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SCHOOL OF GRADUATE STUDIES DEPARTMENT OF CONSTRUCTION TECHNOLOGY AND MANAGEMENT

DETERMINES FACTORS, IMPACTS AND MITIGATION MEASURES STRATEGIES OF CONSTRUCTION REWORK OCCURRENCE IN PUBLIC BUILDING PROJECT IN ADDIS ABABA

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Determines Factors, Impacts and Mitigation Measures Strategies of Construction Rework Occurrence in Public Building Project in Addis Ababa

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DECLARATION

I, the undersigned, therefore certify that this thesis, which was created under the direction of Biruk Tibebu and is titled " Determines Factors, Impacts and Mitigation Measures Strategies of Construction Rework Occurrence in Public Building Project in Addis Ababa ," is my original work. Every source of material used to create the thesis has been properly acknowledged. I further certify that no other higher educational institution has received the thesis, in whole or in part, with the intention of awarding a master's degree.

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ENDORSEMENT

This is to certify that Tezera Tesfaye has conducted this thesis work entitled " Determines Factors, Impacts and Mitigation Measures Strategies of Construction Rework Occurrence a" is under my supervision. This thesis work is original and appropriate for submission in partial fulfillment of the requirement for the award of Masters of Science in Construction Technology and Management.

Biruk Tibebu (Ph.D.) ---------- ----------

Name **Signature** **Date**

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LIST OF ACRONYMS AND ABBREVIATION

BIM: - Building Information Model

BRE: - Building Research Establishment

CAD: – Computer Aid Drawing

CCRI: - Central Road Research Institution

CIDA: - Construction Industry Development Agency

CII: - Construction Industry Institute

COI: - Cost of Incidence

CRRI: - Client-Related Rework Index

CSIR: - Constituent Council of Science and Industrial Research

FRI: - Field Rework Index

IIM: - Importance Index Method

IIRCI: - Importance Index of Rework Cost Impact

IIRTI: - Importance Index of Rework Time Impact

RCI: - Rework Communication Integration

RCM: - Rework Construction Material

RCV: - Compulsory and voluntary change

RDP: - Rework Design Process

REC: - Rework Engineering Consultancy

REE: – Rework External Environment

RII: - Relative Importance Index

RMS: - Rework Management System

RPP: – Rework Project Plan

SI: - Severity Index

SPSS: - Statistical Package for Social Science

TFRF: - Total Field Rework Factor

TIIRI: - Total Importance Index of Rework Impact (in %)

TQM: - Total quality management

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ABSTRACT

The construction industry in Ethiopia is vital for socio-economic development, yet it faces significant challenges that hinder economic growth. One of the primary issues impacting public building projects is construction rework, which has been linked to poor performance in project delivery. This study aims to determine the occurrences of construction rework in public building projects. Three specific objectives were established: determines factors, impacts and mitigation measures and strategies of construction rework occurrence A descriptive research design was adopted, involving a population of 164 professionals. A simple random sampling method was used to distribute questionnaires, complemented by semi-structured interviews for comprehensive data collection. Out of 116 distributed questionnaires, 107 were returned and analyzed, excluding 3 incomplete responses. Analysis revealed 48 factors contributing to rework, with the most frequent being incomplete design, imperfect construction techniques, insufficient skills, non-compliance with specifications, and hiring unqualified contractors. The direct impacts of rework included cost overruns, time delays, profit reduction, and contractual disputes, which subsequently led to indirect effects such as worker stress, low morale, and work inactivity. To mitigate rework occurrences, it is recommended to implement clear drawings and specifications, hire qualified contractors and designers, and enhance communication among project parties. The use of technology, such as Building Information Modeling (BIM) and a Rework Management System (RMS), is also advocated. Additionally, regular training programs for supervisors and workers are essential for capacity building and improving project outcomes.

Key words: Rework, Critical Factor, Impacts, Public Building construction, construction Industry, Project performance

CHAPTER ONE

1. Introduction

The construction industry is crucial for fulfilling societal needs through public infrastructure projects. However, these projects often face challenges like cost overruns, delays, quality issues, and low productivity, which hinder their success. Research has shown that rework, often due to non-compliance with contractual conditions or new requirements, significantly contributes to these challenges. As a result, rework is a major factor impeding the successful completion of construction projects. It is essential to provide the required citation and paraphrase for this information. (Chidiebere and Ebhohimen, 2018; Bajjou and Chafi, 2020). It needs to put the required citation and paraphrase.

1.1. Background of the study

The construction industry has one of the fastest-growing major involvements in political, social, and economic development globally. Mainly, it has been heavily involved in the economic conditions of the country and its economic growth. Nowadays, the construction industry is the major driving force behind the socio-economic development of any nation (Saidu & Shakantu, 2016). Many African and Asian countries are now in the process of construction development (Eze & Idiake, 2018b). As African countries have explained with official economic statistics, despite the fact that they were obstructing the rapid growth of the construction industry (Safapour & Kermanshachi, 2019).

Ethiopia is now in a transitional period of industrial development, where numerous building construction projects are ongoing and make vital contributions to public services, which take up a large portion of the government's vertical infrastructure investment (Mamaru, 2020).

As per the country, many matters have been a challenging phenomenon in all developing countries on the continent that have affected the economy in the construction industry (Safapour, Kermanshachi, & Taneja, 2019). In recent years, the Ethiopian public sector has been funding a huge amount of money in the building sector. As a finding in the project performance, there were underperforming construction projects during the project

execution. However, among the numerous major factors contributing to the underperformance of the building construction project, the main one was “rework” (Safapour & Kermanshachi, 2019). The definition of rework in the Oxford dictionary is to alter something in order to make it better or more appropriate (Ivančič & Fabijanić, 2017). So, by definition, the rework was the foremost reason contributing to this obstruction and the common, justifiable continuous problem in the public building construction project as a whole (Sen et al., 2018).

It has also been facing this significant problem of bad financial performance, high-cost delivery in projects, and the inability to deliver value to customers on time (Shah et al., 2016). In so far as it has suffered from the trouble of rework that leads to ultimate extensive cost overruns and major time overruns, poor-quality products, client dissatisfaction, disputing among contract parties, reduction of profit to the contractor, safety and environmental-related issues have become a common phenomenon and significantly damage the performance of the building construction project as a nation (Ashebir, 2020). In addition, this previous study shows that rework has to contribute 24% to 32% of the schedule growth to projects (Hwang & Yang, 2014).On the other hand, rework contributed to around 50% of projects’ time overruns, and rework costs are accountable for 5%–25% of the contract value (Forcada, Gangolells, et al., 2017; Shah et al., 2016; Ye et al., 2015). Even though the influence does not only affect cost and time, it also has a very high effect of 79.98% on project performance and 80.76% on organizational performance (Eze & Idiake, 2018a). More critically, rework poses intensive in natural resources sustainability as a risk that, given the exhaustion resulting from the waste of materials and energy resources in the re-execution of projects activities (Ghannadpour et al., 2018). The direct Impacts of rework in enormous project are; where it is identified consists of additional time to carry out the rework, extra cost to remedy the occurrence, more materials for rework and wastage, and consequential increase in labor cost to fix the defect plus associated extensions of manpower supervision (Shah et al., 2016). On the other hand, the indirect Impacts of rework at individual level, stress, fatigue, absenteeism, de-motivation, and poor morale was found to be the primary indirect effects of rework. Even though at organization level the indirect impact of rework were founded reduced profit, diminished professional image, inter-organizational conflict, loss of future work and poor morale as indirect effects

of rework at an organization level and finally as project's performance level, works in activity such as waiting time, idle time, travelling time and end-user dissatisfaction was identified as indirect consequences of rework (Enshassi et al., 2017).

Nowadays, in the building construction market, there has been a trend to accept rework as an integral part of construction activities. Mostly, this was highly related to mismanagement during the design and implementation stages, which factors in repetition of some activities or identifies serious weaknesses at the end of construction work (Trach et al., 2019).Although it has also been assumed that the rework took place more than once during the same activity due to its non-conformity with the terms of the contract (Akal & El-Kholy, 2021). Additionally, the occurrence of rework, particularly during the implementation stage, can affect project performance throughout the project lifecycle (Safapour & Kermanshachi, 2019). After those problems were identified, the study focused more on the major determinants of construction rework occurrence in public building construction projects in Addis.

1.2 Statement of Problem

In Ethiopia's construction industry, as it knowingly the major public sectors were pouring in large amounts of fund. However, the industries usually have not been empathetically how much the sectors to contribute in cost as a country. Still, most of construction projects are still not faced with significant problems of high-cost overruns and time overruns directly. Related to this, rework on construction projects is one of the critical factors contributing to these failures. Even though it has been revealed in many studies that the problem has existed for a long time in construction projects and continues to be a chronic problem, it greatly increases the cost and time of a construction project and seriously affects the industry's reputation(Love, 2020).

In addition to this extra cost on site raised from demolitions, repairs, and activities such as replacement and moving up works. Examples in Singapore shows that rework has to contribute 24% to 32% of the construction schedule growth to projects(Hwang & Yang, 2014).In this case, rework contributed to around 50% of projects' time overruns, and rework costs are accountable for 5%–25% of the contract value (Forcada, Gangolells, et al., 2017). Even though , the impact does not only affected the cost and time; it also has a very high effect of 79.98% on project performance and 80.76% on organizational performance, profit reduction and worker de-motivation (Eze & Idiake, 2018a). And including to this the Disputes between contracted parties and dissatisfaction among the parties are some affected in which the professionals' views varied significantly(Eze & Idiake, 2018a)..

In order to this previous research conducted in Ethiopia, it has also been assessed only the defects of rework costs and time constraints of rework in limited building projects were attempted. However, it has also been focused only on limited factor areas such as labor, equipment, and materials as an outcome. Nevertheless, those researchers still the most frequent factors, impacts and its mitigation measures have not been addressed intentionally. So, in order to address this gap, the research focused on numerous related rework occurrences based on the objectives of the study, particularly in Addis Ababa Design and Construction Works Bureau at selected public building construction projects.

1.3. Research Objective

1.3.1. General objective

The general objective of the study is mainly determining the construction rework occurrence on public building projects in Addis Ababa.

1.3.2. Specific objectives

The following are the specific objectives of the study.

- To identify the major factors of rework in public building construction projects.
- To identify the impact of rework in public building construction projects.
- To forward the effective mitigation measure and controlling strategy in public building construction projects.

1.4. Research Questions

This research poses the following questions included.

Who is impacted by rework in public building construction projects?

What are the effective mitigation measures and strategies in public building construction projects?

- Why rework occurred in public building construction projects?
- Which impact of rework occurred in public building construction projects?
- What are the effective mitigation measures and strategies in public building construction projects?

1.5. Scope of the Study

1.5.1 Thematic scope

This research investigates the factors, impacts, and mitigation solutions of construction rework occurrences specifically at randomly selected public building projects in Addis Ababa. It aims to identify the factors contributing to rework by exploring these themes. The study seeks to provide insights that can enhance project efficiency and reduce unnecessary impacts associated with rework.

1.5.2 Spatial scope

The geographical scope of this study is limited to public building projects located at Bole sub-city, Yeka sub-city, and Lideta sub-city and includes Akaki kalitiy. Therefore, the research mainly focused on housing 2B+G+11, 4B+G+8, G+8, and G+5 project facility types such as administration, residential, commercial, educational, hospital, police station, prison, and shed projects, for which eleven construction sites are randomly selected in Addis Ababa to address the professionals working in construction, supervision, and parties involved in the building projects. By focusing on those locations, the research aims to generate findings that are relevant to the local construction industry and can inform future practices in the capital city of Ethiopia.

1.5.3 Temporal scope

The study employs a cross-sectional approach, capturing data at a specific point in time from 6/six/ month. This temporal scope allows for an immediate assessment of current practices and challenges related to construction rework in the selected public projects sites. By utilizing a descriptive research design, the study reflects the contemporary state of the construction sector in Addis Ababa.

1.5.4 Methodological scope

Utilizing a random sampling technique, data were collected and analyzed through descriptive statistics and RII (Relative Importance Index) analysis tools. This methodological approach ensures that the findings are statistically robust and reflective of the broader trends within the selected public construction projects administrated by the city Addis Ababa construction and design works bureau.

1.6 Limitation of the Study

The primary limitation of this research was the lack of engagement from respondents, as many professionals were busy or unwilling to provide comprehensive information during interviews. Additionally, the unavailability of engineers and project stakeholders at critical times of data collection.

Furthermore, the circumstances led to the war among the parties; it causes displacement in my family's as well as mine in the meantime of research. As a result of this personal

instability, which includes family migration, my parents have been forced to leave their home and have had very severe damage to their properties. This has caused me to feel more stressed and agonized all the time of my study, which has led to weariness and absence.

The constraints, however, are unable to undermine my research because, in order to qualify as research, it must be accurate and yield important conclusions.

1.6.1 Escaping methodolgy

Therefore, the constraints are overcome by utilizing a greater level of commitment, growing it, making unimaginable sacrifices over the time, by providing the research a high credit level, utilizing and developing extraordinary communication skills with people who have impacted the research, particularly in light of the tragic events, establish close relationships with my advisors, and making the greatest effort possible.

Lastly, it should be noted that research is valued for more than just providing answers to a particular problem. However, it should also be recognized that research plays a valuable role in strengthening one's ability to overcome a range of obstacles and that research contributes to finding solutions to problems that arise in every aspect of a person's life.

1.7 Significance of the Study

Nowadays, the construction industries in Ethiopia are confronting several challenges to satisfying the national construction demand in every aspect of economic development. Regarding improving this circumstance, rework is still a major problem in many construction industries here as a nation. As a major problem, it is still too stagnant to give an effective and alternative solution to the rework occurrence. Most responsible parties in the public project should be awarded, which is very necessary to determine and develop tremendous strategies that can be used to efficiently and effectively minimize unnecessary direct and indirect impacts in the building construction projects. **T**his study aims to analyze construction rework by understanding its factors and impacts, providing insights for developing effective control systems to mitigate rework. Raising awareness among project stakeholders is essential for improving overall project performance throughout the lifecycle.

1.7 Organization of the Study

This study is organized into five chapters, each serving a distinct purpose in exploring the factors, impacts, and mitigation solutions of construction rework in public building projects.

Chapter One: Introduction

This chapter lays the groundwork for the study by presenting the introduction and background. It articulates the statement of the problem, objectives, research questions, scope and significance of the study. Limitations encountered during the research process are also discussed in this section.

Chapter Two: Literature Review

In this chapter, a comprehensive review of existing literature related to rework occurrence was provided. It examined previous studies and research findings, highlighting key themes and gaps in the current understanding of construction rework.

Chapter Three: Research Methodology

This chapter details the research methodology employed in the study. It described the research approach, population, and sampling techniques, along with methods for data collection and analysis. Relevant verification tools and supportive instruments used throughout the research were also noted.

Chapter Four: Results, Analysis, and Discussions

This chapter presented descriptive results derived from quantitative and qualitative data obtained through structured questionnaire surveys, and semi- structured interviews. The findings were analyzed and discussed, providing insights into the factors influencing construction rework.

Chapter Five: Conclusion and Recommendations

The final chapter summarizes the key findings of the study, drawing conclusions based on the analysis. It offers recommendations for practice and policy, as well as suggestions for further research to enhance understanding and management of construction rework.

CHAPER TWO
LITERATURE REVIEW

2.1 Introduction

The construction sector is vital for economic development and civilization, but its inherent complexity leads to frequent errors and omissions, necessitating rework. This rework negatively impacts project performance by reducing project performance and quality, resulting in cost overruns and delays. Common factors contributing to rework include miscommunication and unanticipated change orders, which are often unintentional and not recognized as risks. Effective control strategies are essential to mitigate these issues and enhance overall project outcomes (Akshay & Konnur, 2020, Love et al., 2022, Love & Smith, 2018).

Based on Building Research Establishment (BRE) figures, 50% of the origins of errors are in the design stage and 40% are in the construction phase. Moreover, total deviation costs created during the design stage were found to be 46%, and deviation costs during construction were figured out to be 22% (Enshassi et al., 2017). similarly indicated that almost 80% of the costs of deviations were related to design and 17% were building construction-related (Enshassi et al., 2017). In building construction research studies, the topic of rework management has become a focus of attention in recent years (Safapour & Kermanshachi, 2019).

Rework in construction leads to significant indirect impacts. At the individual level, it causes stress, fatigue, demotivation, and poor morale. For organizations, the impacts include reduced profits, a tarnished professional image, inter-organizational conflict, and low morale, along with end-user dissatisfaction (Enshassi et al., 2017). Despite recent studies on rework, there is a lack of research on how reducing rework can improve project performance (Jingmond & Ågren, 2015). Future work is needed to adopt effective rework management strategies. This chapter defines rework, reviews relevant literature, and examines practices in building construction projects. It also explores factors contributing to rework and discusses its impacts along with potential solutions for minimizing it.

2.2 Rework conceptualization

2.2.1 Definitions of Rework

The Construction Industry Development Agency (CIDA)'s (Love & Smith, 2018) has two primary concerns of quality and change were taken into consideration as the rework idea developed through time after being introduced in 1995. Nowadays, many levels of complexity are present in building projects, such as managing a large number of stakeholders. The actual work completed differs from the work intended in the project contract document because of the rework (Akshay & Konnur, 2020). On the basis of this, many rework definitions have been disseminated in the literature.

According to (Oyewobi et al., 2011) “Rework is the process when an element of building works fails to meet customer’s needs and specification, or when completed work does not conform to contract documentation”. The English, Oxford dictionary’s according (Abiodun & Nwaogu, 2021) Rework is “to make changes to something in order to improve it or make it more suitable” (Enshassi et al., 2017). According to (Love & Smith, 2018) “Rework is the process when an element of building works fails to meet customer’s needs and “specification, or when completed work does not conform to contract documentation” “Rework is unplanned activity and is seldom identified as a risk”. According to (bat Capabilities Development Command (CCDC) Armaments Center, 2019) “Rework is the repeating of an activity (design) at the same scope and abstraction level”. Additionally, (Wynn & Eckert, 2017) that “Defined rework as redoing tasks in a similar way because inputs or assumptions changed”. (Mitchell & Nault, 2007) “Defined rework as the design changes whose implementation alters work that was previously done upstream and downstream”. (Kennedy et al., 2014) “Defined rework as the work that occurs when a prior decision that was assumed to be final for that project is changed because it was later found to be defective”. (Wynn & Eckert, 2017) “Defined churn as the ongoing corrective iterations where solving problems creates more problems without quick termination”. (Safapour & Kermanshachi, 2019) “Rework can be defined as any change that veers from the agreed upon and signed contract. (McDonald, 2013) “a process in which an item should conform to the original requirements by the correction or completion, or as a correction for at least or more extra than once due to non-conformance to requirements”.

In Other terminology, such as quality-deviations, non-conformance problems, and quality failures, have been used as direct technical synonyms for "rework" in the literature (Garg & Misra, 2021).This terms has been used to describe a variety of non-conformance activities, including mistakes, modifications, deviations, faults, failures, and defects (Forcada, Gangolells, et al., 2017). If errors, omissions, or regulatory changes were found, this must update (Li & Taylor, 2014). Rework errors must be fixed, and changes in non-conformance, scope, quality, and deviations must be handled. These jobs bring no value to the project and were wasteful in terms of rework occurrence (Liu et al., 2020).

2.3 Rework in Building Construction Project

Rework is a serious and problematic issue in all construction projects in Ethiopia. It is one of the key sectors of the economy and of civilization, as such, its essentiality is accepted in all societies (Eze & Idiake, 2018a). Construction projects are inherently dynamic and very resource-intensive in terms of manpower, materials, and equipment. That term is frequently used to describe situations where there were a large number of disciplines involved, including designers, architects, engineers, contractors, subcontractors, suppliers, financial institutions, and clients. This results in a complex environment where many tasks must be completed immediately. Some of the project activities were revised during this project's development for a variety of reasons, such as often occurring non-conformance, omission, errors, revisions, or miscommunications between the project partners involved.

2.4 The Influence Factors of Rework Occurrence

In the occurrence of rework, the most factors that mainly influence are the nature of work, the complexity of the project as well as the method of procurement and bidding process According to(El Hussein, 2014).

A. Nature of the work

Building construction projects as industry are include in general can be residential, commercial, apartments, and condominiums were the main types of buildings that constructed (Simpeh, 2012).

B. Complexity of the project

The performance of a building construction project is frequently related to its degree of complexity, which has a substantial effect. The complexity of any project includes several interrelated work variables with more than one variable (El Hussein, 2014). On the other hand, tasks in building construction projects were divided into functional areas performed by different professionals from several disciplines (Ashebir, 2020). As a result, every discipline makes judgments for itself without considering how those decisions would affect others. This is one of the factors that contributes to the occurrence of rework in building construction projects (Ashebir, 2020).

C. Methods used in procurement and tendering

According to (Zhang, 2010), the right methods of procurement and tendering procedure to be utilized have a significant impact on the frequency of rework in a building project. In contrast, significant levels of rework are more likely to occur in non-traditional methods of application than in traditional techniques, particularly in terms of the frequency of modifications, omissions, and errors. Because non-traditional methods are frequently used in situations where a project is under time pressure (El Hussein, 2014). Recent studies have examined issues relating to clients, design, contractors, external environment, human resource, materials and equipment, and the construction process (Enshassi et al., 2017). In addition to this another rework factor were related factors site, supervisory related factors, contract related factors of rework (Assim Muwafaq AL-JANABI 1, 2020).

2.5 Classification of Rework Factors

Rework factors were classified into three categories: technical, quality, and human resource problems. For each classification, the severity index of the variables is determined. According to the severity index, the three most serious sources of rework in technical factors were substandard products and services, defects, and improper coordination and integration of parties. The top three severe factors to rework occurrences in quality factors were late user participation, lack of support to site management, and poor commitment and trust by participants (Oyewobi & Ogunsemi, 2010).

These factors to rework occurrences were categorized into three groups namely: people, design, and building construction (Ashebir, 2020). Each group consists of numerous sub-factors and Figure 2.1 illustrates this.

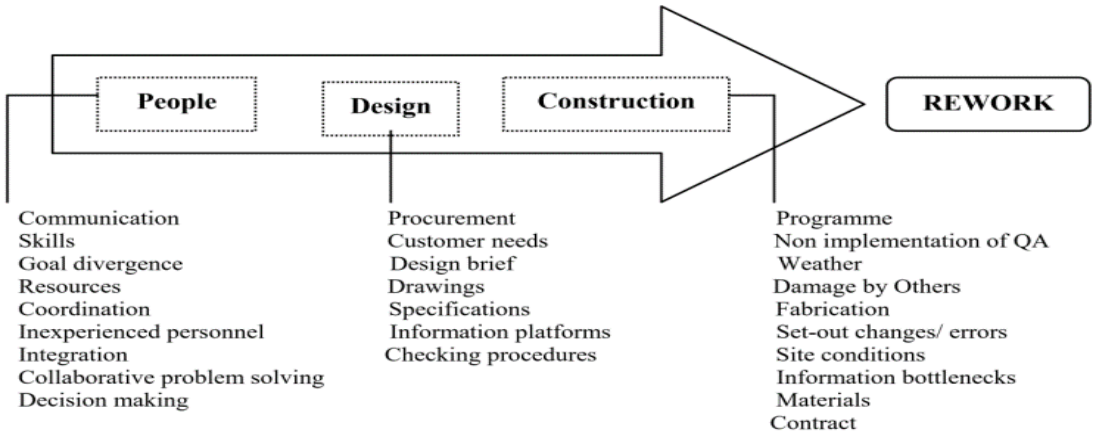


Figure2. 1:Rework Classification

According to Robin model actual root factors to rework occurrences established a fishbone diagram due to its shape to explore all the potential as shown in figure 2.3.

1. **Engineering and reviews**

According to Ashebir the major contributing factors in engineering and reviews were change orders, errors, and omissions (Ashebir, 2020). And lack of professionalism, inadequate procurement methods, poor project documents, design errors and omissions, competitive or low design and incomplete information for design were the major factors relating to design-related factors (El Hussein, 2014). Also, clearly stated in engineering and reviews are four possible factors to rework occurrences: late design change, scope change, and errors and omissions identified on the fishbone classification.

2. **Material and equipment supply**

Rework may be necessary as a result of insufficient material and equipment supply, improper prefabrication, a failure to adhere to specifications, and late deliveries.

3. **Human resource capability**

Also Unclear instructions to workers, poor supervision and job planning, excessive overtime, and insufficient skill levels were also included as the four likely reasons of

rework owing to human resource competence (Ashebir, 2020). Similar to how the critical factors lead to reworks, inadequate work protection, and improper work sequencing are significant variables that result in reworks (Wasfy, 2010).

4. Construction planning and scheduling

According to (Ashebir, 2020) belongs to construction planning and schedule contain four possible factors to rework occurrences : constructability problems, insufficient turnover and commissioning resourcing, late design input, and unrealistic schedules. The preparation of work before the design and construction stages is very significant. Because in construction methods, change leads to rework on-site as well as many indirect impacts (Mastenbroek, 2010).

5. Leadership and communications

Ineffective project team management, a lack of operational personnel, lack of safety and quality assurance and control commitment and poor communication between key stakeholders were four possible offenders in leadership and communications (Ashebir, 2020). Rework in building construction projects is also a result of poor site management, lack of coordination and lack of skills (Mahamid, 2016).

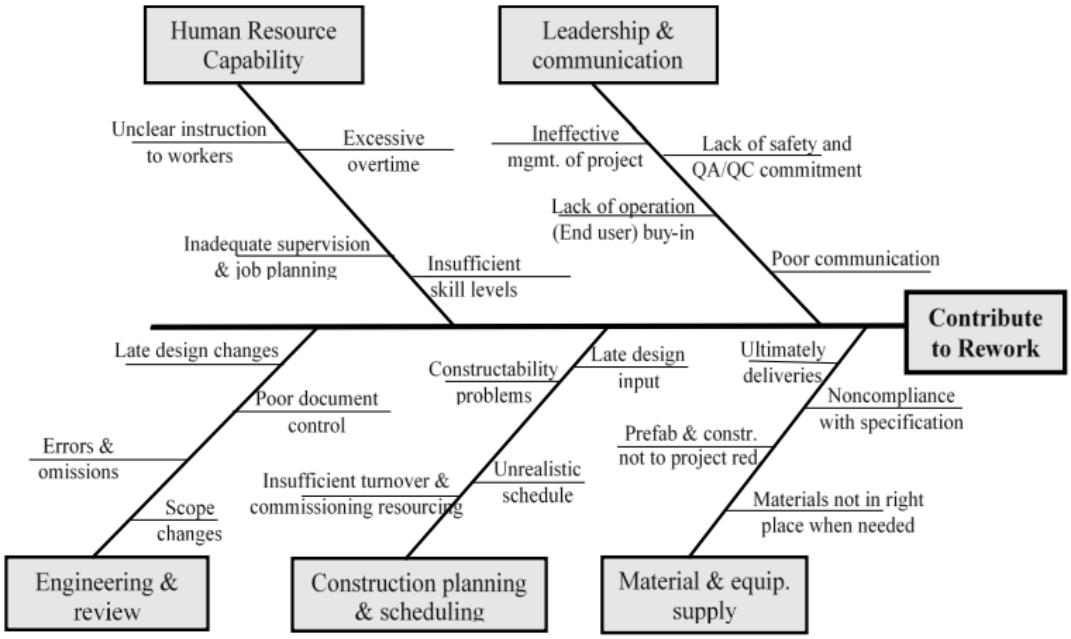


Figure2. 2: Fishbone classification of rework (Robin McDonald, 2013)

2.6 Apparent Indicators of rework

Industries face challenges from diverse stakeholder interests and project changes. Recent literature highlights project-based rework, often due to poor design, unclear scope, and inadequate specifications. Notably, inappropriate design and vague scope definitions are the most common causes of rework (Fageha & Aibinu, 2013).even although Organization-based rework indicators include poor coordination, communication issues, lack of training, inadequate design control, insufficient documentation, and weak management (Ashebir, 2020). Research shows that poor coordination among stakeholders can lead to essential rework during project execution (Safapour, Kermanshachi, & Taneja, 2019). Effective communication is crucial for project success due to the complexity and number of involved parties (Safapour, Kermanshachi, Kamalirad, et al., 2019). Furthermore, Common human-based rework indicators include insufficient experience, skill, knowledge, and motivation among the workforce. For example, designers lacking expertise may produce more errors, leading to increased adjustments and revisions. According to (Forcada, Gangolells, et al., 2017) individuals with limited knowledge and competence are more prone to mistakes in design and construction, and there is a direct correlation between recordable injuries and the number of reworks.

2.7 Major Factors of Rework

The frequent factors of rework should essentially realize well are a key step and an upright direction towards reducing the rework occurrence. Numerous studies have shown that there are a number of factors that influence rework in various categories, and these issues have direct and indirect impacts. Consequently, based on the degree of influence from several different comprehensive literature reviews the main major factors of rework occurrence can be categorized under 10(ten) broad heading groups as discussed below clearly.

2.7.1 Owner/Client Related Factors

The client is the most powerful and significant player in the decision-making process during the project life cycle in the construction project (Assim Muwafaq AL-JANABI 1, 2020). Many previous studies (Eze et al., 2018; Forcada, Alvarez, et al., 2017; Mahamid, 2016; Yap et al., 2017b) discovered that the client was one of the main factors of building construction rework. The most frequent occurrence of rework in a project was material

replacement; the client altered the project's plans and scope, which was the factor that had the biggest impact on the project's performance (Hwang et al., 2014).

According to analysis results, which showed that in Singapore's building projects that were questioned acquired a client-related rework index above 50% and that the total mean CRRI was 58.4% (Ahmed Yousry Akal a, 2021; Hwang et al., 2014). (Hwang & Yang, 2014). The study presented indicates that the total cost of rework is 18.40% of the entire project cost. As summery among many different comprehensive studies listed more: Lack of sufficient knowledge and experience in the design and construction process, Inadequate/incomprehensive briefing and weak feasibility study of project objectives, Lack of funding allocated for consultation and shortage of funding for site investigation, change Specifications by the client, change of plan or scope because of change in officials were client factors of rework (SHAH1, 2016). According to some related factor identified a lack of client involvement in the project, Weak communication/coordination with end user, Weak quality management system.(Chandrusha1, 2017)

2.7.2 Design Related Factors

Any building construction project's design-related factors are essential, and they frequently come with a number of omissions, errors, and changes that contribute to the occurrence of rework both throughout the design and construction phases. Therefore, the majority of researchers have noted that design-related factors are among the most important factors of building construction rework (El Hussein, 2014). According to estimates, just 26% of all rework expenses were related to design, which accounts for 18.91% of rework costs for residential buildings as well (Liu et al., 2020). Typically, as a result of design errors In all kinds of building projects, change orders and modifications are frequent and practically required (Li & Taylor, 2014). Additionally, the Building Research Establishment (BRE) estimates that 50% of errors in buildings originate during the design phase and 40% during the construction phase (Enshassi1, 2017).

The previous study discovered that members of the design team's inadequate integration and coordination because of late information flow. When engineers and architects employed manual procedures and computer aid drawing (CAD) technology, respectively, to document their designs, certain drawings were produced that contained dimensional

errors and information that was missing (Chandrusha1, 2017). Here, in the design process, a technical error is a significant factor in the rework in the building construction, which is nothing more than a design-related factor for the rework occurrence (Akshay1*, 2020). Lack of professionalism on the part of design specialists, competitive or low design fees, and insufficient design information (Enshassi1, 2017). This establishes that the design, planning, and construction phases are responsible for the majority of reworks in building construction projects (SHAH1, 2016).

The sources that are most commonly cited in the literature deal with design-related issues. According to (P. E. Love et al., 2016), design errors, omissions, and alterations account for around 50% of all rework and rework cost. A lack of design details, incorrect design understanding, and improper drawing preparation could result in design errors and subsequent changes. Additionally, owners, designers, and contractor stakeholders may lead to disputes and have a great potential to create difficult problems (Kermanshachi & Safapour, 2019).

As Summery many different comprehensive studies listed, the client related factors to factors to rework occurrences include more: Errors and omissions made during the design phase, a lack of integration and coordination between the design team members and the client, improper or inefficient use of contemporary information technology, lack of professionalism and insufficient experience of the design consultants, Pay competitive/low design fees for the preparation of designs, incomplete design information, Non-compliance with specifications and standards, and improper procurement strategy.

The figure below illustrates the influence of design-related factors of rework on the performance of a building construction project.

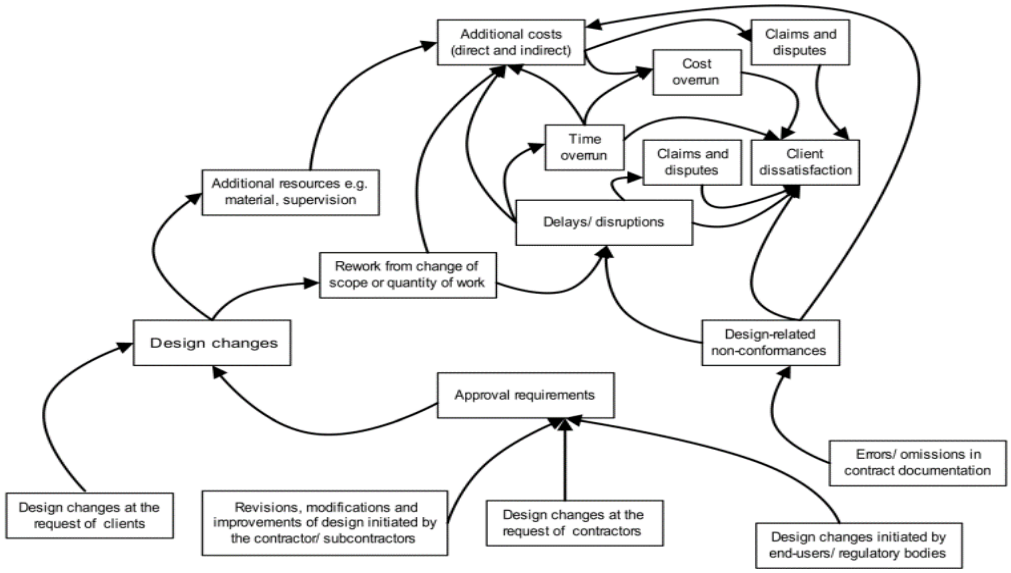


Figure2. 3:Effect of design-related factors (Ashebir, 2020).

2.7.3 Contractors and Subcontractors Related Factors

According to (El Hussein, 2014)Issues relating to the contractor and the subcontractor have a substantial effect on the likelihood of rework in other nations. Additionally, contractors were the organization in charge of carrying out the building construction, and in this capacity, a problem results in rework for the contractors (Garg & Misra, 2021). The contractor and subcontractor are also accountable for 20,10% and 10,54% of the overall cost of rework in Chinese residential buildings (Liu et al., 2020). Therefore, based on their role, they must communicate and understand the design, effectively convey and comprehend the design, and the necessity for efficient supervision, depending on their job (belayneh, 2020). Consequently, due to negligence, low skill levels of building artisans and workers, and poor material selection detrimental to other trade work (Chandrusha1, 2017).

According to Zaiter's research, contractor-related factors relate much more to the contractor's responsibility for rework in building construction projects (Akshay1*, 2020). Even although according to Zaiter & Enshassi (2014), attempts at fraud, hiring technically unqualified contractors, competitive pressure or low contract price or value were the most significant factors to rework occurrence on contractor-related issues (Zaiter & Enshassi, 2014). Also Imperfect construction method, inappropriate construction procedures, insufficient and imperfect observation of acceptance material and mechanical equipment

(Aman Sen, 2018). Insufficient skill and defective workmanship; poor coordination and communication between consultants, such as designers; and between the contractor and sub-contractor (Assim Muwafaq AL-JANABI 1, 2020). and misunderstandings taken on by inexperience (Bon-Gang Hwang, 2018a).

2.7.4 External Environment Related Factors

The majority of environmental related factors that contribute to the occurrence of rework were because by unstable socio-political conditions and natural disasters, such as the political climate, social conditions and resistances (Ashebir, 2020). Particularly, external and environmental factors, including political, economic, and social effects on developing countries, play a role in the performance of building construction projects. For instance, the performance of the construction industry as a whole will be impacted by government capacity failure, which will eventually result in rework. Poor local vocational education and a lack of training programs in construction organizations are examples of the external environment cluster's fourth and seventh places, respectively, in terms of the likelihood of rework occurring in Egyptian building construction projects (Akal & El-Kholy, 2021). In truth, the majority of Egyptian building construction projects employ individuals who lack adequate training and quality vocational education (Akal & El-Kholy, 2021). Zaiter supports this viewpoint as well, because of Political situations, siege conflicts, social resistance, and large acts of God or force, such as weather conditions, are examples of external and environment-related factors to rework occurrences that affect project performance (Zaiter & Enshassi, 2014). According to (Mastenbroek, 2010) also, the followings can be considered as the factors to rework occurrences in external and environmental groups. Related to the government were regulations, taxes, and rates of interest. Inflation, exchange rates, market competitiveness, the availability of labor, materials, and financing are all aspects of the related economy. Even though the social environment changed, resistance was among the social aspects. Based on legal factors, there were changes in legislation, safety or planning laws, institutional influences, codes of conduct, and education regulations. Also, acts of God or force majeure (natural circumstances), weather, and natural disasters, including rain, heat, and cold, are some examples of the physical conditions (Enshassi et al., 2017). According to (Asadi et al., 2021a) also mention financial issues like schedule acceleration to finish the task, lack of

constructability, deviations in the product due to poor handling and safety considerations, and more. According to (Sen et al., 2018) unpredictable influences from various sources, a dangerous natural climate and atmosphere are all factors associated with the environment.

2.7.5 Human Resource Capability Related Factors of Rework

The construction industry is known for being labor-intensive and on the other hand the success of project depends greatly on human resources. On the other side, According to (Enshassi et al., 2017) found that the first rework factors under the heading of human resource capability and related factors was classified as ineffective management and decision-making as the number one rework factor that had a detrimental effect on project performance and 20% of rework was because of human resource capacity. Insufficient skill levels, poor job planning and supervision, and inaccurate worker instructions are categorized under human resource competence. The author explains that the management techniques may lead to time loss, unnecessary overheads, increased errors, rework events, and misunderstandings, all of which have a substantial effect on project performance (Enshassi et al., 2017). In conclusion, industry professionals can greatly benefit from the capacity to forecast probable rework reasons early on in the design and building construction phases (Safapour, Kermanshachi, Kamalirad, et al., 2019). The most significant factors to factors are shown below in order of frequency (Zaiter & Enshassi, 2014). Lack of job security and other safety precautions, situations of emergency, a low degree of skill in the workforce, Weak in technical ability, Carelessness, and lack of employee motivation. According to (Asadi et al., 2021a) state that lack of design and construction knowledge and experience, inadequate monitoring personnel, insufficient personnel to finish the job, team members' limited expertise, their lack of education and training and an improper personal attitude were also mentioned. Even although (Enshassi et al., 2017) added that extra labor, and workload; poor communication system and inadequate coordination; disruptions in the planning of personnel, ineffective management and decision-making. On the other hand, (Al-Janabi et al., 2020)(Al- Janabi et al., 2020) further added that there is also a lack of skilled workers needed to execute jobs, staff relocation or turnover to another place, lack of oversight, poor task planning and unclear work instructions.

2.7.6 Related Factors to Materials and Equipment Supply

In other nations, factors connected to materials and equipment are seen as the main factors of building construction rework (Enshassi et al., 2017; Fayek et al., 2003). These days, the effectiveness of a building project depends on the ability of the tools and materials. In the construction sector, having the proper supplies and tools is crucial to producing high-quality goods. (Enshassi et al., 2017; Fayek et al., 2003) also noted that, with a contribution of 23.5%, the supply of materials and equipment was the element that most significantly contributed to rework. With this material and equipment contributed 20% of the total cost of rework in Sweden and (Enshassi et al., 2017; Fayek et al., 2003) founded that they contributed 14.81% of the cost in Canada. The lack of construction materials on a site when needed is the first and most important element, according to analysis results, the supplier's failure to deliver the goods and equipment on time, and According to research done in building projects by (Enshassi et al., 2017; Mahamid, 2016). In summary, the use of poor materials, adulterated materials, pre-fabrication not in accordance with project requirements, materials not in the proper place, the invalidity of needed tests when needed, and late deliveries of material and equipment are the most significant factors under the material and equipment supply group.(Zaiter & Enshassi, 2014).The following list of rework-related materials and equipment-related variables is included: Improper timing of the supplier's delivery of the materials and equipment, and insufficient contractor oversight of the acceptance of materials and equipment are all examples of bad practices (Al-Janabi et al., 2020). Additionally, mention replacement or loss of material and equipment, ineffective equipment uses or altered material(Asadi et al., 2021b).

2.7.7 Related factors to building construction process

Whether as result of change requests, non-conformance, or faults, the construction phase of a project sees the majority of alterations and revisions. Consequently, a number of investigations have identified construction process-related factors as a key contributor to rework (Enshassi et al., 2017). According to (Al-Janabi et al., 2020; Enshassi et al., 2017) stated that schedule compression and pressure, inadequate pre-construction planning of the project changes as a result of appropriate or challenging on-site construction methods, Change resulting from omissions or deviations from the original design, construction errors

brought on by incorrect design and Lack of use proper and modern building construction technology. According to(Asadi et al., 2021a; Enshassi et al., 2017) Design and construction alterations, improve, and revisions any contract execution and procurement, improper contractor and subcontractor selection. deficiency made throughout the design or building construction phase, insufficient design, Selection of wrong methods and poor contract execution, late design input and failure to implementation quality management practice.

2.7.8 Supervisory Related Factors

The most significant factors that affect the supervisory group and result in rework. Rework can be significantly impacted by ineffective supervision (Oyewobi & Ogunsemi, 2010). Even with the fact that subcontractors are hired for various particular jobs, their work must be properly supervised by skilled and trained supervisors to prevent rework.

2.7.9 Contract-related factors

Factors relating to contracts Poor contract management as a result of the contract documentation's ambiguous and unclear scope was the usual factors of the rework (Ye et al., 2015). With this attributed that the an inexperienced staff to prepare contract documentation of management and Poor implementation of the contract, and the unserious handling of the contract management process and unclear contract documentation by stakeholders, and poor contract implementation (Al-Janabi et al., 2020).

2.7.10 Related Factor to The Site

Rework with related factors to site is more likely to occur when connected elements, such as unplanned storage of raw materials, construction debris, shuttering plates, are not clean and are not managed appropriately (Al-Janabi et al., 2020). additionally, the related factor to the site were: poor site procedures; and a neglected state of the site by the contractor The contractor's lack of support for site management delay by a client in providing the site necessities, such as water, electricity, and Inadequate or incorrect site investigations (Al-Janabi et al., 2020).

2.8 Impact of Rework

Rework has an impact on a building construction project, either directly or indirectly, on how well it performs. For example, has a direct impact on project performance and an indirect impact on organizational performance.

2.8.1 Direct Impacts of Rework

Rework significantly impacts project performance in construction, particularly in the Gaza Strip due to personnel turnover (Enshassi1, 2017). Rework has a long-term effect on a construction company's reputation and capacity to draw in new clients (Chandrusha1, 2017). Rework leads to inter-organizational conflict, reduced supervision, employee demotivation, increased waste, and higher labor and material costs. Ultimately, this results in client dissatisfaction, profit loss, cost overruns, schedule delays, and discontent among design teams (Chandrusha1, 2017).

According to(Eze & Idiake, 2018b; Eze Emmanuel Chidiebere1, 2018; Mamaru, 2020) the direct impacts of rework was:

1. Cost overruns

Cost overruns are common in construction projects, with rework increasing costs by 2% to 30% for residential and commercial towers (Enshassi et al., 2017). Overall, rework accounts for 15% to 20% of a project's total cost rk (Aman Sen, 2018). Direct costs encompass quantifiable expenses like labor, materials, and tools required for renovation (Mastenbroek, 2010). These costs significantly contribute to the overall project budget (El Hussein, 2014). Indirect costs are harder to measure and include lost productivity, claims, ineffective processes, and rework, which can be five times more expensive to rectify than the original direct costs (Ashebir, 2020).

2. Time overrun:

Rework might factor to project's delivery to be significantly delayed. Additionally, revisions produced delays that increased the original durations of various job categories from 10% to 77% (Enshassi1, 2017). And those projects in Singapore are growth for between 24% and 32% of the rise in the building construction schedule (Hwang and Yang, 2014). According to the research, Zainter projects appropriated between 23.3% and 76.7%

longer than expected to complete (Zaiter & Enshassi, 2014). The graphic below the time effect that shows the series of activities that make up rework four projects in Bahir Dar University.

3. Profit reduction in organizational performance:

This were also as great effects of organizational performance based on the issue of non-conformances that were recorded and required rework, it was found that contractors experienced a staggering loss of profit of 28% and 34% (Ashebir, 2020; Smith, 2019).

4. Dispute between contractual parties:

This defined as a discrepancy between at least two independent parties who perceive incompatible goals, scare resources, and interference from other and one of the major factors of unsuccessful projects were the adversarial nature between the project parties which leads to the development of disputes (Alaloul et al., 2019).

5. Contractual claim:

Reworks were one of the main causal factors that generated contractual claims. And despite a number of studies on the impacts of rework occurrences on project performance, there has been limited research examining the relationship between claims and rework on the basis of contract documents (Asadi et al., 2022).

6. Dissatisfaction of end-user, client, design team and contractor:

And most studies have revealed that there is a strong likelihood of heightened stakeholder dissatisfaction and the development of a performance gap when handover is viewed as a date where the keys are turned over to the client or end-user in a hurried and unplanned way (Too et al., 2023).

7. Damage reputation:

According to (Ashebir, 2020) particularly here from the many literatures there are many impacts of one rework on one building construction project. survey, according to (Akshay & Konnur, 2020) which is shown in graphically in figure 2.7.

8. Quality degradation:

According to the FIDIC, poor workmanship and hazardous building construction, as well as delays, cost overruns, and contract disputes, are all signs of low quality in building

construction. It is also said that rework frequently necessitates the replacement of damaged structural components with new ones and the necessity for new materials, resulting in resource waste due to quality compromises (Mastenbroek, 2010)

2.8.2 Indirect Impact of Rework

The other identified indirect impacts of rework were according to Palaneeswaran (Aiyetan, 2013),(Eze & Idiake, 2018b),(Ramin Asadi, 2021): firstly, Psychological well-being of individuals: such as employees' demotivation, stress, low morale of workers, absenteeism, and fatigue. Secondly, inter-organizational conflict, work inactivity, reduced profit, loss of future work and damage to professional image(Ashebir, 2020, Simpeh, 2012). Figure 2.5 illustrates the summary of indirect impacts of rework occurrence in projects performance and organizational performance.

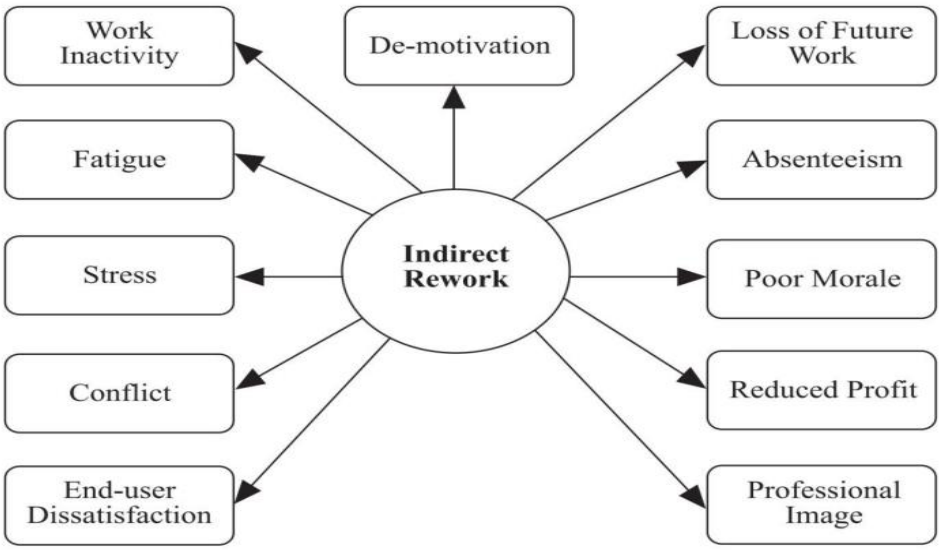


Figure2. 4:Indirect impacts of Rework (Ashebir, 2020)

Firstly, At Individual Level: rework that leads to fatigue, de-motivation, and poor morale. This can increase the likelihood of further errors (Simpeh, 2012). (Eze & Idiake, 2018a).secondly at Organization Level: Reworks at the organizational level have a very strong impact on organizational performance, with an effect of 80.76% and it can result in loss of profit, damage to reputation, inter-organizational conflict, and low worker morale (Eze Emmanuel Chidiebere1, 2018). Finally, At Project Performance Level: Additionally, it was discovered that rework had a 79.98% impact on project performance (Eze Emmanuel

Chidiebere1, 2018). Actually, when someone has to labor for a long period due to errors, changes, or omissions, fatigue and stress are likely to occur, which raises the possibility that even more rework will be needed (Simpeh, 2012).

2.9 Forward Mitigation Measures/Strategy of Rework

According to (Hwang et al., 2014), the application of change management has the most substantial advantages for contractors for those who has adopt in project cost control and time savings and better quality. Even although as researcher more explained that extremely most highly effective solution of rework in Singapore particularly at early stage of project phase assures that project requirements and objectives are reached (Hwang and Yang, 2014).

Rework reduction measures can be controlled by effective client change management and design management were critical to reduce rework (Hwang et al., 2014). Also as (Palaneeswaran et al., 2014) highlighted the importance of reducing design errors in preventing the rework.

According to the author's survey, teamwork effectiveness and strong, qualified supervision were ranked as the next two measures of rework reduction (Zaiter & Enshassi, 2014). Sufficient and capable human resources are ranked as the first measure of rework reduction (Mahamid, 2016). Rework in building construction projects can be decreased by a number of factors, including employees training, the use of technology, a quality control plan, wise contractor/subcontractor selection, and project inspection(Wasfy, 2010). Effective leadership, Sufficient and capable human resources, owner/client involvement, effective communication, qualified designer/ consultant, qualified contractor, supplier pre-qualification, effective planning and scheduling, unification work standards, restrict resistance against cheating fraud fighting, regular meeting also identified by(Zaiter & Enshassi, 2014). In addition to (Palaneeswaran et al., 2014) also Owner involvement, regular meeting were the effective measures of reduction of rework (Mamaru, 2020).

2.9.1 Forward Effective Mitigation Strategy of Rework

Reduction measures to minimize rework were effective client change management and design management was essential. Due to the fact that client-directed changes and design issues were two of the major contributing factors to rework factors (Hwang et al., 2014). Also as (Palaneeswaran et al., 2014) emphasized the need to decrease design error in order to preventing the rework, visualization technologies may also be utilized to eliminate unnecessary field rework.

1. BIM (Building Information Model):

BIM has become a widespread BIM practice as a BIM-assisted design validation process in the design stage. clients regularly employed BIM as the most effective technique to discover building-element clashes and reasons for rework (Lee et al., 2012). If BIM had been used, more than 50% of the design error that because of financial losses could have been avoided (Shang Zhanga, 2018). Additionally, BIM is an integrated data platform to manage accurate building information during the entire lifecycle. BIM improves internal coordination, cross-disciplinary collaboration, issue solving, decision support, risk management, and productivity enhancement while enabling greater control of the building construction process and this might result in less design error and subsequent reworks (Eastman et al., 2011; Volk et al., 2014). A number of Studies have created BIM-integrated systems to find and lessen the reasons for rework throughout the life cycle (Kwon et al., 2014).The top three BIM-related tactics are use of BIM throughout the design and construction phase, design reviews, verifications, and audits to reduce system errors, and rework tracking system to prevent future occurrences of rework (Bon-Gang Hwang, 2018b).

2. Total quality management:

As a result, some research examined rework reduction strategies based on the Total Quality Management (TQM) philosophy. Even though the rework issue would inevitably arise during the construction phase without the application of TQM concepts.(Zhang et al., 2012) presented a generalized model for a rework reduction program to lessen the occurrence and effects of rework using the conventional TQM-based methodology.

3. Rework Management System (RMS):

This study aims to identify and assess the factors contributing to rework and its potential to avoid it in future projects in the Rework Management (RM) domain (Love et al., 2015).

It aims to close the knowledge gap by investigating the impacts of rework for learning from the perspective of contractors (Zhang et al., 2018). Effective RM not only increases profitability but also strengthens contractor management skills, which is crucial in today's competitive building construction industry with thin profit margins (Shang Zhanga, 2018).

4. Adopting control measures for rework:

The process of selecting appropriate control measures involves identifying preventative controls, selecting acceptable controls, or avoiding improper ones (Shang Zhanga, 2018). Additionally, it's crucial to justify the appropriateness of these measures, identify common mode failures, and set performance indicators. The justification should also include critical parameters and performance indicators for the accepted measures. If necessary, reviews of these measures should be initiated when they become no longer effective (Zhang et al., 2018).

2.10 Empirical Review

2.10.1 Major Factors of Rework

The study aimed to identify the main factors causing rework occurrences in Ethiopian projects, particularly in Addis Ababa. Data was collected from the start of the buildings' defect liability period until its conclusion. The primary factors were errors and omissions in contract documents and client-initiated changes. Costs accounted for 5% to 25% of the contract value and led to almost 50% of project time overruns, according (Forcada, Gangolells, et al., 2017).

The research titled "Illustrative" on seven building projects in Sweden found that poor workmanship, inappropriate design, and lack of coordination were the top reasons for rework (Ashebir, 2020). According to the study's findings, the three main reasons for rework in the Gaza Strip were determined also to be a lack of job security and attempts at fraud. An attempt to commit fraud was ranked #1 next to competitive pressure based on

the severity the cost raised by 10% and the project's delay by 77% as a result of rework (Enshassi et al., 2017).

In South Africa, changes requested by the client and the design team were factors of rework (Simpeh, 2012). In Nigeria, late user involvement was found to be the main rework contributing variable in selected building projects. The study also found that in the South African building construction sector, changes requested by the client and the design team were factors of rework (Oyewobi & Ogunsemi, 2010)

According to (Shah et al., 2016) survey in a building project were recognized and grouped into seven categories related design, owner, contractor, construction process, material, human, and environmental. so, from this, the determined most crucial 14 factors derived further by using Importance Index method (IMPI) and for generation of Field Rework Index (FRI) from south Gujarat region. After comprehensive data analysis, misreading of drawings & specifications S.I 67.81,F.I 62.19 and IMPI 42.171, Scope & design changes S.I 67.03, F.I 62.66, and IMPI 41.99, Failure to implement Quality management S.I 66.09, F.I 61.41 and IMPI 40.58, Changes because of change in officials S.I 59.38, F.I 67.5 and IMPI 40.07, Late designer input S.I 62.5, F.I 63.91 and IMPI 39.94, Improper supervision, Maintenance issue relevant to material S.I 57.97, F.I 62.81 and IMPI 36.41, Non-compliance with specification S.I 60.94, F.I 59.69 and IMPI 36.37, Lack of knowledge of construction process and Schedule pressures S.I 58.75, F.I 61.56 and IMPI 34.82 were the most crucial factors for rework (Shah et al., 2016).

However, The study focuses on the occurrence of 38 rework variables in Egypt, with the first recommended criteria being insufficient expertise of the owner's supervisory team (REC5) (Al-Janabi et al., 2020; Mahamid, 2020). The ideal group for this factor is the rework source of related design process (RDP), which should be renamed rework engineering consultancy process (RECP). The second and third factors, staff turnover/allocation to other projects (RCP9) and delay in paying contractual fees (RCM2), are listed under contractor performance (RCP) and contract management (RCM), respectively(Akal & El-Kholy, 2021; Ye et al., 2015). The contractor's compulsory changes due to site conditions are a frequent cause of rework, with a mean score of 3.623. Poor communication among team members, including engineering disciplines, is another

issue. This results in poor integration and coordination, highlighting the importance of a partnership among engineering specialties in project development or execution. Overall, these issues contribute to frequent rework (Akal & El-Kholy, 2021).

The rework of a project has been attributed to several factors, including accelerated timelines, delayed payment of fees, a policy of selecting the lowest financial offer without considering the tender's technical competency, poor local vocational education, design errors due to limited timeframe, and poor contractor workmanship. The project's financial budget was reduced due to staff turnover, lack of training programs, ineffective integration and coordination among engineering discipline members, forced changes due to site conditions, and ineffective communication between executive managers of various engineering disciplines. Moreover, the other empirical study shows that the eleven factors that influence rework in the Egyptian building construction industry were the most dominant factors related to the client. The survey's results indicate that the following were the most significant and impactful elements: Specifications change by the client came in at number four out of 87 reworks factors, with a T.I.I.R.I. of 44.41%. This outcome is consistent with the research done by (Hwang et al., 2014).

Furthermore, Modifications to client demands during the building construction phase can lead to significant changes in project planning and procurement processes (Enshassi et al., 2017). Furthermore, with T.I.I.R.I = 44.28%, Inadequate or weak feasibility study negatively impacts the project's performance, ranking second in this group. Change of plan or scope was the third critical element, ranking sixth with T.I.I.R.I = 43.79%. According to (Hwang et al., 2014) this has a detrimental effect on project cost, schedule, and quality performance. The early design or construction phases without a defined project scope result in regular adjustments and updates to project functions. Poor communication with the contractor or design consultant is ranked 74th out of all rework reasons in the Egyptian client group. However, research from Palestine and Nigeria disagrees, ranking this factor at the top with the greatest influence (Mahamid, 2016), Nigeria(Eze et al., 2018).

A study on 42 Ukrainian building construction projects found that lack of coordination and design changes significantly impact rework. Inadequate coordination, poor communication, and design changes negatively affect the owner's ability to perform the

rework process. Incomplete designs at tender and poorly coordinated designs have the most significant impact on the frequency of reworks. Contractors ranked the design change initiated by them first with a high effect of 53.8%, while poor resource planning and coordination had the lowest effect with 23.1% and 26.9%, respectively (Trach et al., 2019).

In Nigeria, rework incidents are influenced by factors related to clients, designs, and subcontractors. The most highly ranked factors include inadequate coordination, poor communication with the design consultant (mean = 3.90); use of defected materials (mean = 3.83); poor workmanship (mean = 3.79); lack of experience (mean = 3.65); incomplete design, damages, insufficient managerial skills, and defects (mean = 3.75); The least common reasons for rework include staff turnover (mean = 2.97),, absence of client involvement(mean = 2.87),, and insufficient manpower to accomplish tasks(mean = 3.08). These factors contribute to a lack of experience and knowledge in the design and construction process(mean = 3.73 (Ajayi & Oyeyipo, 2015).

After conducting additional research on rework in Malaysian building construction, it was determined that the top five factors contributing to rework occurrences were as follows: poor contractor quality management (Mean = 3.974), poor design team coordination (Mean = 3.923), poor subcontractor management (Mean = 3.897), unclear project management procedures (Mean = 3.744), and construction errors brought on by misinterpretation of the design (Mean = 3.692). However, the consultant group determined that construction errors resulting from misinterpreting drawings (Mean = 3.861), poor quality control by the contractor (Mean = 3.833), an unclear project management process (Mean = 3.806), poor site management (Mean = 3.806), and client-related factors were the top five factors associated with rework occurrences (Yap et al., 2017b). The primary cause was the design team's poor coordination (Mean = 3.816). Low-quality coordinated design and incorrectly detailed drawings are the result of poor coordination or a lack of communication amongst the consultants (Hwang & Yang, 2014).

In a similar vein, Hwang and Yang determined that inadequate communication amongst design consultants ranked as the second most likely cause of rework in the building construction sector in Singapore (Yap et al., 2017b).These factors included inadequate coordination between the designer and the client (Mean = 3.538), poor subcontractor

management (Mean = 3.692), construction errors caused by a misinterpretation of the design (Mean = 3.590), and poor-quality management by the contractor (Mean = 3.590). The majority of contractors concurred that poor communication between the design team and the client is to blame for the frequency of rework. During the building construction phase, contractors are the first to handle design issues and supervise the construction site (Yap et al., 2017b).

The study analyzed factors that contribute to rework occurrences in Ethiopia, focusing on contractor-related, client-related, consultant-related, human resource capability, and external and environmental related factors The mean score for these factors were 3.41, 3.40, 3.27, 3.32, and 2.40 for the degree of occurrence, and 3.66, 3.57, 3.45, 3.40, and 2.69 for the impacts on cost and time performance, respectively.

For the eight developing nations of China, Malaysia, Nigeria, Qatar, Palestine, South Africa, India, and the United Arab Emirates, ten particular studies were selected. The purpose of this was to do a comparative analysis between Egypt's top rework factors and those of other selected nations. To guarantee a fair comparison, in-depth research and rating based on key variables were consequently necessary in these areas. Consequently, the total numbers of rework factors, the ranking of each component, and the technique used for this ranking have been computed for each of the stated countries.

Comparison of main factors to rework occurrences in different countries

In general, this research looked on how to rework events depending on their severity, impacts, and potential solutions for mitigation. The findings require a comparison of the primary variables to modify occurrences in this study with those in other nations. According to the Ethiopian research, delayed material supply was identified as the primary cause of rework, as indicated in Table 2.1 In Saudi Arabia as well as Nigeria, poor communication was ranked highest. In Palestine, India, and China, respectively, attempts at fraud, misreading of drawings and requirements, and unclear project management were identified as the primary causes of rework (Mahamid, 2016). The top five causes that led to the occurrence of rework in various nations are shown in Table 2.10.

Table 2. 1:Comparison of top five rework factors in different studies

Rank	Saudi Arabia	Palestine	India	China	Nigeria	Ethiopia	This research
1	Poor communication	Attempts to fraud	Misreading of drawings & specifications	Ambiguous project management	Poor communication with design consultant	Late material delivery	Incomplete design and inconsistencies, Errors, omission, during the design process.
2	Use of poor-quality material	Competitive pressure / low Contract value	Scope & design changes	Poor quality of building construction technologies	used Use of poor-quality materials	Workmanship error	Imperfect construction technique, methods, procedure and practice.
3	Poor site management	Ineffective management and Decision-making	Failure to implement quality management practices	Use of poor building construction materials	Poor workmanship	Design errors and omissions	Insufficient skill and defective workmanship of contractors
4	Late design changes	Schedule pressures	Change in officials	Active rework made by the contractors to improve quality	Lack of experience and knowledge of design and building construction process	Late design changes by the client	Non-compliance with specification and standards
5	Errors and omissions	The absence of job security	Late designer input	Design error/omission	Incomplete design as at time of design	Lack of skilled labors	Hiring technically unqualified contractors

Source: previous researcher’s survey data

2.10.2 Direct Impacts of Rework

Previous research has demonstrated that, according to Rethinking Construction, at least 10% of materials are wasted, labor is only utilized at 40 to 60% of its maximum efficiency, and up to 30% of building construction is rework. Rework expenses might account for up to 23% of the contract value, according to the study (Shah et al., 2016). The average rework cost in residential building construction projects over the last five years, according to another study conducted in the West Bank and Palestine, varied between 10% and 15% of the original contract cost (Mahamid, 2016)..

Rework factors with degree of occurrence and its Impacts on Cost and Time Performance Mean and Rank respectively. Workmanship errors 3.88, 1st, and 4.06, 1st. Late material delivery 3.77, 2nd and 3.81, 2nd. Design errors and omissions 3.74, 3rd and 3.81 2nd. Late design changes by the client 3.66, 4th and 3.80, 4th. Lack of skilled labors 3.65, 5th and 3.77, 6th. Incomplete drawing 3.60, 6th and 3.68, 9th. Improper subcontractor selection 3.58, 7th and 3.80, 4th. Extra order by the client 3.56, 8th and 3.75, 7th. Insufficient skilled manpower 3.52, 9th and 3.68, 9th. Poor supervision 3.5, 10th and 3.69, 8th. Poor communication with contracting parties 3.50, 11th and 3.58 15th. Inadequate supervision 3.50, 12th and 3.62 13^{th}. Poor site management 3.49, 13^{th} and 3.65 11^{th}. Poor contract document and specification 3.47, 14^{th} and 3.38, 23th. Hiring unqualified contractors 3.45, 15^{th} and 3.62, 13^{th}. Poor communication system 3.43, 16^{th} and 3.67, 10^{th}. Poor client supervision 3.39, 17th and 3.58, 15^{th}. Insufficient training and skill development 3.36, 18^{th} and 3.49, 21th. Poor-quality material selection 3.33, 19^{th} and 3.51, 20^{th}. Lack of employee motivation and rewords 3.24, 20^{th} and 3.29, 26^{th}. Lack of funding allocation 3.24, 21th and 3.54 18^{th}. Use of poor-quality material 3.23, 22th and 3.63, 12^{th}. Poor coordination between design and construction team 3.22, 23th and 3.43, 22th Misreading of drawing and specification 3.16, 24th and 3.52, 19^{th}. Using defective equipment 3.13, 25^{th} and 3.26, $28^{th.}$ and Lack of early client involvement in the project 3.08,27^{th} and 3.31, 25^{th}.

According to (Akshay & Konnur, 2020)have examined the influence from various angles, including time, cost, and party satisfaction. Time overrun, cost overrun, and reduction in profit are the top three effects of rework. According to Abraham's results Additionally, the

RII values for both parameters are 0.688. The RII for client discontent is 0.632, but the degree of conflict arrival resulting from rework occurrences is only 0.556. The eight rework-related outcomes that are examined and graded according to their RII value are shown in the table below.

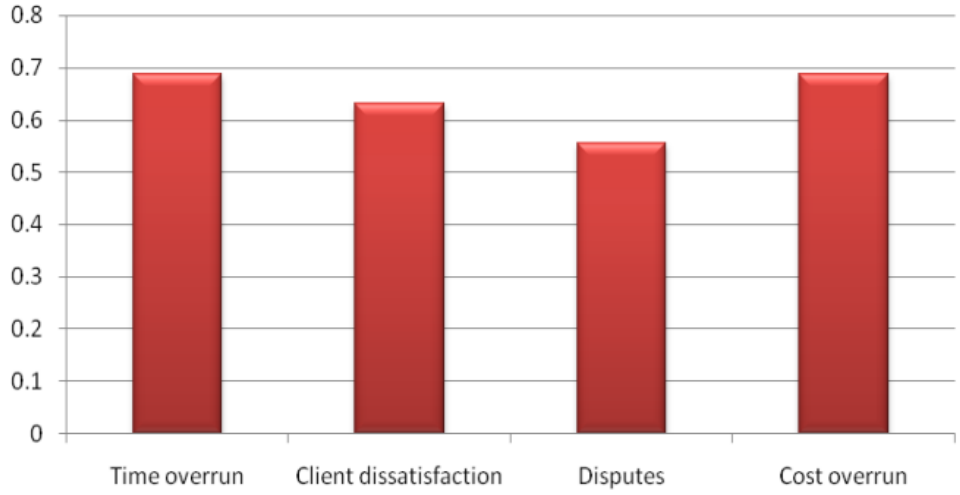


Figure2. 5: Impact of rework occurrence (Akshay & Konnur, 2020)

2.10.3 Mitigation measures /strategies of Rework

Hwang and Yang (2014) found that a strong communication network involving all participants had a high mean value of 4.114, making it the most effective approach. He has maintained that eliminating rework requires effective communication. Proper communication channels between the parties facilitate a better understanding of the project requirements, which helps to reduce rework. Appropriate production planning (Mean = 3.842), the implementation of a good quality management system (Mean = 3.763), and adequate technical skills and workmanship (Mean = 3.754) are the next potential solutions. With mean scores more than 3.0, the alternative answers are also considered relevant by the respondents. The top-ranked measure persisted in providing a good network for communication between all stakeholders. Even a strong network for communication between all stakeholders (Mean = 4.028), sufficient technical know-how and craftsmanship (Mean = 3.778), and an effective site management system (Mean = 3.694). This result shows that the consultant group concentrated on improving contractor site management skills in order to lower rework. The contractor group's top three metrics were effective site

management (Mean = 3.846), effective communication between all stakeholders (Mean = 4.103), and appropriate production planning (Mean = 3.846). This result is consistent with the previously stated result, which stated that the contractor group concluded that inadequate communication is the most likely cause of rework.

The study provides eight rework mitigation strategies, emphasizing the importance of an effective design process management system, team coordination, and contractor engagement. It emphasizes the need for client and design consultant consent at the design stage to increase design integration and constructability. The study, focusing on Malaysian building construction, also highlights the potential for identifying novel reasons and solutions in infrastructure projects (Yap et al., 2017a).

Recording rework occurrences in a project is crucial and implementing a control system is recommended. This can be achieved by raising project participants' knowledge of rework and understanding its contributing factors. This will help project managers find effective ways to boost performance and reduce rework. When choosing new projects, consider factors such as misreading of drawings and specifications, scope and design changes, failure to implement quality management, changes due to officials, late designer input, improper supervision, maintenance issues, non-compliance with specifications, untimely deliveries, lack of audit and control, rigidity to improvement, lack of knowledge of building construction process, and schedule pressures (Shah et al., 2016).

A smaller number of studies have been conducted in building and construction industry in Australia rework factors management strategies may effectively reduce rework. include design management, contract document auditing, design and documentation risk management, quality emphasis, skill improvement, assurance of inspection and supervision, and construction scheduling. 22 strategies were subsequently found by (Zaiter & Enshassi, 2014) to lessen the impact of rework on building construction project performance.

Furthermore, (Hwang et al., 2016) proposed 11 methods to address the rework effects on green construction projects by polling the opinions of 30 Singaporean professionals. Additionally(Yap et al., 2017b) proposed eight solutions for reducing the influences of the 18 main elements that contribute to rework occurrence in the Malaysian building

construction sector. (Balouchi et al., 2019) also have determined that the implementation of a quality control plan, sufficient communication channels between the supervisory team and the design team can effectively control the top factors that require rework in mass housing projects (Akal & El-Kholy, 2021).

2.11 Best Local and international practice /experience/

2.11.1 Local Practice in Ethiopian public building construction project

Since infrastructure development is essential to attaining rapid economic growth, In Addis Ababa's public building construction project, it converts different resources into the social, economic, and physical infrastructure needed for socio-economic development. A vital economic sector that influences the majority of other sectors is the building construction industry (Muluneh & Amsalu, 2022).

The building sector in Ethiopia continues to encounter several challenges, such as construction cost overruns and timetable delays. 8.25% of projects in Ethiopia have attained their planned completion dates, per study by (Koshe & Jha, 2016) He claims that 352% of the projects' completion dates have been missed by the remaining 91.75% of the projects. As an illustration, Eskedar, the researcher who examined material waste in 40/60 condominium building projects sites at Housing Projects in Addis Ababa, claims that the cost of material waste amounted to 10% of the contract price (Koshe & Jha, 2016).

The public building project in Addis Ababa was constructed, managed, and overseen by the Addis Ababa City Housing Development Agency. Using the Relative Importance Index as a guide: (Enshassi et al., 2017) Ethiopia's Rework Effect The top three ranks had time overruns of 0.84, cost overruns of 0.80, and reduced profits of 0.78 for the first, second, and third ranks, respectively. Parties' disagreements scored 0.73 in the fourth rank, contractual claims scored 0.70 in the fifth rank, and end user/client satisfaction scored 0.68 in the sixth rank, placing them in the center.

According to (Ashebir, 2020), reputational damage ranked seventh by 0.65, quality degradation ranked eighth by 0.63, and reputation damage ranked last. There were twenty-seven (27) clients, consultants, and contractors involved in the construction of the Bahir Dar University building. As an impacts, five (5) typical variables and ten (10) significant

categories of building faults were found. The findings show that poor workmanship is responsible for 32% of construction defect factors. Defective materials, poor supervision, design error, and inadequate surface inspection account for 24%, 24%, and 1% of the survey, respectively.

Based on its findings, the study confirmed eight (8) implications of rework occurrence. The first major effect of rework is time overrun, which is followed by cost overrun and profit decline. Using highly competent designers, implementing quality control processes, and conducting frequent site supervision are the top three tactics for reducing building construction defects and rework. Every contractual party pays a portion of the rework, with material suppliers leading the pack with 26.28%, contractors coming in second with 25.94%, designers and supervisors with 25.49%, and clients with 22.29% (Mamaru, 2020).

2.11.2 International Practice in public building construction project

The building construction industry's development and economic and cultural conditions significantly influence the rework factors, impacts, and mitigation strategies. A study comparing Egypt with other emerging nations such as China, Malaysia, Qatar, Palestine, South Africa, India, the United Arab Emirates, Nigeria, and Ethiopia revealed that Ethiopia's primary factors of rework did not align with those of these countries. Research is ongoing to understand factors contributing to rework in the construction industry (Aiyetan, 2013).

According to (Enshassi et al., 2017) identified various reasons for reworking building construction projects, including contractor fraud, competitive pressure, inefficient management, timetable pressures, and job security issues. In the West Bank, factors like poor client communication, low-quality materials, and poor site management contribute to rework. (Mahamid, 2016). (Xiong et al., 2014) identified 39 key criteria for rework in Chinese development projects, including unclear project process management, poor quality of construction technologies, poor materials, active rework, and design errors. (Simpeh, 2012) In South Africa, non-compliance with specifications, poor labor skill levels, incorrect laying out, and revisions made at client request are also factors.

The main reasons for rework in Indian building projects include frequent modifications, unclear contractual conditions, inadequate design details, errors in design drawings, and a

lack of trained labor. On the other hand (Raghuram & Nagavinothini, 2016) found that mistakes due to improper construction techniques, lack of qualified supervisors, and lack of expertise were the most common reasons for rework.

The literature review on rework mitigation measures in Palestine found that hiring qualified designers, providing sufficient time for design preparation and review, hiring skilled labor, organizing training workshops, and motivating labor financially and morally can significantly increase productivity and efficiency.(Mahamid, 2016),(Palaneeswaran et al., 2014) and in Singapore experience the most effective mitigation measures of rework is to utilize BIM. Because when to use the modern tools of BIM throughout the design and construction phase," "design reviews, verifications, and audit to reduce system errors," and "rework tracking system to prevent future occurrences of rework."

In Singapore, the most effective mitigation measures for rework include using Building Information Modeling (BIM) tools throughout the design and construction phase. BIM reduces system errors through design reviews, verifications, audits, and rework tracking systems. Research suggests that using BIM could have avoided over 50% of design errors causing financial losses(Shang Zhanga, 2018). Additionally, BIM is an integrated data platform that manages accurate building information throughout its lifecycle, improving internal coordination, cross-disciplinary collaboration, issue solving, decision support, risk management, and productivity enhancement. This leads to less design error and subsequent reworks, enhancing overall construction process control (Eastman et al., 2011; Volk et al., 2014). This study investigates the impact of rework on contractors' learning mechanisms and aims to bridge the knowledge gap in the construction industry (Zhang et al., 2018). It argues that effective rework management systems not only increase profitability but also strengthen contractors' management skills, which is crucial given the competitive nature of the industry (Shang Zhanga, 2018).

Table 2. 2: Summary international practice of rework.

Res. No	Authors	Country	Year of Public	Rework Group	Top Five Cause of Rework
1	Ayetan et al	Nigeria	2013	1.Client 2. Contractor 3. Design	1.Wrongly laying of blocking work 2. Poor quality of concrete 3. Lack of correct interpretation of 4. customer requirement 4. Poor communication 5. Inadequate construction planning
2	Zeiter et al	Palestine (Gaza Strip)	2017	1. Contractor 2. Human resource capability 3. Design Related Cause 4. External Environment 5. Client Related 6. Material and Equipment Supply 7. Construction Process	1.Attempt to Fraud by The Contractor 2. Low Competitive Price/Pressure 3. Ineffective Management and Decision Making 4. Construction Process 5. The Absence of Job Security Capability
3	Mahamid	Palestine (West Bank)	2016	1. Client Related 2. Contractor 3. Consultant Related Cause 4. External Environment	1. Poor communication with the consultant 2. Poor communication with the contractor 3. Use of poor-quality material 4. Poor site management 5. Poor communication with the design consultant
4	Ye And Skitmore	China	2014	1. Contractor Field Management 2. External Environment 3. Contract Management 4. Sub-contractors Management 5. Design Management 6. Project Communication Management 7. Project Plan Changes 8. Change for Quality Improvement 9. Client Management 10. Project Scope Management 11. Project Process Management	1. Unclear and Ambiguous Project Management Process 2. Poor Quality of Construction Technology Used 3. Use of Poor Construction Material 4. Active Rework Made by the Contractor to Improve Quality 5. Design Error, Omission, Because to Many Design Tasks
5	Simpeh	South Africa (Cape Town)	2012	1. Client 2. Design 3. Site 4. Sub-Contractor	1. Noncompliance with The Specification 2. Low Lab Our Skill Level 3. Shortage of Skilled Laboure 4. Setting Out Error 5. Changes Made at the Request of Client
6	Jarkas et al	Qatar	2015	1. Client 2. Designer 3. Contractor 4. Exogenous	1. Frequent changes during the construction 2. Absence contractual clauses and specification 3. Incomplete design detail at the tendering stage 4. Error and omission in the design drawing 5. Shortage of skill Laboure
7	El Hussein	Dubai	2014	1. Client 2. Design 3. Site 4. Sub-Contractor	1. Specification noncompliance 2. Low Laboure of level skill 3. Shortage of skill level 4. Setting out error 5. Defective workmanship
8	Ajayi $ Oyeyipo	Nigeria	2015	1.Client Related 2. Design Related 3. Sub-Contractor Related	1.Poor communication with the design Consultant 2. Use of Poor-Quality Material 3. Poor Workmanship 4. Lack of Experience and Knowledge of Design and Construction Process 5. Incomplete Design at the Time of Design
9	Eze$ Ganiyu	Nigeria	2018	1. Client 2. Design 3. Site 4. Sub-Contractor	1. Unclear Instruction to Workers 2. Shortage of Skilled Supervisor 3. Incomplete and Inaccurate and Information 4. Error in Setting Out

2.11.3 Conceptual Framework of The Study

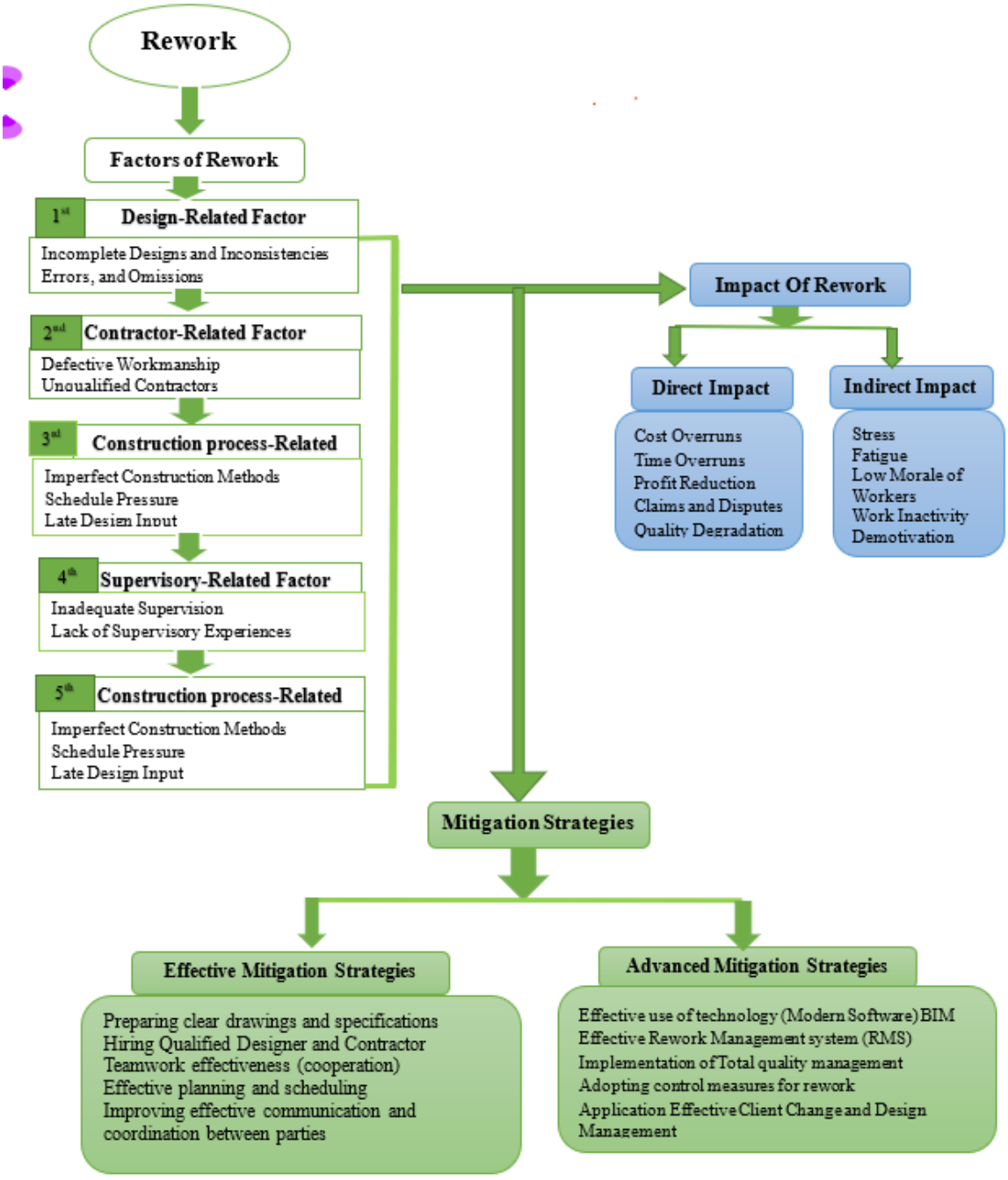


Figure2. 6:Conceptual framework

2.12. Research Gap

The identification of rework on a small number of task categories and specific projects was not addressed in the majority of earlier studies. To reduce the probability of rework, it is important to investigate how frequently each type of activity occurs. Thus, the goal of this study was to determine which task category, given certain in multivariable, is most commonly occurred in rework. Furthermore, there is a lack of comprehensive discussion regarding the quantitative and qualitative analysis of the total impact of the determinants of rework, particularly in the construction projects involving public buildings. As a result, determining the primary causes of rework based on their unique identification of direct and indirect impacts on project performance proved challenging. Thus, the goal of this study was to identify the elements that factors, impacts and it mitigate measures of rework on public building projects.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

The research approach utilized to gather the data for analysis is discussed and explained in the methodology chapter. A review of the study's literature was presented in the previous chapter. It provided fundamental insights into subject on the required concepts related to the determination of construction rework occurrence in public building projects in Addis Ababa. This chapter's key subjects included the study area, research methodology, research design, target population, sample size determination and sampling technique, source of data and its collection methods, and data analysis methods finally data validity and reliability. Figure 3.1 illustrates the general methodology and the process of how the study is implemented in order to achieve the objectives stated in chapter one.

3.2 Study Area

The Addis Ababa Government Design and Construction Works Bureau is a government administered and managed the entire public building construction project. This Government bureau managed and administered the projects as a client. The selected project sites for this research were located in Bole sub-city, Yeka sub-city, Akaki and Lideta sub-city included in randomly selected in Addis Ababa sub-cities. Therefore, the research mainly on apartment housing $2B+G^{+11}$, $4B+G^{+8}$, G^{+8}, G^{+5}, and ground hospitals, educational sectors, apartments, police station, prison, administration offices and other relative building construction projects for which hundred building construction sites are randomly selected.

3.2. Research Design

As a research design, descriptive design was selected based on the research questions. According to (Nawaz et al., 2022) 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 factors and overall impacts of rework and the measures taken to reduce reworking. So, the reason behind using the descriptive design was factors all of the research 15 questions were towards answering the “what” and are explaining or describing the rework phenomenon. As previously

mentioned, surveys are used to gather data from a large number of samples. Therefore, a generalized result can be produced when data is collected from a defined sample. There are 116 people in the sample overall for this investigation. Therefore, a survey was selected as an appropriate study technique in order to collect data from this many samples in a condensed amount of time. So, the questions what are the major factors and impacts of rework and what measures are taken to reduce reworking were answered through survey strategy.

3.2. Research approach

This study was adopted both quantitative and qualitative (mixed) research approach to meet the objectives. According to a number of researchers, the advantage of using a mixed approach is to cover the weakness of each approach with the strength of the other approach and produce a complementary fact.

3.2.1 Quantitative Research Approach

According to Creswell (Kothari, 2004) quantitative research approach count things, analyses data statistically and estimates results in numeric forms. This approach is used to find facts based on evidence or records. The objective of qualitative approach is to develop understanding and to explain the phenomenon. Furthermore, Mark et al. (2016) noted that a survey strategy enables the researcher to get quantitative data and is typically employed in conjunction with a descriptive research approach.

3.2.2 Qualitative Research Approach

A qualitative research approach, according to Creswell (2003), measures attitude through the measurement of opinions, view, and perceptions. This method seeks to clarify and deepen our understanding of the phenomenon. Therefore, using a survey to gather respondents' opinions regarding rework mitigation techniques, a qualitative research strategy was used. Furthermore, this strategy was used to employ ongoing construction projects to locate the origin, the manner in which it occurred, and the accountable party in order to explain the rework problem. In order to fulfill the targeted specific objectives, this research used a hybrid strategy that combined both approaches.

3.3 Target Population

According to Simpeh, defining the population is the first stage in sampling for any research (Simpeh, 2012). The study population and sample size for this research were limited to contract engineers working at various building construction sites within the Addis Ababa government's design and building construction works bureau. Ninety professionals supplied the data from the contractors that are currently in operation, which include Asmelash and Lijochu, Olimer Construction plc, Ankon plc, Merid Tadesse building constructor, Icon Construction, Etete Construction, Zamra Construction, DMA building contractor, Olimarse Construction PLC, and Jemal Seyid building contractor. Other consulting firms include Adib Abidurahiman Consulting and Architect plc, Ethiopian Defense Force, Niya Engineering plc, Eyob Kinfe Consulting and Architect, Scale Consulting, Ultimate Consulting, Axsum Kinfe Building Engineering, Building and Design Agency, Falcon Consulting, Train Consulting, Dynamic Consulting, MJM Consulting, Skyline Consulting, and Niya Engineering plc. But 42 were submitted by client representatives. The respondents were professionals such as project managers, site engineers, resident engineers, and contract engineers, and other relative respondents were professionals who have a significant role in the building construction projects.

3.4. Sampling Technique

To ensure that the study's target population had equal opportunity, a simple random sampling approach was used. According to (Bell & Waters, 2018; Leedy & Ormrod, 2010)survey research methodologies are most commonly utilized in relation with this sampling technique. The authors argue that using random numbers allows us to select a sample without bias. As a result, the randomly selected sample can be considered representative of the target population. Furthermore, the authors indicated that simple random sampling is most effective when there is an easily accessible sampling frame that includes the population as well as a few hundred target populations. Otherwise, the selected sample is likely to be biased. As a result, due to the high accuracy of representation and the availability of contracting party lists, simple random sampling was utilized to pick the sample for this investigation (Fellows & Liu, 2021). Even although according to Yamane sampling technique method in (1967:886) established a simplified formula for computing

sample sizes. This sample formula was used to calculated by using 95% confidence level and P = .5 margin of error are assumed for Equation 1.

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size, and e is the level of precision. When this formula is applied to the above sample, we get Equation 2.

The Addis Ababa city government design and construction works bureau, which is the single client overseeing the projects, has 32 representatives, 42 members who have been consulted, and 90 professionals who have built the buildings, according to the list of building contacting parties that was obtained from the bureau. Thus, there are 164 members in total. So, the questionnaire's target respondents were building construction experts who work for these construction firms. As a result, the sample size for this study was estimated using Yamane's formula (1967). This equation can be used to calculate sample size given a known sampling frame. The sample size was estimated as follows:

^{n}Yamane = N / (1 + Ne2)

Where, n = sample size

N = known population size

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

Total Number of target population= 164

^{n}Yamane = N / (1 + Ne2)

= 164/ (1+164*0.0025)

= 116

3.5 Sources of Data

The necessary information was gathered for the study using both primary and secondary data collection methods.

3.5.1. Primary source of data

In this research was chooses to collect information data directly from sources, the obtained were referred to as primary. To gather direct information from respondents working in the Addis Ababa government design and construction works bureau, a combination of a structured questionnaire survey and interviews with those who play major roles on building construction sites are used to gather this data.

3.5.2. Secondary source of data

Secondary data were already gathered and examined by another party. When using secondary data, the researcher looks into numerous sources from which those might be obtained (Kothari, 2004). After the research's main question has been established, literature evaluations from a variety of sources, including textbooks, journals, conference proceedings, dissertation, thesis and articles, with related materials, have been consulted to gain a thorough understanding of the subject. Particularly, the nature of rework in building projects, frequent critical factors of rework, adverse impacts and its effective mitigation solution on the projects and measured and suggested by previous researches have been made. In expansion to this, a broad writing audit was conducted to create a coherent and comprehensive see of the taking after relevant points: and extensiveness of rework.

3.6 Research methods

3.6.1 Questionnaire Design

A questionnaire is a tool for data collection that consists of a series of questions designed to produce information from certain respondents. A closed-ended questionnaire was created based on a review of existing studies. The questionnaire is divided into six sections: as below shows the study's questionnaire design. Also, questionnaires were designed and distributed to contractors, consultants, and public-client representatives to get their opinion with regard to achieving the specific objectives.

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: Project Characteristics

This section of the questionary added to obtains information concerning project type, project facility type, and other detail.

Section C: Factors of Rework

In order to address the research's initial question, this component of the questionnaire was included. Following several literature reviews, about 48 factors divided into ten groups of reworks were found. The respondents were then asked to rate the frequency to which these factors contributed to the need for rework on their projects.

Section D: Impacts of rework

In order to address the study's second question, this component of the questionnaire was introduced. All of the impacts that were gathered from the literature review and adjusted for the pilot study were listed in this section. That the following rework impacts more impacted the project's performance, according to the respondents.

Section E: Measures taken to reduce rework

In order to address the third study question, this component of the questionnaire was introduced. Survey participants were asked to rate the extent to which they had implemented the approximately 18 mitigation measures and 5 advanced mitigation measures of rework that had been gathered from various research in order to minimize rework in their projects.

Section F: Interview

The research used the semi-structured interview method to gather experts' opinions on rework and related concerns among professionals at the Addis Ababa Government Design and Construction Works Bureau. The interviewer, known as the interviewer, asked questions in face-to-face contact. The qualitative data was collected through interviews with relevant parties involved in site operations, focusing on the occurrence of rework and related concerns. This method ensures accurate and comprehensive data collection.

3.7 Data Analysis Method

During the descriptive study, semi-structured interviews were used to collect qualitative data, which was then subjected to content analysis. The recorded material was transcribed first and foremost. The next step was to search for patterns that appeared throughout the entire set of interviews in order to establish a framework for comparing and contrasting the various respondents. Quantitative data extracted from closed ended questionnaires was encoded using the Statistical Package for the Social Science (SPSS) and results were carefully analyzed statistically using both the descriptive statistical analyses. Given that a descriptive study approach was employed to achieve the objectives, the ordinal data were analyzed using SPSS software utilizing descriptive statistics that comprised measures of frequency, dispersion (standard deviation) and measures of central tendency (mean, median, and mode).

3.7.1 Relative Importance Index (RII)

The RII approach was used to rank all of the factors provided in the questionnaire. The score for each factor was derived by adding the scores assigned to it by the respondents. After computing the RII, the factors were ranked according to their respective values.

The relative importance index (RII) was calculated using the following formula (Holt, 2014).

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

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

RII = Relative Importance Index

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

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

N = Total number in the sample

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

3.7.2 Measurement of scales

As per (Norman, 2010)**,** it is vital to comprehend the measurement level in order to choose the suitable analysis method for every level of measurement. The author claims that the Likert scale is based on the premise that every item on the scale has an equal amount of attitude value. A five-level Likert scale was employed in this study, depending on the questions posed to different categories of participants consultants, contractors, and clients.

The first descriptive study for this research used a semi-structured interviewing approach to get expert opinions on the issue of rework and related issues in Addis Ababa design and construction works bureaus project sites. Finally, tables and graphs with the gathered data were displayed. Making the questionnaire was the first stage in the data collecting procedures that were followed in order to gather the necessary data. The next two tests were used to assess the questionnaire's reliability and content validity.

A. Validity

In essence, validity refers to the suitability of the measures used, the accuracy of the results analysis, and the generalizability of the findings"(Cohen et al., 2017).The authors define validity in terms of questionnaires as the instrument's ability to measure what it was intended to measure. Among the numerous types of validity, content validity determines whether or not the instrument addresses the examined questions. A pilot study was carried out prior to the questionnaire's distribution. To assess content validity, the questionnaire was distributed to 21 experienced in the building sectors, together with the objective and research questions. Following that, the questionnaire was modified based on the comments and distributed to the target populations.

B. Reliability

According to (Mohamad et al., 2015; Saunders, 2016) reliability relates to "replication and consistency," which indicates that if a study can be reproduced using an earlier design and the same results are obtained, the study can be considered reliable. According to the authors, Cronbach's alpha is a value that ranges from 0 to 1 and is used to assess internal consistency by determining whether the variables in the data collecting instrument measure similar things or not. In this study, this coefficient was utilized to determine the

questionnaire's reliability. As shown in the table below, the alpha coefficient was determined for each scaled group factor as well as the full questionnaire. As the results showed, the results for each group ranged from 0.7 to 0.909, with an overall Cronbach alpha of 0.805, meeting the reliability test criterion.

After getting these values, the researcher moved on to the data analysis steps. It was used to determine client, consultants', and contractors' perspectives of the frequency of rework in major work categories, the factors to rework occurrence and their impacts, and mitigation techniques to reduce the occurrence of rework currently on Addis Ababa's design and construction works bureau project sites.

Table 3 1:Cronbach's Alpha

Cronbach's Alpha	Internal Consistency
0.91-1	Excellent
0.81-0.9	Good
0.71-0.8	Acceptable
0.61-0.7	Questionable
0.51-0.6	Poor
0-0.5	Unacceptable

3.8 Ethical Consideration

The study's ethical standards were followed throughout the process. First, when reviewing secondary data from journals, articles, proceeding, and other sources, each source was acknowledged by in-text citation and reference. Second, any engagement with participants occurred following the distribution of the letter created by the institution for this reason. The questionnaire expressly states that responders' participation is completely voluntary. Finally, the respondent's name and organization were not mentioned in any of the study sections, thus each respondent remained anonymous and their response was confidential.

3.9 Methodological Triangulation

As the researcher attempted to use various methods of data collection that are employed in the research, the data collected for the study were analyzed quantitatively and qualitatively in combination to enhance the trustworthiness of the study. Therefore, the study employed a methodological triangulation approach which can be briefly summarized in the following table.

Table 3. 2: Methodological Triangulation

No.	Research Objectives	Methods Employed
1	Identifying The Critical Frequent Factors of Rework	❖ Questionnaire survey ❖ Interview
2	Identifying The Impact of Rework	❖ Questionnaire Survey
3	Forwarded The Effective Mitigation Measures and Strategies	❖ Questionnaire survey ❖ Interview

Source: Researcher's survey data (2024)

Table 3. 3:Operationalization of Variables

Objective	Variables	Research Approach	Source of Data	Data Collection Method	Population Size	Sample Size	Sample Technique	Methods of Data Analysis
Factors of Rework	48	Qualitative And Quantitative Research	Primarily From Comprehensive Literature Review and Secondary Data from Respondents	Questionnaires With 5-Point Likert Scale and Interview	164	116 With 93.55% Respondents' Rate by Using Yamane's (1997) Formula	Simple Random Sampling Technique	Descriptive statistics (frequency distribution, Percentile, mean, Std. deviation and RII Value) with Content Analysis for Interview by SPSS Version 2026
Impacts of Rework	8	Quantitative Research Approach	Primarily From Comprehensive Literature Review	Questionnaires With 5-Point Likert Scale and Interview	164	116 With 93.55% Respondents' Rate by Using Yamane's (1997) Formula	Simple Random Sampling Technique	Descriptive statistics (frequency distribution, Percentile, mean, Std. deviation and RII Value) by SPSS Version 2026
Effective Mitigation Measure and Strategies.	18	Qualitative And Quantitative Research Approach	Primarily From Comprehensive Literature Review and Secondary Data from Respondents	Questionnaires With 5-Point Likert Scale and Interview	164	116 With 93.55% Respondents' Rate by Using Yamane's (1997) Formula	Simple Random Sampling Technique	Descriptive statistics (frequency distribution, Percentile, mean, Std. deviation and RII Value) with Content Analysis for Interview by SPSS Version 2026
Advanced Future Mitigation Measure and Strategies.	5	Qualitative and Quantitative Research Approach	Primarily From Comprehensive Literature Review and Secondary Data from Respondents	Questionnaires With 5-Point Likert Scale and Interview	164	116 With 93.55% Respondents' Rate by Using Yamane's (1997) Formula	Simple Random Sampling Technique	Descriptive statistics (frequency distribution, Percentile, mean, Std. deviation and RII Value) with Content Analysis for Interview by SPSS Version 2026

Source: Researcher's survey data (2024

CHAPTER FOUR
ANALYSIS OF RESULTS AND DISCUSSION

4.1. Introduction

The survey results identified the most frequent critical factors of rework on project performance and the mitigation strategies used in public building construction projects at the Addis Ababa design and construction works and bureau. The questionnaire is divided into four major sections: respondents' identification, rework factors classified into ten groups, adverse direct and indirect impacts of rework, and measures to mitigate and control rework, which are analyzed using data collected through questionnaire surveys and interviews.

4.2. Projects' Description

Table 4.1 shows that there are 90 professionals from contractor and 42 professionals from consultancy and 32 were from client representatives working on the selected building construction projects. Most professionals are eager to collaborate on data collection, while 15 are unavailable due to site work completion, and three express little interest. The remaining professionals, who have a significant role, are purposively considered for the questionnaire survey and interview. Directly involved professionals from the client are also included in the survey and interview.

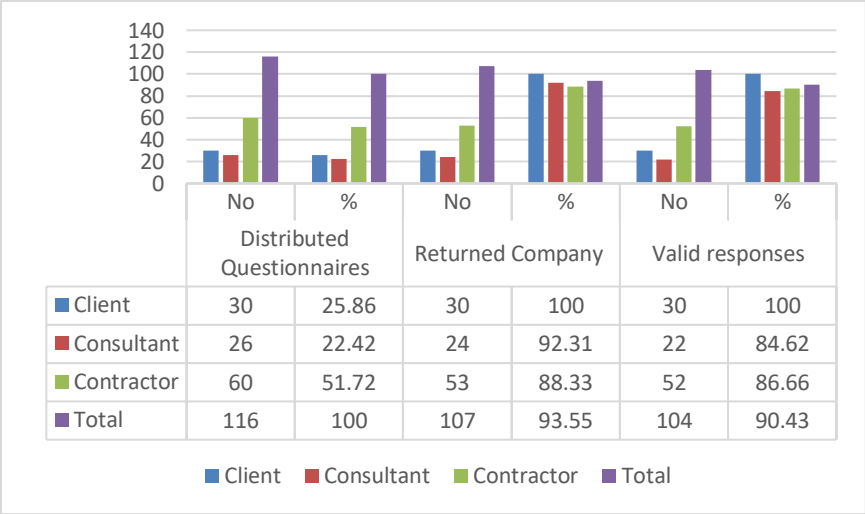
4.3. Questionnaire Survey Results and Discussion

The questionnaire survey aims to meet the three particular specific objectives outlined in Chapter 1. These are to identify the major factor contributing to rework occurrence based on their frequency and impacts, and to propose solutions and control strategies to mitigate the rework.

4.4. Response Rate of Questionnaire Survey

The data was expected to be obtained using a total 116 questionnaires issued to building construction professionals working on public building construction projects under charge of Addis Ababa building construction design and building construction works bureau. Hand-to-hand delivery and an online questionnaire were employed to ensure that every respondent was reached, resulting in a higher response rate and a better understanding of

how to answer or fill out the questionnaire. Out of the total of 116 questionnaires that were distributed, nine were not returned. Three of the 107 returned surveys were rejected due to invalid or incomplete answers. As a result, the study's research considered a total of 104 surveys from three contract parties. The table below shows the number of disseminated, returned, and valid questionnaires.



	Distributed Questionnaires		Returned Company		Valid responses	
	No	%	No	%	No	%
Client	30	25.86	30	100	30	100
Consultant	26	22.42	24	92.31	22	84.62
Contractor	60	51.72	53	88.33	52	86.66
Total	116	100	107	93.55	104	90.43

Figure 4. 1:Questionnaire Response Rate survey data (2024)

4.5. Profile of Respondents

4.5.1. Respondent company

Figure 4.1 shows that 30 (28.85%) client representatives, 52 (50%) contractors, and 22 (21.15%) consultants participated in the study's questionnaire survey. The overall response rate among the three parties was 90.43% (Table 4.2).

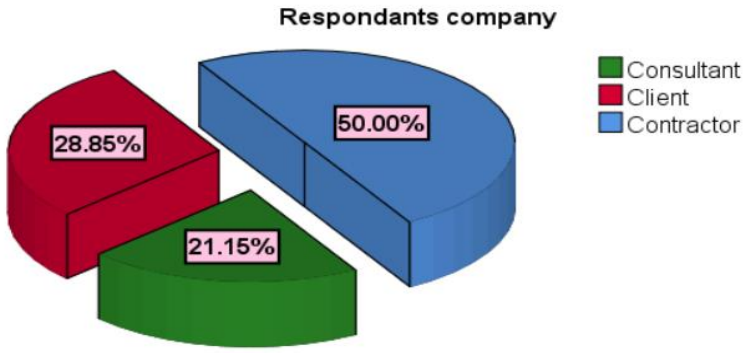


Figure 4.2: Respondents' Companies

4.5.2. Current position of respondents

Table 4.2 illustrates the present positions of the survey respondents. As shown in the table, project managers, supervisors, contract engineers, site engineers and resident engineers engaged in the questionnaire survey at a rate of 19.23%, 7.69%, 26.92%, 16.35%, and 15.38%, respectively. Within this group, 14.42 % "Others" refers to people in charge of civil engineering major tasks.

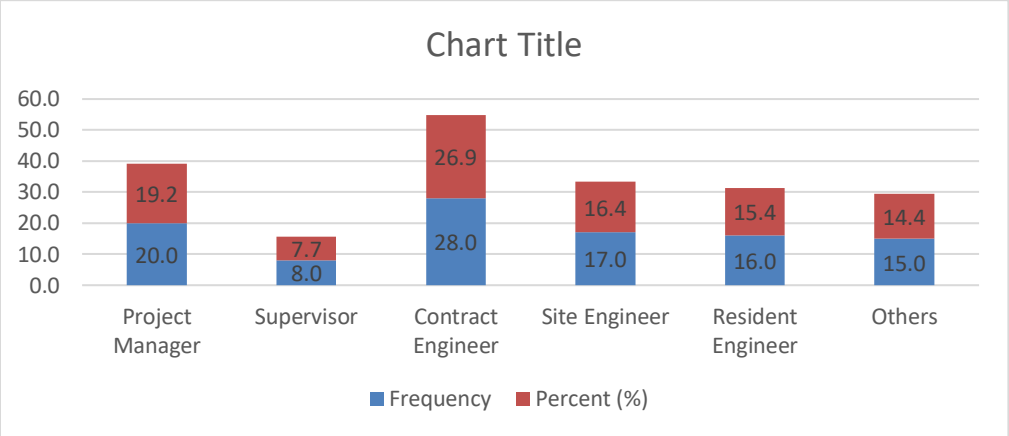


Figure 4.3: Positions of Respondents Source survey data (2024)

4.5.3. Experience of respondents

Respondents' years of experience in public building construction projects were divided into four categories, with the first three having a five-year interval and the final having more than 15. As figure 4.3, the majority of respondents (59.61%) have < 10 years of work experience. Among the 104 respondents, 13.46% had < 5 years of work experience, 46.15% had 5 to 10 years of experience, 16.35% had 10 to 15 years of experience, and 24.04% had more than 15 years of experience.

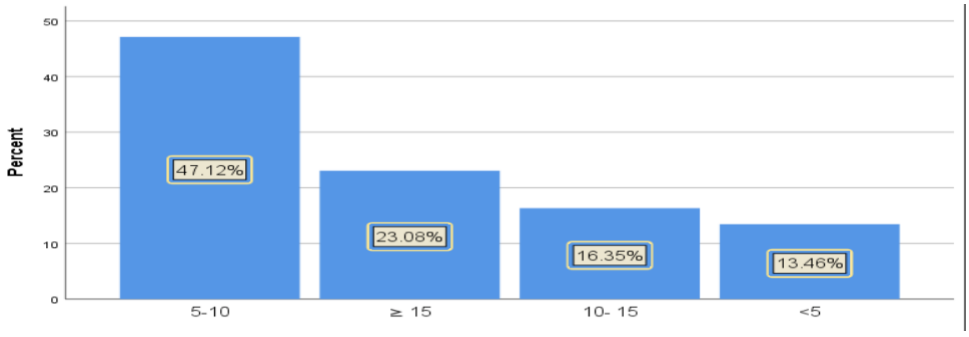


Figure 4.4: Experience Status (SPSS26)

4.5.4. Educational status of respondents

The questionnaire primarily surveyed experts in building construction projects. The majority (66.35%) were BSc., followed by MSc. (29.81%). Advanced diplomas accounted for the lowest (2.88%), with only 0.96 being PhDs. The educational status of respondents varied.

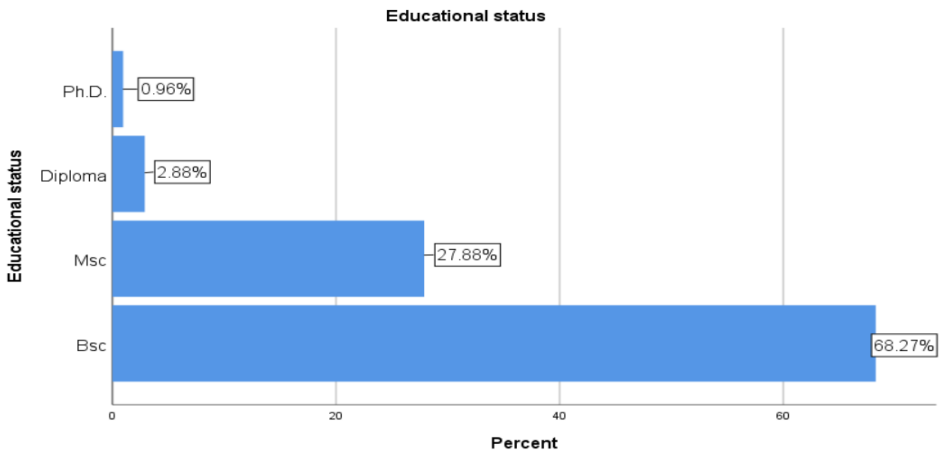


Figure 4. 5: Educational Status (SPSS26)

4.5.5. Project Type

The project type is involved in three different project types: construction projects for public buildings, renovation and refurbishment projects, and new building projects. According to Table 4.5, the three most common project types were new construction (87.5%), renovation/refurbishment (9.6%), and combination (2.9%).

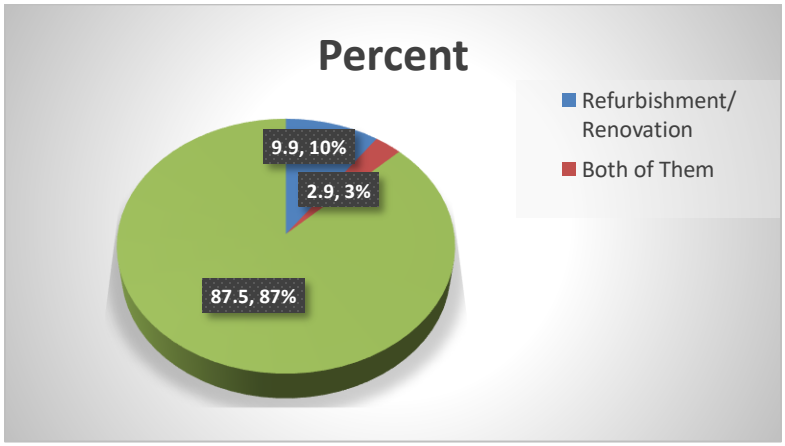


Figure 4. 5: Project Type (Source: survey data 2024)

4.5.6. Types of Facility Project

The purpose of the questionnaire, with regard to facility project types, was to collect data from the general public regarding significant building construction projects. Table 4.6 shows that administrative facilities accounted for 38.5.35% of all facility projects, followed by hospital/health (17.3%), educational facilities (13.5%), industrial and residential facilities (12.5%), and commercial facilities (5.8%).

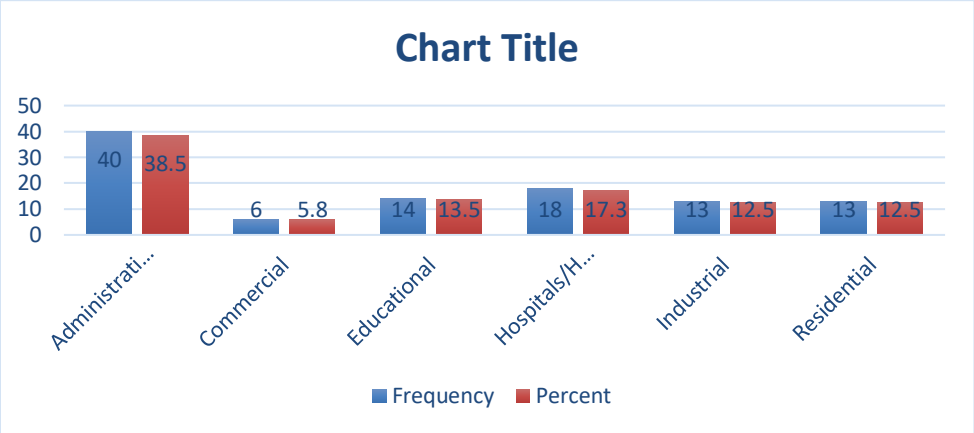


Figure 4. 6 Type of facility project: survey data (2024)

4.6 Major factors to Rework

In this section, various essential frequent factors for rework were investigated. This study prepared 48 major factors to rework, which are divided into ten (10) main groups: client-related factor, design-related factor, contractor-related factor, factor related factors to materials and equipment supply, related factors to construction process, supervisory factors, contract-related factors, and related factor to site. This groups of characteristics were adapted from prior literatures and refined through a pilot survey conducted by experienced professional engineers at the Addis Ababa design and construction works bureau.

Table 4.7 illustrates the rank of the 48 major factors were analyzed using descriptive statistics and ranked using Relative Importance Index (RII) value. According to the obtained results, first the ten groups where the top two significant major factors were discovered to be in the groups of design-related factor and contractors and subcontractors' factor, with mean values of 3.3 and 3.2, respectively, dividing the groups by it has numbers

of number of variables on its own. Most of the groups have a mean value greater than 2.02, indicating that all of the specified factors were agreed upon by the respondents. Each of these ten groupings is examined in detail based on its rank, followed by the top rework factors from each group.

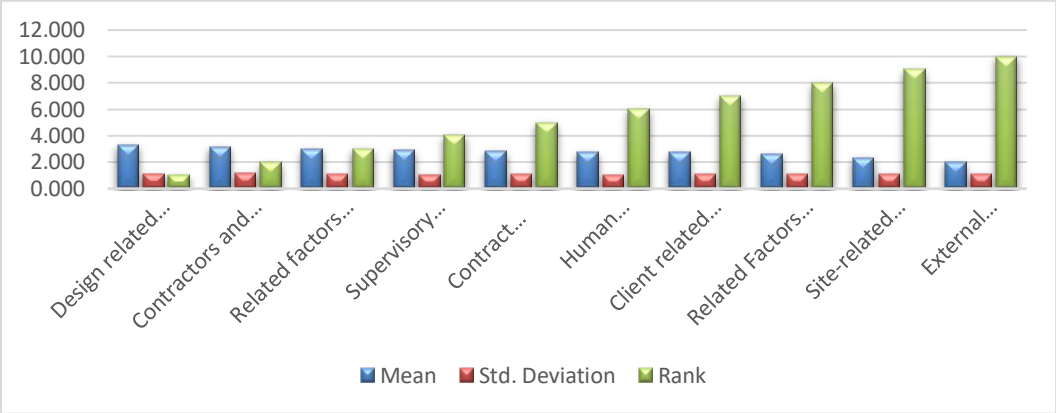


Figure 4.7: Group of major factors (survey data 2024)

4.6.1. Design Related Factor

Table 4.6 shows design-related factors are the most frequent and significant factors, with a mean value of 3.3 and a RII value of 0.66, indicating moderate to medium relevance. A list of five essential design characteristics was adapted from earlier literature and improved by professional experts using a pilot survey.

Table 4.1:Design Related Factor

S.NO	Design Related Factor	Mean	Std. Deviation	RII	Rank	Overall Rank
1	Incomplete design and inconsistencies, Errors, omission, during the design	3.77	1.16	0.75	1st	1st
2	Non-compliance with specification and standards	3.45	1.16	0.69	2nd	4nd
3	Lack of using modern technology and software	3.25	1.1	0.65	3rd	8rd
4	Poor coordination and communication between the design team	3.2	1.1	0.64	4th	10th
5	Lack of experience in design consultants and lack of professionalism	2.83	1.06	0.57	5th	22th

Source: survey data (2024)

Table 4.1 shows that "Incomplete design and inconsistencies, errors, omission, during the design process" was ranked first in the group and among all studied rework factors, with a mean score of 3.77 and RII value of 0.754. As a result, the majority of studies agree that design-related factors are among the most important factors of construction rework (El Hussein, 2014). According to estimations, design accounted for just 26% of all rework cost in residential buildings (Liu et al., 2020). According to (P. E. Love et al., 2016),), design errors, omissions, and modifications account for around 50% of all rework and rework costs. “Non-compliance with specification and standards” can also be the main design related factors of rework which is missing of required design standards and design requirements eventually lead to rework. “Non-compliance with specification and standards” with a mean value of 3.45 was ranked second and RII value of 0.690 the group and fourth among 48 major factors of rework.

“Lack of using modern technology and software” was ranked at the third position in the group of design related factors with a mean value 3.25 and RII value of 0.650. and eighth among 48 major factors of rework. According to (Palaneeswaran et al., 2014) emphasized the need to decrease design error in order to preventing the rework, Lack of using modern technology and software and visualization technologies may also be utilized to eliminate unnecessary field rework. According to research (Shang Zhanga, 2018)using modern technology and software like Building Information Model (BIM) used, it can be avoided more than 50% of the design error that because of financial losses. “Poor coordination and communication between the design team” and “Lack of experience in design consultants and lack of professionalism” was ranked at the fourth and fifth position in the group of design related factor. These were ranked with a mean value of 3.20 and RII value of 0.64; mean value of 2.83 RII value of 0.57 respectively. This implies that design related factors group do significantly the frequent critical factors of rework occurrence in public building construction projects in Addis Ababa. Table 4.2 also illustrates the reliability (internal consistency) of the questions under the design related factors of rework. The Cronbach’s Alpha values for the frequency of occurrence of reworks were 0.841. This indicates that the study proved that the survey results were reliable.

Table 4. 2: Cronbach's Alpha Value of Design Related factors

Frequency of occurrence	
Cronbach's Alpha	N of Variables
0.841	5

Source: Researcher's survey data (2024)

4.6.2. Contractor and subcontractors related factors

Related to contractors and subcontractors were rated second in terms of freuency, with a mean value of 3.16 and a RII value of 0.

633.a list of eight variables forreworkfactorsrelated contractors was adapted from earlier l iterature and refined and modified by experienced experts throughout the pilot survey. The most major factors of rework, as determined by the frequency with which it occurs in projects, are listed below.

Table 4. 3:Contractor Related Factors

S.NO	Contractors and sub-contractors related factor	Mean	Std. Deviation	RII	Rank	Over all Rank
1	Imperfect construction technique, methods, procedure and practices	3.58	1.16	0.7	1st	2nd
2	Insufficient skill and defective workmanship of contractors	3.53	1.14	0.7	2nd	3rd
3	Hiring technically unqualified contractors	3.39	1.11	0.7	3rd	5th
4	Poor coordination and communication with consultants and contractors	3.38	1.17	0.7	4th	6th
5	Misreading of drawings & specifications from lack of knowledge	3.19	1.19	0.6	5th	11th
6	Competitive pressure or low contract price or value	3.02	1.23	0.6	6th	17th
7	Insufficiency and imperfect observation of acceptance material/mechanical equipment's	2.65	1.14	0.5	7th	23th
8	Attempts at fraud	2.52	1.11	0.5	8th	27th

Source: Researcher's survey data (2024)

Respondents identified "Imperfect construction technique, methods, procedure, and practices" as the first critical factor rework occurrence, with a mean value of 3.58 and a RII value of 0.715. This essential factor for rework was likewise placed second among the 48 critical factors. Imperfect construction technique, improper methods, inadequate technical processes, and failure to follow advanced practices all contribute to rework occurrences (Aman Sen, 2018). In terms of this weak construction management process on contractors with a mean value of 3.781 was ranked third factors it is difficult to have efficient communication and coordination work process among different contractor employees in the building (Yap et al., 2017b).

As the results in Table 4.8 illustrate, “Insufficient skill and defective workmanship of contractors” was rated as the most predominant factors of rework in the group of contractor related factors of rework. It was ranked second in the group and third among all explored rework factors with a mean score of 3.53 and RII value 0.70. From the informal interviews, it was found that it can occur due to many reasons including unskilled workman, workers’ negligence and carelessness on the process of conducting any activities in construction projects. Lack of skill and experience can also be the main factors of workmanship error which eventually lead to rework. According to Hussein, shortage of skilled labor was ranked at the third position in the group of subcontractor related factors. Lack of training programs for labors can be one of the factors for this (El Hussein, 2014).

The respondents ranked “Hiring technically unqualified contractors” as third rework factors as related to the contractor according to its effect, and it was ranked as third in the group and fiftieth among 48 factors with a mean value of 3.39 and RII value 0.679. According to (Enshassi et al., 2017) With RII 79% the respondents ranked “Unqualified technically” as third rework related and they ranked it as the sixth among all explored. factors. “Poor coordination and communication with consultants and contractors” were ranked as fourth in the group and sixteenth among 48 factors with a mean value of 3.38 and RII value 0. 677. Hwang and Yang concluded that poor coordination and communication between consultants was the second most probable rework factors with mean value of 3.816 in Singapore building construction industry(Hwang & Yang, 2014).This were followed by “Misreading of drawings and specifications from lack of knowledge” with a mean value 3.19 and RII value 0.638 ranked as fifth in the group and

eleventh among 48 factors. “Competitive pressure or low contract price or value” with a mean value of 3.02 and RII value 0.604 ranked at sixtieth in the group of factors and seventieth among the 48 factors of critical factors. The remaining two factors of rework “Insufficiency and imperfect observation of acceptance material/mechanical equipment’s and “Attempts at fraud” respectively ranked as indicated in Table 4.3. Table 4.4 also illustrates the reliability (internal consistency) of the questions under the Contractors and sub-contractors related factors of rework. The Cronbach’s Alpha values for the frequency of occurrence of reworks were 0.859. This indicates that the researcher proved that the survey results were reliable.

Table 4. 4: Cronbach's Alpha Value of Contractor Related Factor

Frequency of occurrence	
Cronbach's Alpha	N of variables
0.859	8

Source: Researcher’s survey data (2024

4.6.3 Related factors to construction process

This group consisted primarily of rework factors associated with the construction process. According to the results in Table 4.12, factors associated to the construction process were rated third in terms of frequency and magnitude, with a mean value of 2.96 and a RII value of 0.59. A list of six related factors construction processes was adapted from prior literatures and revised and modified by professional experts throughout the pilot survey.

Table 4. 5: Construction Process Related Factors

S. No	Related factors to construction process	Mean	Std. Deviation	RII	Rank	Overall Rank
1	Late design input	3.28	0.95	0.66	1st	7th
2	Inadequate pre-construction planning of the project changes due to inappropriate methods of construction in site	3.06	1.03	0.61	2nd	14th
3	Schedule compression/pressure	3.03	1.07	0.61	3rd	17th
4	Rigidity to improvement and Lack of use proper modern construction technology.	2.97	1.07	0.59	4th	19th
5	Failure to implementation quality management practice	2.85	1.1	0.57	5th	21th
6	Selection of wrong methods and poor contract execution	2.59	1.09	0.52	6th	24th

Source: Researcher’s survey data (2024)

"Late design input" was ranked the first with mean value of 3.28 and RII value 0.66 first in the group and seventh among all rework factors. Late design input has significant to factors of rework. The respondents ranked "Inadequate pre- construction planning of the project changes due to inappropriate methods of construction in site" and "Schedule compression/pressure" in the second and third position with mean value of 3.06 and 3.03 and RII value 0.612 and 0.606 that they ranked them as fourth and seventieth among all explored factors of rework. "Rigidity to improvement and Lack of use proper modern construction technology", "Failure to implementation quality management practice" and Selection of wrong methods and poor contract execution were 4th,5th and 6th with mean value of 2.97,2.85 and 2.59 and RII value 0.59, 0.57 and 0.52 respectively. Table 4.6 also illustrates the reliability (internal consistency) of the questions under the construction process related factors of rework. The Cronbach's Alpha values for the frequency of occurrence of reworks were 0.801. This indicates that the researcher proved that the survey results were reliable.

Table 4. 6:Cronbach's Alpha value of construction process factor

Frequency of Occurrence	
Cronbach's Alpha	N of Variables
0.801	6

Source: Researcher's survey data (2024)

4.6.4 Supervisory Related Factors

Supervisory Related Factors were the fourth most important and critical factors related to the supervisory group with mean value of 3.0 RII value 0.58. The functions of supervision were to use the available resources effectively and efficiently, which depends on experiences and quality of supervision.

Table 4. 7: Supervisory Related Factors

S.NO	Supervisory Related Factors	Mean	Std. Deviation	RII	Rank	Overall Rank
1	Inadequate supervision by design consultant and client	3.21	1.13	0.6	1st	9th
2	Lack of supervisory experiences	2.56	0.94	0.5	2nd	25th

Source: Researcher's survey data (2024)

According to survey results, the notable factors came were, the first was “Inadequate supervision by design consultant and client” ranked in first group related factor of supervisory and ninth among the 48 factors of rework with mean value of 3.21 and RII value 0.64. Based on this, it was noted that the adequate supervision by the consultant and clients of the supervisors effectively minimized rework at the field. The second important factor was “Lack of supervisory experiences” and ranked position second in the group and twenty-fifth among 48 the rework factors with mean value of 2.56 and RII value 0.51. Supervisory experience that to ensure correctness, consequently, can be substantially minimized the construction’s reworks.

Table 4.8 also illustrates the reliability of the questions under the supervisory related factors. The Cronbach’s Alpha values for the frequency of occurrence of reworks were 0.70. This indicates that the researcher proved that the survey results were reliable.

Table 4. 8: Cronbach's Alpha Value of Supervisory Factors

Frequency of Occurrence	
Cronbach's Alpha	N of Variables
0.7	2

Source: Researcher’s survey data (2024)

4.6.5 Contract Related Factors

Contract Related Factors were the fifth most critical factors related to the contract group of factors with average mean value2.80 of and RII value0.56. the unserious handling of the contract management process and unclear contract documentation by contract parties, in poor contract implementation were the critical factors of rework (Al-Janabi et al., 2020).

Table 4. 9::Contract Related Factors

S.NO	Contract Related Factors	Mean	Std. Deviation	RII	Rank	Over all Rank
1	Poor contract management due to ambiguous and unclear scope in the contract documentation	3.06	1.09	0.6	1th	9th
2	Inexperienced staff to prepare contract documentation and management and Poor implementation of the contract	2.55	1.01	0.5	2th	25th

Source: Researcher’s survey data (2024)

According to (Akal & El-Kholy, 2021). According to survey results, the most influential factor was Poor contract management. To attributed the main reason for these to unserious handling for contract management process by stakeholders, the absence of independent departments for contract management, and lack of the professional contract management staff for the construction firms and clients this was thirty-seventh position among all rework factors. The rework usually resulted from "poor contract management due to ambiguous and unclear scope in the contract documentation" and ranked in first group with mean value of 3.06 and RII value 0.61.and ninth position among all rework factors.

"Inexperienced staff to prepare contract documentation and management and Poor implementation of the contract" was the second ranked in the group with mean value 2.55 and RII value 0.51 that at twenty-fifth position among all rework factors.

Table 4.10 also illustrates the reliability (internal consistency) of the questions under the supervisory related factors of rework. The Cronbach's Alpha values for the frequency of occurrence of reworks were 0.725. This indicates that the researcher proved that the survey results were reliable.

Table 4. 10:Cronbach's Alpha Value of contract Related Factors

Frequency Occurrence	
Cronbach's Alpha	N of Variables
0.725	2

Source: Researcher's survey data (2024)

4.6.6. Human Resource Capability Related Factors

Human resource capability was placed sixth among the 10 rework factors selected, with a mean value of 2.8 and a RII value of 0.55, indicating a moderate to medium level of relevance. construction as a whole is a collaborative effort that requires the majority of human engagement. As a result, the output will be mostly determined by the performance of the human force deployed. The majority of the research analyzed suggested that the capacity of the human resource utilized is the critical rework factors component that influences the possibility of experiencing rework; a knowledgeable human resource will minimize the probability of rework occurrence (Enshassi et al., 2017; Simpeh, 2012).

As the result of Enshassi et al., (2017) Human resource capability was identified as the second most important factor in the occurrence of rework, and seven rework factors were selected from the human resource capability categories. Respondents were asked to rate their level of agreement with the identified rework-factors factors. Based on the responses, the factors were sorted as shown in the table below.

Table 4. 11:Human Resource Capability Related Factors

S.NO	Human Resource Capability Related Factors	Mean	Std. Deviation	RII	Rank	Overall Rank
1	Ineffective management and decision-making	3.19	1.06	0.6	1st	11th
2	Inadequate manpower/skill level/ and insufficient educational and training skill development	3.19	1.05	0.6	1st	11th
3	Poor communication system and Inadequate coordination and integration	3.07	1.09	0.6	2nd	13th
4	Inadequate supervision staff and planning for work task	3.04	1.08	0.6	3rd	15th
5	Lack of employee motivation and rewards, carelessness	2.35	0.97	0.5	4th	32th
6	Lack of experience and personal expertise in design and construction	2.27	0.88	0.5	5th	35th
7	Conflict of interest and attempt to fraud	2.26	0.99	0.5	6th	36th

Source: Researcher's survey data (2024)

Respondents ranked both "Ineffective management and decision-making" and "Inadequate manpower/skill level/ and insufficient educational and training skill development" as the first factors of rework occurrence ranked eleventh from the total 48 factors with the same mean value of 3.19 and the same RII value of 0.64. This factor to rework occurrence is further building construction as a whole needs the active and sound decision making on in the project management is very crucial. according to (Enshassi et al., 2017) "Ineffective management and decision-making" were ranked as the first rework factors which has a high impact on project performance with RII of 82.2% and third among all factors explored. And Building construction as a whole further needs the participation of manpower because of its labor-intensive project character. According to (Enshassi et al.,

2017)“Inadequate manpower/skill level/ and insufficient educational and training skill development” of manpower was ranked in the third position in this group with RII of 78.8%, and seventh among all factors. Unskilled and poorly trained labors are commonly characterized with low and faulty outputs coupled with unjustifiably high inputs. Their outputs are usually rejected, either in whole or in part, by the inspection architect/engineer, resulting in extensive and expensive rework, rectifications, or repairs. For instance, (Simpeh, 2012; Zaiter & Enshassi, 2014) ranked it as second major factor for the occurrence of reworking. 43 Based on the responses, this result directly relates to the use of insufficient skill level manpower which is indicated as the first rework causing factor in this category was ranked as the second rework causing factor with mean value of 4.06 and RII value of 0.81.

According to (Akal & El-Kholy, 2021) the critical rework factors in the Egyptian building construction sector was resulted from miscommunication among the members of the same work crew and ‘‘poor integration and coordination among the various engineering disciplinarians of the design team” with mean value of 3.638 and ‘‘poor communication and coordination between the executive managers of different engineering disciplines” with mean value of 3.536. with this respect the respondent “Poor communication system and Inadequate coordination and integration” were the critical factors to rework occurrence with mean value of 3.07 and RII value of 0.61 ranked at second group of human resource capability related factors and thirteenth among the 48 rework factors.

According to the responses collected, respondents ranked both “Inadequate supervision staff and planning for work task” and “Lack of employee motivation and rewards, carelessness” as third and fourth factor with mean value of 3.04, 2.35 and RII value of 0.61, 0.47. 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. They believe that worker carelessness can result from a lack of desire and/or poor monitoring. "Lack of experience and personal expertise in design and construction" and "Conflict of interest and attempt to fraud" ranked sixth and seventh in the group of human resource capability-related factors, respectively, with mean values of 2.27, 2.26, and RII value 0.45, and thirty-fifth and thirty-sixteenth among the 48 rework factors.

Table 4.12 also shows the dependability (internal consistency) of the questions under the Human Resource and Capability Related Factors of Rework. The Cronbach's Alpha value for the frequency of reworks was 0.841. This means that the researcher demonstrated that the survey results were dependable.

Table 4. 12: Cronbach's Alpha Scale of Human Resource and Capability

Frequency Occurrence	
Cronbach's Alpha	N of Variables
0.841	7

Source: Researcher's survey data (2024)

4.6.7. Client related factor

In client-related factors A list of seven rework factors that elated the client was adapted from several literatures and amended based on professional opinions throughout the questionnaire's piloting phase. Respondents were asked to rate the frequency of occurrence, which had a mean value of 2.80 and a RII value of 0.55 and was listed as the eighth category of rework factors. Table 4.18 displays the degree of recurrence in the table; all client-related factors are prioritized by their mean score value.

Table 4. 13: Client Related Factors

S.NO	Client related factor	Mean	Std. Deviation	RII	Rank	Overall Rank
1	Change of plan/scope/Specifications/ because of change in clients and end user	3.13	1.112	0.6	1st	12th
2	Weak communication/coordination with consultant, contractor and end user	3.07	1.026	0.6	2nd	13th
3	Weak quality management system	3.01	1.178	0.6	3th	18th
4	Lack of client involvement in the project and Improper supervision	2.94	1.131	0.6	4th	20th
5	Lack of knowledge and experience in design and construction process	2.55	0.944	0.5	5th	26th
6	Inadequate briefing and weak feasibility study of project objectives	2.35	1.095	0.5	6th	32th
7	Lack of funding allocated for consultation and for site investigation	2.23	0.947	0.4	7th	37th

Source: Researcher's survey data (2024)

"Change of plan/scope/Specifications/because of change in clients and end user" were client factors of rework (SHAH1, 2016). This set of client-related factor rework incidence scored first (mean = 3.13, RII = 0.625), and twelfth out of 48 frequent factors. Additionally, "Weak communication/coordination with consultant, contractor and end user" This was likewise the second group client-related factor of rework occurrence rated with a mean value of 3.07 and a RII value of 0.613, and thirteenth from the total 48 frequent factors repercussions of rework occurrence.

In the client-related category of rework factors, "Weak quality management system" was evaluated as the third rework factor, with a mean value of 3.01 and a RII value of 0.602, and eighteenth out of 48 important frequent factors. The remaining fourth group of frequent rework factors were "Lack of client involvement in the project and Improper supervision," "Lack of knowledge and experience in the design and construction process," "Inadequate briefing and weak feasibility study of project objectives," and "Lack of funding allocated for consultation and for site investigation," which were also ranked with mean value of 2.94, 2.55, 2.35 and 2.23 and the RII value of 0.588, 0.510, 0.469 and respectively twentieth , twenty-sixth, thirty-twos and thirty-seventh among 48 major factors of rework.

Table 4.14 also shows the dependability (internal consistency) of the questions under the Client Related Factors. Cronbach's Alpha values for the frequency of rework were 0.794. This means that the researcher demonstrated that the survey results were dependable.

Table 4. 14: Cronbach's Alpha Value of Client Related Factors

Frequency Occurrence	
Cronbach's Alpha	N of Variables
0.794	7

Source: Researcher’s survey data (2024)

4.6.8 Related Factors to Materials and Equipment Supply

Respondents ranked the rework factors groups material and equipment as the eighth component, with a mean of 2.6 and a RII of 0.52. Three parameters related to building material and equipment categories were discovered. Respondents were asked to rate their

level of agreement with the identified rework-causing factors. Based on the responses, the factors were sorted as shown in the table below.

Table 4. 15:Related Factors to Materials and Equipment Supply

S.NO	Related Factors to Materials and Equipment Supply	Mean	Std. Deviation	RII	Rank	Overall Rank
1	Materials not in the right place when needed invalidity of needed tests and untimely deliveries & defective	2.94	1.069	0.6	1st	28th
2	Adulterated materials	2.45	1.051	0.5	2nd	20th
3	Use of defective/unadvanced equipment	2.41	1.085	0.5	3th	30th

Source: Researcher's survey data (2024)

Respondents ranked "Materials not in the right place when needed invalidity of needed tests and untimely deliveries & defective materials/Prefabrication errors" as the first rework factor with the mean value of 2.94 and RII value of 0.59. This rework occurrence factor was ranked twenty-eighth from the total 48 factors. For instance, according to the study of (Mahamid, 2016) this rework factor was ranked second in its own category. "Adulterated materials" and "Use of defective/unadvanced equipment" as the second and third rework factor in the group of material and equipment supply related factor with the mean value of 2.45, 2.41 and RII value of 0.49, 48 respectively. This rework occurrence factor was ranked twentieth thirtieth among the total 48 factors. table 4.16 also shows the reliability (internal consistency) of the questions in the Related Factors to Materials and Equipment Supply section regarding rework occurrence. Cronbach's Alpha values for the frequency of rework were 0.794. This means that the researcher demonstrated that the survey results were dependable.

Table 4. 16: Cronbach's Alpha Value of Materials and Equipment

Frequency of Occurrence	
Cronbach's Alpha	N of Variables
0.797	3

Source: Researcher's survey data (2024)

4.6.9 Related Factor to The Site

According to the analysis results, related factor to the site were ranked the nine groups. Based on the received responses the factors were ranked as indicated in the table below.

Table 4. 17: Related Factor to The Site

S.NO	Site-related factors	Mean	Std. Deviation	RII	Rank	Overall Rank
1	Bad site practices and site status that is overlooked by the contractor	2.38	1.026	0.5	1st	31th
2	Failure/Inaccurate the site's investigations	2.34	1.039	0.5	2nd	33th
3	Poor site conditions for the contractor by a client, (e.g., soil problems, water, electricity)	2.31	1.089	0.5	3th	34th

Source: Researcher's survey data (2024)

Respondents ranked "Bad site practices and site status that is overlooked by the contractor "and "Failure/Inaccurate the site's investigations" as the first and second in the group of rework factor consequently with the mean value of 2.38, 2.34 and RII value of 0.475, 467. This rework occurrence factor was ranked thirteenth one, thirteenth three and thirteenth fourth from the total 48 factors. For instance, according to the study of (Mahamid, 2016) this rework factor was ranked second in its own category.

Differing site conditions may require changes in design during construction, resulting in for Site-related factors are among significant factors that causing rework (El Hussein, 2014; Simpeh, 2012)This category includes eight factors that factors construction rework in Egypt. According to the analysis results, the critical factors in this group are: "Poor site conditions (e.g. soil problems, water, electricity)" is ranked as the first crucial factor in this group and ranked as eightieth among all rework factors however according to this research survey as the third rework factor in the group of Site- related factor with the mean value of 2.31 and RII value of 0.462. This rework occurrence factor was ranked thirty-fourth among the total 48 factors.

Table 4.18 also illustrates the reliability (internal consistency) of the questions under the related factor to the site of rework. The Cronbach's Alpha values for the frequency of occurrence of reworks were 0.794 This indicates that the researcher proved that the survey results were reliable.

Table 4. 18:Cronbach's Alpha Value of Related Factor to The Site

Frequency of Occurrence	
Cronbach's Alpha	N of Variables
0.846	3

Source: Researcher's survey data (2024)

4.6.10 External Environment Related Factors

As shown in Table 4.19, rework factors related to external and environmental group had relatively less degree of occurrence and low impacts on the time and cost performance projects. A list of 5 rework factors related to external and environmental factors was adopted with mean value of 2.021 and RII value 0.404 ranked at tenth. Table 4.22 illustrated the means of rework factors related to external and environmental factors based on the degree of occurrence.

Table 4. 19::External Environment Related Factors

S.NO	External Environment Related Factors	Mean	Std. Deviation	RII	Rank	Overall Rank
1	Acts of God/Force Major (Natural conditions, Weather and natural disaster, such as rain, heat, and cold	2.43	0.983	0.5	1st	29th
2	Economy related: inflation, exchange rates, market competition, availability	2.31	1.285	0.5	2nd	34th
3	Social: changing social environment, resistances and Legal: changes in legislation: safety or planning laws	1.84	1.062	0.4	3th	38th
4	Government related: change of law (Regulations, taxes. Interest rates)	1.8	1.083	0.4	4th	39th
5	Institutional influences: codes of conduct, education regulations	1.73	0.927	0.3	5th	40th

Source: Researcher's survey data (2024)

As shown in Table 4.19, “Acts of God/Force Major (Natural conditions, Weather and natural disaster, such as rain, heat, and cold” was ranked first with a mean value of 2.43 and RII value 0.487 in the group and twenty-ninths among the 48 factors to rework occurrence. “Economy related: inflation, exchange rates, market competition, availability of labor, materials and finance” was ranked second with a mean value of 2.31 and RII value 0.462 in the group and thirty-fourth among the 48 factors of rework. “Social: changing social environment, resistances and Legal: changes in legislation: safety or planning laws” was ranked third in the group and thirty-eighth among the whole factors with a mean value of 1.84 RII value of 0.367.

“Government related: change of law (Regulations, taxes. Interest rates)” and “Institutional influences: codes of conduct, education regulations” takes the fourth and fifth ranks in the group and thirty-ninths and fortieth and 35th among all investigated factors of rework with the mean value of 1.8 and 1.73 and RII value 0.36, 0.364 respectively. Therefore, it will have an impact on the performance of projects during execution.

Table 4.20 also illustrates the reliability (internal consistency) of the questions under the External Environment Related Factors of rework. The Cronbach’s Alpha values for the frequency of occurrence of reworks were 0.886 This indicates that the researcher proved that the survey results were reliable.

Table 4.20: Cronbach's Alpha Value of External Environment

Frequency of Occurrence	
Cronbach's Alpha	N of Variables
0.886	5

Source: Researcher’s survey data (2024)

According to the survey results in this research, the top 10 most major factors of construction rework occurrence in public building projects in Addis Ababa were identified in the figure 4.8 below.

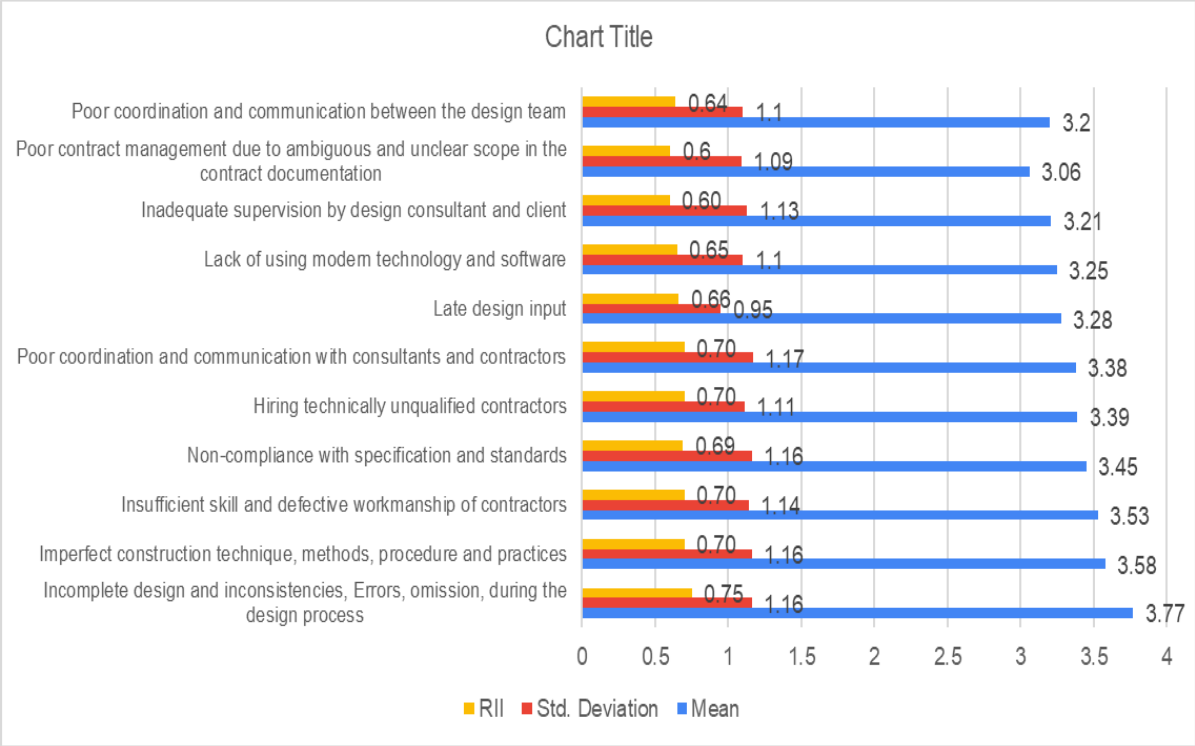


Figure 4.8: Major factors of rework (Survey data SPSS 26)

4. Impacts of Rework

This section of the questionnaire was designed to obtain data about the top major overall impacts of rework occurrence among the different building construction projects in Addis Ababa. In order to obtain that, lists of frequent rework impacts were identified from extensive literature review. After that, a list in each of eight direct and indirect rework impacts were selected and the respondents were identified frequently though given an open space to provide if there are other additional impacts they faced in their project. The rank of each identified impacts was analyzed using descriptive statistics and ranked using Mean Value, Standard Deviation and Relative Importance Index (RII). According to the obtained results the direct and indirect impacts and impacts were ranked as shown in the table 4.28 and table 4.21 below.

Table 4. 21: Direct Impacts of Rework

S.no	1. Direct impacts of Rework on Project Performance	Mean	Std. Deviation	RII	Rank
1	Cost overrun	3.69	1.199	0.738	1th
2	Time overrun	3.59	1.146	0.717	2nd
3	Profit reduction in organizational performance	3.48	1.052	0.696	3rd
4	Contractual claims and Disputes between parties to the contract	3.22	0.945	0.644	4th
5	Quality degradation	3.02	0.985	0.604	5th
6	Damage reputation	2.97	1.056	0.594	6th
7	End-user/client dissatisfaction	2.91	0.967	0.583	7th
8	Design teams and Contractor's dissatisfaction	2.88	0.928	0.577	8th

Source: Researcher's survey data (2024)

Respondents were asked to indicate the level of the rework impacts on affecting the performance of their project directly on a Likert scale of 1=No impact to 5= Extreme impact. 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 "End-user/client dissatisfaction" and "End-user/client dissatisfaction" and which have a moderated impact. According to the results, "cost overrun" Mean Value =3.69 and (RII = 0.74), "time overrun" Mean Value =3.59 and (RII = 0.72) concurrently "Profit reduction in organizational performance" and "Contractual claims and Disputes between parties to the contract" with Mean Value of 3.48, 3.22 and RII Value 0.70, 0.64 respectively were the top major impacts and 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.

According to the survey results in this research, the most frequent direct impacts of rework in public building projects in Addis Ababa were identified in the figure 4.6 below.

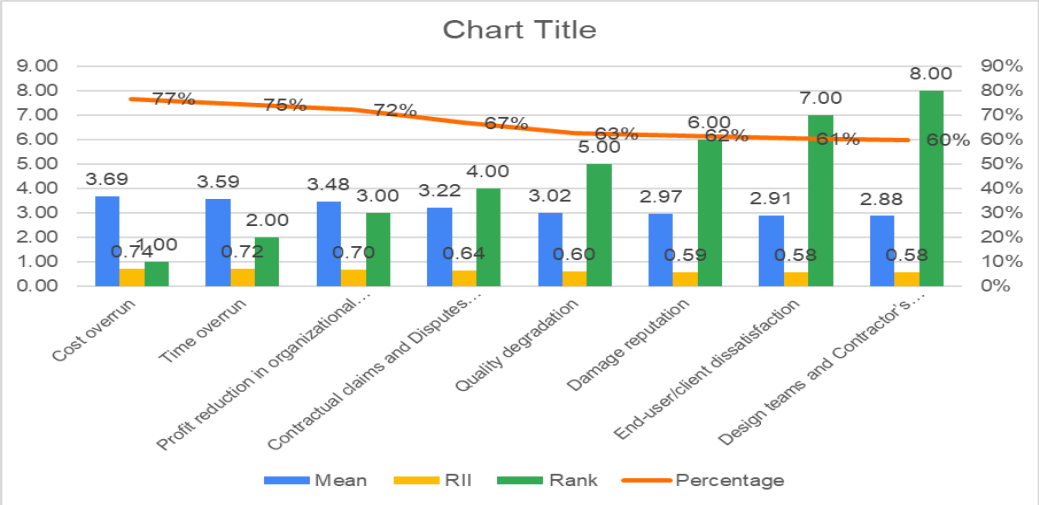


Figure 4.9: Direct Impacts of rework (Survey Data SPSS 26)

Table 4.22 also illustrates the reliability (internal consistency) of the questions under the direct impacts of rework. The Cronbach's Alpha values for the degree of impact of reworks were 0.874 This indicates that the researcher proved that the survey results were reliable.

Table 4. 22::Cronbach's Alpha Value of direct impacts of rework

Degree of Impact	
Cronbach's Alpha	N of Variables
0.874	8

Source: Researcher's survey data (2024)

Table 4. 23: Indirect Impacts of Rework

S.nO	**2. Indirect Impact of Rework on Organizational Performance**	**Mean**	**Std. Deviation**	**RII**	**Rank**
1	Stress	3.54	1.079	0.708	1th
2	Fatigue	3.52	1.106	0.704	2nd
3	Low morale of workers	3.37	0.956	0.673	3rd
4	Work inactivity	3.22	1.190	0.644	4th
5	Demotivation	3.10	1.075	0.619	5th
6	Damage to professional image	3.00	1.088	0.600	6th
7	Interorganizational conflicts	2.93	1.151	0.587	7th
8	Absenteeism	2.72	1.242	0.544	8th

Source: Researcher's survey data (2024

In the expect of indirect impacts of rework occurrences the Respondents were asked to indicate the level of the rework indirect impacts on affecting the performance of their project on a Likert scale of 1=No impact to 5= Extreme impact. 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 "Interorganizational conflicts" and "Absenteeism" and which have a moderated impact. According to the results, "stress" Mean Value =3.54 and (RII = 0.708), "fatigue" Mean Value =3.52 and (RII = 0.704) in other concurrent a "Low morale of workers", "Work inactivity" and "Damage to professional image" with Mean Value of 3.37, 3.22,3.00 and RII Value 0.673, 0.644 and 0.60 respectively were the top major indirect of impacts of rework which have a high influence on the performance of a project. According to the survey results in this research, the most frequent indirect impacts of rework in public building projects in Addis Ababa were identified in the figure 4.7 below.

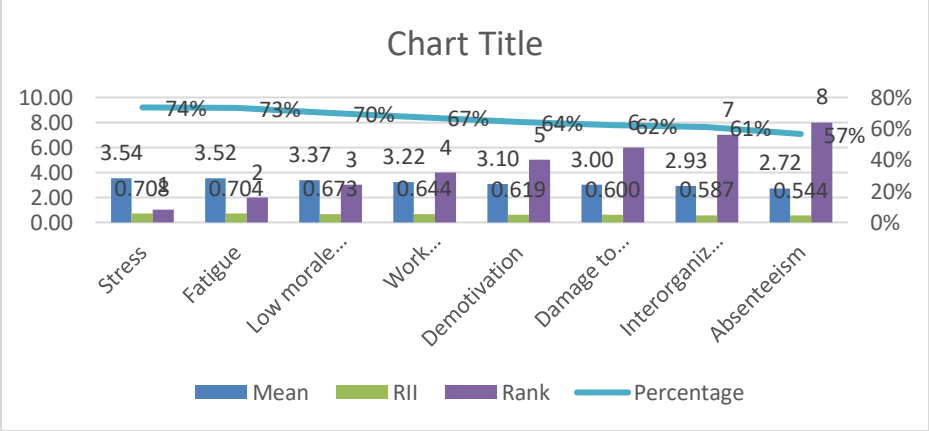


Figure 4.10: Indirect impacts of rework (Survey data SPSS 26)

Table 4.24 also illustrates the reliability of the questions under the indirect impacts of rework. The Cronbach's Alpha values for the degree of impact of reworks were 0.914 This indicates that the researcher proved that the survey results were reliable.

Table 4. 24:Cronbach's Alpha Value of Indirect impacts

Degree of Impact	
Cronbach's Alpha	N of Variables
0.914	8

Source: Researcher's survey data (2024)

4.8 Effective Mitigation Solutions and Strategy

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 18 measures were identified majorly from literature review 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 was analyzed using descriptive statistics and ranked using Mean Value and Relative Importance Index (RII). According to the obtained results, the measures taken were identified as shown in the table below.

Table 4. 25: Effective mitigation measures and strategy

S.no	Effective mitigation measures and strategy	Mean	Std. Deviation	RII	Rank
1	Preparing clear drawings and specifications	4.10	0.919	0.819	1th
2	Hiring Qualified Designer/Consultant, Contractor/Subcontractor	3.99	0.950	0.798	2nd
3	Teamwork effectiveness (cooperation)	3.93	0.851	0.787	3rd
4	Effective planning and scheduling	3.89	0.994	0.779	4th
5	Improving effective communication and coordination between parties	3.81	0.871	0.762	5th
6	Offering Regular Training Programs for Supervisors and Workers	3.69	0.946	0.738	6th
7	Effective leadership/management	3.60	0.887	0.719	7th
8	Sufficient and capable human resources	3.45	0.891	0.690	8th
9	Unification work standards	3.41	1.187	0.683	9th
10	Client involvement during prior stage of any activity	3.17	0.875	0.635	10th
11	Effective material handling and supplier prequalification	3.16	1.098	0.633	11th
12	Using prefabricated products	3.13	1.199	0.627	12th
13	Continuous quality/ rework auditing control	3.07	1.324	0.613	13th
14	Strict resistance against cheating (fraud fighting)	2.83	1.303	0.565	14th
15	Project documentation	2.82	1.406	0.563	15th
16	Well-defined roles and responsibilities	2.71	1.479	0.542	16th
17	Regular meetings	2.70	1.253	0.540	17th
18	Commitment to safety (strict law)	2.50	1.372	0.500	18th

Source: Researcher's survey data (2024)

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 =Very low contribution to 5 = Very high contribution. As it is shown in table 4-26, most of the mean results are hovering around 4.10 to 2.50. So, this result clearly shows that there is a considerable amount of gap on taking serious measures to reduce rework in to these building construction projects in Addis Ababa.

From the selected 18 lists of Effective mitigation solution and controlling strategy, respondents agreed that "Preparing clear drawings and specifications" to mitigate reworking which might come from using of poor preparing clear drawing and specification. As a result, ranked 1st with mean value of 4.10 and RII=0.819. The mean result here indicated that most of the respondents agreed to the small extent that they are using a prepared clear drawing and specification consciously to reduce reworking in their building construction sites. Incomplete design and inconsistencies, Errors, omission, during the design process account for around 50% of all rework and rework cost and estimates that 50% of errors in buildings originate during the design phase (Enshassi et al., 2017) The second rework mitigation strategy which was selected by the respondents was "Hiring Qualified Designer/Consultant, Contractor/Subcontractor" with mean value of 3.99 and RII= 0.798. This strategy was one of the major rework reduction methods to hiring qualified designer/consultant, contractor/subcontractor in the design period and building construction phase of a project will minimize the rework had been carried out jointly. Even though this strategy was ranked second the mean value indicated that the respondents were agreed that to hiring qualified designer/consultant, contractor/subcontractor able working together efficiently and efficiently involved in the project from the very beginning up to the ending project. So, a lot of work needs to be done in this area. This can be thorough reviewing of drawing and contract documents, appropriately qualified main project parties should be assigned so, the occurrence of rework can be reduced.

"Teamwork effectiveness (cooperation)" with a mean value of 3.89 and RII value 0.779 was ranked third as a rework reduction control strategy. Teamwork effectiveness takes effort have a group project key stakeholder of with unique skills and characters, team success and how well team members work together to minimized rework.

“Effective planning and scheduling “with a mean value of 3.89 and RII value 0.779 was ranked fourth as a rework reduction measure. As stated by (Zaiter & Enshassi, 2014), “Effective planning and scheduling” is one of the main effective measures to minimize the occurrence of rework. Due to proper planning and scheduling, some activities that are going to be missed or disordered can be corrected easily. As stated by (Zaiter & Enshassi, 2014), “Effective planning and scheduling” was one of the main effective measures to minimize the occurrence of rework. Due to proper planning and scheduling, some activities that are going to be missed or disordered can be corrected easily.

“Improving effective communication and coordination between parties” also as best solution to minimization of rework with a mean value of 3.81 and RII value 0.762 was ranked at fifth as a rework reduction measure.

“Offering Regular Training Programs for Supervisors and Workers” was ranked at sixth as greater solution to minimization of rework with a mean value of 3.69 and RII value 0. 738.According to the respondents, they also ranked “Effective leadership/management” as the seventh most effective measure to minimize the occurrence of rework with a mean value of 3.60 and RII 0.719. effective management of project in building construction was among the best option of to minimize the occurrence of rework. From these results it can be concluded that, the building 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. According to the survey results in this research, the effective mitigation solution and controlling strategy rework in public building projects in Addis Ababa were identified in the figure 4.11 below.

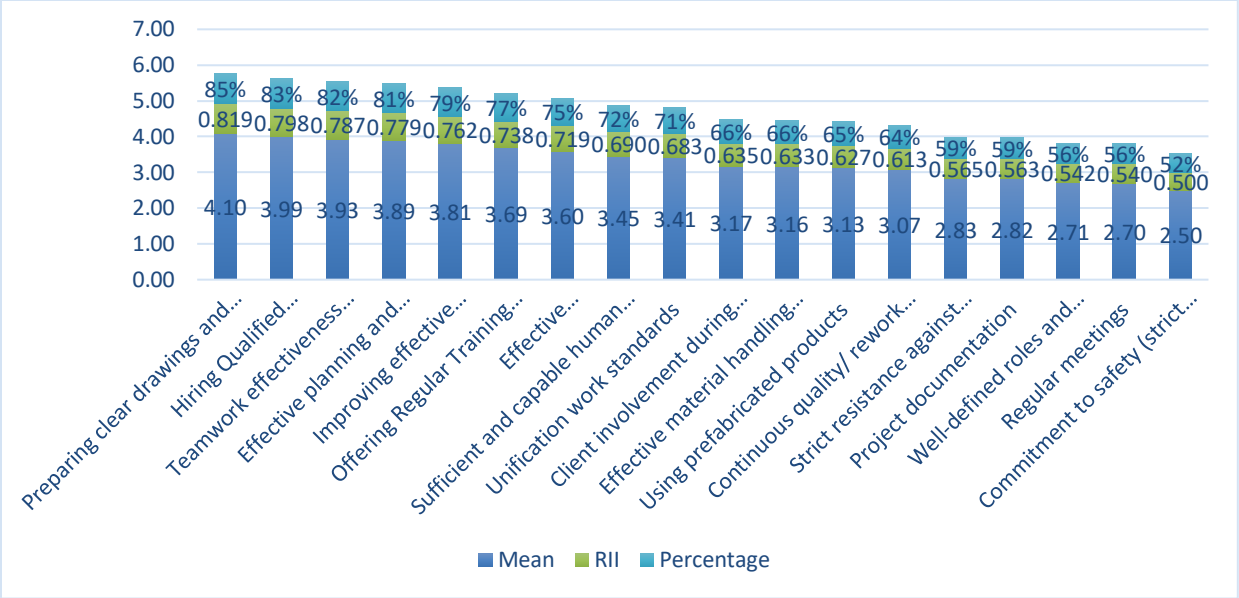


Figure 4.11Eeffective mitigation solution (Survey data SPSS 26)

Table 4.33 also illustrates the reliability (internal consistency) of the questions under the indirect impacts of rework. The Cronbach's Alpha values for the degree of impact of reworks were 0.909 This indicates that the researcher proved that the survey results were reliable.

Table 4. 26:Cronbach's Alpha Value of Indirect impacts

Degree of Contribution	
Cronbach's Alpha	N of Variables
0.909	18

Source: Researcher's survey data (2024)

4.8.1 Future effective mitigation measure and strategy

As Respondents their level of extent in which they the most critical and fundamental solution to this future implement measures purposely to reduce reworking. Due to the fact that changes management system and design issues were two of the major contributing factors to rework factors (Hwang et al., 2014). Also as (Palaneeswaran et al., 2014) emphasized the need to decrease design error in order to preventing the rework, visualization technologies may also be utilized to eliminate unnecessary field rework.

Table 4. 27:Future effective mitigation measures and strategy

S.no	Advanced future mitigation measures and strategy	Mean	Std. Deviation	RII	Rank
1	Effective use of technology (Modern Software) Using BIM	3.96	1.033	0.792	1th
2	Effective Rework Management system (RMS)	3.89	1.088	0.779	2nd
3	Implementation of Total quality management	3.64	1.157	0.729	3rd
4	Adopting control measures for rework	3.12	1.160	0.623	4th
5	Application Effective Client Change and Design Management	3.04	1.190	0.608	5th

Source: Researcher's survey data (2024)

"Effective use of technology (Modern Software) Using BIM" as ultimate degree of medication to Ethiopian building construction industry for the future to minimization of rework with a mean value of 3.96 and RII value 0.792 was ranked at first as a rework reduction measure. BIM has become a widespread BIM practice as a BIM-assisted design validation process in the design stage. clients regularly employed BIM as the most effective technique to discover building-element clashes and reasons for rework (Lee et al., 2012). If BIM had been used, more than 50% of the design error that because financial losses could have been avoided, according to research (Shang Zhanga, 2018).

"Effective Rework Management system (RMS)" also as high degree of minimization of rework with a mean value of 3.89 and RII value 0.772 was ranked at second as a rework reduction measure. With this relation Before rework can be effectively managed, the elements that contribute to its factors should be recognized and assessed (Ye et al., 2015). One of every building construction organization's key competency should be the capacity to learn from mistakes, particularly as they relate to construction activities. Rework can be avoided in forthcoming projects in the RM domain through the learning process (Love et al., 2015)."Implementation of Total quality management" also as high degree of effective minimization of rework with a mean value of 3.64 and RII value 0.729 was ranked at third as a rework reduction measure. according to (Zhang et al., 2012) presented a generalized model for a rework reduction program to lessen the incidence and effects of rework using the conventional TQM-based methodology.

"Adopting control measures for rework" and "Application Effective Client Change and Design Management" was ranked at fourth and fifth as a rework reduction measure with mean value of 3.12, 3.04 and RII value 0.623, 0.608.

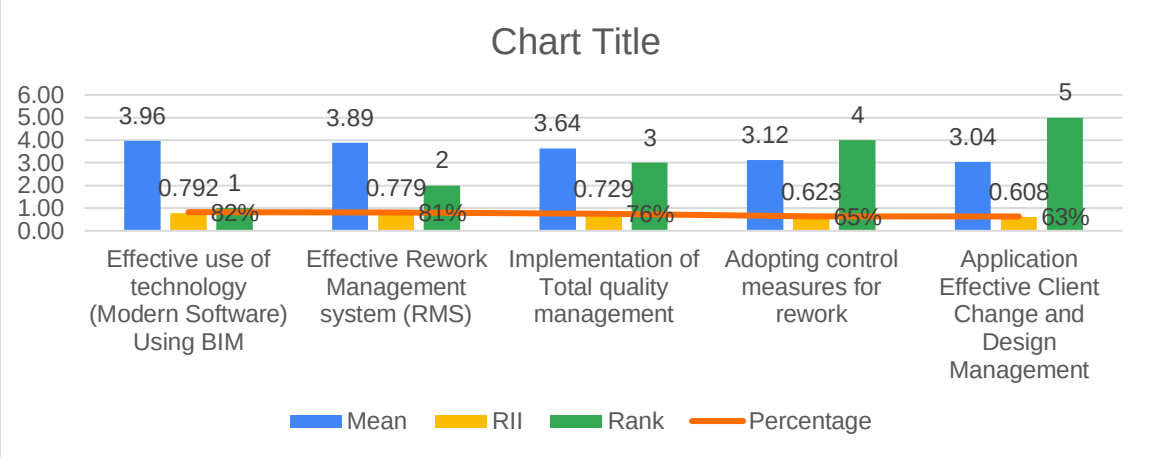


Figure 4. 12: Future mitigation measures rework (SPSS 26)

Table 4.28 also illustrates the reliability (internal consistency) of the questions under the indirect impacts of rework. The Cronbach's Alpha values for the degree of impact of reworks were 0.865 This indicates that the researcher proved that the survey results were reliable.

Table 4. 28:Cronbach's Alpha Value of Indirect impacts

Degree of Contribution	
Cronbach's Alpha	N of Variables
0.865	5

Source: Researcher's survey data (2024)

Finally, in the semi-structured interviews were conducted to obtain important evidence to support the facts. This part researched and assessed several interview questions on reworks in accordance with the research's three specific objectives. In total, 116 semi-structured interviews were conducted, with about 70% of the interviewees providing responses and insights based on their observations. The respondents to the interviews were chosen based on their professional experience, which was more than five years, and the crucial role they play in achieving the project's objectives. In this section, participants asked if there had been any reworks on their specific project and how much recording had been made of the

existing reworks. And 94.87% of all interviewers said "yes," this indicating that rework had occurred. Regarding the recording of reworks, the participants acknowledged that based on content analyzed in SPSS they were not recorded and documented the occurrence of reworks, with only 96.34% not being recorded.

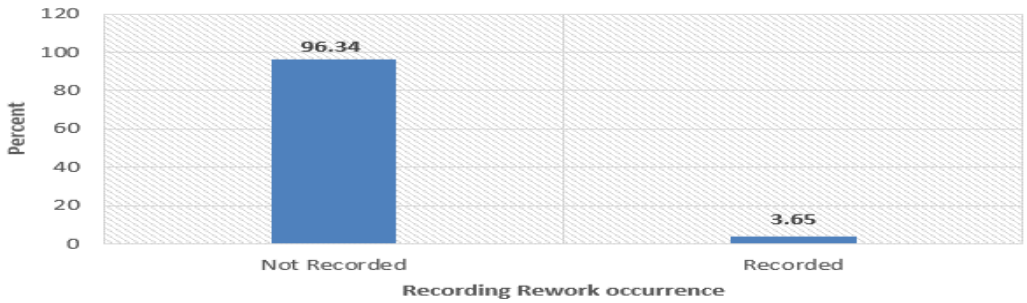


Figure 4. 13 recording rework occurrence

Based on this According to the respondents, all observed reworks were not properly documented in official records. The recorded rework percentages ranged between 0.5% and 19% of the total project cost. When asked how frequently rework occurred, the majority of respondents replied "sometimes," with only a handful stating "always." As practically every interviewee stated, "rework recording is exceedingly tiresome. Because it is a daily task in our project as we continue to create. However, by noting his own problems, the contractor will not be interested in exposing and damaging the company's reputation. As a result, the majority of rework occurrences were not recorded at these building construction sites. Because construction projects are inherently prone to reworking, because it is labor-intensive. Especially in our country, Ethiopia.

The interviews revealed factors contributing to rework, design-related issues, contractor issues, insufficient supervision, poor decision-making, poor temporary materials, construction process challenges, and environmental factors like weak soil and adverse weather. for the minimizing rework include implementing technology, hiring qualified personnel, engaging stakeholders throughout the project lifecycle, effective scheduling and time management practices, enhancing communication and coordination, and measuring effective measures of reducing rework. These can be addressed through project management software, proper training of supervisors and workers, effective scheduling and time management practices, and effective measures of reducing rework.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

There are three sections in this chapter. The study's key findings were summarized in the first part. The main conclusions drawn from the data were discussed in the second section, which also included suggestions for relevant organizations to help lower the amount of rework.

5.2 Summary of major findings

According to the study's findings, three specific objectives listed in the first chapter were reportedly addressed through a questionnaire survey and interview questions. As a result, a summary of the study's findings based on the data compilation, analysis, and discussion of the findings is required.

In the questionnaire survey, the major factors of rework occurrence based on the frequency of occurrence were investigated. According to the result, the top five frequent factors contributing to the rework occurrence for public building projects were incomplete design and inconsistencies, errors and omissions during the design process, imperfect construction technique, methods, procedures, and practices, insufficient skill and defective workmanship of contractors, non-compliance with specifications and standards, and hiring technically unqualified contractors. Furthermore, throughout the interviews, critical factors like design discrepancies with specification, hiring unskilled workmanship, insufficient continuous supervision, and a lack of stakeholder's involvement and communication failures were considered major factors of rework.

The purpose of this study was to identify the direct and indirect impact of rework on project performance in the construction of public buildings. Among these, cost overruns, time delays, profit reductions in organizational performance, contractual claims and disputes between parties to the contract, and quality degradation were the top critical direct effects of rework. In addition to this, among the top five indirect effects of rework critically on the performance of public building projects were stress, fatigue, low morale of workers, work inactivity, and demotivation of workers.

Through the use of a questionnaire survey, a list of steps to mitigate the rework was identified in order to achieve this objective. The survey results indicate that every effective mitigation method that is successful in mitigating reworks significantly contributes to the rework control strategy. The following are the top five practical mitigating strategies for the rework in public building construction projects, as determined by the questionnaire survey:

“Preparing clear drawings and specifications”, “hiring qualified, designer/consultant, contractor/subcontractor”, “teamwork effectiveness)”, and “effective planning and scheduling”. But also, should critically consider the future advanced controlling solutions: “effective use of technology (modern software) using BIM”, “effective rework management system (RMS)”, “implementation of total quality management”, “adopting control measures for rework”, “application effectiveness client changes and design management” were among the greater controlling strategy of rework occurrence. In addition to the questionnaire survey, interviews were conducted to gather views on reducing the occurrence of rework in construction projects. According to the interviews’ response, the major mitigation measures that could be taken to minimize the occurrence of rework are: implement project management software and modern design software, ensure supervisors and workers are properly trained, engage all project stakeholders throughout the project lifecycle and Enhance communication and coordination among all parties involved.

5.3 Conclusion

The main objective of this study was the determinant of construction rework occurrence in public building projects in Addis Ababa. To address the stated specific objectives, data were gathered using a questionnaire survey and interviews. The information gathered from the survey was analyzed using SPSS (version 26). Based on the results obtained, the following major conclusions are drawn.

A survey identifying the top five factors leading to reworks revealed that design-related factors, contractors-related factors, construction process-related factors, supervisory-related factors, and contract-related factors were the top five. The survey ranked 48 critical factors of rework based on frequency of occurrence and Relative Importance Index (RII). The top five factors were incomplete design and inconsistencies, imperfect construction techniques, insufficient skill and defective workmanship, non-compliance with specifications and standards, and hiring unqualified contractors. and Rework has both direct and indirect impacts on public building construction projects. Direct impacts include cost overruns, time delays, profit reductions, contractual disputes, and quality degradation. Indirect effects include stress, fatigue, low morale, work inactivity, demotivation of workers, contractual claims, and disputes also contribute to these issues.

The literature review and respondents indicate that in order to reduce the amount of rework that needs to be done, further advanced and effective mitigation measures should be used. These include using technology such as building information modeling (BIM) and implementing a Rework Management System (RMS), implementing total quality management, adopting control measures for rework application, effectively managing client changes, and design management. To improve capacity-building, it is also stressed how crucial it is for managers and employees to participate in regular training programs.

From the interviews, it could also be concluded that scope changes, designs missing, design discrepancies with specifications and design alterations were the primarily factors to leading rework. Secondary factors to leading rework were Lack of understanding of the scope of work, hiring unskilled manpower and laborers, and ambiguous contracts with subcontractors. insufficient continuous supervision and a lack of stakeholder involvement, communication and coordination failures were the tertiary factors of rework.

5.4 Recommendations

Based on the findings of the study, the following recommendations are forwarded in order to mitigate the occurrence of rework and improve construction projects performance.

This involves regular checks, thorough document reviews, and clear drawings and specifications created with modern design software (BIM).

- Throughout the design phase, the consultant and client shall have open and comprehensive communication to ensure the design aligns with the client's needs and project scope. Because, incomplete design during the design process accounts for around 50% of all rework and rework costs, it is estimated that 50% of errors in buildings originate during the design phase (Enshassi et al., 2017; P. Love et al., 2016)
- Improper techniques cause a significant portion of rework around (40%). To address this, clients, contractors, and supervisors used to implement strict selection criteria to ensure qualified personnel are involved in the project and effective leadership to guide and oversee construction practices during the construction phase.
- Construction is heavily labor-intensive. To address this, contractors and consultants should utilize competent workmanship and professionals for supervision tasks by enhancing their workforce's efficiency through regular training in the program. This will be the responsibility of the construction regulatory organ.
- Implementing Effective Rework Management System (RMS) Total Quality Management Practices on the Total Project Life Cycle.
- The project contract parties should be creating an effective communication channel and establishing strong coordination through the project implementation phase.
- Develop a rework recording system; the data gathering sheet should use a consistent system. Raising awareness among project stakeholders through the quantification of rework in order to prevent similar challenges in future projects, professionals will be motivated to find solutions to reduce rework and share knowledge through solution creation aimed at raising awareness.

5.4.1 Recommendations for further study areas

Based on the findings of the research the following areas need further studies.

- Examine the government's regulatory policies and strategies in relation to the industry's implementation process by using the authority to determine the frequency of construction rework.
- Evaluate and check the required policy functionalities regarding the determination of construction rework occurrences.

Reference

Ahmed Yousry Akal a, A. M. E.-K. b., ⇑. (2021). Exploring the major factorsof rework and assigning strategies. *Journal of King Saud University – Engineering Sciences*, 13.

Aiyetan, A. (2013). Causes of rework on building construction projects in Nigeria. *Interim: Interdisciplinary Journal*, *12*(3), 1-15.

Ajayi, O., & Oyeyipo, O. (2015). Effect of rework on project performance in building project in Nigeria. *International Journal of Engineering Research & Technology (IJERT)*, *4*(02), 294-300.

Akal, A. Y., & El-Kholy, A. M. (2021). Exploring the major factorsof rework and assigning strategies to mitigate their occurrence in the Egyptian construction projects. *Journal of King Saud University-Engineering Sciences*.

Akshay1*, S. D. (2020). Causes, Impacts and Mitigations of Rework in International Journal of Research in Engineering, Science and Management 5.

Akshay, S. D., & Konnur, B. (2020). Causes, Impacts and Mitigations of Rework in Construction. *International Journal of Research in Engineering, Science and Management*, *3*(8), 139-143.

Al-Janabi, A. M., Abdel-Monem, M. S., & El-Dash, K. M. (2020). Factors Causing Rework and Their Impact on Projects' Performance in Egypt. *Journal of Civil Engineering and Management*, *26*(7), 666-689. https://doi.org/10.3846/jcem.2020.12916

Alaloul, W. S., Hasaniyah, M. W., & Tayeh, B. A. (2019). A comprehensive review of disputes prevention and resolution in construction projects. MATEC web of conferences,

Aman Sen, A. K. D., Dr. M.K. Trivedi. (2018). Evaluation of Rework Factors Affecting Cost and Schedule Performance. *International Research Journal of Engineering and Technology (IRJET)* 9.

Asadi, R., Rotimi, J. O. B., & Wilkinson, S. (2022). Investigating the relationship between reworks and contractual claims: The salience of contract conditions. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, *14*(1), 04521046.

Asadi, R., Wilkinson, S., & Rotimi, J. O. B. (2021a). The common causes of rework in construction contracts: a diagnostic approach. *Journal of Engineering, Design and Technology*(ahead-of-print).

Asadi, R., Wilkinson, S., & Rotimi, J. O. B. (2021b). Towards contracting strategy usage for rework in construction projects: a comprehensive review. *Construction Management and Economics*, *39*(12), 953-971. https://doi.org/10.1080/01446193.2021.2004609

Ashebir, A. (2020). CAUSES OF REWORK AND ITS IMPACT ON COST AND TIME OF SELECTED 40/60 CONDOMINIUM CONSTRUCTION PROJECTS: THE CASE OF HOUSING PROJECTS IN ADDIS ABABA

Assim Muwafaq AL-JANABI 1, Mohamed Shawky ABDEL-MONEM2,. (2020). FACTORS CAUSING REWORK AND THEIR IMPACT. *Journal of Civil Engineering and Management*, 24.

Balouchi, M., Gholhaki, M., & Niousha, A. (2019). Reworks causes and related costs in construction: Case of Parand mass housing project in Iran. *International Journal of Quality & Reliability Management*, *36*(8), 1392-1408.

belayneh, a. (2020). CAUSES OF REWORK AND ITS. *DSpace Institution*, 113.

Bell, J., & Waters, S. (2018). Ebook: doing your research project: a guide for first-time researchers. McGraw-hill education (UK).

Bon-Gang Hwang, M. A. (2018a). Effect of BIM on Rework in Construction Projects in. *American Society of Civil Engineers.*, 16.

Bon-Gang Hwang, M. A. (2018b). Effect of BIM on Rework in Construction Projects in. *2018 American Society of Civil Engineers.*, 16.

Chandrusha1, S. (2017). Rework Management in Construction Projects and Comparison with. *Shiridi Sai Institute of Technology & Science, Ananthapuram, Andhra Pradesh, India*, 6.

Chidiebere, E. E., & Ebhohimen, I. J. (2018). Impact of Rework on Building Project and Organisation Performance: A View of Construction Professionals in Nigeria. *International Journal of Sustainable Construction Engineering Technology*, *9*(1). https://doi.org/10.30880/ijscet.2018.09.01.003

Cohen, L., Manion, L., & Morrison, K. (2017). Validity and reliability. In *Research methods in education* (pp. 245-284). Routledge.

Eastman, C. M., Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors. John Wiley & Sons.

El Hussein, K. (2014). *Management of change-induced rework in a construction project* The British University in Dubai (BUiD)].

Enshassi1, A. (2017). Factors Contributing to Rework and their Impact on Construction Projects *International Journal of Sustainable Construction Engineering & Technology (ISSN: 2180-3242)* 22.

Enshassi, A., Sundermeier, M., & Zeiter, M. A. (2017). Factors contributing to rework and their impact on construction projects performance. *International Journal of Sustainable Construction Engineering and Technology*, *8*(1), 12-33.

Eze, E. C., & Idiake, J. E. (2018a). Analysis of cost of rework on time and cost performance of building construction projects in Abuja, Nigeria. *International Journal of Built Environment and Sustainability*, *5*(1).

Eze, E. C., & Idiake, J. E. (2018b). Impact of rework on building project and organisation performance: A view of construction professionals in Nigeria. *International Journal of Sustainable Construction Engineering and Technology*, *9*(1), 29-43.

Eze, E. C., Idiake, J. E., & Ganiyu, B. O. (2018). Rework risks triggers in the Nigerian construction industry: a view of built environment professionals.

Eze Emmanuel Chidiebere1, I. J. E. (2018). Impact of Rework on Building Project and Organisation Performance: . *International Journal of Sustainable Construction Engineering & Technology (ISSN: 2180-3242)*, 16.

Fageha, M. K., & Aibinu, A. A. (2013). Managing project scope definition to improve stakeholders' participation and enhance project outcome. *Procedia-Social and Behavioral Sciences*, *74*, 154-164.

Fayek, A. R., Dissanayake, M., & Campero, O. (2003). Measuring and classifying construction field rework: A pilot study. *Research Rep.(May)*.

Fellows, R. F., & Liu, A. M. (2021). *Research methods for construction*. John Wiley & Sons.

Forcada, N., Alvarez, A. P., Love, P. E., & Edwards, D. J. (2017). Rework in urban renewal projects in Colombia. *Journal of infrastructure systems*, *23*(2), 04016034.

Forcada, N., Gangolells, M., Casals, M., & Macarulla, M. (2017). Factors affecting rework costs in construction. *Journal of Construction Engineering and Management*, *143*(8), 04017032.

Garg, S., & Misra, S. (2021). Causal model for rework in building construction for developing countries. *Journal of Building Engineering*, *43*, 103180.

Ghannadpour, S. F., Rezahoseini, A., Noori, S., & Bodaghi, M. (2018). Reducing rework and increasing the civil projects quality, through total quality management (TQM), by using the concept of building information modeling (BIM). *Journal of industrial and systems engineering*, *12*(Special issue on Project Management and Control), 1-27.

Holt, G. D. (2014). Asking questions, analysing answers: relative importance revisited. *Construction Innovation*, *14*(1), 2-16.

Hwang, B.-G., & Yang, S. (2014). Rework and schedule performance: A profile of incidence, impact, causes and solutions. *Engineering, Construction and Architectural Management*.

Hwang, B.-G., Zhao, X., & Goh, K. J. (2014). Investigating the client-related rework in building projects: The case of Singapore. *International journal of project management*, *32*(4), 698-708.

Hwang, B.-G., Zhao, X., & Yang, K. W. (2019). Effect of BIM on rework in construction projects in Singapore: status quo, magnitude, impact, and strategies. *Journal of Construction Engineering and Management*, *145*(2), 04018125.

Hwang, B., Shan, M., & Tan, E. (2016). Investigating reworks in green building construction projects: Magnitude, influential factors, and solutions. *International Journal of Environmental Research*, *10*(4), 499-510.

Ivančič, I., & Fabijanić, I. (2017). Structural Development of Oxford Advanced Learners' Dictionary. *Journal of Literature and Art Studies*, *7*(5), 588-607.

Jarkas, A. M., & Haupt, T. C. (2015). Major construction risk factors considered by general contractors in Qatar. *Journal of Engineering, Design and Technology*, *13*(1), 165-194.

Jingmond, M., & Ågren, R. (2015). Unravelling causes of defects in construction. *Construction Innovation*.

Kermanshachi, S., & Safapour, E. (2019). Identification and quantification of project complexity from perspective of primary stakeholders in US construction projects. *Journal of Civil Engineering and Management*, *25*(4), 380-398.

Koshe, W., & Jha, K. (2016). Investigating causes of construction delay in Ethiopian construction industries. *Journal of Civil, Construction and Environmental Engineering*, *1*(1), 18-29.

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

Kwon, O.-S., Park, C.-S., & Lim, C.-R. (2014). A defect management system for reinforced concrete work utilizing BIM, image-matching and augmented reality. *Automation in Construction*, *46*, 74-81.

Lee, G., Park, H. K., & Won, J. (2012). D3 City project—Economic impact of BIM-assisted design validation. *Automation in Construction*, *22*, 577-586.

Leedy, P. D., & Ormrod, J. E. (2010). Practical Research: Planning and Design.(p. 62). *New York, NY: Merril*.

Li, Y., & Taylor, T. R. (2014). Modeling the impact of design rework on transportation infrastructure construction project performance. *Journal of Construction Engineering and Management*, *140*(9), 04014044.

Liu, Q., Ye, G., Feng, Y., Wang, C., & Peng, Y. (2020). Case-based insights into rework costs of residential building projects in China. *International Journal of Construction Management*, *20*(4), 347-355.

Love, P., Ackermann, F., Carey, B., Parke, M., & Morrison, J. (2016). The praxis of mitigating rework in construction projects. *ASCE Journal of Management in Engineering*, *32*(5), 10.1061.

Love, P., & Smith, J. (2018). Unpacking the ambiguity of rework in construction: making sense of the literature. *Civil Engineering and Environmental Systems*, *35*(1-4), 180-203.

Love, P. E. (2020). Creating a mindfulness to learn from errors: Enablers of rework containment and reduction in construction. *Developments in the Built Environment*, *1*, 100001.

Love, P. E., Ackermann, F., Teo, P., & Morrison, J. (2015). From individual to collective learning: A conceptual learning framework for enacting rework prevention. *Journal of Construction Engineering and Management*, *141*(11), 05015009.

Love, P. E., Edwards, D. J., & Smith, J. (2016). Rework causation: Emergent theoretical insights and implications for research. *Journal of Construction Engineering and Management*, *142*(6), 04016010.

Mahamid, I. (2016). Analysis of rework in residential building projects in Palestine. *Jordan Journal of Civil Engineering*, *10*(2).

Mahamid, I. (2020). Impact of rework on material waste in building construction projects. *International Journal of Construction Management*, *22*(8), 1500-1507. https://doi.org/10.1080/15623599.2020.1728607

Mamaru, A. (2020). Assessment of major construction defects and rework costs of time constrained projects: A case study of Bahir Dar university building projects

Mastenbroek, Y. (2010). *Reducing rework costs in construction projects* University of Twente].

Mohamad, M. M., Sulaiman, N. L., Sern, L. C., & Salleh, K. M. (2015). Measuring the validity and reliability of research instruments. *Procedia-Social and Behavioral Sciences*, *204*, 164-171.

Muluneh, W., & Amsalu, T. (2022). Financing Urban Infrastructure through Land Leasing: Evidence from Bahir Dar City, Ethiopia. *arXiv preprint arXiv:2211.12061*.

Nawaz, S., Zai, A., Imtiaz, S., & Ashraf, H. (2022). Systematic Literature Review: Causes of Rework in GSD. *The International Arab Journal of Information Technology*. https://doi.org/10.34028/iajit/19/1/12

Norman, G. (2010). Likert scales, levels of measurement and the "laws" of statistics. *Advances in health sciences education*, *15*, 625-632.

Oyewobi, L. O., & Ogunsemi, D. R. (2010). Factors influencing reworks occurrence in construction: A study of selected building projects in Nigeria. *Journal of building performance*, *1*(1).

Palaneeswaran, E., Love, P. E., & Kim, J. T. (2014). Role of design audits in reducing errors and rework: Lessons from Hong Kong. *Journal of Performance of Constructed Facilities*, *28*(3), 511-517.

Raghuram, S., & Nagavinothini, R. (2016). Investigation on the causes and adverse effects of reworks in construction projects and developing a rework reduction model to mitigate time and cost. *Int. J. Innovative Res. Sci. Eng. Technol*, *5*(4), 5790-5796.

Ramanathan, C., & Narayanan, S. (2016). Project Procurement Methods and Success of Infrastructure Projects in Malaysia. *International Journal of Innovative Research in Science, Engineering and Technology*, *5*(14), 346-353.

Ramin Asadi, S. W. a. J. O. B. R. (2021). Towards contracting strategy usage for rework in construction projects: a. *CONSTRUCTION MANAGEMENT AND ECONOMICS*, 20.

Robin McDonald, C., & LEED, G. (2013). Root Causes & Consequential Cost of Rework.

Safapour, E., & Kermanshachi, S. (2019). Identifying early indicators of manageable rework causes and selecting mitigating best practices for construction. *Journal of Management in Engineering*, *35*(2), 04018060.

Safapour, E., Kermanshachi, S., Kamalirad, S., & Tran, D. (2019). Identifying effective project-based communication indicators within primary and secondary stakeholders in construction projects. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, *11*(4), 04519028.

Safapour, E., Kermanshachi, S., & Taneja, P. (2019). Investigation and analysis of the rework leading indicators in construction projects: state-of-the-art review. Proceedings of the 7th CSCE International Construction Specialty Conference,

Saidu, I., & Shakantu, M. (2016). Management of material waste and cost overrun in the Nigerian construction industry.

Saunders, R. (2016). Democracy and the vote in British politics, 1848-1867: the making of the Second Reform Act. Routledge.

Sen, A., Dwivedi, A., & Trivedi, M. (2018). Evaluation of Rework Factors Affecting Cost and Schedule Performance in Construction Projects. *International Research Journal of Engineering and Technology (IRJET)*, *5*(8), 56-72.

SHAH1, K. K. (2016). DEVELOPMENT OF FIELD REWORK INDEX TO *M.E. Student, 2Asst. Professor,* , 6.

Shah, K. K., Shah, R. A., & Sharma, N. D. (2016). Development of field rework index to minimize the impact of rework for effective construction work. *Int. J. Sci. Dev. Res*, *1*(5), 370-375.

Shang Zhanga, b. (2018). Learning on rework management of construction projects: a case stud. *INTERNATIONAL JOURNAL OF CONSTRUCTION MANAGEMENT*, 16.

Simpeh, E., Ndihokubwayo, R., & Love, P. (2012). Evaluating the direct and indirect costs of rework. *Selected Works, Cape Peninsula University of Technology. ICEC2012-72*.

Simpeh, E. K. (2012). An analysis of the causes and impact of rework in construction projects Cape Peninsula University of Technology].

Smith, P. L. J. (2019). Unpacking the ambiguity of rework in construction: making sense of the literature. *School of Civil and Mechanical Engineering, Curtin University, Perth, Australia*, 25.

Too, J., Ejohwomu, O. A., Bukoye, T. O., Hui, F. K. P., & Oshodi, O. S. (2023). Standardising the route to project handover to improve the delivery of major building projects. *International Journal of Business Performance Management*, *24*(2), 175-199.

Trach, R., Lendo-Siwicka, M., Pawluk, K., & Połoński, M. (2021). Analysis of direct rework costs in Ukrainian construction. *Archives of Civil Engineering*, *67*(2).

Trach, R., Pawluk, K., & Lendo-Siwicka, M. (2019). Causes of rework in construction projects in Ukraine. *Archives of Civil Engineering*, *65*(3).

Volk, R., Stengel, J., & Schultmann, F. (2014). Building Information Modeling (BIM) for existing buildings—Literature review and future needs. *Automation in Construction*, *38*, 109-127.

Wasfy, M. (2010). Severity and impact of rework, a case study of a residential commercial tower project in the Eastern Province-KSA. *King Fahd University*.

Xiong, B., Skitmore, M., Xia, B., Masrom, M. A., Ye, K., & Bridge, A. (2014). Examining the influence of participant performance factors on contractor satisfaction: A structural equation model. *International journal of project management*, *32*(3), 482-491.

Yap, J. B. H., Low, P. L., & Wang, C. (2017a). Rework in Malaysian building construction: impacts, causes and potential solutions. *Journal of Engineering, Design and Technology*, *15*(5), 591-618. https://doi.org/10.1108/jedt-01-2017-0002

Yap, J. B. H., Low, P. L., & Wang, C. (2017b). Rework in Malaysian building construction: Impacts, causes and potential solutions. *Journal of Engineering, Design and Technology*.

Ye, G., Jin, Z., Xia, B., & Skitmore, M. (2015). Analyzing causes for reworks in construction projects in China. *Journal of Management in Engineering*, *31*(6), 04014097.

Zaiter, M. M. A., & Enshassi, A. (2014). Causes and effects of rework on construction projects in Gaza strip. *Causes and effects of rework on construction projects in Gaza strip*.

Zhang, D. (2010). Analysis of a construction small-projects rework reduction program for a capital facility University of Waterloo].

Zhang, D., Haas, C. T., Goodrum, P. M., Caldas, C. H., & Granger, R. (2012). Construction small-projects rework reduction for capital facilities. *Journal of Construction Engineering and Management*, *138*(12), 1377-1385.

Zhang, S., Duan, H., Zhao, X., Xia, B., Feng, Y., & Galvin, S. (2018). Learning on rework management of construction projects: a case study. *International Journal of Construction Management*, *21*(3), 246-260. https://doi.org/10.1080/15623599.2018.1521361

Appendix A: Questionnaire Survey-1

Addis Collage

Addis Collage Facility of Civil Engineering Postgraduate Program

Department of Construction Technology and Management (COTM)

Title: Determinant of Construction Rework Occurrence in Public Building Projects in Addis Ababa:

Objectives of The Questionnaire Survey

Dear Respondent,

The aim of this survey is to identify the factors to cause of rework that frequently occurred, to identify impacts of rework and forward its possible measures to mitigation solutions of rework occurrence in public building construction in Addis Ababa. in order to accomplish these objectives, it is crucial to conduct this questionnaire which is required to be filled with relevant facts as much as possible. I would like to confirm that all the data included in this questionnaire will be used only for academic purpose.

General Directions

Please do not write your name

Please checkmark on your given choice

If you cannot get as a satisfying choice among the given alternatives, please write your answer in the space provided at the end of the questionnaire.

Contact Address: -TEZERA TESFAYE KELETA Phone no +251-912-49-00-59

or E-mail rayatigerjet@gmail.com

Thank you in advance for your collaboration

Section A: Respondents' Profile

Mark your answer by indicating the response for the following questions.

1. Which of the following best describes your company?

☐ Client ☐ Consultant ☐ Contractor

2. Which of the following best describes your current position?

☐ Project manager ☐ Supervisor ☐ Residence Engineer

☐ Site Engineer ☐ Contract Engineer ☐ Others _____

3. Experience in design and construction works/projects

☐ < 5 ☐ 5 – 10 ☐ 10 – 15 ☐ ≥ 15

4. Educational status

☐ Diploma ☐ BSc. ☐ 5 MSc. ☐ Ph.D.

5. Contact addresses (optional):

Name: _____

Tel: _____

E-mail: _____

SECTION B: PROJECT CHARACTERISTICS

1. What was the project type?

☐ New Build ☐ Refurbishment/Renovation

Other (please specify) ……

2. What was the facility type that best describes the project?

☐ Administrative ☐ Educational

☐ Hospitals/Health ☐ Commercial

☐ Industrial ☐ Residential

Other (please specify) ……

3. How much was the original contract amount?

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4. How much was the final executed contract amount?

---

5. What was the project's original construction contract period?

SECTION C: MAJOR FACTORSTO OF REWORK

The following are the major factors which might be the factors to rework occurrence. Based on your experience in your project, please indicate the extent to which you agree with the following statements

Frequency of rework Occurrence
1 = Never
2 = Rarely occurred
3 = Sometimes
4 = Often
5 = Always occurred

1. The following are examples of client-related factors which might be the factors of rework. Indicate the extent to which you agree with the following statements:

S.NO	Critical Frequent Factors to Factors of Rework	Frequency of Rework Occurrence				
		1	2	3	4	5
A. Client related factors						
1	Change of plan/scope/, Specifications because of change in clients or end user.					
2	Lack of knowledge and experience in design and building construction process.					
3	Lack of funding allocated for consultation and for site investigation.					
4	Inadequate briefing and weak feasibility study of project objectives.					
5	Weak communication/coordination with consultant, contractor and end user.					
6	Lack of client involvement in the project and Improper supervision					
7	Weak quality management system					

If you have additional idea regarding to this, please add some here. _____.

2. The following are examples of design-related factors which might be the factors of rework. Indicate the extent to which you agree with the following statements:

B. Design Related Factors						
8	Incomplete design and inconsistencies, Errors, omission, during the design process.					
9	Poor coordination and communication between the design team					
10	Lack of using modern technology and software					
11	Lack of experience in design consultants and lack of professionalism					
12	Non-compliance with specifications and standards					

If you have additional idea regarding to this, please add some here.

_____

3. The following are examples of contractor-related factors which might be the factors of rework. Indicate the extent to which you agree with the following statements

C. Contractors and Sub Contractors related factors						
13	Imperfect construction technique, methods, procedure and practice.					
14	Attempts at fraud					
15	Hiring technically unqualified contractors					
16	Competitive pressure or low contract price or value					
17	Insufficiency and imperfect observation of acceptance material/mechanical equipment's					
18	Insufficient skill and defective workmanship of contractors					
19	Poor coordination and communication with consultants, contractors					
20	Misreading of drawings & specifications from lack of knowledge					

If you have additional idea regarding to this, please add some here.

_____

4. The following are examples of external environmental-related factors which might be the factors of rework. Indicate the extent to which you agree with the following statements:

D. External Environment Related Factors						
21	Government related: change of law (Regulations, taxes. Interest					
22	Economy related: inflation, exchange rates, market competition, availability of labor, materials and finance.					
23	Social: changing social environment, resistances and Legal: changes in legislation: safety or planning laws					
24	Institutional influences: codes of conduct, education regulations					
25	Acts of God/Force Major (Natural conditions, Weather and natural disaster, such as rain, heat, and cold.					

If you have additional idea regarding to this, please add some here. _____.

5. The following are examples of human resource capability-related factors which might be the factors of rework. Indicate the extent to which you agree with the following statements:

E. Human Resource Capability Related Factors of Rework							
26	Lack of employee motivation and rewards, carelessness.						
27	Conflict of interest and attempt to fraud						
28	Lack of experience and personal expertise in design and construction						
29	Inadequate supervision staff and planning for work task						
30	Inadequate manpower/skill level/ and insufficient educational and training skill development						
31	Poor communication system and Inadequate coordination & integration						
32	Ineffective management and decision-making						

If you have additional idea regarding to this, please add some here. _____

6. The following are examples of -related factors material and equipment supply which might be the factors of rework. Indicate the extent to which you agree with the following statements:

F. Related Factors to Materials and Equipment Supply							
33	Adulterated materials						
34	Materials not in the right place when needed invalidity of needed tests and untimely deliveries						
35	Use of defective/unadvanced equipment						

If you have additional idea regarding to this, please add some here. _____

7. The following are examples of -related factors to construction process which might be the factors of rework. Indicate the extent to which you agree with the following statements:

G. Related factors to building construction process							
36	Schedule compression/pressure						
37	Inadequate pre-construction planning of the project changes due to inappropriate methods of building construction in site						
38	Late design input						
39	Rigidity to improvement and Lack of use proper modern building construction technology.						
40	Failure to implementation quality management practice						
41	Selection of wrong methods and poor contract execution						

If you have additional idea regarding to this, please add some here. _____.

8, 9, 10 The following are supervisory-related factors, contract and site related factors which might be the factors of rework. Indicate the extent to which you agree with the following statements:

H. Supervisory Related Factors						
42	Inadequate supervision by design consultant and client					
43	Lack of supervisory experiences					
If you have additional idea regarding to this, please add some here. _____						
I. Contract-related factors						
44	Poor contract management due to ambiguous and unclear scope in the contract documentation					
45	Inexperienced staff to prepare contract documentation and management					
If you have additional idea regarding to this, please add some here. _____.						
J. Related Factor to Site:						
46	Poor site conditions for the contractor by a client, (e.g., soil problems, water, electricity)					
47	Failure/Inaccurate the site's investigations					
48	Bad site practices and site status that is overlooked by the contractor					

If you have additional idea regarding to this, please add some here.

If you have additional idea regarding to this, please add some here. _____.

SECTION D: DIRECT AND INDIRECT ADVERSE IMPACTS OF REWORK

11.1 Please indicate the extent to which rework affected the performance of the project directly that you have selected for each of the following impacts:(No impact=1, Limited impact=2, Average impact=3, Much impact=4 and Extreme impact=5).

S.no	Direct Adverse Consequence of Rework on Project Performance	Degree of Impact				
		1	2	3	4	5
1	Cost overrun					
2	Time overrun					
3	Contractual claims and Disputes between parties to the contract					
4	End-user/client dissatisfaction					
5	Design teams and Contractor's dissatisfaction					
6	Quality degradation					
7	Profit reduction in organizational performance					
8	Damage reputation					

S.no	Indirect Adverse Consequence of Rework on Org. Performance	Degree of Impact				
		1	2	3	4	5
1	Demotivation					
2	Stress					
3	Low morale of workers,					
4	Absenteeism,					
5	Fatigue					
6	Work inactivity					
7	Interorganizational conflicts					
8	Damage to professional image					

If you have additional idea regarding to this, please add some here.

_____

SECTION E: EFFECTIVE MITIGATION SOLUTION AND CONTROLING STRATEGY

11.2. Please indicate the extent to which rework affected the performance of organization indirectly that you have selected for each of the following impacts:(No Contribution=1, Limited Contribution =2, Average Contribution =3, Much Contribution =4 and Extreme Contribution =5).

11.3. Please indicate which of the following effective mitigation solution and controlling strategies were implemented in the project you have identified. Also indicate how effective the strategy was for reducing rework:

Effective mitigation solution and controlling strategy		Degrees of contribution				
		1	2	3	4	5
1	Effective material handling and supplier prequalification					
2	Effective leadership/management					
3	Improving effective communication and coordination between parties					
4	Sufficient and capable human resources					
5	Client involvement during prior stage of any activity					
6	Offering Regular Training Programs for Supervisors and Workers					
7	Teamwork effectiveness (cooperation)					
8	Preparing clear drawings and specifications					
9	Strict resistance against cheating (fraud fighting)					
10	Continuous quality/ rework auditing control					
11	Hiring Qualified Designer/Consultant, Contractor/Subcontractor					
12	Using prefabricated products					
13	Project documentation					
14	Well-defined roles and responsibilities					
15	Unification work standards					
16	Regular meetings					
17	Commitment to safety (strict law)					
18	Effective planning and scheduling					

If you have additional idea regarding to this, please add some here.

_____.

12. Please indicate which of the following Future proposed effective rework control and reduction strategy were implemented in the project you have identified. Also indicate how effective the strategy was for reducing rework:

S.no	Future proposed effective rework control and reduction strategy	Degrees of contribution				
		1	2	3	4	5
20	Effective use of technology (Modern Software) Using BIM					
21	Implementation of Total quality management					
22	Application Effective Client Change and Design Management					
23	Effective Rework Management system (RMS)					
24	Adopting control measures for rework					

If you have additional idea regarding to this, please add some here. _____

Appendix B: Interview Questions

Respondent profile

• Current position _____

• Work experience: ≥ 5 years

Questions

1. Were there any rework events in your project?

2. If your answer for question no 1 is yes, did you record the occurrence of rework on your project?

3. How do you rate the degree of occurrence of reworks on your company?

4. Based on your project, what were the main major factors to lead to the occurrence of reworks?

5. What do you forward to minimize the occurrence of reworks?