Management of Change-Induced Rework in a Construction Project

الادارة الناجمة عن تغير اعادة العمل في مشروع البناء

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ABSTRACT

This study has investigated the causes of rework within a construction project, the impact of rework on the performance of the construction project and the possible reduction strategy that needs to be implemented to reduce or prevent the occurrence of rework within construction projects. The broader objective of this dissertation study was to determine the causes and impacts of rework on an existing construction project and to propose solutions on how to reduce/eliminate rework in the project. The specific objectives of the study included: (i) to study the impacts of direct and indirect cost of rework on the construction project, (ii) to compare between planned and actual cost and schedule of the construction project, and (iii) to identify the causes of rework and produce a rework reduction model. This study had been motivated by the apparent lack of concern on the main causes and impact of rework within the construction industry both at the local and international levels.

The study adopted a case study approach in which various stakeholders within a given construction project were interviewed and data was also collected through observation of physical works. The semi-structured interviews were held with relevant parties involved in the construction process and data obtained from 78 professionals involved in construction of the project. The findings showed that rework is primarily caused by changes initiated by the client and the design team as a result of poor coordination, errors, omissions and noncompliance with the original specification. The study has also revealed that rework can impact on the time and cost overrun of the project. Among the rework reduction strategies that this dissertation recommends be implemented include: team building and suppliers' and subcontractors' involvement. This study concludes that construction and design firms need to develop systems

for organizational quality measurement for the purpose of recording the occurrence of rework and the costs associated with it.

ملخص

وقد حققت هذه الدراسة أسباب إعادة صياغة ضمن مشروع البناء، وإعادة صياغة تأثير على أداء مشروع البناء فضلا عن استراتيجية الحد الممكنة التي يجب تنفيذها وذلك للحد من أو منع وقوع إعادة صياغة في مشاريع البناء. كان الهدف الأوسع لهذه الدراسة أطروحة لتحديد أسباب وتأثيرات على إعادة صياغة مشروع البناء القائمة واقتراح الحلول حول كيفية تقليل / القضاء في إعادة صياغة المشروع.
وتضمنت الأهداف المحددة لهذه الدراسة: (ط) لدراسة الآثار المترتبة على التكاليف المباشرة وغير المباشرة على إعادة صياغة مشروع البناء، (ب) للمقارنة بين المخطط والفعلي التكلفة والجدول الزمني لمشروع لتحديد أسباب إعادة صياغة وإنتاج نموذج تخفيض إعادة صياغة. كان الدافع وراء هذه (iii) البناء، و الدراسة من خلال النقص الواضح في الاهتمام على الأسباب الرئيسية وتأثيرها في إعادة صياغة صناعة البناء والتشييد على الصعيدين المحلي والدولي.

اعتمدت الدراسة على منهج دراسة الحالة التي أجريت مقابلات مع مختلف أصحاب المصلحة ضمن مشروع بناء معين وجمعت البيانات أيضا من خلال الملاحظة من الأعمال المادية. تم عقد المقابلات شبه المنظمة مع الأطراف ذات الصلة المشاركة في عملية البناء والبيانات التي تم الحصول عليها من 78 المهنيين العاملين في بناء المشروع. وأظهرت النتائج أن إعادة صياغة ويتسبب في المقام الأول من خلال التغييرات التي بدأها العميل وفريق التصميم نتيجة لضعف التنسيق، وأخطاء وهفوات، وعدم الامتثال للمواصفات الأصلي. وكشفت الدراسة أيضا أن إعادة صياغة يمكن أن تؤثر على الوقت والتكلفة تجاوز المشروع. بين استراتيجيات الحد من إعادة صياغة ان توصي هذه الأطروحة أن تنفذ ما يلي: بناء فريق العمل ومشاركة الموردين والمقاولين من الباطن. وتخلص هذه الدراسة إلى أن شركات البناء والتصميم تحتاج إلى تطوير أنظمة لقياس جودة التنظيمي لغرض تسجيل وقوع إعادة صياغة والتكاليف المرتبطة به.

Table of Contents

List of Figures

List of Tables

CHAPTER 1: INTRODUCTION

1.1 Background of the study

One of the simplest definitions of rework is it refers to effort which is unnecessarily put in redoing a given process or activity that has been implemented in an incorrect way. Various construction projects frequently experience schedule and cost overruns and the significant factor that is always responsible for many such overruns is rework (Hwang et al. 2009). Numerous research studies have been done by institutes of the construction industry and some of them have revealed that rework has a direct cost of on average around 5 percent of the total cost of construction. To give an illustration of what this means, the US construction industry spent around $1,502 billion during the year of 2004, and at least $75 billion of the direct cost of that was as result of rework within that year alone (Hwang et al. 2009). It is therefore a significant empirical matter to consider rework as a major factor affecting the performance of construction costs. Several studies have been undertaken to identify and present classifications of the main causes of rework and at the same time quantify the overall extent it has occurred within the construction industry (Hwang et al. 2009). However, comparatively few concrete results have been reported so far despite the fact that rework potentially can have a great impact on the cost of construction projects. By employing both a qualitative and quantitative research methodology, this dissertation examines the causes and impacts of rework on an existing construction project and proposes solutions on how to reduce/eliminate rework in the project.

By comparing the impacts of direct and indirect cost of rework on the construction project, comparing between planned and actual cost and schedule of the construction project and identifying the causes of rework and coming up with a rework reduction model, the projects which are mostly affected by rework are identified and solutions suggested (Love et al. 2010). In addition, the source of rework that has the highest impact on the cost of construction performance is discussed in detail. After conducting a critical analysis of the impact of rework on cost (both direct and indirect), the main causes of rework are assessed and suggestions on possible solutions are made. It is very important for project managers to recognize the various impacts of rework (Hwang et al. 2009). For the case of projects in which the cost is substantially affected by rework, there is a great need for project managers to minimize the rework by developing a proper model that can effectively address the rework sources. There is likewise a need for thorough implementation of quality management and pre-project plans to be drafted based on an understanding of what causes rework in order to reduce the possible negative impacts, especially those related to the costs of project construction (Love et al. 2010). This study is therefore justified on the basis that it provides a greater understanding of the impact of rework on the cost performance of construction, and hence can be applied to reduce rework and improve the cost performance of projects.

As had been mentioned by numerous scholars, rework is a prevalent problem found within building construction projects and it is one of the areas that has received insufficient research with only a few studies carried out producing comparatively limited results. The limited and recent research has however concluded that rework is the main cause of schedule and time overruns within projects and the extent of rework does not change significantly with the application of current methods of procurement. This paper uses mixed methods to identify the causes and impacts of rework within a construction project and also creates a possible model that can be used to reduce rework within the construction sector.

1.2 Research objectives

1.2.1 Broad objective/aim

The broad aim/objective of this study is to determine the causes and impacts of rework on an existing construction project and propose solutions on how to reduce/eliminate rework in this project

1.2.2 Specific objectives

To be more specific, the study objectives can be reduced down to three main issues of investigation.

1. Study the impacts of direct and indirect cost of rework on the construction project
2. Compare between planned and actual cost against the schedule of the construction project
3. Identify the causes of rework and develop a rework reduction model

1.3 Research questions

Based on the above objectives, this study aims to answer the following research questions:

1. What are the causes of rework within an existing construction project?
2. What are the impacts of direct and indirect cost of rework on the construction project?
3. What are the possible solutions on how to reduce/eliminate rework in this project?

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter, numerous literature pertaining to rework within the construction projects have been reviewed, rework conceptualized as a waste of time and cost and its nature. The section also discusses the pervasiveness of rework and the factors that influence rework together with their causes, the cost of rework, and the impacts that are very often associated with rework within a construction project.

Based on the previous studies which form the basis for this dissertation research, there has been an evident need for an appropriate definition of rework so as to highlight what it is from both research and industry perspectives. As was mentioned above, a straightforward operational definition of rework is the exertion of unnecessary effort in redoing a given activity that had been incorrectly done during its first time of implementation (Love et al. 2010). Rework as a process or activity might include the following: changes that have effect on the activities of construction and design errors, errors of construction, missing or additional scope due to errors committed by the constructor or designer, and errors due to on-site fabrications that always affect the activities of construction (Love et al. 2010).

Schedule and time overruns, deviations in quality and poor safety have all been widely witnessed within construction projects. Additionally, numerous reports initiated by the government across the globe have made many criticisms of the industry due to its fragmented state, lack of communication and coordination existing among the participants involved, existing contractual relationships that are adversarial, lack of supplier-customer focus, selections which are predominantly and even exclusively price based, and use of technology in an ineffective way.

In most cases, such poor management and organizational practices have resulted in wastage of time, costs which are not necessary, increased number of errors, misunderstandings, which ultimately have frequently resulted in rework in the majority of construction projects (Love et al. 2010). Additionally, rework has very often been identified as the main factor that contributes to schedule and time overruns in most construction projects. Today, cost and delay overruns have become almost the rule of construction operations instead of being the exception within construction projects. Most projects have frequently experienced changes in design produced by clients which as a result generate numerous effects that create disruption and delay across the whole project. Most projects at times appear to be progressing in a smooth way until near to the end when the errors that have been made earlier are discovered one-by-one and hence require calls for rework (Love et al. 2010). Such rework at times results in overtime, hiring of additional resources, slippage on schedule, or reduction on the quality or scope of the project. As has been highlighted in numerous studies, the final consequences of such problems and delays might include loss of reputation and market share, reduced profits, increased turnover of the workforce and management, higher costs, and lower overall productivity.

According to many study reports, numerous construction industries have always focused on addressing the symptoms instead of addressing what actually causes the rework problem within the industry (Fayek, Dissanayake & Campero, 2004). This explains why there is need to understand the problem in a manner which is more holistic, and with that in mind, it is necessary to have an empirical examination of what actually takes place within construction projects. By acquiring knowledge on the mechanisms that cause rework and then moving on to how it might be reduced within construction it is hoped that the research can identify some of the principal real causes of rework that previous studies have failed to identify and generalize to multiple construction industry contexts.

2.2 The nature of rework

The nature of rework may be determined by referring to various classifications, interpretations and definitions. Love (2002) argues that rework actually poses numerous interpretations and definitions within the literature on construction management. Some important terms which are usually referred to as synonyms for rework include: deviations in quality, defects, nonconformance, and failures in quality (Fayek, Dissanayake & Campero, 2004). On the same note, field rework is often understood to mean any kind of activity that has to be undertaken more than one time or any activity that removes work which has been previously done though not in the correct manner. With regard to conformance, two main definitions of rework exist. The first one is that rework is the process by which any given item is made to somehow conform to what had been originally required through correction. The second definition, which is given by a development agency of the construction industry, is based on the fact that rework is doing something for more than one time due to the initial nonconformance to what had been required. The literatures has always classified rework as both positive and negative (Fayek, Dissanayake & Campero, 2004). For instance, it might be positive in any situation where there is rework on the design and the participants involved in the design process leave with a better understanding of what was required by the customer. Basically, rework at times becomes important either when an element within the building construction fails to meet what had been required or in a situation where the work completed fails to conform with the documents for the contract. In whichever scenario above, the end-product is always altered for the purpose of ensuring conformity.

2.3 Waste that is often associated with rework

The process of construction always involves both non-value adding and value-adding activities. Value adding is to change the fit, function, and form of a given product with the aim of satisfying the demand of the customer. For example, during the purchase of a facility which is constructed, Love (2002) highlights that the owner or buyer places great value on the components that are installed when the end user or the owner occupies a given building. The activities which are reworked in this case are often components considered to be value adding. Value adding activities are only considered to be part of the completed work during the operation of the construction (Fayek, Dissanayake & Campero, 2004). Trying to maximize the proportion of all of the activities that are perceived to be value adding might increase the overall effectiveness of the addition of value during the construction operations. On the other hand, Love Irani, and Edwards (2004) state that all the activities that result in cost, indirect or direct, and take many resources, time or has a need for storage, but then in the end does not add value or progress the product being constructed can be called activity which is non-value adding or waste. For example, idle labor and idle plant are most likely to be included in the non-value activities raising construction cost during demolitions. In addition, time that has been taken by the designer for understanding the required redesign and change, and the time and cost for litigation in situations where misunderstanding arises between the client and the contractor or the consultant of the client also has a cost impact on the project (Fayek, Dissanayake & Campero, 2004).

According to the published literature, categories of waste can be measured based on their cost, which include opportunity cost. Moreover, other forms of waste are closely related to process efficiency, personnel or equipment. Love, Irani, and Edwards (2004) classified construction waste into three major categories: machinery, labor, and materials. However, any given effort in terms of labor, machinery or materials which has been directed towards the construction of any given element or part of a building and which need to be redone due to lack of conformity to the required design constitute what is referred to as a waste, which is also seen as rework (Zhang et al., 2012). It is argued that activities of construction characterized by high content of activities that are non-value adding always result in low productivity. For this reason, improvements made through eliminating and identifying rework pose a great impact on productivity. Any nonproductive time is considered as waste and waste might include both ineffective work and inactivity (Love et al. 2010). Different authors have stressed that inactivity might include travelling time, idling time, waiting time, and rework time, amongst others. Along the same line of explanation, ineffective work might include rectifying errors and mistakes, inventing work and working slowly. Within those transactions which are project-based, any occurrence of rework is considered as an item which is non-value adding that needs to be avoided, if indeed, it cannot be eliminated completely. Love, Irani, and Edwards (2004) stated that cost of rework can be determined from the point in which rework has been initially identified to the final time during which rework has been completed and the activity being carried out has returned to its original state. These authors argue further that while most stakeholders in the construction industry always have great interest in reducing the cost of over-production, they are in most cases not aware of the extent in which non-value adding activities can have on the overall cost of the construction project.

2.4 Factors that influence the occurrence of rework within a construction project

It is expected that some rework will occur in all construction projects. Factors that greatly influence the occurrence of such rework include the nature of the work involved, the method used for procurement, and the project's complexity.

2.4.1 Nature of the work

Construction includes civil, building and the work of specialists. Building, for instance, includes construction of commercial premises, residential houses and offices, whereas, civil work involves the construction of bridges, roads, and installation of infrastructure. Several studies have indicated that more rework occurs within building construction than it does within civil works as a result of the different interfaces t related to issues of management such as lack of coordination between the building services and building contractors, and also, poor communication between the team responsible for design and the construction team. According to Love (2002), construction that involves renovation and refurbishment is more prone to higher rework costs than are projects which are new build due to the degree of complexity and uncertainty that is associated with the building work being undertaken.

2.4.2 Methods used in Procurement and tendering

Most of the individuals who are involved in building procurement often do not realize the extent of rework that is sometimes incurred. Several research studies have conceded the fact that there is a great need for improving the quality of operations throughout the process of procurement so that the occurrence of rework can be reduced. The method applied in the procurement process might then have a great influence on the extent to which rework occurs in a given project (Zhang et al., 2012). For example, the application of non-traditional methods is more subject to high levels of rework than traditional methods, especially the rates of occurrence of changes, omissions, and errors. Traditional methods might provide the clients with certainty in cost, but non-traditional methods are common in contexts where pressure for completion on time is imposed on a given project. Love, Irani, and Edwards (2004) conclude that one of the main reasons for poor performance in the construction industry is the procurement process which at times is not appropriately managed on construction projects.

2.4.2.1 Traditional methods

Under traditional methods such as the traditional process of agreeing the provisional quantities and the traditional lump sum payment, there is the possibility of determining the cost with considerable accuracy prior to the commencement of the construction. Additionally, researchers have maintained that the applications of traditional approaches can provide a better means of ensuring proper quality control (Zhang et al., 2012). In addition, within traditional methods of construction, documentation and design need to be complete or the client has a major part of it completed before the commencement of construction on-site. On the contrary, traditional methods applied in procurement have received much criticism for their sequential approach to delivery of the project as it is often argued that they contribute to gaps within the procurement process where the process of construction and design are not tied to one another and instead remain separated. It therefore has been argued that organizational, cultural and behavioral differences exist between individual projects (Zhang et al., 2012). The gap in procurement existing between construction and design acts as an inhibitor to integration, coordination, and communication amongst team members of the project which can subsequently lead to rework and affect the performance of the project adversely.

2.4.2.2 Non-traditional methods

In order to satisfy specified construction time frames, a surplus of methods that are non-traditional have appeared in the marketplace facilitating compression of construction schedules and commencement of construction before completion of the final design (Fayek, Dissanayake & Campero, 2004). As the construction and design time are compressed, the degree of concurrency, or overlap, among activities tends to increase resulting in an increase in the complexity of the project with activities being subdivided into work packages (Fayek, Dissanayake & Campero, 2004). For example, under the build procurement and design method, a single contractor will assume the risk for both designing and building a given project. Build and design methods are replete with mechanisms that are time saving and cause numerous activities to overlap hence minimizing possible delays that might prevent on-time completion and reduce the frequency of adjustments associated with the design. One of the main advantages of using design and build is the opportunity it creates for integrating the construction and design components.

Love, Irani, and Edwards (2004) argue that construction and design integration provides good performance in cost and time resulting in few defects. With the procurement method of construction management, the design team is employed by the client and the construction manager is given a part payment so as to coordinate the construction and design activities and also to improve the ability of building by the design. The contracting management, also referred to as a fast-track strategy, is considered more suitable when all work for the design will not be completed before the first work contractors commence working even though all the design necessary for such packages must be completed first. Fayek, Dissanayake & Campero (2004) indicate that a limit exists on the given number of tasks that may be carried out concurrently. Beyond such specified limits, the probability that rework will occur together with the cost and time overruns that are likely to be experienced, leads to a significant increment, mainly as a result of the complexities that are associated with the coordination and communication of numerous tasks that are simultaneously undertaken. The current, non-traditional methods, such as design and construction management, have been deployed to overcome some of the reworking problems inherited from traditional methods (Fayek, Dissanayake & Campero, 2004). In a study conducted by Mitropoulos & Howell (2002) to ascertain how the procurement method and type of the project influence rework costs within construction projects, it is concluded that these methods have minimal benefit.

2.4.3 Complexity of the project

Mitropoulos & Howell (2002) indicate that the type of facility is usually linked to the degree of envisaged complexity and are in turn commonly linked to the performance of the project. The complexity of any project is composed of numerous parts which are interrelated. Complexity involves a given item possessing more than one component or variables. Within construction projects, all of the activities involved are typically divided into the functional areas that are performed by a variety of disciplines like the engineers, architects, and contractors and therefore have an independent operation (Rivas, Borcherding, González & Alarcón, 2011). The common custom and practice is for each of these disciplines to make decisions without giving consideration to the impact it might have on others. These disciplines, it is noted in the literature, tend to develop their own goals, objectives and value systems. As a result, each individual discipline is dedicated to its own functional optimization with very limited regard to its effects on the performance of the whole project.

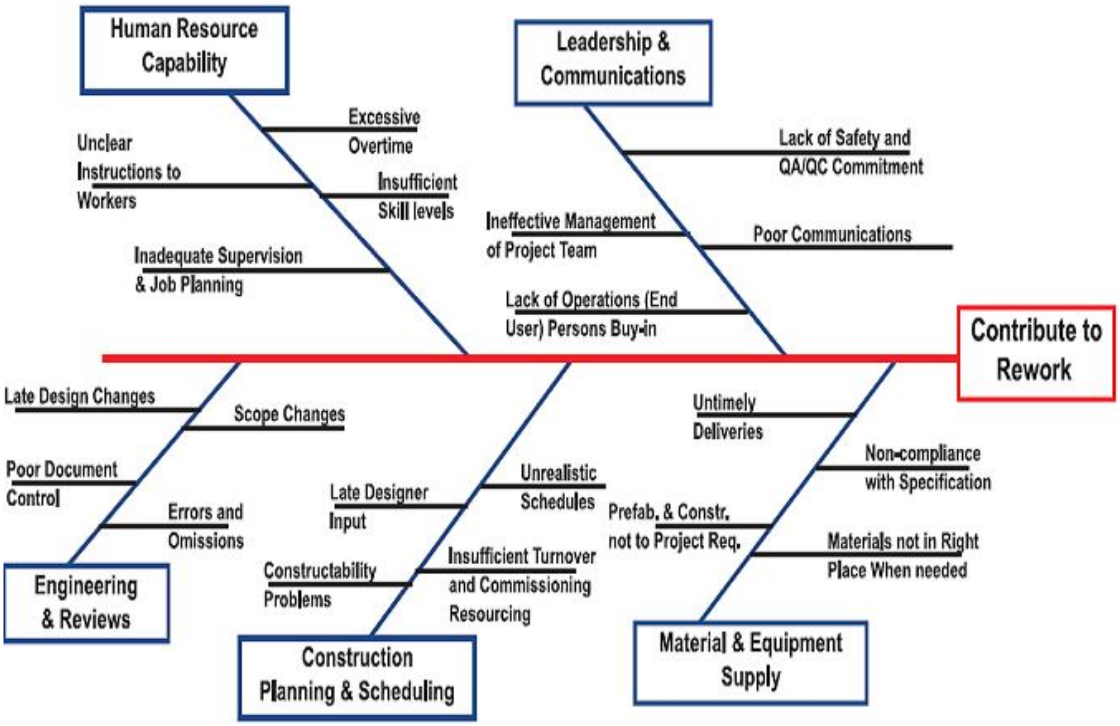
2.5 Causes of rework

A common cause of rework is whenever a service or product fails to meet what the customer requires. The construction project in such cases often has to be altered in order to meet the expectations of the client. An organization participating in a given project rarely aims to produce a product which is substandard or performs a service poorly, and it is usually accepted as a result of human error (Mitropoulos & Howell, 2002). For the procurement of a building to be successful, it has to be produced to the desired level of quality as well as be completed and delivered within the stipulated time, at a minimum cost and within the right market (Wang et al. 2008). For quality to be improved, there is a great need for understanding the root causes associated with rework, the basic reasons why rework exist and the main conditions that stimulate occurrence of rework within a process. Love (2002) argues that the main causes of rework can be grouped into different categories: design-related, client-related, and factors that are contractor- related which include the management of the site and subcontractor factors (Mitropoulos & Howell, 2002). It is important however to remember that rework has become something that is almost routinely accepted within the process of construction.

It has been suggested that uncertainty is the primary cause of rework. Love (2002) asserts that uncertainty is mainly generated by information which in most cases is frequently missing, inaccurate, unreliable, and conflicting; all termed as poor communication. To reduce rework, therefore, it is important to identify what the main causes are and analyze deeply to determine how the identified causes are interrelated (Tse & Love, 2003). It has been widely argued that the level of rework in any given construction project, to a greater extent, relies upon factors that are external like the market conditions and workload which is excessive (Mitropoulos & Howell, 2002). For instance, poor workmanship and increased defects might arise from the limitations existing on the availability of good workers and subcontractors, and unwarranted or additional pressures arising for early completion (Zhen, Qian, Jian & Zillante, 2010). The Association of Owners of Construction (COAA) developed a classification fish-bone that can be used when categorizing the causes of rework.

COAA have utilized a fish-bone diagram, called technically the effect and cause diagram for exploring all the possible causes of rework within a construction project. The figure below illustrates the possible causes of rework (Zhen, Qian, Jian & Zillante, 2010). It comprises of five main causes of rework and another four possible related causes within each category. The five broad areas in this case are: 1) communication and leadership, 2) human resource capability, 3) reviews and engineering, 4) equipment and material supply, and 5) and construction schedule and planning.

Figure 1: Possible causes of rework



Source: (Zhen, Qian, Jian & Zillante, 2010)

2.5.1 Human resource capability

Several literatures have reported four possible causes of rework that arise as a result of the capabilities of human resources: inadequate or inexperienced supervision, insufficient levels of skills or lack of skilled labor, excessive overtime, and unclear instructions given to workers as well as poor job planning (Love, Irani, & Edwards, 2004). On the same note, Love, Irani, and Edwards (2004) reported that lack of proper scheduling; planning, management of materials; quality assurance and quality control can be very critical problems when engaged in construction. It is therefore evident that well-trained and experienced supervisors have a central role when it comes to minimizing the amount of rework that results from defects in construction. In general, construction environments are characterized by numerous problems related to changes in the design, rework, general quality, production, materials availability and quality, and utilization of capacity. Love (2002) indicate that the main challenge facing managers of construction projects is how to encourage innovation throughout the process of project construction so as to ensure that all possible problems are easily identified. Josephson, Larsson & Li (2002) argue in their study to determine the effect that quality supervision has on rework that the quality of supervision of the site has a great influence on the overall efficiency and performance of construction projects.

2.5.2 Leadership and communication

Love, Irani, and Edwards (2004) assert that poor communication and ineffective leadership and decision making can cause rework. They further argued that the underlying contributors of rework related to poor leadership are the strategic decisions that are undertaken by the key decision makers or top management who actually stimulate the conditions that encourage adoption of inappropriate structures, practices, processes, and project technology (Love & Edwards, 2004). The following possible causes have always been associated with communication and leadership: ineffective project team management, lack of quality and safety assurance and commitment for control, poor communication as well as lack of buy-in of managers and employees working in operations. Scholars claim that the principles of quality management and tools are not embedded strongly within the conventional management practices of construction (Love et al., 2009). Consequently, rework is accepted in most cases as an inevitable characteristic of the process of construction, increasing projects' likelihood of overruns in cost and time, and ultimately leading to the dissatisfaction of clients. Josephson, Larsson & Li (2002) suggest that one of the most puzzling issues that construction industry organizations face is their inability to focus on quality. This limitation results in substandard services and products, which inevitably produces rework (Love et al., 2009). Failures of the supervisors to plan their work properly and lack of frequent and proper communication with their workers, combined with inadequate supervision of activities, have all been linked fundamentally to the increasing amount and costs of rework (Love et al., 2009). Such management capabilities, however, can be improved through undertaking more formal and informal training. The clients and respective members of the project team will more frequently experience harmonious communication and work relationships when projects are delivered on time. In summary, there is substantial evidence reported in the literature that poor communication and leadership are major causes of rework.

2.5.3 Engineering and reviews

Omissions and errors are also major contributors to rework. In their study, Josephson, Larsson & Li (2002) found out that errors committed in buildings have at least 50 percent of their origin in the stage of designing and 40 percent in the stage of construction. Researchers have identified factors that strongly cause error in design (Love et al., 2009). They include inadequate training of design consultants, competitive fees, adverse behavior, lack of biorhythm, and improper usage of automation aided by computer. Additionally, inefficient quality assurance, design team poor integration and ineffective coordination have also been identified as causes of rework. A well-cited example reported in a publication by Love (2002) reported that the documentation of the architecture for the package of partitions and ceilings contained some missing information and dimensional errors, and hence had an adverse effect on the set-out of the internal walls. Rework originated from this erroneous and incomplete information during construction (Hwang et al., 2009). Often, changes are made to the design, and the people who have to do the rework often are the design team which in the long run influences their income and fees. Another key source of changes in construction projects emanate directly from architects, who often repeatedly try to improve the building aesthetics and functionality (Hwang et al., 2009). Studies have shown that utilization of under-qualified and inexperienced staff who lack technical skills and knowledge can also result in omissions and errors in the contract documentation that is written.

Hwang et al., (2009) argued that insufficient knowledge creates complicated problems for design firms. In most cases, design firms employ staff who are inexperienced for the purpose of maximizing the profitability of their fee income as well as instigating practices of "time boxing", a specific practice that occurs when there are fixed durations allocated for the task to be undertaken, regardless of the extent of completion of the task or design documentation. Client's project involvement has been studied in connection with issues of rework, and the conclusion is that through empowering the client during the process of design, change orders during the phase of construction can be greatly reduced (Georgy, Luh-Maan & Lei, 2005). This observation holds typically for the clients who routinely procure projects. Factors such as end-user expectations and unreasonable client expectations can also lead to error during the design process. Hwang et al., (2009) concluded that most of the errors that are experienced occur as a result of the failure of designers in understanding and delivering the requirements of the client.

2.5.4 Construction planning and schedule

Love (2002) has asserted that the design stage and work preparations before construction are imperative. He argued that the occurrence of rework is caused by improper planning or insufficient time devoted to the design and construction commences. Knightly (2008) similarly argues that pre-project planning is an important contributor to rework. For example, changes which are a result of improper planning have a significant contribution to the cost of rework and can be as high as 34%, with bad methods of planning (15%) and wrong information (15%) also inflating costs. Changes in methods of construction can lead to on-site rework together with numerous other indirect consequences such as stress. According to Czaplicki (2013), project managers acknowledge that in some circumstances, increased costs are interrelated. For instance, a supervisor who is inexperienced and makes mistakes in selecting the most suitable methods for construction will automatically affect the process of construction (Rivas, Borcherding, González & Alarcón, 2011). There is need therefore to consider several methods of construction and compare them by analyzing each aspect including: reliability, costs, availability of knowledge, applicability and equipment.

2.6 Rework Costs

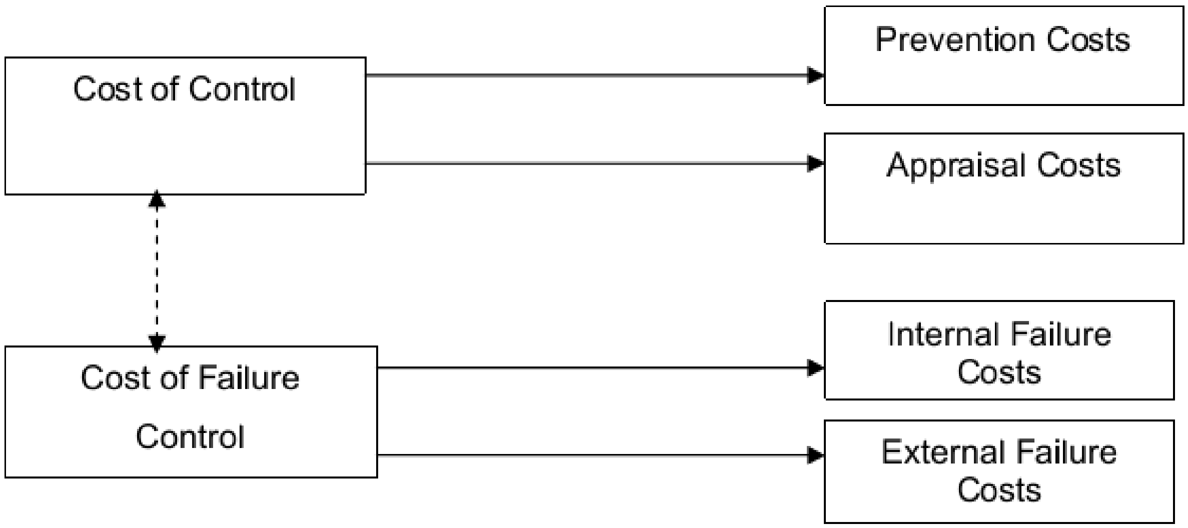
2.6.1 Cost of rework overview

A lack of uniformity exists in the ways that the cost of rework has been calculated. The data collected are based on numerous divergent interpretations as to what actually constitutes rework. As argued by scholars, rework cost measurement in itself never results in improvement, rather it provides a starting point for establishing new knowledge on the subject. In his discussion on the costs of rework, Love (2002) recommends that organizations in design and construction need to implement a management system that is of high quality, supporting quality cost systems for the purpose of reducing rework costs. It is only when the organization measures the cost of rework that they appreciate fully the economic benefits associated with high quality management systems (Karim, Marosszeky & Kumaraswamy, 2005). It has been argued that in order to achieve a substantial reduction in costs, there is great need for eliminating the root causes of rework. It has been argued that around a 15 percent saving from the total cost of construction can be achieved through eliminating rework and by directing more money and time on its prevention (Rivas, Borcherding, González & Alarcón, 2011). In order to improve an organization's construction performance and reduce the cost associated with it, there is a great need for measuring quality and cost. Appraisal and prevention costs are not avoidable and have to be incurred by the consultant firms and construction companies if the products and services are to be delivered right and on time (Czaplicki, 2013). The component of quality costs that have to be incurred by organizations engaged in construction for the purpose of improving their performance and reducing rework is illustrated in the figure below. The components of quality costs are two-fold, cost of failure control, and the cost of control (Nimmo & Moore, 2008). Cost control comprises of appraisal and prevention costs. Prevention cost in this case involves the amount that has been invested for the purpose of reducing defects and errors, while the appraisal costs involve error or defect detections for ensuring conformity is within the required quality level (Czaplicki, 2013). The cost of failure control always includes external and internal failure costs. Internal failure costs can be incurred from scraping, or doing rework for defective products or making compensation for delays in making delivery while external failure costs always involve the cost of returns, repairs, dealing with compensation and complaints after delivering a product to the client. It has been acknowledged in the literature that the cost of rework can be as high as 23 percent of the value of the contract, with numerous factors contributing towards the rework cost. Based on Love's (2002) line of argument, these include the extent that quality management practices have been implemented, the type of project involved, the procurement method that has been applied, and the complexity of the project. In their study, Love and Edwards (2004) reported that the Development Authority for the Construction Industry in Australia found that the average cost of rework in projects with no formal system of quality management is around 6.5 percent of the value of the contract and the higher value of the project beneath the lump sum procurement was approximately 15 percent. Conversely, the average cost of rework for projects that have implemented a quality system was found to be approximately 0.72 percent (Love & Heng, 2000). Rework cost within projects which are poorly managed can even be as high as 25 percent of the value of the contract and 10 percent of the total cost of the project. For instance, the task force for construction in the United Kingdom reported that around 30 percent of construction work is associated with rework. On the same topic, the Construction Industry Institute based in the US published the estimate that the annual loss experienced from rework might be as high as15 billion US dollars for industrial construction projects (Czaplicki, 2013).

Love and Edwards (2004) reported that rework costs for residential, commercial, and industrial building projects ranged from 2 percent to 6 percent of the values of their contracts. They found the cost of rework was at 3.15 percent for a residential building and 2.4 percent for industrial building. Additionally, they found that when a quality assurance system is implemented by the contractor in conjunction with a strategy for continuous improvement, the costs of rework were less than 1 percent of the value of the contract. In some other studies, projects having no quality system in place however experienced an increase of 10 percent of cost associated with rework (Czaplicki, 2013). The costs of quality deviations in heavy and civil industrial engineering projects have been found to be significantly high. Josephson, Larsson & Li (2002) studied nine major engineering projects in order to determine the cost associated with deviation corrections for the purpose of meeting specified requirements. The result of their study indicated that, for all the given nine projects involved in the study, deviation on quality accounted for an average of 12.4 percent of the value of the whole contract (Taylor, & Ford, 2008). A significantly lower figure was reported by another study which found that the cost of non-conformance in a project for highway construction was 5 percent of the value of the contract. In their national survey study in 2004, Love and Edwards reported that rework total cost is a function of both indirect and direct costs.

While there have been numerous studies that seek to determine the direct (tangible) cost and indirect (intangible) cost of project it has never been explored to any great extent within the construction industry. This is due to the fact that it is often difficult to quantify such cost in monetary terms (Czaplicki, 2013). Typically, efforts in research have focused on determining the direct cost of rework cost at the expense of the indirect costs likely to be involved which consequently has remained more unknown.

Figure 2: Quality cost components: cost of failure and control



Source: (Czaplicki, 2013).

2.6.1.1 Direct cost

As numerous construction documents indicate, direct costs are always readily measurable, such as are quoted in the workmanship quality evaluation, and they represent a proportion which is significant to the total cost of the project. The direct cost of rework includes man hours, equipment, space, schedule and materials (Czaplicki, 2013). The development agency of the construction industry in Australia estimated that the direct cost of rework within the construction industry was more than 10 percent of the total cost of the project. If a 10 percent value for the rework is applied to the Australia construction industry's annual turnover, which in 2006, was approximately $43.5 billion per year, then the rework cost can be estimated to be $4.3 billion per year (Czaplicki, 2013). A number of studies that have attempted to quantify rework direct costs in engineering and building projects have found it to be as high as 25 percent of the value of the contract.

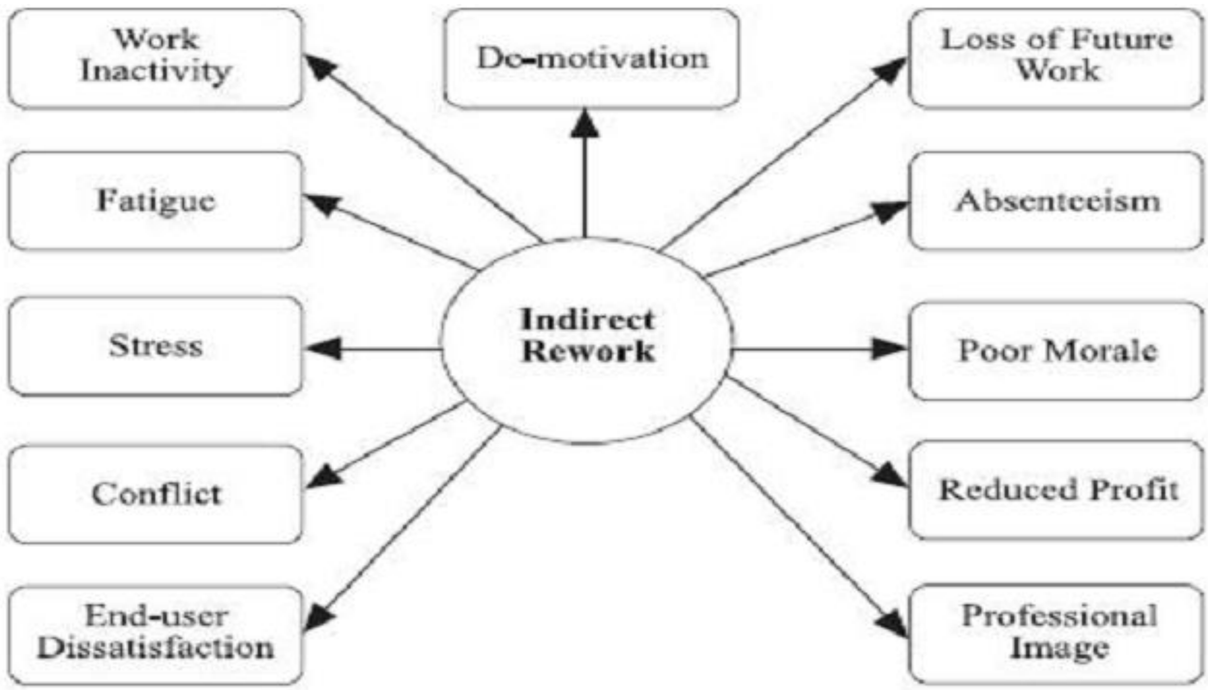
2.6.1.2 Indirect cost

Indirect costs are never directly measurable and they always include loss of productivity and schedule overruns, claims and litigation, and low efficiency in operations (Love & Smith, 2003). Likewise the indirect costs include factors influencing performance, network impacts, coordination, and changeover. Love (2002) claims that little is known about the indirect consequences of rework within construction projects, especially with regard to financial costs. As has been mentioned earlier, a limited amount of research has been carried out for the purpose of determining indirect costs associated with construction projects. In his study on determining the indirect consequences related to rework within a construction project, Love (2002) concluded that the most significant indirect cost for construction firms was associated with the extensions of the original periods of the project contract since it impacts on the capacity of the organization to take on new contracts. Moreover, when the information was made available, other additional resources had to be employed and overtime paid so as to meet the deadline**.**

2.7 Impact of rework on construction projects

Occurrences of rework have adverse impacts on the performance of projects. Taking into account both direct and indirect costs, for example, within a project which is poorly managed, the total gross impact of rework might be equal, or even exceed, the expected profit or mark-up margin levels (Li, & Taylor, 2014). Also, there can be effects on different aspects within the construction project including motivation, stress, reputation and relationship (Love & Smith, 2003). Scholars have identified the following direct impacts of rework within the construction project: additional cost incurred for covering the occurrence of rework, additional time spent in rework, additional materials for rework and the subsequent handling of waste, and the additional labor used in rework and other related extensions used for supervising the manpower. Love (2002) concluded in his findings that rework might cause serious effects on an organization, individual and on the performance of the project in an indirect way. At the level of an individual, absenteeism, fatigue, stress, poor morale, and de-motivation have been found to be the main effects of rework within a construction projects. In fact, when an individual is subjected to long working hours as a result of errors, changes or omissions, stress and fatigue are more likely to emerge, increasing the probability of the occurrence of further rework (Palaneeswaran, Love, Kumaraswamy & Ng, 2008). At the level of the organization, some of the indirect effects of rework that has been identified by scholars include inactivity in work like idle time, waiting time, time for traveling, and the dissatisfaction of the end user. Wan, Kumaraswamy & Liu (2009) identified psychological and physiological consequences that are mostly associated with the undertaking of rework. For instance, increased stress as a result of additional financial burden and profit margin loss, plus having to re-do one thing again, can have consequences which are de-motivating (Mills, Love & Williams, 2009). As has been mentioned earlier, rework can have adverse effects on the productivity and performance of construction and design organizations. Moreover, it is a major contributing factor to the overruns of time and cost within a construction project (Wan, Kumaraswamy & Liu, 2009). Rework in the form of making changes might have an effect on the project or building functions and aesthetics, the nature as well as the scope of work, and its aspects of operation. Rework very often results in adverse impacts on the performance of the construction project in terms of time overruns, cost overruns, degradation of quality and professional relations.

Figure 3: Illustrating the indirect impact of rework on a construction project



Source: (Hwang & Yang, 2014).

2.7.1 Cost overruns

Fayek, Dissanayake & Campero (2004) declare that overrun cost is a very common phenomenon and is associated with almost all projects in the construction industry. Cost has for a very long period of time demonstrates its importance as the predominant factor for establishing the success of any given project (Hwang & Yang, 2014). Many of the major factors that affect the cost of the project are qualitative such as the preferences of the client on the time duration and priorities for construction, the planning capability of the contractor, methods of procurement, and the market conditions including the level of industry activity in construction. As has been argued throughout this chapter, many construction projects routinely incur cost overruns arising from rework. Love (2002) indicated that rework is a type of occurrence that consultants always try to avoid since it leads to increases in cost. Cost overrun can be defined from its simplest definition as a given situation in which the project's final cost exceeds the cost that had been originally estimated. Cost overruns are a serious problem in the development of projects but continue to feature regularly within the construction industry especially in developing countries (Wan, Kumaraswamy & Liu, 2009). Excessive costs incurred by the parties involved in the construction, especially arise for clients and contractors. A study by Love, Irani, and Edwards (2004) on the public roads in Norway indicated that cost overruns could range from 59 percent to 183 percent, and this was very common on relatively smaller projects. Zhang et al., (2012) found that the construction industry in Nigeria witnessed a mean percentage of cost overruns of around 17.34 percent. Other studies conducted in the UK construction industry found that almost one third of clients made a complaint that the cost of their projects had exceeded the original budget. Love (2002) proposed that te identification of the influence and existence of the risk factors of cost overrun can result in appropriate control of the cost of projects, reduce cost overruns and also assist with the identification of possible solutions for avoiding potential future overruns. The available literature indicates that the problem of cost overruns is indeed critical and hence needs to be studied in a more extensive way so as to alleviate such possible overruns in the future (Wan, Kumaraswamy & Liu, 2009). Scholars have pointed out that overrun costs are a major problem in both developed and developing countries. The trend has been reported to be more severe within the developing countries where such overruns at times are more than 100 percent of the initially estimated cost of a given construction project.

2.7.2 Time overrun

Time overrun is commonly defined as an extension of time beyond the initially planned completion time of the project. Rework can always result in delays to the completion of a given construction project and hence result in time overruns (Wan, Kumaraswamy & Liu, 2009). During the phase of construction, rework extends the project cost and delivery. The impact of time overrun on a project or contractor's delay includes reduced profit margin, increased cost, and potential damage to good reputation. Moreover, clients also experience negative effects created by additional charges, reduced income and higher than predicted professional fees resulting from occupancy that has been delayed. Being part of the factors that contribute to delays in the completion of construction, scholars have noted that majority of contractors feel encouraged to make the assumption that the duration that has been set by the client is somehow realistic and hence make appropriate preparations in their bid (Wan, Kumaraswamy & Liu, 2009). Rework occurrences invariably lead to contractors making an evaluation of their project schedules, as delays have the capacity to result in liquidated damages (Hwang & Yang, 2014). For example, if there is a delay experienced due to rework and the contractor is not considered responsible for it, then an extension in time or cost acceleration might be awarded, though this always depends on the type of delay and its impacts on the critical path. Zhang et al., (2012) found that 44 percent of respondents to their survey on the construction industry in Nigeria stated that overruns in time occur quite often (Wan, Kumaraswamy & Liu, 2009). Other studies have also found that time overruns occur on most civil engineering contracts. A pilot study undertaken by Love, Irani, and Edwards (2004) on how to reduce rework as a means of improving the performance levels of construction projects identified a number of incidents of time overrun. Within one sample concerning a private building project, the overrun of time was estimated at

277 days, where the original period for the project was set to be completed in 480 days. Project completion on time is a good indication of a construction industry which is efficient. Inevitably, an ability to predict accurately the time for completion depends in part on the skill, intuition and experience of planning engineers.

2.7.3 Quality degradation

According to many published reports, value to the client is always a subjective and complex issue, though it is recognized that construction quality is one of the main components of the perceived value for clients (Sawhney, Walsh, Bashford & Palaniappan, 2009). As is manifested by FIDIC, poor quality within construction is apparent in non-suitable or poor workmanship and structures that are unsafe, and whenever construction projects are delayed, they often lead to cost disputes and overruns in the contracts of construction (Sawhney, Walsh, Bashford & Palaniappan, 2009). Rework in many cases means scrapping part of the existing built structure and sourcing additional materials needed for rebuilding, creating a compromise in quality compromise resulting in wastage of resources.

2.7.4 Professional relations

The resultant ripple impacts associated with rework frequently damage goodwill and reputation. Love (2002) affirmed that one of the impacts that projects time overrun or completion delays has is bettering of the contractor’s reputation. A good example cited in the case study undertaken by Fayek, Dissanayake & Campero (2004) to investigate the indirect consequences that rework has in construction found it was difficult for the contractor to organize the many subcontractors required to return back to the site to rectify incomplete and defective work, as most of them were already working on other existing projects (Sawhney, Walsh, Bashford & Palaniappan, 2009). Subsequently, some rework such as re-installing outlets for general purpose, installing locks to doors, sanitary appliances, and painting had to be done after the buyers moved into their units.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter explains and discusses the research approach and design. Also included in this chapter is a description of the sampling techniques and size, procedures for data collection, techniques for data analysis, issues of validity and reliability, and ethical considerations.

3.2 Research purpose

Research can be carried out using many approaches. In many cases, an identification and classification of the research methods is done based on the prior knowledge of the researcher on the study topic. The main distinction often made when considering issues of research methodology are: descriptive and explanatory approaches. In the exploratory research approach, the study is based on the researcher's own interpretation of the data collected. The main aim in this scenario is to develop suggestions and propose ideas. Exploratory research is often used when the research community does not have much knowledge about the problem, or when the available knowledge is considered to have considerable gaps and unknowns. The most appropriate technique that should be used in gathering information under exploratory research is use of observation and interviews. Explanatory research seeks to go beyond providing descriptions of various existing conditions or phenomena which are connected to situations, events and individuals. The purpose of such research work is to develop empirical generalizations the outcome of which is theories that are developed and tested. Additionally, there are many descriptive studies which are carried out when the researcher wants to develop more knowledge about a research problem but has no intention of predictively investigating causal relations and outcomes. Descriptive research is mainly recommended when the study involves either primary or secondary data in investigating several aspects of a problem without yet having a well-formed theory worth testing. Explanatory research, in contrast, is selected whenever the main objective is developing a precise theory that can be applied in explaining empirical phenomena and making generalizations about a known population based on a representative study sample. Researchers in such cases develop one or more hypotheses which are put to empirical test. According to most research professionals, a study is only defined as explanatory when the focus is on cause-effect relationships. For example, the theory may be used to explain what specific factors produce specific effects and outlines a simplified and abstract model or framework representing how the cost and effects are related. In this situation, several independent variables are often utilized for investigating whether and how they determine the outcome of one or more dependent variables. For example, how the nature of rework results in the increased cost of construction. Such studies can be carried out using secondary data, primary data or both.

For the purpose of the research questions in this study, it was decided to conduct both an explanatory and descriptive research investigation. It is explanatory because the researcher wants to investigate, predict and test the causes of rework, its impacts and the best solutions available to prevent the occurrence of rework. Two types of variables exist in this study: independent variables (causes of rework) and the dependent variables (impacts of rework on cost and time scheduled for the project). The study is descriptive because a substantial component of the data collection and analysis tends to describe possible empirical causes and impacts of rework within a construction project without testing specific theories or hypotheses.

3.2 Research design

Description of the methodology of the research normally covers the purpose and scope of the study, the research questions, propositions and hypotheses, methods of data collection and analysis and the interpretation and argument developed for the conclusion and recommendations. The literature on research design argues that any research project must have an overall framework for data collection and the subsequent analysis and interpretation. The argument presented by Rivas, Borcherding, González & Alarcón (2011) on the choice of research methods choice is that much consideration should be given to the type of data type that is to be collected for resolving the stated research problem. This study utilised a Case study design which employed both qualitative and quantitative methods to collect primary and secondary data on a specific construction project to help with answering the research question.

3.2.1 Quantitative Research

Quantitative research is one in which things are counted, and data are usually analyzed through statistical methods and techniques with the results stated in numerical forms. Approaches to quantitative research methodology incorporate experimental studies, quasi-experimental studies and descriptive studies. Additionally, there is a preference in quantitative research methodology for seeking to make predictions and give an explanation of the findings which can be generalized from the sample to a wider population. The intention in this case study research, was to validate or confirm relationships and to produce generalizations that can be used in developing the existing theory. The quantitative methods employed in this study sought to categorize and quantify the causes of rework, trade which is associated with rework and the overall time and cost impact that is associated with rework, as well as make relevant suggestions that can be used in solving rework problems.

Qualitative Research

Based on the argument of Rivas, Borcherding, González & Alarcón (2011)**,** qualitative research includes checking on the characteristics or qualities that cannot be presented well as a numerical value. It is the kind of research that focuses on phenomena that takes place within natural settings and involves the study of such phenomena within all their complexity. Within this study context, the literature has suggested researchers follow approaches which are systematic and incorporate structured tracking mechanisms of relationships. These characteristics and processes are essential for the purpose of effective tackling of inefficiencies related to rework. Qualitative methods have been utilized within this case study to determine the detail and diversity of perceptions of the population sampled with regard to the causes of rework, impact of rework and measures that should be undertaken to minimize rework. Like many qualitative studies, this research was field focused. Qualitative research is always exploratory in nature, and it often will include use of observation in building theory from the ground upwards.

3.4 Methods of data collection

The study has utilized both quantitative and qualitative data. While the quantitative data has been obtained through administering questionnaire surveys to the various stakeholders involved in the construction project under study, secondary data as well as in-depth interviews have also been utilized. The study has not relied exclusively on one source of data, but instead, mixed data types and sources for the purpose of making an in-depth analysis and coming to an accurate conclusion regarding the research problem. During the process of interviewing, the researcher visited the construction site. He then conducted interviews with different groups of people involved in the construction project: the client, contract manager, planner and the junior staff manager. Face-to-face interviews were conducted using a semi-structure schedule of closed and open-ended questions. Open ended questions were used for obtaining the insights, perceptions and views of the interviewees regarding what causes rework, the impacts associated with rework especially with regard to time and cost, and their possible suggestions for preventing the occurrence of rework within a construction project. Closed questions were utilized mainly to confirm facts. Additionally, meetings were held with different project stakeholders separately. This was termed as a focus group discussion in which the stakeholders involved in each single meeting were allowed to divide themselves into groups which then were probed by the researcher for the purpose of them expressing their own opinions and relating their experiences on the causes and impact of rework within a construction project. The investigator acted as an inactive member whose role was only to moderate the discussion underway together with putting forward the leading questions but never participated actively during the entire period of the discussion. The interviews enabled the researcher to have a free interaction with the participants of the study and gave them the chance to narrate their points in greater detail. The questionnaires deployed in this study had different sections: demographic information, organizational management practices, rework causes, impact of rework, and measure of rework cost and rework containment strategy. A pre-test was conducted to ensure that all of the relevant questions were precise and clear for accurate gathering of the information needed in the study. In each of the above sections, the study utilized both multiple choice and open-ended questions. The study considered open ended questions as suitable for this study since it provided the interviewees with freedom in answering the questions as they considered fit. The interviewees had the freedom to attend to the questions based on their own individual understanding. This of course resulted in more detailed answers being available for evaluation. Multiple choices questions were also used for the purpose of quantitative data collection method. The advantage of multiple choices questions in this case is their accessible nature for analysis. Within the multiple choice questions, the interviewees responded with specific answers by choosing from the closed set of options that they were provided. The investigator relied heavily on the multiple choice questions compared to open-ended questions due to the advantages they have of being straightforward, simple and easy to analyze.

Another data collection method utilized in this study was observation. The researcher moved to the case study construction project and interacted with various personalities who were involved in the construction process. This made it possible for him to be provided with first-hand information from various stakeholders who undertake the process of project construction. The questionnaires were completed by around ten individuals who were involved in the construction project. The main advantage realized by the researcher for using the questionnaires were: questions that were confidential helped to give participants more confidence to express their opinions, convictions and views without necessarily fearing any kind of pressure to respond in particular ways. It also enabled the researcher to appropriately quantify the findings and results for accurate discussion.

A systematic review of secondary data was another data collection method utilized in this study. This was purposively utilized in defining different construction terms and meanings. Though the strategy of the research mainly involved academic journals, other published materials such as the building and construction inspection reports, construction databases, newspapers and articles were deeply reviewed to obtain information related to causes and impacts of rework within construction projects. Of great relevance and application were books which were very appropriate in defining meanings such as ‘rework’. Academic books that addressed the issues of rework on construction sites were consulted. When reference is made to this kind of secondary data, the investigator chose to focus mainly on academic books so as to better understand the theoretical aspects of rework within construction projects.

3.5 Sampling procedures for data collection

The non-probability sampling technique was adopted in this study. Within non-probability sampling, there does not exist any way of guaranteeing that each individual element within the population will be represented within the sample. Moreover, some individual members within the population pose little or no chance of being sampled. The literature argues that when applying non-probability sampling, the particular units of a given population which comprise the sample are purposively chosen based on the idea that the small mass that has been selected will represent adequately some aspects of the entire population. Within purposive sampling, people or other given units are chosen for a specific purpose. It is a common sampling method which consists of collecting data and information from a population sample that know the research context and are relevant to understanding the research problem. For example, within the preliminary case study that has been undertaken, a purposive sampling method has been utilized in selecting the single construction project for study. This project was also selected partly based on pragmatic considerations, namely its availability, which is known formally as a convenience sampling method. Additionally, the questionnaire respondents are chosen deliberately as representatives of the whole population within the area where the project is located and the questionnaire is designed to collect information specifically from senior individuals within the organization.

3.5.1 Secondary data

Secondary data consisted of literature related to the topic that was being studied. According to Love & Heng (2000), a review of the literature involves reading and evaluating what other people have written about the subject area, including both analytic and descriptive accounts. The literature review is often descriptive in nature in so far as it tends to describe the work done by previous writers, but can also be analytical in the sense that it analyses critically the contributions of others with the aim of identifying the similarities and contradictions in the arguments that have been made by previous writers. A literature includes two distinct types of literature review: full literature review and preliminary. A preliminary literature review related to the factors and sources that are attributed to rework and the classification of such factors together with the impact of rework on cost and time was undertaken in this study to gain insights with the aim of meeting the objectives of the research. Additionally, an extensive literature review has been undertaken to develop a coherent and comprehensive view of some of the pertinent topics such as: causes and cost of rework, pervasiveness and nature of rework, and how rework impacts on cost, quality, time and overall performance of the project. The sources of information for compiling this literature review, as has been stated earlier, included: conference proceedings, journals, textbooks, roundtable discussions, theses and dissertations.

3.5.2 Primary data

Primary data includes sources that collect data through measurement of phenomena within the real world, and may involve detached observation, without disturbance by an intermediate interpreter. Primary data was collected in two stages during the process of this study. First, an exploratory preliminary study was undertaken on a construction site in order to identify and examine the origin and causes of rework and also to develop tools and techniques for measuring the causes and the impacts of rework within that construction project. Based on Love & Heng (2000)**, an** exploratory study is the kind of research undertaken within an area that has never been studied before and in which the researcher seeks to develop initial ideas and a research which is more focused on exploring different perspectives on a set of research questions. The main sources of data used for exploratory study include: observations of physical building, semi-structured interviews, and sources of site documentation including site instructions, progress reports and revised working drawings.

3.5.3 Interviews

Interviews involve a discussion typically between just two people, known as the interviewee and the interviewer. The interviewer begins the interview for specific objective of obtaining information related to the field of study. According to study scholars, a successful interview should uncover the perspectives of the study participant on a specific issue. Additionally, an interview allows for observation of the respondent's behaviors that can provide an extensive insight into the opinions, feelings and motivations of the respondent. Interview has been described further as a distinctive research technique that has three main purposes. First, it might be applied as the main method of gathering information, having a bearing directly on the objectives of the study under research. Second, it might be used in testing the study hypothesis or as a method for proposing new ones as an explanatory device that explain the relationship and identification of variables. The interview might also be used in combination with other data collection methods for the research study. Semi-structured interview was adopted in this study. It was used to fill the spectrum that exists between unstructured and structured interviews. Each interview completed was recorded on tape.

3.5.4 Observation and auditing site documentation

Direct observation of the physical buildings under construction was made and notes taken with the help of a note book and a pen used in deriving the data. Site documentation like the revised working drawings, site instructions and progress reports were thoroughly examined to obtain data. Also, site documentation such as site instructions, revised working drawings and progress reports were examined.

3.6 Data entry and analysis

All the collected data from the study were first edited for readability, consistency and completeness. Mistakes committed by either the interviewee while filling in the questions in the questionnaire or by the researcher while recording information during the period of focus group discussion were checked and corrections made as considered appropriate. Coding of data was then undertaken before being entered into a computer using SPSS (Statistical Package for the Social Sciences) version 17.0 software. First, univarate analysis was performed in the process of identifying different proportions of the study outcome. These included how clients change of instructions can result in rework, the impacts rework has on the construction time and cost of a given construction project and the appropriate model that should be applied to reduce the occurrence of rework. This first phase of data analysis was closely followed by the second phase in which the association existing between the dependent variables (time and cost impacts of rework) and independent variables (causes of rework) was investigated. Data that had been collected during in-depth interviews comprising of various stakeholders involved in the construction projects were first transcribed and read a number of times before their themes were coded in relation to the observed patterns in the data and relevance to the objectives of the study.

3.7 Validity and reliability of the study

In all research studies, there exist concepts that must always be taken into great consideration, especially validity and reliability. Validity can be defined as the ability of a given instrument used in research to make an ideal measure of what actually need to be measured. Reliability refers to the extent a given study shows consistency and stability especially cases where the same techniques are applied using the same methods. The main function performed by reliability in a given research is minimizing error and bias that might be encountered during the process of undertaking the study. In this research, validity was achieved through the use of several activities. Firstly, the questionnaires were designed carefully by the researcher (the key tool used in data collection). Together with other tools for collecting data, the questionnaires were pre-tested so as to maximize their preciseness, relevancy and clarity in answering the research questions. Ambiguous questions were replaced with more meaningful ones as was found appropriate. In addition, research experts including the research supervisor, were consulted frequently at each study stage to offer criticism and suggest corrections to the tools used in collecting data. These actions all aimed to ensure that this research would accurately and faithfully represent what causes rework and the impacts of rework on time and cost of a given construction project.

3.8 Ethical considerations

The principal ethical requirements needed for any form of study were strictly upheld. Firstly, the researcher sought for permission from the university before beginning the process of doing a dissertation. The study began after the researcher had received an ethical clearance certificate from the university regarding the topic under study. Prior to the participation of individuals in the study, the study participants were duly informed about the fact that the study was undertaken purely for academic purposes and that it was hoped that they will be prepared to respond to all the questions contained in the questionnaire. They were then invited to take part in the study, but only after giving their informed consent. Additionally, participants were allowed to withdraw from the study at any given point in time. Their anonymity and confidentiality for all the information they gave was assured, thus complying with the required privacy policy needed in research. Given the fact that this study involved a review of secondary data, especially from academic journals, books, and articles, and the sources used were acknowledged through referencing and in-text citation so as to conform to the policy of plagiarism.

CHAPTER FOUR: DATA ANALYSIS

4.1 Introduction

The analysis of data gathered in the survey of a given construction project using the questionnaire is presented in this chapter. It discusses the pilot questionnaire, the response rates received on the questionnaire and the demographic profile of the respondents on the questionnaire. The section also presents the discussion and interpretation of the results that are related to the causes of rework, the impacts of rework, its direct and indirect costs and the strategy that can be developed to contain it.

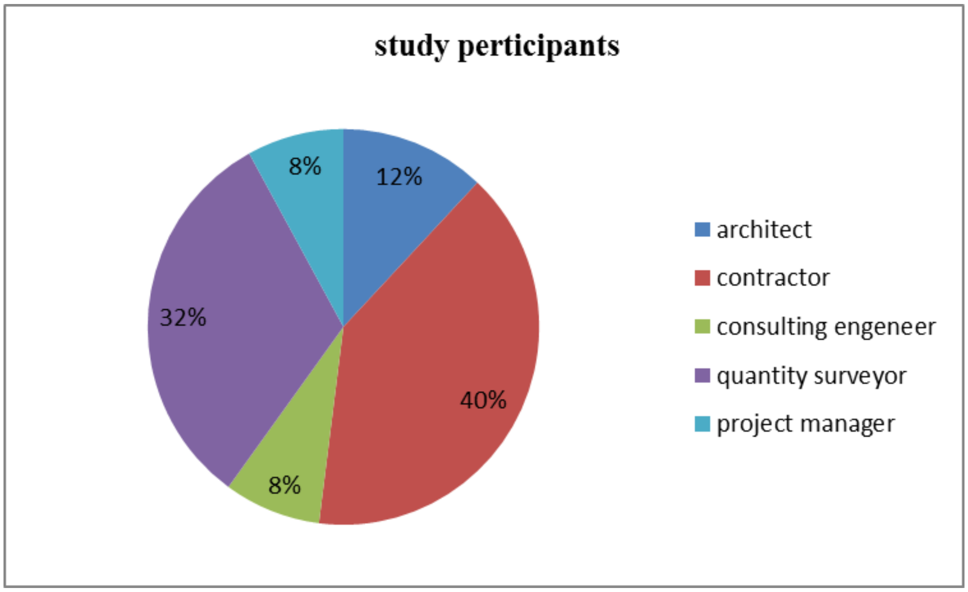
4.2 Response in the questionnaire

Data was collected through the use of a questionnaire surveys. A total of 55 questionnaires were distributed to the project construction officials. Respondents in this case included the consulting engineers, quantity surveyors, contractors, architects and project managers. A total of 55 questionnaires were sent via email to the respondents and out of this, only 50 were returned while completed representing a response rate of 90.91%. Most of these filed questionnaires were collected in person though a few of those who responded returned the questionnaire via email.

4.3 Demographic information of the respondents

This section presents the type of individuals who were involved within the construction project, their current position and work experience. Based on the figure presented below, study participants included project managers (8%), quantity surveyor (32%), consulting engineers (8%), contractor (40%) and architect (12%).

Figure 4: professions of the study participants



4.3.1 Respondents working experience

As illustrated in the table below, the working experience of the respondents within the construction industry ranged from one year to forty years with a median experience being 17 years. While the respondents have been within their current position for a period of ten months to 30 years, the median length of time through which they have worked was found to be 5 years.

Table 1: working experience of the study respondents

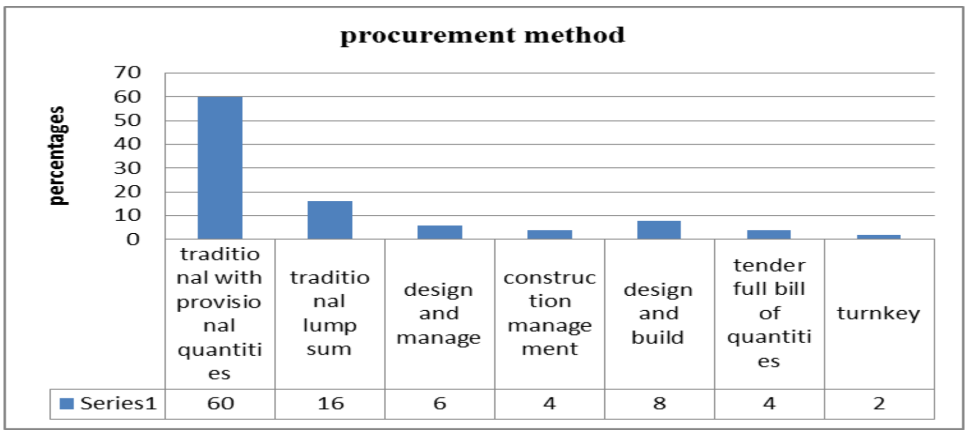
	N	Minimum	Medium	Maximum
Number of years in which one has been employed	50	1.0	17.0	40.0

within the construction industry				
Number of years taken in the present position	50	0.8	5	30

4.3.2 Procurement method

Asked about the procurement method they normally use in their construction project, majority (60%) indicated traditional with provisional quantities, 16% traditional lump sum, 6% design and management, 8% design and build, 4%construction management and tender full bill of quantities and turnkey (2%).

Figure 5: Procurement methods used in the construction project



4.4 Causes of rework

4.4.1 Client related factors

This section mainly explored the knowledge the respondents had about what caused rework within their construction project. In this section, respondents were required to indicate the extent at which some of the listed client-related factors may cause rework. From the findings, poor communication with the consultants (architect/engineers) was ranked first with a mean score of 3.59, second was inadequate experience and knowledge of the process of construction with a mean score of 3.36, followed by inadequate knowledge and experience of the process of design at 3.25, insufficient money and time spent on the briefing process at 3.24, inadequate time and funds allocated for site investigations at a mean score of 3.17 and ranked second last was poor involvement of the client in the project. The least ranking among the client related factors was low fee paid for documentation preparation.

Table 2: client related factors that causes rework

Client-related factors	N	SD %	D %	Mean	Std Dev	Rank
Poor communication with the consultants (engineers/architect)	50	6.4	12.8	3.59	1.19	1
Inadequate experience and knowledge of the process of construction	50	5.1	14.1	3.36	1.09	2
Inadequate knowledge and experience of the process of	50	6.4	16.7	3.25	1.07	3

design						
Insufficient money and time spent on the process of briefing	49	14.3	13.0	3.24	1.27	4
Inadequate funds that was allocated for site investigations	48	10.5	19.2	3.17	1.24	5
Poor involvement of the client in the project	50	14.1	21.1	3.04	1.26	6
Low fee paid for preparing documents for contract	50	16.7	15.4	2.97	1.22	7

All the respondents explicitly agreed that the above first three client related factors contributed greatly to occurrence of rework since they possessed a mean of between 3 and 4. Based on other factors which had not been mentioned among the available options, one of the respondents indicated that time monitoring and implications of cost is another client related factor that caused rework within their project of construction. Additionally, another client indicated that usage of different architects in various construction phases resulted to cases of rework being experienced.

4.4.2 Design-related factors

Questions were designed to help identify client-related factors that cause rework within the construction project. The results illustrated in the table below shows the perception of the respondents that are related to design related factors that caused rework. By making a rank of the means of the respondents, changes made due to the request by the client was ranked first with a mean score of 4.03 as the most frequent factor related to design that causes rework within the construction project. The second most frequent factor under this category was incomplete design during the time of tender at 3.96, with the third one being omission of items from the documentation of contract at 3.63 mean score. From the evidence shown above, respondents accepted the first three factors as the predominant sources of design related rework due to the fact that they had a mean of between 3 and 4. Two of the factors listed; changes initiated by the municipality and other regulatory bodies and poor planning of workloads recorded a mean of 3.05 and 3.06 respectively, indicating that the respondents were neutral with this two options. Moreover, the last two listed factors recorded a mean score that was less than 3, indicating that the respondents disagreed that such factors had great contribution to rework at the stage of design. This information is as illustrated in the table below.

Table 3: Design related factors that causes rework

Design related factors	N	1 %	2 %	3 %	4 %	5 %	Mean	Std Dev	Rank
Changes made at the client request	50	1.9	12.3	6.1	44.5	38.2	4.03	1.04	1
Incomplete design during the time of tender	50	7.7	7.7	11.5	26.8	46.2	3.96	1.26	2
Omission of items from documentation contract	50	1.3	14.1	24.4	41.0	197	3.63	1.00	3
Poor design coordination	50	7.7	11.9	17.6	37.7	25.6	3.62	1.21	4

Changes initiated by the contractor during construction	50	5.2	13.3	27.8	39.5	16.3	3.47	1.07	5
Errors made in the documentation of contract	49	3.8	15.3	28.1	39.6	12.8	3.42	1.03	6
Insufficient time for preparing contract documentation	50	7.7	15.2	21.9	39.1	15.2	3.40	1.16	7
Insufficient level of skill to complete the task required	50	6.5	18.1	27.4	33.5	15.4	3.32	1.14	8

4.4.3 Site management-related factors

The table below gives an illustration of site management factors that caused rework within the construction management project under study. Through ranking on the means, the findings shows that setting out of errors made a dominant contribution with a men score of 4.04. This was followed closely by lack of experience and training with a mean score of 3.93 and the third being poor coordination of resources. From the results, setting out of errors, lack of experience and training and poor coordination of resources were classified by the study participants as the major site management related causes since they had mean scores greater than 3.5

Table 4: Site management related factors that causes rework

Management of site	N	1 %	2 %	3 %	4 %	5 %	Mean	Std Dev	Rank
Setting out of errors	50	3.9	9.3	7.8	32.5	45.2	4.04	1.18	1
Lack of experience and training	50	1.3	14.2	6.6	44.8	32.9	3.93	1.05	2
Poor resource coordination	50	1.3	11.9	14.1	46.7	26.7	3.86	0.99	3
Usage of quality managem,ent practices in ineffective way	50	0.0	15.9	20.6	46.7	16.9	3.86	0.94	4
Poor resources planning	50	5.2	10.4	20.9	44.1	19.4	3.62	1.08	5
Failure to provide protection to the works which has been constructed	49	2.6	11.7	23.5	45.8	14.4	3.59	0.95	6
Lack of safety	50	16.8	16.9	21.9	39.1	9.2	3.04	1.25	7

Excess overtime	50	14.9	21.9	28.8	31.2	5.2	2.92	1.14	8

4.4.4 Factors related to subcontractor

The study also examined rework that was caused by subcontractor-related factors. After ranking all the means of the possible responses highlighted in the questionnaires for this section, specification non-compliance was rated first as the most predominant subcontractor related factor that results into rework with a mean of 4.19. This was followed by low skill of level which had a mean of 4.14 and thirdly being shortage of skilled labor with a mean score of 4.13. Given the fact that all means in this category were greater than 4, it is evidence that the respondents agreed that all the factors highlighted were greatly considered to be subcontractor-related sources that causes rework.

Table 5: Factors related to subcontractor

Subcontractor	N	1 %	2 %	3 %	4 %	5 %	Mean	Std Dev	Rank
Specification non-compliance	50	1.3	5.3	12.8	34.5	40.2	4.19	0.94	1
Low level of labor skill	50	2.26	2.26	6.4	53.8	34.6	4.15	0.85	2
Shortage of skilled labor	50	1.3	2.6	10.3	53.8	32.2	4.13	0.81	3
Few skilled supervisors	50	2.6	3.7	14.2	47.4	32.2	4.03	0.93	4

Defective workmanships	50	3.8	1.3	19.1	39.8	35.9	4.04	0.98	5
Inadequate supervisor	49	2.6	3.7	14.4	53.8	26.4	3.95	0.88	6
Damage due to carelessness	50	2.6	6.4	17.9	39.1	33.2	3.95	1.01	7
Instructions which are unclear to workers	50	2.6	12.9	15.3	35.9	33.4	3.85	1.11	8

4.5 Impact of rework

4.5.1 Impact of rework on project performance

Study participants were asked to state the extent in which rework affected the overall performance of the project based on a 5 point Likert scale in which case 1 represented not at all, 2 (to least extent), 3 (to some extent), 4 (to larger extent) and 5 (to very large extent). Based on the ranking of the means of the respondents under each category, it is evidence that that cost overrun dominated project performance related impact with a mean score of 3.21, followed closely by time overrun at 2.97 mean and the dissatisfaction of the design team at a mean of 2.45. The implications of these findings is that cost overrun and time overrun are the major project performance related impacts of rework while other impacts such as contractual claims, qualities degradations, contractor dissatisfaction, and disputes among the parties doing construction were least reported.

Table 6: Impact of rework on the performance of a construction project

Project performance	N	1 %	2 %	3 %	4 %	5 %	Mean	Std Dev	Rank
Cost overrun	50	3.9	15.3	46.1	24.5	10.2	3.21	0.96	1
Time overrun	50	15.3	14.2	41.1	17.8	11.6	2.97	1.19	2
Design team dissatisfaction	50	20.6	35.9	28.1	7.7	7.7	2.45	1.15	3
Contractual claims	50	32.1	21.9	29.6	12.7	3.9	2.36	1.16	4
Degradation of qualities	50	21.8	47.3	17.8	6.5	6.3	2.29	1.07	5
Dissatisfaction of the contractor	49	24.6	41.7	23.5	3.8	6.4	2.27	1.07	6
Contracted parties related disputes	50	30.9	33.2	21.9	9.1	5.2	2.25	1.13	7
Client/ end user dissatisfaction	50	40.9	21.9	26.8	6.3	6.4	2.11	1.13	8

Respondents were requested to indicate the extent to which rework had impact on the performance of the construction organization. The ranking of the means in relation to how rework impacted on the performance of the organization is illustrated in the table below. Of the greatest impact was reduced profit which was ranked first with a mean score of 2.97. This was followed by de-motivation of workers which had a mean score of 2.06 and third was inter-organizational conflict with a mean score of 1.96. This indicates feelings of neutrality and disagreement among the respondents on how rework impact on the performance of construction organizations since their means were around 2 and 3.

Table 7: Organizational impacts of rework

Organizational impacts	**N**	**1 %**	**2 %**	**3 %**	**4 %**	**5 %**	**Mean**	**Std.Dev**	**Rank**
Reduced profit	50	16.8	17.8	33.4	15.5	16.6	2.98	1.3	1
Workers demotivation	50	39.6	26.8	24.3	5.1	3.8	2.05	1.1	2
Conflict within the organization	50	41.0	27.1	28.1	2.5	1.3	1.97	0.96	3
Poor morale among workers	50	50.1	17.9	25.7	3.9	2.7	1.92	1.08	4
Fatigue	50	48.6	28.3	16.7	2.6	3.9	1.84	1.06	5
Workers absenteeism	50	53.7	24.3	17.8	2.5	1.4	1.74	0.94	6
Loss of work in the future	49	54.6	30.0	10.5	2.7	2.6	1.68	0.96	7

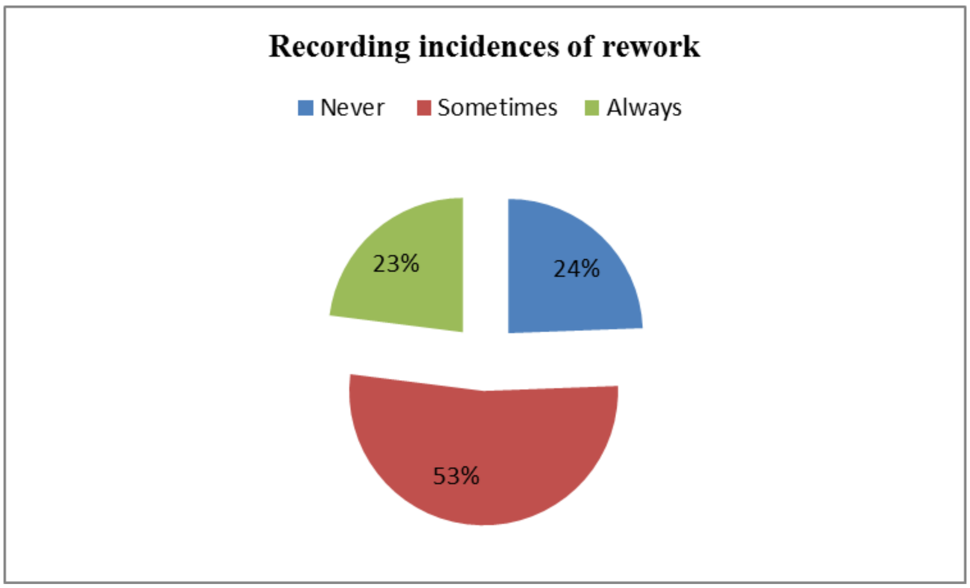
As illustrated by one of the respondents during the study, incidences of rework left workers less motivated. " Doing a given work for more than one times at times leave us less motivated since in most cases the salary always remain constant irrespective of the additional energy and time used in redoing a given work", noted one of the study participants.

4.6 Measuring of the cost of rework

4.6.1 Rework recording

Asked on how frequent they record incidences of rework, 52.6 percent of the respondents indicated "sometimes" , 24.4 percent "never did" and 23.1 percent which is less than a quarter of the respondents indicated "always". This information is illustrated in the figure below.

Figure 6: Recording of incidences of rework



4.6.2 Direct and indirect costs of rework

The respondents were asked to indicate whether or not their organization calculates cost related to rework. Their perceptions in this case were determined using a five point scale in which case included: 1(strongly agree), 2(disagree), 3(neither agree nor disagree), 4(agree), and 5(strongly agree). The findings from the table show that the efficiency of recording the occurrence of rework was ranked first with a mean score of 3.22. This was followed by the efficiency of calculating the direct cost of rework which was ranked second having a mean score of around 3.03. These results shows that the respondents were more neutral concerning the statement stated that the organization had an efficient system that recorded and calculated the direct cost that are related to rework. The adverse impact rework has on cost received the third rank showing that the respondents mostly disagreed with the statement that the adverse impact of the rework cost on the profitability of the organization has not been reported clearly.

Table 8: System for recording rework cost

Statement	N	1 %	2 %	3 %	4 %	5 %	Mean	Std Dev	Rank
System used for recording the occurrence of rework was efficient	50	11.5	11.3	34.1	28.5	14.2	3.21	1.18	1
System used for calculating the direct cost of rework was efficient	50	11.3	19.2	35.1	21.8	11.6	3.03	1.16	2
There has been no clear report on the adverse impact of rework on cost	50	9.6	20.9	51.1	15.7	3.7	2.85	0.93	3

System used for calculating the indirect cost of rework was efficient	50	15.1	17.8	48.7	13.9	3.6	2.73	1.02	4

One of the respondents indicated during the interview, "It is true rework always result into some additional indirect and direct cost. However, there has been no clear system to help calculate the direct and indirect cost of rework in this construction project". "We can always approximate the direct cost of rework in terms of additional funds and time utilized when undertaking rework but has never think of any indirect impacts associated with rework in this construction project.

4.6.3 Rework cost sources that are design-related

Study participants were asked to indicate the extent at which rework cost is attributed to sources that are design related using a five point scale where 1 represent not at all, 2(to the least extend), 3 (to some extend), 4(to larger extent), and 5(to a very large extent). From the findings, it was evidence that changes made as a result of the client's request presented the highest score with a mean of a round 3.27. This implies that the respondents agreed to some extents that the cost of design related reworks are associated with changes that were made as a result of the client's request. Modifications, revisions and improvement of the design that has been initiated by the subcontractor or contractor were ranked second by the respondents havening and average mean score of 2.71. Changes that were made from the contractor's request during the construction process came third in ranking with a mean score of 2.60. Since the means under this category were around 2 and 3, it is evidence that modifications, improvements and revisions of contractor initiated design or the subcontractor and the changes that have been made at the contractor's request during the process of construction results into rework which is design related to some extent.

Table 9: Rework cost sources that are design-related

Design related sources	N	1 %	2 %	3 %	4 %	5 %	Mean	Std Dev	Rank
Changes made at the client request	50	2.6	16.9	40.3	31.1	9.1	3.27	0.95	1
Modification, revision and improvement of the design that has been initiated by the contractor or subcontractor	50	6.5	29.9	51.9	9.1	2.6	2.71	0.82	2
Changes made at the contractor's request	50	14.2	23.3	50.5	10.3	1.3	2.6	0.92	3
Omission of items from the documentation of the contractor	50	18.1	40.3	28.6	9.7	3.9	2.36	1.02	4
Errors made in the documentation of the contract	50	21.8	37.3	29.8	9.5	2.3	2.29	1.00	5
Changes that are initiated by the municipality/end user	50	29.6	31.7	20.5	13.8	6.4	2.32	1.19	6

4.6.4 Sources of rework cost that are construction-related

The investigator asked the respondents to provide an indication in which costs of rework are attributable to sources that are construction related. Evidence from this study has shown that changes in the method of construction due to the condition of the site were ranked first with a mean of 2.88. This was followed by client or occupier initiated changes after undertaking some specific work. This result shows that the study participants agreed, to some extent that changes in the methods of construction as a result of the condition of the site, or changes that have been initiated by the client or the occupier after undertaking some work on site and damages that have resulted from the actions of the subcontractor were factors that were closely attributable to sources of rework cost which are construction related.

4.7 Sources of Cost

The study participants were asked to indicate the areas within the construction project in which the cost increased as a result of rework. The findings according to the illustration from the table shows that cost mostly increased as a result of preliminaries such as carnage and scaffolding. Other costs which increased as a result of rework were overtime costs, cost of supervision, cost incurred in the fees used for the design consultants, disruption cost and acceleration costs. The least ranked as shown in the table were disruption costs with a mean score of 1.96 and the acceleration costs that had a mean score of 1.03. Such results indicate that the respondents mostly disagreed that rework can cause the disruption and acceleration costs. The information is shown in the table.

Table 10: Cost sources

Cost sources	N	1 %	2 %	3 %	4 %	5 %	Mean	Std Dev	Rank
Preliminaries	50	24	13.3	26.7	20	16	2.9	1.4	1
Over cost	50	28	28	24	13.3	6.7	2.43	1.22	2
Supervision	50	32	28	20	12	8.0	2.36	1.27	3
Design consultants fees	49	32.4	29.7	27	6.8	4.1	2.2	1.10	4
Disruption Cost	50	54.7	17.3	12	9.3	6.7	1.96	1.29	5
Acceleration cost	50	52	29.3	8	9.3	1.3	1.79	1.03	6

4.8 Costs of rework

Study participants were asked to provide an estimation of the total percentage of the original contract sum of the project's direct and indirect costs of rework that was witnessed in the project that had been selected. An illustration of the mean and standard deviation of the indirect, direct and total costs for different sections of the construction project selected for this study is shown below. The direct rework cost as indicated by the study respondents were ranging from zero to twenty percent with a standard deviation of 3.87% and a mean score of 2.93%. Indirect rework cost on the other hand ranged from zero to 60 percent with a standard deviation of 7.51%

and mean score of 2.20%. It is very clear from this finding that the respondents indicated that the direct rework cost which stood at a mean of 2.93 was relatively higher than the indirect rework cost which was at a mean of 2.20 for the single project selected. Calculation of the total rework cost was done through the addition of indirect estimates and the direct estimates that were provided by the respondents during the interview sessions. The data from the calculations indicated that the total cost of rework ranged from zero to 75 percent, with a mean of 5.12 percent and standard deviation of 9.94 percent. Concurrently, rework total costs vary with a lot of consideration across the projects. The degree of variability in this case shows some similarities in the study which was undertaken by Love (2002) in which case some respondents reported that rework cost was less than 1 percent of the original total value of the project while others in the same study reported them to be as high as around 80%. In his final report, Love (2002) stated that such degree of variability within the responses of the participants was an evidence that majority of the individuals involved within the construction project are always unsure with the exact total extra cost that rework might add to the project.

Table 11: Costs of rework

Rework cost	**N**	**Minimum**	**Mean**	**Maximum**	**Std Deviation**
Direct rework cost as a sum of percentage of the estimated original cost	50	0	2.93	20	3.87
Indirect rework cost as a sum of percentage of the estimated original cost	50	0	2.20	61	7.5

Total rework costs	50	0	5.12	76	9.95

4.9 Procurement method versus rework costs

Direct and indirect cost of rework for each procurement method is illustrated in the table below. The direct cost of rework suggested mainly by the respondents was on the traditional lump sum method which ranged from zero to fifteen percent with a standard deviation of 4.13 percent and mean of 1.88%. On the opposite side, the indirect cost associated with lump sum method was found to be ranging from o percent to 60 percent with a standard deviation of 16.58 percent and mean score of 4.85 percent. For the part of traditional with the provisional quantities, the direct costs were found to be ranging from Zero to twenty percent having a mean of 1.28 percent and standard deviation of 3.18 percent. With regards to the management and design method, direct rework costs was found to be ranging from 0 percent to ten percent with a standard deviation of 4.20 percent and a mean of 4.08 percent. Subsequently, methods of procurement were classified on non-traditional and traditional. The total costs of rework for both the non-traditional and traditional methods are illustrated in the figure below, giving an evidence that the traditional methods with a mean score of 4.84 percent were more common to higher costs of rework when compared to the non-traditional methods which had a mean of 4.14 percent.

4.10 Strategies for containing/preventing rework

4.10.1 Design management strategy

Under this section, the knowledge of the participants regarding the strategy of design management which could be implemented to reduce the incidence of occurrence of rework within a given construction project was assessed. A five Likert scale question were framed where 1 was for ineffective, 2(least effective), 3(quite effective), 4(effective) and 5(highly effective). From the findings, the most frequently and highly ranked among the design management strategies that can be used to reduce the incidences of rework within a construction project is team building which had a mean score of 3.48. This was closely followed by involvement of subcontractor and the suppliers during the time of design. This had a mean value of around 3.30 and the design for construction like the standardized components that had a mean of 3.26. With the view that the means of the strategies that are highly ranked were between 3 and 4, it is evidence that strategies of design management that were implemented within this construction project were quite effective.

Table 12: Design management strategy for preventing the occurrence of rework

Design Management	N	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean (%)	Std Dev	Rank
Team building	60	1.7	3.3	50.0	35.0	10.0	3.48	0.79	1
Involvement of subcontractor/suppliers during design	54	5.6	11.1	40.7	33.3	9.3	3.30	0.98	2
Design for construction (eg standardised components)	53	1.9	24.5	35.8	20.8	17.0	3.26	1.08	3
Value management	67	1.5	20.9	41.8	26.9	9.0	3.21	0.93	4
Constructability analysis	50	8.0	16.0	50.0	22.0	4.0	2.98	0.94	5
Computer visualisation techniques	51	13.7	27.5	29.4	11.8	17.6	2.92	1.29	6
Design scope freezing	36	19.4	33.3	19.4	16.7	11.1	2.67	1.29	7

4.10.2 Site management strategy

Study participants were asked to indicate the most effective strategies of managing construction site so as to prevent the occurrence of rework. The illustration from the table below shows that involvement of some other subcontractors during the construction process is very important as far as prevention of rework occurrence is concerned. Ranked second was the need for quality control which had a mean of 3.41. This was closely followed by quality management system of the site (3.39), quality audits (3.06), and lastly value engineering (2.98). This information is illustrated in the table below.

Table 13: Site management strategy for preventing the occurrence of rework

Site management	N	1 %	2 %	3 %	4 %	5 %	Mean	Std Dev	Rank
Subcontractors involvement during construction	50	0.0	1.4	39.6	41.5	14.2	3.74	0.75	1
Quality control	50	0.1	2.8	57.6	31.8	6.6	3.42	0.67	2
System for site quality management	50	1.6	3.1	61.3	23.3	10.7	3.39	0.78	3
Quality audits	50	3.2	17.8	48.7	23.9	1.7	3.06	0.79	4
Value engineering		1.5	26.7	47.4	21.2	3.4	2.98	0.83	5

4.11 Regression

4.11.1 Client-related factors

Table 14: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.667[a]	.444	.441	.367

a. Predictors: (Constant), Client-related factors

b. Dependent Variable: Cost of rework

Table 14 illustrates the results of regression analysis. Findings indicate that, there is a weak contribution of client related factors towards cost of rework. This is per the coefficient of determination (R Square) which is 44.1%. This implies that, 44.1% of cost of rework is explained by client-related factors.

Table 15: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.600	1	17.600	130.400	.000[a]
	Residual	22.000	163	.135		
	Total	39.600	164			

a. Predictors: (Constant), Client related factors

Table 15: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.600	1	17.600	130.400	.000[a]
	Residual	22.000	163	.135		
	Total	39.600	164			

b. Dependent Variable: Cost of rework

Table 15 illustrates results on test of significance of the regression model. The probability value in this model indicates that the model has explanatory ability. This conclusion is per the P Value being less than 0.05 ($P<0.05$). These findings are an indication that client-related factors have a significant explanatory power concerning cost of rework.

Table 16: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
	(Constant)	2.667	.098		27.297	.000
	Client Related factors	-.667	.058	-.667	-11.419	.000

a. Dependent Variable: Cost of rework

Table 16 illustrates the regression coefficients. From the table, the independent variable which was client related factors is significant as per the P Value (0.000) being less than 0.05, ($P<0.05$). The model further illustrates that there is a direct positive relationship between client's related factors and cost of rework as shown by the constant value (2.667). When client related factors change by a unit, there is a chance that cost or rework would drop by 0.667 which.

4.11.2 Design-related

Table 17: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.806	.650	.648	.545

a. Predictors: (Constant), Design-related

b. Dependent Variable: Cost of rework

Table 17 illustrates the results of regression analysis. Findings indicate that, there is a strong contribution of design related factors towards cost of rework. This is per the coefficient of determination (R Square) which is 64.8%. This implies that, 64.8% of cost of rework is explained by design related factors.

Table 18: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	90.618	1	90.618	304.665	.000[a]
Residual	48.779	164	.297		

Total	139.398	165

a. Predictors: (Constant), Design-related

b. Dependent Variable: Cost of rework

Table 18 illustrates results on test of significance of the regression model. The probability value in this model indicates that the model has explanatory ability. This conclusion is per the P Value being less than 0.05 (P<0.05). These results imply that, the regression results are significant.

Table 19: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.479	.145		-3.308	.001
	Design-related	1.510	.086	.806	17.455	.000

a. Dependent Variable: Cost of rework

Table 19 illustrates the regression coefficients. From the table, the independent variable which was provision of sanitary towels is significant as per the P Value (0.000) being less than 0.05, (P<0.05). The model further illustrates that there is an inverse relationship between design related factors and cost of rework as shown by the constant value (-0.479). When design related factors change by a unit, there is a chance that cost of rework will reduce by (1.510) dollars.

4.11.3 Site-related factors

Table 20: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.799	.639	.637	.522

a. Predictors: (Constant), Site-related factors

b. Dependent Variable: Cost of rework

Table 20 illustrates the results of regression analysis. Findings indicate that, there is a strong positive contribution of site related factors towards cost of rework. This is per the coefficient of determination (R Square) which is 63.7%. This implies that, 63.7% of cost of rework is explained by site related factors.

Table 21: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	78.977	1	78.977	289.969	.000
	Residual	44.668	164	.272		
	Total	123.645	165			

a. Predictors: (Constant), Site-related factors

Table 21: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	78.977	1	78.977	289.969	.000
	Residual	44.668	164	.272		
	Total	123.645	165			

b. Dependent Variable: Cost of rework

Table 21 illustrates results on test of significance of the regression model. The probability value in this model indicates that the model has explanatory ability. This conclusion is per the P Value being less than 0.05 (P<0.05). These results imply that, the regression results are significant.

Table 22: Coefficients

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.349	.139		-2.515	.013
		1.409	.083	.799	17.028	.000

a. Dependent Variable: Cost of rework

Table 22 illustrates the regression coefficients. From the table, the independent variable which was Site-related factors is significant as per the P Value (0.000) being less than 0.05, (P<0.05).

The model further illustrates that there is an inverse relationship between Site-related factors and cost of rework as shown by the constant value (-0.349). When site related factors change by a unit, there is a chance that cost of rework will also increase by (1.409) dollars.

4.11.4 Subcontractor-related factors

Table 23: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.984[a]	.969	.968	.09809

a. Predictors: (Constant), Subcontractor-related factors

b. Dependent Variable: Cost of rework

Table 23 illustrates that, 96 percent of variations in cost of rework are explained by; subcontractor related factors. This conclusion is per the adjusted R Square and the coefficient of determination, R Square which are 0.968 and 0.969 respectively.

Table 24: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	31.746	3	10.582	1.1003	.000[a]
	Residual	1.029	107	.010		
	Total	32.775	110			

a. Predictors: (Constant), Subcontractor-related factors

Table 24: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	31.746	3	10.582	1.1003	.000[a]
	Residual	1.029	107	.010		
	Total	32.775	110			

b. Dependent Variable: Cost of rework

Table 24 shows the results of Analysis of Variance (ANOVA). The researcher was interested in the F statistics. The p value for the F statistic was 0.000.

Table 25: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.014	.017		.829	.409
	Subcontractor-related factors	.875	.039	.720	22.229	.000

These results indicate that there is a direct positive relationship between the dependent and independent variable. This means that, when there is unfavorable change in Subcontractor-related factors, cost of rework also increases by 28.2 percent.

4.12 Cronbach’s alpha test

Cronbach's Alpha	N of Items
.814	4

4.13 BIVARIATE PEARSON CORRELATION

Correlations table

Variables		**Rework**	Client-related	Design-related	Site-related	Subcontractor-related factors
Rework	Pearson Correlation	1	.889**	.816**	.822**	.688**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	225	225	225	225	225
Client-related	Pearson Correlation	.889**	1	.959**	.942**	.845**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	225	225	225	225	225
Design-related	Pearson Correlation	.816**	.959**	1	.964**	.887**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	225	225	225	225	225
Site-related	Pearson Correlation	.822**	.942**	.964**	1	.935**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	225	225	225	225	225
Subcontractor-related factors	Pearson Correlation	.688**	.845**	.887**	.935**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	225	225	225	225	225

**. Correlation is significant at the 0.01 level (2-tailed).

Results from the correlations analysis revealed a strong positive correlation between the independent variables and the dependent variable. The correlation coefficients between client related, design related, site related, subcontractor factors and rework sources were; 0.889, 0.816, 0.822 and 0.688 respectively. These results indicate a strong positive correlation between the dependent and independent variables. It can therefore be deduced that the independent variables were actually explaining the **dependent** variable.

CHAPTER FIVE: DISCUSSION OF FINDINGS

5.1 Introduction

In this section, the study findings are discussed particularly with respect to the causes, impacts, costs implications and the containment and reduction strategies of rework.

5.2 Causes of rework

From the literature and the study findings, the root causes of rework can be classified into different groups like design-related, client-related and contractor related factors with inclusion of the subcontractor factors and site management. It is therefore empirical to note that the causes of rework within the construction project under study was examined based on the above three broad categories. From these study findings, it has been revealed that poor communication that exists between clients and the design consultants was the main factor that resulted into rework which was client related. This might show an implication that not much interaction between the design team consultants and the clients were in cooperated so as to ensure that the ideas of the clients are properly communicated. As a result of this, rework originates right from the initiation stage, and proceeds through the incubation system until the implementation stage where it manifests itself. Additionally, with the case of design related factors, the most common factor identified by the respondents was changes made due to the request posted by the clients. This may mean that majority of the clients have no experience with regards to the process of design and due to this, their ideas might not be feasible during the process of design. This claim is also supported by Hwang, Thomas; Haas & Caldas (2009) who argued that lack of knowledge and experience of construction and design processes among the client contribute greatly to issues of rework. In relation to the management of site related factors, the respondents indicated setting out errors as the main factor that contributed to rework. This construction project case study established that errors setting out were closely attributable to the supply chain which was sequential in nature and this resulted into poor integration and coordination among the team members of the site management. This was intensified by misinterpretation of the drawings of working due to the inability and inexperience to effectively communicate with the subcontractors. The study has reported that the poor or low skilled labor which was employed by the subcontractors caused rework. In an implicit way, support system of human resource like training, education, motivation and improved level of skill provided by the organizations of the employees so as to enable them perform their jobs in a more effective way was reported to be lacking. Besides that, shortage of skills has been reported as one of the crucial problems that construction industry is facing throughout the world. This is supported by other literatures that indicate that the current construction industries are under pressure due to a combined number of factors such as shortage of skills.

5.3 Impact of rework on organization and project performance

It has been confirmed from literature review and the finding above that rework always results into adverse impact on the overall performance of the construction project. The researcher found it very vital to investigate the impact rework had on the organization and the performance of the project in the construction projects. In this study, the respondents tended neither to disagree nor agree that time overrun, cost overrun and the dissatisfaction of the research team impacted on the performance of the construction project. In his study conducted in Australia to determine the indirect consequences that are related to rework, Love (2002) identified reduction of profit, inter-organizational conflict, a diminished image of the professionals, and workers demotivation as some of the effects of rework. The findings of this study however discloses some feelings of neutrality and disagreement on the respondents part that workers de-motivation, reduced profit and the inter-conflict within the organization had great impact on the construction project performance as a result of rework. Linear regression was utilized in determining the extent to which a relationship exist between the overall performance of the project and the organizational performance and what causes rework. From the analysis, it was revealed that there is no significant correlation ($p>0.05$) that existed between rework causes (site management-related, design-related, client-related, and subcontractor-related as rework sources) and the impact rework has on the performance of a given construction company.

Moreover, the linear regression disclosed that no significant correlation ($p>0.05$) existed between the rework impact on the performance of the project and the site management, subcontractor related and design related. A significant correlation was however witnessed between the rework sources which are client related and the rework impact on the performance of the construction project.

5.4 Rework costs

The above findings revealed that only a few individuals recorded rework incidences as the respondents tended to be neutral in most case with regard to the efficiency and necessity of recording the occurrence of rework. The study also revealed that the respondents somehow remained neutral with regard to direct cost measuring of rework. Moreover, it has been recognized that the respondents made an expression of their disagreements in relation to the efficiency involved in the calculation of the indirect cost of rework. This shows that most respondents never appreciated the economic benefits of measuring the costs of rework, mainly the indirect cost. This findings are supported by Love (2002) who reported that little is known about the indirect consequences of rework within a given construction project, especially with regards to the financial consequences. Besides that, limited research had sought to determine indirect costs that are associated with rework. The estimate percent of the original contract of the project sum provided by the study participants indicated that the direct cost of rework were more than the indirect cost of rework for the case of the construction project that was selected. The respondents gave an estimate that the direct cost associated with rework had a mean of 2.93 percent, slightly higher than the indirect cost of rework which stood at a mean of 2.2 percent. Based on the findings, the mean total cost of rework as a percentage of the original cost of the contract for the construction project was found to be 5.12 percent. Additionally, the total rework costs were found to be having considerable variation among the projects. While some respondents in the case study reported cost of rework to be 0 percent of the original cost of the value of the contract, other respondents reported this rework cost to be as high as 75 percent.

It is evidence from the above literatures that renovation/refurbishment construction projects witnessed higher cost of rework when compared to the projects which are new build. The new values for renovation/refurbishment projects were recorded to be 6.28 percent and 4.89 percent respectively. Such findings also corresponds to other previous research done by Love (2002) which gave a suggestion that renovation/refurbishment projects are highly considered as prone to higher costs of rework than projects which are new build due to the degree of the complexity and uncertainty that is normally associated with the work of building to be undertaken.

5.5 Rework containment strategy

Love, Edwards, Smith and Walker (2009) stated that rework incidences within a construction project is a system which is orientated. Until elimination of rework, conscientious attention has to be given on its prevention. Organizations should also create the required energies to improve the processes that results into rework. Literature has suggested that rework metrics need to be established so that benchmarking process can easily be initiated. Rework can then be reduced significantly and the overall performance and the project output improved. Other scholars have also argued that contract management essence can never be waved away if the occurrence of rework needs to be reduced to a level which is considerable. This is mainly because good management of contract will increase the efficiencies, enhance the mechanism for cost control, minimize waste and improve the overall management of the sites for construction. The findings have also revealed that the respondents have made suggestions that in order to prevent the occurrence of rework within the construction project, the design management strategies like team building, and supplies/subcontractors involvement during the design, and the design used for construction like components which are standardized need to be implemented. With the case of strategy of site management, the study participants suggested the need for the involvement of subcontractors during the process of construction. It is indeed true that subcontractors involvement during the construction and planning stage of any given construction project will increase the effectiveness of communication that exist between the main contractors and their subcontractors. Additionally, the subcontractors' involvement can ensure proper coordination of the activities of the site and hence can eventually minimize rework occurrence on site. These findings are also supported by other literatures that have suggested that construction projects which has quality control which is good experiences less cases of rework. The participants have also indicated that site quality management system implementation can be a better way of minimizing rework incidences. The findings also concurs with other previous studies which had made a suggestion on the need of having quality supervision as one of the best way system for site quality management in order to reduce the occurrence of rework during the process of construction.

Scholars have emphasized that most rework causes are generated during the process of construction. There is therefore a great need for the supervisors to be somehow more proactive in the discovery of such causes. Love, Edwards and Smith (2005) also stated that occurrence of rework can easily be prevented through implementation of the tools for quality management in an effective way like deployment of quality function, control of the statistical process, analysis of failure mode effects among others.

Further literature has suggested the need for having anticipation that can enable putting in place strategies that can help in minimizing the rework impact on the schedule and cost of rework. In order to reduce the occurrence of rework, it is important to predict its possible occurrence before the activities of the construction start taking place on the site. In order to manage and control incidences of rework within a construction project, it is empirical to determine first, its probability of occurrence in the first place.

5.5.1 Proposed rework containment and reduction strategy

The figure below shows an illustration of the proposed rework reduction and containment model in form of a flow diagram. A comprehensive discussion of the flow diagram is as follows:

Rework Prediction (RP): prediction of rework can assist in the discovery of what could actually cause reworking during the process of design and construction phase (identification of rework), the probability that a major incidence of rework will emerge, the possible consequences (assessment of risk) and the available options that can be used in mitigation and prevention of the occurrence of major rework (measures of control). Prediction of rework will also help in the improvement of the productivity and operations and hence reduce rework occurrence.

Adoption of rework control measures: This one includes measures which are proactive control, rejecting measures which are inappropriate and selecting measures which are considered suitable (Love & Heng, 2000)**.** Rejection or selection of measures need to be based on the following: justifying the control measures adequacy, identifying failures which are potentially common mode, and defining the performance indicators to be used for the measures of control.

Performance indicators: In this case, performance indicators relates to the target or standard level of expected performance like quality management system implementation and mechanisms of learning so as to minimize both construction and design related rework (Love & Heng, 2000)**.** The performance indicators and the standards corresponding can play a great role in the 'satisfactoriness' justifications.

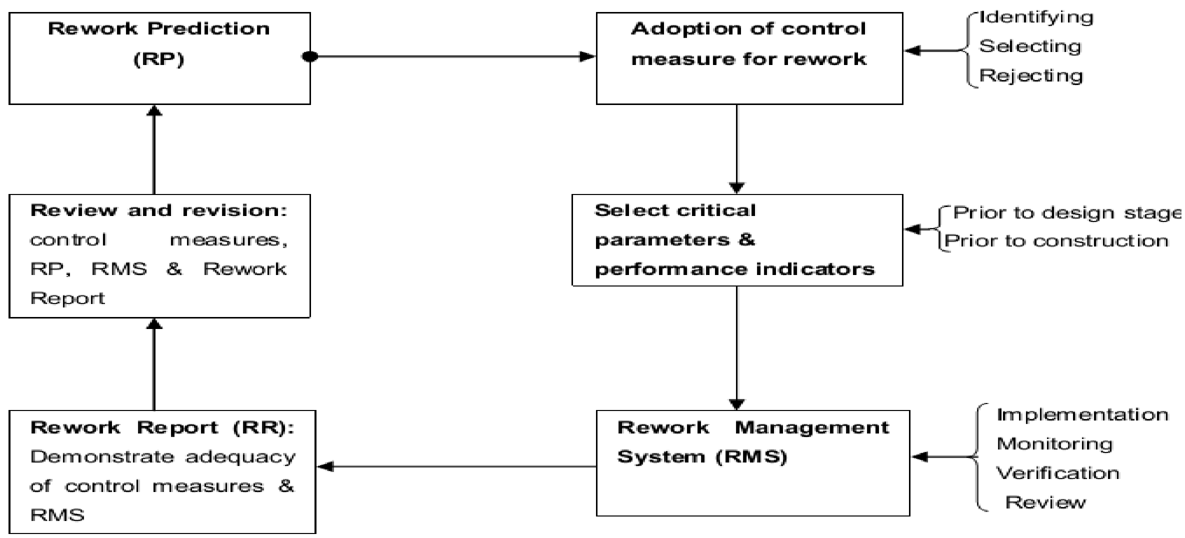
Rework Management System (RMS): This give a demonstration of systematic approach that can be used in ensuring rework management system effective implementation (Love & Heng, 2000)**.** Such systems have to be monitored, reviewed and verified so as to ensure that there is a successful implementation.

Rework Report (RR): rework control measures need to be systematically managed within the system of rework management and need to be presented within the report on rework.

Additionally, the report need to include statements on the effectiveness and viability of the control measures range to be considered, results and methods of the risk assessment corresponding, and the reason behind the rejection and selection of the control measures involved (Love & Heng, 2000)**.** There is also great need of including the performance indicators and critical parameters for the control measures adopted and control measures adequacy justification.

Review and Revision: This can always be used as a learned lesson for management of knowledge and for benchmarking for projects of the future. There is need for the control measures to remain valid during the whole duration of the life cycle of the project (Love & Heng, 2000)**.** It is unlikely however that the control measures will remain to be valid due to changes made during the construction project design stage and new knowledge about control measures and rework options. Control measures review need to be triggered whenever there is a situation which arises that would show that the control measures are no longer effective or valid.

Figure 7: Rework reduction and containment flow diagram



From the beginning, this study background has revealed that construction industry is highly characterized by poor practices of organizational management during the stages of design and construction (Love & Heng, 2000). An improvement in the management practices of the organization and strategies for project management, together with quality total commitment of services being rendered would automatically result to rework occurrence reduction.

5.6 Discussion of findings in the context of the literature review

The findings of this case study analysis has shown that the main rework causes within a construction project are poor communication, errors changes and omissions during the construction and design phase, and lack of adequate construction skills. This was also found to be evidence even in the review of literatures. The findings also shows that rework, to some given extent causes and cost might be influenced by the complexity and nature of the project and the methods used for procurement in the process of project acquisition. The instrument of research revealed that cost experience while undertaking rework in refurbishment/renovation projects was quite high when compared to the cost incurred while undertaking rework in new buildings. In the same way, rework cost incurred for procurement methods which are non-traditional, showed some variations with the ones from traditional methods. This was found apparent within the literature review as well. This study has found out that occurrence of rework within a construction project might result into a detrimental effect on the schedule and cost overrun of the project, which subsequently lead to the reduction of profit that should be obtained from the project. It might as well lead to tarnished reputation and contractual claims as illustrated in the literature review.

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In this chapter, the study conclusion, limitations encountered during the study process and possible recommendations based on the study findings have been is discussed.

Aims and objectives of the research

The broad aim/objective of this study was to determine the causes and impacts of rework on an existing construction project and to propose solutions on how to reduce/eliminate rework in this project. From this broad objective, numerous specific objects were derived.

Specific objectives

1. To study the impacts of direct and indirect cost of rework on the construction project
2. To compare between planned and actual cost and schedule of the construction project
3. To identify the causes of rework and come up with a rework reduction model

6.2 Conclusions

6.2.1 Causes of rework on the construction project

In this case study, it has been evidently found that request made by the design team and client significantly contributed to instances of rework. Love (2002) illustrated that variation that exist during the process of design are in most cases captured when it is already too late due to the sequential supply chain communication structure and lack of integration and coordination that existed between different members of the design team. This was quite apparent within the case study where improper coordination among the consultants of design led to changes which are more design related and affected all the design firms that were involved in the construction project under study. Subsequently this resulted into changes on site, which left many of the subcontractors affected. Moreover, setting errors out due to some sort of poor communication and lack of proper coordination between the subcontractors and the main contractors together with lack of proper skills on the side of the artisans were identified as major causes of rework on the construction project under study. Besides, inexperience witnessed on the part of the hand leading and foremen for trade and their limited ability to accurately interpret some of the structural drawings resulted to rework during the process of construction. Research instrument analysis similarly found out that the most rework predominant sources included specifications non-compliance, setting out of errors, changes made from the request by the client, poor communication that existed among the consultants of design, and limited or low skill labors.

6.3 Impact of rework

The analysis of the case study revealed that rework can lead to inter-conflict within the organization that result into supervision dilution and resulted into workers de-motivation. The study has also revealed that rework incidences increased the cost of project. This was as a result of the required additional materials to be used for the rework, subsequent handling of wastage, cost incurred for recovering the occurrence of rework and the additional labor required for rectifying erroneous activities. Moreover, additional time required for rework and other related extensions of manpower supervising rework were also identified, eventually resulting into the dissatisfaction of the customers and reduced profits that the contractors were supposed to carry home.

It has been revealed from the analysis received from respondents' questionnaire were in most cases tended neither to disagree nor agree that time overrun, cost overrun and the dissatisfaction of the design team due to rework had a negative impact on the performance of the project. On the same note, study participants expressed some sentiments of neutrality and disagreement that less motivation of workers, reduced profit and conflict within the organization could have some negative impact on the performance of the construction project.

6.4 Recording reworks occurrences and the measurement of its costs

It has been revealed from the findings in the questionnaire and during the site observation and interview that majority of the individuals who are involved in the process of construction do not poses systems that can track and record reworking incidences and its impact on cost especially with regards to direct costs, as they at time become problematic to calculate accurately. This was also found to be common in this case study where the study participants acknowledged that they had experience lots of rework within their construction site even though they had no mechanisms in place to record incidences of rework and also capture their corresponding costs. Implication of this could be that rework causes might have not been examined fully with regards to their frequency and the cost impact.

The most finding considered to be conclusive maybe however is the fact that the economic benefits of recording rework incidences and quantifying its related costs might have been overlooked. The total rework cost for different parts of the construction project studied was added and total mean cost established to be 5.12 percent of the original construction project value. It can therefore be concluded that instances of rework may make a contribution which is of significance to the overrun cost of the project. Additionally, cost of rework was found not to be having great variation with the methods of procurement used. Therefore, systems implementation for rework cost measurement might possibly reduce or eliminate rework cost and in a subsequent manner improve the overall cost performance within a given construction project.

6.5 Rework containment strategies

This study has revealed several approaches for innovation and strategies of management that can effectively be used in tackling inefficiencies which are rework related. In addition to this, the study has developed a model that can be used in predicting the occurrence of rework so that effective corrective actions can be initiated before the beginning of the construction stage. A proposed flow diagram has also been developed to be used as a measure of control in reducing the occurrences of rework. From the diagram, it can be evidently seen that if the participants of the project are to reduce the impact and improve the project overall cost and performance of the project due to rework, there must be a process put in place for reduction of rework within the construction projects. This shows that the more awareness is created by the industry on what constitute rework and the root causes, together with tracking mechanism which is structural and systematic approach, the more strategies which are effective can be initiated so as to eliminate the existing problematic waste. The incidences of occurrence of rework together with the impact it has on the productivity and the performance of the construction project as has been mentioned in a number of literatures should not be viewed as something which is inevitable. It is possible to make a conclusion that rework can substantially be reduced through the development of awareness which is adequate as well as systems which are structured for its management.

6.6 Limitations

Review of literature showed that limited study in relation to causes and impact of rework has been carried out within the construction industry. The previous studies have focused majorly on the defects of reworks and issues of quality management within the industry. This study has been limited to only one construction project which has been utilized as a case study. One of the greatest challenges that were faced during the entire process of this study was getting enough respondents who could participate in the study. For instance, during this case study, most individuals involved in the construction process were not readily willing to provide information regarding rework costs within their areas of works. Getting the respondents who would complete the questionnaire was also not easy since some showed no interest at all in participating in the study. Also, another group of individuals were not interested since they lacked experience regarding what actually constitute the term rework and what does not constitute rework. Though most people completed the questionnaires and returned them in good time, others proved disturbing and ended up not submitting the questionnaire forms. For the purpose of this study, rework definition was strictly limited to changes that affected the activities of construction, errors in design, errors in construct ability, missing or additional scope due to the errors of contractor or design and onsite fabrication errors that had effect on the activities of construction. The questionnaire used in the survey was structured in a manner that it would easily address this kind of specific occurrences.

6.7 Recommendations

Lack of proper differentiation of terms like defects, quality failure and error with rework has resulted into incomplete and inaccurate rework measurement and possibly strategies which are inappropriate for reducing rework occurrences. Issues of rework have currently become the norm and with regard to that, it has become acceptable and inevitable within the construction industry. For example, literature has reported that "making mistakes which are occasional" is viewed as acceptable by others. On the same manner, Love (2002) view rework as something frequent within the process of construction, a view which is never conducive to the understanding and problem eradication. Reduction and strategies for rework containment might only be developed in the case where there exist a clear distinction between what actually constitutes rework and what does not constitute it. In addition to this, there is need for the industry to change it mindset belief that rework is something inevitable in the construction process. This proposed interventions which is combined based on what has been discussed in the literature review and the data findings.

Creation of awareness on the impact that rework might have on the performance of the project under construction cab probably be the most effective intervention and the beginning point of identifying the knowledge which is in-depth on what actually causes rework. Understanding of what actually causes rework should be the first thing that the contractors and consulting firms need to understand so as to eliminate or reduce the possible causes of rework and its associated impact within the performance of construction project. The study has also revealed that the economic benefits associated with rework total costs, both indirect and direct, have been greatly overlooked. Moreover, it has been established that rework has a possible contribution to the cost overrun of the project. To reduce the direct and indirect costs associated with rework and to improve the overall performance of the project, this study recommends that all the organizations involved in construction begin to have some consideration, and measure them so as to capture the understanding of their magnitude. There is also need for more efforts to be made in improving knowledge and skills; otherwise delays, disruption and the loss of reputation to the construction and other losses such as one on profit will soon become products of rework that originate on-site.

From these findings, the following need to be implemented during the stage of design in order to reduce or prevent occurrence of rework: involvement of suppliers, subcontractors and construction designers as well as team building. In relation to the strategy of site management, there is great need for involving the subcontractors in the process of construction, control of quality, and or with quality system of site management. There is therefore great need for more studies to establish how both contractors and the design firms can be assisted in implementing these strategies.

6.8 Areas recommended for further research

It has been evidence from the literature that economic benefits associated with measuring of rework cost, more specifically indirect cost has been overlooked. Moreover, limited research has been undertaken to determine some of the indirect costs associated with rework. More investigation on impact and cost of rework, specifically the indirect costs, is highly needed to reveal the cost hidden while undertaking rework. While a number of studies have successfully suggested rework containment and reduction strategies, incidences of rework still persists within the construction industry. There is therefore need for further research on the possible alternative solutions that can be used in mitigating the occurrence of rework within the construction projects. Such future research need to in cooperate a large sample of construction projects from different geographical areas so as to maximize on the validity and reliability of the study result since this research only involved one case study.

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Appendix: Participant's questionnaire

Section 1: Demographic information of the study participant

1. Which of the following can best describe your profession?
   (a) Architect (b) consulting Engineer (c) project manager (d) contractor (e) quantity surveyor
2. For how long have you been working in the construction industry

……………………………………………………………

3. What is your current position within your organization

……………………………………………………………………………….

4. For how long have you been in your current position

………………………………………………………………………………..

Characteristics of the project

5. How much was the original tender sum of the project ……………………………..
6. How much was the final contract sum……………………………………………………
7. What was the original construction period of the project…………………………..
8. What was the actual construction period of the project………………………
9. what was the type of procurement method used for the construction project
   a) traditional lump sum
   b) Novation
   c) Traditional that have provisional quantities
   d) Contracting of management
   e) Design and build

f) Design and manage

Section 2: Causes of rework

10. The following are some of the examples of client related factors that might cause rework within a construction project. Indicate the extend at which you agree with the following statements regarding your construction project

Client-related factors	**Strongly agree**		**Neither agree nor disagree**		**Strongly disagree**
Inadequate experience and knowledge on the process of design	1	2	3	4	5
Inadequate experience and knowledge on process of construction	1	2	3	4	5
Lack of funds that is allocated for investigation of site	1	2	3	4	5
Lack of involvement of the client on the project	1	2	3	4	5
Inadequate money and time spent on the briefing process	1	2	3	4	5
Poor communication with the design consultants	1	2	3	4	5
Low fees paid for contract documentation preparation	1	2	3	4	5

11. The following are examples of design related factors that are likely to cause rework. Indicate the extend at which you agree with the following statements regarding your construction project

Design -related factors	**Strongly agree**		**Neither agree nor disagree**		**Strongly disagree**
Changes made at the client request	1	2	3	4	5
Changes made during construction by the contractor	1	2	3	4	5
Changes that were initiated by the regulatory bodies/municipality	1	2	3	4	5
Errors made within the contract documentation	1	2	3	4	5
Omission of items that were in the contract documentation	1	2	3	4	5
Improper usage of quality management practices	1	2	3	4	5
Improper usage of information technologies	1	2	3	4	5

12. The following are examples factors that are site-related that might cause rework. Indicate the extend at which you agree with the following statements regarding your construction project

Management of site	**Strongly agree**		**Neither agree nor disagree**		**Strongly disagree**
Usage of effective management practices in ineffective way	1	2	3	4	5
Inadequate training and experience	1	2	3	4	5
Setting out of errors	1	2	3	4	5
Problems with constructability	1	2	3	4	5
Poor resources coordination	1	2	3	4	5
Poor resources planning	1	2	3	4	5
Excess overtime	1	2	3	4	5

13. The following are factors related to subcontractor that might cause rework. Indicate the extend at which you agree with the following statements regarding your construction project

subcontractor	Strongly agree		Neither agree nor disagree		Strongly disagree
Giving unclear instructions to workers	1	2	3	4	5
Failure to comply with the specification	1	2	3	4	5
Shortage of supervisors who are skilled	1	2	3	4	5
Low skill level of labour	1	2	3	4	5
Inadequate supervisor tradesmen ratios	1	2	3	4	5
Workmanship which is defective the design consultants	1	2	3	4	5
Shortage of skilled labour	1	2	3	4	5

Section 3: Impact of rework

14. Kindly state the extent at which rework affect the performance of your construction project based on the following factors:

Performance of the project	Not at all		To some extent		To a very large extent
Time overrun	1	2	3	4	5
Cost overrun	1	2	3	4	5
Contractual claims	1	2	3	4	5
Client/ end user dissatisfaction	1	2	3	4	5
Dissatisfaction of the design team	1	2	3	4	5
Quality degradation	1	2	3	4	5
Low fees paid for contract documentation preparation	1	2	3	4	5

15. Kindly state the extent in which rework has affected your construction project based on the following factors:

Organization	Not at all		To some extent		To a very Large extent
Workers absenteeism	1	2	3	4	5
Inter-organizational conflict	1	2	3	4	5
Fatigue	1	2	3	4	5
Poor workers morale	1	2	3	4	5
Workers demotivation	1	2	3	4	5
Loss of the future work	1	2	3	4	5
Reduced profit	1	2	3	4	5

Section 4: Measurement of the cost of rework

16. From your own personal experience, how frequent have you recorded rework incidences within this construction project

a) Never b) Sometimes c) Always

17. With reference to this current construction project, to what extent are you in agreement with the following statements in which case 1= strongly disagree, 2= disagree, 3=neutral, 4=agree, 5= Strongly agree

Statement	Strongly agree		Neither agree nor disagree		Strongly disagree
System used for recording the occurrence of rework was efficient	1	2	3	4	5
System used for calculating the direct cost of rework was efficient	1	2	3	4	5
Lack of funds that is allocated for investigation of site	1	2	3	4	5
System used for calculating the indirect cost of rework was efficient	1	2	3	4	5
The adverse impact of the cost of rework on profit has not been clearly reported	1	2	3	4	5

Organization	Not at all		To some extent		To a very Large extent
Workers absenteeism	1	2	3	4	5
Inter-organizational conflict	1	2	3	4	5
Fatigue	1	2	3	4	5
Poor workers morale	1	2	3	4	5
Workers demotivation	1	2	3	4	5
Loss of the future work	1	2	3	4	5
Reduced profit	1	2	3	4	5

18. To what extent were cost of rework attributable to each of the following sources which are design related

Sources which are design related	Not at all		To some extent		To a very Large extent
Changes made from the contractor's request during the process of construction	1	2	3	4	5
Changes made from the client's request	1	2	3	4	5
Changes made by the end user/municipality	1	2	3	4	5
Modifications, revision and improvements that were initiated by the subcontractor or the contractor	1	2	3	4	5
Errors made in the documentation of the contract	1	2	3	4	5
Items omission from documentation contract	1	2	3	4	5

19. To what extent does cost of rework attributable to the following construction related sources?

Sources that are construction related	Not at all		To some extent		To a very Large extent
Changes in the construction method so as to improve the constructability of the project	1	2	3	4	5
Changes in the methods of construction due to the conditions of the site	1	2	3	4	5
Changes made by the end user/municipality	1	2	3	4	5
Changes initiated by the client	1	2	3	4	5
Changes initiated by the contractor for the purpose of quality improvement	1	2	3	4	5
Errors made due to inappropriate methods of construction	1	2	3	4	5

20. Kindly provide an estimate of the following rework cost on your construction project

a) Direct costs……………………………………………………….

b) Indirect costs…………………………………………………….

Section 5: Strategies for rework containment

21. Kindly indicate which of the below mentioned strategy for design management have been implemented in your construction project

Design management	Highly Ineffective		Quite effective		Highly effective
Value management	1	2	3	4	5
Construction design	1	2	3	4	5
Techniques of computer visualisation	1	2	3	4	5
Suppliers and subcontractors involvement during the design process	1	2	3	4	5
Analysis of contractability	1	2	3	4	5
Team building	1	2	3	4	5

22. Kindly indicate which of the below mentioned management strategies have been implemented in you project

Site management	**Highly ineffective**		**Quite effective**		**Highly effective**
Subcontractors involvement during the process of construction	1	2	3	4	5
Quality management system for site	1	2	3	4	5
Quality audits	1	2	3	4	5
Quality control	1	2	3	4	5
Value engineering	1	2	3	4	5
Others (specify)……	1	2	3	4	5

23. Provide the details of any issues that you feel have not been addressed.

……

……………………………..