and therefore mostly not controllable. Love et al. (2002) categorised external risk into government-related (regulations, taxes, interest rates), economy-related (inflation, exchange rates, market competition, availability of labour, materials and finance), social (changing social environment, resistances), legal (changes in legislation: safety or planning laws), technological (materials, techniques, labour, facilities, machines), institutional influences (codes of conduct, education regulations), physical conditions (infrastructure, transportation, degree of saturation, district development plans), and acts of God (weather, natural disasters).

According to Miller and Lessard (2001), uncontrollable external risks, such as inflation, natural disasters, government policies, currency exchange rates, and socio-cultural influences can only be forecasted and preparations made to avoid, absorb or transfer their related risks. For example, a forecasted weather change over a period of time could lead to the reinforcement of bunkers to withstand strong weather patterns. Similarly, forecasted high inflationary rates could inform the project on the contingency costs to allocate to the budget.

Love et al. (2009) further emphasise that rework might also occur due to errors, where construction errors are the result of incorrect construction methods and procedures and are human-related. Errors in themselves have causes, some of which are negligence, lack of or bad communication, poor coordination and integration and lack of or inadequacy of skills and training.

The CCOA (2001) devised a framework for analysing the causes of rework in construction, which Fayek et al. (2003) modified (see Figure 2.1). Fayek et al. (2003) categorise the causes of rework in construction under five main themes; labelled human resource capability, leadership and communications, engineering reviews, materials and equipment supply, and construction planning scheduling. These themes conform to the CCOA"s (2001) original fishbone model. According to Fayek et al. (2003), low human resource capacity contribute to rework through unclear instruction to workers, excessive overtime leading to fatigue build up, insufficient skill level, and inadequate supervision.

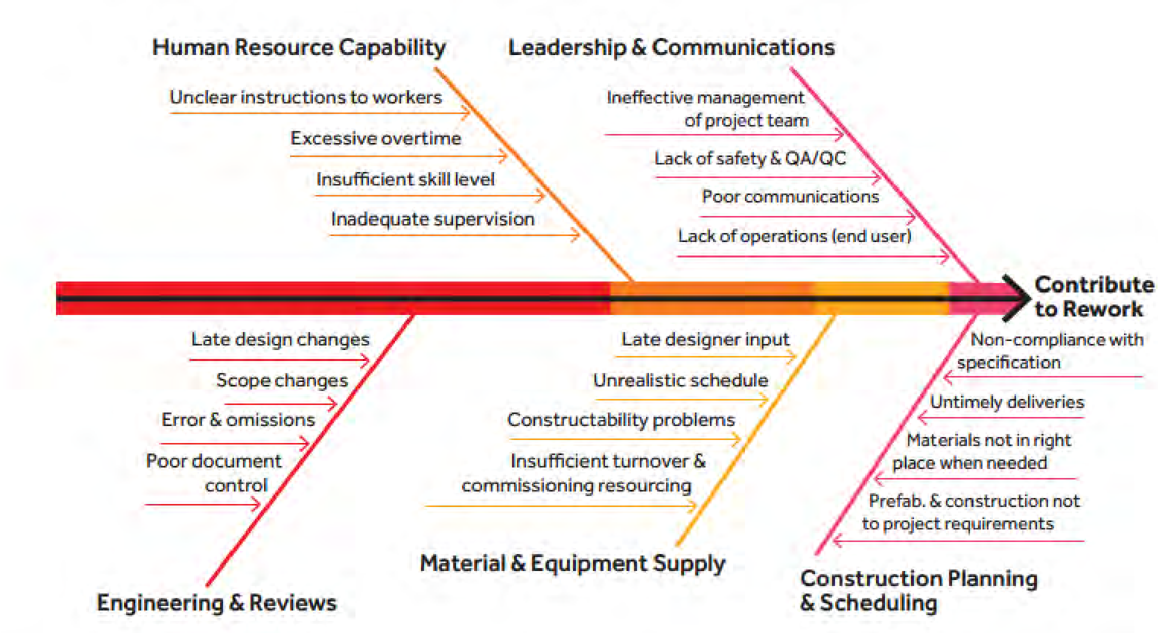


Figure 2.1: Model of the Root Causes of Rework
Source: Fayek et al. (2003)

The model in Figure 2.1 also depicts that three other blocks, including the engineering errors and omissions, problems with the supply of construction materials and equipments, as well as challenges with the planning and scheduling of construction projects amount to rework. Fayek et al. (2003) identified four possible causes of rework due to human resource capability, namely excessive overtime, insufficient skills levels, inadequate supervision and job planning and unclear instructions to workers.

Literature supports most of the assertions made by Fayek et al. (2003). Love et al. (2000), for example, indicated that contract documentation quality may be compromised when a firm submits a low design fee for a project, especially when design tasks are time bound. The authors also found that erroneous documentation contribute to rework under poor engineering reviews, which leads to rework. Lopez et al. (2010) argued that insufficient knowledge simply masks a more complicated problem inherent with design firms.

Poor documentation is underlain by certain factors. For example, Coles (1990) and Rounce (1998) noted that poor workload planning within design organisations can also result in inadequate time to prepare complete design documents. Moreover, Coles (1990) noted that use of inexperienced staff that lack technical knowledge could lead to errors and omissions in contract documentation being made. Tilley and McFallen (2000) also found that unrealistic client demands for earlier completion of projects was a major contributing factor to the production of incomplete and erroneous contract documentation. Love et al. (2010) further argued that lack of professionalism by design professionals due to reduced design fees can further result in inadequate contract documentation leading to rework.

Fayek et al. (2003) deduced their model from earlier works, for example, the Business Roundtable (1982) and found that lack of adequate planning scheduling materials management, quality control, and quality assurance were critical problems during construction. Moreover, Akintoye (1995) found that rework is associated with problems related to production, general quality of work, design changes, material quality and availability and capacity utilisation. Alwi et al. (2001) also stated that inadequate supervision, inexperienced supervisors and lack of skilled labour are the major causes of rework.

Fayek et al. (2003) identified the following possible causes pertaining to leadership and communication as ineffective management of project team, lack of safety and quality assurance and control commitment, poor communication and lack of operation persons‟ buy-in. Poor leadership could also contribute to inappropriate „time boxing‟ practices, a practice which occurs when fixed durations are allocated to undertake tasks, irrespective of how complete (or incomplete) the design documentation or design task is (Love et al., 2008). That is, a fixed period of time may be allocated to complete each task, irrespective of whether the documentation or each individual task is complete or not.

Love et al. (2009) further explained that the underlying contributors of rework due to poor leadership are strategic decisions taken by top management or key decision-makers who stimulate the conditions for the adoption of inappropriate structures, processes, practices and technologies for projects. Several other studies, such as Walker (1994), Jaafari (1996), Love at al. (1999) and Alwi et al. (2001) have asserted that an important issue facing organisations is the inability of supervisors to plan work, communicate with workers, and direct activities adequately.

Lopez et al. (2010), in another study, indicated that design error, adverse behaviour, inadequate training of design consultants and competitive fees, and ineffective utilisation of computer-aided automation are major factors underlying rework. They also included that inadequate quality assurance, ineffective coordination, and poor integration of the design team, resulting from poor reviews contribute to rework in construction.

Sverlinger (1996) also found that severe deviations in construction are often attributable to deficient planning and/or resource allocation, deficient or missing input and changes. Rounce (1998) found that poor management practices contribute to the generation of rework, and they include:

- Jobs not having projected drawing lists to quantify the design workload;
- Jobs not having design programmes based on project drawing lists and therefore specific design deliverables are unable to be identified;
- Difficulty in estimating the physical progress of design;
- Uncertainty in advising other designers/ quantity surveyors (QS)/clients/contractors when information is likely to be available;
- Difficulty in justifying resources required to in-house managers based on actual workload; and
- Lack of specific procedures (non-administrative) generally to control the design process in programme terms.

Love (2002) argued that the occurrence of rework can usually be put down to poor planning or devoting of insufficient time to the planning and design before commencing construction. Josephson et al. (2002) and Hwang et al. (2009) also affirmed that inadequate pre-project planning contributes to rework costs.

Warhoe and Giammalvo (2009) categorised their notion of the causes of rework under design deficiencies, criteria changes, differing site or unforeseen conditions, changes in scope directed by owner and other miscellaneous causes. Warhoe and Giammalvo (2009) indicated that design deficiencies, also known as designer errors and omissions are changes that result from faulty or confusing aspects of construction designs and specifications, attributable to the designer that are only detected well after the construction phase of the project has started.

As opposed to the other types of change, design deficiencies are often the result of ineffective quality control in the design process, and are controllable. The most prevalent explanation for the frequency of designer errors in construction is that clients transfer their finance to designers to complete projects in unreasonable time frame short period with cost cutting measures that encourage error through haste. Fayek et al. (2003) alluded to this explanation when they established that unrealistic time schedules and late designer inputs lead to errors that contribute to rework in construction.

Warhoe and Giammalvo (2009) also attributed rework to criteria changes, which refer to changes in building specifications. They assert that for most projects, clients refer to a specific version of their design or construction standards. However, the clients may revise those standards after the construction has been awarded based on a previous version. Fayek et al. (2003) capture this under their concept of „scope changes", which they classify as a technical factor contributing to rework.

Warhoe and Giammalvo (2009) aligned rework in construction with differing site and unforeseen conditions as the third category of factors underlying rework. Love et al. (2004) classified this under their concept of internal and external uncertainties. In

Warhoe and Giammalvo"s (2009) conceptualisation, they lump both internal and external uncertainties together. They assert that a differing site or unforeseen condition occurs when latent and unanticipated site conditions of a construction project are uncovered after the project execution. The risk is that these latent conditions would not have been included in the contract documentation and thus may not have been budgeted for.

Chang and Ive (2007), however, established that unanticipated site conditions are worth making note of only if the contractor experiences an increased cost and/or delay. For example, a contractor performs earth excavation and uncovers objects or soil types that were previously unforeseen, and require extraordinary measures to accommodate. These extraordinary measures can easily cost the contractor additional money and/or time above that for which they were originally contracted.

Client"s changes in scope are mentioned by Fayek at al. (2003) as a common source of rework. Warhoe and Giammalvo (2009) are of the idea that changes in scope directed by the owner are not the most frequent changes, but they are the most controllable on the part of the owner. These changes represent those in which the customer, the owner, chooses to make changes to the final product after the design has been completed and the contractor has been hired. According to Bramble and Callahan (2000), „most construction contracts give the owner the right to make changes within the general scope of the contract without breaching or invalidating the contract".

Simpeh (2012) identified three distinct categories of thematic factors that influence rework in construction, namely, client-related factors, design related factors, and contractor related factors. Essentially, all these factors are categorised under internal uncertainties by Love et al. (2002). According to Palaneeswara (2006), client-related factors include lack of experience and knowledge of design and of the construction process; lack of funding allocated for site investigation; lack of client involvement in the project; inadequate briefing; poor communication with design consultants (Love et al., 2002); and inadequacies in contract documentation (Fayek et al., 2003).

Design-related factors, in Josephson and Hammarlund"s (1999) opinion, can include lack of design coordination and integration on the part of the design team, which amounts to design deficiencies and exacerbates the causes of rework. This opinion is supported by Fayek et al. (2003) who include the thought that the source of rework in construction is also underlain by communication problems.

Contractor-related factors relate to the ineptness of contractors to properly plan work, communicate with workers and direct activities, which amounts to overrun costs of rework (Faniran et al., 1999). The success of site management team and sub-contractors" project is hinged on the effectiveness of the main contractor"s construction planning efforts (Chan, 1998; Ireland, 1985; Walker, 1994). Cusack (1992) also emphasised that projects without a quality system in place typically experience a 10 percent cost increase because of rework.

Contractors could make setting-out errors, which are errors resulting from the misreading of dimensions on the working drawings and building out of alignment (Josephson & Hammarlund 1999), or they could make errors resulting from excessive workload, multitasking and unwarranted pressures for early completion. These often contribute to increased defects and poor workmanship (Love et al., 1999). Contractors may also fail to provide protection to works. For example, erection of scaffold on floor finishes such as tiling without protection may cause damage leading to rework or failure to protect certain parts of a building during alteration works (Barber et al., 2000). In the case of subcontractors, Love et al. (1999), Josephson et al. (2002), as well as Love and Smith (2003) found specific factors that contributed to rework as inadequate supervision, damage to other trade work due to carelessness, low skill level of construction artisans and labour, and poor choice of materials.

Rounce (1998) indicated that a major source of non-value adding activities, such as rework, in construction projects can be traced back to poor managerial practices of individual firms involved in projects, especially those employed in architectural firms. Similarly, Nesan and Holt (1999) asserted that other stakeholders such as consulting engineers, contractors, and project managers who are integral to the procurement of projects are also prone to the implementation of poor managerial practices. In terms of rework costs, Love et al. (2002) noted that a large portion of rework costs are underlain by the poor skill levels of the client"s project manager as well as the design team and subcontractors.

2.5 Effects of Rework on the Construction Projects

The occurrence of rework clearly has an adverse impact on project performance. Rework can lead to several overruns, and so these overruns indicate that somewhere in the construction process rework might have occurred (Palaneeswaran et al. 2007). Indicators of rework are mentioned below. According to Palaneeswaran (2006), there are several indicators of rework, which differentiate the concept of rework from other changes done in construction. This distinction helps in identifying rework and assessing the real effects of rework.

Love and Li (2000) asserted that rework can be indicated by the time, labour and cost overruns resulting from the changes made in the construction project. For example, if work has been done incorrectly, this can be seen as non-productive time and rework takes effort and thus extra labour. If more hours (and thus more labour costs) were needed to realise a project than estimated, it might have been because of rework actions. Moreover, rework often means that parts of a structure have to be scrapped and new material is needed to rebuild it. It was observed that the factors mentioned above have in common, delayed, extra labour and extra materials and cost overrun, which are seemingly the most important indicators for rework.

Palaneeswaran (2006) maintained that rework has both direct and indirect impact on project performance. Essentially, the indicators of rework, as mentioned by Palaneeswaran (2006) are all direct consequences of rework, and are rather easy to identify if administration has been done properly. Palaneeswaran et al. (2007) also confirmed that the direct impact of rework on project management transactions include additional time to rework, additional costs for covering rework occurrences, additional materials for rework and subsequent wastage handling, and additional labour for rework and related extensions of supervising manpower.

Love (2002) proposed that rework can also seriously affect an individual, an organisation and a project"s performance indirectly. Firstly, Love (2002) maintains that indirect costs of rework are a lot harder, if not impossible to trace. For example, the direct costs of a particular rework consist of the labour costs for the time needed for the rectification and the extra materials that were used. The indirect cost would be the hourly payment for the travelling time and the additional loss of productivity.

According to Burati et al. (1992), rework can have direct effects on the aesthetics and functional aspects of the building, the scope as well as the nature of work, and its operational aspects. Rework adversely impacts construction project performance in terms of cost overruns, time overruns, quality degradation and professional relations. Chan and Kumaraswamy (1997) and Love (2002) also suggested that rework can adversely affect the performance and productivity of design and construction organisations.

2.5.1 Cost Overrun

Cost overrun represents the most direct effect of rework. Avots (1983) defined cost overrun as situations in which the final cost of the project exceeds the original estimates. Azhar et al. (2008) asserted that cost overrun is very frequent within the construction industry. Most of the significant factors affecting project costs are qualitative, such as the client‟s priority on construction time; contractor‟s planning capability, procurement methods, and market conditions, including the level of construction activity (Elchaig et al., 2005). Love (2002), as well as Endut et al. (2005) however, noted that cost overruns are major problems in project development and that rework also leads to potentially high cost increases.

2.5.2 Time overrun

According to Endut et al. (2005) the impact of project time overrun or delays for contractors includes increased costs, reduced profit margin and battered reputation. Furthermore, clients are also affected by additional charges and professional fees and reduced incomes resulting from delayed occupancy. As part of the factors responsible for delays in construction completion, Ng et al. (2001) noted that most contractors assume that duration set by the client is realistic and prepare their bid accordingly. Love (2002) affirmed that the occurrence of rework will invariably result in the contractors re-evaluating their project schedules; as delays have the potential to lead to the incurring of liquidated damages. Depending on the type of delay and how it impacts the critical path, an extension of time or acceleration costs may be awarded.

Scott (1993), Alkass et al. (1995, 1996), Majid and McCaffer (1998), Al-Khalil and Al-Ghafly (1999) have all shown that time overruns occur on the majority of major civil engineering contracts and that this is a most common problem. According to Chan and Kumaraswamy (1997), as well as Palaneeswaran (2006), completing projects within the time is an indication of an efficient construction industry. According to Chan and Kumaraswamy (1998), the ability to estimate the completion time is normally dependent on the intuition, skill and experience of the individual planning engineer. Mezher and Tawil (1998), however, noted that as time overruns in the construction industry cost a great deal of money, there is an undeniable needs to find more effective methods for overcoming rework problems.

2.5.3 Indirect Impacts of Rework on Construction Projects

There are also several more indirect consequences of rework that are a lot harder to express in terms of money or costs. At the individual level, stress, fatigue, absenteeism, de-motivation, and poor morale have been found to be the primary indirect effects of rework (Abdul-Hamid & Madnick, 1991). Love et al. (2000) established that when an individual is subjected to prolonged work hours, errors, changes or omissions, fatigue and stress are likely to emerge, increasing the likelihood of rework occurring.

At the organisation level, Love (2002) identified reduced profit, diminished professional image, inter-organisational conflict, loss of future work and poor morale as indirect effects of rework. At the project level, work inactivity such as waiting time, idle time, travelling time and end-user dissatisfaction were identified as indirect consequences of rework. Love (2002) also identified physiological and psychological consequences associated with undertaking rework. For example, increased stress due to the additional financial burden and the loss of profit, as well as having to re-do something again, can have de-motivating consequences. Love and Edwards (2004) maintained that one of the resultant ripple impacts of rework is damaged reputation and goodwill. Endut et al. (2005) agreed that one impact of project time overrun or delays for contractors is battered reputation.

2.6 Rework Reduction Strategies in the Construction Industry

In construction projects, any occurrence of rework is considered as unnecessary and non-value adding activity that should be avoided or eliminated (Love et al. 1999). Palaneeswaran et al. (2005) noted that inconsistent and non-systematic approaches for monitoring rework occurrence underlay construction failure and rework, because rework impacts on performance and productivity aspects have been somehow resolved by adopting various tactics and measures, such as through contract management, quality management, project management, and value management.

Different strategies, according to Palaneeswaran (2006), have been applied to reduce rework in the construction industry. However, instead of any ad hoc measures, rework reduction or elimination is targeted for enhancing the sustainability of the project and profitability. One of the pertinent strategies is risk management in the supply chain and another involves compensable recoveries from other parties, through contractual claims.

Flanagan and Norman (1993) referred to risk management as a discipline for living with the possibility of adverse effects that may get caused by future events. Brown and Chong (2000) and Skorupka (2003) also conceived of risk management as a group of techniques and actions for decreasing disturbances which may occur during the project life cycle and ensuring the realisation of the project objectives. They assumed the aim of this process at identifying and analysing risks and then applying proper mitigating actions. Uher (2003) also followed that risk management as a systematic way of looking at areas of risk and consciously determining how each should be treated. It is a management tool that aims at identifying sources of risk and uncertainty, determining their impact, and developing appropriate management responses.

A systematic approach to reducing rework is proposed by Palaneeswaran et al. (2003) to include spotting rework items, category mapping, responsible tracking, impact assessment, compensability checking, corrective actions, and recording lessons. According to Palaneeswaran (2006), the main idea of the framework is that rework arises from risks which should be managed through a risk identification process, as in spotting rework items, through quality inspections and routine observations.

Risk identification in rework is characterised by isolating the possible risks by breaking down the risk structure and brainstorming the sources, classification and effects of the risks (Flanagan & Norman, 1993; Maytorena, 2005). Several other surveys conducted among the construction industry (Akintoye & MacLeod, 1997; Uher & Toakley, 1999; Lyons & Skitmore, 2004) show that checklists and brainstorming are mostly used in identification of possible rework risk.

Category mapping in rework reduction process conforms to assessment, classification, and prioritisation of possible rework activities. According to Ozeki (1990) a classification for identifying rework problems may include those related to worker skill and attitude; the workplace quality system; lack of motivation to solve problems; problems in workplace culture; and problems that originate from design, the manufacturer or supplier. Grabel (2010) and Mumtaz et al. (2011) also indicated that the specific techniques could include probability analysis, sensitivity analysis, scenario analysis, simulation analysis, and correlation analysis, whereas qualitative techniques may cover direct judgment, ranking options, comparing options and descriptive analysis. The purpose is to develop taxonomies or rework items.

Responsibility tracking, according to Palaneeswaran (2006) refers to aligning responsibilities to the various parties in the procurement and contractual agreement. Impact assessment, on the other hand, involves time impacts, cost impacts, as well as indirect and direct costs, and whereas, compensability checking involves checking the eligibility such as from client led changes. Corrective actions are tantamount to the risk response strategy identified by the Projects in Controlled Environments (PRINCE, 2009).

Berkeley et al. (1991), Flanagan and Norman (1993) have divided the risk responses to avoidance, reduction, retention and transfer. Figueiredo and Kitson (2009) have further divided the responses into risk avoidance, mitigation, acceptance, research, transfer, and monitoring. Risk avoidance involves changing some aspect of the project so that the threat either cannot have an impact anymore or can no longer happen. However, an inadvisable aversion to risk may result in overlooking opportunities for profits, as risk may be associated with benefit (Loosemore et al., 2006).

Risk reduction is a proactive action taken to either reduce the probability of the event occurring or to reduce the impact of it, whereas fall-back refers to a reactive form of reducing the impact of the threat with no influence on the probability. Transferring risks involves reducing the impact of risks, mostly only the financial impacts, by assigning the risk reduction responsibility to a third party (Zou et al. 2006). In accepting the risk, a conscious decision is taken for retaining the threat, but the risk can be shared within pre-agreed limits, among the stakeholders of the project (Loosemore et al. 2006).

Palaneeswaran (2006) summarised the rework reduction strategies into quality management. Acharya et al. (2006) noted that while totally eliminating errors on a sustained basis is difficult, taking measures to ensure top quality at each discrete step will reduce errors and their cost and impact on businesses. According to Palaneeswaran et al. (2007), methods of achieving source quality fall into two broad categories; early detection and prevention. Early detection in a multi-step process causes less disruption, cost, and impact on schedule than one found several steps down stream. This requires reduction on the reliance on final inspection, because final one-point in time inspection may keep errors from reaching customers, but it does little to prevent them or to reduce the cost of producing good quality.

In „source management" Atkinson (1999) maintained that workers may be required to verify the quality of their own work. The advantage according to Atkinson (1999) is that this approach is cost effective and places responsibility for quality on those performing each step. However, this also requires proper training and tools which could enable workers to detect a large percentage of errors .In spite of the training, self-evaluation may not be objectively conducted and thus, Warhoe and Giammalvo (2009) recommended independent and anonymous peer reviews of others‟ works. The advantage of this method is that there is the possibility to detect errors overlooked during self-checks.

According to Love and Edwards (2004), rework prevention should begin by focusing on change mitigation. Clients cannot always be explicit about their requirements at the project‟s outset because of the many different interests that have to be satisfied. Therefore, a degree of change can be expected in a project (O‟Brien, 1998). Karma (1999), as well as Wyatt and Smith (2000) indicated that clients should freeze the scope of their project as early as possible to minimise the risk of cost and schedule increases. This decision should be underlain by an effective project scoping strategy based upon a strategic needs analysis and quality function deployment (QFD).

Love (2010) has also shown that design scope freezing, value management, constructability analysis, and teambuilding are key strategies for reducing rework, particularly design-related changes. However, the author further cautions that design scope freezing can also increase change if the scoping process has been ineffectively undertaken. Dell‟Isola (1997) states that value management should be performed as early as possible in the project development process if management seek to curtail the investment that is required to implement a change. Value management study is ideally undertaken with the entire project team, including the contractors and relevant subcontractors so as to improve project constructability and reduce the potential for change.

Design is an iterative process and therefore design changes are inevitable, if a realistic solution to a problem is to be developed. Fundamentally, the creative leap is more a process of building a bridging concept between the problem and the solution (Lawson, 1997). To find an acceptable design solution requires a team-based approach to problem solving (Miller, 1993; Sonnenwald, 1996). Once the solution is identified a design team will invariably try to make it work, especially if members have some form of input into the design process (Akin, 1986). This is, however, contrary to the conventional-based approach, where an architect identifies several possible solutions and each is evaluated and refined until a proposed solution is considered acceptable (March,1976).

The challenge is that the process of interactive design can be time-consuming and frustrating for some clients, especially those who are inexperienced, as many are unable to define their specific requirements. Simply understanding the client‟s problem and translating such into a design that can be effectively documented and constructed is one of the panaceas for reducing change initiated rework.

Measuring quality in the project‟s design phase is arguably difficult because, in many instances, the designer is not the final user assessing the product‟s quality performance (Abdul-Rahman, 1993). Arge (1995) suggested, therefore, that direct and constant communication between the architect and client/end-user is critical factor to the final product‟s quality. Furthermore, Arge (1995) suggested that if architects are to deliver clients/end-users quality architecture, they must improve their internal management practices and consider limiting the commissions they undertake.

Contractors are the custodians of the production process hence, they must receive „the right‟ information, to enable them to manage their subcontractors. Incomplete, conflicting, inappropriate, or changed information causes rework, which can delay the project‟s progress. The CII (1990) noted that contractors‟ quality systems are unable to prevent errors and omissions, which originate from consultants, nor can they thwart changes, but they can provide prevention mechanisms and give early warnings of poor quality. A lack of input into finding a mutually beneficial problem solution and being involved at a later stage of the project‟s development may discourage a sense of project ownership amongst design team members (Love & Edwards, 2004). This can lead to ineffective design coordination at respective interfaces, which can inadvertently translate into errors and omissions being contained within contract documentation.

Poor coordination and integration of design team members with respect to contract documentation also significantly contributes to rework. The CII (1990) advised that in cases where there is insufficient time to complete contract documentation, the design team should provide the contractor with an assessment of design status and the potential for change. The advantage is that the information enables the contractor to provide a realistic tender price and project programme as well as establish the mechanisms and procedures for administrating changes.

In order to ensure quality in contract documentation, design consultants and contractors when using design and construct methods, should give greater attention to (Hollis, 1993);

- The requirements of clients and end-users;
- Producing correct and complete drawings and specification;
- Coordinating and checking contract documentation (including inter-organisational coordination);
- Conducting design verification through design analysis reviews;
- Controlling changes (e.g. scope freezing); and
- Committing to providing a quality service.

The author asserted that adequate attention to these preventative items design quality assessment can be improved, which in turn will reduce errors, and omissions.

The quality of human resource is also important for militating against rework. According to the author, organisations have to harness the skills of the right people at the right time and integrate and coordinate their work with other organisations involved with a project. Hellard (1991) noted that lack of knowledge and carelessness contributes to errors occurring in the projects, both of which can be corrected. Human resources should be given appropriate attention since they are capable of producing and preventing errors. Oakland and Sohal (1996) indicated that effective human resource management is an integral component of total quality management and therefore provides the foundation for error prevention. Mandal et al. (2000) demonstrated that the investment in training can reduce rework costs, but Love and Sohal (2002) found no significant relationship between training and rework costs. Generally, however, improved training and skill development can improve the competence base of site management and subcontractors.

Howell et al. (1993) and Ashford (1992) indicated that site management and subcontractors can play an active role in reducing errors by providing ameliorated supervision and leadership on-site. Site personnel (such as the foreman) invariably assume the role of production inspectors and therefore possess knowledge, on the causes and prevention of rework. Such site personnel, according to Ballard (1997), should not be treated as quality inspectors but rather guides who are capable of convincing those making errors that it is „safe" to report them.

Hollis (1993) established that a major factor of rework is poor planning and coordination of project teams. For instance, poor planning and coordination on the contractor"s behalf can directly influence the resource planning of subcontractors. Therefore, both the contractor and subcontractor need to work together to ensure that when planned activities deviate, remedies are available to minimise possible disruption and delays. Poor coordination leads to project variability, as Ballard and Howell (1997) have revealed that one-third of all projects deviate from the actual plan due to poor coordination.

Deviations are controlled through project inspections. Project inspection was defined by Division of Engineering (2004) as a process that ascertains that the works of the contractor are complied with the requirements of the contract. The frequency and method of the construction inspections, however, vary based mainly on the project complexity and the construction codes. Love and Edwards (2004) pointed out that, the inspections are the responsibilities of the construction inspector and the field inspector, for the purposes of ascertaining the compliance of all construction activities with the contract requirements and that all performed work is complied with best construction practices.

However, project rework might occur, because inspections do not cater for uncertainties and planned activities may not cover all unforeseen events. In such situations, Ballard (1994) recommends utilising the last planner approach. The last planner is responsible for the operational planning of the production process (Ballard, 1994). The foreman is typically the last planner and should select only those activities that can and will be done rather than those activities that should be done to compensate the project"s schedule for the rework that has occurred (Ballard, 2000). If what should be done is addressed instead, then the site workforce may inherit the uncertainty and variation of workflow that have not been prevented. This may result in a high degree of non-productive time and a de-motivated workforce.

2.7 Empirical Review

This section presents a sample of studies that have been conducted in other countries and in Ghana, on issues related to rework in the construction industry. The purpose is to identify methods and procedures that worked and have been approved in conducting such studies, as well as likely results which can be used as a guide for this study.

Mastenbroek (2010) analysed how to reduce rework costs in construction projects of the Grupo Williams (GW) in Spain. The study aimed to assess the rework costs in GW"s construction projects; to determine the most relevant causes of rework and to suggest improvement to reduce rework costs. The study adopted both quantitative and qualitative approaches in a mixed method. The indicators used were the costs of material, labour, time, as well as total costs. A model checklist including predefined indicators were used and categorised under errors, omissions, and change, which were aligned to costs. Managers and supervisors of the projects were also interviewed.

The study found that average total cost overrun (average failure costs) of five projects was 13 percent. Both labour and material costs contributed to these cost overruns. Material cost overruns were as high as 59 percent and labour costs were even found to be 232 percent higher. The causes of rework in the design-phase included; a design change is initiated by the contractor; a design change is initiated by the end user/occupier; a design change is initiated due to financial changes; a design change is initiated due to economic changes; and lack of co-ordination. At the construction phase the causes were:

- Changes in clients" wishes
- Extra orders by client
- Machine breakdown or defects
- Machine not working satisfactorily
- Late deliveries of materials
- A change in construction methods in order to improve constructability
- A change in construction methods due to site conditions

- Mistakes in executing rules
- Noncompliance of rules
- Slips/lapses of attention
- Damage caused by GW or a subcontractor

The study grouped the causes of rework into the change orders, lack of coordination, late material deliveries, construction methods and personnel. The study suggested GW to adopt inter-project learning more strictly. However, inter-project learning would succeed if the rework events were properly evaluated. Rework avoidance was also recommended through consistent orders, proper coordination, punctual deliveries, proper construction methods and proper staffing.

Simpeh (2012) assessed the underlying causes of rework during construction, and its impact on the overall project performance in order to develop effective prevention strategies in the Cape Peninsula. The study adopted a mixed approach in which 78 senior management from construction and consulting firms were purposively selected. Data were obtained through a self-administered questionnaire, containing both open and closed-ended questions. Interview guides were also used to collect data from the respondents.

The study revealed that the most predominant source of rework included non-compliance with specification, setting out errors, changes made at the request of the client, poor communication with design consultants and low labour skill levels. The causes of rework were found not to vary significantly with various project types. The respondents tended neither to agree nor disagree, that the cost overrun, time overrun and design team dissatisfaction were as a result of rework impacted on project performance. It was also found that the more the industry continues to create awareness about the root causes and what constitutes rework coupled with a systematic approach and structured tracking mechanisms, the more effective strategies can be developed to eliminate rework. The study recommended that, to reduce rework during the design stage, team building, as well as the involvement of subcontractors, suppliers and designers for construction should be ensured.

2.8 Conceptual Framework

The conceptual framework portrays that rework is a factor of several concepts and activities in the construction industry. In theory, information asymmetry resulting from the incompleteness of information between a principal and an agent has a direct influence on rework. According to the framework, information asymmetry results from the differences in the motives of the principal and agent, as well as differences in their objects and experiences. The client also has some expectations of the contractor‟s skills and abilities of which the client does not have full knowledge. However, signalling, such as references and qualification certificates, can be adopted to identify whether the contractor is endowed with such abilities.

In practice, human resource capacity, leadership and communications, engineering and reviews, construction planning and scheduling, as well as material and equipment supply influence also contribute to rework. These factors are also underlain by several internal and external risks that influence rework on construction projects.

However, risk reduction strategies may be employed, as in signalling, in theory and last planner approach, practice which could reduce the extent of rework. Risk reduction practices including scope freezing, monitoring, bonding, training, quality management and following a systematic rework elimination approach as proposed by Palaneeswaran (2006) can be adopted to minimise the occurrence and scope of rework. However, rework might still occur and in that case the last planner approach can be adopted to salvage the project and reduce the negative effects of rework on the project.

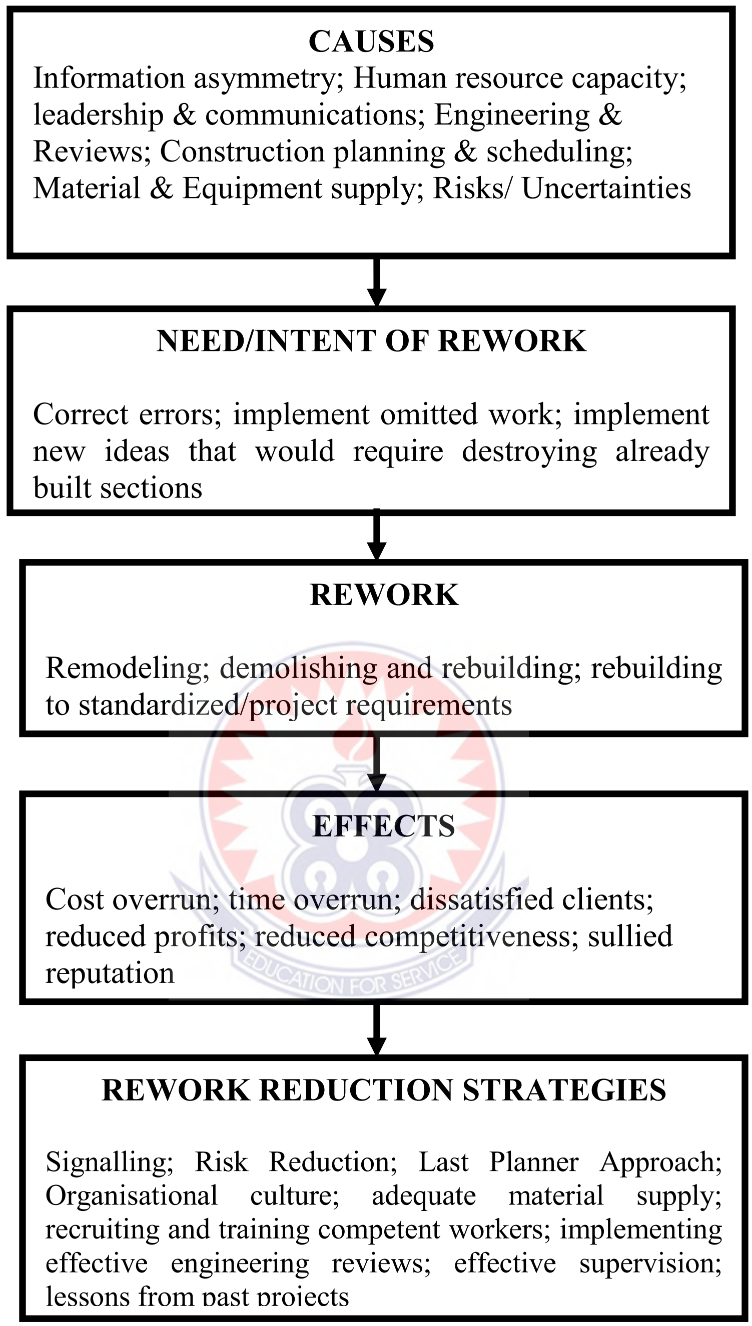


Figure 2.2: Conceptual framework for analysing rework

Sources: Author‟s construct (2015)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents methods adopted to achieve the objectives of the study and to answer the research questions posed in chapter one. This chapter presents the research strategies used in this study. It discusses research design, population, sampling, data collection and data analysis.

3.2 Research Design

The research design is the overall strategy for integrating the different components of a study in a coherent and logical way, thereby, ensuring effective analysis of the research problem (De Vaus, 2001). This study adopted a quantitative research approach, which involves numerical representation and manipulation of observations for the purpose of describing and explaining the phenomenon that those observations reflect (Babbie, 2005). This allowed the collection of quantitative data and also enabled the use of quantitative methods in the analysis of data. However, the quantitative results do not often lend themselves to contextual factors to help interpret the results or to explain variations in behaviour between the unit of analysis with similar economic and demographic characteristics.

The research designs adopted are the descriptive and cross-sectional designs. Weissberg and Buker (1990) reports that methods involved in a descriptive study design range from survey which describes the status quo, correlation study which investigates the relationship between variables, to developmental studies which seek to determine changes over time. Sarantakos (1998) confirms that descriptive research aims at describing social systems, relations or social events and providing background information about the issue in question and also to stimulate explanations. A descriptive design is therefore adopted because the study ultimately seeks to examine factors associated with the occurrence of rework in construction projects and to develop a framework for minimizing it.

Cross-sectional studies are carried out at one time point or over a short period (Levin, 2006). It is often described as taking a "snapshot" of a group of individuals (Carlson & Morrison, 2009). The purpose of a cross-sectional study is descriptive, often in the form of a survey, and usually does not involve hypothesis testing. The aim is to describe a population or a subgroup within the population with respect to an outcome and a set of rework factors. This limits the ability of cross-sectional studies to make causal inferences (Bland, 2001; Levin, 2006). This study therefore assumes the limitations of the selected research approach and designs.

3.3 Population and Sampling Frame

3.3.1 Population of the Study

The targeted population of the study comprised all registered Architectural Consultancy Firms (ACF) with good standing in building construction industries in Ghana. Their total number for the population was one hundred and seventy (170) firms across the country (Architectural Consultancy Firms, 2014). The registered Architectural

Consultancy Firms were used for the study because they are involved in the design phase of the building and work closely with the construction team at the construction site.

3.3.2 Sampling Frame

"Sampling frame is a list of items from which statistical sample is taken from" (Danso, 2010). The target participants of the study comprised all registered Architects in the construction firms with good standing across the country. Therefore, the sampling frame for this study is one hundred and seventy Architectural Firms with good standing under the Architectural Registered Council of Ghana.

3.4 Sampling and Sample Technique

3.4.1 Determination of Sample Size

The target population was 170 members of the Architectural Consultancy Firms. However, a sample was taken due to the relative short period for completion of the study, as well as resource constraints and the fact that a representative sample could be generalised for the entire population (Creswell, 2003). The Kish (1965) formula, which gives a procedure for calculating minimum sample size, was applied for this study. Assaf et al., (2001), Abdul-Hadi (1999), Aziz and Hafez (2013) and Enshassi et al. (2010), among others have used this equation in their studies. The sample size deduced from Kish (1965) survey sampling is calculated as follows using equation 3:1

$$n = \frac{n'}{\left\{1+\left(\frac{n'}{N}\right)\right\}} \qquad \text{……………….. Equation 3:1}$$

Where n = Sample Size from finite population

N = Total or target population

n′ = Sample Size from infinite population calculated from; n′ = S^2 / V^2, Where

V = Standard error of sample population equal to 0.05 for the confidence level 95%,

t = 1.96

S^2 = Standard error variance of population elements,

S^2 = P (1 - P); Maximum at P = 0.5.

The sample size of the Architectural firms with good standing can be calculated from the afore mentioned equations as follows:

$n' = \frac{S^2}{V^2} =$

S^2= P (1- P)

Where P = 0.5

S^2= 0.5 (1- 0.5)

S^2= 0.5×0.5

S^2= 0.25

To find V^2, let V=0.05 level of confidence.

$V^2 = (0.05)^2$

V^2= 0.0025

$\therefore\ n' = \frac{S^2}{V^2} = \frac{0.25}{0.0025}$

n'=100

sn (Architectural Firms with good standing) = $\frac{100}{\{1+(\frac{100}{170})\}}$= 63 Firms across Ghana.

Therefore, the minimum number of architects for this survey by the Kish (1965) formula was sixty-three (63) architectural firms in Ghana. Forty (40%) of sixty-three (63) was added for non-respond questionnaires, which increased the minimum sample size to eighty-nine (89) firms.

3.4.2 Sampling Technique

The respondents were selected using simple random sampling method. The required number of the population for the Architects was deduced from the list of one hundred and seventy (170) currently registered Architectural Consultancy Firms with good standing in Ghana by Kish (1965) formula. One Architect was selected from each firm within the target population. The reason was to give equal chance to the respondents in the selection process. Furthermore, the reason for using this technique was the nature of the targeted population, which allows representative sample, and generalise the findings to the large population. For the selection of the members of ACF, the researcher numbered ACF from 1 through 170. The researcher then selects randomly 89 from the entire population of 170.

3.5 Data Collection Procedure

3.5.1 Sources of Data

Two main sources of data used for the research work was primary source data and secondary source. The methods used in collecting the primary data included questionnaire on the factors underlying rework in the construction industry, the direct and indirect effects of rework, as well as the rework reduction strategies used by the construction firms and the challenges confronting construction firms in minimising rework on projects. Secondary sources included data from published and unpublished books, magazines, journals, and websites and so on.

3.5.2 Instruments for Data Collection

Questionnaires were used to solicit primary data from the architects, because the study assumes that these groups of people are literate and can therefore read, understand and also answer the items on the questionnaire accordingly. The questionnaire was divided into five sections comprising closed-ended items. The questionnaire was divided into two parts. The first part sought information on the demographic profile of the respondents as well as the profile of their firms; names of companies, gender, number of years of experience in the construction industry, position of respondent, educational background.

The second part of the questionnaire was sub-divided into four sections. The first section sought information on the factors underlying rework. These factors were ranked based on a rating scale of 1 to 5 where “1= Strongly Disagree and 5= Strongly Agree”. The second part of the questionnaire is on rework reduction strategies used by the architectural firms. The respondents were again asked to rank based on a rating scale of 1 to 5 where “1= Not at all important and 5= Very important”. The third section sought information on the effects of rework in the construction industry in Ghana. These factors were ranked based on a rating scale of 1 to 5 where “1= Strongly Disagree and 5= Strongly Agree”. Finally, the last aspect of the questionnaire sought information on the challenges architectural firms face in minimising rework on construction projects. The factors were ranked based on a rating scale of 1 to 5 where “1= Strongly Disagree and 5= Strongly Agree”.

3.6 Pre-Testing of Questionnaire

Prior to the major survey, a pilot survey was undertaken. The aim of pre-testing the research tool was to check for logic in the sequence of the questions asked. It was also meant to correct language difficulty and verify the average duration of time needed to answer each questionnaire item. Using simple random sampling techniques, the research instruments were pre-tested using a sample of 10 randomly selected practising Architects. The sample size of 10 for the pilot study is based on the observation of Borg et al. (1983) that it is hardly essential to include more than 20 subjects for a pilot study. All 10 respondents were included in the main survey. The pilot questionnaires (fully addressed) were hand delivered after which it was retrieved. A covering letter explaining the purpose of the pilot study accompanied the questionnaires.

Furthermore, it helped to check and try the planned statistical tests of association between variables. Besides these, the pre-test enabled the researcher to revise the contents of the questionnaire thereby revising the instruments to achieve the reliability and validity standards required in scientific research.

3.6.1 Validity

Validity refers to whether the questionnaire or survey measures what it intends to measure (Polit & Hungler 1985). While there are very detailed and technical ways of proving validity, there are some concepts that are useful to keep in mind. The overriding principle of validity is that it focuses on how a questionnaire or assessment process is used. Reliability is a characteristic of the instrument itself, but validity comes from the way the instrument is employed.

In statistics, a valid measure is one which is measuring what it is supposed to measure. Validity implies accuracy. A valid measure must be reliable, but a reliable measure need not be valid. Validity refers to getting results that accurately reflect the concept being measured.

The researcher assessed the statistical validity of the questionnaire by principal component analysis. The researcher had validity of 0.70 and above and this result means that the questionnaire were very accurate for factor analysis.

3.6.2 Reliability

Reliability of an instrument is the degree of consistency with which it measures the attribute it is supposed to be measured or/and, it is a property of the measuring instrument (Polit & Hungler, 1985). A period of two weeks to a month is recommended between two tests (Burns & Grove 1987). The reliability of a questionnaire is the ability of the questionnaire to give the same results when like-minded people in similar circumstances fill it out. The researcher conducted reliability tests on the pilot study sample using Alpha- Cronbach's Method. This method is used to measure the reliability of the questionnaire between each field and the mean of the whole fields of the questionnaire. The normal range of Cronbach‟s coefficient alpha value between 0.0 and + 1.0, and the higher values reflect a higher degree of internal consistency. The researcher achieved

Cronbach‟s coefficient alpha results 0.80 and above and this results means the instruments were consistent and reliable for factor analysis. This result is considered high and these results ensure the reliability of the questionnaire.

3.6.3 Exploratory factor analysis

The (KMO) and Bartlett‟s test were used to check the degree of inter-correlation among the variables and the appropriateness of factor analysis (Field, 2005). Bartlett test of sphericity was used to check for the presence of correlation among the variables and provides the probability that correlation matrix has significant correlation among at least, some of the variables as an accession of (Hair et al. 2007; Field, 2005).

Kaiser-Meyer-Olkin (KMO) measure was performed to check the degree of inter-correlation among the items and the appropriateness of factor analysis. Kim and Mueller (1978) and SPSS 6^{th} edition suggested that KMOs in the range of 0.5-0.6 are considered poor, those in the range of 0.6-0.7 are average, those in the range of 0.7-0.8 are considered good, 0.8-0.9 are great and values greater than 0.9 are superb. The KMO values obtained were greater than 0.7, which indicated that, the data is adequate and appropriate for factor analysis.

3.6.4 Ethical issues

The researcher sent a letter of introduction to the administration of the ACF explaining the purpose of the research and officially seeking permission to conduct the research using their members. This assisted the researcher to gain the needed support or co-operation from the members of the associations. The researcher explained the purpose of the study to all participants and only included them in the study based on their informed consent. The respondents were assured of their confidentiality.

3.7 Data Analysis

The answered questionnaires were edited to detect unanswered questions and also to eliminate errors such as double answers. The data were later cleaned and coded for entry into the Statistical Package for Social Sciences (SPSS) for Windows software by the researcher. Factor analysis is employed to condense large number of variables with a view to identifying the underlying variables that really explains the pattern of correlation with a set of observed variables. The main essence of factor analysis is to describe the covariance relationship among large number of variables in terms of a few groups Johnson and Witchen (2007) in (Awakul and Ogunlana, 2002). Factor analysis model specifies that variables are determined by common factors (the factors estimated by the model) and unique factor which (do not overlap between observed variables); with the assumption that all the unique factors calculated correlate with each other and with the common factor**.** Analysis was also undertaken to generate a descriptive picture of the data gathered. Descriptive statistics calculations of overall mean and standard deviations were used to analyse the quantitative data obtained from the architectural 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

PRESENTATION AND ANALYSIS OF RESULTS

4.1 Introduction

This chapter presents the views from respondents which were elicited to find out the strategies for minimizing reworks in construction industry in Ghana. Primary data were collected through questionnaires to address the objectives of the study which were to: examine the factors underlying rework in the construction industry in Ghana; assess the effects of rework in the construction industry in Ghana; identify key rework reduction strategies in the construction industry; and identify the challenges construction firms face in minimising rework on their projects.

4.2 Response Rate

From Table 4.1, 89 questionnaires were distributed to architectural firms in Ghana. 59 questionnaires which constitute (66.3%) were returned, out of which 56 were useable. 3 questionnaires representing (3.4%) were found to be invalid for analysis because of improper filling yielding an effective response rate of approximately 62.9%. This response rate is considered adequate, as Oladapo (2005), Newman and Idrus (2002) and Ellhag and Boussabaine (1999), have indicated that a response rate of 30% is good enough in construction studies.

Table 4.1: Percentage of questionnaires distributed and responses received

Respondents	Questionnaires Distributed	Responses Returned	Screened out Responses	Percentage of Response
Architectural Firms	89	59	3	62.9%

Source: Field Work **(2016)**

4.3 Demographic Characteristics

This section presents the demographics of respondents. It includes gender, age of respondents, academic qualification, working experience, and age of respondents. The demographics of the respondents was essential to the study since they play significant roles in the development of people‟s perceptions about a particular issue as well as how they respond to issues.

4.3.1 Gender of Respondents

The respondents were asked to indicate their gender by ticking the appropriate column they belonged. The purpose was to find out the number of males and females who actually participated in the study. Table 4.2 shows that out of the 56 respondents who participated in the study, majority 41 of the respondents representing 73.2% were males, while the remaining 15 respondents representing 26.8% being females. Naturally, males and females have different attitudes and views toward career or professional based probably on nature of work (Singer, 1996).

Table 4.2: Respondents based on Gender

Gender	Frequency	Percentage (%)
Male	41	73.2
Female	15	26.8
Total	56	100.0

Source: Field Work (2016)

4.3.2 Age of Respondents

Table 4.3 depicts the age distribution of respondents who participated in the study. The purpose was to find out the average age of the architects who are actively involved in the operations within the organisation. The table shows that 13 respondents representing 23.2% fall within the age brackets 21-30 years; 28 representing 50.0% fall within the age brackets 31-40 years. 8 respondents representing 14.3% fall within 41-50 years, 5 respondents which constitutes 8.9% fall within the age bracket 51-60 years while the remaining 2 representing 3.6% were above 60 years. The data shows that majority of the employees in the organisation fall within 31-40 years. This implies that the respondents were matured enough to give answers which are accurate.

Table 4.3: Respondents based on Age

Age	Frequency	Percentage (%)
21-30 years	13	23.2
31-40 years	28	50.0
41-50 years	8	14.3
51-60 years	5	8.9
Above 60 years	2	3.6
Total	56	100.0

Source: Field Work (2016)

4.3.3 Highest Academic Qualification of Respondents

The respondents were asked to indicate their educational background. The purpose was to find out the academic/professional qualifications of employees who participated in the study. Table 4.4 shows responses elicited, 13 respondents representing 23.2% have obtained diploma certificate; 12 respondents representing 21.43% have obtained bachelor degree certificate. Again, 9 respondents who constitute 16.1% have post graduate diploma degree, also 20 respondents which constitute 35.7% have master"s degree certificate while the remaining 2 respondents representing 3.6% have doctorate degree certificate. Furthermore, 55 of the respondents which constitute 98.2% belong to relevant professional body while 1 of the respondents does not belong to any professional body. The data shows that majority of the respondents have attained some level of education whose opinions and views are guided and well informed.

Table 4.4: Respondents Based on Academic Qualification

Qualification	Frequency	Percentage (%)
Diploma	13	23.2
Bachelor"s degree	12	21.43
Postgraduate Diploma	9	16.1
Master"s degree	20	35.7
Doctorate Degree	2	3.6
Membership of Relevant Professional Body	55	98.2
Total	56	100.0

Source: Field Work (2016)

4.3.4 Working Experience of Respondent

Table 4.5 depicts the working experience of employees who participated in the study. The objective was to determine how long and consistently employees have worked in the organisation. The data gathered shows that 14 respondents representing 25.0% have worked under 5 years in the organisation; majority (17) representing 30.4% have worked between 5-10 years in the organisation; 7 respondents representing 12.5% have worked above 10 but less than 15 years in their company. Again, 7 respondents which constitute 12.5% have worked between 15-20 years; also 5 respondents representing 8.9% have above 20 but less than 30 years working experience while the remaining 6 respondents representing 10.7% have above 30 years working experience. The available data shows that majority (30.4%) of the employees have been working for between 5-10 years and therefore have acquired the necessary competencies and consistency in their work.

Table 4.5: Respondents Based on Experience

Experience	Frequency	Percentage (%)
Under 5 years	14	25.0
5-10 years	17	30.4
Above 10 but less than 15 years	7	12.5
15-20 years	7	12.5
Above 20 but less than 30 years	5	8.9
Above 30 years	6	10.7
Total	56	100.0

Source: Field Work (2016)

4.4 Factor Analysis of Critical Factors Underlying Rework in the Construction Industry in Ghana

Factor analysis was used to assess the critical factors underlying rework in the Construction Industry in Ghana. In the preliminary analysis, the Kaiser-Meyer-Olkin (KMO) test of sampling adequacy achieved a high of 0.750. The Bartlett test of sphericity shows overall significance of the correlation matrix at the 0.000 significance level. Principal components extraction with varimax rotation was employed. The Kaiser criterion (eigenvalue >1) was employed in conjunction with evaluation of scree plots. The screen test indicates that only 8 factors should be considered. In Table 4.6, the rotated component matrix indicates that, 19 out of the original 37 variables could be the underlying themes using a cut-off point of 0.60. Factor retention was by the eigenvalue 1.0 criterion, suggesting that only factors that account for variances greater than one should be included in the factor extraction. The thirty-seven items obtained a Cronbach alpha (α) value of 0.950 thereby satisfying the reliability scale. All the 37 factors had communalities of 1.00 (as shown in Table 4.8), indicating their appropriateness for the factor analysis. The 37 significant factors were further reduced to 10 component factor patterns.

According to Table 4.6, factor 1, employee turnovers and unrealistic schedules emerged the highest with a factor loading of (0.721), followed by "lack of experience and knowledge of design of the construction process (0.666)". For factor 2, Re-construction due to quality failures (0.843) emerged the highest, followed by pressure for early completion (0.622) and correction on-site errors in design (0.607). For factor 3, Lack of design coordination and integration (0.760) came top, followed by Inadequacies in contract documentation (0.727). For factor 4 had Client initiated changes in design and execution (0.754), Re-construction due to non-conformance to original design (0.723) and late changes in scope of project (0.668). Factor 5, Errors and omissions (0.682) emerged the highest, followed by inadequate briefing (0.651). For factor 6 had Soil characteristics (0.725) and Inadequate of funding allocated for site investigation (0.660). Factor 7 had Poor multi-tasking (0.815) and late design changes and poor documentation (0.809). Factor 8 had poor communication with design consultants (0.817). Factor 9 also had Community hostility (0.860). Finally factor 10 also had unclear instructions to workers (0.645).

The initial eigenvalues (see Table 4.7) indicates that, if all the factors are ranked, factor 1 account for 37.586% of the variance, factor 2 accounts for 6.042% of the variance, factor 3 accounts for 5.406% of the variance, factor 4 accounts for 4.726% of the variance, factor 5 accounts for 4.194% of the variance, factor 6 accounts for 3.950% of the variance, factor 7 accounts for 3.235% of the variance, factor 8 accounts for 3.193% of the variance, factor 9 accounts for 2.946% of the variance, factor 10 accounts for 2.855% of the variance. Together, the ten identified factors accounted for 74.132% of the variance. Results of the factor analysis indicate a high level of construct validity of the measure of 0.750.

Given that, most of the variables in factor 1 are more or less linked to design and construction the researcher decided to name this factor as design and construction related. Issues in factor 2 could also be linked to Re-construction due to quality failures; hence, factor 2 was termed Re-construction due to quality failures related. Factor 3, coordination and integration related. Issues in factor 4 are associated with client involvement in the project; hence, it was named client involvement in the project related. Factor 5, errors and omissions related. Factor 6 was named site investigation related. Issues of factor 7 could be linked design changes and poor documentation, so the researcher named this poor documentation related. Factor 8 poor communication with design consultants related. Factor 9 was named community hostility related. Finally factor 10 could be linked to unclear instructions to workers and it was named unclear instructions related.

Factor analysis enabled the 37 critical factors to be placed under ten (10) components as follows:

Component 1: Design and construction mechanism variances

Employee turnovers and unrealistic schedules, lack of experience and knowledge of design and of the construction process.

Component 2: Re-construction due to quality failures mechanism variances

Re-construction due to quality failures, pressure for early completion and correction on-site errors in design.

Component 3: Coordination and integration mechanism variances

Lack of design coordination and integration and Inadequacies in contract documentation

Component 4: Client involvement in the project mechanism variances

Client initiated changes in design and execution, Re-construction due to non-conformance to original design and late changes in scope of project.

Component 5: Errors and omissions mechanism variances

Errors and omissions and inadequate briefing.

Component 6: Site Investigation mechanism variances

Soil characteristics and Inadequate of funding allocated for site investigation.

Component 7: Poor documentation mechanism variances

Poor multi-tasking and Late design changes and poor documentation

Component 8: Poor communication within design consultants' mechanism variances

Poor communication with design consultants.

Component 9: Community hostility mechanism variances

Community hostility.

Component 10: unclear instructions mechanism variances

Unclear instructions to workers.

Table 4.6: Rotated Component Matrix[a]

Factors	Component									
	1	2	3	4	5	6	7	8	9	10
unclear instructions to workers	.202	.153	.323	.050	.162	.150	.088	.150	.040	.645
Inadequate job planning and poor safety measures	.404	.094	.517	.307	.091	.224	.033	.218	.182	.055
Insufficient skill level of workers	.176	-.043	.378	.194	.345	.022	.185	.538	-.045	.258
Inexperienced supervisors and consultants	.155	.371	.484	.290	.464	-.010	.022	-.033	-.095	.205
Ineffective management of project team	.545	.245	.357	-.028	.195	.209	.143	.140	.086	.180
Inadequate commitment to quality assurance	.535	.220	.032	.286	.501	.004	.085	-.227	.027	.207
Miscommunication among workers	.420	.109	.179	.211	.480	.310	.219	.021	.020	-.006
Late design changes and poor documentation	.091	.232	.176	.157	.091	.188	.809	-.042	-.106	.174
Errors and omissions	.134	.027	.125	.041	.682	.377	.089	.270	.212	.053
Inadequate integration of design team	.288	.086	.195	.280	.432	.322	.345	.141	.053	.263
Late designer input	.570	.328	.095	-.221	.204	.205	.174	.025	.000	.064
Employee turnovers and unrealistic schedules	.721	.071	.166	.042	.112	.094	-.016	-.045	-.047	.311
Insufficient commissioning of resources	.277	.168	.365	.069	.278	.553	.045	-.316	.100	-.104
Poor work load planning	.460	.128	.176	.336	.164	.270	-.034	.208	.466	.190
Supplier's non-compliance with requirements	.511	.018	.228	.029	.441	.075	.313	.350	.130	-.028
Soil characteristics	.220	.194	.168	.247	-.035	.725	.090	.119	.153	.208
Changes in government regulations	.300	-.021	.542	.169	.199	.219	.173	.289	.330	.101
Price fluctuations	.199	-.030	.226	.217	.194	.332	.217	-.084	.420	.291
Community hostility	-.082	.075	.030	.031	.117	.092	.038	-.071	.860	-.003
Lack of experience and knowledge of design and of the construction process	.666	-.043	.104	.204	.132	.151	.214	.089	-.002	-.150
Inadequate of funding allocated for site investigation	.428	.251	.249	-.118	.185	.660	.089	.075	.133	.018
Inadequate briefing	.110	.322	.280	.085	.651	-.127	.133	.128	.283	.141
Client initiated changes in design and execution	-.017	-.067	.227	.754	.290	-.017	.121	.071	-.098	-.174
Poor communication with design consultants	.009	.236	.101	.210	.087	.039	-.068	.817	-.054	.054
Inadequacies in contract documentation	.140	.171	.727	.024	.204	.344	-.005	.159	-.086	.102
Lack of design coordination and integration	.160	.120	.760	.078	.141	.046	.141	.018	.124	.106
Late changes in scope of project	.215	.206	-.083	.668	.093	.295	.213	.239	.110	.278
Poor structural design	.546	.118	.400	.090	-.224	.197	.093	.047	-.064	.186
Correction on-site errors in design	.020	.607	.154	.465	.214	.260	.074	.064	.066	.258
Correcting off-site prefabrication errors	.538	.585	.045	.198	.152	.149	.177	.049	.142	-.129
Re-construction due to non-conformance to original design	.108	.319	.102	.723	-.051	.016	.142	.171	.227	.090
Re-construction due to quality failures	-.024	.843	.034	.081	.072	.266	-.061	.108	-.039	.173
Setting out errors	.439	.384	.422	.409	-.104	.092	.199	-.065	.243	.051
Poor multi-tasking	.252	.060	.032	.168	.156	-.020	.815	.033	.211	-.027
Pressure for early completion	.320	.622	.196	.067	.121	-.187	.261	.000	.180	.068
Inadequate protection to work	.173	.460	.187	.064	.124	.071	.262	.256	.266	.477
Poor choice of construction materials	.277	.588	.290	.077	.006	.244	.249	.198	-.061	-.351

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 22 iterations.
Source: Field Work (2016).

Table 4.7: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	13.907	37.586	37.586	13.907	37.586	37.586	4.504	12.172	12.172
2	2.235	6.042	43.627	2.235	6.042	43.627	3.502	9.464	21.636
3	2.000	5.406	49.033	2.000	5.406	49.033	3.481	9.408	31.044
4	1.749	4.726	53.759	1.749	4.726	53.759	2.887	7.804	38.848
5	1.552	4.194	57.952	1.552	4.194	57.952	2.822	7.626	46.474
6	1.461	3.950	61.902	1.461	3.950	61.902	2.612	7.058	53.533
7	1.197	3.235	65.137	1.197	3.235	65.137	2.247	6.072	59.605
8	1.182	3.193	68.331	1.182	3.193	68.331	1.849	4.997	64.602
9	1.090	2.946	71.277	1.090	2.946	71.277	1.845	4.987	69.589
10	1.056	2.855	74.132	1.056	2.855	74.132	1.681	4.544	74.132
11	.983	2.657	76.789						
12	.916	2.476	79.265						
13	.815	2.202	81.467						
14	.744	2.010	83.477						
15	.692	1.870	85.348						
16	.588	1.590	86.938						
17	.564	1.524	88.461						
18	.544	1.469	89.931						
19	.457	1.236	91.166						
20	.439	1.187	92.353						
21	.364	.983	93.336						
22	.338	.914	94.250						
23	.296	.800	95.051						
24	.284	.767	95.818						
25	.239	.645	96.463						
26	.212	.574	97.037						
27	.211	.569	97.606						
28	.184	.498	98.104						
29	.137	.371	98.475						
30	.126	.341	98.816						
31	.104	.282	99.098						
32	.096	.259	99.357						
33	.067	.180	99.537						
34	.063	.170	99.707						
35	.048	.131	99.838						
36	.033	.089	99.927						
37	.027	.073	100.000						

Extraction Method: Principal Component Analysis.
Source: Field Work (2016).

Table 4.8: Communalities

Factors	Initial	Extraction
unclear instructions to workers	1.000	.668
Inadequate job planning and poor safety measures	1.000	.677
Insufficient skill level of workers	1.000	.725
Inexperienced supervisors and consultants	1.000	.748
Ineffective management of project team	1.000	.647
Inadequate commitment to quality assurance	1.000	.771
Miscommunication among workers	1.000	.640
Late design changes and poor documentation	1.000	.859
Errors and omissions	1.000	.771
Inadequate integration of design team	1.000	.708
Late designer input	1.000	.610
Employee turnovers and unrealistic schedules	1.000	.677
Insufficient commissioning of resources	1.000	.748
Poor work load planning	1.000	.768
Supplier's non-compliance with requirements	1.000	.753
Soil characteristics	1.000	.790
Changes in government regulations	1.000	.733
Price fluctuations	1.000	.601
Community hostility	1.000	.783
Lack of experience and knowledge of design and of the construction process	1.000	.615
Inadequate of funding allocated for site investigation	1.000	.824
Inadequate briefing	1.000	.776
Client initiated changes in design and execution	1.000	.769
Poor communication with design consultants	1.000	.797
Inadequacies in contract documentation	1.000	.781
Lack of design coordination and integration	1.000	.693
Late changes in scope of project	1.000	.829
Poor structural design	1.000	.618
Correction on-site errors in design	1.000	.803
Correcting off-site prefabrication errors	1.000	.789
Re-construction due to non-conformance to original design	1.000	.758
Re-construction due to quality failures	1.000	.841
Setting out errors	1.000	.809
Poor multi-tasking	1.000	.832
Pressure for early completion	1.000	.687
Inadequate protection to work	1.000	.733
Poor choice of construction materials	1.000	.800

Extraction Method: Principal Component Analysis.

Source: Field Work (2016).

4.5 Factor Analysis on the Effects of Rework in the Construction Industry in Ghana

Factor analysis was used to assess effects of rework in the Construction Industry in Ghana. In the preliminary analysis, the Kaiser-Meyer-Olkin (KMO) test of sampling adequacy achieved a high of 0.821. The Bartlett test of sphericity shows overall significance of the correlation matrix at the 0.000 significance level. Principal components extraction with varimax rotation was employed. The Kaiser criterion (eigenvalue >1) was employed in conjunction with evaluation of scree plots. The screen test indicates that only 4 factors should be considered. In Table 4.9, the rotated component matrix indicates that, 11 out of the original 26 variables could be the underlying themes using a cut-off point of 0.70. Factor retention was by the eigenvalue 1.0 criterion, suggesting that only factors that account for variances greater than one should be included in the factor extraction. The twenty-six items obtained a Cronbach alpha (α) value of 0.968 thereby satisfying the reliability scale. All the 26 factors had communalities of 1.00 (as shown in Table 4.11), indicating their appropriateness for the factor analysis. The 26 significant factors were further reduced to 4 component factor patterns.

According to Table 4.9, factor 1, increased expenses of labour wages and pay emerged the highest with a factor loading of (0.806), followed by “increased expenditure on building materials (0.774)”, increased time to construct the project and/or correct errors (0.770), increased total cost of project (0.760), reduced profit (0.747), Increased expenses of labour wages and pay (0.740). For factor 2, poor morale (0.766) emerged the highest, followed by Fatigue (0.717). For factor 3, Loss of future work (0.722) came top. For factor 4 had increased cost of labour (0.769) emerged the highest, followed by Additional waste, handling cost (0.735).

The initial eigenvalues (see Table 4.10) indicate that, if all the factors are ranked, factor 1 accounts for 55.963% of the variance, factor 2 accounts for 6.577% of the variance, factor 3 accounts for 5.075% of the variance, factor 4 accounts for 4.565% of the variance. Together, the four identified factors accounted for 72.180% of the variance. Results of the factor analysis indicate a high level of construct validity of the measure of 0.821.

Given that, most of the variables in factor 1 are more or less linked to labour, time, and cost the researcher decided to name this factor as labour wages and pay related. Issues in factor 2 could also be linked to poor morale; hence, factor 2 was termed poor morale related. Factor 3, Loss of future work related. Issues in factor 4 are associated with cost of construction workers; hence, it was named cost of construction related.

Factor analysis enabled the 26 critical factors to be placed under four (4) components as follows:

Component 1: Labour, time, and cost mechanism variances

Increased expenses of labour wages and pay, increased expenditure on building materials, increased time to construct the project and/or correct errors, increased total cost of project and reduced profit.

Component 2: Poor morale mechanism variances

Poor morale and Fatigue

Component 3: Loss of future work mechanism variances

Loss of future work

Component 4: Cost of construction mechanism variances

Increased cost of labour, Additional waste and handling cost.

Table 4.9: Rotated Component Matrix[a]

Factors	Component			
	1	2	3	4
Increased total cost of project	.760	.176	.354	.212
Increased expenses of labour wages and pay	.740	.179	.271	.342
Increased time to construct the project and/or correct errors	.770	.238	.287	.172
Increased time to redesign section of the project	.614	.233	.239	.437
Increased waiting time to recover from destruction to project sections	.332	.636	-.022	.463
Increased the number of construction workers	.422	.129	.396	.291
Additional waste handling cost	.626	.526	.073	.151
Extension of supervision man-power	.675	.470	.245	-.020
Stress	.327	.692	.421	.116
Fatigue	.287	.717	.404	-.049
Absenteeism	.275	.338	.577	.094
De-motivation	.398	.672	.359	.044
Poor morale	.289	.766	.043	.319
Reduced profit	.747	.329	.085	.299
Diminished professional image	.409	.570	.243	.310
Inter-organizational conflict	.263	.681	.164	.416
Loss of future work	.346	.130	.722	.066
Poor morale	-.019	.671	.494	.255
Increased expenditure on building materials	.774	.282	.202	.110
Increased expenses of labour wages and pay	.806	.233	.309	.139
Increased time to construct the project and/or correct errors	.600	.296	.321	.409
Increased time to redesign section of the project	.432	.465	.479	.378
Client dissatisfaction	.278	.231	.685	.292
Increased waiting time to recover from destruction to project sections	.417	.313	.362	.460
Increased cost of labour	.154	.112	.407	.769
Additional waste and handling cost	.387	.446	-.030	.735

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 23 iterations.
Source: Field Work (2016).

Table 4.10: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	14.550	55.963	55.963	14.550	55.963	55.963	6.874	26.438	26.438
2	1.710	6.577	62.540	1.710	6.577	62.540	5.403	20.782	47.220
3	1.319	5.075	67.614	1.319	5.075	67.614	3.459	13.305	60.526
4	1.187	4.565	72.180	1.187	4.565	72.180	3.030	11.654	72.180
5	.966	3.716	75.896						
6	.899	3.456	79.352						
7	.704	2.709	82.061						
8	.636	2.445	84.506						
9	.602	2.316	86.822						
10	.476	1.831	88.654						
11	.449	1.728	90.381						
12	.416	1.599	91.980						
13	.326	1.253	93.233						
14	.314	1.210	94.442						
15	.250	.962	95.404						
16	.229	.880	96.285						
17	.206	.793	97.078						
18	.168	.644	97.722						
19	.153	.587	98.309						
20	.105	.406	98.715						
21	.093	.358	99.073						
22	.080	.308	99.381						
23	.062	.240	99.621						
24	.045	.173	99.794						
25	.036	.137	99.931						
26	.018	.069	100.000						

Extraction Method: Principal Component Analysis.
Source: Field Work (2016).

Table 4.11: Communalities

Factors	Initial	Extraction
Increased total cost of project	1.000	.779
Increased expenses of labour wages and pay	1.000	.770
Increased time to construct the project and/or correct errors	1.000	.762
increased time to redesign section of the project	1.000	.679
Increased waiting time to recover from destruction to project sections	1.000	.729
Increased the number of construction workers	1.000	.436
Additional waste handling cost	1.000	.697
Extension of supervision man-power	1.000	.738
Stress	1.000	.777
Fatigue	1.000	.763
Absenteeism	1.000	.531
De-motivation	1.000	.741
Poor morale	1.000	.774
Reduced profit	1.000	.763
Diminished professional image	1.000	.648
Inter-organizational conflict	1.000	.732
Loss of future work	1.000	.662
Poor morale	1.000	.759
Increased expenditure on building materials	1.000	.732
Increased expenses of labour wages and pay	1.000	.820
Increased time to construct the project and/or correct errors	1.000	.718
Increased time to redesign section of the project	1.000	.775
Client dissatisfaction	1.000	.686
Increased waiting time to recover from destruction to project sections	1.000	.614
Increased cost of labour	1.000	.793
Additional waste handling cost	1.000	.889

Extraction Method: Principal Component Analysis.
Source: Field Work (2016).

4.6 Rework Reduction Strategies used by the Architectural Firms

In order to evaluate the rework reduction strategies used by the construction firms in Ghana, the study sought to undertake a simple descriptive statistics showing all the factors that can be used to evaluate the rework. The results obtained are ranked in descending order as shown in Table 4.12. Fifteen factors were used to address this objective as shown in Table 4.12. The factors were measured by mean and standard deviations and the significant mean level was pegged at 3.5. Anything above the 3.5 threshold is considered as a strong factor and those factors below the cut-off point is rejected and considered as a weak factor.

From the table, 11 factors out of the 15 had their mean values above the 3.5 threshold therefore, considered as strong factors. The factors are as follows; monitoring as the project proceeds, brainstorming in meeting, probability analysis, deducing from past experience, checklist of risk factors, ranking options, correlation analysis, sensitivity analysis, scenario analysis and direct judgment. The rest of the factors had their mean value below 3.5 thresholds and it means either the respondents were uncertain or disagrees with the responses.

Table 4.12: Descriptive of Statistics of Rework Reduction Strategies

Factors	Mean	Std. Deviation	Ranking
Monitoring as the project proceeds	4.32	0.716	1st
Brainstorming in meetings	4.27	0.751	2nd
Risk identification	4.23	0.786	3rd
Probability analysis	4.04	0.762	4th
Checklist of risk factors	4.02	0.774	5th
Deducing from past experience	4.02	0.798	6th
Ranking options	3.88	0.715	7th
Correlation analysis	3.82	0.917	8th
Sensitivity analysis	3.75	0.858	9th
Scenario analysis	3.66	0.880	10th
Direct judgment	3.59	1.005	11th
Aligning responsibility to stakeholders	3.23	1.144	12th
Simulation analysis	3.21	0.986	13th
Spotting rework possibilities	2.84	1.187	14th
Prioritisation of possible rework activities	2.75	1.164	15th

Source: Field Work (2016)

4.7 Challenges Construction Firms face in Minimising Rework on their Projects

In order to address the challenges construction firms face in minimising rework in Ghana, the study sought to undertake a simple descriptive statistics showing all critical factors that construction firms face in minimising rework. The results obtained are ranked in descending order as shown in Table 4.13. Eight factors were used to address this objective. The factors were measured by mean and standard deviations and the significant mean level was pegged at 3.5. Anything above the 3.5 threshold is considered as a strong factor and those factors below the cut-off point are rejected and considered as weak factors.

From the table, 6 factors out of the 8 had their mean values above the 3.5 threshold and it considered as strong factors. The factors are as follows; carelessness of workers, uncertainty about design changes from client, adverse behaviour of some workers, and difficulty in supervision, clients unable to define their specifications and recruitment problems in getting the right calibre of workers. The rest of the factors had their mean value below 3.5 thresholds and it means the respondents were uncertain.

Table 4.13: Descriptive Statistics on Challenges Architectural Firms faced in Minimising Rework

Factors	Mean	Std. Deviation	Ranking
Carelessness of workers	4.18	0.575	1st
Uncertainty about design changes from client	4.18	0.917	2nd
Adverse behaviour of some workers	4.13	0.764	3rd
Difficulty in supervision	4.04	0.852	4th
Unclear specification	4.00	0.831	5th
Recruitment problems in getting the right calibre of workers	4.00	1.027	6th
Lack of requisite materials and technology	2.88	1.161	7th
Poor communication	2.71	1.385	8th

Source: Field Work (2016)

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 Introduction

This chapter presents detailed discussion of the results of the study. The results are discussed in accordance with the research questions and objectives, and attempts are also made to relate findings to alternative or supportive views as stated in the literature review. This discussion is based on the four specific objectives of the study namely, examine the factors underlying rework in the construction industry in Ghana; assess the effects of rework in the construction industry in Ghana; identify key rework reduction strategies in the construction industry; and identify the challenges construction firms face in minimising rework on their projects.

5.2 Critical Factors underlying rework in the Construction Industry in Ghana

In order to examine critical factors underlying rework in the construction industry in Ghana, questionnaire was designed to ask a number of questions from respondents who were architects to determine the critical factors underlying rework in Ghanaian construction sites. On this objective, the study shows that, 19 extractions were made out of 37 factors. The factor extraction was under 10 components, therefore resulting in 10 major variable themes. In view of this, factor "1" had "design and construction related" with other two sub factors under it. As opposed to the other types of change, design deficiencies are often the result of ineffective quality control in the design process, and are controllable. The most prevalent explanation for the frequency of designer errors in construction is that clients transfer their finance to designers to complete projects in unreasonable time frame (short period) with cost cutting measures that encourages error through haste. Fayek et al. (2003) alluded to this explanation when they established that unrealistic time schedules and late designer inputs lead to errors that contribute to rework in construction. Furthermore, design related factors can also include ineffective use of quality management practices, poor coordination between different design team members, ineffective use of information technologies, lack of manpower to complete the required tasks, poor planning of workload, time boxing/ fixed time for a task, staff turnover/ re-allocation to other projects, insufficient time to prepare contract documentations, incomplete design at the time of tender, and inadequate client brief to prepare detailed contract documentation.

The result reveals that; factor "2" "re-construction due to quality failures related" had three sub themes under it. According to, Warhoe and Giammalvo (2009) design deficiencies, also known as designer errors and omissions are changes that result from faulty or confusing aspects of construction designs and specifications, attributable to the designer that are only detected well after the construction phase of the project has started.

Factor "3", "coordination and integration related" had two sub factors under it. Poor coordination and integration of design team members with respect to contract documentation also significantly contributes to rework. The CII (1990) advised that in cases where there is insufficient time to complete contract documentation, the design team should provide the contractor with an assessment of design status and the potential for changes. The advantage is that the information enables the contractor to provide a realistic tender price and project programme as well as establish the mechanisms and procedures for administrating changes.

Factor “4”, “client involvement in the project related” had three sub factors under it. This emerged as a critical factor that causes rework in Ghanaian construction firms. According to Palaneeswara (2006), client-related factors include lack of experience and knowledge of design and of the construction process; lack of funding allocated for site investigation; lack of client involvement in the project; inadequate briefing; poor communication with design consultants (Love et al., 2002); and inadequacies in contract documentation (Fayek et al., 2003).

Factor “5”, “errors and omissions related” had two sub factors under it. This emerged as a critical factor that causes rework in Ghanaian construction firms. According to Love and Li (2000), the general cause of construction rework results from three related concepts, namely, change, errors, and omissions. According to the authors, change refers to a directed action altering the currently established requirements; errors are items or activities in a system that are performed incorrectly resulting in a deviation, and omissions are parts of a system including design, construction, and fabrication that have been left out resulting in a deviation. Again, Love et al. (2009) further emphasise that rework might also occur due to errors, where construction errors are the result of incorrect construction methods and procedures and are human-related. Errors in themselves have causes, some of which are negligence, lack of communication, poor coordination and integration and lack of, or inadequacy of skills and training.

Factor "6", "site investigation related" had three sub themes under it. Chang and Ive (2007), however, established that unanticipated site investigation and conditions are worth making note of only if the contractor experiences an increased cost and/or delay. For example, a contractor performs earth excavation without knowing the previous use of the land such as mining activity, former refuse damp etc. These extraordinary measures can easily cost the contractor additional money and/or time above that for which they were originally contracted.

Factor "7", "poor documentation related" had three sub factors under it. Poor documentation is underlain by certain factors. For example, Coles (1990) and Rounce (1998) noted that poor workload planning within design organisations can also result in inadequate time to prepare complete design documents. Moreover, Coles (1990) noted that the use of inexperienced staff that lack technical knowledge could lead to errors and omissions in contract documentation being made. Tilley and McFallen (2000) also found that unrealistic client demands for earlier completion of projects was a major contributing factor to the production of incomplete and erroneous contract documentation. Love et al. (2010) further argued that lack of professionalism by design professionals due to reduced design fees can further result in inadequate contract documentation leading to rework.

Factor "8", "poor communication with design consultants related" contributes to rework in architectural firms in Ghana. Fayek et al. (2003) identified the following possible causes pertaining to communication and leadership as ineffective management of project team, lack of safety and quality assurance and control commitment, poor communication and lack of operation persons‟ buy-in. Poor leadership could also contribute to inappropriate „time boxing‟ practices, a practice which occurs when fixed durations are allocated to undertake tasks, irrespective of how complete (or incomplete) the design documentation or design task is (Love et al., 2008). That fixed period of time may be allocated to complete each task, irrespective of whether the documentation or each individual task is complete or not.

Factor "9", "community hostility related" contributes effectively to the causes of rework in Ghana. Community hostility is undue pressures that are exerted by the community to the contractor in an attempt to complete the project. This pressure can be due to over delay of the completion date of the project and this leads to a lot of errors and omissions in the project.

Finally, factor "10", "unclear instructions related" had three sub themes under it. This means that architects may give instructions to workers to follow but the mode of passage; the operatives may not understand and apply. Unclear instructions to operatives can result in a lot of errors in the project.

5.3 Effects of Rework in the Construction Industry in Ghana

In order to assess the effects of rework in the construction industry in Ghana, questionnaire was designed to ask a number of questions from respondents who were architects to determine the critical factors that affect rework in Ghanaian construction sites. On this objective, the study shows that, 11 extractions were made out of 26 factors.

The factor extraction was under 4 components, therefore resulting in 4 major variables themes.

Factor "1" "labour, time and cost related" had six sub factors under it. Labour, time and cost factors that affect rework in construction site in Ghana. This is in conformity with Love and Li (2000) who asserted that, rework can be indicated by the time, labour and cost overruns resulting from the changes made in the construction project. For example, if work has been done incorrectly, this can be seen as non-productive time and rework takes effort and thus extra labour. If more hours (and thus more labour costs) were needed to realise a project than estimated, it might have been because of rework actions. Moreover, rework often means that parts of a structure have to be scrapped and new material is needed to rebuild it. It is observed that the factors mentioned above have in common, delayed, extra labour and extra materials and cost overrun, which are seemingly the most important indicators for rework.

Again, factor "2""poor morale related" affects rework greatly at the construction site. According to Abdul-Hamid and Madnick (1991) there are several more indirect consequences of rework that are a lot harder to express in terms of money or costs. They are of the view that, at individual level, stress, fatigue, absenteeism, de-motivation, and poor morale have been found to be the primary indirect effects of rework. Love et al. (2000) also established that when an individual is subjected to prolonged work hours, errors, changes or omissions, fatigue and stress are likely to emerge, increasing the likelihood of rework occurring.

Moreover, factor "3", "loss of future work related" has indirect repercussions on rework. This implies that, shoddy work of current contract will make it difficult for the contractor winning new contract. This will affect the credibility of the contractor. This is in line with Love (2002) who identifies that loss of future work as indirect effects of rework at organisational level.

Finally, factor "4", "cost of construction related" affects rework in Ghanaian construction industry.Many research studies have sought to determine the amount of rework costs within projects.Cost overrun represents the most direct effect of rework. Avots (1983) defined cost overrun as situations in which the final cost of the project exceeds the original estimates. Azhar et al. (2008) asserted that cost overrun is very frequent within the construction industry. Most of the significant factors affecting project costs are qualitative, such as the client‟s priority on construction time; contractor‟s planning capability, procurement methods, and market conditions, including the level of construction activity (Elchaig et al., 2005). Love (2002), as well as Endut et al. (2005) however, noted that cost overruns are major problems in project development and that rework also leads to potentially high cost increases.

5.4 Rework Reduction Strategies used by the Architectural Firms

In order to assess the rework reduction strategies used by the architectural firms, the questionnaire was designed to ask a number of questions from respondents which bordered on architects efforts to establish the rework reduction strategies used by the architectural firms in Ghanaian construction industry. The respondents were asked to score their objective on the likert scale of 1-5. The objective was ranked using the overall mean and standard deviations as shown in Table 4.12.The results show that only 11 out of 15 factors had their mean value above 3.5 threshold and those factors below the 3.5 cut-off were rejected as weak factors. The study revealed the following:

The study shows that, the “monitoring as the project proceeds” factor had a mean value of 4.32 as shown in Table 4.12. This assertion is in conformity with Palaneeswaran et al. (2005) who noted that inconsistent and non-systematic approaches for monitoring rework occurrence underlay construction failure and rework, because rework impacts on performance and productivity aspects have been somehow resolved by adopting various tactics and measures, such as through contract management, quality management, project management, and value management.

Furthermore, the factor “brainstorming in meetings” emerged the second highest with a mean value of 4.27. This result means that the respondents either agree or strongly agree in the five-point likert scale that brainstorming in meetings is one of the rework reduction strategies in architectural firms in Ghana. The ability to think in meetings helps architects to give good suggestions that can help to reduce reworks in Ghana. This is in line with the assertion by Flanagan & Norman (1993) and Maytorena (2005) that brainstorming is the sources, classification and effects of the risks. Again, brainstorming is mostly used in identification of possible rework risk (Akintoye & MacLeod, 1997; Uher & Toakley, 1999; Lyons & Skitmore, 2004).

More so, the factor "Risk identification" emerged the third highest reduction strategy with a mean value of 4.23 as shown in Table 4.12. This shows that, the respondents either agree or strongly agree with the five-point likert scale. This assertion is in line with Palaneeswaran (2006) that, the main idea of the framework is that rework arises from risks which should be managed through a risk identification process, as in spotting rework items, through quality inspections and routine observations. Again, risk identification in rework is characterised by isolating the possible risks, by breaking down the risk structure and brainstorming the sources, classification and effects of the risks (Flanagan & Norman, 1993; Maytorena, 2005).

Also, the factor, "probability analysis" had a mean value of 4.04 and it means that the respondents agree with the five-point likert scale. This means that rework can be reduced through probability analysis. Again, risk reduction is a proactive action taken to either reduce the probability of the event occurring or to reduce the impact of it, whereas fall-back refers to a reactive form of reducing the impact of the threat with no influence on the probability. Probability analysis involves reducing the impact of risks, mostly only the financial impacts, by assigning the risk reduction responsibility to a third party (Zou et al., 2006).

Again, the study shows that the factor "checklist of risk factors" had a mean value of 4.02 and it means that the respondents agree with the five –point likert scale. The checklist tries to assess the safety of the work by considering only the unsafe conditions existing in the work site irrespective of either small or large projects. Specifications or list of risk factors in contract project helps to identify portions where cautions should be taken. This helps the artisans to be cautious at the site.

Moreover, the study shows that the factor “deducing from past experience”had a mean value of 4.02 and it means that the respondents agree with the five –point likert scale. This implies that knowledge and experience from previous project helps the artisans to minimize errors in the present contract. This is in conformity to the assertion by Coles (1990) that use of inexperienced staff that lack technical knowledge could lead to errors and omissions in contract documentation being made.

In addition, the study shows that the factor “ranking options” had a total value of 3.82 and it implies that the respondents agree the five –point likert scale. Ranking options of factors demonstrated according to their importance level on rework reduction strategy. This shows that, the most contributing rework reduction strategy factors and categories (those need attention) are ranked in order to minimize and control rework in construction projects.

Also, the study shows that the factor “correlation analysis” had a total value of 3.82 and it implies that the respondents agree with the responses. This shows the degree and type of relationship between any two or more quantities in which they vary over period. This means the willingness to undertake risk by the architect in the construction projects.

More so, "sensitivity analysis"" had a total value of 3.75 and it implies that the respondents agree with the responses. Knowing that design quality assurance is not always perfect; the construction architects can improve construction performance by eliminating the impact of design undiscovered rework on the construction phase. Sensitivity analysis is thorough recheck the drawings that were approved by design quality assurance department prior to initial completion in the construction phase. So the Contractor needs to pay extra money to the architects and engineers they hired to recheck the drawings. By doing this, most of the design errors can be found before the work is installed.

Again, the factor "scenario analysis"" had a total value of 3.66 and it implies that the respondents agree with the responses. Scenario or situation analysis by the architect is one of the measures that can help reduce rework. Situation report by the architect on the project given details of the project from the start to completion can reduce rework at the construction in Ghana.

Finally, the factor, "direct judgment"" had a total mean value of 3.59 and it implies that the respondents agree with the responses.During construction, architects can reduce rework that is attributable to human error or poor workmanship by making direct decision that will be accepted by all. He/she shouldprovide ameliorated supervision and leadership on-site and invariably assume the role of production inspectors and therefore possess knowledge, on the causes and prevention of rework. During construction, he/she is the project driver, as they direct the specific work that needs to be undertaken (Howell et al., 1993).

5.5 Challenges Construction Firms face in Minimising Rework on their Projects

In order to assess the challenges construction firms face in minimising rework on their project site, the respondents were asked to score their objective on the likert scale of 1-5. The objective was ranked using the overall mean and standard deviations as shown in Table 4.13. The results show that only 6 out of 8 factors had their mean value above 3.5 threshold and those factors below the 3.5 cut-off were rejected as weak factors. The factor "carelessness of workers" emerged the highest with mean value of 4.18. Carelessness of workers shows the workers do not obey simple rules and regulations governing rework at the site. This has contributed immensely to the increases in rework at the construction site. This is in conformity to the assertion by Hellard (1991) that, lack of knowledge and carelessness contribute to errors occurring in the projects, both of which can be corrected.

Furthermore, the factor "Uncertainty about design changes from client" also emerges the second great challenge construction firms faced in their attempt to minimise rework on their project site. This arises from indecisiveness on the part of the client with respect to design changes. When there is a design change in the course of construction, portions of the construction suffers in terms of cost and time in redesigning. This assertion is in conformity to Ballard (1994) that project rework might occur, because inspections do not cater for uncertainties about design changes from client and planned activities may not cover all unforeseen events.

Also, the factor "adverse behaviour of some workers" emerged the third great challenge architectural firms in Ghana confront in their attempt to minimize rework. Workers behaviour in terms of materials specifications, interpretation of working drawings and others poses great challenge to rework. Also, the quality of human resource is important for militating against rework. According to Hollis (1993), organisations have to harness the skills of the right people at the right time and integrate and coordinate their work with other organisations involved with a project. Lack of knowledge and carelessness contribute to errors occurring in the projects, both of which can be corrected (Hellard, 1991). Human resources should be given appropriate attention since they are capable of producing and preventing errors.

Again, the factor "difficulty in supervision" emerges the fourth great challenge from the perspective of the respondents in the five-point likert scale. Poor supervision of construction works at site give room for shoddy works. When this happens the client needs to invest more money for rework to be carried out. This affects the client in terms of cost and more time will be spent on the project. This is in conformity to the assertion by Love et al. (1999) that, the specific challenges that contribute to rework include inadequate supervision. Again, Alwi et al. (2001) also stated that inadequate supervision, inexperienced supervisors and lack of skilled labour are the major challenges of rework.

Moreover, the factor “unclear specification” emerged the fifth important challenge that architectural firms in Ghana in an attempt to minimize rework face. Unclear specification on the part of the project managers, architects, engineers and other professionals give room for a lot of reworks occurring at the site. Difficulty in interpreting construction designs and specification give room for more rework occurring at the site.

Finally, the factor “recruitment problems in getting the right calibre of workers” poses other challenge architectural firms in Ghana face. Failures to recruit experienced and qualified workers who can interpret designs contribute immensely to rework in Ghana. Recruiting inexperienced personnel is a serious challenge, as they may be unable to define their specific requirements and also understand the client"s problem and translate such into a design that can be effectively documented and constructed is another challenge militating against minimising rework in Ghana.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter provides a summary of the main findings, conclusions and recommendations of this research. The area for further research is also discussed at the end of this chapter. It begins with how it was carried out and then touches on the summary of the main findings of the work

6.2 Summary of Findings

This section outlines the main findings and outputs of the study. The research objectives are revisited to highlight the extent to which they were accomplished through the various phases of the research. It is divided into three sub-sections to facilitate an appropriate correspondence of the outcomes with the specific objectives enumerated in chapter one.

6.2.1 Objective 1: Factors Underlying Rework in the Construction Industry in Ghana

An extensive literature review was carried out on the factors underlying rework in the construction industry in Ghana. The first objective to the study was examining the factors underlying rework in the construction industry in Ghana. This objective has been fulfilled in that; 37 factors underlying rework in construction sites were empirically identified from literature. The findings indicated that, the eight most highly ranked influential factors to be considered to improve rework at construction sites are:

- Employee turnovers and unrealistic schedules

- lack of experience and knowledge of design and of the construction process,
- re-construction due to quality failures
- pressure for early completion
- correction of on-site errors in design
- Lack of design coordination and integration
- inadequacies in contract documentation
- client initiated changes in design and execution

6.2.2 Objective 2: To Assess the Effects of Rework in the Construction Industry in Ghana

An extensive literature review was carried out on the effects of rework in the construction industry in Ghana. The second objective to the study was assessing the effects of rework in the construction industry in Ghana. This objective has been fulfilled in that; 26 factors underlying rework in construction sites were empirically identified from literature. The findings indicated that, the four most highly ranked influential factors to be considered to improve rework at construction sites are:

- increased expenses of labour wages and pay
- increased expenditure on building materials
- increased time to construct the project and/or correct errors
- increased total cost of project

6.2.3 Objective 3: To Identify Key Rework Reduction Strategies in the Construction Industry

An extensive literature review was carried out on the rework reduction strategies in the construction industry in Ghana and the results were ranked. The third objective to the study was identifying key rework reduction strategies in the construction industry. This objective has been fulfilled in that 15 key reduction strategies factors in construction sites were empirically identified from literature. The findings indicated that, the six most highly ranked influential factors to be considered to improve rework at construction sites are:

- monitoring as the project proceeds
- brainstorming in meetings
- Risk identification
- probability analysis
- checklist of risk factors
- deducing from past experience

6.2.4 Objective 4: To Identify Challenges to Minimising Rework on Projects Sites.

An extensive literature review was carried out on the challenges construction firms face in minimising rework on their projects in Ghana and the results were ranked. The forth objective to the study was identifying the challenges construction firms face in minimising rework on their projects in Ghana. This objective has been fulfilled in that 8 challenges construction firms faced in minimising rework on their projects were empirically identified from literature. The findings indicated that, the six most highly ranked influential challenges to be considered to improve rework at construction sites are:

- carelessness of workers
- uncertainty about design changes from client
- adverse behaviour of some workers
- difficulty in supervision
- unclear specification
- recruitment problems in getting the right calibre of workers

6.3 Conclusions

Based on the findings of the study, the following conclusions are drawn:

- The analysed results proved that the eight critical factors underlying rework in Ghanaian construction sites are; Insufficient turnovers and unrealistic schedules, lack of experience and knowledge of design and of the construction process, re-construction due to quality failures, pressure for early completion, correction on-site errors in design, lack of design coordination and integration, inadequacies in contract documentation and client initiated changes in design and execution.
- Again, from the analysed results, the four critical effects of rework in Ghana are; increased expenses of labour wages and pay, increased expenditure on building materials, increased time to construct the project and/or correct errors and increased total cost of project.
- Furthermore, the results proved that, the six factors considered as effective rework reduction strategy in the construction industry in Ghana are; monitoring as the

project proceeds, brainstorming in meetings, risk identification probability analysis, checklist of risk factors and deducing from past experience.

- Finally, analysed results proved that the six key challenges construction firms face in their attempt to minimise rework on their projects in Ghana are carelessness of workers, uncertainty about design changes from client, adverse behaviour of some workers, difficulty in supervision, unclear specification and recruitment problems in getting the right calibre of workers.

6.4 Recommendations

Based on the findings the following recommendations are drawn:

- Architects should review newly release working drawings in order to prevent any field inconsistency prior to construction. He/she should carefully double-check all specifications and designs to verify their compatibility with actual project construction (especially when adopting the same design from a previous project).
- Numerous rework incidences occurred on site fixing errors originally made in the shop yard. There should be an effective and timely communication between field personnel and the shop yard to discuss any field changes that could lead to rework. For example, if a change occurs on the field, the shop yard should be immediately informed about this change, and then make the proper modifications to avoid sending the incorrect piece of material that would then need to be fixed on site (and thereby contributing to rework).
- Rework cause classification should be an unbiased process. The field rework coordinator should consult all parties involved in the incidence, before classifying

rework causes and apportioning percentages. The field rework coordinator should also have access to information at both field and engineering management levels.

- It is recommended that architects responsible for the most affected types of project should be aware of the different cost impacts of rework when drafting pre-project and quality management plans.
- Furthermore, architects should develop or implement systems for tracking and controlling contractor error/omission for owners, design change for contractors, and owner change and design error/omission for both owners and contractors in order to reduce rework by these sources.
- Also, if rework in construction has to be reduced or eliminated there is the need for consensus on a workable mechanism to bring together the client, consultant and the contractor to minimize change orders and introduction of additional works during construction phase.
- Again, it is recommended that the clerk of work should be part of the construction at the design stage of the project. This helps the clerk of work to be abreast with the working drawings and specification at the design stage.
- Moreover, the architect should intensify supervision during the execution stage of the project. This will help to minimise reworks in the construction industry.
- Furthermore, the architect should liaise with the contractor during recruitment of personnel for the project. This will help to get the right calibre of personnel who has an in-depth knowledge to execute the contract to minimise reworks.
- Finally, it was evident from the findings that the economic benefits of quantifying the total costs of rework, both direct and indirect, have been overlooked. Besides,

it was established that rework can make a significant contribution to a project‟s cost overrun. Therefore, to decrease the direct and indirect rework costs and improve overall project performance, it is recommended that construction organisations begin to consider and measure them, so that understanding of their magnitude can be captured. Also, effort needs to be made to improve skills and knowledge; otherwise the loss of reputation, delays and disruptions to construction and loss of profit will become products of rework that arises on-site.

6.5 Suggestions for Future Research

With its particular focus on the field of architectural consultancy firms in Ghana, the case study used in this research is not perfectly representative of the overall construction industry. Several areas of research therefore remain to be examined;

- Rework on the perspective of clerk of works at the design and execution stage of the construction contract in order to avoid rework in the construction industry in Ghana. The researcher is of view that the appointment and working relationship between the clerk of works and the contractor has a significant role in the cause of rework in construction industry.
- More pilot studies involving a variety of construction groups will increase awareness of the impact of rework and reduction strategies especially on road construction in Ghana. Huge sum of money is invested road construction; research should be conducted to come out with cause and reduction strategies in to reduce cost of road construction in Ghana.

- On the other hand, when the problem is viewed from the perspective of prevention, if an area that has a high possibility of rework can be detected, and appropriate preventive action can be taken, the costs will be significantly reduced. To implement such a process, one approach recommended for the further studies is to quantify and classify the characteristics of the job during which the rework occurs according to the terms of the detailed scope of the work, the technology applied, the skills required on the part of the crew, the materials and equipment, and the specific circumstances. Recognizing similar job characteristics can enable the detection of areas that have a strong possibility of rework.

REFERENCES

Abdul-Hadi, N. H. (1999). *Factors affecting bidding and mark up decisions in Saudi Arabia* [Master"s Thesis, King Fahd University of Petroleum &Minerals, Dhahran, Saudi Arabia: Gold Coast, Australia]. Engineering and Construction Services Department, UNRWA, Gaza City, Israel.

Abdul-Hamid, T. K. & Madnick, S. E. (1991). *Software project dynamics -an integrated approach.* Prentice-Hall, Englewood Cliffs, NJ

Abdul-Rahman, H. (1993). *The management and cost of quality for civil engineering projects.* Unpublished Ph.D. dissertation submitted to the Institute of Science and Technology, University of Manchester.

Abdul-Rahman, H. (1995). The cost of non-conformance during a highway project: A case study. *Construction Management and Economics, 13*(1), 23–32.

Acharya, N. K., Lee, Y. D., & Kim, J. S. (2006). Design errors: Inefficiency or carelessness of designer? *Journal of Performance of Constructed Facilities, 20*(2), 192-195.

Adams C.E. (*1994*). *Management Behaviour towards Operatives on Construction Sites,* Thesis, Virginia Polytechnic Institute and State University www.ajaronline.com/index.php/AJAR/article/download/173/143

Akin, O. (1986). *Psychology and architectural design*. London: Pion.

Akintoye, A. (2000). Analysis of factors influencing project cost estimating practice, *Construction Management and Eco-nomics18*: 77–89

Akintoye, A. S., & Macleod, M. J. (1997). Risk analysis and management in construction. *International Journal of Project Management, 12*(1), 31-38.

Alkass, S., Mozerolle M., Tribaldos, E., & Harris F. (1995). Computer aided construction delay analysis and claims preparation. *Journal of Construction Management and Economics, 13*, 335-352.

Alkass, S., Mozerolle, M., & Harris, F. (1996). Construction delay analysis techniques. *Journal of Construction Management and Economics, 14*(5), 375-394.

Al-Khalil, M. I., & Al-Ghafly, M. A. (1999). Delay in public utility projects in Saudi Arabia. *International Journal of Project Management, 17*(2), 101-106

Alwi, S., Hampson, K., & Mohamed, S. (2001). Effect of quality supervision on rework in the Indonesian context. *Asia Pacific Building and Construction Management Journal, 6,* 1- 9. And ownership structure", *Journal of Financial Economics, vol. 3, no. 4, pp. 305-306.*

Aramo-Immonen, H., & Vanharanta, H. (2009). Project management: The task of holistic systems thinking. *Human Factors and ergonomics in Manufacturing & Service Industries, 19*(6), 582–600.

Architectural Consultancy Firm (2014) Ghana Institute of Architect, Accra Ghana.

Arge, K. (1995). Architectural quality. *Building Research and Information, 23*(4), 234–236.

Ashford, J. L. (1992). *The management of quality in construction*. London: E & F Spon.

Ashworth, A. (2001). Contractual Procedures in the Construction Industry, UNITEC, New Zealand

Assaf S. A., Abdul-Aziz, B. A., Atiyah S., & Al-Shahri, M. (2001). The Management of construction company overhead costs, *International Journal of project Management*, *19,* 295-303.

Assah-Kissiedu, M., Fugar, F.D.K. & Badu, E., (2010). Triggers of Disputes within the Ghanaian Construction Industry. *In Proceedings 5th Built Environment Conference (*Vol. 18, p. 20

Atkinson, A.R. (1999). The role of human error in construction defects. *Structural Survey, 17*(2), 231-236.

Avots, I. (1983). Cost-relevance analysis for overrun control. *International Journal of Project Management, 1*(3), 142-148.

Awakul, P. and Ogunlana, S.O. (2002), "The effect of attitudinal differences on interface conflicts in large scale construction projects: a case study", *Construction Management and Economics,* 20 (4), 365-77.

Azhar, N. Farooqui, R. U. & Ahmed S. M. (2008). *Cost overrun factors in construction industry of Pakistan*. First International Conference on Construction in Developing Countries (ICCIDC–I) "Advancing and Integrating Construction Education, Research & Practice" August 4- 5, 2008, Karachi, Pakistan.

Aziz, R. F. & Hafez, S.M., (2013). *Applying lean thinking in construction and performance improvement. Alexandria Engineering Journal.* [Online publication date: 1-May-2013].

Babbie, E. (2005). *The Basics of Social Research* (3rd ed). Thomson/Wadsworth.

Ballard G (2000). Phase Scheduling, White Paper #7, Lean Construction Institute, *Available at www.lean- construction.org*

Ballard G. (1994). *The last planner*. California: Northern Californian Construction Institute.

Ballard, G. (1997). *Look ahead planning*. Proceedings of the 5th Annual Conference of the International Group for Lean Construction, Griffith University, Gold Coast, Australia, July, 1997.

Ballard, G., & Howell, G. (1997). Shielding production: an essential step in production control. *ASCE Construction Engineering and Management, 124*(1), 11–17.

Barber, P. Sheath, D. Tomkins, C., & Graves, A. (2000). The cost of quality failures in major civil engineering projects. *International Journal of Quality and Relational Management, 17*(5), pp. 479–492.

Barber, P., Graves, A., Hall, M., Sheath, D., & Tomkins, C. (2000). Quality failure costs in civil engineering projects. *International Journal of Quality and Reliability Management, 17*(5), 479–492.

Barber, R. B. (2005). Understanding internally generated risks in projects. *International Journal of Project Management, 23,* 584–590.

Berkeley, D., Humphreys, P. C. & Thomas, R. D. (1991). Project Risk Action Management, *Construction Management and Economics*, 9(1),317.

Bland, J.T. (2001). Front Line Participatory Behavior in the Era of Networks, *Doctor of Philosophy In Public Administration/Public Affairs*. Virginia Polytechnic Institute and State University.

Borg, W. R., Gall, J. P., & Gall, M. D. (1993). *Applying educational research*, (3rd ed.). New York: Longman.

Bramble, B. B., & Callahan, M. T. (2000). *Construction delay claims*. New York: Aspen Publishers.

Brown, E. M., & Chong Y., (2000). *Managing Project Risk*, Person Education Limited, London.

Building Research Establishment. (1982). *Quality in traditional housing: An investigation into faults and their avoidance*. London: Building Research Establishment.

Bums, N., & Grove, S. K. (1987). The practice of nursing research: Conduct, critique and utilization. Philadelphia : W .B. Saunders.

Burati, J. L., Farrington, J. J., & Ledbetter, W. B. (1992). Causes of quality deviations in design and construction. *Journal of Construction Engineering and Management, 118*(1), 34–49.

Burati, J., & Farrington, J. (1987). *Cost of quality deviations in design and construction*. Austin: Construction Industry Institute.

Business Roundtable (1982). Modern Management Systems. A Report of Construction

Carlson, M. D. Morrison, R. S. (2009). User's guide to research in palliative care: Why is a new series needed? J Palliat Med.;11:1258–1261.

Ceric, A. (2003). *A framework for process-driven risk management in construction projects.* Unpublished PhD Thesis, Research Institute for the Built & Human Environment, School of Construction and Property Management, University of Salford, Salford.

Ceric, A. (2012). *Strategies for minimizing information asymmetries in construction projects: Project managers' perceptions.* Engineering Project Organizations Conference Rheden, The Netherlands July 10-12, 2012

Chan, D. W. M., & Kumaraswamy, M. M. (1997). A comparative study of causes of time overruns in Hong Kong construction projects. *International Journal of Project Management, 15*(1), 55-63.

Chan, D.W.M. (1998), "Modelling construction durations for public housing projects in Hong Kong*", unpublished PhD thesis, The University of Hong, Hong Kong*

Chang, C. Y., & Ive, G. (2007). The hold-up problem in the management of construction projects: A case study of the channel tunnel. *International Journal of Project Management, 25*(4), 394-404.

Cheung, Y. K., &Chau, K. W. (2005). *Tall buildings from engineering to sustainability*. Sixth International Conference on Tall Buildings, Mini Symposium on Sustainable Cities, Mini Symposium on Planning, Design and Socio-Economic Aspects of Tall Residential Living Environment Hong Kong, China, 6 – 8 December 2005

Coles, E. J. (1990). *Design management: A study of practice in the building industry*. London: The Chartered Institute of Building.

Construction Industry Development Agency. (1995). *Measuring up or muddling through: best practice in the Australian non-residential construction industry*. Sydney: Construction Industry Development Agency and Master Builders.

Construction Industry Institute (CII) (2003). *Benchmarking and metrics program* [online]. [Accessed 29 March 2011]. Available at: http://cii-benchmarking.org/downloads/ 3_the_metrics.ppt/ [cited 15 February 2003].

Construction Industry Institute. (1990). The impact of changes on construction cost and schedule. Texas: Construction Industry Institute.

Construction Industry Institute. (2001). *The field rework index: early warning for field rework and cost growth*. Austin: Construction Industry Institute.

Construction Owners Association of Alberta (COAA) (2001). *Field rework committee meeting minutes*. Edmonton: Construction Owners Association of Alberta.

Creswell, J.W. (2003). Research Design, Qualitative, Quantitative and Mixed Methods Approach, (2nd ed.), University of Nebraska, Omaha, Sage Publications.

Cusack, D. (1992). *Implementation of ISO 9000 in construction.* ISO 9000 Forum Symposium, the International Group for Lean Construction, Gold Coast, Australia, 157-167.

Danso, F. O. (2010). *Occupational Health and Safety issues involving casual workers on building construction sites in Ghana*, a Kumasi study, MSc thesis, Kumasi: Kwame Nkrumah University of Science and Technology.

De Vaus, D.A (2001). Research Design Social Research, SAGE Publication, London.

Dell'Isola, A. (1997). *Value engineering: Practical applications for design, construction, maintenance and operations*. Kingston, MA: RS Means.

Diekmann, J. E., & Nelson, M. C. (1985). Construction claims: Frequency and severity. *Journal of Construction Engineering and Management 111*(1), 8-15.

Division of Engineering (2004). Construction Inspection Handbook (360 FW 4) U. S. Fish and Wildlife Service Department of the interior https://www.fws.gov/policy/consthdbk-1.pdf

Dixit, Vasudev N. (2002). "Familial Allocentrism and Ethnic Identity Salience Among Asian Indians Living in the United States" SetonHall University Dissertations and Theses (ETDs).Paper 1899.

Egan J (1998). Rethinking construction. In Aminudin, BA (2006).Exploitation of contract documents for construction project planning and controlling. Unpublished Master of Science thesis, faculty of Civil Engineering, Universiti Teknologi, Malaysia.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, 14: 532–55.

Elchaig, T., Boussabinaine A., & Ballal T. (2005). "Critical determinants of construction tendering costs: Quantity surveyors" standpoint*", International Journal of Project Management*.

Elhag T. M. S., & Boussabaine A. H. (1999). "Evaluation of Construction Costs and Time Attributes", *Proceedings of the 15th ARCOM Conference. Vol. 2,* Liverpool: John Moores University, 473-80.

Endut, I. R. Akintoye, A., & Kelly, J. (2005).*Cost and time overruns of projects in Malaysia*. Proceedings of the 2nd Scottish Conference for Postgraduate Researchers of the Built and Natural Environment (PRoBE) 16-17 November, Glasgow Caledonian University.

Enshassi, A., Mohamed, S., & El Karriri, A. (2010). "Factors affecting the bid/no bid decision in the Palestinian construction industry", *Journal of Financial Management of Property and Construction, Vol. 15*Iss: (2) pp.118 – 142.

European Commission. (2011). *FWC sector competitiveness studies: Sustainable competitiveness of the construction sector.* Retrieved on December 29 2014 from

Faniran, O. O., Love, P. E. D., & Li, H. (1999). Optimal allocation of construction planning resources. *ASCE Journal of Construction, Engineering Management, 125*(5), 311–319.

Fayek, A., Dissanayake, M., & Campero, O. (2003). *Measuring and classifying construction field rework: A pilot study.* Executive Summary prepared to the Construction Owners Association of Alberta, Department of Civil and Environmental Engineering, The University of Alberta, Canada.

Field, A. (2005). “Discovering Statistics using SPSS for Windows” London: Sage

Figueiredo, F., &Kitson, B. (2009). Defining risk and contingency for pipeline projects. *AACE International Transactions, 8*(1), 1-10.

Flanagan, R.., & Norman, G. (1993), Risk management and construction. Oxford: Blackwell Scientific Publications.

Frimpong, Y., Oluwoye, J., & Crawford, L. (2003). Causes of delays and cost overruns in construction of groundwater projects in developing countries: Ghana as a Case Study. *International Journal of Project Management, 21,* 321-326.

Fugar, F. D. K., &Agyakwah-Baah, A. B. (2010). Delays in building construction projects in Ghana. *Australasian Journal of Construction Economics and Building*, 103-116

Grable, J. E. (2010). Financial risk tolerance and additional factors that affect risk taking in everyday money matters. *Journal of Business and Psychology*, 625-630.

Hair, J.F., Anderson, R. E., Tatham, R.L., & Black, W.C., (2007), “Multivariate Data Analysis with Reading”, Prentice-Hall, Englewood Cliffs, NJ

Hellard, R. B. (1991). *Total quality management in construction practice, in practice management: New perspectives for the construction professional.* London: E & F Spon.

Hollis, W. (1993). Design in the service sector. *Managing Service Quality, 3*(3), 33–37.

Horne, J. (2008). *Signalling and screening*. Palgrave McMillan: Hampshire.

Horner, R. M. W., &Talhouni, B. T. (1995). *Effects of accelerated working, delays, and disruptions on labour productivity*. London: Chartered Institute of Building.

Howell G., Laufer A., & Ballard G., (1993). Interaction between sub-cycles: one key to improved methods, ASCE *Journal of Construction*, *Engineering and Management*, 119(4), 714–728.

Howick, S. (2003). Using system dynamics to analyse disruption and delay in complex projects for litigation: can the modelling purposes be met? *Journal of the Operational Research Society, 54*, 222-229. *http://ec.europa.eu/enterprise /sectors/construction/files/compet/sustainable_competitiveness/ecorys-final-report_en.pdf.*

Hwang, B.-G., Thomas, S., Haas, C., & Caldas, H. (2009). "Measuring the impacts of rework on construction cost performance by project characteristics and sources or rework". *ASCE Journal of Construction Engineering and Management* , 187-198.

Idrus, A.B. & Newman, J.B. (2002). Construction related factors influencing the choice of concrete floor systems. *Journal Construction Management and Economics, 20,13 19*.

Industry Cost Effectiveness Project. The Business Roundtable, New York.

Ireland, V. (1985). The role of managerial actions in the cost, time and quality performance of high rise commercial projects. *Construction Management and Economics, 3*(1), 59-87.

Jafaari, A. (1996). Human factors in the Australian construction industry: Towards total quality management. *Australian Journal of Management, 21*(2), 159-185.

Jager, C. (2008). *The principal-agent theory within the context of economic sciences*. Norderstadt: Books on Demand.

Jensen, M.C. & Meckling, W. H (1976). "Theory of the firm: Mssssanagerial behavior, agency costs

Johnson, R.A., & Witchen, D.W. (2007). Applied multivariate statistical analysis. *UpperSaddle River Upper Saddle River, NJ: Pearson Prentice Hall.*

Josephson, P. E., & Hammarlund, Y. (1999). The causes and costs of defects in construction. A study of seven building projects. *Automation and Construction, 8*(6), 642–681.

Josephson, P. E., Larsson, B., & Li, H. (2002). Illustrative benchmarking rework and rework costs in Swedish construction industry. *ASCE Journal of Management in Engineering, 18*(2), 76-83.

Kaminetzky, D. (1991). *Design and construction failures: Lessons from forensic investigations.* New York: McGraw-Hill.

Karma, J. M. (1999). "Client requirements processing for concurrent life-cycle design and construction," Ph.D. dissertation, Univ. Teeside, Newcastle, U.K.

Kim & Mueller (1978), Introduction to actor analysis: What it is and How to do it, Sage Uuniversity. www.researchconsultation.com/online

Kish, L. (1965). Survey Sampling Publishers: John Wiley & Sons Inc. New York.

Klimczak, K. M. (2005). Corporate Risk Management from Stakeholders' Perspective*",* TRANS" 05, SGH, Warszawa, Poland, pp. 371-380.

Kumaraswamy, M.M., & Chan, W.M. (1998). What contributes to construction delays. *Journal of Construction Management & Economics*, pg 17-29. *www.megaproject.eu/assets/exp/resources/JSERTIC_STSM_Literature_reviw.*

Lawson, B. (1997). *How designers think: The design process demystified*. Butterworth Heinemann: Architectural Press.

Levin, B. (2006). ``English Object Alternations: A Unified Account", unpublished ms., Stanford University, Stanford, CA.

Loosemore, M., Raftery, J., Reily, C., &Higgon, D. (2006). *Risk management in projects* (2nd ed.). Oxon: Taylor and Francis.

Lopez, R., Love, P. E. D., Edwards, D. J., & Davis, P. R. (2010). Design error classification, causation, and prevention in construction engineering. *ASCE Journal of performance of constructed facilities, 24*(4), 399-408.

Love P. E. D., & Sohal, A. S. (2002). *Influence of organisational learning practices on rework costs in projects*. Proceedings of the Eight International Conference on ISO 9000 & TQM (Change Management), Centre for Management Quality Research (CMQR) at RMIT University, RMIT Storey Hall, Melbourne, Australia, 13th–15th April .

Love, P. E. D. (2002). Influence of project type and procurement method on rework costs in building construction projects. *Journal of Construction Engineering and Management, 128*(1), 18-29.

Love, P. E. D., & Josephson, P. E. (2004). Role of error-recovery process in projects. *Journal of Management in Engineering, 20*(2), 70-79.

Love, P. E. D., & Li, H. (2000). Quantifying the causes and costs of reworking construction. *Construction Management and Economics, 18*(4), 479-490.

Love, P. E. D., & Smith, J. (2003). Bench-marking, bench-action and bench-learning: rework mitigation in projects. *Journal of Management in Engineering, 19*(4), 147-159.

Love, P. E. D., (2008). *Determinants of Rework in Australian Construction Projects*, Unpublished PhD Thesis, Monash University, Melbourne, Australia.

Love, P. E. D., Davis, P. R., Ellis, J. M., & Cheung, S. O. (2010). Dispute causation: Identification of Pathogenic Influences. *Engineering, Construction and Architectural Management, 17*(4), 404-423.

Love, P. E. D., Edwards, D. J., Irani, Z., & Walker, D. H. T. (2009). Project pathogens: The anatomy of omission errors in construction and engineering projects. *IEEE Transactions on Engineering Management, 56*(3), 425-435.

Love, P. E. D., Mandal, P., Smith, J., & Li, H. (2000). Modeling the dynamics of design error induced rework in construction projects. *Construction Management and Economics, 18*(5), 567-574.

Love, P. E. D., Smith, J., & Li, H. (1999). The propagation of rework benchmark metrics for construction. *International Journal of Quality and Reliability Management, 16*(7), 638-658.

Love, P., Irani, Z., & Edwards, D. (2004). "A rework reduction model for construction projects". *IEEE Transportation of Engineering Management, 51 (4).*

Love, P.E.D., Edwards, D.J., Irani, Z., & Walker, D.H.T. (2008). Project pathogens: The anatomy of omission errors in construction and resource engineering projects. *IEEE Transactions on Engineering.*

Love, PED, Holt GD, Shen L. Y, & Irani Z, (2002). Using systems dynamics to better understand change and rework in construction project management systems. *International Journal of Project Management,20:425-36*

Lyons, T., &Skitmore, M. (2004). Project risk management in the Queensland engineering construction industry: A survey. *International Journal of Project Management, 22*(1), 51-61.

Majid, A. M. Z. & McCaffer R., (1998). Factors of non-excusable delays that influence constractors‟ performance, *Journal of Management in Engineering*, May/June *Management* (*In Press).*

Mandal P., Love P. E. D., & Shah K. (2000). *Propagation of quality costs to formulate quality improvement strategies.* Fifth International Conference on ISO 9000 & TQM School of Business, HK Baptist University & Productivity & Quality Research Centre, National University of Singapore, Singapore, 25th–27th April, 156–160.

March L. (1976). *The logic of design and the question of value, in the architecture of form*. Cambridge: Cambridge University Press.

Mastenbroek Y.C. (2010). *Reducing rework costs in construction projects*, Published Bachelor‟s degree Thesis, University of Twente.

Maytorena, E. (2005). The Influence of Experience and Information Search Styles on Project Risk Identification Performance‖, *IEEE Transactions on Engineering Management*, vol. 54, no. 2, pp. 315–326.

McDonald, R. (2013). Root Causes & Consequential Cost of Rework. Retrieved on January 13, 2015 from *http://xlgroup.com/~/media/1048e70923e549b49905d503c19abf14. McGraw.*

Mezher, T.M, &Tawil, W. (1998). Causes of delay in the construction industry in Lebanon. *Journal of Engineering, Construction and Architectural Management, 5*(3), 252-260.

Miller L. G. (1993). *Concurrent engineering design: Integrating the best practices for process improvement.* Dearbon, MI: Society of Manufacturing Engineers.

Miller, R., & Lessard, D. (2001). Understanding and managing risks in large engineering projects, *International Journal of Project Management*, 19, pp. 437-443. www.megaproject.eu/assets/exp/resources/JSERTIC_STSM_Literature_review

Moffat, L. K. (1998), ―Tools and Teams: Competing Models of Integrated Product Development Project Performance‖, *Journal of Engineering and Technology Management, vol.15, no. 1, pp. 55–85. www.jimsjournal.org/11%20Hong%20Long%20Chen.*

Mumtaz, M. M., Hugh, H., & Hana, P. R. (2011). Mixtures and their risk assessment in toxicology. In S. Astrid, S. H, & S. K. O. Roland. (Eds.), *Metal ions in toxicology* (pp.61–80). London: Royal Society of Chemistry.

Nesan, J. L., & Holt, G. D. (1999). *Empowerment in construction: The way forward for performance improvement.* Hertfordshire: Somerset Research Studies Press.

Ng, S. T., Mak, M. Y. M., Skitmore, R. M., Lam, K. C., &Varnam, M. (2001). The predictive ability of Bromilow‟s time-cost model. *Journal of Construction Management and Economics, 19*(2), 165-173.

Nylen, K. O. (1996). *Cost of failure in a major civil engineering project*. Licentiate Thesis, Division of Construction Management and Economics, Department of Real Estate and Construction Management, Royal Institute of Technology, Stockholm, Sweden.

O‟Brien, J. J. (1998). *Construction Change Orders: Impact, Avoidance and Documentation*. NY: McGraw-Hill,

O‟Connor, J. and Tucker, R. (1986). Industrial project constructability improvement. *Journal of Construction and Engineering Management, 112*(1), 69–82.

Oakland, J. S., &Sohal, A. S. (1996). *Total quality management: Text with cases*. Melbourne: Butterworth-Heinemann.

Oladapo, A. A. (2005). An Investigation into the Use of ICT in the Nigerian Construction Industry, from Http://Www.Itcon.Org/Data/Works/Att/2007_18.Content.02391.Pdf, Assessed On 30 November 2009.

Ozeki K. (1990). *Handbook of quality tools: The Japanese approach*. Englewood Cliffs: Prentice-Hall Inc.

Palaneeswaran, E. (2006). *Reducing rework to enhance project performance levels*. Proceedings of the One Day Seminar on Recent Developments in Project Management in Hong Kong, Centre for Infrastructure and Construction Industry Development, Hong Kong, 5.1- 5.10.

Palaneeswaran, E., Kumaraswamy, M. M., Ng, T. S. T., & Love, P. E. D. (2005). A framework for monitoring rework in building projects. In Y. K. Cheung, and K. W. Chau (Eds.), (2005), *Tall buildings from engineering to sustainability* (pp.710-715)., Hong Kong: World Scientific Press.

Palaneeswaran, E., Kumaraswamy, M.M., Rahman, M.M. & Ng, T.S.T. (2003). Curing congenital construction industry concerns through relationally integrated supply chains. *Building and Environment Journal*, 38(4): 571–582

Palaneeswaran, E., Ramanathan, M., & Tam, C.M. (2007). *Reducing design rework in construction projects.* Proceedings of the 4th World Project Management Week on Project Management: Driving Growth, Creating Equality Conference, Singapore.

Palaneeswaran, E., Kumaraswamy, M., Ng, T., & Love, P. (2006). *Neural network modeling for rework related cost overrun and contractual claims in construction projects.* Paper presented at the Joint International Conference on Computing and Decision Making in Civil and Building Engineering (ICCCBE XI), Montreal, Canada.

Polit, D. & Hungler B., (1985). "Essentials of nursing research; methods and applications, G. B. Lippincott Company.

Projects in Controlled Environments (PRINCE). (2009). *Managing successful projects with Projects in Controlled Environments II* (5th ed.). London: The Stationery Office.

Rhodes B. & Smallwood J. J. (2003). Defects and rework in South Africa construction projects, Proceedings of the first CIBD post graduate conference, Port Elizabeth, South Africa, 12-14 October, 228-236

Rogge, D. F., Cogliser, C., Alaman, H., & McCormack, S. (2001). *An investigation into field rework in industrial construction*. Austin: Construction Industry Institute.

Ross, J. E. (1973). *Corporate Management in Crisis*, Prentice-Hall

Rounce, G. (1998). Quality, waste, and cost consideration in architectural building design management. *International Journal of Project Management, 16*(2), 123-127.

Sarantakos, S. (1998). *Social Research,* 2nd Ed: Macmillan Publishers China.

Scott, D. L. (1993). Guidelines for the diagnosis, investigation and management of osteoarthritis of the hip and knee. *Journal of the Royal College of Physicims Of Lortdon*; S7(4): 39 1-396

Simpeh, E. K. (2012). *An analysis of the causes and impact of rework in construction projects.* Unpublished Master‟s dissertation presented to the Higher Degrees Committee of the Cape Peninsula University of Technology in fulfilment of the requirements for the degree of Master of Technology: Construction Management.

Skorupka, D. (2008). "Identification and initial risk assessment of construction projects in Poland", *Journal of Management in Engineering, 24(3), 120-12.*

Sonnenwald, D. H. (1996). Communication roles that support collaboration during the design process. *Design Studies, 17*(3), 277–301.

Spence, M. (1973). Job market signaling. *Quarterly Journal of Economics, 87*(3), 355–374.

Svelinger, P.-O., (1996). *Organisatorisk samordning vid projektering* (Organisational Coordination in the Design Phase). Report 44, Institution for byggnadsekonomi och byggnadsoganisation, Chalmers techiska ho¨gskola, Go¨teborg, Sweden.

Tilley, P. A., & McFallan, S. L., (2000). Design and Documentation Quality Survey Designers‟ Perspectives, BCE DOC 00/113. CSIRO – *Building, Construction and Engineering*, Melbourne, Australia.

Uher, T. (2003). *Programming and scheduling techniques.* Sydney: UNSW Press.

Uher, T. E. & Toakley, A. R., (1999). Risk management in the conceptual phase of a project. *International Journal of Project Management 17* (3) 73, 1. www.craig.csufresno.edu/ijb/Volumes/Volume%2015/V151-6

Walker, D. H. T. (1994). *An investigation into the factors that determine building construction time performance.* Unpublished PhD thesis, Department of- Building and Construction Economics, Faculty of Environmental Design and Construction, Royal Melbourne Institute of Technology, Melbourne, Australia.

Warhoe, S. P., &Giammalvo, P. (2009). *Understanding the effects of rework and change of scope on productivity and project performance using systems thinking.* Bainbridge Island: ESC Lille.

Weissberg R. & Buker S. (1990). *Writing up Research*. Englewood Cliffs, NJ: Prentice Hall

Wooten, T.C., (2003). "Research about Audit Quality", *International Journal of Business*, 15(1), 2010

Wyatt R., Smith, J., (2000). Digital simulation of option-choice behaviour, Computers, *Environment and Urban Systems*, 24, 331–354.

Yukon Government (YG), 2010. History of Mining in Yukon. Energy, Mines and Resources Mining Portal Website. Accessed 2 June 2010, http://www.emr.gov.yk.ca/mining/history.html

Zack, J. G. (2013). *Professional development: Avoid construction rework*. http://epubs.democratprinting.com/article/Professional+Development%3A+Avoid+Construction+Rework/1300169/0/article.html

Zou, P. X. W., Zhang, G., & Wang, J-Y. (2006). *Identifying key risks in construction projects: Life cycle and stakeholder perspectives*. Retrieved on January 5, 2015 from http://www.prres.net/papers/Zou_risks_in_construction_projects.pdf

APPENDICES

SURVEY QUESTIONNAIRES FOR ARCHITECT

TOPIC: Strategies for Minimizing Reworks in the Building Construction Industry in Ghana.

Cover letter

29th March 2016

My name is Da-Costa Adomah, a postgraduate candidate of the Department of Technology, University of Education Winneba–Kumasi (UEW-K). I am conducting this research as part of partial fulfilment of the award of Master of Philosophy Degree in Construction Technology (M.Phil. Construction Technology) Programme. This is a quest for data for an academic study dubbed "factors underlying rework and rework minimisation framework". The purpose of the study is distinctively for academic exercise. Please be candid in your responses as the quality of the study is based on the quality of your responses. If you require clarification and any further information, kindly contact me on my mobile 0243245995.

Thank you for your co-operation.

Yours faithfully,

Da-Costa Adomah

(M.Phil. Construction Technology Candidate)

SECTION A: PARTICULARS AND GENERAL INFORMATION ABOUT RESPONDENTS

1. What is the age category you belong? *(Please tick).*

Under 20 years [ ]	☐	21 – 30 years [ ]	☐
31 – 40 years [ ]	☐	41 – 50 years [ ]	☐
51 – 60 years [ ]	☐	Above 60 years [ ]	☐

2. Please indicate your gender. *(Please tick)*

Male	☐
Female	☐

3 What is your current job title? *(Please tick).*

Architect	
Site manager	
Other please state	

4 What is the number of years you have been working in the construction industry? *(Please tick)*

Under 5 years	☐]	5 – 10 years [ ]	☐
Above 10 but less than 15 years	[ ]☐	15 – 20 years [ ]	☐
Above 20 but less than 30 years	☐[ ]	Above 30 years [ ]	☐

5 What is your highest academic qualification? (Please tick or write in the space provided below)

Ordinary Level [ ]	☐	High National Dip [ ]	
Advanced Level [		Bachelor`s Degree [ ]	
Postgraduate Diploma [	☐	Master`s Degree [ ]	
Construction Tech. Cert. [	☐	Other(s) Specify…………………	

SECTION B: THE SECTION SEEKS YOUR EXPERT OPINION ON THE ROOT CAUSES OF REWORK, ITS EFFECTS, CHALLENGES AND REDUCTION STRATEGIES.

6. **To what extent do you agree on the following factors as causes of rework in the construction industry?** *Please rate using a scale of 1-5 where 1 represents strongly disagree, 2 represents disagree, 3 represents uncertain, 4 represents agree and 5 represents strongly agree.*

No	Factors	1	2	3	4	5
	Human-related factors.					
CR1	Unclear instructions to workers					
CR2	Inadequate supervision					
CR3	Inadequate job planning and poor safety measures					
CR4	Insufficient skill level of workers					
CR5	Inexperienced supervisors and consultants					
CR6	Ineffective management of project team					
CR7	Inadequate commitment to quality assurance					
CR8	Late design changes and poor documentation					
CR9	Errors and omissions					
CR10	Inadequate integration of design team					
CR11	Late designer input					
CR12	Employee turnovers and unrealistic schedules					
CR13	Insufficient commissioning of resources					
CR14	Poor work load planning					
CR15	Suppliers‟ non-compliance with requirements					
	Uncertainties related factors					
CR16	Weather patterns					
CR17	Changes in government regulations					
CR18	Price fluctuations					

CR19	Community hostility					
	Client Related factors					
CR20	Lack of experience and knowledge of design and of the construction process					
CR21	Inadequate of funding allocated for site investigation					
CR22	Inadequate briefing					
CR23	Lack of client involvement in the project					
CR24	Poor communication with design consultants					
CR25	Inadequacies in contract documentation					
	Design-related factors					
CR26	Lack of design coordination and integration					
CR27	Late changes in scope of project					
CR28	Poor structural design					
CR29	Correcting on-site errors in design					
CR30	Correcting off-site prefabrication errors					
CR31	Re-construction due to non-conformance to original design					
CR32	Re-construction due to quality failures					
	Contractor-related factors					
CR33	Setting-out errors					
CR34	Poor multi-tasking					
CR35	Pressure for early completion					
CR36	Inadequate protection to work					
CR37	Poor choice of construction materials					

7. Which of the following would you agree as an effect of rework in the construction industry? *Please rate using a scale of 1-5 where 1 represents strongly disagree, 2 represents disagree, 3 represents uncertain, 4 represents agree and 5 represents strongly agree.*

No	Factors	1	2	3	4	5
	Organisation and Project's Performance Factors					
DE1	Increased total cost of project					
DE2	Increased expenses of labour wages and pay					
DE3	Increased time to construct the project and/or correct errors					
DE4	Increased time to redesign section of the project					
DE5	Increased waiting time to recover from destruction to project sections					
DE6	Increased number of construction workers					
DE7	Additional waste handling cost					
DE8	Extension of supervision man-power					
	Workers Factors					
DE9	Stress					
DE10	Fatigue					
DE11	Absenteeism					
DE12	De-motivation					
DE13	Poor morale					
	Organizational Factors					
DE14	Reduced profit					
DE15	Diminished professional image					
DE16	Inter-organisational conflict					
DE17	Loss of future work					
DE18	Poor morale					
	Project Level Factors					
DE19	Increased expenditure on building materials					

DE20	Increased expenses of labour wages and pay					
DE21	Increased time to construct the project and/or correct errors					
DE22	Increased time to redesign section of the project					
DE23	Client dissatisfaction					
DE24	Increased waiting time to recover from destruction to project sections					
DE25	Increased number of construction workers					
DE26	Additional waste handling cost					

8. **Indicate the level of importance of the following as rework reduction strategies**? *Please use a scale of 1 to 5 where 1 represents not at all important, 2 somehow important, 3 uncertain, 4 important and 5 very important.*

No	**Rework Reduction strategies**	**1**	**2**	**3**	**4**	**5**
RS1	Risk identification					
RS2	Spotting rework possibilities					
RS3	Prioritisation of possible rework activities					
RS4	Aligning responsibility to stakeholders					
RS5	Brainstorming in meetings					
RS6	Checklist of risk factors					
RS7	Deducing from past experience					
RS8	Monitoring as the project proceeds					
RS9	Probability analysis					
RS10	Sensitivity analysis					
RS11	Scenario analysis					
RS12	Simulation analysis					
RS13	Ranking options					
RS14	Direct judgment					
RS15	Correlation analysis					

9. **To what extent do you agree on the following as challenges confronting your efforts to reduce rework?** *Please rate using a scale of 1 to 5 where 1 represents strongly disagree, 2 represents disagree, 3 means uncertain, 4 represents agree and 5 strongly agree.*

No	**Challenges in Managing Rework**	**1**	**2**	**3**	**4**	**5**
CH1	Uncertainty about design changes from client					
CH2	Inexperience of client in construction issues					
CH3	Misunderstanding of what the client wants					
CH4	Clients unable to define their specifications					
CH5	Adverse behaviour of some workers					
CH6	Difficulty in supervision					
CH7	Carelessness of workers					
CH8	Recruitment problems in getting the right calibre of workers					

APPENDICES II

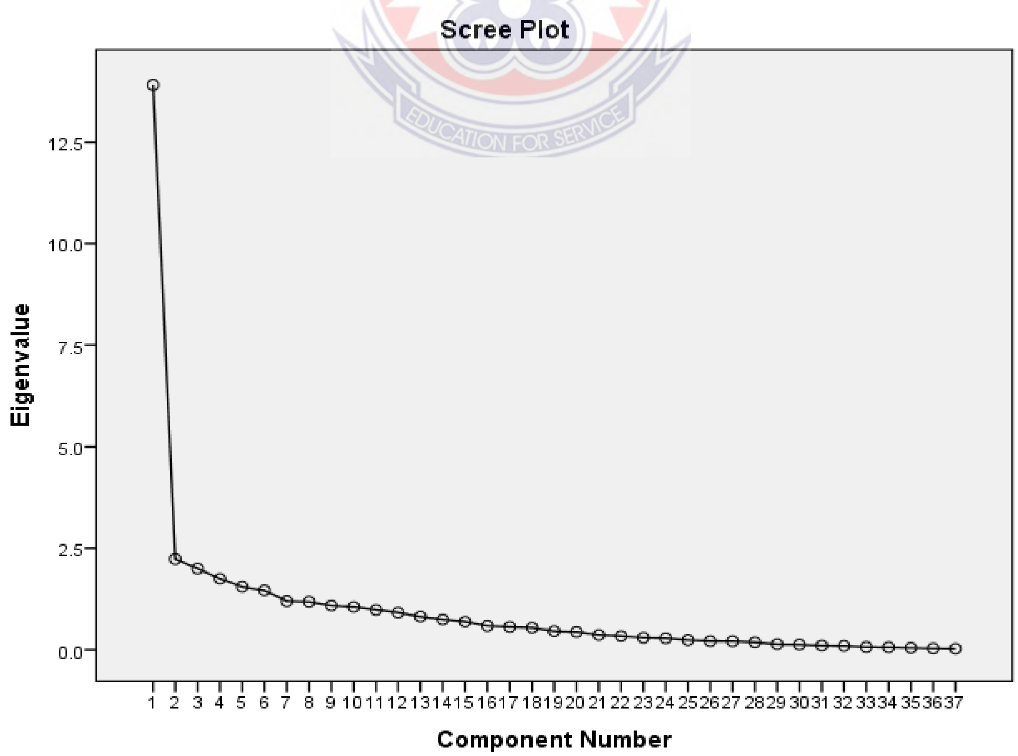
CAUSES OF REWORK

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.950	.952	37

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.750
Bartlett's Test of Sphericity	Approx. Chi-Square	1392.405
	Df	666
	Sig.	.000



DIRECT AND INDIRECT EFFECTS OF REWORK

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.821
	Approx. Chi-Square	1409.112
Bartlett's Test of Sphericity	Df	325
	Sig.	.000

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.968	.968	26