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INVESTIGATING THE CAUSAL IMPACT OF DESIGN ERRORS AND ITS IMPACT ON COST PERFORMANCE IN THE GHANAIAN CONSTRUCTION INDUSTRY

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DECLARATION

I hereby declare that, this study submission is my own work towards the Master of Science in Project Management, and that, to the best of my knowledge, contains no material previously published by any person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

The subject of project success is of major concern to many construction practitioners especially project managers. Hence, it is the desire of every construction manager to deliver project to time, quality and cost. One issue that has hindered this success is errors in design documents which often lead to rework and cost and time overruns. Due to this, this research studies therefore sought to investigate the causal mechanism of design errors and its impact on cost performance in the Ghanaian construction industry. In order to achieve the set aim, three objectives were set; to identify the critical factors influencing design documents deficiencies, to assess designers' and contractors' perception of the achievement of design documents and to assess the impact of design errors on cost of construction projects in Ghana. On this basis, critical review of literature was carried out which led to identification of the factors that influence design documents deficiencies and also attributes of quality construction documents. Questionnaires were administered to D1K1 and D2K2 construction firms in Kumasi. Data collected from the survey was analysed using descriptive statistics. The findings from this research show that lack of coordination, incomplete or inaccurate information received from other designers and high stress situations are the major factors that influence design document deficiencies in the Ghanaian construction industry. Moreover, most of the documents produced are complete and standardized. However, the documents are mostly not produced on time and also it does not normally depict exactly what is to be constructed. In addition, the major effect of design errors, is its huge impact on construction cost, normally resulting in cost overruns. The research therefore recommended that the time period for preparation of design documents should be well planned and experts should be consulted for design documents whenever the need be. The study also recommended that other research work be done with relatively large sample size.

Keyword: Design, Errors, Causal, Perception, deficiencies, Cost, Performance

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DEDICATION

I dedicate this project report to the almighty God for seeing me through this programme despite all the setbacks and challenges, to mother Mrs. Rejoice Ametsitsi, my father Mr. Alfred Ametsitsi and my brother and sister Elikem and Senam Ametsits for their immense support.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Authors such as Han (2011) attributed design error to human error. Petroski (1991) opines that since at the design stage people decide what is to be done, how it is to be done and who have to do what, it can be assumed that all design errors emanate from humans and therefore errors in design can be attributed to blunders caused by humans. The failure of planned actions to achieve desired goals, where the failure occurs without some unforeseeable chance or intervention is referred to as human errors (Reason & Hobbs, 2003). Busby (2001) opined that due to impaired human cognition, there is a possibility that designers can make errors during decision making which can be as a result of designers facing workplace pressure due to cost and schedule pressures. The author elaborated further on the causes of human errors as failure on the part of the designer to engage others in design decision making, notify others of assumptions considered, or comprehend the history of solving problems related to replicated design. A study by Love et al., (2011) mentions the factors that influence design consultants to perform tasks effectively. They include schedule pressure, design fees, client procurement strategy and skilled labour supply. Since these factors are considered a part of the designer's work, it comes as no surprise when Love et al., (2011) opined that doubt and inevitability of mistake are not perceptions but are a reality for design consultants.

Busby (2001) when addressing errors in cognitive design processes examined errors from both positive and negative angles. As a negative effect, error is one of the major influences which limits the performance of a mission and also results in a huge cost especially in organisation and could in extreme causes lead to fatalities. Additionally, Vlatas (1986) argued that design errors are the major causes of contract claims and change orders during construction. Variations as reported by Sawada (2000), Kangari (2005) and Ahmed 1999)

consider design errors as a risk to project success. Kartam & Kartam (2001) undertook a survey in Kuwait in which it was reported that design errors are one of the most significant risks to project delays. A survey of seventy-nine Japanese contractors by Anon (2000) revealed that, 44% of the respondents frequently experience major amount of design documentation hitches. Some of the hitches include ability to construct, conflictions in structural designs, inadequate temporal design works, poor construction methods and differing site condition data. Project changes may also have indirect consequence on project performance including conflicts and claims, reduced productivity, unbalanced work gangs and resource allocations, changes occurring in cash-flow forecasts, decreased morale of the work force and loss of float which does not auger well for project success (Hanna et al., 1999).

However, error is essential in learning a task and understanding the nature of the obligation that has become customary, power-driven or just taken for granted (Busby, 2001). Hence, the author argued that design organizations could also benefit from monitoring design errors and putting in place proper measures to prevent their occurrences. Petroski (1991) argued that several mistakes have been made in the past regarding the production of conceptual designs. Hence, we stand a good chance of not repeating these errors by studying how they occur so that we do not get to repeat them in subsequent designs.

It has been a challenge for researchers to gain a clearer comprehension of project changes especially with regards to the causes of errors in design and their cascading effect.

In Lind (1984) different analytical methods for representing and predicting errors were developed. The trend in the study of design errors has seen the use of computer based tools for managing design errors. Moreover, several researchers have provided insights into the

nature of errors and its role in the growth of engineering knowledge (Blockley and Henderson, 1980, Brown, 1986; Allen, 1984).

Construction projects have the propensity to undergo cost, schedule overruns. Design error is a major factor that immensely impacts on these overruns. The industry of construction institute reports that design errors which mostly lead to rework on construction sites average 5% of the contract sum (CII,2005). Josephson and Hammarlund (1999) reported that the cost of remedial works on building projects ranges from 2 to 6% of the cost of the works, specifically on residential, commercial and industrial projects. Rework on industrial buildings is estimated to be about 2.4% of the cost of the work (Love & Li, 2000). The significant cost resulting from design errors calls for critical attention and hence the need to address design errors in the construction industry. It is against this backdrop that this study seeks to investigate the impact of design errors on cost performance of projects in the Ghanaian construction industry.

1.2 Problem Statement

The perception of poor performance and underperformance in the construction industry is widespread. Kpamma and Adjei-Kumi (2010) opined that the industry is characterised by delays, increase in cost and defect in quality of construction. One cause of the problem can be attributed to the errors in design which results in dynamics at different stages of a project (Burati et al., 1992; Love et al., 1999; Love & Li, 2000). Design errors aside the above mentioned features comes with other undesirable impacts such as increased workload, loss of time, revisions of designs and its relative increase in cost.(Bower, 2000; Aibinu & Jagboro, 2002). Lopez et al., (2010) poses that design errors are a major cause of accidents and research has revealed that gross errors can cause 80 - 90% of the failures occurring on buildings, bridges and other civil engineering structures. The huge impact of design errors on construction projects have led to several research on the causes of design errors in developed

countries (Petroski, 1991; Busby, 2001; Melchers, 1989; Love et al., 2009; Lopez et al., 2010). Since what may have been considered a cause in developed countries may be different from that in developing countries, this research seeks to explore the causal mechanisms of errors in design and its effect on cost performance of a construction project in Ghana.

1.3 Aims and Objectives of Research

1.3.1 Aim

The major aim of this research is to investigate causes of design errors and its impact on cost performance of construction project

1.3.2 Objectives

In order to accomplish the aim of the study, three (3) major objectives have been set and these include

i. To identifying the critical factors influencing design documents deficiencies

ii.To assess contractors' perception of the achievement of design documents.

iii. To assess the impact of design errors on cost of Ghanaian construction projects

1.4 Research Question

i. What are the specific causes of design errors and shortfalls in design documents?

iii. What is the perception of contractors on what design documents are set to achieve?

ii. What impact does design errors have on cost in the Ghanaian construction industry?

1.5 Scope of the Study

Geographically, the extent of this research is narrowed to Kumasi because of its convenience and proximity to the researcher. Contextually, the study will limit itself to the construction industry with much focus on the causes of design errors and its effect on cost performance of construction projects in Ghana.

1.6 Methodology

The study adopted the quantitative approach of enquiry. A critical review of literature was conducted to ascertain the theoretical models supporting the subject and helped to detect existing causes of errors in design and their impact on cost performance of construction projects. The review will use reliable and scientific data from literature and this will be through unpublished thesis, journals, books and publications retrieved from of corporate bodies. Structured questionnaires were prepared to solicit the views of respondents on the causes of design errors. Respondents would be reached using the purposive and snowball sampling techniques and the information obtained would be analysed using descriptive analysis and mean score rankings.

1.7 Justification of Research

The Ghanaian construction industry like other sectors of the economy in the world has its own challenges. Ofori (2010) stated that time overruns, poor communication structure, low productivity and poor quality of work due to technical know-how, lack of skilled personnel and unreliable material supply are some of the many challenges facing the construction industry in Ghana. Studies on design errors is of much significant to the construction industry since knowledge about the causes of design errors in Ghana will help reduce its impact in the construction industry. Minato (2003) poses that uncovering the causes of design errors is an important step in the effort to reduce design errors in construction industry. Love (2012) poses that design companies who become aware of the causes of design errors learn from their mistakes and this has led to the modification of building and engineering standards. Undoubtedly, a study on the causes of design errors and its impact on cost performance of construction projects will contribute to a reduction in the cost and time overruns on projects and also contribute to knowledge in the field of research.

1.8 Organization of Research

This research was organized sequentially, representing research process and is built comprehensively to ease of understanding and communication of thought. The background on which this research was classified are into five chapters. Chapter one covers the introduction to the research. The second chapter is on review of literature of the study. This review provides an extended coverage on earlier works and the topic. Chapter three examines the details of the research methodology. Chapter four focuses on the analysis and discussion of the data collected for the study. Chapter five discusses the summary, conclusion and recommendations for the study.

CHAPTER TWO

2.1 Introduction

This thesis focusses on the causal mechanisms of design errors and its impact on cost performance, especially in the Ghanaian construction industry. In other to achieve the set objectives, various books, published papers and currently preceding research papers on construction project performance was reviewed. Particularly, this thesis will focus on the causal mechanisms of design errors and its impact on cost performance of construction projects in Ghana.

2.2 Overview of the Ghanaian Construction Industry

The Ghanaian construction industry serves as the backbone to the Ghanaian economy contributing about 13.7% to the overall Gross Domestic Product (GDP) (GSS, 2017) and this contribution according to Ofori-Kuragu (2013) is as a result of the few barriers of entry which allows most individuals and business entities to register as contractors. This increase in the construction activities in the country has made the performance of Ghanaian contractors a major cause of concern to client and other stakeholders in the Ghanaian construction industry. Several challenges confront the construction industry including the high rate of inflation which results in a decrease of the capital of contractors (Danso, 2005). Additionally, Ghanaian contractors are normally criticised for their inability to meet targets and the resulting cost overruns and quality defects of construction (Ahadzie, 2008; Kpamma & Adjei-Kumi 2010). Vulink, (2004) poses that these challenges make it difficult for Ghanaian construction firms to compete with foreign firms for works in Ghana.

Another feature of the Ghanaian construction industry which have contributed to the challenge in the industry is the segregation that exists between design and construction in which all the professionals seem to function independently with allegiance to their individual professional institutions. These professional bodies or institutions include Ghana Institution

of Architects (GIA), Ghana Institution of Engineeers (GIA), Ghana Institution of Engineers (GhIE) and Ghana Institution of Surveyors (GIS). This according to Ahadzie (2007) results in confrontational relationships which are very prominent in the construction industry of Ghana. Moreover, firms' failure to secure adequate working capital, insufficient management, inadequate engineering capacity and poor workmanship were identified in Ofori (2012) study of the challenges facing contracting and consultancy firms in Ghana. In addition, Laryea (2010) study on the Building and Civil Engineering Contractors in Ghana identified low technology, inadequate supervision of contracts and poor design quality as the major challenges facing the Ghanaian construction industry.

2.3 The design Team

The construction, (Management and Design) Regulations (2015) defined the designer as an establishment or separate entity whose work involves arranging or adjusting designs for projects, or arranging for, or directing, other people to do this. Design details, drawings, bills of quantities, specifications and design computations are examples of designs. The designer can be consulting engineers, consulting architects, quantity surveyors or cost engineers and interior designers or anybody whose specializes in the specification and alterations of designs as part of their work. According to the construction regulations (2015), the designers could also be the principal contractor, artisan and tradesman or commercial customer depending on their involvement in the design work for the project. Usually the services of a designer become necessary once an owner recognizes the need for a project and deems it economically feasible and practical. Hence designers are expected to consider the owner's ultimate needs regarding the project and makes plans to complete the design.

Love (1999) asserted that, the operation of most designers are somewhat independent resulting in making decisions without due regard for the other participants on the project. The miscommunication appears as a wall between the team members leading to errors in design

and construction. The design team mostly works separate from the construction team and according to Love et al. (1999), this has resulted in major behavioural, cultural and organisational differences between individuals and organisations involved with the procurement of building and engineering facilities. The lack of integration is therefore of a major concern to designers and contractors in general. The CDM (2015) recommended that designers to communicate effectively among themselves and other participants such as the client, main contractor and subcontractors on the project in order to achieve project success.

2.4 Design Errors

According to Reason and Hobbs (2003), errors involve some sort of nonconformity, whether a deviation from a planned target, departing from a part of action targeting a desired goal or nonconformity with the suitable behaviour of work. Davis & Ledbetter (1989) opined that errors in design show the effectiveness of a project in its entirety and major design quality issues come up during construction when errors, omissions and uncertainties in design becomes evident. Since the design phase is the first stage of the construction process, it is logical to attribute design errors as the root cause of various catastrophic accidents on construction sites. The decisions made during the design phase has a tremendous impact on the overall cost of the project (Minato, 2003). Hence, design organisations such as the consulting firms are very careful in their activities so as not to give way for error. Busby (2001) studied errors and cognitive designs and asserted that although errors are very costly, they contribute to the growth of knowledge of the firm. Also, errors can reveal important information about works which have become habitual, automated and taken for granted resulting in the discovery of relevant information required for performance improvement. According to Reason and Hobbs (2003), errors can be committed by either an individual person or a group. Sassou and Reason (1999) propose a ‘committed error taxonomy’ involving individual, independent shared and dependent shared, dependent individual.

‘Independent’ as referred to in this taxonomy is a condition where the data provided to the originator of an error is accurate, while dependent means situations in which the data provided to any single person or team is not entirely appropriated or completed.

Mistakes or errors can be made by everyone irrespectively of how competent the individual may be. Even the most competent and highly knowledgeable persons make the mistakes with the worst consequence (Reason, 2000). Some contracting organisations have systems in place which enable their design team to identify all design errors before they become an issue on construction site. On the side, some design firms rely on contractors to identify design errors contained in contract documents that they produce. Many consultants do not want to disclose their errors for the purposes of commercial pressure or personal esteem. Wardhana and Hadiopriono (2003b) poses that some of the commercial reasons include a fear of litigation or contractual claims whereas ignorance of reporting procedures or a sense of inadequacy or shame caused by high self-expectation forms the personal esteem reasons.

Research by Hurst et al. (1991) and Andi and Minato (2004) developed proposals or models which are deemed useful for assessing potential risks in projects. One such tools by Rogue et al. (2001) provided early warning of possible rework prior to construction, based on the underlying conditions that could contribute to its occurrence. The regularity of engineering verifications, the extent of design schedule compression and the degree of design coordination that is undertaken are some of the conditions that could contribute to the occurrence of error. Similarly, a probabilistic model was designed by Manavazhi (2001) which helps in forecasting the chances that a project could encounter design revisions. Manavazhi and Xunzhi (2001) opined that since the probability of occurrence of design errors are inevitable and forms a major part of the design process, firms should provide proper plan and management processes to manage errors as and when they occur. They pose that the design errors that leads to rework arise through errors, incomplete misinformation,

and changes and can have a detrimental effect on workers' productivity, morale, designer attitudes and the overall profitability of the design practice.

2.5 Causes of Design Errors

Musa and Obaju (n.d) identified several causes of design errors in construction projects which they classified into eleven different groups. A cause of defect is defined as the reason that proves the existence of the defect. Often there are several causes to particular defect, which hence the word 'root' is used to denote the most important cause to the defect. The groups were further divided into design and construction defects. The design defects included errors in civil design, defects in architectural design, maintenance practicality design defects and adequacy, consultant's administrative staff design defects and defects related to construction drawings. The construction defects or errors include defects due to construction reviews, civil construction defects, contractor administrative defects, defects relating to construction equipment, construction material defects and defects with regards to specifications. Of these, they identified narrow stairs, passages and door as the common design errors as architectural defects. Inadequate concrete cover was also found to be the common civil design error and designers' ignorance of material properties and misjudgement of user's intended used was ranked third, and fourth as defects due to consultant firm administration.

Busby (2001) identified flawed decisions undertaken during design due to reduced human understanding which can be attributed to human errors as one of the major causes of design errors. This is normally caused by pressure and stress at work place due to loaded schedules (Love et al, 2008). In a similar way, designers may not involve others in making design decisions, notify others of decisions made, enquire other's needs and schedules, or understand the source of solving a problem in a replicated design (Busby, 2001). In love et al. (2011), relying too much on scope changes to solve issues that may come up during

construction, one of the causes of design errors was also identified to be the installation and commissioning stages of the project. They opined that project team members fail to access thoroughly the impact of such sudden changes in scope or design leading to alteration in the project execution sequence.

The causes of design errors identified by Busby (2001) also mentioned that if the project at hand involved interactions;

i. Among a lot of participants during the design process;
ii. Between the design and participants
iii. Interactions between tools used and participants in the design process;
iv. Between participants and the organisation;
v. Between participants and the environment.

The findings from Busby's (2011) research shows that most of the design errors occur as a result of the interaction among several participants in the design process. For example, one project may have designers such as the architect, structural engineer, services engineer and mechanical engineers. If the work is not coordinated well among these participants, minute error in the architectural drawings will lead to an error in the structural drawings and eventually appear as a big error during the construction stage as it comes with rework and extra cost. This is normally caused by the failure of the designer to involve others in the design decisions, omitting to tell others about the assumptions made during the design and omitting to elicit others needs or schedule.

Connections between participants and the design was ranked second in Busby's (2011) research. This is the failure of the participants err in their dealings with a design typically since they might have misread the intentions behind someone else's design or because they do not clarify the design they send to others. When participants fail to give cues that will help

other team members read and interpret the data which is being provided, it leaves other team members to guess or assume the norm which may lead to an error in the design.

Other causes of design are also seen in the works of Josephson (1999). He asserted that lack of motivation, knowledge and information are the major causes of design errors followed by carelessness on the part of the designer. Earlier, Josephson (1994) had classified design errors as risk and asserted that since risk cannot be reduced entirely there is always a probability of its occurrence. Reason (1995) opined that one of the underlining cause of errors is mistake. Mistake which come about as a result of unawareness of the precise task or the right way to execute it can either be regulation based or knowledge based. Rule based errors or mistakes occur when a practitioner misapplies a rule that functioned in a preceding condition on a current work whiles the knowledge based errors or mistakes that occur as a result of lack of knowledge on the part of the practitioner on that aspect of design or work. When designers are faced with something that lies outside their knowledge area, practitioners normally turn to slowdown the effortful thinking and as a result are prone to creating errors (Reason, 1995). Another source of error aside mistakes is noncompliance. Noncompliance is an error which occurs because an individual decides not to carry out a task or not carry it out the way he/she has been instructed or expected. This could be as a result of low motivation on the part of the individual particularly low morale, poor supervision or perceived lack of concern. Another cause of design errors is seen in the work of Love and Sohal (2002) is the low-moderate learning capability in construction organisation which can contribute recurrence of errors. They opine that even when organisations are able to collect data regarding errors, they are unable to transform it into information and as a result no lessons are learned. According to McMaster (2000) this happens as a result of the pressures that comes with the delivering of projects especially design documents. Tilley and McFallen (2000) asserted that, designers

repeatedly producing design documentation containing dimensional errors and omission are evidence of these pressures.

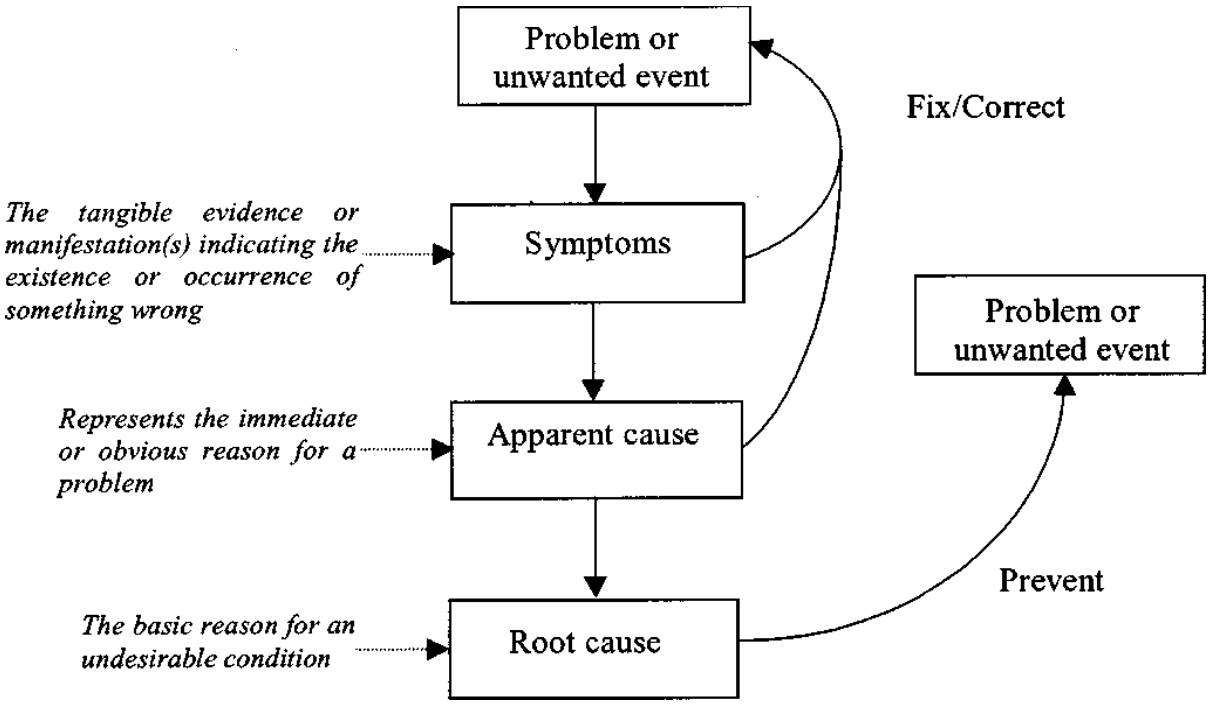

Figure 2.1 Design error prevention cycle

2.6 Prevention measures for design errors

From the figure 2.1 illustrated above, error prevention in design should be seen as a process that is unceasing rather than an outcome of certain activities or behaviours (Gherardi & Nicolini, 2000). Therefore, error prevention requires that one explores the people, organisation and project management system to map dependencies and interfaces that influence the process. Moreover, they opined that the exploration goes hand in hand with learning from the errors that has already been made. However, most of the time, correction of defects are often prioritize over learning. The learning process does not only involve the organization of the design but particularly the whole project team depending on the nature and complexity of the environment of the project within which designers operate. Research has shown that, the causes and effects of committing errors are not unidirectional or linear,

but involves a relationship that is reciprocal or looped (Tsang and Zahra, 2008). In other to prevent errors in design, there is the need to understand how such relationships emerge and interact with one another. Busby (2001) and Love et al. (2009) poses that one approach to tackle error prevention is to view errors as symptoms of underlying problems so they become sources of information to appreciate how systems work. Hence, instead of completely frowning at design errors, Edmondson (2004) asserted that the design errors and the rework that occurs as a result should be viewed as tools that can be used to define margins of risk and safety so that learning how to prevent them can occur. Thus, this approach relies on the fact that humans are capable of making mistakes and that they are to be expected and that the poor performance of individuals should not be seen as a big issue. However, the failures in the procedures, processes, teams and the organisation should be the main focus when learning from mistakes. Thus, an organisation stands a chance to learning more from its errors when it recognizes feedback from work process, data, discussion amongst colleagues and other members of the project team. Sense (2007) recognize the approach of learning from the causes of error through collaboration and contribution from others as an effective learning for their prevention. The best approach of learning that has been recommended is the situational dimensions of learning which concerns itself with practical and social aspects within a context. Usually most designers learn on the job through participation and interaction of people and their collective sense making activities as their competencies are developed and also they are able to construct their identities to function effectively (Gherardi and Nicolini, 2000).

Kalra (2004b) emphasize the importance of interaction when learning to prevent errors. Interactions encourages the sharing of ideas and experiences which can enable designers to recognize the need for project learning and interaction so as to make sense of their activities. Reason (2000) and Moller et al. (2006) share the view that situated learning for error

prevention is generally good, its effectiveness depends on the individual's capacity to learn. The knowledge of an individual is typically limited to their own activities which can even contribute to their not being able to detect errors. Moreover, the experience of people differs and that they may interpret situations in this errors in different ways. In Stock et al. (2007), it was suggested that design organisations foster an enriched leadership culture and network that engenders groups and teams to come up with blunder free work practices as their deterrence can only be achieved to a restricted extend by involvements at an administrative level. Another way to prevent errors in design is that people should take responsibility for their actions and should not give in to slips and lapses. Reason (2002) recommended the use of personal aids like post-it notes and tie-on labels to serve as reminders. Incentives such as remuneration and additional leave can be used to motivate people to improve process quality, reduce errors and increase an individual's learning ability Love and Smith (2003).

When designers are provided with adequate time for the production of documents, implementation of audits, reviews and verifications, using CAD applications, circumventing time boxing is likely to bring about errors (Manavazhi and Xunzhi, 2001; Reason 2002). Love and Edwards (2004) also recommended that the implementation of constructability analysis, building information modelling, benchmarking, quality management, risk management, alliancing and integrated procurement methods can be used at the project level to contain errors. However, Atkinson (2002) opined that, these strategies are rarely used. If they were many of the problems that arise in projects due to safety, rework, claims and disputes could be prevented. The systematic model developed by Love et al (2011) proved the extent of the above mentioned strategies. They opined that there is no single strategy that can be used to prevent errors in design but rather a multitude of strategies that need to be adopted.

Sasou and Reason (1991) developed an error recovery process which involved three stages; detection, indication and correction. They pose that the first step in recovering errors is to detect the occurrence of the error. The indication stage has to do with the whether or not the error is brought to the attention of the person who is responsible for its correction. Errors which are detected but are not brought to the attention of the person who is responsible for its correction may not be recovered. The last step which is the correction stage has to do with the actual correction of the errors. Once the error is detected and identified, it is prudent to put in the necessary measures to correct the error. If the error is not corrected, the actions based on the error will remain unchecked. The longer it takes to detect the error the higher the cost of correction. Also love (2001) opined that an error which is not corrected will inhibit learning because it becomes difficult to understand and analyse the error as to why it occurred. He further opined that early detection of errors even before activities commences is a better way of preventing errors. However, poor planning, lack of knowledge and experience of personnel and lack of quality management procedures often leads problems in the detection of errors.

2.7 Factors that influence design document deficiencies

Andi and Minato (2003) performed a study to examine the factors that influence the quality of design documents. In order to arrive at these factors, respondents were provided with a tall list of influencing factors in which they were asked to indicate the frequency and impact of each factor using a rating scale. The findings from their research indicate the two major factors that influence design document quality; time and fee for design works. Insufficient time was regarded as the major influencing factor to design document quality. Mostly designer have to complete their jobs within a short period of time with limited number of qualified personnel. Moreover, client ability to shop around for design fee and low design fee as the most important influencing factor affecting design document deficiencies. Other factors include high stress situations, lack of construction knowledge, client lack of

leadership, lack of coordination and communication with owner and contractors, incomplete or inaccurate information received from other designers and lack of experience or incompetent designers. Additionally, lack of motivation by designer, ineffective organisation structure of design team, interpersonal skill problems of designers and lack of leadership by design leader were also considered to be influencing factors in the literature. Andi and Minato (2003b) also grouped the influencing factors into two; organisation factors and workplace factors. Environmental factors, client decisions and designers parent organisation were considered under the organisational factors. The workplace includes error and violation producing conditions in the working place at specific time, some of which included unawareness of change in standard, inadequate design knowledge, over reliance on computers, inadequate construction knowledge, unawareness of change in design information and carelessness during design process. The table 2.1 summarizes the influencing factors for design documents deficiencies.

Table 2.1 Influencing factors

Organisation factors	**Workplace factors.**
Limited site survey : topography and geology	Unawareness of change in standard
Inadequate checking of design input	Inadequate design knowledge
Failure of tools, such as computer software	Over reliance on computers
Inadequate communication/coordination between designers within company	Inadequate construction knowledge
Inadequate communication/coordination between designers and other external parties	Unawareness of change in design information
Deficiency in standard for design/checking	Carelessness during design process
Inadequate training for designers	Inadequate believe in making judgement
Inadequate documentation system	Over trust of other designers
Inadequate information from client	Time pressures

2.8 Effects of design errors on construction projects

Effects of errors refer to a change event's direct or indirect impact on numerous facets of a project. Lopez et al. (2010) reveal that most of the accidents which occur on construction sites are as a result of errors in design. Their findings indicated that gross errors in design can cause about 80-90% of the failures occurring on building, bridges and other civil engineering structures. Errors contained in contract documents such as drawings, specifications and schedules alone contributes to rework, claims and disputes on construction projects. In certain circumstances the waste caused by the design is larger than the cost of the design itself (Koskela, 1992). A study conducted by Bijen (2003) confirms that engineering failures accounts for as much as 10% of the total investment in the new project. Additionally, the effect of the failure is inextricably linked to less tangible environmental and social costs. More specifically, deviations on project accounts for on average 12.4% of the entire cost of project and design errors add up to 78% of the entire magnitude of deviations, 79% of the total deviation costs and 9.5% of the entire project cost. A survey in Kuwait by Kartam et al. (2001) stated that design deviations forms part of the main risks to delays in projects and a study in Hong Kong by Ahmed (1999) confirmed this when defective design was considered to be critical risk to projects. Stasiowski et al. (1994) in their research on how to improve quality in design firms find that a lot of design institutions spend 25-50% of design time correcting and redoing works that had been once already done, correcting details that have already been designed on other projects, and remedying errors found during design appraisals. Anon (2000) study shows that design errors result in problems such as difficulty with construction of the design on the ground, conflicting details in structural design, insufficient provisional work designs, poor construction methods, and data on differing site situations or conditions. Musa & Obaju (n.d) identified several effects of design errors on construction project. Some of these include a reduction in the quality of design details, lack of faster implementation of action on site, setback in quantity of work to be achieved and the

slowdown in designer work. Moreover, if the client makes design changes later in the design process, it may lead to project failure. Also, design errors normally result in safety measure drawback, excessive consumption of funds in correction work, conflicts among the project stakeholders and more importantly conflict on who should pay for design error.

Examining the effect of design errors from a different angle presents some basic importance of error in design. In Busby (2001) error has been regarded as a necessary element in learning a task and adapting to its changing needs. Organisations stand a good chance from benefiting from the smaller adaptions made from time to time. Errors can be revealing in the sense that it contributes to the understanding of the nature of task that has become habitual, automated or just taken for granted.

Love et al (2011) opined that one of the harmful effects of design errors is rework or revision of the work. In addition to rework, Bower (2000) poses that other negative effects such as extra work, time loss, design revisions and increase in cost of work also add to the problem. Bower (2000) further continued the list of effects by tackling indirect effects of design errors. They include disputes and claims, loss of productivity, loss of rhythm, unbalanced gangs and resource allocations, changes in cash flow and increased risk of co-ordination failures. In Sun and Mend (2009) the effects of design errors on construction projects were classified into four; time and cost related effects, productivity related effects, risk related effects and other effects. The results show that time and cost overruns are associated with design errors and also ultimately leave customers dissatisfied. The productivity related effects considers the effects design errors have on the speed and efficiency with which a particular task is completed. Studies by Moselhi et al (2005) establishes that the higher the error in design the higher the productivity degrading. Arain and Pheng (2005) also attributed that pressure that comes from the need to make huge changes to projects as a cause of productivity loss. They

pose one of the consequences is the damage on staff morale and staff fatigue which results in low productivity.

2.9 The impact of design errors on cost performance

The performance of a project is of great concern to all project participants. However, the performance criteria set by individual participants depend on their perspectives. Past researchers have explored different criteria such as compliance to schedule, cost and quality to evaluate the project performance (Hwang et al., 2009). Hwang et al (2009) set out to measure the effect of remedial works on the performance of construction projects. The findings from their work indicates that design error (DE) and owner change were frequently found to have the greatest impact of cost performance. In addition, their study identified projects within the ranges of $50 million to $100 million to be the most susceptible projects to experience design changes. The impact of design errors on cost performance identified in Hwang et al. (2009) recommended the implementation of systems such as project change management, pre-project planning, effectiveness of design, conformity and constructability for tracking and controlling design errors. The impact of defective designs by Andi and Minato (2003) considered different aspects such as rework, delays, cost overruns, changes, accidents, disputes and loss of profits as the contributing factors to poor project cost performance. Their findings indicate that the cost of defective design constitute about 30% of rework and cost overruns. The deviations on projects which could be as result of owner change, contractor error/omission or design error accounts for an average of 12.4% of the total costs and design deviations constitute about 75% of the total number of deviations. The total deviations on a particular project can amount to 79% of the deviation costs and 9.5% of the total cost of the cost of the entire project (Burati et al, 1992). Stasiowski et al (1994) asserted that design firms spend about 25-50% of man hours redoing work that has been done before which in the long run affects the cost and time of the project. Studies in the United

States also reported that 20 civil infrastructure projects across 17 states, with estimated total cost ranging from $205 million to $2.6 billion, experienced significant cost overruns between 40% to 400% (General Accounting Office, 2002). Iyer and Jha (2005) conducted a study on the factors affecting cost performance on construction projects. The factors were grouped into success factors which is to be encouraged and failure factors which should be reduced if a positive project cost performance is required. The major areas considered under the success factors include the competence of project managers, support from top management, the coordinating and leadership skills of the project manager, monitoring and feedback, coordination between project participants, committed project participants and owner's competence and favourable climatic condition. The failure factors include conflict among project participants, ignorance and lack of knowledge, presence of poor project specific attributes and nonexistence of cooperation, hostile socio economic and climatic condition, reluctance in timely decision, aggressive competition at tender stage and short bid preparation time. All these factors have attributes or variables which elaborates more on the factor in consideration. Their work shows that lack of coordination among project participants which is a negative variable has a greater impact on cost performance and hence efforts should be made to reduce its impact. Additionally, they asserted that lack of coordination results in duplicated works which leads to wasteful expenditures which presents a negative influence to cost performance of projects. Success variables such as regular meetings among project participants and the development of rapport among the project participants can improve the skills of participants and lead to less errors in design. Josephson and Hammarlund (1998) have the opinion that the best way to reduce the cost impact of design errors is to uproot the cause of these errors. They discovered the major causes of design errors to be centred on the stability of the client organisation, clients project control, user involvement, time pressure,

composition of the project organisation, cost pressure support to the site organisation and motivation.

CHAPTER THREE

3.1 Introduction

Research methodology is defined by Kothari as a systematic way of solving research problems using appropriate research methods (Kothari, 2004). Cooper and Schindler (2003) argued that the subsequent step after literature review is very crucial for achieving the aim of the study. This chapter therefore focus on the most appropriate research methods, techniques and analytical tools that will be used in achieving the aim and objectives of the study.

3.2 Research Paradigm

The concept of the paradigm has a great influence on the research process. Research paradigm is defined as a cluster of beliefs which guide researchers to decide what should be studied and how the findings should be analysed and interpreted (Kuhn, 1996). There are three essential components of paradigms: Ontology, Epistemology and Methodology (Guba & Lincoln, 1994). Ontology according to Grix (2002) is regarded as the starting point of all research and it is concerned with the reality and how people perceive it (Crotty, 1998). Epistemology on the other hand is the study that shows the source, nature, approaches and validation of the awareness of humans (Hofers & Printrich, 2002).

This research is based on epistemological consideration where it deliberates on information and its rationality and suitability. Carson et al., (2001) classified epistemology into two categories which are positivist and interpretivist. Interpretivist according to Hudson & Ozanne (1988) hold the view that realism is numerous and comparative and hence interpretivist research pursues the comprehension and ravaging the understanding of behaviour trait contrary to predicting the cause and consequence (Nuemen, 2000)

3.3 Descriptive research

Descriptive research describes the position of matters of a condition or fact (Kothari, 2004). One major characteristic of descriptive research is that the variables have no control by the

researcher, but can only report on the current status of the subject matter. Although the variables in descriptive research cannot be controlled, the researcher tries to report on the causes of events. Reference to this background, the nature of this research is descriptive as it attempts to describe the causal mechanisms of design errors on construction projects in Ghana.

3.4 Research Approach

There are three approaches to research. They include; qualitative approach, quantitative approach and a combination of qualitative and quantitative approaches also called the triangulation method. Fellows and Liu (2003) opined that the fundamental issues which guide the selection of a particular approach for a research includes the research question, constraints and perhaps most particularly what is to be measured and the requirements of reliability and validity.

According to Kothari (2004) qualitative approach to research is relevant when it comes to investigating human behaviour to unveil various factors promoting human behaviour in a particular manner. This approach is used mostly in case study, where the aim is to gather detailed information and obtain detailed understanding of the research problem. It is very effective when looking for people's attitude and may be undertaken 'open ended' by means of focus groups or detailed interviews

Yin (1994) described quantitative approach as the pursuit for information that will define, quantity and clarify our reality. This approach is characterised as well as organised. This approach tries to appraise the data and characteristically use some form of arithmetical analysis (Malhotra, 2007). Quantitative research could be inferential, experimental or simulation approach.

This study is of the opinion that the causal mechanisms of design errors on construction projects in Ghana must be carried out in an unbiased way (free of researcher effects) which can be replicated and hence the quantitative approach.

3.5 Research Methods

Research methods are procedures used in investigation conduction (Kothari, 2004). They help the researcher to find data from the field investigation for analysis and valuations. Some examples of research methods according to Aina (2001) include the following: social survey research, historical research, case study research, Delphi studies, experimental research and the use of questionnaires.

3.6 Research Procedure

This part of the research methodology reports on issues relevant to the methods used in order to accomplish the objectives of the research and the aim of the topic. Reasons behind the choice of the sampling techniques, data collection instruments and tools are addressed. Figure 3.1 illustrates the impression of the research procedure.

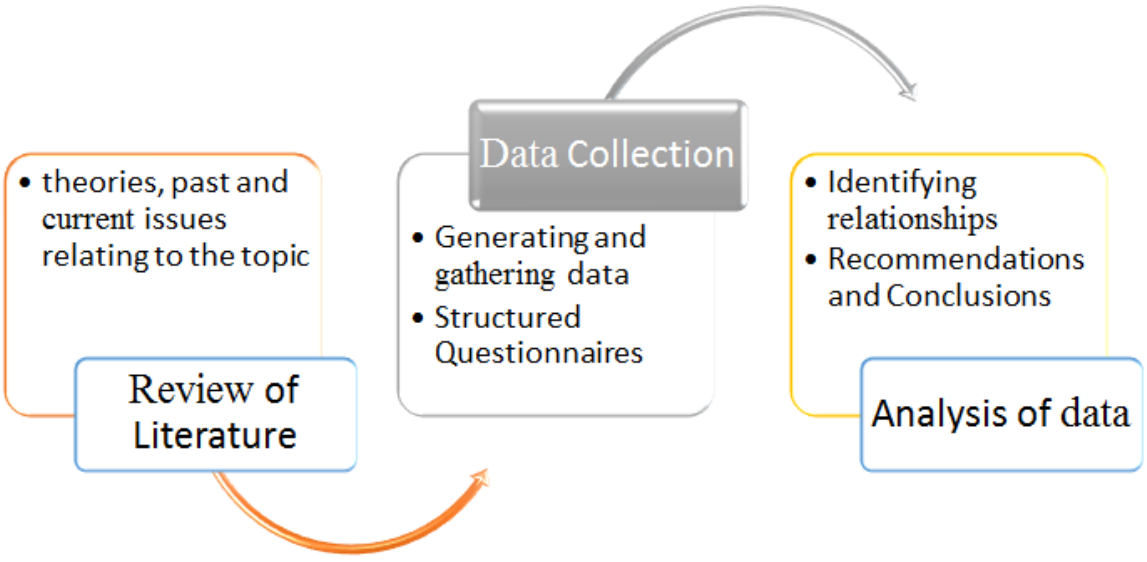

Figure 3.1: Flow process chart for the research procedure (Source: Mensah, 2013)

3.6.1 Population of the study

According to Brynard and Henekom (2006) population refers to the objects, subjects, incidentals, happenings, events or activities stated for the purpose of sampling. According to the Association of Building and Civil Engineering Contractors (ABCEC), there are 70 construction firms who are in good standing with the association in Kumasi. From this information, the total number for the population size (N) is 70.

3.6.2 Census Survey

This feature with regards to the methodology is a data collection activity involving a sample of the population. The census survey collected information about every member of the population. However, this survey employed a questionnaire to measure the specific characteristics of the population. A **census survey** technique collected complete information from all the participants in the population.

3.7 Data Collection and Instrumentation

This portion focuses basically on collection of data, tools and processes. It gives complete clarifications to all the techniques used in appraising the aims, the objectives, and the questions of research. Data collection is a major factor, as the information collected helps to have a better comprehension of a theoretic history (Bernard, 2002). Data collection will be undertaken through primary sources and secondary sources. The primary data deals with the collecting of the practical information through case survey questionnaires. Primary data are information that the researcher gathers because it has not been compiled and published for public accessibility (Bernard, 2002). Review of literature has been conducted thoroughly and the study placed within a theoretical setting, therefore a questionnaire of case study was utilized for the search. Secondary data was taken from materials both published and unpublished.

The literature review findings formed the theoretical outline for the research. The respondents as earlier stated are construction professionals involved in the design and construction works in Ghana.

3.8 Development of Questionnaires

The questionnaires are based on the three objectives which constitute the identification of the factors influencing design document deficiencies, the perception contractors and designers per what the designs are meant to achieve and the impact of the errors on construction projects in terms of cost. The nature of this survey questionnaire is structured into to include the invitation, introduction, question types and close. There invitation includes the introduction. The introduction is a brief background of the research what the research questionnaire is focused on and the major objectives. The second part is the selection of the respondents. The reason why people in the construction industry; mainly contractors and consultants are engaged is because the form part of the category of people who can relate to the research and give the response that may be valid as per the objectives of the research. A census sampling technique was then used to make the choice of the respondents. The sample size of 70 represented the total number of questionnaires which was distributed. This was extracted from records from the Association of Building and Civil Engineering Contractors (ABCEC), who have the records of construction companies that are in good standing with this professional body. The introduction part of the survey questionnaire includes an attractive introduction which clearly portrays the aim of the research.

Five steps were used to develop the questionnaire. This basically involved determining the aim, finalizing the attributes to gauge, recognize the type of audience, select the scales of measurement and finally check the reliability and the validity of the survey. Section A of the questionnaire is about the background for the respondents with regards to academic

qualification, professional affiliation, years of experience and the type of projects undertaken. Section B is about the ranking of the factors that influence the design documentation as extracted from the literature review and based on the objectives. Section C is structured to rank the perception of the designers and contractors' with regards to what the design documents achieve based on attributes from the literature review. This section also ranks the percentage level of defects caused by errors in design on variables also based on the literature review.

3.9 Data Presentation and Analysis

The retrieved questionnaire will be coded and analysed using statistical tools such as the IBM SPSS (International Business Machines Statistical Package for Social Sciences) version 21.00. To throw more light on the discussion in this scope, the data attained would be presented graphically and in tabular forms. Information involving the background of respondents would be presented using tables and cross tabulations. The outcome of the study would be correspondingly assessed with the research objectives. Sequentially, the results would be analysed statistically using descriptive statistics to determine the causal mechanisms of designs errors on construction projects in Ghana.

4.0 Chapter Summary

This chapter addressed the methodology used for the research and the reasons for its adoption.

The research approach used and the method of data collection were discussed in detail. The

Chapter concluded with the research process and covered issues such as; the population, sources of data, questionnaire developments, sample size determination and finally data presentation and analysis.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

This chapter discusses the data obtained from the retrieved questionnaires distributed for the study. Statistical tools such the descriptive statistics were employed to analysed the demographic data and the dependent variables as well. For better understanding and analyses, the results are presented in tabular forms and explained accordingly. One aspect of this chapter talks about the profile of the respondents and how that affects the credibility of the information they provided for the study. The other sections tackle the objectives of the study which were set for the study with regards to the impact of design errors on cost of projects in Ghana.

Seventy (70) questionnaires were distributed to construction professionals who work in construction companies in the Kumasi metropolis and a number of forty-five (45) were retrieved. All the retrieved questionnaires were filled and thus could all be subject to analysis. This represents a responds rate of 64%. This is higher than the 30% response rate suggested by Oladopo (2005) as adequate for construction studies. The limited amount of time available for the researcher to distribute the questionnaire, the response rate is considered relatively high and the high responds rate can be attributed to the fact that the questionnaire was administered in person coupled with successive follow-ups.

4.2 Analysis of the Demographic Data and Background Information

The demographic data obtained from respondents covered questions seeking basic information from the respondents to help understand their profile as this generates confidence in the credibility of the data collected and hence the research work. Table 4.1 shows information in relation to the academic qualification of respondents, professional body in which respondents is affiliated and years of professional practice. Number of full time

employees in the company in which respondents work, the kind of projects the company undertakes and years company has been in business which were some of the information regarding the company's background in which respondents work with were also included in this survey.

4.2.1 Academic Qualification of Respondents

This part of the background information of the respondents was used to establish the academic qualification of the respondents. The academic qualification of the respondents gives relevance to the kind and quality of information that will be given out. The information provided by these respondents would be the basics for future research and hence the researcher needed to confirm that the respondents are qualified academically to comment or share their opinion on the issue at hand thus the information obtained give a clue about the capabilities of the respondents. From Table 4.1 it can be seen that none of the respondents have a PHD qualification, 4 of the respondents representing 8.89% have MPhil, 25 of the respondents constituting 55.56% have MSc/MEng, 2 respondents have P.G. Diploma representing 4.44% and 14 respondents constituting 31.11% BSc degrees. It is not uncommon to have no respondent with a PHD qualification since most people with such qualification are usually seen in the academia in Ghana other than working in the industry. it can be deduced from the academic qualification information that majority of the respondents have a Master's degree which parallels the quality of information provided by the respondents for the study.

4.2.2 Professional Affiliation

This section of the study sought to find out about the professional affiliation to which each of the respondents belongs. From Table 4.1, it can be seen that 3 of the respondents representing 6.67% belongs to the Ghana Institute of Construction (GIOC), 6 respondents representing 13.33% are part of the Ghana Institute of Engineers (GhIE). In addition, 11 of the respondents constituting 24.44% belongs to the Ghana Institute of Architects (GIA), 10 respondents representing 22.22% belongs to the Ghana Institute of Surveyors while 15

respondents representing 33.33% are affiliated to no professional body. Construction association and affiliations use stringent methods in selecting its members. Some of these methods includes the number of years of experience of the person and the academic degree. Hence, obtaining information from respondents who are part of a professional affiliation is an indication of the quality of information being obtained, for such people have the prerequisite knowledge and experience in matters relating to the field of study. It can be deduced from the table that about 66.67% surveyed are part of a professional body which is an indication of the quality of information obtained.

4.2.3 Years of Professional Practice

Information regarding the years of professional practice of the respondents was to ascertain the working experience of the respondents. This information has a direct influence on the kind and quality of information obtained from the respondents. Table 4.1 shows the professional experience of the respondents. Apparently most of the respondents have work experience ranging from 11-15 years constituting 46.67% and 10 of the respondents representing 22.22% have work experience ranging from 16-20 years. This shows that most of the respondents have relative experience in the field of study. Contrary to the above, few respondents have less than 5 years working experience which indicate that most of the respondents have rich experience in their relative field of study.

4.2.4 Number of Full Time Employees

In addition to the information obtained on the background of the respondents, efforts were made to take information regarding the companies with which the respondents work for. The purpose of which is to give a clue about the quantity and size of the works undertaken by the respondents. With regards to size of the companies in which respondents work for, majority of the respondents work for companies with full time employees exceeding 41 and above constituting 46.67%, 13 respondents work for companies with full time employees between 31-40 representing 28.89%.

Table 4.1 Presentation of demographic data of respondents & background information

VARIABLES	OPTION	FREQUENCY	PERCENTAGE (%)
Academic qualification	PHD	0	0.00
	MPHIL	4	8.89
	MSC/Meng	25	55.56
	P.G. Diploma	2	4.44
	B.S.C	14	31.11
Professional Affiliation	GIOC	3	6.67
	GhIE	6	13.33
	GIA	11	24.44
	GhIS	10	22.22
	No Professional Affiliation	15	33.33
Years of Professional Practice	Less than 6 years	4	8.88
	6 – 10 years	7	15.56
	11 -15 years	21	46.67
	16 – 20 years	10	22.22
	Above 20 years	3	6.67
Number of Full-time employees	1-10	0	0.00
	11-20	6	13.33
	21-30	13	28.89
	31-40	5	11.11
	41 and above	21	46.67
Kinds of Construction Projects Undertaking	Building	10	22.22
	Civil Construction	3	6.67
	Both Building and Civil Construction	32	71.11
Years in Business	1-5 years	4	8.89
	6-10 years	14	31.11
	11-15 years	17	37.77
	16 -20 years	7	15.56
	21 and above	3	6.67

Source: Field survey, 2018.

This shows that, most of the respondents work for large companies and hence are involved in undertaking large and complex projects which will require a lot of detailed and complex drawings.

4.2.5 Kind of Construction Projects Undertaking by Respondents' Firm

As part of the research endeavour, it became imperative to identify the kind of construction projects undertaken by the firm of the respondents. The kind of construction projects identified would help the researcher when analysing information regarding the impact of design errors on construction cost. This information will guide the researcher when making conclusions about the research findings without generalising the outcome of the study. In Table 4.1, 32 of the respondents representing 71.11% worked for companies which undertake both building and civil construction projects. 10 respondents constituting 22.22% work in firms which undertake building construction projects only while 3 respondents representing 6.67% work in firms which undertake civil construction projects only. The increase in the number of firms which undertake both building and civil works can be attributed to the fact most construction companies are registered as D1K1 where the D represents building works while K represents civil works. So although in reality most of these firms undertake building projects, they consider themselves as both building and civil works.

4.2.6 Years in Business

The number of years a construction firm has been in business provides a lot of information about it management systems. A company which has been in business for a considerable period of time might have in place proper measures for identifying errors in drawing designs. From Table 4.1, majority of the respondents work with firms which has been in business for a period from 6-10 years and 11- 15 years constituting 31.11% and 37.77% respectively. This information gives a clear indication that the respondents worked with firms which has been in business for a longer time and hence may have proper measures for dealing with design errors on construction projects.

4.3 Analysis of Dependent Variables

This section discusses how the analytical tools such as the mean score ranking was used to analyse the data obtained through the questionnaire survey. The mean score rankings were used to ascertain the factors that influence design document deficiencies and also grasp the perception of the achievement of design documents used in the Ghanaian construction industry. The procedure, findings and relevant discussions are deliberated upon in the succeeding subjects.

4.3.1 Factors that influence design document deficiencies in the Ghanaian construction industry

This section discusses the relevant factors that influence design document deficiencies in the Ghanaian construction industry. Fifteen (15) factors that influence design document deficiencies were identified in the literature and respondents were asked to rate the extent to which the factors influence design document deficiencies in the Ghanaian construction industry on a scale of 1-4, where 1 = very low, 2 = low, 3 = high 4 = very high.

The mean score rankings were used in the analyses to determine the most influencing factors. The main aim of the analyses was to assist in the selection and ranking of the influencing factors with regards to the factors that influence design document deficiencies. Table 4.2 reveals the mean score rankings in descending order. It can be seen that lack of coordination ranked first with a mean score of 3.68. Incomplete or inaccurate information received from other designers and high stress situations ranked 2nd and 3rd with mean scores of 3.57 and 3.54 respectively. The 4^{th}, 5^{th} and 6^{th} were occupied by lack of construction knowledge, lack of experience or incompetent designers and over trust of other designers with mean scores of 3.54,.3.49 and 3.34 respectively.

Table 4.2 Factors that influence design document deficiencies in the Ghanaian construction industry

No.	**Factors that influence design document deficiencies**	**N**	**Mean**	**Standard Deviation**	**Ranking**
1	lack of coordination	45	3.68	0.836	1st
2	Incomplete or inaccurate information received from other designers	45	3.57	0.548	2nd
3	high stress situations	45	3.54	0.774	3rd
4	lack of construction knowledge	45	3.54	0.810	4th
5	lack of experience or incompetent designers	45	3.49	0.635	5th
6	Over trust of other designers	45	3.34	0.910	6th
7	Time pressures	45	3.28	1.057	7th
8	low design fee	45	3.22	0.925	8th
9	Unawareness of change in standard	45	3.22	1.025	9th
10	lack of motivation by designer	45	2.89	0.885	10th
11	client lack of leadership	45	2.64	0.845	11th
12	interpersonal skill problems of designers	45	2.48	0.445	12th
13	Inadequate training for designers	45	2.35	0.985	13th
14	Failure of tools, such as computer software	45	1.97	1.236	14th
15	Ineffective organization structure of design team	45	1.45	1.125	15th

Source: Field survey, 2018.

The other influencing factors such as time pressure (7th), low design fee (8th), unawareness of change in standard (9th), lack of motivation by designer (10th), client lack of leadership (11th), interpersonal skill problems of designers(12th), inadequate training for designers (13th), failure of tools such as computer software (14th) and lastly ineffective organisation structure of design team (15th).

4.3.1.1 Discussion of the factors that influence design document deficiencies in the Ghanaian construction industry.

The literature reviews heighted some major factors that influence design document deficiencies in the construction industry. Andi and Minato (2003) highlighted on some of these factors after a tall list of factors were presented to respondents to using a scale. Unlike the findings from Andi and Minato (2003), this study highlighted the lack of coordination as the major factor that influence design document deficiencies followed by incomplete or inaccurate information received from other designers. These factors according to Andi and Minato (2003) are all part of organisational factors rather than workplace factors. Thus, these findings indicate that there is therefore the need for organisations to adapt proper technical innovation tools which ensure proper coordination such as Building Information Modelling (BIM) which ensures proper coordination among designers. Moreover, Anon (2003) study also shows that design errors leads to constructability problems on construction sites which has been confirmed by this study as lack of construction knowledge(5th) can influence design document deficiencies.

4.3.2 Perception of the Achievement of Design Documents in the Construction Industry

This section discusses the perception of the quality of design documents used in the Ghanaian construction industry. Eleven (11) attributes which makes up a good quality documents were retrieved from literature and respondents were asked to rank on a scale of 1-4 where 1 = not good, 2 = fairly good, 3 = good and 4 = very good. In addition, the results were analysed with the help of the Statistical Package for Social Science version 20.0. This analysis helped to

identify which attributes performed well regarding design documents and which of them requires additional improvement in the Ghanaian construction industry.

Table 4.3 perception of the achievement of design documents used in the Ghanaian construction industry

No.	**Attributes**	**N**	**Mean**	**Standard Deviation**	**Ranking**
1	Completeness	45	3.21	0.836	1st
2	Standardization	45	3.08	0.452	2nd
3	Accuracy	45	2.85	0.365	3rd
4	Clarity	45	2.69	0.554	4th
5	Consistency	45	2.69	0.774	5th
6	Site Representation	45	2.47	0.810	6th
7	Coordination	45	2.24	0.845	7th
8	Relevance	45	1.98	0.910	8th
9	Conformity		1.78	0.335	9th
10	Timeliness	45	1.63	1.057	10th
11	Certainty	45	1.58	0.784	11th

Source: Field survey, 2018.

From the mean score rankings as illustrated in table 4.3 above, it can be seen that generally the mean scores are very small and the standard deviations are very close as well indicating the agreement of the respondents' response on a particular attribute. From the rankings, it can be seen that the ''completeness'' as an attribute was ranked first with a mean score of 3.21.

Standardization and Accuracy was ranked 2nd and 3rd with mean scores of 3.08 and 2.85 respectively. The 4th, 5th, 6th and 7th positions were occupied by the attributes; clarity, consistency, site representation and coordination with mean score rankings of 2.69, 2.69, 2.47 and 2.24 respectively. However, the attributes such as timeliness and certainty were the last two attributes occupying the 10th and 11th positions respectively.

The quality of the documents produced in the Ghanaian construction industry was ascertained using attributes such the accuracy of the drawings, clarity, consistency, standardization, coordination and so on. The mean scores obtained from this study gives a clue about the quality of design documents used in the industry. With the highest mean score of 3.21 and followed by 3.08, one can easily conclude that quality of drawings produced in the Ghanaian construction industry is not very high. Moreover, the respondents believe that most the drawings produced are complete, up to standard and to some extent accurate. However, the results also indicate that the drawings produced are mostly not in conformity with each other, are not produced on time and also the chances that, what is produced will be the exact copy of what is required on the field is questionable. These findings are in line with Musa and Obaju (n.d) study on the effect of design errors on construction projects. They discovered that lack of conformity results in lack of faster implementation of action on site which slows done the entire construction process.

Table 4.4 The percentage level of defects caused by errors in designs

No.	Variable	N	Mean	Standard Deviation	Percentage range	Ranking
1	Cost Overruns	**45**	**3.78**	**0.447**	**31-40**	**1st**
2	Profit	**45**	**3.69**	**0.265**	**31-40**	**2nd**
3	Rework	**45**	3.55	0.836	31-40	3rd
4	Changes	**45**	3.12	0.945	31-40	4th
5	Delays	**45**	2.89	1.025	21-30	5th
6	Accident	**45**	2.21	0.774	21-30	6th
7	Disputes	**45**	1.89	0.810	10-20	7th

Source: Field survey, 2018.

4.3.4 Percentage Level of Defects Caused by Errors in Design

This section considered the percentage level of defects caused by errors in design. In other to grasp an understanding of the effect of design errors, respondents were asked to rate the percentage level of defects caused by errors in design on a scale of 1- 4 where 1 = 1 -10%, 2 = 11 -20%, 3 = 21-30%, 4 = 31-40%. The mean score rankings indicate that cost overruns are the major effects caused by design errors in the construction industry with mean score of 3.78. Profit is the next variable which is much affected after cost overruns. Table 4.4 shows that the mean score for profit to be 3.69 which in percentage wise falls between 30 – 40%. Rework, changes, delays, accidents and disputes was ranked 3rd, 4th, 5th 6th and 7th with mean scores 3.55, 3.12, 2.89, 2.21 and 1.89 respectively.

The findings from the survey indicates that defects in design or design errors mostly leads to cost overruns. This is in line with Owusu Manu (2008) who discovered in his study that the Ghanaian construction industry like most other countries are faced with the problem of time overrun and cost overrun. Studies by Hwang et al (2009 about the impact of rework on construction cost performance found that design error was frequently found to have the greatest impact on construction cost performance. However, their studies also identified that the impact of design errors on cost performance increases with project size. Hence, the larger the project, the greater the impact.

4.4 Chapter Summary

The respondents' demographic information on academic requirement, associated profession and experience were considered as key in this survey as it gave an indication as to the credibility and reliability of the survey date collected for analysis. Descriptive statistical tools such as the mean score ranking was used to ascertain the most relevant factors that influence design document deficiencies in the Ghanaian construction industry

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The research aim was to investigate causal mechanisms of design errors and its impact on cost performance of construction project in Ghana. The research objectives are revisited in this chapter to show the extent to which the aim of the study has been achieved throughout the various stages of the study. The chapter presents recommendations based on the findings form the study and states the limitations of the study as well. The result of this research was specified in brief to permit the reader appreciate the subject matter in its entirety.

5.2 Review of Objectives

The three objectives that were set to guide the study towards the achievement of the aim of this study include:

i. To identify the critical factors influencing design documents deficiencies

ii. To assess designers' and contractors' perception of the achievement of design documents.

iii. To assess the impact of design errors on cost of a construction project.

5.2.1 Critical Factors that Influence Design Documents Deficiencies

Fifteen (15) factors that influence design document deficiencies were identified from literature and respondents were asked to rate the extent to which the factors influence design document deficiencies in the Ghanaian construction industry. Results from the retrieved data shows that lack of coordination among designers is one of the most influencing factors of design document deficiencies. Moreover, incomplete or inaccurate information received from other designers and high stress situations ranked 2nd and 3rd with mean scores of 3.57 and 3.54 respectively. The 4th, 5th and 6th were occupied by lack of construction knowledge, lack of experience or incompetent designers and over trust of other designers with mean scores of

3.54,.3.49 and 3.34 respectively. The other influencing factors such as time pressure (7th), low design fee (8th), unawareness of change in standard (9th), lack of motivation by designer (10th), client lack of leadership (11th), interpersonal skill problems of designers(12th), inadequate training for designers (13th), failure of tools such as computer software (14th) and lastly ineffective organisation structure of design team (15th).

The leading factors influencing design errors based on the classification from Andi and Minato (2003b) are organisation factors. The problem of coordination which was identified to be the leading factor can be dealt with using technological tools such as Building Information Modelling. The problem of the use of incomplete or inaccurate information from other designers which was also identified as a major factor in the Ghanaian construction industry truly reflect the nature of the industry. Most clients do not use qualified professionals for their designs with the hope that things will corrected during the construction stage which results in a lot of changes and rework and cost overruns. Most designers lack the practical experience and therefore are unable to picture how their designs will perform on the field. Thus, Anon (2003) indicated lack of constructability as on the major causes of defects in design.

5.2.2 Perception of the Achievement of Design Documents in the Construction Industry

This section discusses the perception of the quality of design documents used in the Ghanaian construction industry. Eleven (11) attributes which makes up a good quality documents were retrieved from literature and respondents rate them on a scale of 1-4. The retrieved data was analysed by ranking them using their means. Form the rankings, it can be seen that the 'completeness' of the drawing was ranked first with a mean score of 3.201. 'standardization' and 'accuracy' were ranked 2nd and 3rd with mean scores of 3.08 and 2.85 respectively. The attributes such as timeliness and certainty were the last two attributes occupying the 10th and 11th positions respectively.

The mean scores obtained from this study gives a clue about the quality of design documents used in the industry. With the highest mean score of 3.21 and followed by 3.08, one can easily conclude that quality of drawings produced in the Ghanaian construction industry is not very high. Moreover, the respondents believe that most the drawings produced are complete, up to standard and to some extent accurate. However, the results also indicate that the drawings produced are mostly not in conformity with each other, are not produced on time and also the certainty that, what is produced will be the exact copy of what is required on the field is questionable. The findings were in line with Musa and Obaju (n.d) studies on the effects of design errors on construction projects. They discovered that lack of conformity results in lack of lack faster implementation of action on site which slows down the entire construction process in this case the non-conformity of drawings.

5.2.3 The percentage level of defects caused by errors in designs

This section considered the percentage level of defects caused by errors in design. This is in effect help us to understand the impact of design errors on construction cost performance. The mean score rankings indicate that cost overruns are the major effects caused by design errors in the construction industry with mean score of 3.78. Profit is the next variable which is much affected after cost overruns. Table 4.4 shows that the mean score for profit to be 3.69 which in percentage wise falls between 30 – 40%. Rework, changes, delays, accidents and disputes was ranked 3rd, 4th, 5th 6th and 7th with mean scores 3.55, 3.12, 2.89, 2.21 and 1.89 respectively

The findings from this study indicates that most of the cost overruns experience during project execution is caused by defects or errors in the design documents. Owusu Manu (2008) studies highlighted that cost and time overruns is a long time problem facing the Ghanaian construction industry. Hwang et al (2009) studies show the impact of design errors on cost

performance increases with increase in project size. Thus, the larger the project, the greater the impact.

5.3 Conclusion

The need for measures to reduce the impact of errors in design is very urgent in the Ghanaian construction industry. The factors identified as the influencing factors for defects in design documents should guide construction practitioner especially managers to in place proper measures to curb the time and cost overruns faced by the construction industry. Moreover, this study also shows that the most pressing factors are organisation factors (Andi and Minato, 2003) and hence construction firms have a lot to play to ensure lesser defects in design documents. The perception of the achievement of design documents should guide the guide construction practitioners as to the areas that needs to be improve to achieve quality documents and finally the study shows that indeed the design errors have a huge impact on construction cost performance as most design errors results in cost overruns and as such has huge impact on company profit.

5.4 Recommendations

The studies highlighted the key factors that influence design document deficiencies and also assessed the perception of the quality of design documents used in the Ghanaian construction industry. As a result, the following recommendations have been proposed:

1. The period for producing design documents should be well planned so as to reduce errors that come from lack of coordination and time pressures.
2. Effective monitoring and management of designers in the organisation is also required to ensure that quality documents are produced.
3. Expects should be consulted for design documents by client in order to reduce the impact of cost overruns and rework.

4. Conferences, workshops, fairs and exhibitions should be frequently organised by professional bodies and other regulatory bodies to educated construction practitioners on the need to produce quality design documents.

5.5 Limitations of the Research

As with most survey research, this study also had limitations that need to be acknowledged. It is important to recognise the relative small sample size used for the study. Moreover, retrieving questionnaires from the respondents was difficult as most of the respondents had busy schedules and needed successive follow-ups and phone calls. This made the distribution and retrieval of the questionnaires quiet a laborious task.

5.6 Directions for future Research

Although several research has been done on the impact of design errors, few has been done in the Ghanaian construction industry and as a result several opportunities exist. The following recommendations are made for future research:

1. This study focused on designers who work with construction firms, future studies can explore the factors that influence deficiencies from the perception of architectural firms in Ghana.
2. Moreover, the sample size for the studies was very small as it focussed on construction firms in Kumasi. Other research studies can consider increasing the sampling size by conducting survey studies in other regions of Ghana.

REFERENCES

Ahmed, S.M (1999). Risk management trends in Hong Kong construction industry: a comparison of contractors and owner's perceptions", Engineering, Construction and Architectural Management 1999; 6(3):225–34.

Aibinu AA, Jagboro GO. (2002). The effects of construction delays on project delivery in Nigerian construction industry. Int J Project Manage 2002;20(8):593–9.

Aina, L. O. (2001). Research in information sciences: An African perspective. Ibadan: Stirling-Horden, pp. 1-3.

Allen, D E (1984) 'Structural failures due to human error: what research to do?' in M Grigoriu, (ed.) Risk, structural engineering and human error University of Waterloo Press, Waterloo, Canada (1984) pp 127–138

Andi and T. Minato (2003), "Design documents in the Japanese construction industry: Factors influencing and impacts on construction 99999999999999process," Int. J. Proj. Manage., vol. 21, pp. 537–546, 2003b.

Andi and T. Minato (2004), "Representing causal mechanism of defective designs: Exploration through case studies," Constr. Manage. Econ., vol. 22, pp. 183–192.

Anon (2000). Impossible to be built design drawing. Nikkei Construction; 253:60–85 [in Japanese].

Arain FM, Pheng LS (2005). The potential effects of variation orders on institutional building projects. Facilities pp;23(11):496–510.

Atkinson, A. R. (2002). "The pathology of building defects: A human error approach." Eng., Constr., Archit. Manage., 91, 53–61.

Bernard, H. R. (2002). Research Methods in Anthropology: Qualitative and quantitative methods. 3rd ed. California: AltaMira Press, Walnut Creek.

Blockley, D I (1988) 'Analysis of structural failures' Proceedings Institution of Civil Engineers part 1 Vol 62 (1977) pp 51–74 11 Brown, C B and Yin, X 'Errors in structural engineering' Journal of Structural Engineering Vol 114 pp 2575–2593

Blockley, D I and Henderson, J R (1980) 'Structural failures and the growth of engineering knowledge 'Proceedings Institution of Civil Engineers Part 1 Vol 68 pp 719–728

Bower D. A (2000) systematic approach to the evaluation of indirect costs of contract variations. Constr Manage Econ;18(3):263–8.

Brynard, P., & Hanekom, S. X. (2006). Introduction to research in management- related fields. Van Schaik.

Burati JL, Farrington JJ, Ledbetter WB. (1992) Causes of quality deviation in design and construction. J Constr Eng Manage;118(1):34–49.

Burns, N., & Grove, S. K. (2005). The Practice of Nursing Research: Conduct, Critique, and Utilization, 5th edition. St. Louis: Elsevier Saunders.

Carson, D., Golmore, A., Perry, C. & Gronhaug, K., (2001). Qualitative Marketing Research. London: Sage.

Construction Industry Institute (CII,2005). "Making zero rework A reality." *RS 203-1 (Nov.)*, The Univ. of Texas at Austin, Austin, Tex.

Cooper, D., & Schindler, P. (2003). Business research methods, 8th Edition. Boston: McGraw-Hill.

Crotty, M. (1998). The foundations of social research: Meaning and perspective in the research process. London: Sage.

D. F. Rogge, C. Cogliser,H.Alaman, and S. McCormack (2001), An Investigation of Field Rework in Industrial Construction (RR153-11). Austin, TX: Construction Industry Institute.

Dansoh, A. (2005). Strategic Planning Practice of Construction Firms in Ghana, Construction Management & Economics Taylor & Francis Group Ltd .

Davis, K., Ledbetter, W. B., and Burati, Jr., J. L. ~1989!. ''Measuring design and construction quality costs.'' J. Constr. Eng. Manage., 115~3!, 385–400.

Dias, W P S and Blockley, D I (1994) 'Galileo's confirmation of a false hypothesis: a paradigm of logical error in design (Discussion)' Civil Engineering Systems Vol 11 (1994) pp 75–77.

Edmondson, A. C. (2004). "Learning from failure in health care: Frequent opportunities, pervasive barriers." Qual. Saf. Health Care, 132, ii3–ii9.

Fellows, R., & Liu, A. (2003). Research Methods for Construction. 2nd ed. Oxford: Malden

General Accounting Office (2002) Transportation Infrastructure: Cost and Oversight Issues on Major Highway and Bridge Projects. GAO-02-702T, Washington, DC.

Gherardi, S., Nicolini, D., (2000). The organizational learning of safety in communities of practice. Journal of Management Inquiry 9 (1), 7–18.

Grix, J. (2002). Introducing students to the generic terminology of social research, Politics, Vol.22, pp.175-186.

Guba, E. G., & Lincoln, Y. S. (1994). Competing Paradigms in Qualitative.

Hanna AS, Russell JS, Vandenberg PJ. (1999) The impact of change orders on mechanical construction labour efficiency. Construction Manage Econ;17(6):721–30.

Hofers, B. & Printrich, P., (2002). Personal Epistemology-The Phycology of Belief About Knowledge and Knowing. 1st ed. New Jessey: Lawrence Erlbaum Associates, Inc.

Hudson, L. & Ozanne, J., 1988. Alternative Ways of Seeking Knowledge in Consumeer Research.. *Journal of Consumer Research,* 14(4), pp. 508-521.

J. Reason (1995), "Safety in the operating theatre—Part 2: Human error and organisational failure," Anaesth. Crit. Care, vol. 6, pp. 121–126.

J.S. Busby (2001), Error and distributed cognition in design, Design Studies 22, 233–254.

J.T. Reason, A. Hobbs (2003), Managing Maintenance Error: A Practical Guide, Ashgate Publishing Company.

Josephson, P. E., and Hammarlund, Y. (1999). "The causes and costs of defects in construction: A study of seven building projects." Autom. Constr., 86, 681–687.

Josephson, P.-E. ~1994!. ''Causes of defects in building: A study of causes and consequences of defects and impediments of learning in building projects.'' PhD thesis Dept. of Building Economics and Construction Management, Chalmers University, Go¨tenborg, Sweden, ~in Swedish!

Kalra, J. (2004b). "Medical errors: Overcoming the challenges." Clin. Biochem., 37, 1063–1071.

Kangari R. Risk management perceptions and trends of US construction. Journal of Construction Engineering and Management 1995;121(4):422–9.

Kartam NA, Kartam SA. (2001) Risk and its management in the Kuwaiti construction industry: a contractors' perspective. International Journal of Project Management; 19:325–35.

Kish, L. (1965). Survey Sampling. New York; John Wiley and Sons, Inc. p. 78-94.

Koskela, L. (1992). Application of the New Production Philosophy to Construction. Technical Report # 72, Center for Integrated Facility Engineering, Department of Civil Engineering, Stanford University, CA.

Kothari, C. R., (2004). Research Methodology; Methods and Techniques. 2nd ed. New Delhi: New Age Internation Limited.

Kpamma, Z., & Adjei-Kumi, T. (2010). The Lean Project Delivery System (LPDS): Application at the design and documentation stage for construction projects in Ghana. Proceedings of the West Africa Built Environment Research (WABER) Conference (pp. 597 - 604). Accra: Reading University.

Kuhn, T. S. (1996). The Structure of Scientific Revolutions, 3rd edn. Chicago: The University of Chicago Press.

Kumar, R. (1999). Research methodology: A step-by-step guide for beginners. London, England: Sage,

Laryea, S. (2010). CHALLENGES AND OPPORTUNITIES FACING CONTRACTORS IN GHANA. Proceedings of the West Africa Built Environment Research (WABER) Conference Ghana (pp. 215-226.). Accra: Reading University.

Lind, N C (1984) 'Optimal allocation to control gross errors in structures' in Grigoriu, M (ed.) Risk, structural engineering and human error University of Waterloo Press, Waterloo, Canada pp 192–204

Lopez R, Love PED, Edwards DJ, Davis PR (2010) Design error classification, causation and prevention for constructed facilities. ASCE J Perform Constr Facil 24(4):399–408

Love PED, Li H. (2000) Quantifying the causes and costs of rework in construction. Constr Manage Econ;18(4):479–90.

Love PED, Mandal P, Li H. (1999) Determining the causal structure of rework influences in construction. Constr Manage Econ 1999;17(4):505–17.

Love, P. E. D. ~(2001)!. ‘‘Determinants of rework in Australian construction projects.’’ PhD thesis, Department of Management, Faculty of Business and Economics, Monash Univ., Melbourne, Australia.

Love, P. E. D., and Edwards, D. J. (2004). “Forensic project management: The underlying causes of rework in construction projects.” Civil and Environmental Engineering Systems, 213, 207–228.

Love, P. E. D., and Smith, J. (2003). “Bench-marking, bench-action, and bench-learning: Rework mitigation in projects.” J. Manage. Eng., 194, 147–159.

Love, P. E. D., and Sohal, A. S. ~(2002)!. ‘‘Influence of organizational learning practices on rework costs in projects.’’ Proc., 8th Int. Conf. on ISO 9000 & TQM (Change Management), Center for Management Quality Research ~CMQR! at RMIT Univ., RMIT Storey Hall, Melbourne, Australia.

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

M. R. Manavazhi (2004) "Assessment of the propensity for revisions in design projects through the dichotomous characterisation of designer effort," Constr. Manage. Econ., vol. 22, no. 1, pp. 47–54.

M. R. Manavazhi and Z. Xunzhi (2001), "Productivity orientated analysis of design revisions," Constr. Manage. Econ., vol. 19, no. 4, pp. 379–391,2001.

Manavazhi, M. R., and Xunzhi, Z. (2001). "Productivity oriented analysis of design revisions." Constr. Manage. Econom., 194, 379–391.

McMaster, G. ~(2000)!. ''Can we learn from project histories?'' PM Network, 66–67.

Mensah, J. K. (2013). Exploring innovative financing mechanisms for delivering sanitation infrastructure in Ghana, Unpublished thesis (BSc), Kwame Nkrumah University of Science and Technology.

Minato, T. (2003). Design documents quality in the Japanese construction industry: factors influencing and impacts on construction process. International Journal of Project Management, 21(7), 537-546.

Moller, A. C., Deci, E. L., and Ryan, R. M. (2006). "Choice and egodepletion: The moderating role of autonomy." Pers. Soc. Psychol. Bull., 328, 1024–1036.

Moselhi O, Assem I, El-Rayes K (2005) Change orders impact on labor productivity. J Constr Eng Manage;131(3): 354–9.

Musa, S., & Obaju, B. N. EFFECTS OF DESIGN ERRORS ON CONSTRUCTION PROJECTS. ARCA, 137.

N. W. Hurst, L. J. Bellamy, T. A. W. Geyer, and J. A. (1991). Astley, "A classification scheme for pipework failures to include human and socio-technical errors and their contribution to pipework failure frequencies," J. Hazard. Mater., vol. 26, pp. 159–186.

Nuemen, L. W., (2000). Social Research Methods: Qualitative and Quantitative Approaches. 4th ed. USA: Allyn and Bacon.

Ofori, G. (2012). Developing the Construction Industry in Ghana: the case for a central agency. Singapore.

P.E.D. Love, R. Lopez, D.J. Edwards, Y. Goh (2011), Error begat error: design error analysis and prevention in social infrastructure projects, Accident Analysis and Prevention, in press.

Petroski, H (1994) Design paradigms. Case histories of error and judgment in engineering Cambridge University Press, Cambridge.

Polit, D. F., & Hungler, B. P. (1999). Nursing Research: Principles and Methods. 6th ed.(Revised). London: : Lippincott Williams & Wilkins.

Reason JT (1995) Safety in the operating theatre–Part 2: human error and organizational failure. Anaesth Crit Care 6:121–126.

Reason, J. T. (2002). "Combating omission errors through task analysis and good reminders." Qual. Saf. Health Care, 11, 40–44.

Reason, J.T., (2000). Human error: models and management. British Medical Journal 320 (7237), 768–770.

Sasou, K., and Reason, J. T. (1999). "Team errors: Definition and taxonomy." Reliab. Eng. Syst. Saf., 651, 1–9.

Sawada M. A fundamental study of risk management in construction projects—risk allocation between owners and contractors for public works. Unpublished Master thesis, University of Tokyo, Japan; 2000 [In Japanese].

Sense, A. J. (2007). “Learning within project practice: Cognitive styles exposed.” Int. J. Proj. Manage., 25, 33–40.

Stasiowski, F. A and Burstein, D (1994). Total Quality Management for the design Firm, Wiley, NY, pg 48.

Stock, G. N., McFadden, K. L., and Gowen, C. R., III (2007). “Organizational culture, critical success factors, and the reduction of hospital errors.” Int. J. Prod. Econ., 106, 368–392.

Tilley, P. A., and McFallan, S. L. ~(2000)!. ‘‘Design and documentation quality survey designers’ perspectives.’’ Rep. No. BCE DOC 00/113, Commonwealth Scientific and Industrial Research Organisation ~CSIRO!, Building, Construction and Engineering, Melbourne, Australia.

Tsang, E.W.K., Zahra, S.A., (2008). Organizational unlearning. Human Relations 61 (10), 1435–1462.

Vlatas DA (1986). Owner and contractor review to reduce claims. Journal of Construction Engineering and Management;112(1):104–11.

Vulink, M. (2004). Technology Transfer in the Construction Industry of Ghana. Eindhoven: Unpublished Thesis submitted to the Department of Technology and innovation Policies, Technische Universiteit Eindhoven.

Wardhana, K., Hadipriono, F.C., (2003b). Study of recent building failures in the United States. ASCE Journal of Performance of Constructed Facilities 17 (3), 151–158.

Yankah, J. E. (2013). Marketing orientation of quantity surveying consultancy firms in Ghana: practices, barriers and potential innovations. Unpublished thesis. Kwame Nkrumah University of Science and Technology. Ghana.

Yin, R. K. (1994). Case Study Research: Design and Methods, Second Edition. Thousand Oaks, CA: Sage Publications Ltd.

APPENDIX A

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF ART AND BUILT ENVIRONMENT

DEPARTMENT OF BUILDING TECHNOLOGY

RESEARCH QUESTIONNAIRE

TOPIC: INVESTIGATING THE CAUSAL MECHANISM OF DESIGN ERRORS AND ITS IMPACT ON COST PERFORMANCE OF CONSTRUCTION PROJECTS IN GHANA.

My name is Makafui Ametsitsi, an MSc Construction Management student from the Department of Building Technology at the Kwame Nkrumah University of Science and Technology, Kumasi.

This research questionnaire is focused on soliciting information from practicing Contractors, Project Managers, Engineers, Architects and Quantity Surveyors owing to their experience. It is aimed at:

i. To identify the critical factors influencing design documents deficiencies

ii. To assess designers' and contractors' perception of the achievement of design documents.

iii. To assess the impact of design errors on cost of construction projects in Ghana.

Information provided will be used for academic purposes only and will be kept confidential. The findings will also form the basis for ascertaining the causal mechanisms of design errors in the Ghanaian construction industry.

I am most appreciative for your cooperation in dedicating some time off your schedule to complete this questionnaire. In case you have any questions or comments, kindly contact me on 0245331430 or via email; makafuiametsitsi@gmail.com. Your time and cooperation is unreservedly appreciated. Thanks.

Please tick [√] in the box where appropriate

Section A – Background of Respondents

1. Kindly indicate your academic qualification?
   a. PHD
   b. MPHIL
   c. MSC/MEng

d. P. G. Dipoma

e. BSC

f. Others please specify……

2. Which professional body are you affiliated to?

a. Ghana Institute of construction (GIOC)

b. Ghana Institution of Engineers (GhIE)

c. Ghana Institute of Architects (GIA)

d. Ghana Institution of Surveyors (GhIS)

e. No Professional Body

3. For how long have you been in professional practice?

a. Less than 6 years

b. 6 – 10 years

c. 11 – 15 years

d. 16 – 20 years

e. Above 20 years

4. How many full time employees does your company have?

a. 1-10

b. 11-20

c. 21-30

d. 31-40

e. 41 and above

5. What kind of construction projects does your firm undertake?

a. Building

b. Civil Construction

c. Both

6. How long have your company been in business?

   a. 1-5 years

   b. 6 – 10 years

   c. 11 – 15 years

   d. 16 – 20 years

   e. 21 and above

Section B (Objective 1)

7. Kindly indicate the extent to which the following factors influence design document deficiencies in the Ghanaian construction industry by ticking (√) where appropriate, where 1 = very low, 2 = low, 3 = high 4 = very high

	Factors that influence design document deficiencies	**1**	**2**	**3**	**4**
1	lack of coordination				
2	low design fee				
3	high stress situations				
4	lack of construction knowledge				
5	client lack of leadership				
6	Over trust of other designers				
7	Time pressures				
8	incomplete or inaccurate information received from other designers				
9	lack of experience or incompetent designers				
10	, lack of motivation by designer				
11	ineffective organization structure of design team				
12	interpersonal skill problems of designers				
13	Failure of tools, such as computer software				
14	Inadequate training for designers				
15	Unawareness of change in standard				

Section C (Objective 2)

8. Kindly rate the following attributes by ticking in the box ( ) about your perception of the achievement of design documents used in the Ghanaian construction industry. You can select one project you have worked on and based on the outcome provide the answers. Rate on a scale of 1- 4 where 1 = not good, 2 = fairly good, 3 = good, 4 = very good.

	Attributes	**1**	**2**	**3**	**4**
1	Completeness				
2	Clarity				
3	Consistency				
4	Accuracy				
5	Standardization				
6	Relevance				
7	Timeliness				
8	Coordination				
9	Certainty				
10	Conformity				
11	Site Representation				

9. Kindly indicate the percentage level of defects caused by errors in designs on the following variables by ticking in the appropriate box (√). Rate on a scale of 1- 4 where 1 = 1 -10%, 2 = 11 -20%, 3 = 21-30%, 4 = 31-40%.

	Variable	**1 (1-10%)**	**2 (11-20%)**	**3 (21-30%)**	**4 (31-40%)**
1	Rework				
2	Delays				
3	Cost Overruns				
4	Changes				
5	Accident				
6	Disputes				
7	Profit				

Thank you.