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MANAGING TECHNICAL RISK IN GHANAIAN CONSTRUCTION PROJECTS

By

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Declaration

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

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Abstract

Many previous studies have been conducted within the field of risk management but each presents a different approach to this concept. Not much has been done on managing technical risk which in most cases is the root of majority of risk found in the construction industry and runs through the project life cycle. As part of a much larger project aiming to articulate and manage key risks associated with construction projects, this research seeks to identify, prioritize and develop a risk checklist of major technical risk that have the ability to greatly endanger the success of Ghanaian projects. A qualitative approach was employed to develop an initial understanding of sources and types of risk considered as technical in the construction industry which served as a base for further decision making. Thirty three (33) key risks were identified under four categories thus: feasibility stage, design stage, tendering stage and construction stages, based on which questionnaires were developed and administered randomly to 50 experts in the construction industry in Western and Central Regions of Ghana. These questionnaires consisted of two sections, section one gather information on the respondent while section two ask respondents to review and indicate the likelihood of occurrence and impact of the risks. A likert scale was used to rank these risks as high, medium and low for likelihood of occurrences of risks and the level of impact of each of the risk base on cost, time and quality of the project as high, medium and low. Data from the questionnaires were analyzed using average means and significant index methods. The research found that all the 33 identified risks affected both projects cost and time, whilst only 25 affected quality of projects. It was evident from the ranking of these risks that the impact of risks on projects varies from one objective to the other.

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CHAPTER ONE

INTRODUCTION

1.1 Background of study

Risk is considered an abstract concept, difficult to define and in most cases impossible to measure with any precision (Raftery , 1994).

It can be defined however as a potential for complication and problems with respect to the completion of a project and the achievements of its goals (Mark, et al., 2004). Its uncertainty has the tendency of either impacting negatively or in some cases positively be it financially, physical damage or delay on the projects life-span (Chapman, 1997)

Most often, risk is handled through the application of contingencies (money) or floats (time) that are not determined based on a comprehensive analysis of the risks that can affect a particular project, and that in many cases are clearly insufficient to cover the consequences of risks that do occur during the project realization (Serpella, et al., 2014).

Compared with many other industries, the construction industry is subject to more risks due to the unique features of construction activities, such as long period, complicated processes, abominable environment, financial intensity and dynamic organization structures (Flanagan and Norman, 1993; Akintoye and MacLeod, 1997; Smith, 2003).

Project risk can be categorized into a number of ways by considering the level of detail and viewpoint (Klemetii 2006). All projects risks can be divided into three main categories: known risk, known unknowns and unknown unknowns. Their difference is the decreasing ability to predict or for see the risk.

Risk in construction can be broadly grouped into five (Baloi &Price 2003):

I. Technical risk
II. Logistical risk
III. Financial risk
IV. Political risk
V. Construction risk

According to the Project Management Institute (PMI) (2004), project risk management is one of the nine most critical parts of project commissioning. Gajewska & Ropel (2011) indicates a strong relationship between managing risks and a project success. Its application is promoted in all projects in order to avoid negative consequences.

For the purpose of this study, emphasis has been placed on managing technical risk, which is risk rising from activities such as design and engineering, manufacturing, technological processes and test procedures (Business dictionary, 2014). It also includes poor design, inadequate site inspection, and uncertainty over resources and availability of materials and appropriateness of specification

Research on risk in the construction industry has mainly focused on examining the impacts of risks on one aspect of project strategies with respect to cost (Chen *et al.*, 2000), time (Shen, 1997) and safety (Tam*et al.*, 2004). Some researchers investigated risk management for construction projects in the context of a particular project phase (Zou et al, nd), such as conceptual/feasibility phase (Uher and Toakley, 1999), design phase (Chapman, 2001), construction phase (Abdou, 1996), rather than from broader group that encompasses all project phases.

The construction industry operates in a very uncertain environment where conditions can change due to the complexity of each project (Sanvido et al., 1992, cited by Gajewska & Ropel, 2011). The aim of each organization is to be successful and risk management can facilitate it. However it should be underlined that risk management is not a tool which ensures success but rather a tool which helps to increase the probability of achieving success. Risk management is therefore a proactive rather than a reactive concept (Gajewska & Ropel, 2011).

As part of a much larger project aiming to articulate and manage key risks associated with construction projects, this research seeks to identify and prioritize potential technical risks that are associated with Ghanaian construction industry.

1.2 Problem statement

Not much has been done on managing technical risk which in most cases is the root of majority of risk found in the construction industry and runs through the project life cycle.

1.3 Aim

To create a management framework that will be used to identify, prioritize and develop a risk checklist of major technical risk that have the ability to greatly endanger the success of projects in the Ghanaian construction industry.

1.4 Objectives

The specific objectives of this study are:

1. To identify key technical risks that has the highest potentials of hampering the success of construction projects in Ghana.
2. Prioritize potential technical key risks in Ghanaian construction.
3. Propose a technical risk management control check list that will help both clients and construction firms manage their potential technical risk.

1.5 Research questions

1. What are technical risks?
2. How can these risks be prioritized?
3. How prepared are construction managers to face these risks?

1.6 Research methodology

The research employed the use of both qualitative and quantitative.

A qualitative approach was used to identify types of risk considered as technical in the construction industry which served as a base for further decision making. A quantitative approach was then be used to quantify data and generalize results and measure the incidence of various views and opinions.

1.7 Significance of study

Technical risk runs through all the phases of a construction project (inception, design, tendering/bidding, construction and occupation), therefore identifying these risks and prioritizing it, will help in the preparation of a management check list that will facilitate stakeholders in the management of such risk so as to realize the objectives of projects.

1.8 Organization of study

Chapter 1 is the general introduction to the research.

Chapter 2 reviewed literature on technical risk in construction industries.

Chapter 3 is the methodology used in the analysis of data.

Chapter 4 is the analysis of the questionnaires.

Chapter 5 is conclusion and recommendation.

1.9 Limitation of the study

The research is limited to technical risk and its impact on construction projects in Ghana.

1.10 Scope of the study

This research is limited to:

- Building contractors registered with their professional bodies.
- Consultants in the building industry
- Construction site in Western and Central regions of Ghana.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

There are many approaches in literature that has examined the impact of risk in construction industries notable are the following:

Tipili and Ilyasu, (2014) identified and assessed the likelihood of occurrence and degree of impact of the risk factors on construction projects within the Nigerian construction industry, a self-administered questionnaire was employed to the construction industry professional for their responses on the likelihood of occurrence of risk factors and the impact of these risk factors on project performance. A total seventy eighty questionnaires were sent to construction industry professionals which comprised of Contractors, Architects, Quantity Surveyors and Engineers but fifty eight was returned which was later analysed using descriptive statistic and analyses of variance (ANOVA) and subsequently exposure rating levels were determined which enable the categorization of the probability- impact score been Low, medium and high levels. The study indicates a disparity of the ranking of the degree of occurrence and impact among the group. Based on composite of risk factors, cost related risk and time related risk were found to be the most likely to occur and have the most impact on project, whereas environmental risk factor was found to be a low risk, since it had the least likelihood to occur and the least impact score.

Rabechini and Marly (2013) in their study of understanding Impact of Project Risk Management on Project Performance, aimed at investigating the degree of diffusion of risk management practice in Brazilian companies. They surveyed 415 projects at different levels of complexity in different industrial sectors in several states in Brazil. The outcomes demonstrate that risk management practices have a significant positive impact on project success. The study's principal limitations were the methodological choice of non-probability sampling and a questionnaire based on respondent perception. Paying attention to uncertainties in the course of the project, making use of the risk management techniques and totally understand the commercial environment are critical success factors. The results confirmed the impact of risk management practices on project accomplishment. They also showed a positive impact from the presence of a risk manager on project achievement. Also, it proved the importance of soft skill in risk management.

Waghmare & Pimplikar, (2012) and Firmansyah et al., (2006) alluded to the fact that investments in projects will increase when treatment is on risk at the feasibility stage of a project. They administered questionnaires to professionals in the construction field. Risk judgments were given by the researcher in the form of inputs and referencing of such risk. It was analyzed by using probability matrix analysis technique.

Zou et al., (n.d.), identify key risks associated with the achievement of all project objectives in on cost, time, quality, environment and safety. 20 key risks were highlighted on a comprehensive assessment of their likelihood of occurrence and level of impacts on project goals. "Tight project schedule" was seen to have significant impact on all five aspects while the rest risks can significantly influence at least one aspect of project objectives. An inventive attempt to examine these key risks from the perspectives of project stakeholders and project life cycle presented the following insights– clients, designers and government bodies should work cooperatively from the feasibility phase onwards to address potential risks effectively and in time; contractors and subcontractors with robust construction and management knowledge must be employed early to make sound planning for undertaking safe, efficient and quality construction undertakings.

In the analysis of technical risk in construction by means of FMEA by Mecca and Marco , (2002) it was concluded that an FMEA technique for building construction could be the most important tool in managing quality plans to obtain a suitable and adequate and subsequently more efficient system to build in conformity with specifications. Given the nature of the construction process and unambiguously, the doubt and the environmental, technical and organizational complication, a tool is needed that fit in the analysis and treatment of environmental, technical and organizational risk issues. The analysis of risk factors, the identification of criticality conditions and the evaluation of every critical point of the project together allow the linking up of data on failure modes, obtainable from technical literature, guidelines, on-site results, personnel knowledge, to specific risk prediction for a precisely identified project. This allows the application of an FMEA-type tool to episodic production processes such as building sites and to make non-quantitative evaluations from which it is possible to identify judgement parameters. A common classification of risk factors can help technicians and managers in organizational and technical risk analysis. Technical risk assessment in building construction emphasizes the role of project quality planning in client satisfaction and should be one of the main tools for evaluating the reliability of quality systems.

Senthilkumar et al., (2014)in their bid to bring out common elements of risk and issues involved for any project life cycle, highlighted 45 key risks based on a comprehensive assessment of their deduction in advance, severity of loss Probability of occurrence and level of impacts on project objectives. Data from their questionnaires were analysed using

1. Deduction Index (D.I.) (%) = Σ a (n/N) x 100/3
2. Impact Index (I.I.) (%) = Σ a (n/N) x 100/3

3. Frequency Index (F.I.) (%) = Σ a (n/N) x 100/5
4. Severity Index (S.I.) (%) = Σ a (n/N) x 100/5
5. Importance index:(IMP.I) (%) = ((F.I (%) x S.I (%))/100+ (I.I (%) x D.I (%))/100)/2

A checklist of identified risks was developed that will be helpful to contractors in identifying potential risks in the future projects in different phases; they can be specialized due to conditions of their project.

From the above literature, it's undoubtedly important for the study of ways to manage risk in construction.

2.2 Construction risk management

2.2.1 Risk management:

Many explanations and definitions of risks and risk management have been recently developed, and thus it is difficult to dwell on one. Each author provides his own perception of what risk means and how to manage it. The description depends on the profession, project and type of business (Samson, 2009, cited by Gajewska & Ropel, 2011). Parsons Transportation Group (2004) defines risk management as making decisions to influence risks and, ultimately, taking cost effective actions to reduce adverse risks and to realize opportunities. The process involves preparing an action plan that prioritizes risks, identifies the underlying causes of risk events, and describes ways to change the likelihood of risk events and their possible costs and time impacts. This action plan can be determined as the risk management plan, probably the most important tangible result of the overall risk analysis process.

Risk management in general is a very broad subject and definitions of risk can therefore differ and be difficult to apply in all industries in general. For the purpose of this research one definition of risk and risk management will be chosen, in order to have a clear understanding of these concepts in construction industry (Gajewska & Ropel, 2011).

2.2.2 Risk definition:

The term risk can be defined in many ways depending on the project that is been worked on. Winch (2002) defines risk as a stage where there is a lack of information, but by looking at past experience, it is easier to predict the future. Cleden, (2009) sees risk is the statement of what may arise from that lack of knowledge. Risks are gaps in knowledge which we think constitute a threat to the project. Webb,(2003) also sees risk as a situation in which he possesses some objectives information about what the outcome might be. Risk exposure can be valued either positively or negatively.

2.3 Risk management process

The risk management process involves the systematic application of management policies, processes and procedures to the tasks of establishing the context, identifying, analysing, assessing, treating, monitoring and communicating risks (Cooper et al., 2005 cited by Gajewska & Ropel, 2011).

Southern Cross University ,(n.d), Project Management for Instructional Designers,(n.d).and ClearRisk, (2010), explained the process of risk management as follows:

2.3.1 Identifying Risks:

Risk assessment process begins with the identification of risk categories. An organization most likely will have several risk categories to analyze and identify risks that are specific to the organization. What can possibly go wrong?

A more disciplined process involves using checklists of potential risks and evaluating the likelihood that those events might happen on the project.

2.3.2 Analyzing risk:

After the potential risks have been identified, the project team then evaluates the risk based on the probability that the risk event will occur and the potential loss associated with the event. What is the likelihood of the risk occurring and if so what is the impact? Not all risks are equal. Some risk events are more likely to happen than others, and the cost of a risk event can vary greatly. Evaluating the risk for probability of occurrence and the severity or the potential loss to the project is the next step in the risk management process.

Table 1 Risk likelihood levels

Likelihood Level	Likelihood Definition
High	The threat's source is highly motivated and sufficiently capable, and controls that prevent the vulnerability from being exercised are ineffective.
Medium	The threat's source is motivated and capable, but controls are in place that may impede a successful exercise of the vulnerability.
Low	The threat's source lacks motivation or capability, and controls are in place to prevent or significantly impede the vulnerability from being exercised.
Risk Likelihood Levels (Adapted from NIST's *Risk Management Guide for Information Technology System as cited by*(online Internal Auditor, 2007)	

2.3.3 Assessing risk:

The next step is to determine the impact that the threat could have on the organization.

Table 2 Risk impact levels

Impact	Definition
High	High impact risks may result in the **high** costly loss of assets; risks that **significantly** violate, harm, or impede operations; or risks that cause human **death** or serious injury.
Medium	Medium impact risks may result in the costly loss of assets; risks that violate, harm, or impede operations; or risks that cause human injury.
Low	Low impact risks may result in the loss of **some** assets or may noticeably affect operations.
Risk Impact Levels (Adapted from NIST's *Risk Management Guide for Information Technology Systems cited by*(online Internal Auditor, 2007)	

2.3.3.1 *Risk priority*

The risk priority scale determines the nature of the risk and the action required. They are indicators to assist in the decision making of what action is warranted for the risks.

Table 3 Risk probability

Threat Probability	Low Impact (1–10)	Medium Impact (11–20)	High Impact (21–30)
High (1.0)	Medium 10 (10 x 1.0)	Medium 20 (20 x 1.0)	High 30 (30 x 1.0)
Medium (0.5)	Low 5 (10 x 0.5)	Medium 10 (20 x 0.5)	Medium 15 (30 x 0.5)
Low (0.1)	Low 1 (10 x 0.1)	Low 2 (20 x 0.1)	Low 3 (30 x 0.1)
Threat Probability Table(online Internal Auditor, 2007)			

2.3.4 Treat the risks:

Risk treatment involves identifying the range of options for treating the risk, evaluating those options, preparing the risk treatment plans and implementing those plans. It is about considering the options for treatment and selecting the most appropriate method to achieve the desired outcome. Project Management for Instructional Designers,(n.d.) outlined the following treatment methods:

2.3.4.1 Risk avoidance

Usually involves developing an alternative strategy that has a higher probability of success but usually at a higher cost associated with accomplishing a project task. A common risk avoidance technique is to use proven and existing technologies rather than adopt new techniques, even though the new techniques may show promise of better performance or lower costs.

2.3.4.2 Risk sharing

Involves partnering with others to share responsibility for the risk activities. Many organizations that work on international projects will reduce political, legal, labour, and others risk types associated with international projects by developing a joint venture with a company located in that country. Partnering with another company to share the risk associated with a portion of the project is advantageous when the other company has expertise and experience the project team does not have. If the risk event does occur, then the partnering company absorbs some or all of the negative impact of the event. The company will also derive some of the profit or benefit gained by a successful project.

2.3.4.3 Risk reduction

Is an investment of funds to reduce the risk on a project. On international projects, companies will often purchase the guarantee of a currency rate to reduce the risk associated with fluctuations in the currency exchange rate. A project manager may hire an expert to review the technical plans or the cost estimate on a project to increase the confidence in that plan and reduce the project risk. Assigning highly skilled project personnel to manage the high-risk activities is another risk reduction method. Experts managing a high-risk activity can often predict problems and find solutions that prevent the activities from having a negative impact on the project. Some companies reduce risk by forbidding key executives or technology experts to ride on the same airplane.

***2.3.4.4 Risk* transfer**

Is a risk reduction method that shifts the risk from the project to another party. The purchase of insurance on certain items is a risk transfer method. The risk is transferred from the project to the insurance company. A construction project in the Caribbean may purchase hurricane insurance that would cover the cost of a hurricane damaging the construction site. The purchase of insurance is usually in areas outside the control of the project team. Weather, political unrest, and labour strikes are examples of events that can significantly impact the project and that are outside the control of the project team.

2.3.4.5 Monitoring and communicating risks:

Project Management Body Of Knowledge, (2000) sees monitoring and control to be a process of keeping track of the identified risk, monitoring residual risks and identifying new risk, ensuring the execution of risk plans, and evaluating their effectiveness in reducing risk. Risk monitoring and control records risk metrics that are associated with implementing contingency plans. Risk monitoring and control is an ongoing process for the life of the project. The risks change as the project matures, new risks develop, or anticipated risks disappear. Good risk monitoring and control processes provide information that assists with making effective decisions in advance of the risk´s occurring. Communication to all project stakeholders is needed to assess periodically the acceptability of the level of risk on the project.

2.4 Risk analysis techniques for construction projects

Variety of risked faced in the construction industry is enormous and there are correspondingly various techniques available to respond to their critical situation in the aim of designing responses to them (Thaheem et al. 2012).

Project risk analysis techniques can be classified into two main categories, namely qualitative and quantitative techniques, with associated sub-categories of semi-quantitative and simulation techniques (PMI, 2009) as cited by (De Marco & Thaheem, 2014).

2.4.1 Quantitative risk **analysis**

Is a way of numerically estimating the probability that a project will meet its cost and time objectives.(Project Risk Management Handbook, 2012). Here, the impact of consequences is defined as a monetary value and the likelihood by the frequency of risk occurrence based on past series of available data. In brief, quantitative techniques numerically analyse the effect of identified risks on the project objectives (PMI, 2009) as cited by (De Marco & Thaheem, 2014).The main quantitative techniques are:

Decision tree analysis: A decision flow diagram subject to the influence of future events with a known probability of occurrence (Schuyler, 2001) as cited by (De Marco & Thaheem, 2014);

Expected monetary value: Takes into consideration the probability aspect of the system states and is based on a gain matrix (PMI, 2009) as cited by (De Marco & Thaheem, 2014).

Expert judgment: Based on expert opinions to evaluate the failure rate and success chances of the overall project (PMI, 2009) as cited by (De Marco & Thaheem, 2014).

Fault Tree Analysis (FTA): Possible derivative risk events are derived from a top event (DelCano, 2002) as cited by (De Marco & Thaheem, 2014).

Fuzzy logic: A simple way to reach a definite conclusion based on vague, imprecise, noisy or missing input (Konstandinidou*et al*., 2006) as cited by (De Marco & Thaheem, 2014).

Probability distributions: Continuous probability distributions represent the uncertainty in values, such as durations of schedule activities and costs of project components (Del Cano, 2002; PMI, 2009) as cited by (De Marco & Thaheem, 2014).

Sensitivity analysis/tornado diagram: Helps to determine which risks have the greatest potential impact on the project. Using a Tornado diagram, an attempt is made to capture how much risk impacts a particular metric, such as revenue or earnings (Lyons and Skitmore, 2004)as cited by (De Marco & Thaheem, 2014).

2.4.2 Qualitative risk analysis techniques does not operate on numerical data, presenting results in the form of descriptions, recommendations and ordinal scores (Hubbard and Evans, 2010) cited by (De Marco & Thaheem, 2014). Where risk assessment is connected with qualitative description and determination of qualitative scales for the probability and impact of the consequences of risk. Qualitative techniques can be lists of risks, risk rankings, or risk maps. These techniques prioritize risks for subsequent further analysis or action by assessing and combing their probability of occurrence and impact. The risk is evaluated in more conceptual terms, such as high, medium or low, depending on the collected opinions and risk tolerance boundaries in the organization. The main qualitative analysis techniques are:

Brainstorming: Best possible solutions of project risk are generated and determined under the leadership of a facilitator (Berg, 2010) cited by (De Marco & Thaheem, 2014).

Cause and effect diagram: Also known as the Ishikawa or fishbone diagram, it is useful for identifying and analysing causes of risks (Del Cano, 2002) cited by (De Marco & Thaheem, 2014).

Checklists: A detailed aide-memoire for the identification of potential risks based on past similar projects (Del Cano, 2002) cited by (De Marco & Thaheem, 2014).

Delphi: A facilitator uses a questionnaire to solicit ideas about the major project risks and project risk experts participate anonymously (Berg, 2010) cited by (De Marco & Thaheem, 2014).

Event Tree Analysis (ETA): Models the range of possible outcomes of one or a category of initiating events and usually provides qualitative descriptions (Del Cano, 2002) cited by (De Marco & Thaheem, 2014).

Risk Breakdown Matrix (RBM): An 'activities and threats' matrix, where the risk number for each activity and the most frequent overall risks are evaluated (Hillson *et al*., 2006) cited by (De Marco & Thaheem, 2014).

Risk data quality assessment: Evaluates the extent to which a risk is understood and the accuracy, quality, reliability and integrity of the risk data (PMI, 2009) cited by (De Marco & Thaheem, 2014).

2.5. Technical Risk in Construction

Project Management Institute, (2008), defines a project risk as "an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one project objective". There are many possible risks which could lead to the failure of the construction project, and through the project, it is very important what risk factors are acting simultaneously.

Projects often run into trouble even when they are apparently well-planned and effectively managed. The common reasons for this are that the technical risks affecting the projects are more complex than have been allowed for and consequently they have not been clearly identified (London Bridge Associates LTD, n.d.).

Technical risk is related to a project's failure due to a technical cause. Failure is considered as a shortfall in succeeding to meet the project's requirements. Technical cause is anything associated with the process of the project's development and operation. Therefore, the category of technical risks comprises all the aspects that may endanger project's success (e.g. material and equipment failure, deviations from designs and schedule, limited expertise of labor and personnel, etc.) (Xenidis & Angelides, n.d.).

Construction information Services, (2014) Sees Technical risk to be incomplete designs, inadequate site investigations, and uncertainty over the source and availability of materials and appropriateness of specifications.

Shen et al., (2001) Also sees technical risk to be changes and errors in design, equipment failure, shortage of resources, injuries and accidents, etc.

Most technical risks are as a result of internal actions or inactions and are controllable (Rezakhani, 2012).

2.5.1 Identification of Technical risk

It is important to identify risk in order to be able to create and monitor a risk management program (ClearRisk Inc. , n.d.). The risk identification phase is one of the most important stages within the risk management process, (Garrido et al., 2011)

In identifying risk, ClearRisk Inc. ,(n.d.), outlined twelve methods

Brainstorming is a technique that is best accomplished when the approach is unstructured (the facilitator encourages random inputs from the group). It is not intended for an in-depth risk analysis of risk.

Surveys are a technique where lists of questions are developed to seek out risk in a particular area. A limitation of this method is that people inherently don't like to complete surveys and may not provide accurate information.

Interviews are an effective way to identify risk areas. Group interviews can assist in identifying the baseline of risk on a project. The interview process is essentially a questioning process. It is limited by the effectiveness of the facilitator and the questions that are being asked.

Working Groups are great way to analyse a particular area or topic in a discussion process to identify risks that may not be obvious to the risk identification group.

Experiential Knowledge is the collection of information that a person has obtained through their experience

Documented Knowledge is the collection of information or data that has been documented about a particular subject. This is a source of information that provides insight into the risks in a particular area of concern

Risk Lists are usually lists of risks that have been found in similar municipalities and/or similar situations. Caution must be used when using this type of information to ensure it is relevant and applicable to the current situation.

Risk Trigger Questions are lists of situations or events in a particular area of a municipality that can lead to risk identification. These are situations or areas where risks have been discovered within the organization. These trigger questions may be grouped by areas such as performance, cost, schedule, software, etc.

Lessons Learned is experiential knowledge that has been organized into information that may be relevant to the different areas within the organization.

Outputs from Risk-Oriented Analysis - There are various types of risk oriented analysis. Two such techniques are fault tree analysis and event tree analysis.

Historical Information is basically the same as documented knowledge. The difference is that historical information is usually widely accepted as fact.

Engineering Templates are a set of flow charts for various aspects of the development process.

2.5.2 Types of risk considered as technical risk

Risk related to requirements, technology, complexity and interfaces, performance and reliability, quality, process and analytics are considered technical risk (Hulett, n.d.).

U.S. Department of Transportation, (2006), classified technical risk to Design and construction phases, with design phase technical risk emanating from:

1. Owner involvement in design
2. Inadequate and incomplete design
3. Change in seismic criteria
4. Errors or in completion of structural / geotechnical / foundation
5. Wrong selection of materials
6. Take off data (traffic demand, water consumption demand, etc.)
7. Need for design exceptions

Whilst the construction phase technical risk emanates from:

1. Inaccurate contract time estimates
2. Construction procedures
3. Construction occupational safety
4. Work permissions
5. Utilities
6. Late surveys, incomplete or wrong
7. Delayed deliveries and disruptions
8. Worker and site safety
9. Innovative projects
10. Unsuitable equipment and materials

11. Environmental risks (such as projects close to a wild river, floodplain, coastal zone, high sensitivity for paleontology area, and so on)

In a bit to identification and classification of risks in a new modelling process for build – operate – transfer projects, Xenidis & Angelides, (n.d.) listed the following as technical risk

1. Non-beneficial procurement arrangement
2. Delay in land acquisition
3. Inadequate access to project location
4. Delay in other project servicing the project land
5. Delay to obtain design approval on time
6. Insufficient time for bid preparation
7. Set of unrealistic goals
8. Lack of realistic data for preparation of bid
9. Defects (or absence) of feasibility studies
10. Defects of the design
11. Application of innovative and unrealistic processes
12. Equipment failures
13. Construction schedule overruns
14. Failure to meet contracts specifications
15. Constructions personnel safety risk
16. Risk due to working in congested and overcrowding areas
17. Inadequate project organization structure
18. Incompetence of the project management team
19. Lack of coordination between subcontractors

20. Deterioration of quality standards in operation and maintenance

21. Environmental risk

22. Supply risk

23. lack of appropriate domestic partners

24. Lack of skilled workforce and personnel

25. Prolong negotiation period prior to project initiation

2.5.3 Sources of technical risk in construction.

Sources of technical risk usually come from the source below (Hillson & Simon, 2007).

- Scope definition
- Requirements definition
- Estimates, assumptions & constraints
- Technical processes
- Technology
- Technical interfaces
- Design
- Performance
- Reliability & maintainability
- Safety
- Security
- Test & acceptance

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research approach

The research employed the use of both qualitative and quantitative.

A qualitative approach was used to identify types of risk considered as technical in the construction industry which served as a base for further decision making. A quantitative approach was then be used to quantify data and generalize results and measure the incidence of various views and opinions.

3.2 Study population and sample size

The study dealt primarily with contractors and construction firms with good reputation, thus: Architects, quantity surveyors, project managers and contractors.

A total of 50 questionnaires were distributed randomly to these experts in Western and Central regions of Ghana.

3.3 Sources of data

To carry out this study a review of specialized literature was carried out in an attempt to understand the issue conceptually and to identify existing gaps in this area of knowledge. (Roque & Marly, 2013).

Questionnaires were designed based on identified technical risk sourced from Xenidis & Angelides, (2005), Hillson & Simon, (2007) and U.S. Department of Transportation, (2006).

These identified risks in table 1 below, will be used to develop a risk break down structure which will be the basics for the questionnaires.

The questionnaires consisted of two sections, section one gathered information on the respondent while section two asked respondents to review and indicate the likelihood of occurrence and impact of the risks.

3.4 Data analysis

A likert scale was used to rank these risks as highly, medium and low for likelihood of occurrences of risk, and the level of impact of each of the risk base on cost, time and quality of the project as high, medium or low.

The data provided by the questionnaire was analyzed using:

Risk Significant score Method will be used to analyze the data from the questionnaires as prescribed by (KansalL & Sharma, 2012).

The accumulated data was grouped into categories risk and its magnitude of consequence on project objective in term of Cost, Time, and Quality. The three point scales for the risk α (Highly, medium, low) and the consequence β (High magnitude, Medium magnitude, Low magnitude) will be converted into numerical scales. A three point rating scale will be chosen according to Shen et al and Zou et al. (2001) and Wang and Liu (2004), High, Highly take value of 1, Medium takes a value of 0.5 and less or Low take a value of 0.1.

Table 4 Table 6 matrix for the calculation of significant score

β / α		High impact (1)	Medium impact (0.5)	Low impact (0.1)
likelihood	High (1)	1	0.5	0.1
	Medium (0.5)	0.5	0.25	0.05
	Low (0.1)	0.1	0.05	0.01

The average score for each risk considering its significance to the project can be calculated by

$$r_{ij}^{k} = \alpha_{ij}\,\beta_{ij}^{k}$$

Where r_{ij}^{k} =Significance scores assessed by respondent *j* for the impact of risk *i* on project objective *k ij*. i = ordinal number of risk. *k* = ordinal number of project objective.

3.5 **Results presentation**

Risks were ranked based on their significant scores, averages of their means on cost, time and quality. A technical risk management checklist was then developed based on their ranking.

CHAPTER FOUR

ANALYSIS AND DISCUSSIONS

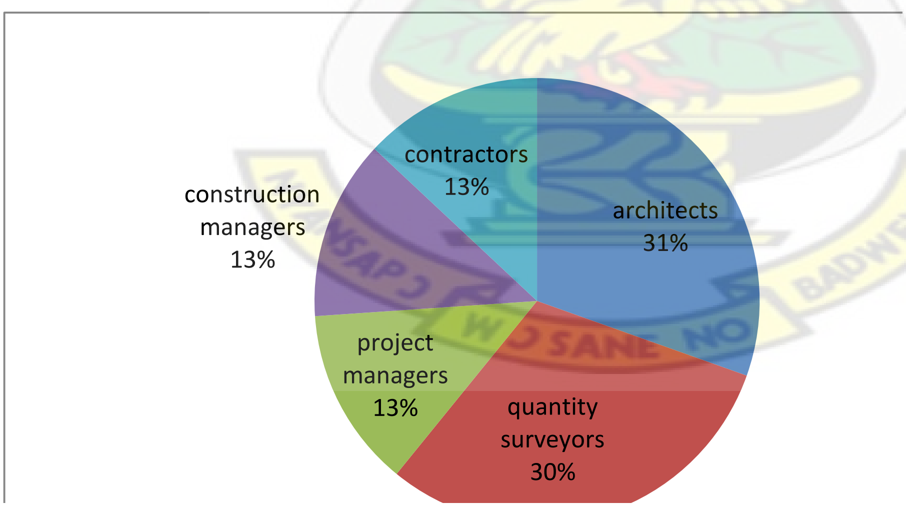
4.1 Research finding

Risk identified and observed in the questionnaires are applicable to all construction projects The main aim of the investigation is to get first-hand information from experts in the building industry in respect to risk considered as technical for the purpose of prioritization of the said risk based on their impact on projects objectives.

A total of 50 questionnaires were administered after 4 trial questionnaires were administered and changes made so as to suit practitioners in the building industry. These practitioners included architects, quantity surveyors, project managers, construction managers and contractors.

A total of 23 questionnaires were returned, counting for 46% of administered questionnaires.

Figure 4. 1 composition of respondents



Risks were grouped into four main categories thus feasibility, design, tender and construction stages, each category having its own unique risk. Each category was ranked twice.

The first ranking was done based on cumulative significant scores (∑ of likelihood * impact) of risk accessed by respondents on projects objectives thus cost, time and quality.

The second ranking was based on the averages of project objectives accessed by respondents.

Table.5 below shows ranking of risk based on cumulative significant scores.

A total of 33 risk where identified and ranked. Six were related to feasibility stage of projects, eight related to design stage of a project, five also relating to tendering stages and finally fourteen relating to construction stages risk.

Table 5 Risk significant score ranking

Identified risk	**Significant score**	**Average**	**Ranking**
feasibility stage			
Absence of feasibility studies	10.88	0.47	1st
Improper scope definition	10.7	0.44	2nd
lack of project owners involvement	9.1	0.40	3rd
Incomplete design team	8.5	0.37	4th
Delay in land acquisition	6.1	0.26	5th
Set of unrealistic goals	4.88	0.21	6th
design stage			
Errors in drawing	12.95	0.56	1st
Wrong specification of materials	11.1	0.48	2nd
Time constraints	10.6	0.46	3rd
lack of owners involvement	10.5	0.46	4th
Incomplete designs	9.5	0.41	5th
lack of coordination amongst design team	9.4	0.41	6th
lack of expertise on the design team	8.32	0.36	7th
Application of unrealistic methods in construction	7.66	0.33	8th
tendering stage			
Incomplete designs for bid preparations	12.25	0.53	1st
Set of unrealistic schedules	9.05	0.39	2nd
Errors in drawing	8.9	0.39	3rd

lack of realistic data for bid preparations	7.55	0.33	4th
Insufficient time for bid preparations	6.23	0.27	5th
construction stage			
Failure to meet contracts specifications	11.55	0.50	1st
Inaccurate contract time	11.4	0.496	2nd
lack of coordination amongst subcontractors	10.56	0.46	3rd
lack of skill workforce and personnel	10.52	0.46	4th
Unsuitable equipment's and materials	10.3	0.44	5th
lack of clear construction procedure	9.31	0.40	6th
Construction schedule overruns	8.82	0.38	7th
Delay in other project servicing the project	8.52	0.37	8th
Inadequate project organizational structure	7.77	0.34	9th
Delay in acquiring work permit.	7.25	0.32	10th
Equipment failures.	7.18	0.31	11th
late, incomplete or wrong surveys	5.6	0.24	12th
Delayed deliveries and disruptions	4.54	0.20	13th
Inadequate access to project location	3.9	0.17	14th

Out of 23 respondents who returned questionnaires, percentages of the impact of the identified risks on projects objectives (cost, time and quality) was derived as shown in Table 6 below.

Table 6 Percentages of risk on projects objectives

IDENTIFIED RISK	COST	TIME	QUALITY
FEASIBILITY STAGE			
lack of project owners involvement	44.4%	44.4%	11.1%
Absence of feasibility studies	58%	17%	25%
improper scope definition	54%	23%	23%
incomplete design team	23%	38%	38%
delay in land acquisition	20%	80%	0%
set of unrealistic goals	55%	45%	0%
DESIGN STAGE			
lack of owners involvement	58%	42%	0%
incomplete designs	50%	13%	38%
errors in drawing	42%	50%	8%
wrong specification of materials	50%	6%	44%
application of unrealistic methods in construction	22%	67%	11%
lack of expertise on the design team	20%	40%	40%
lack of coordination amongst design team	45%	36%	18%
time constraints	11%	67%	22%

TENDERING STAGE	COST	TIME	QUALITY
insufficient time for bid preparations	56%	22%	22%
lack of realistic data for bid preparations	63%	25%	13%
incomplete designs for bid preparations	88%	13%	0%
errors in drawing	57%	43%	0%
set of unrealistic schedules	30%	50%	20%
CONSTRUCTION STAGE			
inaccurate contract time	36%	45%	18%
lack of clear construction procedure	23%	23%	54%
Delay in acquiring work permit.	36%	64%	0%
late, incomplete or wrong surveys	8%	50%	42%
delayed deliveries and disruptions	36%	64%	0%
unsuitable equipment's and materials	27%	27%	47%
inadequate access to project location	33%	67%	0%
delay in other project servicing the project	44%	44%	11%
construction schedule overruns	64%	27%	9%
inadequate project organizational structure	17%	42%	42%
lack of coordination amongst subcontractors	29%	47%	24%
lack of skill workforce and personnel	7%	36%	57%
failure to meet contracts specifications	61%	6%	33%
Equipment failures.	15%	54%	31%

These risks were also ranked according to their influence on projects objectives thus cost, time and quality. As seen in tables 7, 8 and 9 below.

Table 7 Cost related risk ranking

COST RELATED RISK RANKING		
IDENTIFIED RISK	**AVERAGE SCORE**	**RANKING**
FEASIBILITY STAGE		
Absence of feasibility studies	0.58	1st
Set of unrealistic goals	0.55	2nd
Improper scope definition	0.54	3rd
lack of project owners involvement	0.44	4th
Incomplete design team	0.23	5th
Delay in land acquisition	0.20	6th
DESIGN STAGE		
lack of owners involvement	0.58	1st
Incomplete designs	0.50	2nd
Wrong specification of materials	0.50	3rd
lack of coordination amongst design team	0.45	4th
Errors in drawing	0.42	5th
Application of unrealistic methods in construction	0.22	6th
lack of expertise on the design team	0.20	7th
Time constraints	0.11	8th
TENDERING STAGE		
Incomplete designs for bid preparations	0.88	1st
lack of realistic data for bid preparations	0.63	2nd
Errors in drawing	0.57	3rd
Insufficient time for bid preparations	0.56	4th
Set of unrealistic schedules	0.30	5th
CONSTRUCTION STAGE		
Construction schedule overruns	0.64	1st
Failure to meet contracts specifications	0.61	2nd
Delay in other project servicing the project	0.44	3rd
Delay in acquiring work permit.	0.36	4th
Delayed deliveries and disruptions	0.36	5th
Inaccurate contract time	0.36	6th
Inadequate access to project location	0.33	7th
lack of coordination amongst subcontractors	0.29	8th
Unsuitable equipment's and materials	0.27	9th
lack of clear construction procedure	0.23	10th
Inadequate project organizational structure	0.17	11th
Equipment failures.	0.15	12th
late, incomplete or wrong surveys	0.08	13th
lack of skill workforce and personnel	0.07	14th

Table 8 Time related risk ranking

TIME RELATED RISK RANKING		
IDENTIFIED RISK	AVERAGE SCORE	RANKING
FEASIBILITY STAGE		
Delay in land acquisition	0.80	1st
Set of unrealistic goals	0.45	2nd
lack of project owners involvement	0.44	3rd
Incomplete design team	0.38	4th
Improper scope definition	0.23	5th
Absence of feasibility studies	0.17	6th
DESIGN STAGE		
Application of unrealistic methods in construction	0.67	1st
Time constraints	0.67	2nd
Errors in drawing	0.50	3rd
lack of owners involvement	0.42	4th
lack of expertise on the design team	0.40	5th
lack of coordination amongst design team	0.36	6th
Incomplete designs	0.13	7th
Wrong specification of materials	0.06	8th
TENDERING STAGE		
Set of unrealistic schedules	0.50	1st
Errors in drawing	0.43	2nd
lack of realistic data for bid preparations	0.25	3rd
Insufficient time for bid preparations	0.22	4th
Incomplete designs for bid preparations	0.13	5th
CONSTRUCTION STAGE		
Inadequate access to project location	0.67	1st
Delay in acquiring work permit.	0.64	2nd
Delayed deliveries and disruptions	0.64	3rd
Equipment failures.	0.54	4th
late, incomplete or wrong surveys	0.50	5th
lack of coordination amongst subcontractors	0.47	6th
Delay in other project servicing the project	0.44	7th
Inaccurate contract time	0.45	8th
Inadequate project organizational structure	0.42	9th
lack of skill workforce and personnel	0.36	10th
Construction schedule overruns	0.27	11th
Unsuitable equipment's and materials	0.27	12th
lack of clear construction procedure	0.23	13th
Failure to meet contracts specifications	0.06	14th

Table 9 Quality related risk ranking

QUALITY RELATED RISK		
IDENTIFIED RISK	AVERAGE SCORE	RANKING
FEASIBILITY STAGE		
Incomplete design team	0.38	1st
Absence of feasibility studies	0.25	2nd
Improper scope definition	0.23	3rd
lack of project owners involvement	0.11	4th
DESIGN STAGE		
Wrong specification of materials	0.44	1st
lack of expertise on the design team	0.40	2nd
Incomplete designs	0.38	3rd
Time constraints	0.22	4th
lack of coordination amongst design team	0.18	5th
Application of unrealistic methods in construction	0.11	6th
Errors in drawing	0.08	7th
TENDERING STAGE		
Insufficient time for bid preparations	0.22	1st
Set of unrealistic schedules	0.20	2nd
lack of realistic data for bid preparations	0.13	3rd
CONSTRUCTION STAGE		
lack of skill workforce and personnel	0.57	1st
lack of clear construction procedure	0.54	2nd
Unsuitable equipment's and materials	0.47	3rd
Inadequate project organizational structure	0.42	4th
late, incomplete or wrong surveys	0.42	5th
Failure to meet contracts specifications	0.33	6th
Equipment failures.	0.31	7th
lack of coordination amongst subcontractors	0.24	8th
Inaccurate contract time	0.18	9th
Delay in other projects servicing the project	0.11	10th
Construction schedule overruns	0.09	11th

4.1.1 Graphical representation of identified risk on projects objectives

Further exploration of these key risks will not only help to understand how many project objectives each risk can influence but also help to compare the magnitude of the significance of different risks on a particular project objective (Zou et al., n.d.). As such further explanations are made on table 2, which show the relationship of each risk with respect to the key objectives of projects (cost, time and quality).

Figure 4.2 below also shows the impact of risks on projects quality at the feasibility stage.

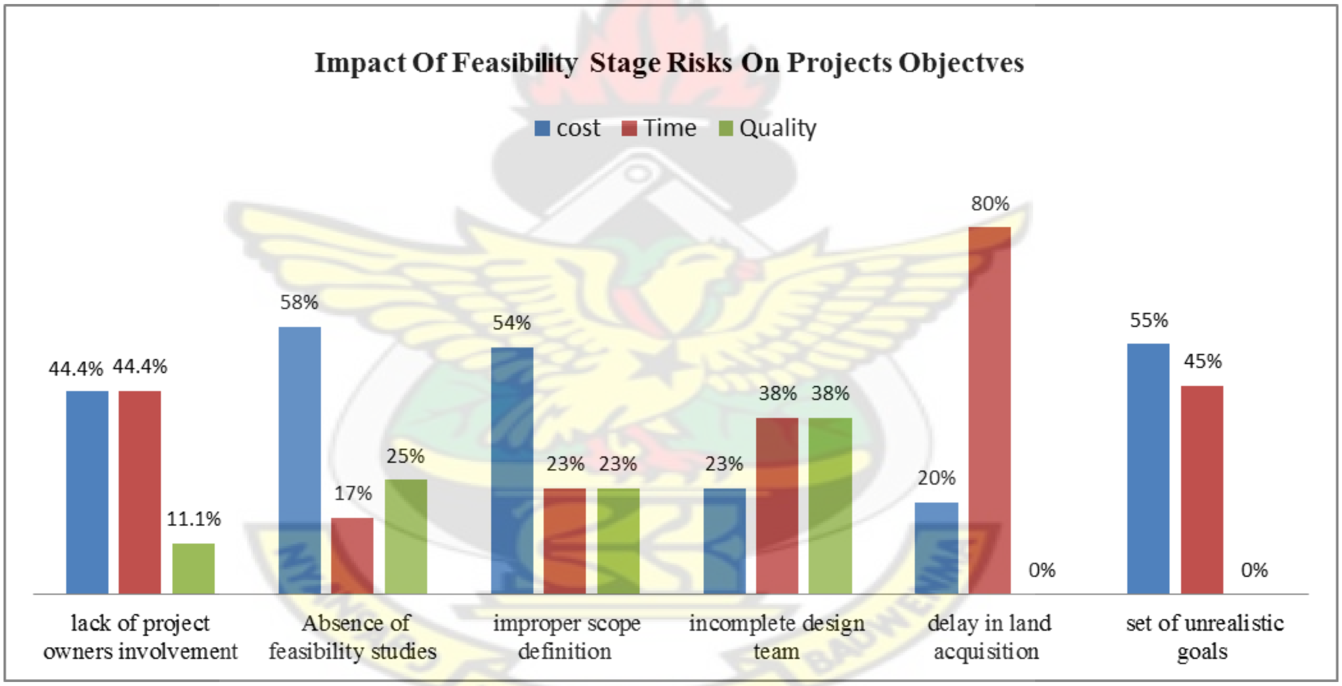


Figure 4. 2 Impact of feasibility stage risks on projects objectives.

Figure 4.3 below shows the impact of identified risks in design stage of projects on the projects objectives.

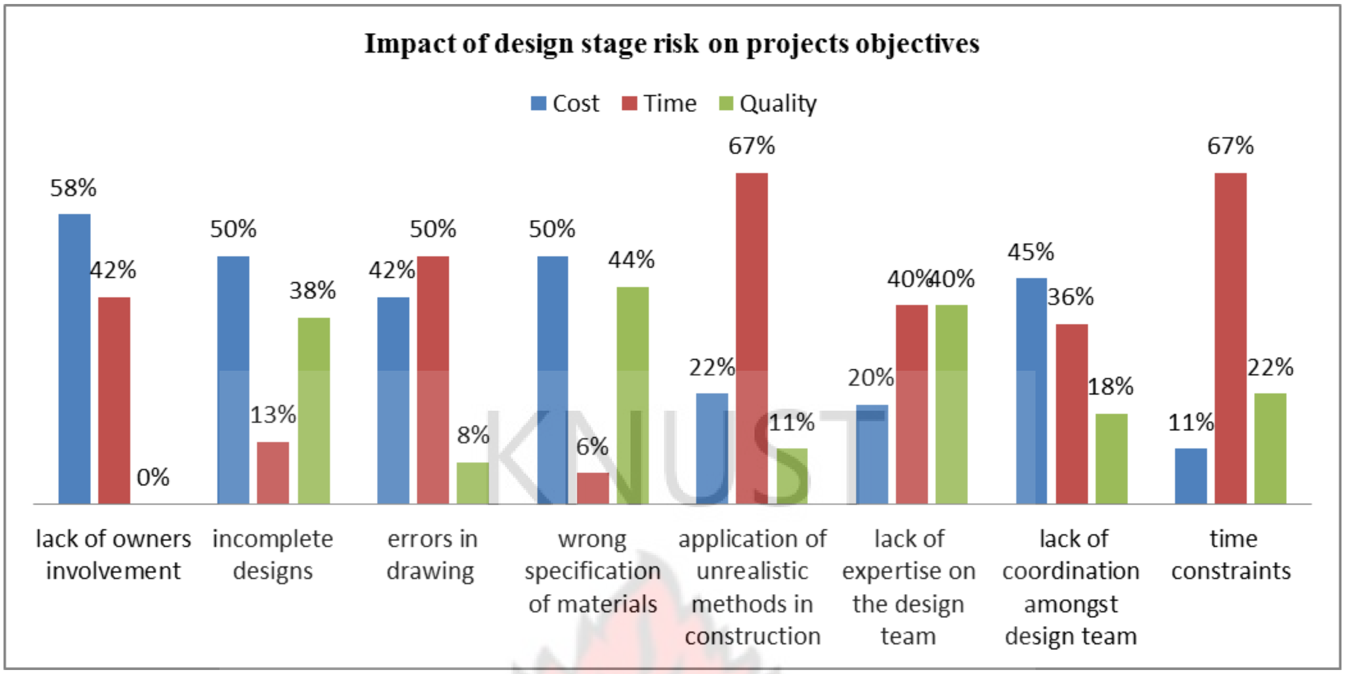


Figure 4. 3 Impact of design stage risk on projects objectives

Figure 4. 4 below show the impact of tendering stage risks on projects objectives.

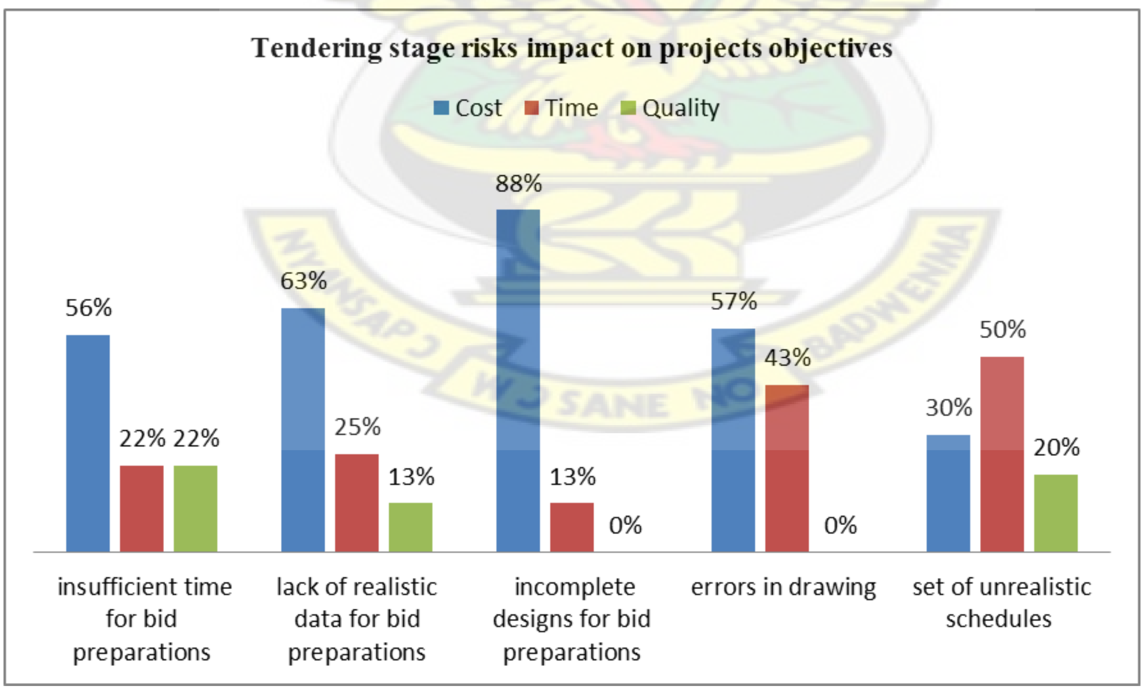
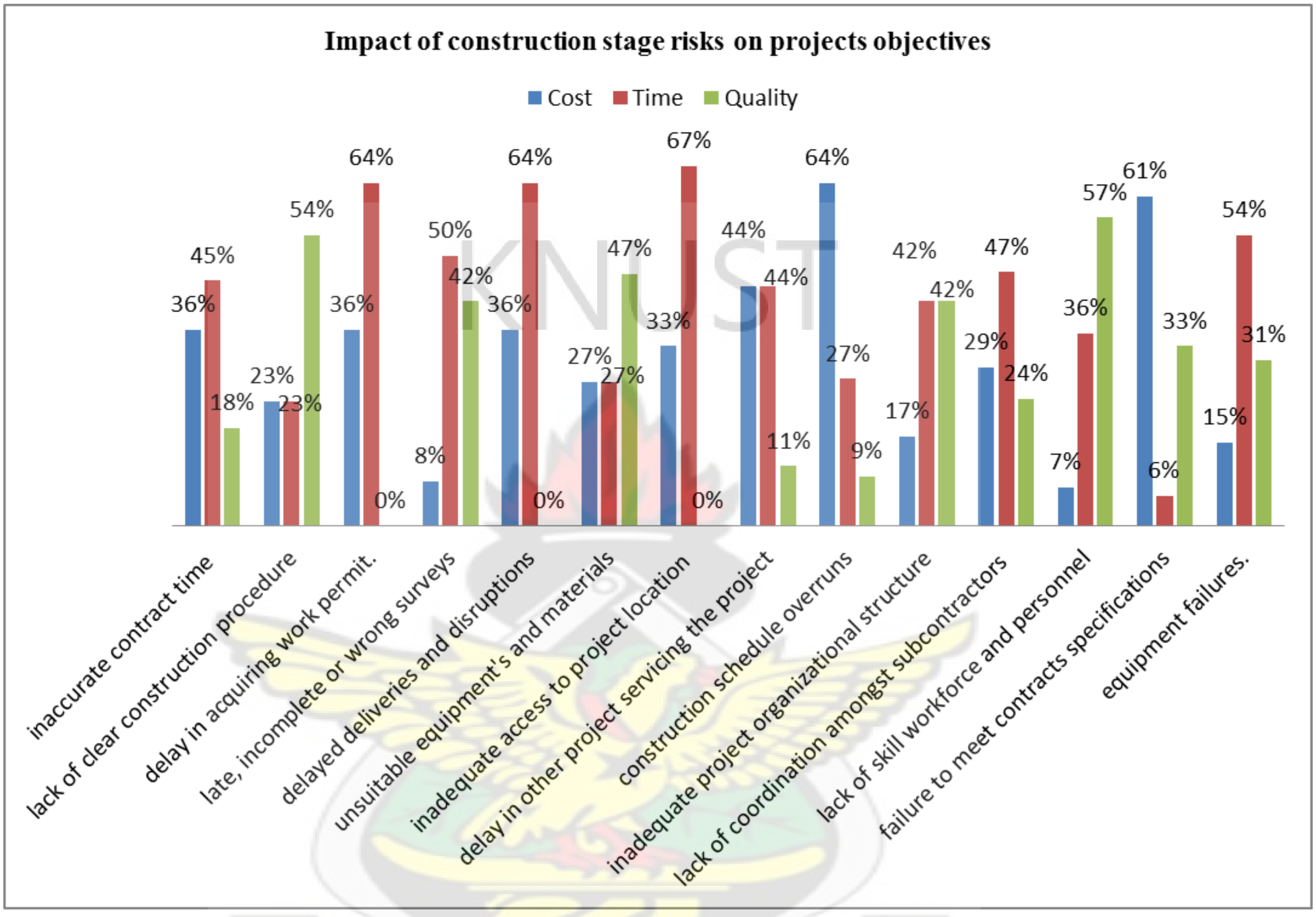


Figure 4. 4 Impact of tendering stage risks on projects objectives

Figure 4. 5 below show the impact of construction stage risk on projects objectives.

Figure 4. 5 Impact of construction stage risk on projects objectives.



4.2 Discussions of survey results.

From the above identified risks, it's clear that technical risk is not just incomplete designs, inadequate site investigations, uncertainty over the source and availability of materials and appropriateness of specifications as described by Construction information Services, (2014), changes and errors in design, equipment failure, shortage of resources as defined by Shen et al., (2001). But rather encompasses the above definitions and any other that are as a result of internal actions or inactions associated with the process of the project's development and operation which are controllable.

As part of a much larger project aiming to articulate and manage key risks associated with construction projects, this research identified through literature review, 33 key risk that greatly affect projects objectives thus cost, time and quality as shown on table 6 . Table 10 below is the ranking of the identified risk based on projects objectives and risk significant scores.

Table 10 Ranking of risk

IDENTIFIED RISK	RANKING BASED ON :			
	SIGNIFICANT SCORE	COST	TIME	QUALITY
FEASIBILITY STAGE				
Absence of feasibility studies	1st	1st	6th	2nd
Improper scope definition	2nd	3rd	5th	3rd
lack of project owners involvement	3rd	4th	3rd	4th
Incomplete design team	4th	5th	4th	1st
Delay in land acquisition	5th	6th	1st	No impact
Set of unrealistic goals	6th	2nd	2nd	No impact
DESIGN STAGE				
Errors in drawing	1st	5th	3rd	7th
Wrong specification of materials	2nd	3rd	8th	1st
Time constraints	3rd	8th	2nd	4th
lack of owners involvement	4th	1st	4th	No impact
Incomplete designs	5th	2nd	7th	3rd
lack of coordination amongst design team	6th	4th	6th	5th
lack of expertise on the design team	7th	7th	5th	2nd
Application of unrealistic methods in construction	8th	6th	1st	6th
TENDERING STAGE				
Incomplete designs for bid preparations	1st	1st	5th	No impact
Set of unrealistic schedules	2nd	5th	1st	2nd
Errors in drawing	3rd	3rd	2nd	No impact
lack of realistic data for bid preparations	4th	2nd	3rd	3rd
Insufficient time for bid preparations	5th	4th	4th	1st

CONSTRUCTION STAGE				
Failure to meet contracts specifications	1st	2nd	14th	6th
Inaccurate contract time	2nd	6th	8th	9th
lack of coordination amongst subcontractors	3rd	8th	6th	8th
lack of skill workforce and personnel	4th	14th	10th	1st
Unsuitable equipment's and materials	5th	9th	12th	3rd
lack of clear construction procedure	6th	10th	13th	2nd
Construction schedule overruns	7th	1st	11th	11th
Delay in other project servicing the project	8th	3rd	7th	10th
Inadequate project organizational structure	9th	11th	9th	4th
Delay in acquiring work permit.	10th	4th	2nd	No impact
Equipment failures.	11th	12th	4th	7th
late, incomplete or wrong surveys	12th	13th	5th	5th
Delayed deliveries and disruptions	13th	5th	3rd	No impact
Inadequate access to project location	14th	7th	1st	No impact

From the ranking in table 10 above, it's clear that the impact of risk on projects varies from one objective to the other as alluded to by Tipili & Ilyasu, (2014).

4.2.1 discussions of feasibility stage risk rankings.

Out of the six risk identified under this stage, the risk of absence of feasibility studies had the highest impact on a project when combining all the projects objectives thus cost, time and quality. It also had the highest impact on cost of projects at this stage. It had the least impact on durations of projects. Eventhough delay in land acquisition and the setting of unrealistic goals are important key risks that greatly affect a projects cost and time, in the feasibility stages of a project, it has no impact on quality of a project.

4.2.2 Discussions of design stage risk rankings.

The risk of errors in drawing had the highest impact on the design stages of a project. The risk of lact of owners involvement had the greatest in pact on cost of projects at this stage. The risk of lack of application of unrealistic methods in construction had the higest impact on duration of projects. The risk of wrong specification of materials had the highest impact on quality of projects at this stage of construction. However the lack of owner's involvement had no impact on quality of projects at this stage of construction.

4.2.3 Discussions of tendering stage risk rankings.

The risk of incomplete designs for bid preparations had the highest impact at this stage of a project. It was also ranked first in terms of cost of projects. The risk of unrealistic shudules set up for a project at this stage of a constrution had the highest impact on durations of projects.

The risks of imcomplete designs for bid preparations and errors in drawings had no impact on quality of projects during tendering process.

4.2.4 Discussions of construction stage risk rankings.

The risk of failure to meet contracts specifications was ranked first in this stage of a construction process. The risk of construction schedule overruns had the highest impact on projects cost, the risk of inadequate access to projects location had the highest impact on projects durations. The risk of lact of skill workforce and personnel was also adjudged to have the highest impact on quality of projects during construction. However the risks of delay in acquiring work permit, delay deliveries and distruptions and inadequate access to project location had no impact on quality of projects during costruction.

It therefore menas that a risk does not neccessarily have to influence all the objectives of a project before its considered important as suggested by Zou et al., (n.d).

From the above anaylsis and ranking, a management checklist has been developed (refer to Appendix 1) to help construction managers plan for such risk.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

While most research has focused on some aspects of construction risk management, this research endeavoured to identify, piroritize and develop a management checklist of key technical risks associated with the achievement the basic project objectives in terms of cost, time and quality.

- From the thirty three (33) identified technical under the feasibiliy stages, dsign stages, tendering and construction stages of a projects, out of the six identified under feasibiliy stage, only only four (4) had impact on all the projects objectives, two of the risk had no impact of quality of projects at this stage.
- Except only one risk which did not have an impact on quality of a project at the design stages of projects, all the seven identified risks had impacts on all the projects objectives.
- Out of the five (5) risks identified at the tendering tages of construction, two had no impact on quality of projects at this stage.
- Also out of the fourteen (14) risks idenified during the construction stages, three did not have impact on quality at this stage of a project.
- From the anaysis of these risks, it was evident that the impact of risks on projects objectives varies from one objective to the other.

5.2 Recommendations

- The impact of risk varies from one project objective to the other hence risk each risk should be anaylsed to ascertain its impact before a remedy proposed for it.
- Further research needs to be conducted on technical risks so as to develop ~~a~~ furmulars that ~~is~~ are unique to each projects objectives and can be applied in the determination of its impact.~~.~~
- Before the beginning of each project, a technical risk checklist should be first developed and used by all projects paticipants.
- Risk should not only be handled by projects managers but should be the perogative of all projects stakeholders.

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APPENDIX A

(Management Checklist)

NAME OF PROJECT:	PROJECT LOCATION:
INSPECTED BY	DATE

TECHNICAL RISK MANAGEMENT CHECKLIST

	Feasibility stage	Yes	No
1	Project owners involvement		
2	Feasibility studies		
3	Proper scope definition		
4	Complete design team		
5	Delay in land acquisition		
6	Are project goals realistic		
	Design stage	Yes	No
1	Project owners involvement		
2	Are designs complete		
3	Are there errors in drawing		
4	Right specification of materials		
5	Are construction methods proposed realistic		
6	Are design team members experts		
7	Is there coordination amongst design team		
8	Can designs be completed on time		
1	**Tendering stage**	Yes	No
2	Is there sufficient time for bid preparations		
3	Are data used in bid preparation realistic		
4	Are designs completed for bid preparations		
5	Has the drawings been cross checked for errors		
6	Are schedules realistic		
	Construction stage	Yes	No
1	Is contract time accurate		
2	Are construction procedures clear		
3	Are there delays in acquiring work permit		

4	Are survey works correct and completed		
5	Are deliveries and disruptions been delayed		
6	Are equipment's and materials suitable for the project?		
7	Is there adequate access to project location		
8	Are there delays in other project servicing the project		
9	Is construction schedule been overrun		
10	Are project organizational structures adequate?		
11	Is there coordination amongst subcontractors		
12	Are workforce and personnel skilled		
13	Are contracts specifications been met		
14	Are equipment failing		

APPENDICES B

(Questionnaires)

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ARCHITECTURE AND PLANNING

FACULTY OF ARCHITECTURE AND BUILDING TECHNOLOGY

DEPARTMENT OF BUILDING TEHNOLOGY

MSc Construction Management

TOPIC: **MANAGING TECHNICAL RISK IN GHANAIAN CONSTRUCTION PROJECTS**

QUESTIONNAIRES

By: Asamannaba Godwin

AIM OF QUESTIONNAIRES

The aim of these questionnaires is to get firsthand information from experts in the building industry in respect to risk considered as technical so as to develop a management checklist that will serve as a guide in the management of such risk.

RESPONDENTS BACKGROUND

1. Name of organization:…………………………………………………………………
2. Core business of organization…………………………………………………………
3. How many years have you been in the construction industry…………………
4. area of specialization (pls check)

a. Architecture ☐ b. Quantity surveying ☐ c. Project management ☐

d. Construction management ☐ e. General construction works ☐

f. Others (pls specify)……………………………

RISK IMPACT, AREA AND LIKELIHOOD.

Please grade the following risk base on their level of impact, area of impact and likelihood of it occurring on construction projects by ticking the appropriate box or boxes.

Risk	Level of impact			Area of impact			Likelihood of occurrence		
	High	**Medium**	**Low**	**Cost**	**Time**	**Quality**	**High**	**Medium**	**Low**

FEASIBILITY STAGE									
1. Lack of projects owners' involvement.									
2. Absence of feasibility study									
3. Improper scope definition									
4. Incomplete design team									
5. Delay in land acquisition									
6. set of unrealistic goals									
Pls provide any other risk you will consider in this category and tick accordingly.									
7. .									
8. .									
9. .									
DESIGN STAGE									
	Level of impact			Area of impact			Likelihood of occurrence		
	High	**Medium**	**Low**	**Cost**	**Time**	**Quality**	**High**	**Medium**	**Low**
1. Lack of owner's involvement in design									
2. Incomplete design									
3. Errors in drawings.									

4. . Wrong specification of materials									
5. Application of unrealistic methods in designs									
6. lack of expertise on the design team									
7. lack of coordination amongst design team									
8. time constraints									
Pls provide any other risk you will consider in this category and tick accordingly.									
9.									
10.									
11.									
TENDERING STAGE									
	Level of impact			Area of impact			Likelihood of occurrence		
	High	**Medium**	**Low**	**Cost**	**Time**	**Quality**	**High**	**Medium**	**Low**
1. . Insufficient time for bid preparation									
2. . Lack of realistic data for preparation of bid									
3. Incomplete designs for bids preparations.									

4. Errors in tendering documents									
5. Set of unrealistic schedules									
Pls provide any other risk you will consider in this category and tick accordingly.									
6.									
7.									
CONSTRUCTION STAGE									
	Level of impact			Area of impact			Likelihood of occurrence		
	High	**Medium**	**Low**	**Cost**	**Time**	**Quality**	**High**	**Medium**	**Low**
1. . Inaccurate contract time									
2. Lack of clear construction procedures.									
3. delays in acquiring work permits									
4. . Late, incomplete or wrong surveys									
5. Delayed deliveries and disruptions									
6. Unsuitable equipment and materials									
7. Inadequate access to project location									

8. Delay in other project servicing the project site									
	Level of impact			Area of impact			Likelihood of occurrence		
	High	**Medium**	**Low**	**Cost**	**Time**	**Quality**	**High**	**Medium**	**Low**
9. Construction schedule overruns									
10. Inadequate project organizational structure									
11. Lack of coordination amongst subcontractors									
12. Lack of skilled workforce and personnel									
13. Failure to meet contracts specifications									
14. Equipment failures									
Pls provide any other risk you will consider in this category and tick accordingly.									
15.									
16.									
17.									
18.									
