ST. MARY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

IDENTIFYING THE MAJOR CAUSES AND OVERALL IMPACTS OF REWORK IN ADDIS ABABA BUILDING CONSTRUCTION PROJECTS

BY

SAMRAWIT TSEGAYE

DECEMBER2019

ADDIS ABABA, ETHIOPIA

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ID NO. SGS/0116/2010B

A THESIS SUBMITTED TO ST. MARY'S UNIVERSITY, SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIRMENTS FOR THE DEGREE OF MASTERS OF ARTS IN PROJECT MANAGEMENT

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APPROVED BY BOARD OF EXAMINERS

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DECLARATION

I, the undersigned, declare that this thesis is my original work; prepared under the guidance of Temesgen Belayneh (Ph.D.). All sources of materials used for the thesis have been duly acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning institution for the purpose of earning any degree.

Samrawit Tsegaye ----------

Name Signature

St. Mary's University, Addis Ababa **December, 2019**

ENDORSEMENT

This thesis has been submitted to St. Mary's University, School of Graduate Studies for examination with my approval as a university advisor.

TEMESGEN BELAYNEH (Ph.D.) ----------

Advisor Signature

St. Mary's University, Addis Ababa **December, 2019**

Table of Contents

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LIST OF ACRONYMS

BC - Building Contractor

BRE - Building Research Establishment

CII - Construction Industry Institute

COAA - Construction Owners Association of Alberta

DB - Design Build

DBM - Design Build Memorandum

FRI - Field Rework Index

GC - General Contractor

MoWUD - Ministry Of Works and Urban Development

PLC - Private Limited Company

PRD - Project Rework Reduction

PRRI - Project Rework Reduction Index

PRRT - Project Rework Reduction Tool

RDP - Rework Reduction Program

RII - Relative Importance Index

SD - Standard Deviation

SPSS - Statistical Package for Social Science

UK - United Kingdom

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Rework according to this study is an unnecessary effort of redoing a construction activity that was wrongly carried out the first time. The objectives of this study were, i) To identify the major causes of rework in building construction projects which are located in Addis Ababa, ii) To identify the overall major impacts of rework in building construction projects which are located in Addis Ababa, iii) To give an insight into the financial impact of rework on cost performance of a building project and; iv) To examine the measures taken so far to minimize reworking. From the number of building constructions found in Addis Ababa, building contractors one, two and three were selected as the target population. To meet the objective of the study, a survey strategy followed by a questionnaire, semi-structured interview, and site document review were used as data collection tools. Among the distributed 118 questionnaires for the construction companies, 89 were collected. Based on the collected data, the result of the study revealed that "Change instructions given by the client after some work had been carried out", "Use of an insufficient skill level manpower" and "Defective workmanship" were the three major causal factors of rework among the 33 identified factors. In addition to this, the study revealed that cost overrun, time overrun and disputes between parties in the contract as the major rework impacts. Besides this, the results obtained from the survey indicated, the rework minimizing measures are not implemented at an efficient level. Finally, the study mainly recommended for the three major participants (contractors, clients, and consultants) to develop a continuous means of communication and specifically for the contractors and consultants to have a rework event, cause and impact recording system which is going to be helpful towards reducing its occurrence.

Keywords: Rework, Building construction, Project performance, Cause factors, Impact, Addis Ababa, Ethiopia

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

The construction industry is one of the significant industries that contribute to the socio-economic growth of a country. Bossink and Brouwers (1996) stated that the construction industry plays an important role that is required for the socio-economic development of a country and also directly contributes to the economic growth. In spite of its significance, the industry faced and is facing different problems like cost overrun, time overrun, poor quality, material wastage, poor performance and ineffective productivity (Abdul-Rahman, et al., 2013; Simpeh 2012). According to Hussin, et al., (2013), the construction industry faces different problems like time overrun (70% of projects), cost overrun (average 14% of contract cost), and waste generation (approximately 10% of the material cost).

According to the study of Hwang et al., (2009) among different frequent problems the construction industry is facing, rework is one of the major causes which make the construction industry to face cost and time overrun problems. Another study which was carried out by Love et al., (2004) strengthens this by pointing out rework as the main contributor for time wastage and schedule overruns. According to the researchers, rework has an impact on project performance by increasing the total cost of the project and wastage of resources; and decreasing the quality (Love et al., 2004).

Koskela (1994) classified the activities which are carried out in the construction process as value-adding and non-value adding activities. He further described the non-value adding activities as time, space and resource-consuming activities but doesn't add any value to the end output. Related to this, Alwi, et al., (2002) and Josephson et al., (2002) recognized rework and wastages as non-value adding endemic symptoms that seriously affect the performance and productivity aspects of construction projects. Alwi et al., (2002) opined rework as a significant factor that directly contributes to these waste. So minimizing the rework means minimizing most of the wastage generated in the construction industry.

The adverse impacts of rework include but not limited to lower productivity, an additional cost of covering reworks occurrences, additional time for rework, quality degradation and costly litigation between participants over responsibility for cost and time overrun. The additional costs

will be incurred due to the additional materials for rework, subsequent wastage handling, costs for covering rework occurrences and additional labor to rectify activities (Palaneeswaran, 2006).

This shows that rework; the problem which gets a little attention is affecting the major constraints of a project which are time, cost and quality. So having this in mind, this study aimed at identifying the major causes and impacts of rework in building projects which are located in Addis Ababa so that applicable and efficient minimizing strategies can be developed.

1.2 Statement of the Problem

The construction industry plays an important role in the socio-economic development of a country. Construction projects have their own processes and challenges from initiation to completion of the whole process. The challenges included but not limited to time overrun, cost overrun, and waste generation (Hussin, et al., 2013).

As it is stated by MoWUD (2006), the Ethiopian construction industry have a shortage of meeting the stated local and international quality standards and the performance demand expected from the sector. The industry suffers from many problems and complex issues related to time, cost, quality, client satisfaction, productivity and safety (Biyadglign, 2017). In addition to these problems, the study identified the cost of rework as one of the factors affecting the performance of building construction projects. Also, Asmara (2015) identified rework as one of the major causes of wastage generation in public housing projects.

Different researchers around the globe regarded rework as a serious problem in the construction industry. For instance, according to the study of Enshassi et al., (2009), rework is a serious problem in the construction industry of the Gaza strip and has been identified as one of the key causes for cost overrun, delay and client dissatisfaction. Similarly, Love and Edward (2004) confirmed that rework is a major contributor for time overruns which eventually impacts the cost, resources, and quality of a project. As confirmed by research which was made in Australia, the direct and indirect rework costs in building projects were 6.44% and 5.6% of contract value respectively (Love, 2002). Also, Josephson and Hammarlund (1999) on their research made in Sweden examined the causes and costs of seven building projects and found that the cost of rework ranged between 2.3% and 9.4% of the contract cost. Likewise, Oyewobi et al., (2011) made a study on 25 building construction projects which are located in Nigeria. According to the obtained results, the additional cost incurred due to rework ranges up to 5% of the total estimated cost.

When it's compared to the seriousness of the consequences of rework, the attention given to the root causes is still limited (Simpeh, 2012; Ye et al., 2014; Zaiter, 2014 and; Chandrusha and Basha, 2017).

Similarly, when we come to our country, little or no attention has been given for this area of study regarding of its adverse consequences. Based on the selected three projects in this study, the additional cost of reworking can range up to 2.5% of the total construction cost of a building. This indicated that the seriousness of the issue which made this area of study worth to dig deep. As a result, the study went one step ahead towards solving the problem by identifying the major causes and impacts of rework on building construction projects which are located in Addis Ababa.

1.3 Research Questions

- What are the major causes for the occurrence of rework with regards to project constructability, human resource capability, site management, project communication; and material and equipment?
- What are the major overall impacts of rework in building projects which are located in Addis Ababa?
- What measures have been taken in order to minimize reworking?

1.4 Research Objectives

1.4.1 General Objective

To identify the top major causes and overall impacts of rework in Addis Ababa building construction projects. If this research can solve 50% of the problem by identifying the causes, applicable rework minimizing strategies can be developed to increase the performance and efficiency of the industry.

1.4.2 Specific Objectives

- To identify the major causes of rework in building construction projects which are located in Addis Ababa
- To identify the overall major impacts of rework in building construction projects which are located in Addis Ababa
- To examine the measures taken in order to minimize rework.

1.5 Significance of the Study

The identified top root causes are one of the results which are obtained from this study. So this result, in addition to the identified rework minimizing measure gaps will pave a way for construction professionals to come up with rework minimizing solutions. In addition to that, the identified financial impacts of rework will have the potential of creating awareness of its consequences. As a result of this, different construction participants like project managers, consultants, contractors, site engineers will be conscious enough to think about minimizing rework incurring activities in the construction sites.

1.6 Scope and Limitations of the Study

First, the research only focused on building projects which are in the construction phase and located in Addis Ababa. Second, the research focused on building contractor one (BC1), building contractor two (BC2) and building contractor three (BC3) companies that are located in Addis Ababa and registered by Addis Ababa City Construction Bureau.

This study was limited to show the rework incident in construction phase in the perspective of professionals on contractor's side. But the perspective of clients and consultants need to be seen separately in detail.

The other limitation is that, the study was carried out using descriptive research design and analyzed using descriptive statistics using RII analysis tool to identify the causes and impacts of rework. But regression would be the best tool that needs to be used for analysis.

1.7 Organization of the Study

The first chapter provided a background to the researched topic of the study. The section explained about the problem statement, objective of the study, significance and limitation of the study. The second chapter of the study reviewed related literatures regarding the topic area and provided exhaustive information about the main subjects of the study by reviewing the works of different authors. The section mainly focused on the causes, impacts and rework minimizing measures in building projects. The third chapter explained about the methodology implemented in order to come up with the findings of the study. Specifically, the chapter explained about the research approach and design, population and samples; and data collection methods used to find out the needed data. The fourth chapter explained about the results after analyzing the collected data. The section organized and discussed about the findings of the study which were collected. Finally, in the last chapter of the study, the key findings were summarized and after that the chapter concluded the study and gave recommendations based on the findings.

CHAPTER TWO
REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter provides a detailed review of different works of literature related to the objectives of the study. The chapter commences by reviewing the term rework on the point of view of different researchers to come up with the operational definition of the study. Then the review continues with, the causes and impacts of its occurrence in the construction industry and finalized by reviewing the rework reduction methods from different departments and studies.

2.2 Review of theoretical literature

2.2.1 Definitions of rework

Rework is not a term that is introduced in the early times; different scholars at different times gave their interpretation in construction management literature by relating it with quality deviations, defects, failures, and non-conformance. According to the Construction Industry Development Agency CIDA (1995), rework is doing something at least one extra time because of the non-conformity of the previously done activity. A rework definition opined by Construction Industry Institute CII (2001) is an activity that needs to be done repeatedly and also includes undoing the works which were already performed. These definitions give emphasis and relate to rework with its repetition. From this, it can be understood that rework is doing an activity more than once.

On another definition, Ashford (1992) defined rework as a process by which an item is made to conform to the original requirement by completion or correction. Love and his fellow researchers (1997) defined rework in a more detailed way as it is an activity that is considered to be finished but not able to satisfy the customer. Due to that, the activity is required to be changed based on the requirement of the client (Love et al., 1997). Here, rework is defined as it's more of like an adjustment process made to an item or activity. These two definitions are about a bringing of a process or an item to a stated requirement. The requirements could come from clients or standards.

Josephson and others (2002) defined rework as it is an unnecessary effort of correcting construction errors. Here; the researchers' give emphasis only on error based reworks. Other

sources like an omission, damage and change are not considered. The other researchers who gave an almost similar definition are Love and Li (2000). According to them, rework is *"Unneeded effort of redoing an activity or operation that was enforced in a wrong way from the beginning"*. According to another definition given by Love (2002), rework is the "*Unnecessary effort of redoing a process that was incorrectly implemented the first time"*. Based on these definitions of the researchers, rework is an unnecessary effort we make. So it confirms that rework is a non-value-adding activity like Alwi et al., (2002) stated.

From the above definitions, there are three main terms which describe rework that needs to be pointed out. These are,

- Rework is a repeated work,
- Rework is a process towards conformance ,
- Rework is an unneeded/unnecessary effort.

Oyewobi et al., (2010) stated that rework in the construction industry becomes necessary either when an element of building works fails to meet customer requirements, or when the completed work does not conform to the contract documents.

So based on the definition of Love and Li (2000), as an operational definition, rework for this study is defined as ***an unnecessary effort of redoing a construction work which was wrongly carried out the first time.***

2.2.2 Rework in construction industry

Rework is a significant problem in construction projects mostly in building constructions. That is because of the involvement of multiple disciplines like architects, engineers, contractors, suppliers, and clients; which leads to the existence of a complex environment that makes many activities to be carried out simultaneously. In this process, some of the activities will be reworked due to non-conformance, omission, errors, changes or misunderstandings between the involved parties (Love et al., 2000).

The construction industry accepted rework as unavoidable process. Due to this, it is perceived as part of a construction process. Due to this, it is not usually observed when much effort is made on reducing or eliminating it. As a result of this, rework is one of the problems which leads a project to face time and cost overruns, degrade the quality and leads to client dissatisfaction. Even though

it has these serious impacts, the parties who are involved in the industry do not realize the actual extent of its occurrence (Nihal, 2013).

According to different studies which are carried out in different countries found that the cost of reworking is about 10% - 15% of the total cost of the project (Love and Li, 2000; Josephson et al., 2002; Palaneeswaran, et al., 2005; Oyewobi et al., 2011; Enshassi et al., 2017). Several human, design and construction-related causes are raised for the occurrence of this hard to ignore the amount of wastage in the industry.

It was suggested that for effective reduction of this cost, having an understanding of the root causes is the first measure that needs to be taken. Besides, it will be necessary for the industry to become responsive and adoptive for change (Nihal, 2013).

2.2.3 Categories of rework

Error

According to Love et al., (1998), an error is defined as *"any item or activity in a system that is performed incorrectly resulting in a deviation"*. As stated by the researchers, rework is aggravated by errors made during the design process, errors which then appear in the procurement process and construction phase. As opined by Simpeh (2012), the extent of rework required depends on how long the error has remained unnoticed. For instance, if there are any design-related errors in the design of the building, the error might not be detected until it is physically constructed. As a result of this, as error goes undetected, the greater likelihood of rework occurring that significantly impacts cost and schedule (Simpeh, 2012).
As stated by Love et al., (2009), an error can occur due to the physiological and psychological limitations of humans. According to their study, an error can arise due to 3 major reasons.

(a) Non-compliance: this error occurs when an individual decided not to carry the task at all or in the way it is required. This might arise due to low motivation and/or poor supervision.

(b) Slips and lapses of attention: this error occurs due to the forgetfulness or psychological habit of an individual. Usually, this kind of error arises from routine tasks that are carried out in similar working environments.

(c) Mistake: an error occurs because of ignorance of the individual towards the correct task or the correct way of doing the task.

Omission

According to Reason (2002), Omission errors arise when the mental process of action control is subjected to strain or distraction. Omission errors are a result of pathogens within a system that translates into error-provoking conditions within the firm and project. Omission errors can be caused due to inexperience, fatigue, time pressure and understaffing (Reason, 2002).

As defined by Love et al., (2009), *"Pathogens are latent conditions and lay dormant within a system until an error comes to light".* As they stated, many pathogen oriented errors in engineering firms were based on practices; which means pathogens from people's deliberate practices that is attempted to solve a particular problem. The following are the examples given by the researchers;

1. To save time and money, design detail, specifications, and other contract documents will be reused to another project without considering the nature of the project;
2. To meet the project's schedule there is a practice of starting working based on tentative information;
3. If a practice provides an outcome which is satisfactory for an individual, then the practice will be used for further project even if it is inappropriate for this project;
4. Due to the financial and time pressure imposed by clients towards designers, important activities like checking, verifying and reviewing before releasing the documents will be omitted;
5. Lack of attention to quality management during the design process is a reason for rework;
6. Contractors and subcontractors may not be strictly adhering to the quality, safety, and environmental management system constraints. Due to these tasks needed to be reworked.

Change

Construction projects, in general, will rarely be built as per the original design (Smith et al., 2001). As a result of that, change orders are inevitable and undesirable events of all types of construction projects (Safapour et al., 2018). As it is defined by Hester et al., (1991), *"change is any event which results in modification of the project work, schedule or cost".*

As stated by Love et al., (2004), from design-related rework causes, change orders are the major source of rework in construction projects. As opined by Habibi et al., (2018), change orders usually includes, a design change or modification initiated by contractor or client during the construction phase or it could be initiated due to financial, economic, social or legal changes. The

operational aspects of change affect the cost of a project, create scheduling delays, and decrease productivity (Kermanshachi et al., 2016). The issued rework also has a potential of creating serious challenges among the project stakeholders (Habibi et al., 2018). According to Mastenbroek (2010), when a project is carried out, many changes will occur but all of them are not attended. But both the attended and unattended changes can influence the project negatively or positively.

2.2.4 Causes of rework in construction projects

Mastenbroek (2010) carried out a case study at Grupo Williams (GW); a real estate and construction company which is located at Honduras, Central America. One of the objectives of the study was to find the causes of the rework events. The researcher classified the rework causing categories broadly in to two; design and construction. Under each category the causes are classified as error, change and other. Using interview as a data collection method, the researcher ranked the design and construction phase reworks as it is showed in the table below.

Table 2- 1 Major causes of rework in Honduras

Phase	**Type**	**Cause**
Design	Change	A design change is initiated by the client
	Change	A design change is initiated by the end user/occupier
	Change	A design change is initiated due to financial changes
	Change	A design change is initiated due to economic changes
	Other	Lack of coordination
Construction	Change	Changes in clients' wishes
	change	Extra orders by client
	Other	Machine breakdown or defects
	Other	Machine not working satisfactorily
	Error	Late delivery of materials

Source:(Mastenbroek, 2010)

Josephson et al., (2002) on their study pointed out the top five causes of rework which contribute for the overall project cost. The study was carried out in Sweden. The researchers identified the causes by selecting seven different building projects which were monitored for about 10 months. Observation and interview were used as data collection means. The researchers classified the

rework cause categories as client, design, workmanship, production management, machine and material. The result of the research revealed that erroneous workmanship as the top major cause for the occurrence of rework. Here are the top five causes.

Table 2- 2 Top five causes of rework in Sweden

Causes	**Cause category**	**Rank**
Erroneous workmanship	Workmanship	1st
Unsuitable or faulty design	Design	2nd
Lack of coordination	Design	3rd
Late deliveries	Material	4th
Mistakes in planning	Production management	5th

Source: (Josephson et al., 2002)

Another study was carried out by Enshassi et al., (2017) to identify the causes of rework which have a high degree of impact on project performance in the construction industry of Gaza Strip. A structured questionnaire was selected as the main data collection means to identify the top causes. The researchers collected a set of 57 rework factors which are categorized under seven groups. Based on the results of the study, attempts to fraud, competitive pressure, and ineffective management are the major rework factors that influence the performance of a project. The following table summarizes the top major causes of rework which have an impact on the performance of a project.

Table 2- 3 Top five causes of rework in Palestine

Causes	**Category**	**Rank**
Attempt to fraud	Contactor	1st
Competitive pressure/low contact value	Contactor	2nd
Ineffective management and decision making	Human Resource capability	3rd
Schedule pressures	Construction process	4th
The absence of job security	Human Resource capability	5th

Source: (Enshassi et al., 2017)

Classification of rework causes

Three different ways of classifying the causes of rework are identified from different works of literature. First, according to Love and his fellow researchers (1997), the causes of rework can be classified into three groups. These are people, design, and construction. This classification was made based on the finding of their research which focuses on both residential and industrial development constructions. They stated different sub causes on each group. In their conclusion, they confirmed that some causes are interrelated due to the complexity of construction operations. Also, they further stated that reworks that are carried out due to peoples account the majority percentage (60%). The following figure illustrates the researchers' classification.

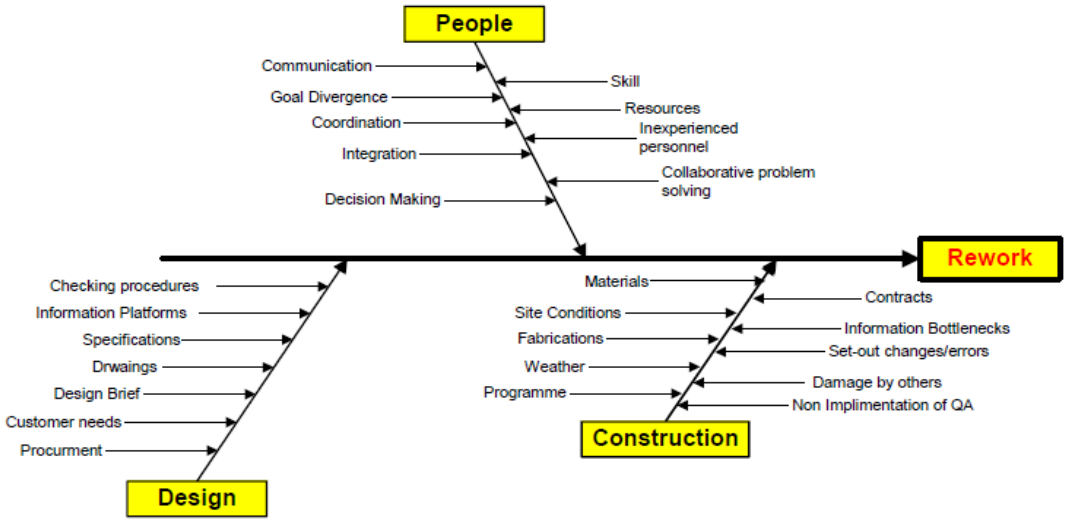


Figure 2- 1 Classification of causes of rework

Source: (Love, et al., 1997: p. 13)

The second classification of rework was proposed by (Love and Edwards, 2004). According to the researchers, the root causes of rework can be classified as Client related factors, Design related factors and Contractor related factors (includes site management and subcontractor factors). As it is stated by them, most of the time, the client related factors arise from both design and construction-related sources. The rework could come from either a design change made due to the client's requirement or construction-related changes initiated by the client. The changes might be requested after some phase of work had been undertaken on-site or it might even be after the completion of the work. According to the study of Love and Edwards (2004), the client related rework factors includes inadequate funding provided during site investigations, inadequate

time and funds attributed to the briefing process, payment of low fees for preparing contract documentation, ineffective use of information technology and poor design coordination between design team members.

The second root cause of rework is design-related factors. Here, the changes could be made by different parties such as clients, contractors, subcontractors, and regulatory bodies. The design-related rework factors as confined by Love and Edwards (2004) includes; redesign due to an inadequate brief, changes arising from unchecked drawing issue, redesign due to inappropriate drawing scale, accepting and changing designs due to client's requirement.

The third root cause of rework is contractor related factors. This factor includes the subcontractor related factors which include low skill level, damages, defects, poor workmanship, inadequate supervision, and use of poor quality materials. The other factor is related to constructability. This includes setting out errors, failure to protect constructed works, changes in construction methods to improve constructability, errors due to inappropriate construction methods, and omission of some activity (Love and Edwards, 2004).

The third classification of rework cause is based on the categorization method proposed by the Construction Owners Association of Alberta COAA (2001). It is developed using a fishbone diagram. The diagram was further modified by Fayek et al.,(2003). The classification is based on five major causes of rework and each major causes consists of four sub causes. Figure 2-2 illustrates the rework cause classification.

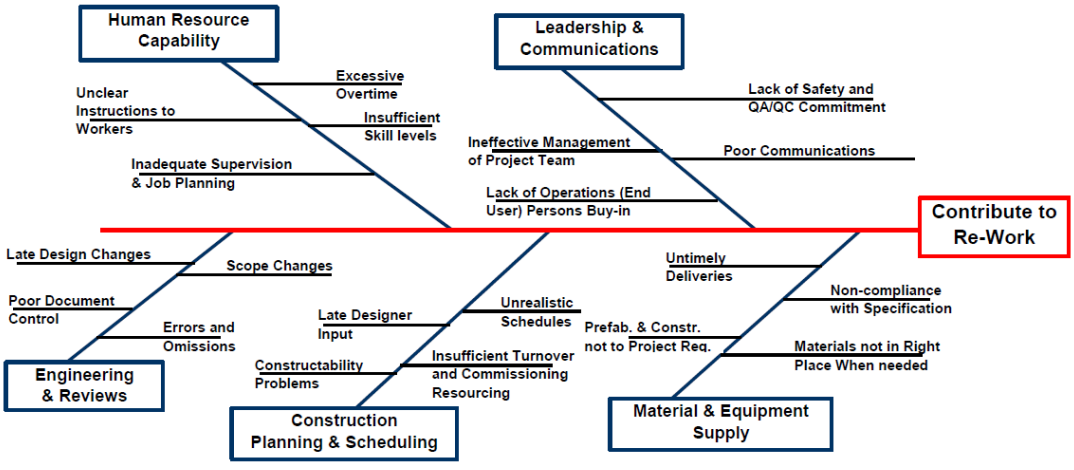


Figure 2- 2 Fishbone rework cause classification

Source: (Fayek, et al., 2003: p.18)

A. Leadership and Communication

According to Fayek el al., (2003) classification, leadership, and communication is the first level rework cause. As per their classification, there are four possible causes that are considered as second-level causes for this rework cause category. These are lack of safety and quality assurance or quality control commitment, ineffective management of project team, poor communication and lack of operation (End-user) person's buy-in.

Alwi et al., (2001) affirmed that one of the major problems in the construction industry is their inability to become quality focused. Due to that, products and services will be below the standard which will gradually lead and result to rework. According to their study, in Indonesia, quality management principles and tools are not included in construction management practice. This leads the industry to face cost and time overruns which leads to client dissatisfaction. Without having a quality management practice, reducing or eliminating rework is almost impossible.

According to Love et al., (2009), strategic decisions taken by top management or key decision-makers who stimulate the conditions for the adoption of inappropriate structures, processes, practices, and technologies for projects are the major contributors of rework under the leadership and communication category.

B. Human Resource Capability

According to Fayek et al., (2003) classification, human resource capability is one of the first-level rework causes. As per their classification, there are four possible causes that are considered as second-level causes for rework. These are excessive overtime, insufficient skills levels, inadequate supervision and job planning; and unclear instructions to workers.

As stated by Alwi et al., (2001) in their study on determining the effect of quality supervision on rework, experienced and well-trained supervisors have an important role in minimizing rework in construction. According to their study, the researchers identified inadequate supervision, lack of supervisors' skill and lack of skilled labors as major causes of rework. In addition, they stated that the quality of site supervision has a major influence on the overall performance of the efficiency of construction projects. Similarly, Palaneeswaran et al., (2005) identify a lack of managerial and supervisory skills as the main factor that causes rework in Hong Kong construction projects.

Josephson et al., (2002) in their study made in Sweden quantified the factors related to this category. According to their study, workmanship as a whole takes 20% of the total rework cost and from that group, erroneous workmanship takes 65% of the 20% rework cost.

As stated by Toole (2005), in the time when a project is behind schedule, there needs to be utilizing excessive overtime. According to the research, excessive overtime will cause fatigue to workers and through time it will reduce worker's productivity. As a result, the output of the workers will be in poor quality so the works will be needed to be reworked.

C. Engineering and Reviews

According to Fayek et al., (2003) classification, engineering and reviews is the other first-level rework cause. As per their classification, there are four possible causes that are considered as second-level causes for rework. These are late design change, scope change, poor document control, errors, and omission.

According to Love and Li (2000), errors and omissions which are made in contract drawings are the major contributing factors to rework. Construction rework arose out of this incomplete and erroneous information. As opined by Love et al., (2004), poor technical knowledge and lack of experience can be the causes for the results of error and omission in design documents. According to the researchers, this has a potential of leading to rework. Similar to this, Lopez et al., (2010) confirmed that insufficient knowledge simply masks more complicated problems inherent with design firms. Besides, Love et al., (2004) suggested that, besides the inexperience of the design team, the limited duration allocated to design tasks has an effect on the quality of contract documents and this also stated as one cause of rework. As stated by Love and Li (2000), the other cause of rework is changes. This change is direct from the architects because of their need to improve the functionality and aesthetics of the building. But these change, whether they are initiated by clients, contractors or design team members, it has a capacity of leading to rework.

As confirmed by Josephson et al., (2002), one of the categories of classifying rework costs is design. This category accounts for 26% of the overall rework cost. Under the design category, lack of coordination (28%) and unsuitable design (18%) are the major causes of rework.

D. Construction Planning and Schedule

According to Fayek et al., (2003) classification, construction planning and schedule is the fourth first-level rework cause. As per their classification, there are four possible causes that are considered as second-level causes for rework. These are unrealistic schedules, late designer input, insufficient turnover and commissioning resourcing and constructability problems.

As stated by Mastenbroek (2010), work preparation before both the design and construction stage is very important. In relation to this, Hwang et al., (2009) identified inadequate pre-project planning as a rework causing factor. Love (2002) in detail stated that poor planning and design

are causes for rework. He further confirmed that the insufficient time allocated for design and planning before the construction is started is the major cause for rework. Josephson et al., (2002) on the other hand quantified in the contribution of the factors for the existence of rework. According to them, the production management category as a whole takes 25% of the overall rework cost. Under this category, mistakes in planning and faulty work preparation account 24% and 18% respectively.

In the case of constructability problems, Alwi et al., (2001) opined that the construction method selected might lead to rework if they are selected wrongly. So as the researchers stated, selecting the construction method depending on different perspectives like cost, reliability, applicability and other issues needs to be seriously considered before just directly jumping to the construction phase.

E. Material and Equipment supply

According to Fayek et al., (2003) classification, material and equipment supply is the other first-level rework cause. As per their classification, four possible causes are considered as second-level causes for rework. These are untimely deliveries, non-compliance with the specification, materials not in the right place when needed, prefabrication and construction not to project requirement.

Josephson and his fellow researchers (2002) in their research classified this category in to two as material and machinery. The material cause contributes 17% of the overall of categories are late deliveries (37%), faulty manufacturing (30%), material hard to work with (8%), delivery with wrong type (10%) and other causes (18%). As the result shows, late deliveries and faulty manufacturing of material are the major ones. According to the researchers, usual examples include delay in delivering doors, windows, and prefabricated components, or delivered materials that were in the wrong dimensions and quantities. The other category is machinery; which accounts 3% of the overall rework costs. Machine breakdown and machine not working satisfactorily were the major causes of rework under this category.

Since one of the objective of this study is to identify the major causes of rework, causing categories will be determined according to the above literatures. Identification of the categories will be on avoiding the repetition, based on the scope and target population of the research and based on our country's existing situation.

2.2.5 Impacts of rework

Palaneeswaran (2006) opined that the uncontrolled rework occurrences in construction projects have serious impacts on project performance. According to the researcher, rework has both direct and indirect effects on the performance of construction projects. The direct impacts of rework include additional time to rework, additional costs for covering rework occurrences, additional materials for rework and subsequent wastage handling, additional labor for rework and related extensions of supervision manpower. On the other hand, the indirect impacts of rework include conflict among parties, reduced profit, end-user dissatisfaction, de motivation among workers are identified as the indirect impacts of rework (Love, 2002).

Hwang (2009) stated that rework is a direct contributor for both time and cost overrun. The researcher identified that changes requested by clients, omissions, and errors in design are the major causes of a project to face cost overrun. As stated by Simpeh (2012), rework is one of the major factors responsible for the construction industry to be held up.

A. Cost overrun

As stated by Fayek et al., (2003), cost overrun is one of the most common problems which usually face by most construction projects. Completing a project with the planned budget is one of the predominant factors that can be considered as a success of any given project (Hwang and Yang, 2014). As it is opined by Wan et al., (2009) cost overrun is one of a serious problem in the construction industry especially in developing countries.

According to different studies which are carried out by different scholars proved that rework is one of the causes for the arising of cost overrun in the industry. For the sake of comparison, it's important to summarize different researches which are carried out in developed and developing countries. A study which was conducted by the famous guru of rework Love (2002) in Australia tried to give an insight into the impact of rework in the cost performance of a project. In the study, a total of 161 projects were studied. The result of the study revealed that the average direct and indirect costs are 6.4% and 5.6% of the contract cost respectively.

Josephson and his fellow researchers (2002) carried out research in Sweden. The study identified the cost of rework by classifying the rework cost factors into six groups. These are client, design, production management, machines, workmanship, and material. The researchers identified the cost of rework by selecting seven building projects. According to their conclusion, the rework cost of the selected seven building projects ranges from 2.3% - 9.3% of the contract value.

The study of Palaneeswaran (2006) quantified the additional cost incurred due to rework by using a case study approach on building projects which are found in Hong Kong. The result of the study revealed that the direct and indirect costs of rework are 3.5% and 1.7% of the contract value.

On another study which was carried out in Palestine using a questionnaire survey of 86 contractors from the West Bank indicated that the average of rework cost in residential building construction projects experienced during the last five years ranged between 10% and 15% of the original contract cost (Mahamid, 2016).

Oyewobi et al., (2011) carried out research in selected projects which are located in Nigeria, Niger state. The study was carried out by showing the contribution of every element of the selected buildings. The result of the research was analyzed by using a simple percentile. At last, the study revealed that 4.49% of the total project cost is wasted due to reworking.

So according to the above studies which are carried out in both developing and developed countries showed that the cost of rework ranges approximately up to 3%-10% of the total project cost. These figures illustrate the fact that the additional costs due to rework had a considerable adverse impact on project performance.

B. Time overrun

In addition to the cost incurred due to rework, the additional time required to redo the work would also result in a delay which would probably be affecting the project schedule. As defined by Aibinu and Odeyinka (2006) delay is a situation in which the contractor and the project owner jointly or separately contribute to the completion of the project on the predetermined contract period. As stated by Ravisankar et al., (2014), delay is one of the most common problems encountered in the construction industry.

As opined by Wan, et al., (2009) rework can always contribute to the delay to the completion of a construction project and results in the project to face time overruns. In addition to this, as confirmed by Love and Edwards (2004) delays in construction can affect the quality, cost, and resources of a project as well. As confirmed by Alavifar and Motamedi (2014) and Ravisankar et al., (2014) rework is identified as the major cause for a construction project to face time and cost overrun followed by shortage of labor, owners design change, price fluctuation and high waiting for the availability of work teams.

According to a study which was carried out to determine the additional time due to rework pointed out that, the rework duration consists of the standby time, rework time and gear up time

(Fayek et al., 2003). The study further explains the standby time as a waiting time until the rework is being identified, the rework time as a time for redoing the activities and the gear time as the required time to go back and continue the original project activities. The following figure illustrates the components of time added due to rework.

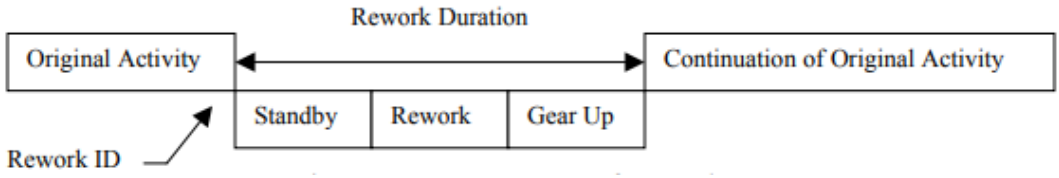


Figure 2- 3 Components of additional time due to rework
Source: (Fayek et al., 2003: p.15)

According to a study by Meshksarr (2012) on a study of the impact rework on time and cost in building a reinforced concrete structure indicated that time delay of rework ranges up to 5.18% of the total construction period.

C. Quality degradation

According to the earliest definition of rework Burati et al., (1992), it is a quality deviation which indicates quality variation from the stated specification. As discussed by Simpeh (2012), lack of quality in construction is manifested in poor workmanship, cost and time overruns and disputes in construction contracts. Mastenbroek (2010) stated that rework often means that parts of a structure have to be scrapped and new material needed to rebuild, a result of a compromise with quality which leads to wastage of resources.

D. Contract parties' dissatisfaction

As stated by Leung et al., (2004), the construction industry involves several stakeholders who have different responsibilities. The satisfaction of these involved stakeholders has the potential to influence the performance of a project directly.

According to Zaiter (2014), the occurrence of rework in projects could increase the potential for conflicts and disputes to occur which will gradually lead to delay, cost overrun and will create an adverse relationship between the contract parties. Besides, if the dispute is not resolved as early as possible it may reach the climax stage and will require litigation processes; a costly process.

According to Simpeh (2012), client dissatisfaction, contractual claims, contractor dissatisfaction and dispute between parties are the impacts of rework in project performance other than cost and time overrun.

In addition to the impact of rework on cost and time performance of a project, it also harms organizational relations and the psychological wellbeing of individuals (Love and Edwards, 2004). As stated by Chidiebere and Ebhohimen (2018), rework has an impact on organizational productivity by affecting the morale level of workers and by creating fatigue, conflict, and absenteeism. According to the researchers, intra/intergroup and personal conflicts are organizational conflicts that may arise due to rework. For instance, the conflict between contactor and client might arise due to questions related to the cause of rework; which is classified as an indirect impact of rework (Love, 2002).

Love (2002) on the other hand discussed the indirect impacts of rework by classifying them into two categories. These are the impact of rework on individuals and organization performance. At an individual level, the researcher identified fatigue, de-motivation, absenteeism, stress and poor morale as indirect impacts of rework which minimized the performance of an individual. Simpeh (2012) also supported that when an individual is forced to work for long work hours because of errors, changes, or omissions, fatigue and stress are likely to emerge and this will facilitate the likelihood of occurrence of further rework by affecting the performance of the individual which will gradually lead to a reduction in organizational productivity. At an organization level, Love (2002) identified reduced profit, diminished professional image, inter-organizational conflict, loss of future work and poor morale as indirect impacts of rework The researcher concluded that rework, in general, can affect the productivity of both design and construction firms.

2.2.6 Costs of rework

According to researches which is made on Australia and Sweden confirmed that the cost of rework ranges up to 10% of the total cost of a project (Love and Irani 2002; Josephson et. al., 2002). In the early studies which are carried out in developing countries like Nigeria and Palestine, the rework cost ranges from 10-15% of the total project cost (Oyewobi et al., 2011; Ibrahim, 2016).

As suggested by Love et al., (1999), only when organizations begin to measure their rework costs carefully will fully appreciate the economic benefits of achieving high quality. But only measuring the cost of rework by itself will not improve the industry, rather it will provide a starting point for establishing a new knowledge (Love and Holt, 2000). According to the

researchers, the advantage of quantifying the rework cost will be utilized by management to evaluate the quality management process and to identify the problems throughout the construction process.

According to Love and Li (2000), the cost of quality can be classified as conformance and non-conformance costs. Under the conformance costs, the researchers included maintenance, testing, audits, validation, verification, training and indoctrination costs. Whereas the non-conformance costs include warranty repairs, waste of material and rework costs. So rework is a group of non-conformance costs.

The other classification was suggested by (Love and Irani, 2002). According to them, the total cost of rework can be classified as a direct and indirect cost. Further, they explained that the indirect (intangible) costs are the unexplored rework costs in construction. The reason behind this is its difficultness to quantify them in monetary terms. As a result, researches mainly give major emphasis on determining the direct costs of reworking.

A. Direct cost

As stated by Love and Irani (2002), direct costs of rework can be quantified in a monetary form and can represent a portion of the total cost of a project. According to Tommeleinet. al., (2007) direct costs of rework include labor, equipment, material, schedule and space costs. According to the Construction Industry Development Agency in Australia CIDA (1995), the direct cost of rework is greater than 10% of the construction cost. According to this, if a 10% rework value applied to the annual turnover of the Australian construction industry, which in 1996 was estimated to be $43.5 billion per annum then the cost of rework could be estimated to be $4.3 billion per annum. On the other study, Barber and others (2000) estimated the cost of direct rework to be 25% of the contract cost. So direct cost of rework is the cost incurred due to rework which can be measured and quantified. (Chidiebere and Ebhohimen, 2018).

B. Indirect cost

As stated by Love (2002), indirect costs cannot be measured directly. The indirect (intangible) costs of rework include loss of schedule and productivity, low operational efficiency and; litigation and claims. The researcher further indicated that there is a little known about the indirect costs of rework especially its monetary value.

As opined by Love (2002), indirect costs are impossible to trace. For instance, the direct cost of rework for a project includes the labor cost for the time needed for redoing the activity, and the

materials used. At this moment, the employee who is carrying out the reworking activities will not be able to work on the other works of the same site. Due to this, there will be an additional loss of productivity. The researcher identified the loss of productivity as an indirect cost of rework. Also, the researcher confirmed that, that there is not much known about the indirect consequences of rework that is because of the limitedness of researches on this area.

Love (2002) on his study of auditing the indirect consequences of rework found out that the major indirect cost of rework relates with the extension of the contract period of a project which affects the capacity of the organizations to take new projects; which will gradually decrease the productivity of the organization. Besides, the researcher tried to quantify the indirect cost of rework and according to the results of his study, its cost ranges to 5.6% of the contract value.

Another study which was carried out in Hong Kong in seven selected building projects revealed that 1.7% of the contract cost is wasted due to the indirect costs of rework.

2.2.7 Rework reduction methods

According to the definition of Love (2002), rework is an unnecessary effort of redoing an incorrectly implemented activity. So it is an activity without adding a single value. Since rework is an activity that negatively affects a project in terms of cost, quality and time, reduction methodologies need to be carried out to minimize if possible, eliminate reworking.

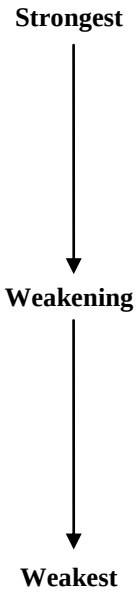
There are several rework reduction methods proposed in the construction industry. The indices focus on minimizing if possible eliminating of rework through giving an early warning (CII, 2001), understanding of rework causes (COAA, 2006; Zhang, 2009) and measuring the impact of rework (Zhang, 2009). So in this section, these major rework reduction methodologies will be reviewed.

The Field Rework Index-FRI

The Field Rework Index (FRI) is a tool that was developed by the Construction Industry Institute (CII) research team153. The tool was developed to provide an early warning for the field rework (CII, 2001). The tool is designed to be used before the commencement of the construction. To develop the FRI, a list of 14 field rework predictors were identified and tested with data that was taken from completed construction projects through a questionnaire survey. After that, an analysis was carried out to determine the relationship between the predictors and field rework. The result of the research confirmed that there is a significant relation between field rework and 14

identified variables. The table below shows the identified Field Rework Index variables and their level of relation with field rework.

Table 2- 4 Variables with statistically significant relationships with field rework

FRI Variables	Relationship
Owner alignment	
Design rework	
Constructability commitment	
Interdisciplinary design coordination	
Degree of project execution planning	
Design firm's qualification	
Field verification	
Expected craft worker availability	
Expected construction overtime	
Engineering overtime	
Design leadership changes	
Design schedule compression	
Supplier pre-qualification	
Supplier information	

Source: Construction Industry Institute (CII, 2001)

The FRI tool is not a tool that is used to predict the percentage of the amount of field rework. Rather it is a tool that gives an early warning for field reworks and cost growth. The research team developed a field rework questionnaire index which is going to be helpful in identifying the need for rework early on projects (CII, 2001).

To apply this tool, first, the FRI user will rate the variables from a range of 1-5; 1 receives 1 point, 2 receive 2 points and goes like that. The second step is adding the obtained score of each result to get the total score. The last step is grouping using the FRI score categorizing chart depending on the obtained total score which ranges between 14 and 70 (CII, 2001). The FRI score chart is shown in the figure below.

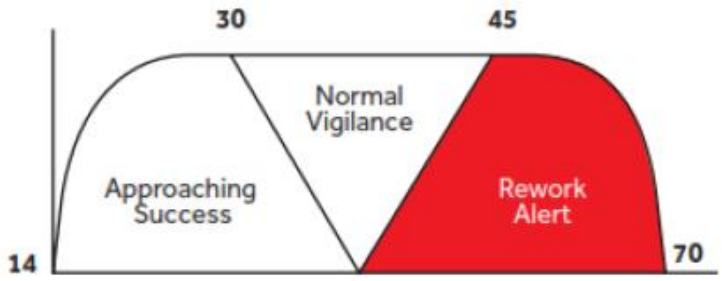


Figure 2- 4 Field rework index score chart

Source: Construction Industry Institute (CII, 2001: p. 16)

Construction Owners Association of Alberta's project rework reduction tool

The Construction Owners Association of Alberta (COAA) has introduced a methodology called Project Rework Reduction Index (PRRI). The index is used to measure organizations in terms of rework level. The software developed for this purpose is called Project Rework Reduction Tool (PRRT). The whole idea of the tool is facilitating project performance against a previously identified cause of rework which will be done at any stage of a project. According to COAA (2006), to prevent the rework in project execution, there needs to be early recognition for the existence of the problem. Due to this, the performance of a project in relation to the reworking level will be measured by considering the well-known classification of rework causes which was first proposed by Fayek et al., (2003). The categories are Engineering and Reviews, Construction Planning and Scheduling, Leadership and Communication, Material and Equipment Supply and Human Resource Capacity. Based on this classification, COAA (2006) evaluated the most important 20 causes for the existence of rework.

The project evaluation in terms of rework is done through a questionnaire which contains from 29 to 90 questions. The study classified the phases of the project's life cycle into five. These are the completion of the Design-Build Memorandum (DBM), emission of engineering specifications, 20% completed from the detailed engineering phase, 20% completed from the construction phase, 50% completed from the construction phase. Each of the five phases has their own questionnaire. The answers which are obtained from the questionnaire for any evaluation can be evaluated by mathematical weighting; i.e. the higher the degree obtained is the less likely it is to rework (COAA, 2006).

Finally, after a periodic evaluation of the obtained results, the average rating will allow issuing a trend analysis for the causes. In addition, the tool also offers suggestions on practical solutions and through best practices to be introduced for eliminating rework.

Zero field rework self-assessment opportunity checklist

This checklist is developed by the Construction Industry Institute (CII) research team 203. The aim of developing this tool is to point out areas that need improvement to strengthen a construction site quality process through the journey of zero field rework (CII, 2005). According to the researchers, a number of previously developed quality checklists mostly focused on data, material control, and manuals or procedures. Due to this, the team aimed at producing a checklist that is different from the previous ones by making this one focus on human performance aspects so it takes a behavior-based approach to minimize rework (CII, 2005). Here are the eight elements which are identified for the self-assessment.

- Teamwork
- Documentation
- Absence of shortcuts
- Quality/rework auditing
- Leadership
- Sufficient and capable resources
- Employee involvement
- Communication

After the completion of the assessment through these eight elements, the project manager will determine ways of sharing the results with employees of the organization to communicate about the implementation plan and involvement of employees.

Rework Reduction Program (RRP)

Zhang (2009) developed a generalized conceptual model for a rework reduction program. The purpose of the rework reduction model is to track construction rework, reduce the occurrence of rework and its impact on project performance and to increase productivity. The functions of the reduction program includes identifying the construction field rework, determining and classifying the rework root causes, documenting the rework events and deliver the rework lessons to the relevant group, quantifying the impact of the rework on project performance, developing a correction action plan to eliminate the cause, planning and updating improvement scenario for changes to the project management system, implementing the corrective action plan, and verifying the effectiveness for eliminating the causes. The rework reduction program is intended to reduce rework through managing these four continuous improvement processes.

A. Rework tracking and cause classification

This process determines which of the implemented activities are rework and points out which types of conditions resulted in the rework. In this process, the events need to be recorded by including the exact time, duration, material, equipment, labor hours, schedule shift and the characteristics of the causes of the executed rework (Zhang, 2009). According to the study, the rework classification structure provides a guideline for tracking and classifying the rework and should be proposed based on the physical condition of the project, contractual conditions, and characteristics of the construction.

B. Rework impact evaluation and trend analysis

In this process, a data fusion will be conducted and the impact of rework will be quantified on project performance in terms of time, cost and quality. At last, this process identifies trends of the impact of overtime. Evaluating the impact of rework shows the potential and substantial impact of rework on project performance and the outcome of corrective action for improving rework management (Zhang, 2009). The table below is a rework evaluation structure which is proposed by the researcher.

Table 2- 5 Rework evaluation structure

Performance	**Criterion**	**Measurement**
Quality and safety	Frequency of rework events	- Occurrence of rework in units of time duration - Rework events that result in human health hazard or equipment failure
Productivity	Labor hours over unit production	- Total work value for a specific duration - Total labor hours in the specific duration - Total labor hours for rework in the specific duration
Cost	Direct cost and relative direct cost	- Expenses of labor, material, equipment and related resources directly consumed in rework - Monetary loss due to the delay of work
Schedule	Time shift for schedule	- Time shift of the subsequent job - The impact of time shift on critical path of the project

Source: (Zhang, 2009)

C. Corrective Action Planning (CAP)

This process simply means developing options and actions to reduce rework which will bring change to the system of the project management. The process includes tracing the symptoms of rework from its causes, producing solutions, implementing changes and checking the effectiveness of the implemented changes (Zhang, 2009).

Before making any corrective actions, the CAP process requires the actions to be appropriate to the magnitude of rework and the identified causes. Because according to the study, not all rework events need corrective actions, only the vital on rework causes does. As a result of this the collected, documented and analyzed data will be able to determine the vital rework cause which needs the corrective action and helps to determine the scope of the action required. The data collection and analysis will be done in the previous processes; which are classifying the cause of rework and evaluating the impacts of rework (Zhang, 2009).

D. Intervention and integration with the project management system

The RRP alone by itself cannot perform the activity of controlling the rework. Rather, the program needs to be integrated with the project management system. This way the program can bring a change by improving the system then rework will be reduced. At last, the feedbacks or the result of improvement will be collected and analyzed by the program which is going to be helpful to facilitate the adjustment of the next repetition of the improvement plan.The figure below is the RRP model consists of the four processes as proposed by the researcher.

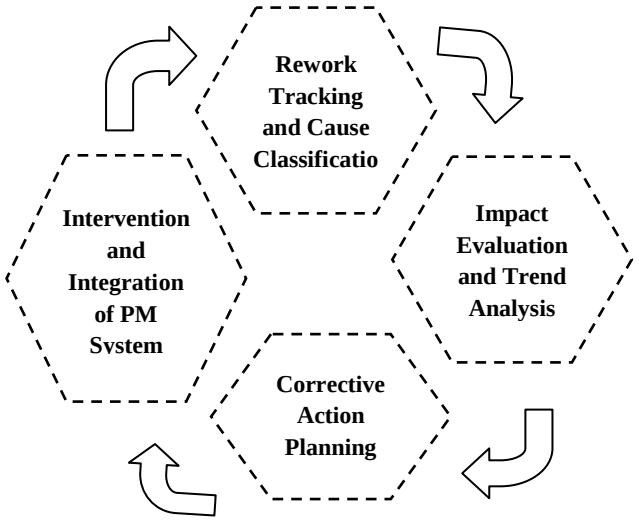


Figure 2- 5 Process flow chart of RRP

Source: (Zhang, 2009: p. 26)

2.3 Review of empirical review

A study with the title of *Quantifying the causes and costs of rework in construction* was carried out by Love and Li (2000) to quantify the causes and costs of rework in construction projects located in Australia. The main objective of the research was to identify the causes of rework and to quantify the cost of quality. To do that, the researchers used a case study approach. So, two projects construction projects were selected that have a different contract type. The first project was a six storey residential building that has 43 units and the other project was a two storey warehouse. The data was collected from the beginning to the completion of the defect liability period of the buildings. The research revealed that changes initiated by the client plus errors and omissions which are found in the contract documents were the major rework cause factors. Also, the study found out that the rework cost of each project is 3.15% and 2.4% of the contract value of the projects.

A study titled *Illustrative Benchmarking Rework and Rework Costs in the Swedish Construction Industry* was carried out on selected building projects which are located in Sweden. The study was carried out by Josephson (2002) to identify the causes, magnitudes, and cost of rework. The researchers used a case study as the main research strategy and worked on selected seven building projects which are located in Sweden for about six months in each project. After collecting the necessary data, the study revealed that Erroneous workmanship, Unsuitable or faulty design and Lack of coordination were the top three rework causing factors on the selected projects. Besides this, the results of the study showed that the cause of rework on the selected projects ranges up to 4.4% of the construction values and 7.1% of the total time of work done (Josephson, 2002).

The other study conducted by Enshassi et al., (2017) titled as *Factors Contributing to Rework and their Impact on Construction Projects Performance*. The study is both descriptive and exploratory in nature. The objective of the research was to identify the causes of rework and determine their severity level on affecting the cost and time performance of a project. The researcher used both questionnaires and case study approaches to meet the stated objective. The result of the study revealed that the absence of job security, Emergency conditions and Attempts to fraud were found out to be the three major rework causing factors on the Gaza strip. Based on the severity level of the identified causal factors, an attempt to fraud was ranked first next to competitive pressure. The result further indicated that rework increased the cost of rework up to

10% and the project delay due to rework up to 77%. The study further revealed that there is insufficient awareness about the causal factors of rework in the construction industry of Gaza.

The other study was carried out by Simpeh (2012) in his study titled *an analysis of the causes and impact of rework in construction projects*. Identification of the causes and impacts of rework in the construction industry of South Africa was the main objective In addition to the aim of revealing whether the causes of rework varies depending on the project type or not. The study used a questionnaire, observation, and semi-structured interview as a means of data collection. In order to meet the objectives of the study, 78 questionnaires were collected from construction professionals. According to the collected results, the study revealed that changes initiated by the client changes initiated by the design team are the major rework cause factors. In addition, the study revealed that the cause of rework doesn't differ depending on the construction project type but the additional cost incurred due to reworking is a must until rework reduction strategies are identified.

The other study was a research conducted by Oyewobi and Ogunsemi (2010) in Nigeria titled *Factors influencing reworks occurrence in construction: A study of selected building projects in Nigeria*. The major objective of the study was to identify and evaluate the variables rework factors that are influencing the performance of building projects in Niger state. The researchers used a survey on selected projects that have experienced reworking. 77 rework variables under three categories were identified, among which 32 of them were contributed to the occurrence of rework on the selected building projects. Using the severity index and factor analysis, the study identified that, late user involvement, lack of support to site management and disturbance in personnel planning were identified as the major rework contributing variables in for the selected building projects.

2.4 Conceptual framework of the study

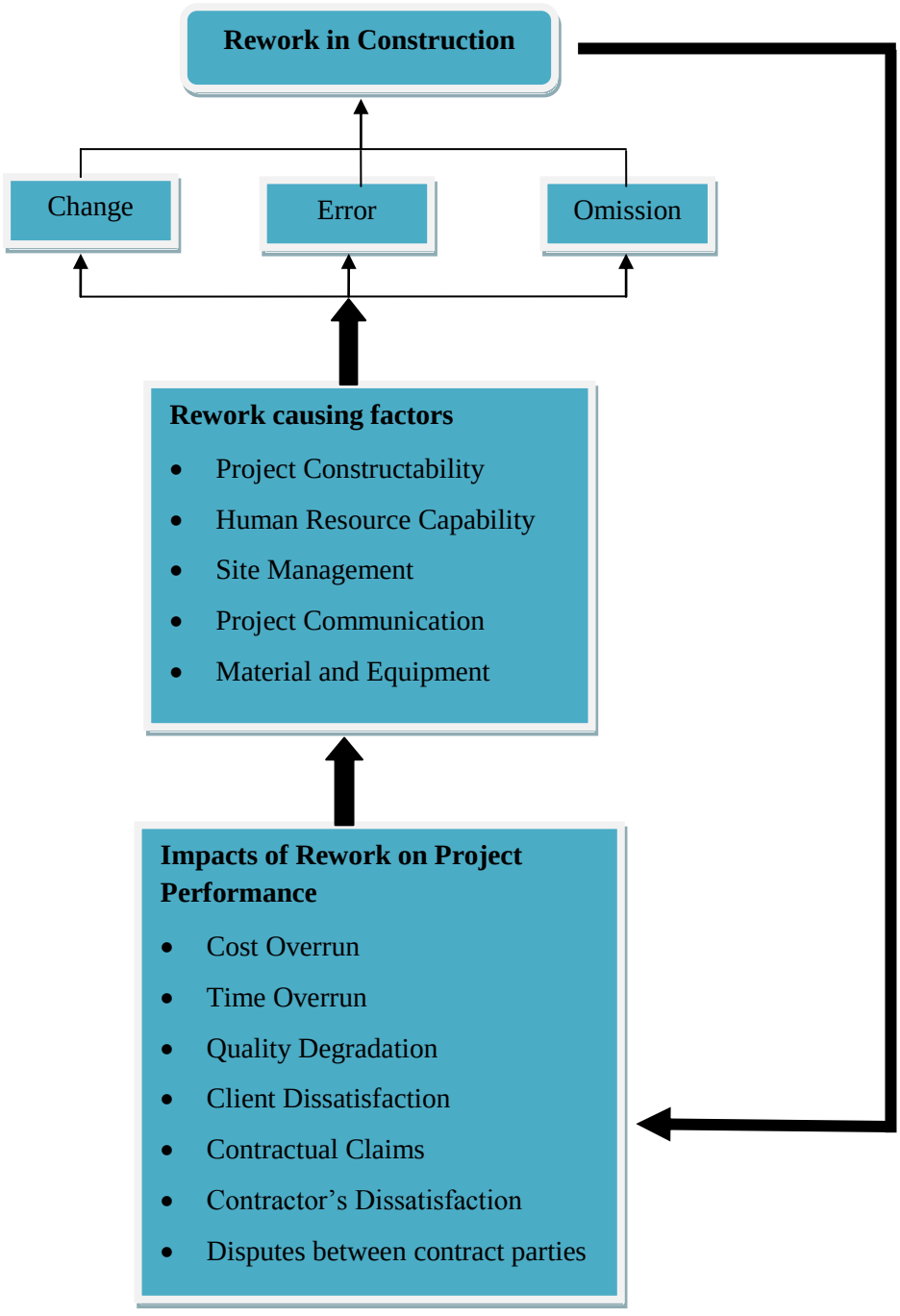


Figure 2- 6 Conceptual framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter includes the methodology used in order to meet the objective of the study. This section specifically explains in detail about the research approach and design, population and samples, data collection tools used, data analysis and ethical considerations.

3.2 Research approach and design

To meet the objectives of the study, both quantitative and qualitative (mixed) research approach was adopted. The advantage of using a mixed approach is to cover the weakness of each approach with the strength of the other approach (Mark, 2009).

According to Creswell (2003) quantitative research approach count things, analyses data statistically and quotes results in numeric forms. This approach is used to find facts based on evidence or records. The method relies on experiments and surveys to collect measurable data (Creswell, 2003). Therefore a quantitative research approach was adopted to rank the causes, impacts of rework and to find out the measures taken so far to minimize reworking through survey strategy.

As stated by Creswell (2003), a qualitative research approach measures attitude based on opinions, views and perceptions measurement. The objective of this approach is to develop understanding and to explain the phenomenon. Therefore a qualitative research approach was adopted to grasp the opinions (recommendations) of respondents towards rework minimization methods through a survey. In addition, this approach was implemented to explain the rework phenomenon by identifying how it happened, the root cause and the responsible party using existing building projects.

As a research design, descriptive design was selected based on the research questions. According to Naoum (2007), descriptive research is used to describe a specific population or a phenomenon and to answer the "what" question. As it is stated earlier, the objectives of this study are mainly to identify the major causes and overall impacts of rework and the measures taken to reduce reworking. So the reason behind using the descriptive design is because all of the research

questions are towards answering the "what" and are explaining or describing the rework phenomenon.

As a research strategy, a survey was used to answer the study questions. The survey strategy was used to identify the major causes, the impacts of rework and the measures taken for minimizing reworking.

As stated by Naoum (2007), surveys are used to obtain data from a large number of samples within a short period of time. Thus, when data is collected from a defined sample, a generalized result can be obtained. The total number of the sample for this study is 118. As a result, to obtain data from this number of sample within a limited time, a survey was chosen as an applicable research strategy. In addition, Mark et al., (2016) stated that a survey strategy is usually used for a descriptive research approach and allows the researcher to collect quantitative data. As it is stated above, this study has a quantitative approach followed by a descriptive design and to obtain data from a number of samples, a survey strategy was used. So the questions what are the major causes and impacts of rework and what measures are taken to reduce reworking were answered through survey strategy.

3.3 Population and sampling

This study focused on rework in the construction phase of a building project. As a result, the population of the study was registered contracting companies who are working in Addis Ababa. According to the list which was collected from the Addis Ababa construction bureau, there are a total of around 1720 building contracting companies who are registered from level one to level six. So it's not possible to take all of these groups so it is a must to decide which group to take as a sampling frame.

From the general population of the study, as a sampling frame, building contractor one (BC1), building contractor two (BC2), and building contractor three (BC3) were selected as a sampling frame for the study.

Based on the obtained list of registered contacting companies from the Addis Ababa Construction Bureau, the total number of registered contracting companies as building contractors one, two and three are 149.

BC1= 65

BC2= 37

BC3= 47

Total = 149 building construction companies

Therefore, the sampling frame was contracting companies of BC1, BC2 and BC3 who are registered by the Addis Ababa construction bureau were selected for this study. So the targeted respondents of the questionnaire were construction professionals who are working on these construction companies. This includes project managers, site engineers, and office engineers.

Since it is impractical and costly to take all of the targeted population, it was a must for this study to take a sample. Due to this the sample size for this study was calculated using Yamane's formula (1967). This equation is applicable to calculate a sample size with a known sampling frame. The sample size was calculated as follows

$n_{Yamane} = N / (1 + Ne^2)$……..(3.1)

Where, n = sample size

N = known population size

e = error level (in this case it is 5% with a confidential interval of 95%)

For Building Contractor 1 (BC1)

Total Number of BC1= 65

$n_{Yamane} = N / (1 + Ne^2)$

= 65/ (1+65*0.0025)

= 56

For Building Contractor 2 (BC2)

Total Number of BC2= 37

$n_{Yamane} = N / (1 + Ne^2)$

= 37/ (1+37*0.0025)

= 20

For Building Contractor 3 (BC3)

Total Number of BC3 = 47

$n_{Yamane} = N / (1 + Ne^2)$

$= 47/ (1+47*0.0025)$

$= 42$

Table 3- 1 Sample size of the study

Class	Number of companies (population)	Sample
BC1	65	56
BC2	37	20
BC3	47	42
Total	149	**118**

The probability sampling method was used to give equal opportunity for the targeted population of the study. This sampling method is most commonly associated with survey research strategies (Mark et al., 2016). As opined by the authors, selecting random numbers allows us to select a sample without bias. So the sample which is selected randomly can be said it is representative to the targeted population. Besides, the authors stated that simple random sampling is best used when there is an easy and accessible sampling frame that lists the population and for a few hundred target population. Otherwise, the sample selected will have a probability of being biased. As a result, to give the targeted population an equal probability of getting into the sample, its high accuracy of representation and the availability of the lists of contracting companies, simple random sampling was used to select the sample for this study.

3.4 Data sources and data collection tools

Data sources

The study used both primary and secondary data sources to obtain sufficient and relevant data that was used to answer the research questions. The primary sources were gathered through questionnaires and semi-structured interview which includes a discussion made with the construction professionals. Whereas the secondary data sources were collected from available organizational documents especially site book, status reports, bill of quantity files were reviewed and used.

Data collection tools

I. Questionnaire

As it is stated by Mark et al., (2016), a questionnaire is the most widely used method in survey strategy. As the authors suggested, it is because the respondents were asked to respond to the same questions which will provide an effective way to collects responses from a large sample before making quantitative analysis. To obtain the needed data, a structured questionnaire was used as a data collection tool, due to the sample size and the quantitative approach of the study.

Questionnaire design

The questionnaire was undertaken as a data collection tool to identify the major causes of rework and the measures taken to minimize it. The questions were prepared to be filled with construction professionals who are directly involved in the construction phase. Based on the objective of the study the questions were classified into four sections. All of the questions are closed-ended except for the last one.

Section A: Respondent's identification

This section is included to obtain information about the respondents. The questionnaire includes the three important questions which are; category of the firm, position and year of experience in the company they are working.

Section B: Causes of rework

This section is of the questionnaire was added to answer the first question of the research. About 33 causes with five groups were identified from different literature reviews and then the respondents were asked to identify the level of agreement on the identified factors to be the cause of rework on their project.

Section C: Impacts of rework

This section of the questionnaire was added to answer the second question of the study. In this section, all impacts collected from the literature review and modified in the pilot study were listed. The respondents were asked to identify which of the listed rework impacts more affected their project performance.

Section D: Measures taken to reduce rework

This section of the questionnaire was added to answer the third question of the study. About 12 rework reduction measures were collected from different studies and the respondents were asked to indicate the degree in which the listed measures were taken to reduce rework in their project.

At last, an open-ended question was raised for the respondents to add if there were any methods used in their site and if there are any recommendations they want to give to minimize rework in building projects (attached on appendix A).

Measurement of scales

As stated by Naoum (2007), understanding the level of measurement is essential to be able to select the appropriate method of analysis and for each type of measurement. According to the author, the Likert scale, an assumption that shows each item on the scale has equal attitudinal value.

In this research, a five-level Likert scale was used depending on the questions. To rate the rework causing factors a range from strongly agree to strongly disagree was used. On the other hand from very high influence to very low influence was the rating scale used to rate the impacts of rework. Finally, to rate the extent of implementation of rework reduction methods, a rating scale ranges from a very large extent to not at all.

II. Semi structured interview

As stated by Mark et al., (2016) semi-structured interview is a qualitative data collection tool in which the interviewer does not strictly stick to formal questions rather has a list of a generally listed theme and a list of some key questions. In this study, a semi-structured interview was carried out to collect data from the three projects selected. The data obtained through this tool was about a general description of the project, the rework phenomenon and; the root causes of the rework incidence. Identifying the root causes of rework was used for triangulating the responses obtained from the questionnaire survey. During the interview period, the questions varied depending on the rework incidents but a general framework work prepared to guide the questions (attached on appendix B).

III. Document review

To obtain the additional material, equipment and labor cost incurred due to rework, the researcher reviewed site documents specifically site book and bill of quantity. A site book is a book that is found on a construction site in which daily construction activities will be recorded. So using these documents the researcher was able to quantify the additional cost incurred due to rework.

3.5 Procedures of data collection

The first step taken to collect the needed data was preparing the questionnaire. So based on the reviewed literature rework causal factors were identified. After that, the content validity and reliability of the questionnaire were checked using the following two tests.

A. Validity

"Validity, in essence, refers to the appropriateness of the measures used, the accuracy of the analysis of the results and generalisability of the findings" (Mark et al., 2016: p.202). According to the authors, validity in terms of questionnaire refers to the ability of the instrument to measure what was intended to measure. Among the different types of validity, content validity is one of the types which show whether the investigated questions are covered by the instrument or not. To do this a pilot study was carried out before distributing the questionnaire. The process involves giving the questionnaire to some number of respondents who have knowledge of that area to give comments on it. To test the content validity, the questionnaire was distributed by attaching it with the objective and research questions to ten experienced professionals who are currently working on the construction industry and academic areas. After that, the questionnaire was modified based on the received comments and distributed to the targeted populations.

B. Reliability

As stated by Mark Saunders et al., (2016: p.202) reliability refers to "replication and consistency" which means if a study can be replicated by an earlier design and one can achieve the same results, that study can be seen as reliable. According to the authors, Cronbach's alpha is a value that ranges between 0 to 1 and used to measure the internal consistency by checking if the items in the data collection instrument measure similar things or not. In this study, this coefficient was used to measure the reliability of the questionnaire. As shown in the table below, the alpha coefficient was calculated for each scaled group factors and the entire questionnaire. As the result indicated the result of each group ranges from 0.7 to 0.9 and the overall alpha coefficient was 0.87 which satisfies the reliability test requirement. After obtaining these values, the researcher proceeded to the data analysis step.

Table 3- 2 Summary of Cronbach's Alpha results

Statement	Cronbach's Alpha Coefficient
Cause of rework: Project constructability	0.78
Cause of rework: Human resource capability	0.78
Cause of rework: Site management	0.74
Cause of rework: Project communication	0.8
Cause of rework: Material and equipment	0.8
Impact of rework on project performance	0.76
Measures taken to reduce rework	0.92
All Questions	0.87

3.6 Methods of data analysis

Since the research design used to meet the objectives was descriptive, descriptive statistics that involve both measures of central tendency (mean, median, and mode) and measures of dispersion (standard deviation) were used to analyze the ordinal data using SPSS software. At last, the collected data were presented in tables and graphs.

I. Relative Importance Index (RII)

The RII method was implemented to determine the ranks of all factors listed in the questionnaire. The score for each factor was calculated by summing up the scores given to it by the respondents. After calculating the RII value, the factors were ranked based on their respective values. The relative importance index (RII) was calculated using the following formula (Sambasivan and Soon, 2007).

$$RII = \frac{\sum PiUi}{N\,(n)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.2)$$

$(0 \leq RII \leq 1)$Where,

RII = Relative Importance Index

Pi = respondent's rating of cause of rework (From 1 to 5)

Ui = number of respondents placing identical weighting/rating on cause of rework

N = sample size

n = the highest attainable score on cause of rework (i.e. 5 in this case)

II. Rework cost calculation

To calculate the additional cost incurred due to rework of the sheet consists of six columns which include rework description, causes of rework, additional material, labor, and equipment cost incurred due to rework and finally the responsible body for reworking (attached in appendix C).

To fill the sheet, a detailed discussion was made with the construction professionals by refereeing the site book and bill of quantity. After the data was obtained, the quantification calculation was done using a known and commonly used formula which was developed by (COAA, 2001). The formula was developed to quantify the impact of rework on the cost performance of a construction project; here is the formula used for the study.

$$\textbf{\% Field Rework} = \frac{\textbf{Total cost of rework performed}}{\textbf{Total construction phase cost}}$$

Total cost of rework performed= Total direct field cost of rework +
Total Indirect field cost of rework

Total direct cost of rework= ∑ Direct field labor and supervision cost of rework
+ Direct equipment cost of rework
+ Material cost of rework
+ Subcontract cost of rework
+ Vendor's and supplier's cost of rework

For this study

- Only the direct field cost of rework was considered because the indirect cost is difficult to quantify in a monetary item,
- Total cost of rework performed is the sum of additional material, labor and equipment cost incurred due to rework till the current phase of the construction,
- Total construction phase cost is the total cost of construction till the current phase.

3.7 Ethical considerations

Throughout the process of doing the study, the ethical requirements of a study were carried out. First, when reviewing secondary data from journals, articles, proceedings and related sources, every source used was acknowledged both in-text citation and referencing. Secondly, making any interaction with participants was carried out after giving the letter the university prepared for this purpose. It is specifically declared on the questionnaire that the participation of the respondents is purely voluntarily. Finally, the respondent's name and the organization were not stated in any of the study parts so every respondent was anonyms and their response was confidential.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This section illustrates in detail about the results and discussion of the collected data using survey. The major cause factors, major impacts of rework on project performance, measures taken to reduce it in the construction sites of the three building construction companies were identified in the survey results.

The questionnaire have four major sections which includes respondents identification, rework causing factors categorized in five groups, impacts of rework, measures taken to reduce rework and an open ended question which was used to collect the opinion of the respondents towards minimizing reworking in Ethiopian construction industry.

A. Respondent's firm level

This section of the questionnaire was prepared to classify the respondents contracting firm. As shown in Table 4-1, the respondents were consisted of (46%) construction companies of BC1, 14 construction companies of BC2 and 34 construction companies of BC3 depending on the population number.

Table 4-1 Respondent's firm level

Firm level		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BC1	41	46.1	46.1	46.1
	BC2	14	15.7	15.7	61.8
	BC3	34	38.2	38.2	100.0
	Total	89	100.0	100.0	

Source: Survey (2019)

Out of 118 questionnaires distributed in three construction companies, 89 of them were received with a response rate of 75.4%. The rest of the questionnaires were not used in the analysis process because 11 of them were not received and the rest 18 of the respondents gave incomplete and illogical responses.

B. Respondent's position

The questionnaires were received from 89 professionals who are working in different position within their construction company. As shown in figure 4-2, the respondents position illustrated that 73% of the respondents were project managers and site engineers.

Table 4- 2 Respondent's work position

Position		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Project Manager	29	32.6	32.6	32.6
	Site Engineer	36	40.4	40.4	73.0
	Office Engineer	15	16.9	16.9	89.9
	Foremen	9	10.1	10.1	100.0
	Total	89	100.0	100.0	

Source: Survey (2019)

C. Years of work experience

According to the 89 received questionnaires, 21 (23.6%) of the respondents have 1-5 years of experience, 28 (31.5%) have 6-10 years of experience, 25 (28.1%) have 11-15 years of experience and 15 (16.8%) of the respondents have more than 15 years of experience. In general, more that 50% of the respondents have ≥ 10 years of work experience. So it can be said that the given answers have a good accuracy.

Table 4- 3 Respondent's years of experience

Years of experience		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5 years	21	23.6	23.6	23.6
	6-10 years	28	31.5	31.5	55.1
	11-15 years	25	28.1	28.1	83.1
	> 15 years	15	16.9	16.9	100.0
	Total	89	100.0	100.0	

Source: Survey (2019)

4.2 Factors Causing Rework

This section of the questionnaire was designed to obtain data about the top major rework causing factors among the three construction companies. In order to obtain that, a list of frequent rework

causing factors were identified from literature review and modified based on the feedbacks collected from the pilot study. After that, a list of 33 rework causing factors were selected and grouped in to five groups as causing factors related to project constructability, human resource capability, site management, project communication and; material and equipment.

The rank of the five categories and each 33 causing factors were analyzed using descriptive statistics and ranked using Relative Importance Index (RII) value. According to the obtained results first the five groups were ranked as follows.

Table 4- 4 Rework cause categories

Cause Categories	N	Mean	SD	RII	Rank
Human Resource Capability	89	3.8587	0.65	0.77	1st
Project Communication	89	3.8067	0.69	0.76	2nd
Project Constructability	89	3.7000	0.50	0.74	3rd
Site Management	89	3.6404	0.71	0.73	4th
Material and Equipment	89	3.5712	0.73	0.71	5th

Source: Survey (2019)

As shown in the above table, the top three major causes of rework were found to be in the categories of human resource capability, project communication and project constructability. Most of the categories have a mean value which is greater than 3.6 that indicate each of the selected causing factors were agreed by the respondents. Each of these five groups are discussed in detail according to their rank; after that the top three rework causing factors from each category are discussed below.

4.2.1 Factors related to human resource capability

From the selected five rework causing categories, human resource capability was ranked first with mean value of 3.8 and RII value of 0.77 which lies high to medium level of importance. Construction as a whole is a team work which needs most of human's participation. As a result, the output will mainly be depends up on the performance of the human force used.

Most of the studies reviewed indicated that the capability of the human resource used is the major rework causing factor that determines the probability of facing reworking; a skilled human

resource will decrease the probability of rework occurrence (Fayek et. al., 2003; Josephson et al., 2002; Hwang, et al., 2009; Simpeh, 2012; Enshassi et al., 2017). The result of Fayek et al., (2003) and Enshassi et al., (2017) ranked human resource capability as the second major cause for the occurrence of rework, whereas Josephson et al., (2002) ranked this rework category as first rework causing factor in construction phase of a building projects; which is the same as this study.

Seven rework causes were selected under the human resource capability category. Respondents were asked to indicate their level of agreement on the listed rework causing factors. Based on the received responses the factors were ranked as indicated in the table below.

Table 4- 5 Factors related to human resource capability

Human Resource Capability					
Rework causing factors	**Mean**	**S.D**	**RII**	**Rank**	**Overall Rank**
Use of an insufficient skill level manpower	4.11	1.071	0.822	1st	2nd
Defective workmanship	4.06	0.946	0.812	2nd	3rd
Carelessness of workers(laborers)	3.89	0.982	0.778	3rd	8th
Lack managerial and supervisory skills	3.89	1.049	0.778	3rd	8th
Lack of exhaustive experience	3.84	1.076	0.768	5th	10th
Reduction of motivation to work	3.73	0.902	0.746	6th	15th
Random human error	3.49	0.955	0.692	7th	29th

Source: Survey (2019)

Respondents ranked *"Use of an insufficient skill level manpower"* as the first cause of rework causing factor with the mean value of 4.11 and RII value of 0.82. This rework causing factor is further ranked 2nd from the total 33 factors.

Construction as a whole needs the participation of manpower because of its labor intensive project character. According to Meshksarr (2012) one of the major problems which affect a project's performance is using an insufficient skill level of manpower. Studies which are carried out in this area indicated the use of insufficient skill level manpower as the top major rework causing factor. For instance Alwi et al., (2001), Simpeh (2012), and Zaiter, (2014) ranked it as second major factor for the occurrence of reworking.

Based on the responses, *"Defective workmanship"* was ranked as the second rework causing factor with mean value of 4.06 and RII value of 0.81. This rework causing factor further ranked as 3rd from the total 33 factors. This result directly relates to the use of insufficient skill level manpower which is indicated as the first rework causing factor in this category. It will not be expected to obtain a good quality output if an insufficient level skill manpower is used rather a defected output is expected. As a result, the top two factors are highly related to each other. According to the studies which were carried out in this area indicated poor workmanship as one of the major rework cause factor related to human resource capability Fayek et al., (2003) , Mastenbroek (2010) and Simpeh (2012). But mostly Josephson et al., (2002) ranked this factor as the first cause for reworking. According to their result, workmanship as a whole takes 20% of the total rework cost and from that, erroneous workmanship takes the 65% of it. The study ranked this cause factor first from the whole.

According to the responses collected, respondents ranked both *"Lack of managerial and supervisory skills"* and *"carelessness of workers (laborers)"* as 3rd factor with mean value of 3.89 and RII value of 0.778. Since most of the construction workers daily laborers who does not have detailed knowledge about construction, attention must be given on the skill of the site engineers and supervisors. Alwi et al., (2001) ranked the factor as second where as; Fayek et al., (2003),Palaneeswaran et al., (2005) and Simpeh (2012) ranked this causing factor as third; which is the same as this study. On the other hand, the factor carelessness of workers was first identified by Love et al., (2009) in the category of error and the researchers ranked this cause as the second rework causing category. According to them carelessness of workers might be developed from low motivation and/or insufficient supervision.

4.2.2 Factors related to project communication

From the selected five rework causing categories, causes related to project communication was ranked second with mean value of 3.8 and RII value of 0.76 which lies high to medium level of importance. This rework cause factor indicates any information flows, communications and instructions given and received among the client, contractor, and consultant of the building project during construction phase. Under the project communication category, 5 rework causes were selected. Respondents were asked to indicate their level of agreement on the listed rework causing factors. Based on the received responses the factors were ranked as indicated in the table below.

Table 4- 6 Factors related to project communication

Project Communication					
Rework causing factors	**Mean**	**S.D**	**RII**	**Rank**	**Overall Rank**
Change instructions given by the client after some work had been carried out	4.17	0.882	0.834	1st	1st
Insufficient communication between project stakeholders (client, consultant, contractor)	4.04	0.976	0.808	2nd	4th
Poor communication path of project instructions	3.80	0.932	0.76	3rd	13th
Inadequate communication of the client's need and priorities among the project team	3.65	0.918	0.73	4th	19th
Insufficient briefing has been given to the client	3.37	0.934	0.674	5th	30th

Source: Survey (2019)

Respondents ranked *"Change instructions given by the client after some work had been carried out"* as the first rework causing factor with the mean value of 4.17 and RII value of 0.834. This rework causing factor was also ranked 1st from the total 33 factors.

The factor change instruction illustrates the change orders which includes change in project scope and/or modification of project function which came from the client after some or the whole work is completed. Studies related to rework included this factor as the major cause of rework. For instance Love (2002) stated that this factor contributed 48% of rework cost.

On other study, Simpeh (2012) ranked this cause as 2nd in its own category. In addition to this, Mastenbroek (2010) stated this factor as change in clients wish in construction phase and ranked this factor as 1st both in its group and from the whole identified rework cause factors the same as this result.

The second cause identified based on the responses was *"Insufficient communication between project stakeholders"* with mean value of 4.04 and RII value of 0.808.This rework causing factor ranked 4th from the total cause factors. Communication as a whole is vital for any project otherwise the output will be full of changes and errors that will lead to rework. So the

coordination of the major stakeholders is very much important for decreasing reworking by reducing the occurrence of changes and errors.

The cause factor communication between clients, consultants and contractors was raised first by Love (2004) in his rework cause classification study. Simpeh (2012), Mahamid (2016) and Hussein (2014) gave focus for this rework cause factor and ranked it. Both Simpeh (2012) and Hussein (2014) ranked this factor first from the category and Mahamid (2016) ranked this factor as 1st both in its own category and the whole 43 selected rework factors for his study. The ranking given is not exactly the same with this study but still the studies showed that the factor lies in the top.

According to the responses collected, *"Poor communication path of project instructions"* ranked third from the category with mean value of 3.8 and RII value of 0.76. This cause factor ranked 13th from the total identified rework cause factors. This factor illustrates poor flow of instruction among the project participants. This includes the instruction path flow which starts from the upper project manager to the lower daily laborer. According to the study of Ye et al., (2014), this rework factor cause was ranked 1st in its own project communication management category and ranked 9th among 39 selected rework causes.

4.2.3 Factors related to project constructability

From the selected five rework causing categories, causes related to project constructability was ranked third with mean value of 3.7 and RII value of 0.74 which lies high to medium level of importance. This category indicates the rework causing factors which might come from problems exactly during the construction process. Under the project constructability category, 10 rework causes were selected. Respondents were asked to indicate their level of agreement on the listed rework causing factors. Based on the received responses the factors were ranked as indicated in the table below.

Table 4- 7 Factors related to project constructability

Project Constructability					
Rework causing factors	**Mean**	**S.D**	**RII**	**Rank**	**Overall Rank**
Error due to incomplete/faulty design	3.96	0.796	0.792	1st	5th
Use of insufficient construction methods	3.94	0.981	0.788	2nd	6th
Non- compliance of work with specification	3.72	0.879	0.744	3rd	16th
Changes in construction methods due to site conditions	3.71	0.869	0.742	4th	17th
Ineffective use of construction standards	3.71	1.199	0.742	4th	17th
Constructability problems	3.65	0.740	0.73	6th	19th
Damages caused by subcontractors	3.64	0.968	0.728	7th	21st
Errors due to misunderstanding of drawings and specifications	3.61	1.144	0.722	8th	22nd
Attempt to fraud	3.56	1.055	0.712	9th	25th
Changes initiated to improve quality	3.52	0.854	0.704	10th	27th

Source: Survey (2019)

Respondents ranked *"Errors due to incomplete/faulty design"* as the first rework causing factor with the mean value of 3.96 and RII value of 0.792. This rework causing factor is also ranked 5th from the total 33 factors. As stated by Love, et al., (2010), incomplete / faulty design is one of the major and frequently happening problem in construction sites. According to the study, the reason behind this problem is lack of professionalism of the design team due to the small amount of payment is given and inadequate time given. Studies related to rework included this factor as the major cause of rework. For instance, Zaiter (2014) ranked this factor 4th from its own category. On the other hand, Josephson et al., (2002) ranked this factor 2nd and further explained that this factor contributes 8.1% from the total rework cost. The same way Simpeh (2012) ranked this cause factor 2nd in its own category. The result of Josephson et al., (2002) and Simpeh (2012) is very much close to this study.

The rework cause factor ranked second in this category was "*Use of insufficient construction methods"* with mean value of 3.94 and RII value of 0.788.This rework causing factor is ranked 6th from the total identified 33 factors. This factor illustrates the construction method selected and used by the contractor considering different perspectives. According to Alwi et al., (2001), wrong

selection of construction method might lead to reworking. So it's better to select the construction methods based on the perspectives of cost, reliability, applicability and other issues before starting the construction process.

According to the responses collected, *"Non-conformance of work with specification requirements"* ranked third from the category with mean value of 3.72 and RII value of 0.744. This cause factor ranked 16th from the total identified rework cause factors. The study of Ye et al., (2014), Simpeh (2012) and Zaiter (2014) indicated that the non-conformance of the executed construction activity is one of the major rework causes in construction. Different assumptions can be given for this factor. For instance it might be due to unclear specifications given from the consultant or the contractor might attempt to fraud and execute the work with low quality or different reasons can be raised. According to the result of Simpeh (2012) and Hussein (2014), this factor was ranked first from its category, whereas Zaiter (2014) ranked this factor 4th.

4.2.4 Factors related to site management

Respondents ranked the rework cause category site management as fourth with mean value of 3.64 and RII value of 0.73. This cause indicates the site management practices of the contractor which includes construction activities, labor and resources usage. A total of five selected cause factors attributed to site management categories were identified. Respondents were asked to indicate their level of agreement on the listed rework causing factors. Based on the received responses the factors were ranked as indicated in the table below.

Table 4- 8 Factors related to site management

Site Management					
Rework causing factors	**Mean**	**SD**	**RII**	**Rank**	**Overall Rank**
Inadequate supervision	3.91	1.007	0.782	1st	7th
Ineffective use of quality management practices	3.84	1.065	0.768	2nd	10th
Poor planning and coordination of resources	3.58	1.020	0.716	3rd	24th
Failure to provide protection to the executed on progress works	3.51	0.943	0.702	4th	28th
Setting out error	3.36	1.025	0.672	5th	31st

Source: Survey (2019)

Based on the results obtained from survey, respondents ranked *"Inadequate supervision"* as the first rework causing factor with the mean value of 3.91 and RII value of 0.782. This rework

causing factor is ranked 7th from the total 33 factors. Inadequate supervision illustrates the degree of the supervision level of the site engineers and supervisors towards guiding and correcting the laborers. Inadequate supervision in general has an impact on the performance of a construction project in terms of time and cost Meshksarr (2012). So when it comes to rework, even though the workers have insufficient skill, a continuous and adequate supervision has a probability of decreasing the occurrence of rework (Alwi, et al., 2001). Simpeh (2012), Hussein (2014), Mahmid (2016), Fayek et al., (2003) and Josephson et al., (2002), included inadequate supervision as one of the rework cause factors. But majorly Alwi et al., (2001) identified it as major rework causing factor in accordance with lack of supervisors' skill and lack of skilled labors.

The rework cause factor ranked second in this category was "*Ineffective use of quality management practices"* with mean value of 3.84 and RII value of 0.768.This rework causing factor is ranked 10th from the total identified 33 factors. This rework factor illustrates the quality planning, assurance and control practices in the contractor's side. Fayek et al., (2003) and Alwi et al., (2001) gave more emphasis on quality management practices on their study. According to the study of Fayek et al., (2003) this factor ranked first from its category and named the factor as lack of quality assurance and quality control practices. The same way, Alwi et al., (2001) and Palaneeswaran et al., (2005) stated lack of quality management as the major rework causing factor in Indonesian construction industry.

The rework cause factor ranked 3rd by the respondents in the site management category was "*Poor planning and coordination of resources"* with a mean value of 3.58 and RII value of 0.716. This factor is ranked 24th from the overall factors. Hwang et al., (2009), Simpeh (2012), Mahmid (2016) and Hussein (2014) identified this factor as one of the major rework causing factors in the construction industry. In addition Palaneeswaran et al., (2005) stated that poor coordination of resources and ineffective use of quality management practices as the most frequent rework causing factors in the category of site management. In this study this rework factors were ranked as 2nd and 3rd. On the other hand, Zaiter (2014) identified the factor poor planning and coordination of resources as 2nd rework cause factors, where as Simpeh (2012) and Hussein (2014) ranked this factor as 3rd causing factor from its category which is the same as this study.

4.2.5 Factors related to material and equipment

Respondents ranked the rework cause category material and equipment as fifth factor with mean value of 3.57 and RII value of 0.71. Fayek et al., (2003) illustrated this category first on their fishbone rework cause classification. In addition, Josephson et al., (2002) classified this category independently as material and equipment. The material category contributes for the 17% additional rework cost whereas; the equipment accounts 3% from the overall rework cost.

A total of six cause factors attributed to construction material and equipment categories were identified. Respondents were asked to indicate their level of agreement on the listed rework causing factors. Based on the received responses the factors were ranked as indicated in the table below.

Table 4- 9 Factors related to material and equipment

Material and Equipment					
Rework causing factors	**Mean**	**SD**	**RII**	**Rank**	**Overall Rank**
Use of poor quality of materials	3.81	1.086	0.768	1st	12th
Use of insufficient equipment/machinery	3.78	1.031	0.756	2nd	14th
Non-compliance of materials with the specification	3.60	1.041	0.747	3rd	23rd
Late delivery of materials	3.54	1.088	0.708	4th	26th
Machine/equipment breakdown and defects	3.36	1.047	0.672	5th	31st
Damage due to incorrect way of handling a machinery	3.35	1.024	0.67	6th	33rd

Source: Survey (2019)

Respondents ranked *"Use of poor quality of material"* as the first rework causing factor with the mean value of 3.81 and RII value of 0.768. This rework causing factor is ranked 12th from the total 33 factors. The factor illustrates about the quality of construction material used by the contractor. Using poor quality of material might be one of the results of poor site supervision. That is because supervision includes checking the quality of material before it is used. The other reason might be attempt to fraud. The contractor might construct the building with low quality material to get a large amount of profit. Studies related to rework included this factor as the major cause of rework. For instance, according to the study of Mahamid (2016) this cause factor was ranked 2nd in its own category. In addition to this, Ye et al., (2014) ranked this factor as 1st in its group the same as this study.

According to the responses collected, *"Use of insufficient equipment/machinery"* was ranked 2nd from the category with mean value of 3.78 and RII value of 0.756. This cause factor ranked 14th from the total identified rework cause factors. Josephson et al., (2002) gave more emphasis for rework cause factors related to machinery and separate it from material category. The study identified machine breakdown and machine not working satisfactorily as major causes of rework under this category In addition to them Ye et al., (2014) and Mahamid (2016) also identified this group and ranked the cause factor. According to the study of Mahamid (2016) and Mastenbroek (2010) the causing factor use of insufficient equipment ranked fourth in its own group; whereas Josephson et al., (2002) and Ye et al., (2014) ranked it as second in its own category the same as this study.

The rework cause factor ranked 3rd by the respondents in material and equipment category was "*Non-compliance of materials with the specification"* with a mean value of 3.6 and RII value of 0.747. This factor is ranked 23rd from the overall factors. According to the study of Josephson et al., (2002), this rework factor accounts 10% of the additional rework cost of material. The researchers ranked it as the 4th major factor of reworking related to material the same as Zaiter (2014). On the other hand, Simpeh (2012) and Fayek et al., (2003), ranked this factor as 1st and 2nd respectively on its own material and equipment category.

The following are the top five major rework cause factors from the overall 33 factors. All of them are discussed above in detail in their own category.

Table 4- 10 Top five factors causing rework

Rework causing factor	**Cause Categories**	**Mean**	**SD**	**RII**	**Rank**
Change instructions given by the client after some work had been carried out	Project Communication	4.17	0.882	0.834	1st
Use of an insufficient skill level manpower	Human Resource Capability	4.11	1.071	0.822	2nd
Defective workmanship	Human Resource Capability	4.06	0.946	0.812	3rd
Insufficient communication between project stakeholders (client, consultant, contractor)	Project Communication	4.04	0.976	0.808	4th
Error due to incomplete/faulty design	Project Constructability	3.96	0.796	0.792	5th

Source: Survey (2019)

4.3 Impacts of rework

This section of the questionnaire was designed to obtain data about the top major overall impacts of rework among the three construction companies. In order to obtain that, lists of frequent rework impacts were identified from literature review. After that, a list of seven rework impacts were selected and the respondents were given an open space to provide if there are other additional impacts they faced in their project. The rank of each identified impacts were analyzed using descriptive statistics and ranked using Relative Importance Index (RII). According to the obtained results the impacts were ranked as shown in the table below.

Table 4- 11 Impacts of rework

Impacts of Rework	Mean	SD	RII	Rank
Cost overrun	4.53	0.545	0.906	1st
Time overrun	4.49	0.586	0.898	2nd
Disputes between parties in the contract	3.91	0.973	0.782	3rd
Quality degradation	3.88	0.975	0.776	4th
Client dissatisfaction	3.84	0.940	0.768	5th
Contractual claim	3.78	0.914	0.756	6th
Contractor's dissatisfaction	3.54	0.942	0.708	7th

Source: Survey (2019)

Respondents were asked to indicate the level of the rework impacts on affecting the performance of their project on a likert scale of 1= very low influence to 5 = very high influence. Based on the obtained results, the majority of the mean results as shown in the above table indicated that almost all of the listed impacts have a high influence on the performance of a project except the impact *"Contractor dissatisfaction"* which have a moderated influence.

According to the results, cost overrun (RII = 0.906), time overrun (RII = 0.898) and disputes between parties in the contract (RII = 0.782) were the top major impacts of rework which have a high influence on the performance of a project.

The additional amount of cost and time may differ depending on different conditions but rework can lead a project to incur an additional cost which will increase project's completion date. It needs additional material, labor, machinery and other indirect costs which lead to an extension of time to correct the failures or the needed changes which Fayek et al., (2003) classified and stated as standby, rework and gear up time. On the other hand, the third impact dispute between contract

parities happens because a rework cannot be a desirable incidence for each party at the same time. For instance, if reworking is needed due to change in the client's request, the client's interest will be fulfilled but the contractor will not be happy because it is a time consuming process. As Zaiter (2014) stated, when rework arise in projects, it will be a reason for the occurrence of disputes which will gradually lead to affecting the construction time and cost. So the impacts are actually related to each other.

Simpeh (2012) in his study ranked cost and time overrun as 1st and 2nd rework impacts. Whereas he ranked disputes between the contract parties as 4th next to contractual claims. Another study which was carried out in Nigeria ranked the top three impacts of rework in engineers' perspective exactly the same as this study.

The respondents were given an option to list out if there are any additional impacts of rework other that the listed ones and the following additional impacts were collected. Out of the collected questionnaires only five of the respondents identified additional impacts. The following are the selected impacts which are only related to the project performance.

- Termination of contract,
- Damaging other works,
- Material cost rise.

4.4 Measures taken to reduce rework

This section of the questionnaire was designed to obtain data about the measures taken to reduce reworking among the three construction companies. In order to obtain that, a list of 12 measures were identified majorly from COAA (2006), CII (2001) , Zhang (2009) and Zaiter (2014) and a slight modification have been made in the pilot study. The importance of identifying the extent to which the measures are taken is to identify the current situation and figure out where actually the gaps are. This is helpful to give the right recommendations on the needed areas.

The rank of each identified measures were analyzed using descriptive statistics and ranked using Relative Importance Index (RII). According to the obtained results, the measures taken were identified as shown in the table below.

Table 4- 12 Measures taken to reduce reworking

Measures taken to reduce reworking	**Mean**	**SD**	**RII**	**Rank**
Using qualified suppliers	3.69	1.072	0.738	1st
Involving the client	3.67	1.106	0.734	2nd
Sufficient supervision	3.65	1.024	0.73	3rd
Strict resistance against fraud	3.63	1.152	0.726	4th
Using sufficient and capable human resource	3.6	1.115	0.72	5th
Developing options and to reduce reworking	3.57	1.075	0.714	6th
Identifying the root causes of rework in detail	3.5	0.827	0.7	7th
Continuous evaluation before and during the implementation of work	3.45	1.005	0.69	8th
Quantifying the impact of rework on projects performance in terms of cost and time	3.45	1.197	0.69	9th
Develop effective communication between project participants	3.43	0.865	0.686	10th
Tracking and documenting rework incidents	3.26	1.082	0.652	11th
Using effective planning and scheduling	3.25	1.151	0.65	12th

Source: Survey (2019)

Respondents were asked to indicate their level of extent in which they implement the listed measures purposely to reduce reworking on a likert scale of 1= Not at all to 5 = Very large extent. As it is shown in table 4-12, most of the mean results are hovering around 3.69 to 3.2 (i.e. from small extent to not at all). So this result clearly shows that there is a considerable amount of gap on taking serious measures to reduce rework in these three construction companies.

From the selected 12 lists of rework reduction measures, respondents agreed that they use a qualified material supplier to reduce reworking which might come from using of poor material. As a result the measure "*Using a qualified suppliers*" ranked 1st with mean value of 3.69 and RII=0.738. The mean result here indicated that most of the respondents agreed to the small extent that they are using a qualified supplier consciously to reduce reworking in their construction sites.

The second rework reduction strategy which was selected by the respondents was "*Involving the client*" with mean value of 3.67 and RII= 0.734. This strategy was proposed by CII (2005) as one of the major rework reduction methods. Involving the client on both the design and construction phase of a project will decrease the probability of the client to change his/her instructions after the work had been carried out; which is the first rework causing factor identified in this study. Even though this measure was ranked second the mean value indicated that the respondents were agreed that the client is not efficiently involved in the project. So a lot of work needs to be done in this area.

The third rework reduction measure selected by the respondents was "*Sufficient supervision"* with mean value of 3.65 and RII=0.73. This strategy was first proposed by COAA (2006) and Zhang (2009). Proper and continuous site supervision is one way of decreasing a number of rework causing factors like quality degradation, defective workmanships, attempt to fraud, errors, non-compliance of work with the specifications and the like. But like the rest of the rework measures taken, the result of this also indicated that this measure is not taken sufficiently.

From these results it can be concluded that, the construction professionals are not using rework reduction measures in an efficient level. The reason for this might be giving less attention for the issue or not having clear awareness about what a rework impact can actually brought to a project.

Responses of open ended question

In this section of the questionnaire the respondents were asked to state any of their recommendations towards minimizing reworking in building projects. The following results were obtained by collecting all of the responses in nine categories. According to the results, implementing proper planning and scheduling, effective communication between the project parties and creating awareness about rework were the major reduction measures recommended by the respondents.

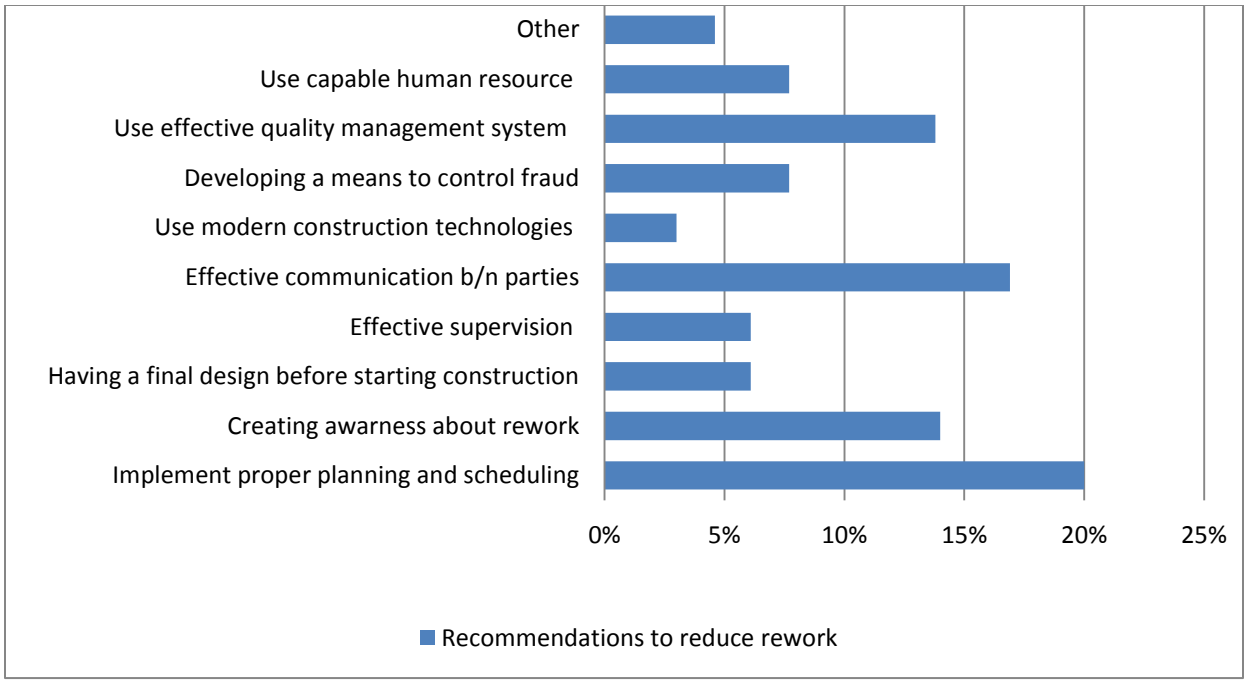


Figure 4-1 Responses of open ended question

Source: Survey (2019)

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter is consisted of three sections. The first section presented summary of major findings of the study. The second section explained about the general conclusions reached depending on the findings and finally gave recommendations for concerned bodies who can contribute towards reducing rework.

5.2 Summary of major findings

According to the collected data through questionnaires, semi-structured interviews, and site document reviews, the study revealed the following results.

- Among the identified rework causing factors, the top major cause factors were related to problems that happened due to poor communication between the project participants and problems related to using insufficient skill level manpower.
- The major cause for reworking was change of client's interest after work had been carried out which was the same as causes for the selected projects studied before the survey followed by poor supervision, poor workmanship and using poor quality of the material.
- Among the rework impacts, cost and time overrun were identified as the major ones. In addition, rework was identified as one of the reasons for the initiation of disputes between the contract parties. But above all this, the additional cost incurred due to rework was identified as the top major impact of rework on the performance of building projects.
- There was an insufficient way of tracking and documenting rework incidents in the construction sites. The root causes and impacts of rework were not sufficiently recorded to be used as a lesson learned for the next project and/or to come up with rework reduction strategies.
- From the identified rework reduction measures, the majority of the measures were not purposely implemented by the construction professionals to reduce reworking. This indicated the existence of a considerable amount of gap in taking serious measures to reduce rework.

5.3 Conclusion

The purpose of this study was to identify the causes and impacts of rework, a problem the construction industry is facing but doesn't obtain sufficient attention. Before coming to rework reduction strategies, identifying the major root causes of the problem is the first and helpful intervention. Rework in the first place is an unnecessary non-value-adding activity which can totally be reduced if applicable strategies are employed. It consumes our money energy and time for nothing.

The study identified the major rework causing factors that needs a serious intervention by the construction professionals. According to the identified causes, the top rework causing factors mainly lies in the category project communication and Human resource capability. In the communication category, continuous change instructions made by the client were the major cause factor for the occurrence of rework. It has been frequently stated that communication is vital for the success of a project especially for a construction project which needs teamwork. So the practical implication of this research is that reduction of rework requires the collaboration and sufficient communication between the 3 C's (client, consultant, and contractor) and needs using a capable human resource from the beginning to the end of the project in addition to using.

The other point of this research was that as different researchers indicated, the degree of attention given to the consequences of rework is insufficient. Let alone the measures taken to reduce rework, the researcher find out that the rework incidences are not even recorded sufficiently as rework event. Due to this, showing the impacts of rework in the cost performance of a project was used as a way of creating awareness and consciousness towards reducing the problem.

Finally, the reduction of rework needs the coordination of the construction parties towards the development of the reduction strategies. To do this, the attention given to this issue needs to be increased with more studies by extracting additional cause factors through considering additional views of owners and consultants. Besides, the impact of rework on time performance need also be considered in further studies. That way, an applicable and efficient rework reduction strategies will be introduced and proved that rework is not an inevitable problem faced in the construction industry.

5.4 Recommendations

Based on the obtained results, the following recommendations were given to the major project participants to reduce rework on construction phase of building projects.

- In the design phase of the project, the consultant and the client need to communicate exhaustively towards the scope of work based on the client's interest. They need to make a scheduled meeting program with a specific time interval like at the beginning of the design, after the completion of 20% of the design, after the completion of the 60% of the design and after the final completion. In these processes, if the client is not able to do this, he/she can hire a professional consultant to do the task who will facilitate the communication between the contract parties. This will be helpful to minimize the client's change instruction after work had been carried out. Much work needs to be carried out in the design stage because it is better to rework the design that the constructed activity.

- Whenever the contractor is not responsible for the design work, the design work needs to be discussed in detail about its constructability and completeness issues with the consultant prior to the commencement of the construction phase. This can be achieved by taking some time (depending on the project type) by the contractor's professional (could be site engineers) to make a detailed review of the design. If there are any problems, it needs to be corrected by the consultant before the construction phase is started. That way the rework incidents happening due the faultiness and incompleteness of designs can be reduced.

- The construction industry by itself is a labor-intensive industry. As a result, working on making an effective and efficient human resource can reduce a lot of problems in the industry. Here also, two out of the three major rework causes came with the capability of human resources. Due to this, both the contractor and consultant should use capable human resources in doing both the design and supervision works. Their efficiency can be increased by giving training regarding project planning and scheduling methods, quality management, project communication and the like depending on the identified gaps.

- A continuous rework recording system should be developed by both the consultant and the contractor side based on the responsible body for that rework incident. To do that, a sheet can be developed to record the rework events happened, the major causes and every additional cost and time incurred due to the rework. This will be helpful to increase the consciousness of the project parities about the magnitude of rework and its impact on the performance of their project. As a result, the professionals will gradually come up with rework reduction solutions. In addition, the collected data can also be used as a lesson learned not to be repeated in other projects.

- Effective supervision should be carried out by the contractor's side. The labor force which is used in the construction industry doesn't have detailed knowledge about the construction methods. Due to this, closer supervision needs to be carried out to decrease the poor workmanship, which is identified as one of the major rework cause factors. So that the supervision work shouldn't be the only assignment of the consultant, the contractor should also give attention towards supervising the labor force.

5.4.1 Recommendations for further study areas

This study was carried out in the building contracting companies of one; two and three so further studies should be made on the rest of the construction companies to identify additional root causes of reworking. Besides, further studies should include the perspective of consultants and clients in this area. Furthermore, this study only showed the additional cost incurred in relation to labor, equipment, and material as a result, the indirect costs need to be identified to give an increased awareness about the impact of reworking.

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APPENDIX A

Questionnaire

Project Management Department

M.A thesis on Project Management

Dear Respondent,

I am kindly requesting your willingness to participate in this research "**Identifying the Major Causes and Overall Impacts of Rework in Addis Ababa Building Construction Projects**" by filling this questionnaire. Any information you are willing to provide will be greatly appreciated.

The objective of this research is to identify the major causes of rework and its impact on the performance of building projects, and to examine the measures taken so far to minimize it.

All the data collected will only be used for academic purpose. If you have any inquiry please feel free to contact me through the provided addresses.

Thank you for giving 15 minutes of your time and your kind cooperation for the research.

Contact Address

Samrawit Tsegaye

E-mail: Samrisha19@gmail.com

Phone No: 0913733985

Code ----

Rework in this study is defined as ***an unnecessary effort of redoing a construction activity that was wrongly carried out the first time***.

- **Please note that it is very important that each question are read carefully and answered consciously.**

Please tick or write in words as required on the space provided at your convenience to respond the questions.

SECTION A: RESPONDENT'S IDENTIFICATION

1. Category of your firm: Level

[1] BC1 ☐

[2] BC2 ☐

[3] BC3 ☐

2. Your position in the company

[1] Project Manager ☐

[2] Site Engineer ☐

[3] Office Engineer ☐

[4] Forman ☐

[5] Other please specify ----------

3. For how long have you been working on the construction industry?

[1] 1-5 years ☐

[2] 6-10 years ☐

[3] 11-15 years ☐

[4] >15 years ☐

SECTION B: Rework Causing Factors

4. The following are selected factors that might be causes for the occurrence of rework in construction projects. Please indicate your level of agreement on the following statements regarding to your project.

A. Cause factors related to Project Constructability		**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**
1.	Errors due to incomplete/faulty design					
2.	Use of insufficient construction methods					
3.	Errors due misunderstanding of drawings and specifications					
4.	Attempt to fraud					
5.	Changes initiated to improve quality					
6.	Non compliance with specification					
7.	Changes in construction methods due to site conditions					
8.	Constructability problems					
9.	Damages caused by subcontractors					
10.	Ineffective use of construction standards					
B. Cause factors related to Human Resource Capability		**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**
1.	Use of an insufficient skill level manpower					
2.	Lack of exhaustive experience					
3.	Reduction of motivation to work					
4.	Lack managerial and supervisory skills					
5.	Random human error					

6.	Carelessness of workers(laborers)					
7.	Defective workmanship					
C. Cause factors related to Site Management		**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**
1.	Ineffective use of quality management practices					
2.	Failure to provide protection to the executed on progress works					
3.	Poor planning and coordination of resources					
4.	Inadequate supervision					
5.	Setting out error					
D. Cause factors related to Project Communication		**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**
1.	Insufficient communication between project stakeholders (client, consultant, contractor)					
2.	Poor communication path of project instruction					
3.	Inadequate communication of the client's need and priorities among the project team					
4.	Change instructions given by the client after some work had been carried out					
5.	Insufficient briefing has been given to the client					

E. Cause factors related to Material and Equipment		Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
1.	Use of poor quality of materials					
2.	Non-compliance of materials with the specification					
3.	Late delivery of materials					
4.	Use of insufficient equipment/machinery					
5.	Damage due to incorrect way of handling a machinery					
6.	Machine/equipment breakdown and defects					

SECTION C: IMPACTS OF REWORK ON PROJECT PERFORMANCE

5. The following are identified impacts of rework. Please indicate the level of their influence on affecting the performance of your project.

	F. Impacts of rework	Very high influence (5)	High Influence (4)	Moderate influence (3)	Low influence (2)	Very low influence (1)
1.	Cost overrun					
2.	Time overrun					
3.	Quality degradation					
4.	Client dissatisfaction					
5.	Contractual claims					
6.	Contractor's dissatisfaction					
7.	Disputes between parties in the contract					
	Other					
1.						
2.						

SECTION D: MEASURES TAKEN TO REDUCE REWORK

6. Please indicate the degree in which the following measures are taken purposely to reduce rework in your project.

G. Measures taken to reduce rework		**Very large extent (5)**	**Large extent (4)**	**Small extent (3)**	**Very small extent (2)**	**Not at all (1)**
1.	Using sufficient and capable human resource					
2.	Sufficient supervision					
3.	Developing effective communication between project participants					
4.	Continuous evaluation before and during the implementation of work					
5.	Involving the client					
6.	Using effective planning and scheduling					
7.	Using qualified suppliers					
8.	Strict resistance against fraud					
9.	Tracking and documenting rework incidents					
10.	Identifying the root cause of rework in detail					
11.	Developing options and actions to reduce reworking					
12.	Quantifying the impact of rework on project performance in terms of cost and time					
	Other					
1.						
2.						
3.						

7. Do you have any recommendations to reduce rework in Ethiopian building construction projects?

Thank You Very Much!

APPENDIX B

Semi Structured Interview Questions

1. Can you give me a general explanation about your project?
2. Can you explain how the rework incident occurred in your project site?
3. What was the root cause for the rework incident?
4. Who took the responsibility and covered all of the incurred costs?
5. Do you consciously record rework incidents and their impact? If yes, how?

APPENDIX C

Rework Recording Sheet

NO.	Rework description	Causes of rework	Additional material cost incurred due to rework	Additional labor cost incurred due to rework	Additional equipment cost incurred due to rework	Total Additional cost incurred due to rework	Who was responsible?
1.							
2.							
3.							

APPENDIX D

Overall Results of Rework Causing Factors

		Frequency								
Rework Cause Factors	**N**	1	2	3	4	5	**Category**	**Mean**	**SD**	**RII**	**Rank**
Change instructions given by the client after some work had been carried out	89	-	7	7	39	36	Project Communication	4.17	0.882	0.834	1st
Use of an insufficient skill level manpower	89	3	7	7	32	40	Human Resource Capability	4.11	1.071	0.822	2nd
Defective workmanship	89	2	6	13	44	24	Human Resource Capability	4.06	0.946	0.812	3rd
Insufficient communication between project stakeholders (client, consultant, contractor)	89	2	5	13	36	33	Project Communication	4.04	0.976	0.808	4th
Error due to incomplete/faulty design	89	-	7	9	54	19	Project Constructability	3.96	0.796	0.792	5th
Use of insufficient construction methods	89	3	5	12	43	26	Project Constructability	3.94	0.981	0.788	6th
Inadequate supervision	89	3	8	7	47	24	Site Management	3.91	1.007	0.782	7th
Carelessness of workers(laborers)	89	1	10	12	41	25	Human Resource Capability	3.89	0.982	0.778	8th
Lack managerial and supervisory skills	89	4	6	12	41	26	Human Resource Capability	3.89	1.049	0.778	8th
Lack of exhaustive experience	89	4	9	8	44	24	Human Resource Capability	3.84	1.076	0.768	10th

Rework Cause Factors	N	1	2	3	4	5	Category	Mean	SD	RII	Rank
Ineffective use of quality management practices	89	3	10	10	41	25	Site Management	3.84	1.065	0.768	10th
Use of poor quality of materials	89	2	13	11	37	26	Material and Equipment	3.81	1.086	0.768	12th
Poor communication path of project instructions	89	1	9	16	44	19	Project Communication	3.80	0.932	0.76	13th
Use of insufficient equipment/machinery	89	1	13	14	38	23	Material and Equipment	3.78	1.031	0.756	14th
Reduction of motivation to work	89	3	4	21	47	14	Human Resource Capability	3.73	0.902	0.746	15th
Non- compliance of work with specification	89	1	8	20	49	14	Project Constructability	3.72	0.879	0.744	16th
Changes in construction methods due to site conditions	89	-	11	17	48	13	Project Constructability	3.71	0.869	0.742	17th
Ineffective use of construction standards	89	6	11	11	36	25	Project Constructability	3.71	1.199	0.742	17th
Inadequate communication of the client's need and priorities among the project team	89	-	14	16	46	13	Project Communication	3.65	0.918	0.73	19th
Constructability problems	89	-	5	30	45	9	Project Constructability	3.65	0.740	0.73	19th
Damages caused by subcontractors	89	-	16	15	43	15	Project Constructability	3.64	0.968	0.728	21st
Errors due to misunderstanding of drawings and specifications	89	4	15	13	37	20	Project Constructability	3.61	1.144	0.722	22nd
Non-compliance of materials with the specification	89	2	14	19	37	17	Material and Equipment	3.60	1.041	0.747	23rd
Poor planning and coordination of resources	89	2	15	15	43	14	Site Management	3.58	1.020	0.716	24th

Rework Cause Factors	**N**	1	2	3	4	5	**Category**	**Mean**	**SD**	**RII**	**Rank**
Attempt to fraud	89	2	12	29	26	20	Project Constructability	3.56	1.055	0.712	25th
Late delivery of materials	89	1	18	22	28	20	Material and Equipment	3.54	1.088	0.708	26th
Changes initiated to improve quality	89	1	10	28	42	8	Project Constructability	3.52	0.854	0.704	27th
Failure to provide protection to the executed on progress works	89	-	15	27	34	13	Site Management	3.51	0.943	0.702	28th
Random human error	89	2	11	29	35	12	Human Resource Capability	3.49	0.955	0.692	29th
Insufficient briefing has been given to the client	89	-	20	24	37	8	Project Communication	3.37	0.934	0.674	30th
Setting out error	89	2	18	27	30	12	Site Management	3.36	1.025	0.672	31st
Machine/equipment breakdown and defects	89	2	21	20	35	11	Material and Equipment	3.36	1.047	0.672	31st
Damage due to incorrect way of handling a machinery	89	2	18	28	29	12	Material and Equipment	3.35	1.024	0.67	33rd

1 = **Strongly Disagree**, 2 = **Disagree**, 3 = **Neutral**, 4 = **Agree**, 5 = **Strongly Agree**

APPENDIX E

Magnitude of rework for the selected projects

This explained about rework activities and the additional cost incurred in three building projects which are located in Addis Ababa. As a data collection means, an exhaustive discussion through semi structured interview and document review (especially site book and status reports) were used. The discussions were made based on the following major issues.

1. Description about the rework
2. The causes for the occurrence of that specific rework
3. The additional material, labor and equipment cost incurred due to the rework
4. The responsible party for the rework incidence

N.B The layout is attached in appendix C

To keep the reputation of both the contracting and the consulting companies and since there will be no contribution for the research, the name of the contractor and consultant of the each project was not stated. But every information and data gathered were explained in detail.

Things that needs to be considered

The rework cost means for these cases

1. Direct cost which includes only material, equipment and labor costs.
    - The costs of supplier, sub-contractor, rework delay cost, and indirect costs were eliminated due to poor rework documentation process of the construction sites.

2. As it is confirmed by the construction professionals of the three projects that there will definitely be unrecorded reworking activities but the major ones were stated.

3. All of these rework costs were incurred during construction phase of a project; rework in design phase is not included.

Building Project One

General description about the project

The international community school building project was designed to give a class room function. The buildings are classified in to three blocks. Block A and B ; B+G+4 and block C; B+G which are built to give class room function for international community school located in Addis Ababa, Nefas Silk Lafto Sub City. The project was started in January 2015 and was planned to be completed in August 2017. Currently the project is almost completed and is giving the intended function. The contract type was a design build. So, the contractor was the one who was responsible for both the design and building process of the project.

Project description (Project one)

A.	Client	International Community School (ICS)
B.	Location	Addis Ababa ,Nefas Silk Sub City
C.	Total project cost	243,800,000 ETB
D.	Percent completed	100 %
E.	Project started date	January 2015

***Source*:** Site document

Activity	Additional material cost incurred due to rework	Additional labor cost incurred due to rework	Additional equipment cost incurred due to rework	Total additional cost incurred due to rework
Demolishing existing	Since it is a	395,000 ETB	Cart away cost for	500,000 ETB

Major rework activities occurred in the project

Right after the award is given; the contractor finished the structural design of the building and started the construction overconfidently without even getting the approval of the consultant. After that, the consultant did the structural analysis which proved that the column dimension and the rebar was not enough to bear the load. This test leads the consultant to make a decision of reworking. So a decision has been made to demolish the constructed 48 foundation columns and reconstruct.

1. To rework the construction based on the consultant's request, the first activity needed to be done was demolishing the constructed 48 footing pads and the foundation columns which was followed by excavation and concrete works. Here is the total cost incurred due to the activity.

48 foundation columns and removing the debris	demolishing activity there was no material needed.		the demolished debris 105,000 ETB	
Excavation and Earth work				468,000 ETB
Concrete Work	2,084,339.16 ETB	1,621,152.68 ETB	926,372.96 ETB	4,631,864.80 ETB
Total additional cost incurred due to rework				**5,599,864.80 ETB**

Source: Site documents and discussion

The major cause for the occurrence of the reworking was due to two major reasons. The first one was is due to the faulty design which was carried out by the contractor's side. The second cause was the intention of the contractor to accelerate the project and took the risk of continuing the project without the approval of consultant. This also indicates there is poor supervision practice in the site. As a result of this, the contractor was the one who took the full responsibility and paid the additional incurred cost of reworking. This is one of the massive reworking incidence occurred in this site.

2. The other reworking activity occurred in this project was during constructing stone cladding of the external wall. After the work was completed, the wall begins to be exposed to a rainy and sunny weather condition, the stone claddings were started to fall. When the cause was investigated by the consultant, it was identified that the contractor selected and used a less quality adhesive material that couldn't withstand such weather fluctuation. Due to this, it was a must for the contractor to rework using a better adhesive material. Here is the additional cost incurred

Activity	Additional material cost incurred due to rework	Additional labor cost incurred due to rework	Additional equipment cost incurred due to rework	Total additional cost incurred due to rework
Replacing of falling external stone cladding	248,322 ETB	135,461 ETB	166,217 ETB	550,000 ETB

Source: Site documents and discussion

The causes for this rework activity was as the same as the above. The contractor took a risk by using less quality material to minimize its cost and get a better profit. So here again the contractor was the one who took the full responsibility.

Therefore, the total material, equipment and labor cost of this project was

5,599,864.80 ETB

550,000.00 ETB

= 6,149,864.8 ETB

$$\% \text{ Field Rework} = \frac{\text{Total cost of rework performed}}{\text{Total construction phase cost}}$$

$$= \frac{6{,}149{,}864.8 \text{ ETB}}{243{,}800{,}000 \text{ ETB}} = \mathbf{2.5\%}$$

Building Project Two

General description about the project: Nibras hotel project

The second building project selected to show the financial impacts of rework was a building which is located around piazza and it is 2B+G+10 building. The project was initially started in 2003E.C and 44.07% of the project has been completed for the past 8 years. According to the project manager, this time elapse is occurred due to the client's lack in financial capability. Due to this, whenever the client gets some amount of money to continue the construction, some phase of the project will be carried out and when there is a budget scarcity, the project will be ceased for some period of time, some times more than a year. So by passing through this processes the building reached to 44.07%. Even though this time elapse is not a direct contributor for the occurrence of reworking, it became the cause for it.

First the client's plan and interest was to get in to a hotel business and started the construction. So according to that, the design, structural and block works has been completed within 7 years. The problem here is that within this time interval, another new hotel project was constructed and almost finished right in front of this site. After this incident, the client decided to change the function of the building from hotel to mixed use building.

A.	Client	Nibras Hotel Plc
B.	Location	Addis Ababa , Arada Sub City
C.	Total project cost	142,236,404.34 ETB
D.	Percent completed	44.07%
E.	Project started date	May 2010 GC
F.	Project completion date	August 2013 GC and revised to be completed in May 2015 GC

***Source*:** Site document

Major rework activities occurred in the project

1. Due to the client's interest change, the first rework activity that needed to be carried out was demolishing the structural cantilevers. Here are the additional costs incurred due to this change.

Activity	**Additional material cost incurred due to rework**	**Additional labor cost incurred due to rework**	**Additional equipment cost incurred due to rework**	**Total additional cost incurred due to rework**
Demolishing structural cantilevers	Since it is a demolishing activity there was no material needed	37,000 ETB	Simple available handy equips were used for chiseling	37,000ETB

Source: Site documents and discussion

Since the reason for this rework was due to the change in the client's interest, the client took full responsibility and paid the additional incurred amount.

2. The other rework activity occurred in this project was during wall plastering. The rework was occurred over 786 square meter area of the 2nd and 4th floor of the building. The major cause for this plastering rework was poor workmanship of the laborers.

Activity	**Additional material cost incurred due to rework**	**Additional labor cost incurred due to rework**	**Additional equipment cost incurred due to rework**	**Total additional cost incurred due to rework**

Plastering rework (2^{nd} and 4^{th} floor)	157,200 ETB	35,370 ETB	12,500 ETB	205,070 ETB

Source: Site documents and discussion

In this reworking incidence, the contractor's workers were the one who were responsible for the occurrence of the rework. So the contractor was the one who took the full blame for this rework and paid the total incurred cost.

3. The other rework activity was carried out due to the change of the building from a hotel to a mixed use buildings. The partition work which was carried out previously will not be convenient for a mixed use building which led in to a massive reworking activity.

From the second to the seventh floor of the building, the design was first planned to be a hotel bed rooms and after the design change occurred, it was necessary to demolish most of the partition walls constructed and make the open spaces for mixed use purpose.

Activity	**Additional material cost incurred due to rework**	**Additional labor cost incurred due to rework**	**Additional equipment cost incurred due to rework**	**Total additional cost incurred due to rework**
Demolishing of partitions from 2^{nd} to 7^{th} floor.	Minor additional costs might be incurred but they are not still carried out in the project.	714,819ETB (demolishing cost) 220,000 ETB (loading the debris)	23,000 ETB (cart away cost for the demolished material)	957,819 ETB

Source: Site documents and discussion

The same as the first rework activity, this activity was also carried out due to the client's change of interest. So the client was the one who took the full responsibility.

Therefore, the total material, equipment and labor cost of this project was

37,000 ETB

205,070 ETB

957,819 ETB

1,199,889 ETB

$$\% \text{ Field Rework} = \frac{\text{Total cost of rework performed}}{\text{Total construction phase cost}}$$

$$\frac{1{,}199{,}889 \text{ ETB}}{44.07\% \text{ of } 142{,}236{,}404.34 \text{ ETB}} = \mathbf{1.91\%}$$

Building Project Three

General description about the project: G+8 Apartment building

The third building project selected to show the financial impacts of rework was a building which is located around Kazanchis. The building is G+8 storey building which is planned to be an apartment. The same as project one, this project was also started before about 5 years and it is done phase by phase due to the financial issues of the client. Due to this time elapse the client interest was changed to rearrange the apartment rooms. Currently around 80% of the project has been completed. The additional rework cost is calculated based up on the completed amount of work.

A	Client	W/ro Munira Nassir
B	Location	Addis Ababa ,Nefas silk sub city
C	Total project cost	43,370,410ETB
D	Percent completed	80%
E	Project started date	June 2020
F	Project completion date	Unknown but planned to be completed in 2020

***Source*:** Site document

Major rework activities occurred in this project

1. As it is indicated above, the first rework incident occurred in this project was demolishing and repartitioning to rearrange the rooms. This reworking was carried out due to the client's change interest. Due to this demolishing the existing hollow concrete block and partition walls and rearranging of the rooms was carried out as per the client's request. In order to complete the reworking activity the following additional costs were incurred.

Activity	**Additional material cost incurred due to rework**	**Additional labor cost incurred due to rework**	**Additional equipment cost incurred due to rework**	**Total additional cost incurred due to rework**
Demolishing of existing HCB wall and making edges good and cart away	Since it is a demolishing activity there was no material needed.	31,084.21 ETB	Cart away cost for the demolished debris 7,771.06 ETB	44,683.55 ETB
Block work	32,425.36 ETB	20,634.32 ETB	5,895.52 ETB	67,798.48 ETB
Finishing work	103,304.3 ETB	65,739.1 ETB	18,782.6 ETB	216,000 ETB
Total additional cost incurred due to rework				**328,482.62 ETB**

Source: Site documents and discussion

This rework incidence was carried out due to change in the client's interest. As a result, the client was the one who took full responsibility and covered all of this additional rework costs.

2. The second rework incident happened in this project was the activity of shifting internal water downpipes to external wall. After the downpipes were installed the water began to leak and started to affect the internal wall and rooms form internally installed water downpipes. Due to this it was a must to shift the internal water downpipes to the external walls. The cause for this reworking incidence was mainly due to defective workmanship, poor design and lack of proper supervision. In doing the rework activity the following additional costs were incurred.

Activity	Additional material cost incurred due to rework	Additional labor cost incurred due to rework	Additional equipment cost incurred due to rework	Total additional cost incurred due to rework
Shifting of internal downpipes to external wall	39,019.5 ETB	17,342 ETB	30,348.5 ETB	86,710 ETB

Source: Site documents and discussion

Since this rework was carried out due to poor workmanship and design, responsibility was shared equally by the consultant and contractor. Then the total cost for the reworking was shared equally by each responsible party.

Therefore, the total material, equipment and labor cost of this project was

328,482.62 ETB

86,710.00 ETB

451,192.62 ETB

$$\% \text{ Field Rework} = \frac{\text{Total cost of rework performed}}{\text{Total construction phase cost}}$$

$$\frac{\text{451,192.62 ETB}}{\text{80\% of 43,370,410 ETB}} = \mathbf{1.3\%}$$

In general, when it compares to the three projects, project one have a better rework recording system than the other two projects. Mostly rework incidents are recorded as one work activity not as it is a reworked activity. In addition to this, none of the three projects classified and tried to study the causes of rework or tried to quantify the amount of additional cost incurred due to reworking. So in order to come up with solutions to reduce reworking, its magnitude needs to be identified after classifying the causes. That way, effective rework minimizing strategies can be developed by the construction professionals.