



**ADDIS COLLEGE
DEPARTMENT OF CONSTRUCTION TECHNOLOGY AND
MANAGEMENT**

**A STUDY ON DESIGN ERRORS AND ITS EFFECT ON THE
COST OF PUBLIC BUILDING PROJECTS IN LEDETA SUB-CITY**

BY:

NAHOM NIGUSSIE NEDI

NOVEMBER, ADDIS ABEBA

A STUDY ON DESIGN ERRORS AND ITS EFFECT ON THE
COST OF PUBLIC BUILDING PROJECTS IN LEDETA SUB-CITY

By: NAHOM NIGUSSIE NEDI (GSR/057/2011)

Advisor: DR BELACHEW ASTERAY

A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of
the Requirements for the Degree of Master of Science in Construction
Technology and Management

DECLARATION

I, the undersigned, declare that the study entitled “a study on design errors and its effect on the cost of public building projects in ledeta sub-city” is the result of my own effort and study that all sources of materials used for the study have been acknowledged.

This study has not been submitted for any degree in any university. It is conducted for the partial fulfillment of the Master of Science Degree in construction technology Management.

Name: NAHOM NIGUSSIE NEDI

Email: nigussienahom2@gmail.com

Signature: _____

ADVISOR’S APPROVAL SHEET

This is to certify that the thesis entitled “A study on Design Errors and its effect on the cost of public building projects in ledeta sub-city” submitted in partial fulfillment of the requirements for the degree of Master’s in Construction Technology and Management, and has been carried out by Nahom Nigussie, (ID.No GSR/057/2011), under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

DR. BELACHEW ASTERAY

Name of Advisor

Signature

Date

EXAMINERS' APPROVAL SHEET



ADDIS COLLEGE
School of Graduate studies
Department of Construction Technology and Management

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Construction Technology and Management

BY: NAHOM NIGUSSIE NEDI

Endorsed by:

1. Advisor	Signature	Date
<u>Dr Belachew Asteray</u>	_____	_____
2. Internal Examiner	Signature	Date
<u>Dr Meseret Getnet</u>	_____	_____
3. External Examiner	Signature	Date
<u>Dr Tsegaye</u>	_____	_____
4. Chairperson	Signature	Date
<u>Dr Mesfin</u>	_____	_____
5. School Dean	Signature	Date
<u>Ato Amlaku Melese (MSc.)</u>	_____	_____

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ABSTRACT

Many of the root causes of poor project performance which induce cost and schedule overruns, and poor quality are traced to some types of errors during the design process. Numerous researchers worked on the factors responsible for cost and time overrun as well as change orders in the construction projects and the result of the study showed that design related problems are prominent. This paper aims to determine the types of design errors, the causes of design errors and the cost wise effects of design errors in the performance of public building projects in Ledeta Sub-city. A comprehensive study of literature review and archival document review of completed projects and those on progress, in which the project history were recorded, were investigated thoroughly. About 2 projects were sampled for the analysis, type and causes of design errors in the sampled public building projects were identified. A questionnaire survey was undertaken on relevant parties participated in the sample projects. The study showed that, omission of necessary items/ incompleteness of design, error in project contextual factors, discipline coordination problems (within the same discipline), inaccuracy of details, poor coordination (between discipline), CAD related problem were the top five types of design errors that occur in the public buildings of the sub-city. The study revealed the five causes of design error were lack of proper field investigation and inspection, concurrent design activities of designers, poor briefing of project scope, unavailability of quality management/ quality control, time schedule pressure.

Keywords: Design Error, Public projects, Effects of design errors, Sub-city

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LIST OF ABBREVIATIONS AND ACRONYMS

BSc.	Bachelor of Science
CAD	Computer Aided software
MSc.	Masters of Science
NEDO	National Economic Development Office
SPSS	Statistical Package for Social Science
TTC	Teachers Training College
TVET	Technical and Vocational Education and Training

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CHAPTER ONE

1. INTRODUCTION

1.1 Background of the Study

Successful project management is both an art and a science which attempts to control and corporate resources within the constraints of time, cost, and quality (Kerzner, 2008). The triangle of time, cost, and quality is a combination that should be continuously pursued by the every project team member throughout the life cycle of the project (Hackett, 2007).

Generally, these three parameters are attached and placed to each type of contractual procedures and arrangements have been recognized as established norms within the construction industry (Ahmed, 2000). Clients want to receive completed projects that are of high quality as the required specification, within the planned budget and as the scheduled time. Construction professionals such as designers and contractors want to build a facility to meet the client's needs within the tender figure, but also ensure making a reasonable profit. However, the current situation in practice is that overruns in costs and delays to projects are becoming severe. The cause of such nonconformities in projects varies, depending on project configurations and variables (Ashworth, 2004).

The prevalence of design errors and their subsequent combined negative consequence upon the financial performance of organizations and projects is becoming very high within the construction industry (Edmonson, 2004).

The importance of early control of the project during the design stage is not a doubt. The most effective benefits are gained at the beginning of the project, in establishing scope and levels of quality, making schedule decisions and translating requirements into design concepts.

Despite the advisory role of designers in providing professional advice to the client, many researchers indicate that designers play a major role in project cost overrun, owing to the lack of adequate information, errors in designs and quality of contract documents (Rukn, 1999). Choy, (1991) point out that 51% of significant variations generated is from design documentations in construction projects. Furthermore, the research of Burati, (2003) found that design deviations accounted for 67-90% of the total amount of deviations on the project and that the design deviations generally accounted for the greatest increase in total project cost, ranging from 0.4% to 20.6% of the total project cost, with an average of 12.4%.

Similar to the case with other developing countries, the Ethiopian construction industry also shares many of the difficulties and challenges the industry is facing in other developing countries, perhaps with greater severity. Fetene, (2008) found out that out of 70 completed public building construction projects in Ethiopia; 67 buildings suffered cost overrun with rate of cost overrun ranges up to 126% of the contract price. According to Yeneneh, (2019) even though projects are the tools through which development policies and programs are translated into practice, many public sector development projects implemented take more time; require

additional budget and are of poor quality modification as a result of design deficiencies.

Mekonnen, (2011) noted that variations/change orders in the constructions in Ethiopia are a result of errors and changes in design by consultants. Fetene, (2008) also revealed that most of changes that cause overruns during construction result from poor design of the project. As a result of the adverse effects of these errors in designs of projects, it is important to identify the factors that are responsible for them and it is also necessary to assess their level of impact on the cost of construction, so that the professionals involved in the preparation of the documents can know the factors well. Hence, this research focus on the investigation of design errors and their cost wise effects on the performance of public building projects in Ledeta sub-city.

1.2 Statement of the Problem

More than half of construction project owners' worldwide experienced underperforming projects in terms of time cost and quality constraints, despite confidence in early project planning (Edmonson, 2004). The prevalence of design errors and their resultant cumulative negative effect upon the financial performance of organizations and projects is critical within the construction industry. Design errors dominate the cause of accidents, and it has been revealed that gross errors cause 80 to 90% of failures to buildings, bridges, and other civil engineering structures (Lopez and love, 2012).

Robinson, (2003) found out during engineering and review processes of construction projects, 68% of rework costs were attributable to design errors. Similarly, a study revealed 56% of all contract modifications are made due to design deficiencies. (Gherardi and Nicolini, 2000) Also point out that design errors accounted for 50% of quality failure costs in civil engineering projects.

In Ethiopia, assessment done on public buildings, out of 70 completed construction projects, 67 buildings failed in achieving initial contract amount due to design errors of the projects as main cause (Fetene, 2008). Mekonnen, (2011) noted that out of the cost impact of change Orders on projects in Ethiopia, total cost increment of 38.6% is caused due to design errors.

1.3 Objectives of the Research

1.3.1 General objective

The main aim of the study is to investigate about design errors and determine their impact on the cost of public building projects in Ledeta sub-city.

1.3.2 Specific objectives

- ✓ To investigate the types of design errors and their impacts in Ledeta sub-city public building projects.
- ✓ To determine the causes of design errors and their associated cost wise impact in public building construction projects in Ledeta sub-city.
- ✓ To formulate mitigation measures for future public building construction projects in Ledeta sub-city

1.4 Research Questions

- ✓ What are the types design errors in public building construction projects in Ledeta sub-city?
- ✓ What are the causes of design errors in public building construction projects in Ledeta sub-city?
- ✓ What effect can design errors have on the cost performance of public building projects in Ledeta sub-city?
- ✓ What are the mitigation strategies?

1.5 Significance of the Study

Over the last two decades, the construction industry of Ethiopia has boom more than any period in the history of the county's construction industry (Mekonnen, 2011). As compared to other economic sectors, the construction sector has invested enormous capital investment for the construction of different infrastructures such as dams, railroads, roads, building complexes, water supply facilities. of this capital investment, relatively considerable amount was allocated to the building construction sector.

However, projects in the country have come across construction changes, schedule delays and cost overrun due to various causes during the course of implementation. One of the main reason is due to design errors in the design of proposed projects which are mostly observed and noticed at the construction stages rather than the design stages.

As a result of the adverse effects of the design errors, it is important to identify the factors that are responsible for them so that the professionals involved in the preparation of the designs can know the factors upon as well as level of impact on the cost of construction projects.

In order to achieve that, a study needs to be done to identify the severe design errors affecting the building construction sector, so that future projects design get sufficient care on matters regarding to the effects of fault in design stage. And this study have an output in finding the factors behind the problem and recommending the ways of minimization, and lay the foundation for future research so that problems related to design and design errors can be properly addressed.

The research also attempts to contribute to the body of knowledge in construction management relating to the design decisions influencing the number of design errors generated in the construction projects.

1.6 Scope and Limitations of the Study

Owing to the international nature of the problem, research in this area is relevant to the construction industry; however, the research scope has been limited only to public building construction projects in Ledeta sub-city which are financed by the sub-city. Moreover, the study has been undertaken by taking projects (both active and completed). The study is limited to public building projects in the sub-city because of availability of data, limited time and fund for the study.

CHAPTER TWO

2. LITERATURE REVIEW

This chapter commences with the definitions of errors given by different authors. It progresses into discussions on general types of design errors under erroneous, omission, non- conformance, process, coordination and other classifications. The chapter also explains the general causes of design errors with respect to client, consultant and project character classifications. It ends with discussions on the effects of design errors and their way of prevention.

2.1 Definition of Terms

Design: The basic definition of design, according to Webster, is "the making of drawings or plans to plan and fashion the form and structure of an object to have intentions or purposes." The quality of planning and design is one of the primary factors of success in any project endeavor. The design includes every aspect of the facility construction including operation and maintenance. The design incorporates a set of specifications to guide the contractor in developing his means and methods of construction.

Error: An error is defined, according to Webster, as "a deviation from accuracy or correctness; a mistake, as in action or procedure; an inaccuracy, as in speaking or writing.

There is no such a thing as a perfect design in all construction projects, therefore professionals must anticipate some design faults and those design problems must be converted into construction problems (Acharay, 2004). As this research

revolves around errors, it is necessary to define and make clear what is meant by the word "errors" for the purpose of the investigation.

The above definition reveals that reveal that;

- 1) There is a standard to be followed in order to achieve a certain purpose.
- 2) The standard is either discarded or not completely conformed with.
- 3) The gap between (1) and (2) above is called an error.

Design Error: Erikson, (2002) from the definitions above a simple definition of design error is "a deviation from the plans and specifications. It is the failure of humans to design tasks within time limits and accuracy.

Contract: Erikson, (2002) defined Contract as an agreement that creates an obligation binding upon the parties thereto. The essentials of a contract are as follows: (1) mutual consent; (2) a legal consideration, which in most instances need not be pecuniary; (3) parties who have legal capacity to make a contract; (4) absence of fraud or duress; and (5) a subject matter that is not illegal or against public policy.

2.2 Errors and the Construction Industry

Josephson, (2008) Indicates that, on average, 32% of the defect costs are originated in the early phases i.e., in relation to the client and the design. Moreover (Robert, 2007) found that 50% of errors in buildings had their origin in the design stage and 40% in the construction stage.

The consequences of human errors in design deficiencies, such as catastrophic disaster or death and safety, have been frequently reported in many professional publications (Andi, 2003) .A survey by (Kertam, 2000)reported that defective design is one of the most significant risks to project delays. Burati, (2003) Found that deviation costs of the design change categories amounted to an average of 54.2% of the total deviation costs. These statistics are clear evidence how design errors are critical problems in the construction industry.

2.3 Design Error's in Construction

Design, according Love, (2008) is a complex and creative process that is usually driven by personal motivation in line with the desire to satisfy client's needs. It is also the personal need to satisfy creative desire which is restrained within the limitations of what is possible in the architectural and engineering course by economical restraint (Gherardi and Nicolini, 2000). 'Design errors' refers to the failures of humans to design tasks within time limits and accuracy. Deviation from actual values, inadequate precision and inconsistencies in measurement are also considered as design errors (Hagan and Mays, 2004)

2.4 Types of Design Errors

One of the objectives of this research is to identify types of design errors specific to Ledeta sub-city, but before this is done it is necessary to identify the different types of design errors through literature survey. According to Mohammed, (2007) types of design errors are classified into five categories as it is shown in Table 2.2 below. These are erroneous, omission, non-conformance, process, coordination and others discussed in detail with respect to the types of errors under each of them. The classification of design errors provides the foundations to consider the appropriateness of strategies to mitigate errors.

Table 2.1: Classification of construction design errors

	Classifications	Types of design errors
1	Erroneous	<ul style="list-style-type: none"> ✓ Error in project contextual factors, (not compatible with the site) ✓ Miscalculation
2	Omission/incompleteness	<ul style="list-style-type: none"> ✓ Inaccurate details /additional views or detail needed ✓ Missing or incorrect and notes on the drawings
3	Non-Conformance	<ul style="list-style-type: none"> ✓ Non- conformance of document to code
4	Process	<ul style="list-style-type: none"> ✓ CAD related problems ✓ Dimensional errors
5	Coordination	<ul style="list-style-type: none"> ✓ Coordination problem within the same discipline ✓ Coordination problem between disciplines

2.4.1 Erroneous

These are errors that occur when an aspect on design is based on wrong information. These include error in project contextual factors, (not being compatible with the site), miscalculations, and omissions or incomplete designs.

2.4.1.1 Error in project contextual factors

Morgen, (2004) have identified unknown site conditions as one of the major causes of contract modifications. This type of design error is mainly the result of missing or misleading information about the project site. This lead to delay of the startup of the project as well as additional cost to the projects so as to correct the design as per the site conditions and requirements (Mohammed, 2007).

2.4.1.2 Miscalculations

Every discipline is based on some standards which are used to calculate different needs and requirements. Failure to follow to these calculations results in violation of the codes, and failure of the system used for that discipline. Miscalculations have been in form of adding lengths together to make a whole in designs and also in the form of additions, subtractions, multiplication and division as it relates to figures in designs (Acharay, 2004). This type of error is not easy to discover during the process of preparing of design. When the error is discovered during the construction stage of projects raise the contractor's change variation orders and a claim for an extension of time and compensation for the extra costs (Mohammed, 2007).

2.4.2 Omission or incompleteness

This type of design error occurs when some information or aspects of design are missing or are incomplete. This refers to extra or additional views or details needed and missing or incorrect notes on the drawings (Elijah, 2017)

2.4.2.1 Inaccurate details

This design error occurs when the designs need more details to be clear and understandable due to the ambiguities in the current situation of the designs. This is because; the designs do not transfer and allocate the information to the contractors for construction purposes clearly enough as they should. This type of error might raise many queries during the tender stage, it may also result claims for extension of time during the construction stage when the details are missing or the design is not clear (Stassiowski, 2004)

2.4.2.2. Missing or incorrect notes on the drawings

The notes are the text on the drawings which convey the intent clearly, describe the substances or set up the conditions for the applicability of the design in the drawings (Sawada, 2000). Written information's on drawings often causes poor coordination because it can be hard to ensure that all affected designs are changed during design period. The error in this category include the following, when the information is not appropriate and applicable to the drawings, when the information describes wrongly what it is intended to be or an additional note is needed to make the drawings understandable. In other words this means, texts on drawings are missing or the content is vague (Dosumu and Adenuga, 2013)

2.4.3 Non-conformance

Non-conformance of design occurs when there are aspects of design or documentation that do not conform to established rules (Elijah, 2017).

2.4.3.1 Non- conformance to design code

The major regulatory instrument for the design of buildings and structures is the building code, as it provides fundamental design parameters for a large number of design and construction details (Tilley, 2005). Compliance with the building code generally is a burden that cannot be delegated, and code violations in construction documents may be considered evidence of negligence on the designer's part (Dosumu and Adenuga, 2013). Failure to conform to the code at the beginning of the project result in design modification later and delay the project.

2.4.4 Process

These are types of error that occur as a result of the process of preparation of design documents. Types of error in this respect include CAD related problems and dimensional errors.

2.4.4.1 CAD related problems

Since computer-aided design CAD was presented to design organizations, they have reduced the number of staff they employ and have become far leaner (Hoxley, 2000). In contrary to this unhealthy overdependence on computer-aided automation can lead to design errors being committed whereby design consultancy firms overlook realistic considerations. These include checking the

designs produced for any inconsistencies and discrepancies, moreover, design organizations that utilize incompatible software applications aggravate the effects of undertaking design errors with tentative or incomplete information (Busby, 2005).

2.4.4.2. Dimensional errors

Dimensioning highly requires an understanding of the sequence of construction (Hagan and Mays, 2004). This is because new assemblies can only be placed with respect to assemblies already in place. Necessary dimensioning should be numerically portioned on the designs. This is because the contractors are not expected to depend on scaling the drawings for dimensioning (Rukn, 1999).

2.4.5 Coordination

These include design errors that occur due to poor coordination during documentation. Coordination problem between disciplines and coordination within the same discipline are the two types of design errors under this category. (Hagan and Mays, 2004)

2.4.5.1 Coordination problem within the same discipline

The design process is difficult enough to control when there are numerous disciplines to bring together, each of which can affect the performance of others. Elijah, (2017) reported that more than half of the errors and omissions in construction drawings and specifications are caused by poor coordination with in design disciplines. Poor design coordination may be caused by inadequate attention being given to detailed design.

2.4.5.2 Coordination problem between disciplines

According to Acharay,N,(2004) this type of error occur when the coordination problem between plans, elevations, sections and the detail drawings, between the elevations and the drawings or between the drawings and the specifications. When this type of error is not discovered during the design process then it raise problems later in the construction stage and raise claims for extension of time and sometimes extra costs.

2.5 Causes of Design Error

Errors always occur and reoccur when their causes are not revealed. In order to reduce the occurrence of errors, it is compulsory to understand the factors behind their occurrence (Andi, 2003) .Cause of error can be defined as a proven reason for the presence of errors. These factors are an important step toward completing the process of finding mitigation measures for the errors.

According to Mohammed, (2007) causes of errors in design are classified into three. The classifications are done with respect to the sources and origins from which the causes arise. And these are project related factors, client related factors and consultant/designer related factors.

Table 2.2 Causes of design error

No	Classification	Cause of error
1	Project related factors	<ul style="list-style-type: none"> ✓ Uniqueness of the project ✓ Time schedule pressure ✓ Project budgeted cost ✓ Complexity of the project
2	Client related factors	<ul style="list-style-type: none"> ✓ Poor briefing of project scope ✓ lack of experience of the client ✓ Construction time constraint imposed by the client ✓ Minimum client point of contact with consultants ✓ Inadequate financial provision
3	Consultant related factors	<ul style="list-style-type: none"> ✓ Poor management ✓ Organizational structure ✓ Shortage of technical knowledge of designers ✓ Lack of designer experience ✓ Insufficient overall design time ✓ Lack of proper field Investigation and inspection ✓ Inefficiency of design team ✓ Unavailability of quality management/ quality control ✓ Lack of effective consulting team ✓ Lack of information ✓ Lack of coordination and communication ✓ Lack of transfer of knowledge between consultants ✓ High work load of the consultants ✓ Concurrent design activities of designers ✓ Poor consultancy fees ✓ Unsatisfactory reputation of consultants ✓ Less number of designers

2.5.1 Project related factors

The project characters influence the number of errors generated in the design of projects, because they establish the size, budget and timeframe for the accomplishment of the projects (Love and Edwards, 2004).The following factors are under the umbrella of project related factors:

2.5.1.1 Uniqueness of the projects

The unique nature of projects often results in organizations responsible for their delivery being confronted with a pressure to satisfy the needs of clients, since every construction project has a defined specification and deliverable which makes it to be unique (Andi, 2003). The uniqueness of the project reinforces the necessity of co-ordination and communication to achieve a successful completion of the project (Elijah, 2017). Uniqueness of project result in a number of errors as a result care taken during the design of the project (Atkinson, 1999).

2.5.1.2. Time schedule pressure

Insufficient design time is the most important issue influencing design document quality (Tilley, 2005). Some projects force certain time schedule pressures which have to be met for different reasons, or there is no need for the project, such pressure influence the overall design times the projects. The design stage is the one most sacrificed, as the project start on site without complete design, enough study or coordination (Busby, 2005).

2.5.1.3. Project budgeted cost

A project budget is an amount of money that is accounted to spend over a period of construction time, or on a specific work. A lower project budget in fact decrease the possibility of selecting of a proper project team directly which decrease the quality of design (Elijah, 2017). This factor is highly caused by inadequate financial provision of clients.

2.5.1.4 Complexity of the project

Complexities in the shape and size of building projects have been marked as a cause of design error in construction projects (Elijah, 2017). A building is said to be complex when it has complicated parts that are difficult to understand (Edmonson, 2004).

Rowland, (2008) has shown that project size have an impact in the number of errors; because risks are higher on larger projects, more care must be shown in the building and planning processes; thus, the cost overrun may be reduced.

2.5.2 Client related factors

The client is the entity that ascertains the need for a building and is the genesis of the construction process. The client defines project objectives independently or together with advisers. Shaping a project's scope therefore, lies very much in the hands of the clients (Andi, 2003). The following factors come under the umbrella of client related factors.

2.5.2.1. Poor briefing of project scope

The development of the brief is the process of clarifying and defining the objectives and requirements of a project. The purpose of this stage is for clients to communicate to the design team with their needs and objectives in initiating the project (Elijah, 2017).

An effective client briefing process is crucial to the accomplishment of client objectives with respect to time, cost and quality for construction projects.

According to Nina, (2004) how the brief requirements are formulated and used for communication between the client and the contractor are very important factors for the success of building projects.

2.5.2.2. Lack of experience of the client

Less experienced clients may have impractical and unrealistic expectations of consultants. NEDO, (2008) demonstrated the key influence of the client on the outcome of building projects which is reflected by the client's skill in clearly expressing project objectives in terms of building requirements, cost and time budgets; determining the level of service expected from each member of the project team. Clients express their brief in a variety of ways, ranging from highly developed requirements, such as extension or expansion plans for manufacturing plants, to vague impressions of shortcomings in an existing facility (Robert, 2007).

2.5.2.3. Construction time constraint imposed by the client

The construction time constraint by clients imposes a time pressure on the project team to finalize the project, regardless of the actual time required to finish the project. Such pressure reduce the time for coordination and increase the parallelization of activities during the preparation of the designs of projects, which leads finally to an increase in the number of errors in the pre-contract stages (Love, 2008).

2.5.2.4. Minimum client point of contact with consultants

Busby (2001) has demonstrated that of central importance of a well-managed connection between design and construction for project success is that the client must avoid disunity in the interaction with the design team. Clients should participate actively and supportively throughout the project life cycle (Acharay, 2004). The maximum client point of contact ensure that changes to decisions are minimized, that timely decision making is taking place, and that the briefing stage is properly undertaken (Elijah, 2017).

2.5.3 Consultant related factors

Despite the professional advice to the client, many researchers indicate that designers play a major role in project cost overrun, owing to the lack of adequate information, errors in designs and quality of contract documents (Rukn, 1999).The following factors comes under the umbrella of consultant related factors.

2.5.3.1. Poor organizational structure

According to Koskela, (2002) a good organizational form achieve effective communication that are appropriately responsive to client objectives, project and external environment characteristics, management style, and the organizational cultures of project stake holders. Organizational structure helps to ensure that planning is undertaken to anticipate potential errors, forecast data to investigate plans of action to overcome potential errors and to support decision making.

2.5.3.2. Unavailability of quality management/ quality Assurance

Inadequate reviews, check and corrective control are the main cause of failure in design quality. However, despite its widespread advocacy, the use of checking and inspection suffers from two limitations. First, checking is intermittent and cannot be expected to detect all errors. Second, checkers frequently make the same errors as the original perpetrators, thus rending the process ineffective (Sawada, 2000). Tools exist for keeping track of quality in every phase of pre-design and design. These include project checklists, CAD standards, document formats, detail libraries, documents coordination and checking systems, punch lists, and a variety of other quality management methods and systems.

In conclusion, the availability of quality management and quality assurance in place influence the number of errors generated in the design of construction projects.

2.5.3.3. Shortage of technical knowledge of designers

Qualification in technical knowledge of the managers and the consultants are very significant; when the consultant is technically qualified, the level of reported cases of defects is low. The more highly qualified technically and professionally a consultant is the more know-how he possesses which result to very low occurrence of errors (Atkinson, 1999). Proper education of the professional designer delivers all the necessary knowledge about the process of the development of the design documents (Sawada, 2000).

2.5.3.4. Lack of designer experience

Sufficient design experience for the type of the project in hand influences the number and types of errors in the design of the projects. Professional inexperience is one of the causes of error in the design of projects (Dosumu and Adenuga, 2013). Experience is the knowledge or skill of a particular job that has been gained through working at the job for a long time. The knowledge and skill already gained by respective consultants in past projects influences the occurrence of errors on the construction documents they produce.

2.5.3.5. Insufficient overall design time

A realistic time schedule for design is important for the number of errors produced in design stage of projects. (Andi, 2003) Found that the designers found out that insufficient design time as the most important issue influencing design quality. Projects with quality problems are often those which are behind with their program (Love, 2008).

2.5.3.6. Lack of proper field investigation and inspection

A field site investigation is the general process for the collection of information, appraisal of data, assessment and reporting. Feasibility studies, planning, design and construction all require reliable and relevant data about the ground conditions of a potential site, this data must be gained competently, in a timely manner and to a degree which is adequate and appropriate to each stage of design and development. In this way risk and liability is minimized, the potential for economic and safe design is maximized and the project is more likely to be completed on time and within budget (Bea, 2005).

2.5.3.7. Inefficiency of design team

The effectiveness of the design team is highly linked with the ability of the project team to be cohesive. Overall project efficiency depend on the coordinated efforts of the individual and the group's ability to become customer focused and work together toward common goals within a project organizational system (Lopez and love, 2012). Other types of consultant related factors as discovered by (Mohammed, 2007) are:-

- ✓ Lack of effective consulting team
- ✓ Lack of information
- ✓ Lack of coordination and communication in design team

2.6 Effects of Design Error

The effect of design error is critical in the construction industry. The occurrences of the above discussed causes of design error give rise to appearances of the effects. (Al-Dubaisi, 2000) determined the effects of design error to be:-

- ✓ Delay in completion schedule
- ✓ Increase in project cost
- ✓ Dispute between contractors, consultants and owners, and
- ✓ Demolition and rework.

Design errors have serious effects on construction projects and these effects are mostly manifested at the construction and post-construction stages of projects. The major effects identified are design-induced rework, propagation of failure structural collapse, financial loss, inconvenience, deterioration of buildings, personal injury and sickness, time delay, damaged equipment, defects, wastages and inconveniences (Love, 2008).

The research carried out in Australia reveals that ninety-two percent (92%) of the variation in their construction industries were attributable due to designs errors and the clients shared 40% and design team shared 60% (Choy , 1991).

Diekmann and Nelson, (1995) also discovered that the largest amount of change orders and modifications originated from the owners or their representatives (consultants/designers) and these account for 46% of claims in projects. In another study, Kerzner (2008) found that most design firms spend 25-50% of

design time redesigning details that have already been designed on other projects and correcting errors found during design reviews.

The study conducted by Burati, (2003) on nine fast-track industrial construction projects show that while construction deviations average 16% of the entire number of deviations, design deviations averaged 78% of the total number of cost deviations. Koskela, (2002) revealed that it sometimes seems that the waste caused as a result of design error is larger than the cost of the design itself. In a research carried out by Kertam, (2000) revealed that design error is of the most substantial risks to project delays.

Gherardi and Nicolini, (2000) Discovered that design error accounted for 50% of design defects cost. Lopez and love, (2012) Surveyed 139 projects and total cost of design errors calculated from the sum of direct and indirect design errors and stated that there is a 38% deviation. This also shows a serious negative effect of error on construction projects.

Rework as a result of design error has become a serious problem in construction projects that when not restrained it may result into huge economic ruin (Rogge, 2001). In a study of design and documentation quality and its impact on the construction process by (Tilley, 2005) and reported that when design and documentation quality is considered to be very poor, an average of just over 11% was added to both the project initial cost and delivery period or contract time.

2.7 Design Error Mitigation

Viewing design error prevention as a continuous process rather than a product of certain activities or behaviors comprises the exploration of people, organization, and project management system to map dependencies and interfaces that influence the design error prevention process (Gherardi and Nicolini, 2000).

Furthermore, a process view implies that learning from the design errors is a combined capacity that can produce individual and organizational error prevention practices. Given the complexity of the project environment within which designers work, the creation of a collective capacity would involve the learning habit of not only design organizations but the whole project team (Sawada, 2000).

The ideal design error prevention approach is to view design errors as symptoms of underlying problems so they become sources of information (Busby, 2005). Design errors and the resultant effect that occurs should be viewed as tools that can be used to define margins of risk and safety so that learning how to prevent them can occur (Edmonson, 2004).

The focus must be on the failure in procedures, processes, teams, and the organization. Prominence must be on feedback from work processes, information, reflection discussion between colleagues and other project team members (Busby, 2005). Learning about error causation through interaction and participation with others is believed an effective learning setting for their prevention (Sense, 2007).

Most designers learn on the job in culturally set in habits. Interaction is a prerequisite for learning how to prevent design errors as it allows the sharing of experiences to be acquired (Kalra, 2004). This situated perspective may inspire designers to understand the need for project learning and interaction so as to make sense of their doings (Reason, 2002).

Design organizations need to adopt a leadership supplemented culture and structure that creates groups and teams to develop error free work practices, as their prevention can only be achieved through their involvements at an organizational level (Kalra, 2004).

Providing designers with necessary time to produce documentation reviews and verifications are some ways of in eradicating errors (Reason, 2002). Similarly, at the project level, the implementation of building information modeling, quality management, and risk management can also be adopted to minimize design errors (Love and Edwards, 2004).

2.8 Summary and Gap Analysis

An examination of existing literature on construction projects in Ethiopia reveals the following major gaps and room for improvement:

- ✓ While a large amount of research is devoted to investigating details of Time, cost, quality problems, cause and effect and change order management practices, very few have focused on exploring design-related errors.

- ✓ A small number of researchers have focused more of their attention on an analysis of the impact of construction change orders, with consideration of a number of factors influencing changes.
- ✓ Existing research primarily quantifies the impact of overruns delays and change orders, in the construction industry, No study was found explicitly exploring the impact of design errors, in order to improve the predictability and accuracy of project budget and schedule at project endorsement.
- ✓ There is no a meaningful amount of research directly addressing the issue of design Errors, particularly in Ledeta sub-city.

Analyzing the literature on this topic revealed that none of the existing studies thoroughly examined the key factors contributing to design errors specifically in public building projects. This study aims to bridge some existing knowledge gaps by:

- (1) exploring about design errors, causes and effects, and identifying key factors contributing to this problem in public building construction projects in Ledeta sub-city, and
- (2) Proposing a mitigation measure so as to prevent the effect of design error affecting the public building construction projects in Ledeta sub-city.

The outcome of this study may increase project participants' certainty about the cost impact of design errors, and may also enhance the accuracy of cost estimates as a project's execution phase begins.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the procedures undertaken to achieve the research objectives. The procedures adopted, including all the information relevant to the data collection and where those data were obtained are discussed. In addition, research instruments, sample size and method of analysis are presented.

3.2 Study Area

Lideta is one of the 10 sub cities of Addis Ababa, the capital of Ethiopia. As of 2011 its population was of 214,769. The district is located in the central-western area of the city, nearby the center. It borders with the districts of Addis Ketema, Arada, Kirkos, Nifas Silk-Lafto and Kolfe-Keranio.

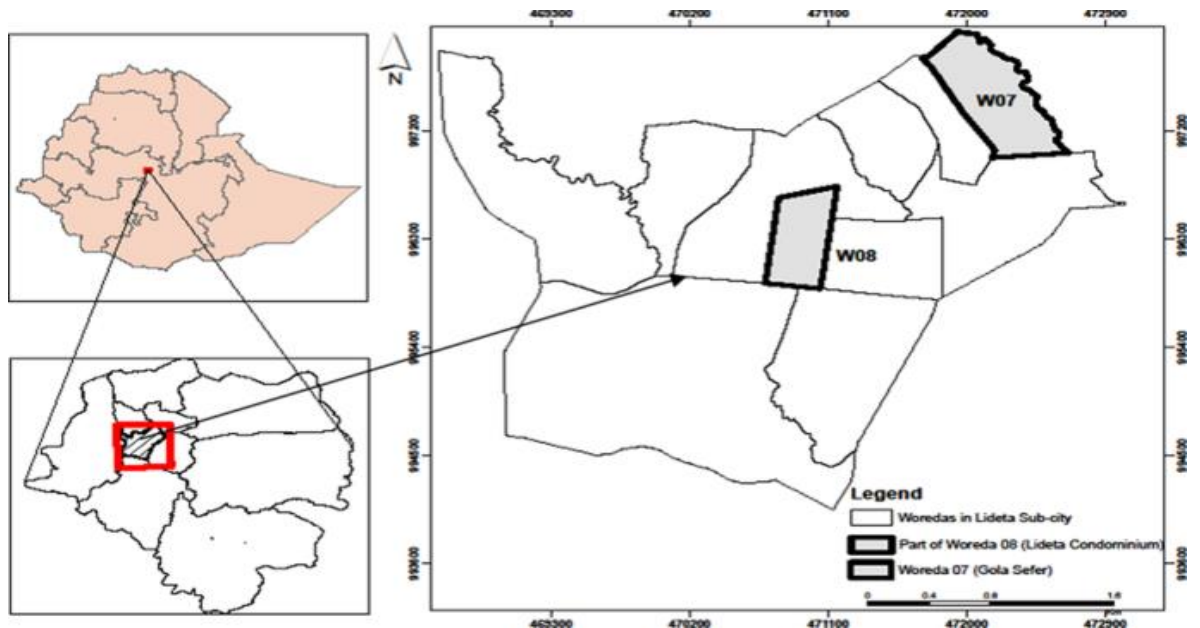


Figure 3.1: Diagrammatic representation of the study area and sample projects

3.3 Research Design

Research design refers to the plan or organization of scientific investigation. Designing a research study encompasses the development of a plan or strategy that guide the collection and analyses of data (Naoum, 2001). A starting point in trying to understand the information for research purposes is that there are two wide approaches: quantitative research and qualitative research.

In consideration of the nature of the research, a combination of both quantitative and qualitative research design is selected to accomplish the objective of the research. This mixed research approach is sometimes called triangulation or multi method. Quantitative methods have the advantage of higher internal validity, as the experiment may be repeated with similar result experienced whereas qualitative methods involve the analysis of complex descriptive data in which the researcher may increase his or her involvement and probe to gain additional information. (Naoum, 2001). As the data in quantitative approach are numerical, the numbers are readily collected, coded, summarized and analyzed.

On the other hand, when the data are concerned with a qualitative phenomenon, the data analysis may involve qualitative analysis. Qualitative data are not numerical nor are they usually subjected to statistical methods of analysis. It involves the analysis of complex descriptive data in which the researcher may increase his or her involvement and probe to obtain additional information. Qualitative data collection and analysis add richness and details that numbers cannot provide. (Kothari, 1998).

3.4 Methods of Data Collection

The primary data for this study was gathered through questionnaires, case study and a literature review was undertaken in order to capture the gap in knowledge about construction design errors and gain secondary data for the research. Generally literature review was used in the process of collecting data about the research problem.

In order to obtain actual data archival documents were also reviewed from reports of completed projects and those on progress, in which the project history was recorded and investigated thoroughly which were very important in identifying the recurrent problems related to design errors on public building projects in Ledeta sub-city. It was mainly carried out to obtain actual data from the source documents which included the contract documents, supplementary agreements, variation orders and progress reports to have contextual bases on design error on the building projects and to assess the extent of the problem.

3.4.1 Questionnaire

The questionnaire survey in this study used to assist the researcher in obtaining the data about the types, causes and effects of design errors on the cost performance of public building projects in Ledeta sub-city. It was distributed to clients, contractors and consultants involved in the construction of the sampled public building projects in the sub-city.

The questionnaire used in this research has 3 parts which were designed in such a way making it to be useful in achieving the research objectives. The first part of the questionnaire contained general information about the respondents. The second and third parts were about the type and cause of design errors occurring in the projects .This section aimed to achieve the first and second objectives that intend to identify and rank the most common types and causes of design errors in the construction projects in Ledeta sub-city. The questionnaires are well structured with options as probable answers. It was provided with a covering letter explaining the purpose of the study, the way of responding, the aim of the research and the security of information in order to encourage a high response.

The questionnaire was carefully designed in light of getting high response rate from respondents. The variables of major causes and types of design error were identified from literature review as well as archival document review. Then respondents are asked about their agreement on these variables.

3.4.2 Case Study

According to Naoum,(2001) a case study method is a form of qualitative analysis where in careful and complete observation of an individual or a situation or an institution is done, efforts are made to study each and every aspect of the concerning unit in details and then from case data generalizations and interpretations are drawn.

The main objective of undertaking case study in this research is to cross check and validate the result gained from questionnaire. Therefore out of the 30 sampled

projects two case study projects were therefore selected. The criteria for its selection of the case studies comprehensiveness and accessibility of project records and documentation and availability of project key personnel's. However, the data required to conduct the case study analysis was collected through an in-depth review of project documentation (archival records) and face-to-face interviews with project professionals.

3.5 Population and Sampling

3.5.1 Population

The first step in developing any sample design is to clearly define the set of objects, technically called the universe (population), to be studied (Fellows, 2005). The populations for this study were the client, consultant and contractor of public building projects which include both completed projects and those which are on progress. The projects which had been completed and projects whose current progress reached more than 50% from 2012 up to 2013E.C were purposively considered as a population for the research (*see Appendix C*). Accordingly, a total of 30 projects were revealed by the researcher from the Ledeta sub-city construction office for questionnaires.

3.5.2. Sampling

It was not practically possible to look at every object in the situation being investigated. This is the reason for sampling. In order to select the appropriate sample from the target population the formula used.

$$n = \frac{N}{1+N*e^{-2}} \dots \dots \dots \text{equation 3.1}$$

Where n =sample size N =population size e =level of precision Z = value for 95% confidence level $e=0.50$

So, the total population of this study is 111 which match the proposed objective of the research by giving one sometimes two questionnaires for participating parties the client, consultant and contractor for 30 projects.

$$n = \frac{111}{1+111*(0.05)^2} = 87 \text{ samples}$$

The questionnaire is distributed to the entire eighty seven project participants' or contracting parties; clients, consultants and consultants. A total of eighty seven questionnaires comprising thirty six for the contractors, thirty six for the consultants and fifteen for the clients were sent totally.

3.6 Validity and Reliability of the Data

One of the methods to test validity of a research is content validity, which refers to whether or not the content of the apparent variables (questionnaire) is right to measure the concept that the researcher is trying to measure (Asika, 2000).

The content validity of the questionnaire was addressed by obtaining the feedback from the advisor the study. The questionnaires have been reviewed by the advisor to evaluate the procedure of questions and the method of analyzing the results. The comments and concerns raised by the advisor during this review process have been acknowledged and incorporated to improve the questionnaire instrument for use in data collection stage. Finally it was agreed that the questionnaire was valid and suitable enough to measure the purpose that the questionnaire is designed for.

3.6.1 Cronbach's α Statistics

This method is used to measure the reliability of the research data. This statistic uses interim correlations to determine whether basic items are measuring the same domain (Rattray and Jones, 2007). Cronbach's α reliability coefficient normally ranges between 0 and 1, the closer α is to 1.0, the greater the internal consistency of the items in the scale. Reliability of data is at low level when Cronbach's α is less than 0.3 this suggests that data is not reliable and cannot be accepted. Reliability is high when Cronbach's α is more than 0.7 (Stewart, 1992). The test results for each group of variables and the overall Cronbach's α for the entire data set are presented in Table 3.1 and 3.2 respectively.

Table 3.1 Cronbach's α reliability coefficient for type of design errors

Reliability Statistics	
Cronbach's Alpha	Number of Items
0.904	10

Table 3.2 Cronbach's α reliability coefficient for causes of design errors

Reliability Statistics	
Cronbach's Alpha	Number of Items
0.864	25

Thereby, from the above table it can be concluded that the researcher proved that the questionnaire was reliable, and is ready for distribution for the sample population.

3.7 Ethical Considerations

When using participants in a research study, extreme caution must be used to ensure that their rights are respected. By keeping the information acquired confidential, the respondents' privacy and confidentiality were safeguarded.

This helped the respondents to make knowledgeable decisions with respect to the questions asked. Respondents voluntarily partook in the research without any form of pressure or manipulation. All sources of information were duly acknowledged.

3.8 Data Analysis Techniques

The study was analyzed based on descriptive statistics analysis. The descriptive statistics was employed to quantitatively describe variables using mean, standard deviations, frequency or mode. The data analyzed and presented in the form of diagrams, charts, and tables by using SPSS (Statistical Package for Social Science) software version 20. Various statistical tools such as descriptive arithmetic mean of constructs and correlation were used to analyze the variables. Finally, conclusions were made based on the findings/results of the study and recommendations were forwarded on the basis of the data analyzed.

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter provides the analysis and discussion of the data gathered through questionnaire survey from professionals who are working for the client, consultants and contractors involved in the construction of public building projects in Ledeta sub-city.

The principal purpose is the identification of the major types and cause and the cost wise impact of the design errors on the performance of public building construction projects.

4.2 Analysis of Questionnaire Response

A total of 87 questionnaires were sent to the three groups of respondents clients, contractors and consultants .Out of 87 questionnaires; 66 questionnaires were collected which comprises 12 from clients, 25 from consultants and 29 from contractors. This gives a response rate of 75% as shown in Table 4.1 below.

Table 4.1: Summary of overall survey response rate

Groups	Questionnaire Distributed	Questionnaire Returned	Percentage returned
Clients	15	12	80%
Consultants	36	25	69%
Contractors	36	29	80%
Total	87	66	75%

4.3 Analysis and Discussion of Results

In this section, analysis of respondent's perception regarding the questionnaire distributed has been analyzed and discussed.

4.3.1 Respondents academic background

The survey result shows that 8 % of the respondents have MSc educational qualification, the rest 76% have a BSc Degree Educational qualification and the rest 16% have other Educational qualification as shown in the figure 4.1 below.

The percentage distribution of the various professionals indicates that the majority of the questionnaires were completed directly by professionals involved in the construction industry. The survey also shows that it was well represented by better qualified professionals in the construction management and these groups of respondents are expected to have plenty of knowledge on the subject matter.

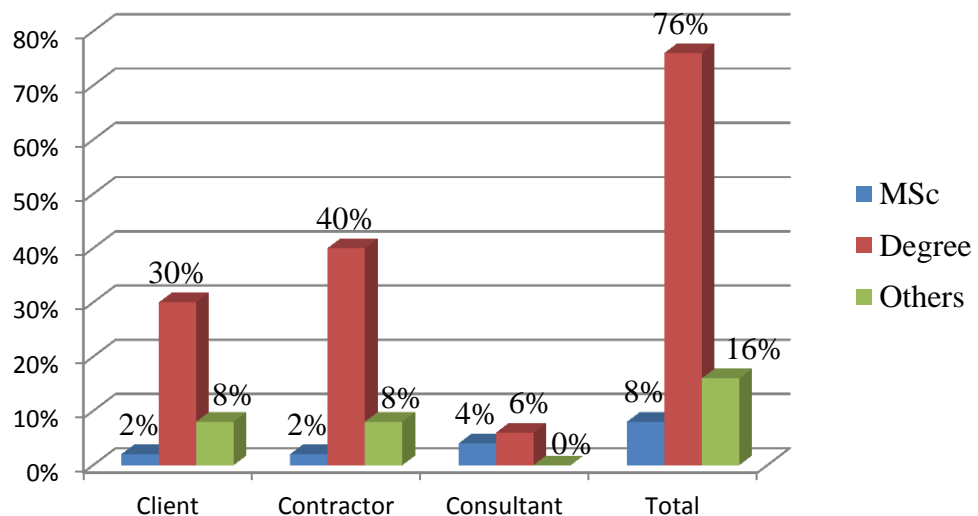


Figure 4.1: Academic Background of Respondents

4.3.2 Experience of respondents

Out of the 12 respondents on the client side 68.3% of the respondents had 1 to 5 years of working experience, 25% had 6 to 10 years of experience, 4.3% had 11 to 15 years of experience and 2.4 % had more than 15 years of experience.

Out of the 25 respondents of the consultants 75% of the respondents had 1 to 5 years of working experience, 20% had 6 to 10 years of experience, 3 % had 11 to 15 years of experience and 2 % had more than 15 years of experience.

Out of the 29 respondents by the contractor 30% of the respondents had 1 to 5 years of working experience, 40% had 6 to 10 years of experience, 14 % had 11 to 15 years of experience and the rest 16 % had more than 15 years of experience.

4.3.3 Profession of respondents

Out of the 66 respondents 30% were architects, 60% of them were civil engineers, and 7% of them were electrical engineers and 3% of them were mechanical engineers.

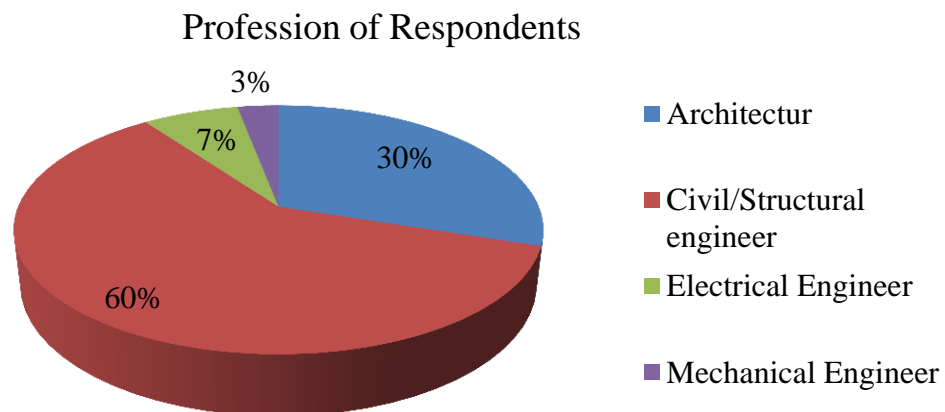


Figure 4.2: Profession of Respondents

4.3.4 Types of design errors in the public building projects in ledeta sub-city

The types of design errors identified from literature review and archival document review of projects was tabulated and distributed to respondents. The following Table 4.2 shows the mean and standard deviation of the results. The types were ranked according to the mean score. The ranks of all factors that are selected for the study were tabulated under each category.

Table 4.2: Descriptive statistics of types of error

Types of design errors	Client			Consultant			Contractor		
	Mean	Standard Deviation	Rank	Mean	Standard Deviation	Rank	Mean	Standard Deviation	Rank
Omission of necessary items/ incompleteness of design	4.83	0.389	1	4.16	0.85	1	4.72	0.649	1
Poor Coordination (between discipline)	4.50	0.522	6	3.92	0.862	3	4.28	0.882	5
Discipline coordination problems (within the same discipline)	4.67	0.492	3	3.76	1.165	5	4.17	0.602	8
Inaccuracy of details	4.50	0.522	7	3.96	0.790	2	4.21	0.917	7
CAD related problem	4.75	0.452	2	3.64	1.186	6	4.24	0.636	6
Non-Conformance to design Code	4.42	0.669	8	3.24	1.300	9	4.07	0.923	10
Incorrect or missing notes	4.33	0.492	9	3.40	1.354	8	4.45	0.736	4
Error in project contextual factors	4.67	0.492	4	3.92	0.776	4	4.55	0.686	2
Dimensional errors	4.58	0.515	5	3.52	1.159	7	4.48	0.688	3
Error in design calculation	4.25	0.452	10	3.20	1.443	10	4.07	0.799	9

Accordingly, the analyses of results of the respondents' response on ranking of the types of errors in the design of the projects were ranked by the mean weight response of the respondents and it is summarized in the following Table 4.3.

Table 4.3: Ranking Types of Error in Public Building Projects Based on Combined Response

Types of design errors in the construction of the sub-city public building projects	Weighted mean	Rank
Omission of necessary items/ incompleteness of design	4.53	1
Error in project contextual factors	4.34	2
Poor Coordination (between discipline)	4.18	3
Inaccuracy of details	4.17	4
Discipline coordination problems (within the same discipline)	4.14	5
CAD related problem	4.11	6
Dimensional errors	4.112	7
Incorrect or missing notes	4.03	8
Non-Conformance to design Code	3.82	9
Error in design calculation	3.77	10

✓ Omission of Necessary Items/ Incompleteness of Design

According to contractors, consultants and clients; omission of necessary items or incompleteness in design was the most frequent type of design error as it is ranked first among all types with an average mean equals to 4.53.

This finding is similar with the finding of (Dosumu and Adenuga, 2013) on the types of design error. From the findings of Dosumu and Adenuga, (2013), incompleteness of design and design details was the major type of design problem

in construction projects investigated through the study. Omission of necessary items occurs when necessary items or different aspects in the drawings or details are omitted. Therefore additional information, views or details are needed for the missing or incomplete designs. This type of design error is the main cause of deviation in the cost of public building projects of the sub-city. Rework, cost overrun, time overrun are possible outcomes of this type of error.

✓ Error in Project Contextual Factors

Error in project contextual factors has been ranked by contractor's respondents in the second position with mean weight equal to 4.34. It has been ranked by client, consultant and contractors respondents with a mean of 4.67, 3.92 and 4.55 respectively.

As standard procedure, there is always a feasibility study and a geotechnical survey and site visit before starting the design of the project, but it has been found that some errors occur in the designs of the projects by ignoring some important factors which are critical in the design of the project, such as soil characteristics, site contours, and the access to the site.

This type of error is mainly the result of missing or misleading information regarding the project site. It leads to delay of the startup of the project and increase the planned project cost while correcting the designs as per the site conditions and requirements. Therefore unknown site conditions that are not considered in design stage are one of the major types of error causing contract modifications in the public building projects.

✓ Poor Coordination (Between Disciplines)

Poor coordination between disciplines has been ranked in third place by the respondents with a weighted mean of 4.18 by the clients, consultants and contractors, as a type of error in the design documents of the sub-city public buildings. The design process is difficult enough to control when there are several disciplines to bring together, each of which can affect the performance of others. Poor design coordination may result from inadequate attention being given to detailed design, this in turn is causing the contractors claiming extension of time and/or extra cost for correction of the drawings.

✓ Inaccuracy of Details

Questionnaire data revealed that respondents agreed that inaccuracy of detail in design is another major type of error in design and it's ranked in fourth place with a weighted mean of 4.17.

The details are the sketched on drawings and the notes appear in text form on drawings; all these describe the intent clearly, describe the contents or set up the conditions for the applicability of design in the drawings. When details or notes are not correct, the intent of the drawings wrongly interpreted.

✓ Discipline Coordination Problems (Within the Same Discipline)

Fifth ranked type of error in design is discipline coordination problems interdisciplinary co- ordination problem with a weighted mean of 4.14, by clients, by consultants and contractors. This type of error occur within one discipline e.g.

the coordination problem between plans, elevations, sections and the detail drawings, between the calculations and the drawings. This type of error which is not discovered during the design preparation process is causing problems later in the construction stage and raise extra costs in the projects.

✓ CAD Related Problem

CAD related problem in designs has been ranked by the respondents in sixth place by the clients; with a weighted mean of 4.11 by the clients, consultants and contractors respectively, as a type of error in the design documents of the sub-city public buildings. This type of error in a design relates to the capability of Computer Aided Design (CAD) software used, and setup of the CAD standards and procedures. This can cause an effect in the duration of the project and raise claims from the contractor as more time and cost might be needed to resolve problems and update drawings.

✓ Dimensional Errors

Respondents asserted that dimensional error is one of the common types of errors in the designs of the projects in the seventh place with a mean of 4.112 by the client consultants and contractors of the projects. This type of error occurs in the designs have wrong dimensioning, missing dimensions, and unclear dimension. A lot of time is wasted for this type of error to be rectified as the contractor has to take clarifications from the architect or design engineers.

✓ Incorrect or Missing Notes

The notes are the text on the drawings which convey the intent clearly, describe the contents or set up the conditions for the applicability of the design in the drawings. The questionnaire results indicated that this error represents is the eighth type of error in the design of the projects. The occurrence of this type of design error raises requests for time extension and cost compensation.

✓ Non-Conformance to Design Code

This type of design errors is ranked as in ninth place by the respondents with a weighted mean of 3.82 by the clients, consultants and contractors respectively. Failure to conform to the code at the beginning of the project results in design change later and delayed the project.

Spearman's Coefficient of Correlation for Types of Design Errors

Spearman's coefficient of correlation (or rank correlation) was analyzed to test for agreements on the project related causes of design errors in the public building projects. A significance association between the sets of ranks from calculated Spearman's rank correlation coefficients (r_s) is calculated, in order to see whether there is agreement between two groups of respondents in ranking the types of design errors; the level of significance 95% ($p = 0.05$) is used. This allows proving whether there is "agreement" between respondents' response.

Table 4.4 Spearman's coefficient of correlation for types of design errors

Group of respondents	Spearman's coefficient (r_s)	Critical value(r_o)
Client vs. consultant	0.63	0.648
Clients vs. contractor	0.56	0.648
Consultant vs. contractor	0.69	0.648

As shown in the above Table 4.4 Spearman's correlation coefficient of 0.63 and 0.56 were obtained for client vs. consultants and clients vs. contractor respectively. These values are less than critical correlation coefficient. This reveals that there is difference in perception between client and consultants as well as between clients and contractors regarding ranking project related causes of design error.

On the other hand, Spearman's correlation coefficient of 0.69 was obtained for consultant and contractors which is greater than the critical value. This reveals that there is a significant agreement between clients and consultants regarding ranking types of design errors.

4.3.5 Causes of design errors in public building construction projects

To attain the objectives of this research, Causes of design errors on construction projects has been identified and grouped into three major groups. These factors were ranked in each group based on their mean score from the viewpoint of clients, contractors and consultants. The respondents were asked to rate the levels of agreement on each of the possible causes of design errors.

As discussed in the literature review, the causes of design errors on construction projects were grouped into three categories. These are client related factors, consultant related factors, and projects related factors .The mean score of each cause in each category are calculated to select the most significant causes of design errors on the public building projects in Ledeta sub-city. The following is a brief description of responses of the parties about the factors in each group.

4.3.5.1 Project related factors

Table 4.5 shows the results of survey analysis and rank of project related factors. Responses were ranked based on mean score between group of respondents of client, contractor and consultant.

Table 4.5: Descriptive statistics of project related causes of design error

Causes of Design Errors		Client			Consultant			Contractor		
		Mean	Standard deviation	rank	Mean	Standard deviation	rank	mean	Standard deviation	rank
Project related factors	Uniqueness of the project	3.58	1.03	1	3.86	0.50	4	4.00	0.886	4
	Time schedule pressure	3.58	0.90	2	4.33	0.476	3	4.17	0.848	3
	Project budgeted cost	2.50	1.24	4	4.48	0.714	2	4.28	0.882	1
	Complexity of the project	2.75	1.05	3	4.52	0.51	1	4.24	0.636	2

As indicated in the above Table 4.5 the clients has ranked, uniqueness, complexity and time schedule pressure as the top three projects related factors respectively. The response from the consultant’s side indicated time schedule pressure, project budgeted cost and time schedule pressure are the significant project related cause of design error in the public building projects. As of the contractors side project budgeted cost, complexity of the project and time schedule pressure were ranked as the top three significant project related factors causing the design errors.

The following Figure 4.6, 4.7 and 4.8 shows the percentage of clients, consultants and contractors response on projects related factors respectively.

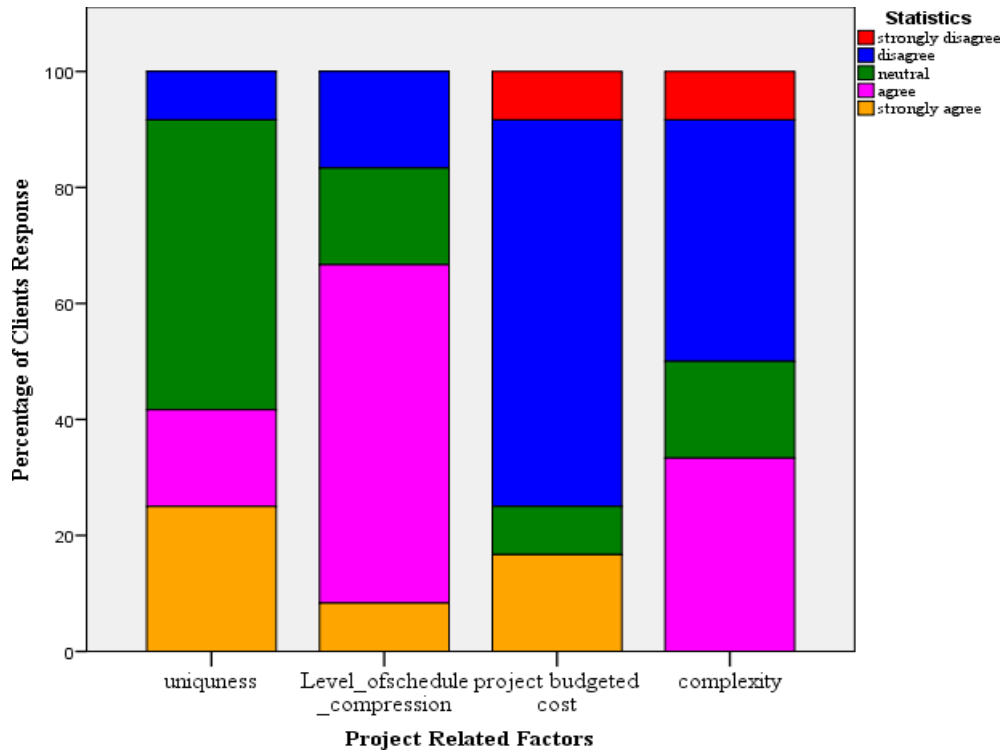


Figure 4.6: Client's response on project related factors

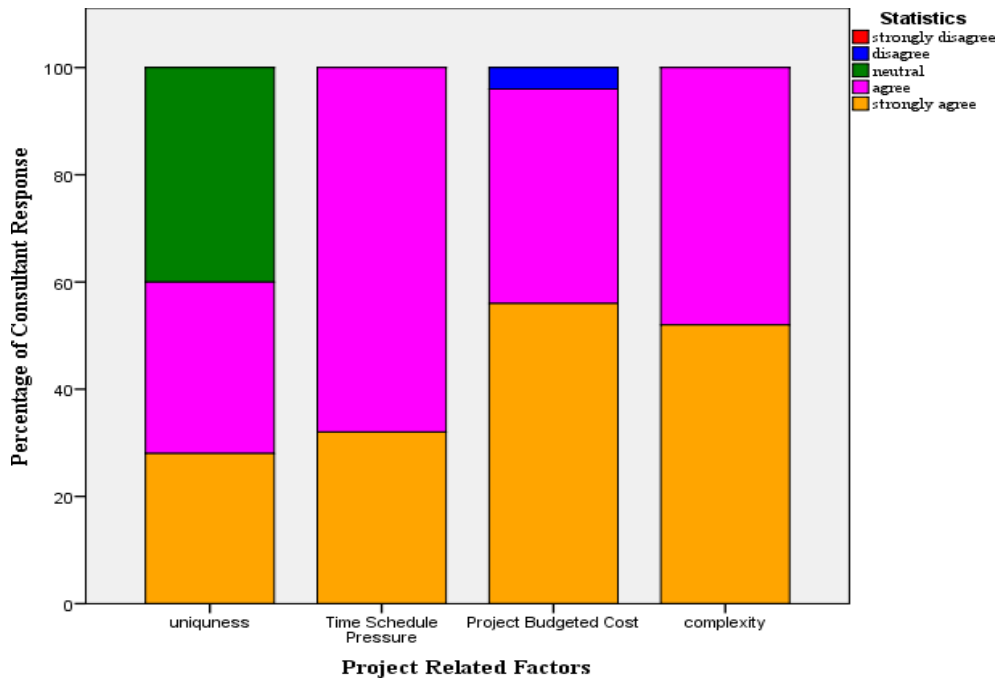


Figure 4.7: Consultant's response on project related factors

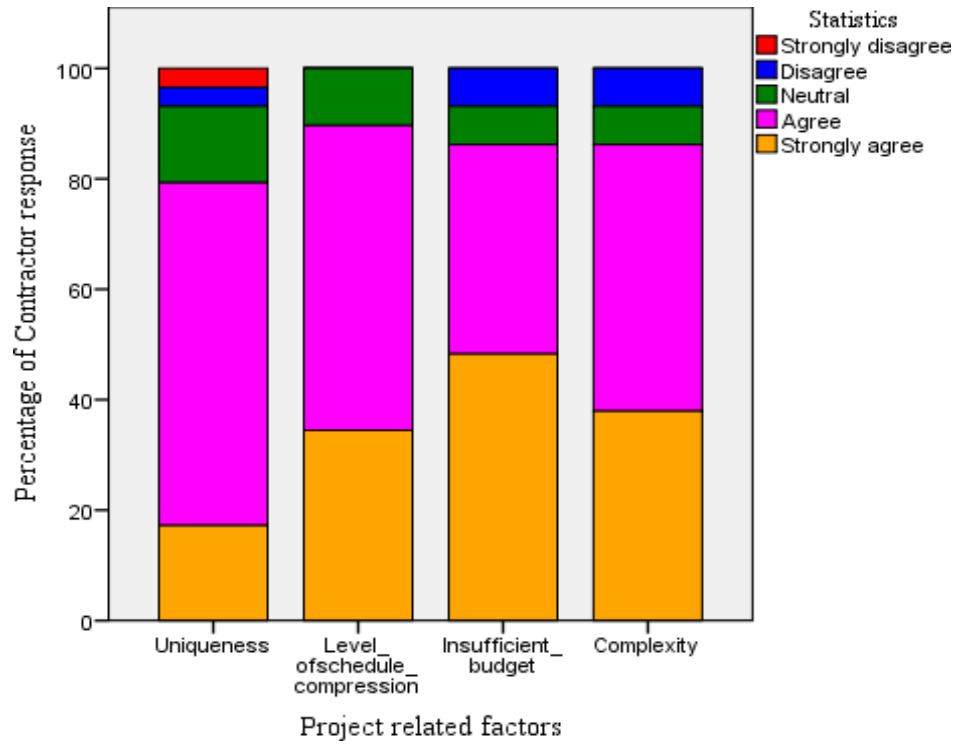


Figure 4.8 Contractor's response on project related factors

Spearman's coefficient of correlation for project related factors

Spearman's coefficient of correlation (or rank correlation) was analyzed to test for agreements on the project related causes of design errors in the public building projects.

Table 4.6 Spearman's coefficient of correlation for project related factors

Group of respondents	Spearman's coefficient (r_s)	Critical value(r_o)
Client vs. consultant	0.9	1
Clients vs contractor	1	1
Consultant vs contractor	0.9	1

Spearman's correlation coefficient of 0.9, were obtained for both client vs. consultant and consultant vs. contractors. These values are less than critical correlation coefficient. This reveals that there is difference in perception between client and consultants as well as between consultants and contractors regarding ranking project related causes of design error. On the other hand, Spearman's correlation coefficient of 1 was obtained for Client vs. contractor which is equal to the critical value. This reveals that there is a significant agreement between clients and contractors regarding ranking project related causes of design error.

4.3.5.2 Client related factors

The following Table 4.7 shows the results of survey analysis and rank of client related factors.

Table 4.7: Descriptive statistics of client related causes of design error

Classification causes of errors		Client			Consultant			Contractor		
		Mean	Standard deviation	rank	Mean	Standard deviation	rank	mean	Standard deviation	rank
Client	Poor briefing of project scope	2.92	1.084	1	4.72	0.458	1	4.48	0.688	2
	lack of experience of the client	1.92	.669	4	4.48	0.586	5	4.21	0.902	4

Construction time constraint imposed by the client	2.00	0.426	2	4.56	0.507	4	4.45	0.736	3
Minimum client point of contact with consultants	1.92	0.900	3	4.60	0.500	3	4.07	0.923	5
Inadequate financial provision	1.58	0.669	5	4.64	0.490	2	4.72	0.649	1

As shown in the above Table 4.7 poor briefing of the project scope ranked first by the consultant, client responses as a client related cause of design error, this indicates inadequate project brief from client has been discovered from the data collected as one of the causes of error in the design of the public building projects. Furthermore, the responses from the contractor side shows inadequate financial provision as the most significant factor behind the design errors occurred in the public building projects. The following table 4.6 shows the results of survey analysis and rank of client related factors.

The following Figures i.e. Fig 4.9, Fig 4.10 and Fig 4.11 show the percentage of clients, contractors and consultants response on client related factors.

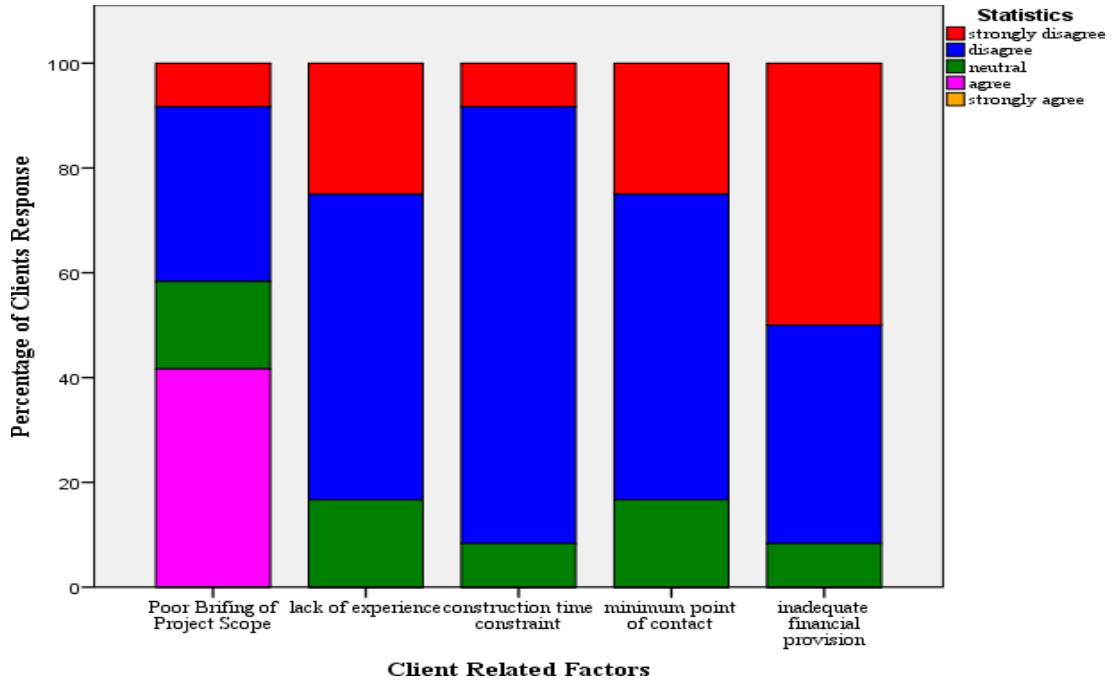


Figure 4.9: Client's response on client related factors

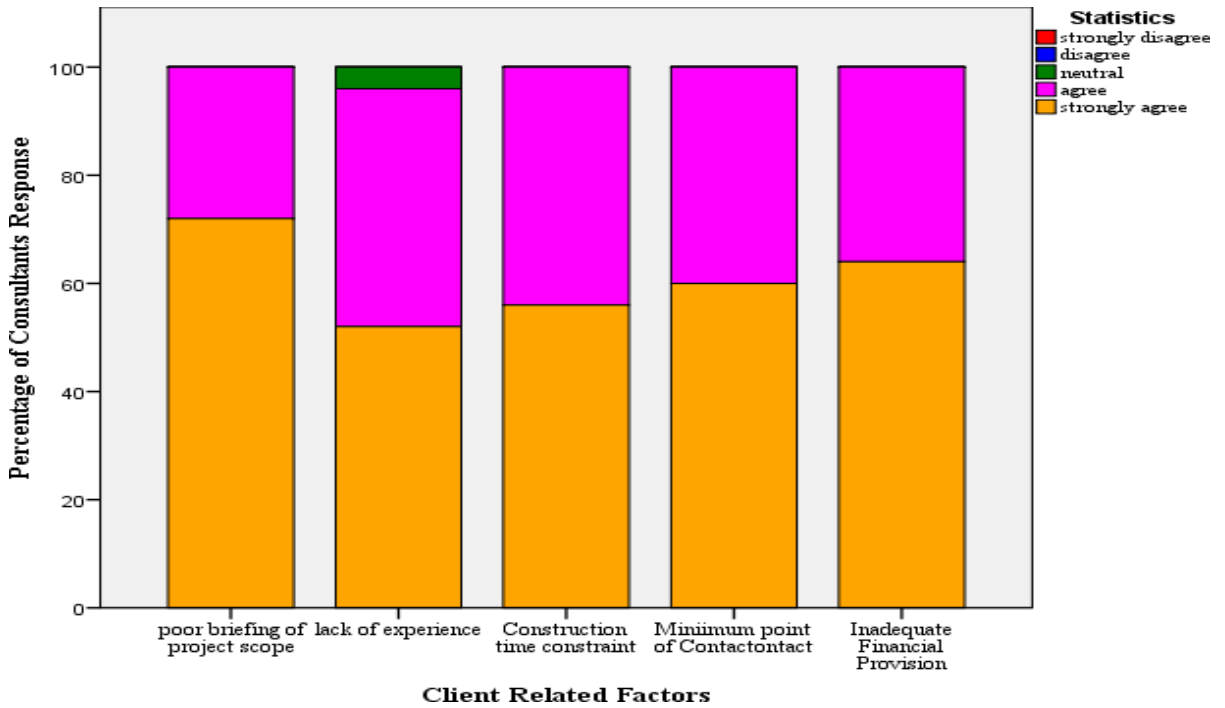


Figure 4.10: Consultant's response on client related factors

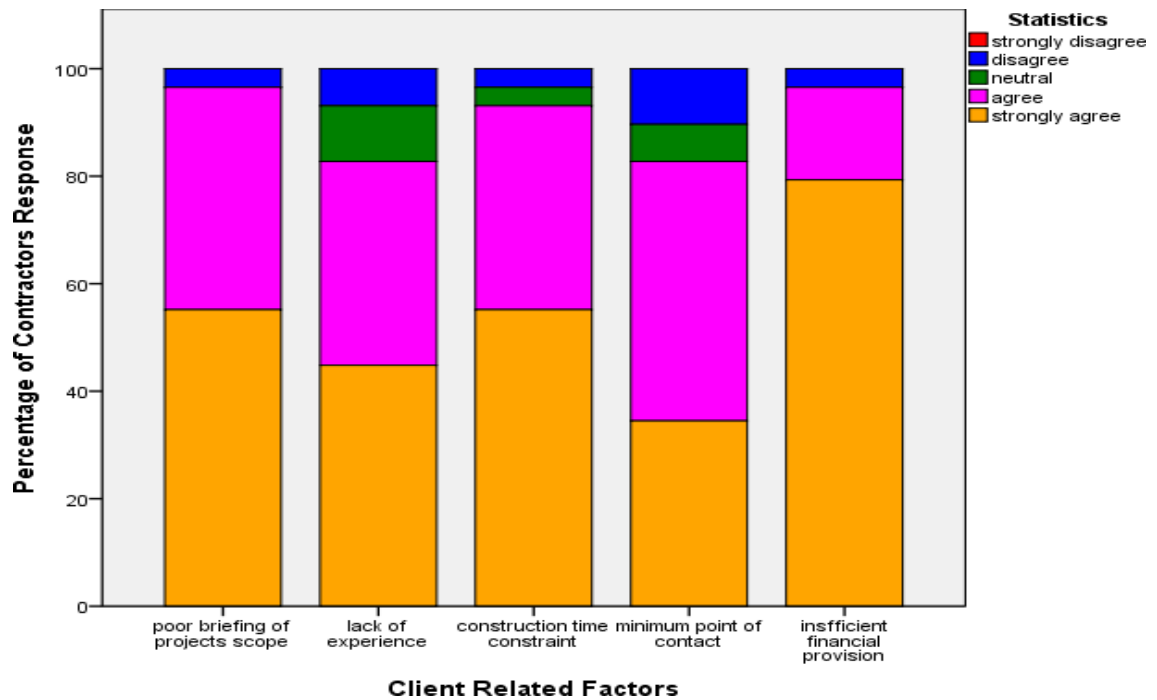


Figure 4.11: Contractor's response on client related factors

Spearman's coefficient of correlation for client related factors

Spearman's coefficient of correlation (or rank correlation) was analyzed to test for agreements on the client related causes of design errors in the public building projects.

Table 4.8 Spearman's Coefficient of Correlation for client related factors

Group of respondents	Spearman's coefficient (r_s)	Critical value(r_o)
Client vs. consultant	0.52	0.886
Clients vs. contractor	0.82	0.886
Consultant vs. contractor	0.91	0.886

Spearman's correlation coefficient of 0.52 and 0.82 were obtained for both client vs. consultants and clients vs. contractors. These values are less than critical correlation coefficient. This reveals that there is difference in perception between client and consultants as well as between clients and contractors regarding ranking project related causes of design error.

On the other hand, Spearman's correlation coefficient of 0.91 was obtained for consultants and contractor which is greater than the critical value. This reveals that there is a significant agreement between consultants and contractors regarding ranking client related causes of design error.

4.3.5.3 Consultant related factors

The following Table 4.9 the results of survey analysis, mean and rank of consultant related factors.

Table 4.9: Descriptive statistics for consultant related cause of design error

Causes of Design errors		Client			Consultant			Contractor		
		Mean	Standard deviation	Rank	mean	Standard deviation	Rank	mean	Standard deviation	Rank
Consultant / Designer related factors	Poor management Organizational structure	4.00	0.426	5	3.24	0.970	7	4.17	0.805	12
	Shortage of technical knowledge of designers	4.33	0.492	2	2.64	0.700	16	4.17	0.889	11
	Lack of designer experience	4.17	0.577	4	2.72	0.843	15	4.21	0.819	9
	Insufficient overall design time	3.75	1.215	6	3.52	1.005	4	4.17	0.889	10
	Lack of proper field investigation and inspection	4.42	0.515	1	3.00	0.764	10	4.72	0.528	1
	Inefficiency of design team	4.24	0.622	3	2.92	0.702	14	4.48	0.634	5
	Unavailability of quality management/ quality control	4.17	0.577	4	3.40	1.041	5	4.52	0.738	4
	Lack of effective consulting team	4.25	0.622	3	3.00	0.957	11	4.38	0.820	6
	Lack of information	3.00	1.279	10	3.92	0.909	1	4.10	1.02	13
	Lack of coordination and communication in design team	4.42	0.515	1	2.96	0.978	12	4.55	0.736	3
	Lack of transfer of knowledge between consultants	4.00	1.044	5	2.92	0.954	13	4.24	0.739	7
	High work load of the consultants	3.58	1.240	8	3.84	0.987	3	3.76	0.988	16

Concurrent design activities of designers	4.42	0.515	1	3.12	0.833	8	4.59	0.628	2
Poor consultancy fees	3.17	1.337	9	3.88	0.971	2	3.86	1.060	15
unsatisfactory reputation of consultants	3.67	0.651	7	3.24	0.779	6	4.07	0.998	14
number of designers	4.25	0.622	3	3.12	0.881	9	4.21	0.902	8

As indicated in the Table 4.9 above the clients has ranked, lack of coordination and communication in design team, shortage of technical knowledge of designers and lack of effective consulting team as the top three consultant related factors cause of design error respectively. The response from the consultant’s side indicated that lack of information; poor consultancy fees and high work load of the consultants are top significant consultant related cause of design error in the public building projects. Management/ quality control were ranked as the top three significant projects related factors causing the design errors.

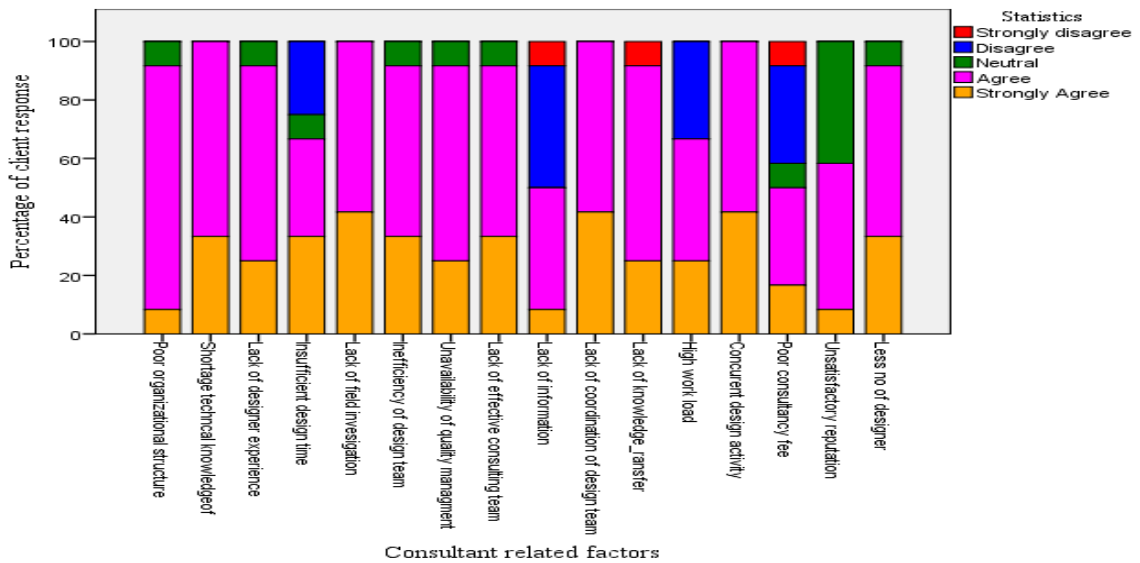


Figure 4.12: Client’s response on consultant related factors

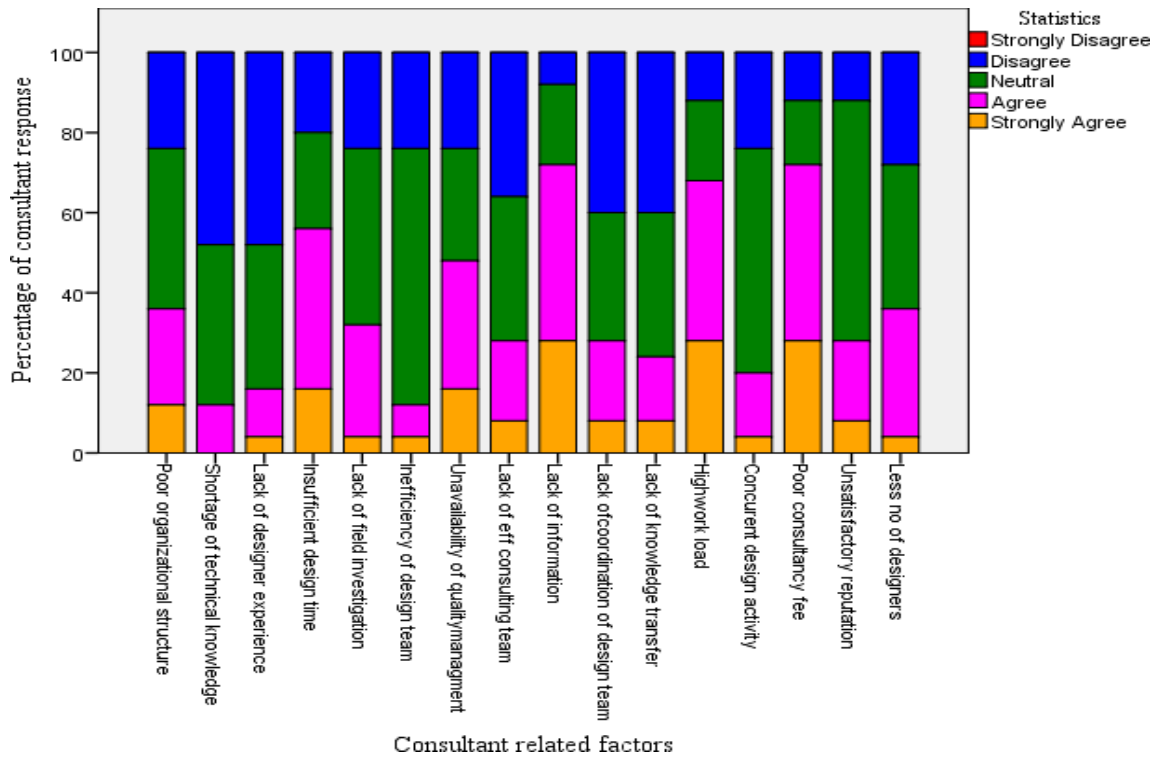


Figure 4.13: Consultant's response on consultant related factor

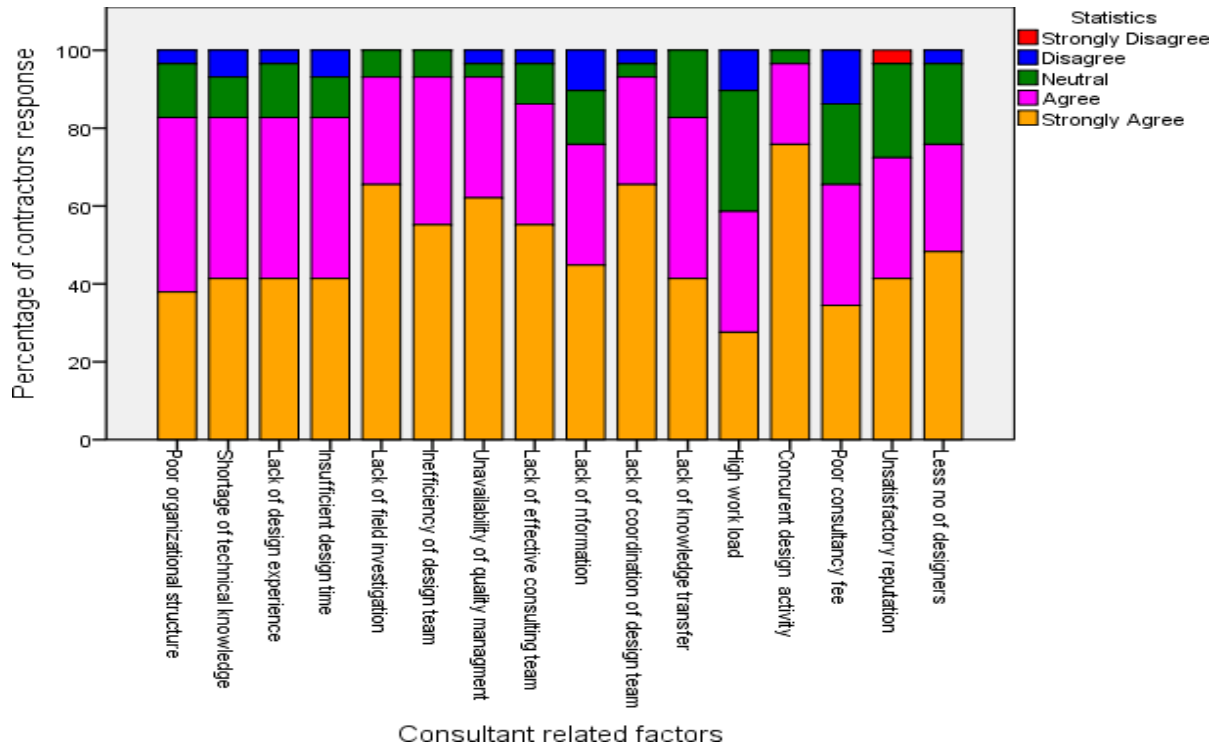


Figure 4.14: Contractor's response on consultant related factors

Table 4.10: Summary of causes of design error based on combined response

Causes of Design Errors	Client		Consultant		Contractor		Mean weight	Over all rank
	mean	rank	mean	rank	mean	rank		
Lack of proper field investigation and inspection	4.42	1	3	19	4.72	1	4.046	1
Concurrent design activities of designers	4.42	1	3.12	17	4.59	3	4.043	2
Poor briefing of project scope	2.92	19	4.72	1	4.48	6	4.04	3
Unavailability of quality management/ quality control	4.17	8	3.4	13	4.52	5	4.03	4
Time schedule pressure	3.58	14	4.33	8	4.17	16	4.02	5
Lack of coordination and communication in design team	4.42	1	2.96	21	4.55	4	3.97	6
Inefficiency of design team	4.24	7	2.92	22	4.48	6	3.88	7
Lack of effective consulting team	4.25	5	3	19	4.38	9	3.87	8
Less number of designers	4.25	5	3.12	17	4.21	13	3.86	9
Complexity of the project	2.75	20	4.52	4	4.24	11	3.83	10
Insufficient overall design time	3.75	12	3.52	14	4.17	16	3.81	11
Poor management Organizational structure	4	10	3.24	15	4.17	16	3.80	12
Uniqueness of the project	3.51	16	3.86	11	4	23	3.79	13
Project budgeted cost	2.5	21	4.48	6	4.28	10	3.75	14

High work load of the consultants	3.58	14	3.84	12	3.76	25	3.726	15
Lack of transfer of knowledge between consultants	4	10	2.92	22	4.24	11	3.72	16
Shortage of technical knowledge of designers	4.33	4	2.64	25	4.17	19	3.71	17
Lack of designer experience	4.17	8	2.72	24	4.21	13	3.7	18
Lack of information	3	18	3.92	9	4.1	20	3.673	19
Construction time constraint imposed by the client	2	22	4.56	5	4.45	8	3.67	20
unsatisfactory reputation of consultants	3.67	13	3.24	15	4.07	21	3.66	21
Inadequate financial provision	1.58	25	4.64	2	4.72	1	3.64	22
Poor consultancy fees	3.17	17	3.88	10	3.86	24	3.63	23
lack of experience of the client	1.92	23	4.48	6	4.21	13	3.536	24
Minimum client point of contact with consultants	1.92	23	4.6	3	4.07	21	3.53	25

In the above subsection, discussion was made on the causes of design errors from the perception of clients, consultants and contractors. In this section, discussion made for combined response for causes of design errors taking their average means score value.

Lack of proper field investigation and inspection:-is the first ranked cause of design error in the public building projects in Ledeta sub-city with a mean of 4.04. This finding is similar to the discoveries of (Dosumu and Adenuga, 2013), who found out that inadequate site investigation is the primary cause in their study of the impact of design errors and incomplete drawings on construction

projects. An adequate and properly structured site investigation is therefore an essential part of any civil engineering or building project. In contrast to this most of the projects under this study lack this analysis making the design incompatible with the site condition.

Concurrent design activity by the designers: - is the second ranked cause of design errors in the projects as responded by the parties with a mean of 4.043. This finding is similar with the findings of (Ebekozi, 2015). Although a concurrent design is done at with minimum costs in even less time required the amount of cost incurred in the construction stage is very due to non-compatible design in.

Poor briefing of project scope: - is the third cause of design error seen in the public building projects of the sub-city as responded by the respondents with a mean of 4.04. The finding that project brief is one of the causes of errors in design errors is similar with the discovery of (Ayodele.O, 2008) who found out that designers were not given project brief by clients.

Clients of the public building projects in Ledeta sub-city do not give their comprehensive project brief to the consultants. Therefore it is ranked as one of the most significant problems to affect the public projects is poor or inadequate scope definition by the clients. This induces a high amount of design change throughout the execution phase, causing scope growth, rework and ultimately an increase in the total cost and duration of project.

Unavailability of quality Management/ quality control: - is the fourth ranked cause with a mean of 4.03. The outcome of design and if the design is of poor quality, remain also affected no matter how good is the execution of project is. (Love et.al, 2000) find out one of significant factor contributing to design consultants producing poor quality documentation is their reluctance to embrace quality assurance.

Time schedule pressure /inadequate document preparation time: - with mean score value of 4.026. The respondent's ranked Time schedule *pressure* as the fifth cause of design error in the public building projects. Clients of the sub-city public building projects have been known to always be in a hurry to procure their projects. This has always shortened design preparation time and also made the consultants to hurriedly produce their documents.

Lack of coordination and communication in design team: - The analysis shows that lack of coordination and communication in design team is the sixth cause of design error having a mean of 3.97. Faulty in line of communication between participants in the design process is a significant cause of design error. The occurrence of this factor influences the sharing of knowledge, solving problems and the quality of work which finally influences the rate of error occurrence in the construction document.

Inefficiency of design team: - the seventh cause of design errors is inefficiency of design team with a mean of 3.88. The designers of the projects didn't seem to understand that an efficient team must have an increase in the communication.

Communication on the other hand increases the efficiency of the design team. An increase in communication increase knowledge among the team members and this lead to more solving of the errors correctly.

Lack of effective consulting team: - The analysis showed that Lack of effective consulting team was the eighth cause behind the design errors within the public building of the sub-city with a mean of 3.87. The existence an effective design team minimize the occurrence of errors in the pre-contract stages because these teams capitalize on and enhance their skills resulting the work to be modified and improved over time.

Number of designers: - with a mean of 3.86 less number of designers in the project is selected as a factor behind the design errors in the public building projects. This shows that availability of sufficient staff with enough time to pay attention to the project has a lot of influence on the number of design errors occurred.

Complexity of the project: - tenth ranked cause of design error is the complexity of the projects with a mean of 3.83. Project size influences the number of design errors. Because the risks are higher on larger projects, more care may be exercised in the design stage of the projects.

Spearman's coefficient of correlation for consultant related factors

Spearman's coefficient of correlation (or rank correlation) was analyzed to test for agreements on the consultant related causes of design errors in the public building projects.

Table 4.11 Spearman’s coefficient of correlation for consultant related factors

Group of respondents	Spearman’s coefficient (r_s)	Critical value(r_o)
Client vs. consultant	0.49	0.506
Clients vs. contractor	0.62	0.506
Consultant vs. contractor	0.48	0.506

Spearman’s correlation coefficient of 0.49 and 0.48, were obtained for both client vs. consultants and consultant vs. contractors respectively. These values are less than critical correlation coefficient. This reveals that there is difference in perception between client and consultants as well as between consultant and contractor regarding ranking project related causes of design error. On the other hand, Spearman’s correlation coefficient of 0.62 was obtained for Client vs contractor which is greater than the critical value. This reveals that there is a significant agreement between clients and contractors regarding ranking consultant related causes of design error.

4.3.6 Effect of design error on the cost of public building projects in ledeta sub-city

The objective of the research is to determine the cost wise effect of the design errors on the public building projects in the sub-city. Below are the answers as inferred from the data collected and are analyzed in terms of percentage.

4.3.6.1. Types of the projects

From the investigated 30 projects 33.33% of them were Educational projects, 26.67 % of them were Sport, 16.67% of them were Health, and 23.33% of them were them were other types of buildings. The following Figure 4.15 shows the types of the types of the projects analyzed.

Types of project

■ Educational ■ Sport ■ Health ■ Other

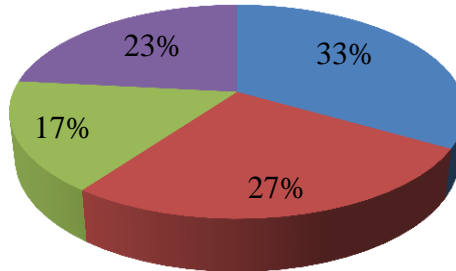


Figure 4.15: Type of the projects

4.3.6.2. Initial budgets of the projects

From the investigated projects, 3.33% of the project have initial budget of below 1 million, 36.67% of the projects were of 1-2 million projects i, and 33.33% were of 2-4 million, 13.33% of them were of 4-6 million, 6.67% were 6-10 million and the rest 6.67% of the projects were above 10 million projects initially.

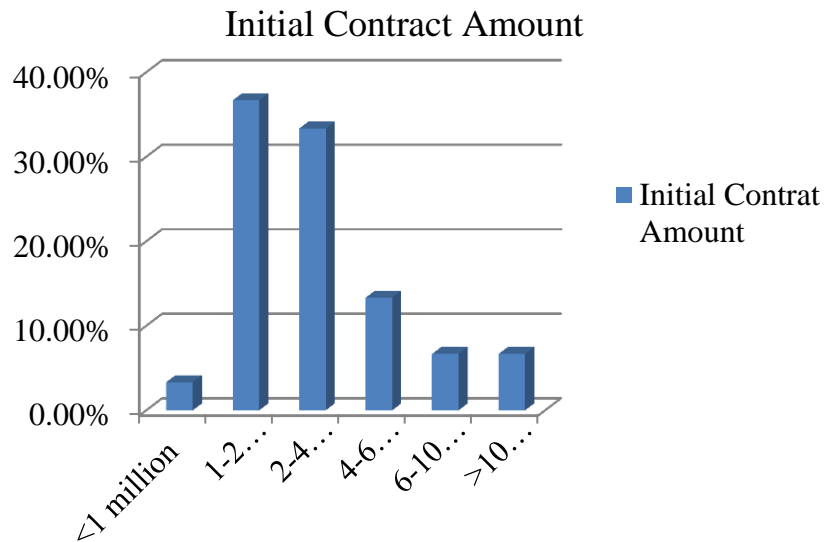


Figure 4.16: Initial contract amount of the projects

4.3.6.3. Percentage of the effect of design error on the cost of the public building projects

Table 4.12: Percentage of the effect of design error on the cost of the projects

No	Project name	Contract amount of projects	Approved Variation	Variation due to design error	Percentage of the cost deviation as a result of design error	current contract price
1	Karamara school toilet work	1,127,939.56	338,125.85	124,963.4	29.9	1,466,064.85
2	Ferhiwot kg tilet work	1,330,006.3	231,456.12	200,134.8	17.4	1,561,462.42
3	Selam kg tilet work	1,288,513.53	336,987.21	128,012	26.2	1,625,500.74
4	Selam kg Dining room work	2,155,024.22	256,896	256,896	11.9	2,411,902.22
5	M/G/Haylom school Dining room work	1,518,075.91	129,284.06	32,484.63	8.5	1,647,359.97
6	Alemaya school Dining room work	1,690,173.32	50,489.23	50,489.23	2.98	1,740,662.55
7	Africa Berhan school Dining room work	2,105,103.37	484,203.12	152,369.24	23	2,589,306.49
8	Edget Besera school fence work	6,722,433.75	983,442.63	487,259.56	14.63	7,705,876.38
9	Ledeta TVET	4,168,415.39	1,249,569.74	654,245.62	29.9	5,417,985.43
10	Meskerm 1 school 2 in 1 sport filed	1,949,389.38	581,023.96	159,357.32	29.8	2,530,413.34

11	Tesfakokeb school 3 in 1 sport filed	5,366,474.07			0	5,366,474.07
12	Alemu football sport filed	2,551,632.93			0	2,551,632.93
13	Kebele 37 school 2 in 1 sport filed	3,388,775.67			0	3,388,775.67
14	Edget Besera school 3 in 1 sport filed	3,964,024.77	622,637.59	453,362.27	15.7	4,586,662.36
15	Karamara school 3 in 1 sport filed work	2,865,480.93	450,390.23	124,256.89	15.8	3,315,871.16
16	Daget meda football filed & fence work	6,886,611.34	1,733,555.72	951,156.87	25.2	8,620,167.06
17	Africa hibret school 2 in 1 sport filed	2,418,662.2	352,490.52	235,657.16	14.5	2,771,152.72
18	Wereda 3 library maintenance	1,588,259.7	128,456.35	128,456.35	8.08	1,716,716.05
19	Wereda 7 library maintenance	2,222,219.7	235,596.59	235,596.59	10.6	2,457,816.29
20	Wereda 8 youth center maintenance	1,892,195.97	388,590.99	149,367.25	20.5	2,280,786.96
21	Wereda 1 youth center maintenance	1,209,296.3	323,178.40	256,145.49	26.72	1,532,474.70
22	Wereda 5 youth center maintenance	1,266,479.53	280,316.50	79,733.30	22.12	1,546,796.03
23	Abent Health center maintenance work	3,453,907.27	340,652.23	340,652.23	9.86	3,794,559.50

24	w/ro Beletshachew center APTS renovation work	1,082,223.42	134,810.68	100,259.35	12.45	1,217,034.10
25	Tekelehaymanot Health center maintenance work	2,471,472.25	431,879.45	331,879.45	17.4	2,903,351.70
26	Dagim Hedase Health center maintenance work	4,192,311.43	1,188,622.93	756,894.17	28.35	5,380,934.36
27	Wereda 7 administration office fence work	648,452.5	79,452.13	79,452.13	12.25	727,904.63
28	Gandi memorial hospital cafeteria sanitary and electrical work	4,102,634.08	929,938.02	408,043.46	22.6	5,023,572.10
29	Mezegebe Berhan school G+4 structural and finishing	25,973,643.25	7,625,816	6,525,126	29.35	33,599,459.2
30	L/K/Abedisa aga Kg G+3 structural and finishing	17,228,635.60			0	17,228,635.60
Average Cost Deviation					16.20%	

Based on archival document review of contract documents and projects records of the 30 sample projects, average cost deviation 16.20% has been found in the study.

4.4 Case study

This portion of the study depicts some public building projects in Ledeta sub-city, with the intention to show the level of design error problems by comparing the originally agreed costs each of these projects with the respective actual figures achieved at current level of the projects.

Two case study projects were selected for validating the results of this research. The projects are easily accessible to collect the data and to get in depth information about design errors. The researcher reviewed the main project records and documentation to be examined for analysis of design errors based on the interviews with practitioners involved in the projects.

4.4.1 Building Project One

The building is a G+ 4 Mezegebe Berhane school class rooms located in wereda 2, Ledeta. The total contract price of this project was Twenty Five million nine hundred seventy three thousand six hundred forty three birr and twenty five cents (25,973,643.25). Currently the project cost has increased a total 30% from the initial contract amount which is Seven million six hundred twenty five thousand and eight hundred sixty (7,625,816.0) .The project is not completed and its physical progress is 71% currently. The total schedule given in contract was 270 calendar days.

Types of design errors in the project

- ✓ Omission /Incomplete design:-The Architectural part of the design was not completed but still it was approved by the consultants and procured. The contractor asked a change or variation order at the construction stage .The cost increases attributable this error is 14 of the total cost deviation which is 30%.

- ✓ Error in project contextual factors:-The design is initially designed for a normal ordinary soil, but the actual soil type in the site is a rocky soil. This showed that lack of feasibility study and a geotechnical survey and site visit before starting the design of the project. The design was then revised. The cost increases attributable this design error is 16% of the total cost deviation which is 30%.

Cause of the design errors of the project

1. Insufficient project brief by the client:-scope or requirement change by the client was one of the major causes of the design error, and the designer is forced to add an additional two halls which were not included in the project brief of the client initially. The client of the project did not give their comprehensive project brief to the consultants at an early stage before the execution phase of the project.

2. Lack of field investigation and inspection: - Error in project contextual factors has been occurred due to the lack of proper field investigation in the design period of the projects. The consultant did not have a reasonably accurate conception of the physical properties, arrangement of underlying materials and the soil types before designing the project. Initially the project was designed for a normal ordinary soil,

but the actual soil type in the site was a rocky soil. The design was changed and this induces a great variation in the project cost.

3. Insufficient design time/ Time schedule pressure

One of the main causes of incomplete design in the project is that the designer is not given enough time to thoroughly design the building. The design time of the project was only two month as ordered by the client. The clients had decided they would like to undertake it as soon as possible. These forces the designers quickly to meet the building completion date. Less time was spent in paying attention to the smaller details; instead they focused on the overall design to get it complete on time. This has resulted a double increment of the projects cost.

4.4.2 Sport filed Project Two

The project is a 2 in 1 sport filed located in Weredea 1,Ledeta .The total contract price of this project was one million nine hundred forty nine thousand three hundred eighty nine birr and thirty eight (1,949,389.38) .The total time agreed in the contract is 120 calendar days, the project is finished. Currently the cost the project increased 33% form the initial contract amount which is five hundred eighty one thousand twenty three birr and ninety six (581,023.96 birr).

Types of the design errors in the project

- ✓ Omission /Incomplete design:-part of the sport filed was omitted in the design stage. The filed design was prepared and a variation of 20% occurred due to this error.

Cause of the design errors of the project

1. Insufficient project brief by the client:-A clear statement of need by the client is not given before the design stage. The clients need originally was to construct a 3 in 1 sport filed, but the client have made a requirement change and demanded in making it a 2 in 1 sport filed .So the an additional scope change makes the consultants to add additional designs which induces a 13% increase in the cost of the project.
2. Insufficient design time/ Time schedule pressure:-The overall design time of the project was limited to one month. Clients of the project were in a hurry to procure the projects. This has shortened the design time and also made the consultants to hurriedly produce their designs.

Table 4.13 Profile of case study projects

Characteristics		Case study 1	Case study 2
Project type		G+4 School class rooms	2 in 1 sport filed
Main contract price		44,959,138.34 birr	1,949,389.38 birr
Current contract amount		91,893,126.0 birr	2,530,413.34 birr
Project duration	Detailed Design time	1 month	1 month
	Initial contract period (cal. days)	270	120
	Actual time	360 days.	150 days
Percentage of cost deviation		30%	33%
Physical progress of the projects		71%	100%

The following figure 4.17 shows the current physical progress of the projects and the cost overrun of the projects

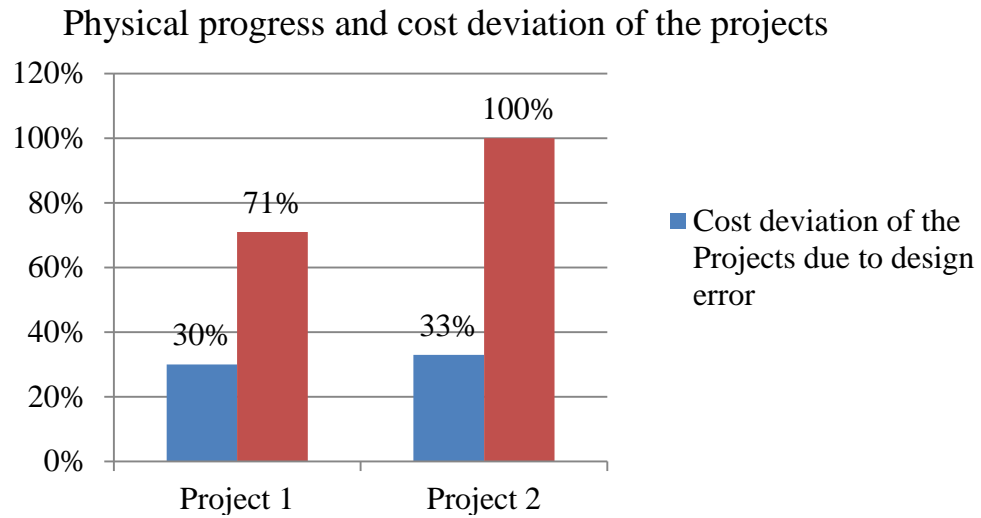


Figure 4.17: Current physical progress and the cost deviation of projects

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The research aims to study on design error and its effect on the cost of public building projects in Ledeta sub-city with the objectives, to identify the type, cause and the cost wise effect of design errors on the performance of public building projects in Ledeta sub-city.

The study used a mixed research approach, both quantitative and qualitative data with questionnaire and case study method. Both descriptive and statistical tools were used to analyze collected data. Spearman's rank correlation coefficient was used to examine the agreement in the ranking of the causes and effects of management failure between the respondents.

The first objective of this study was to determine the type of design errors in public building construction projects in Ledeta sub-city. From the data analysis, the types of errors that occur in the design of the public buildings of the sub-city are omission of necessary items/ incompleteness of design, error in project contextual factors, Poor Coordination (between disciplines), inaccuracy of details, discipline coordination problems (within the same discipline), CAD related problem, dimensional errors, incorrect or missing notes, constructability problem, and non-Conformance to design Code. The statistical testing, Spearman's correlation coefficient, of the degree of agreement among the three respondents i.e. clients contractors and consultant participated in the survey, indicated that there is a good agreement on the rank of types of errors in the design of public building construction projects.

The second objective of the research was to determine the causes of design errors and their associated cost wise impact in public building construction projects in Ledeta sub-city. The top ten causes by the study were, lack of proper field investigation and inspection, concurrent design activities of designers ,poor briefing of project scope, unavailability of quality management/ quality control, time schedule pressure, lack of coordination and communication in design team, inefficiency of design team, lack of effective consulting team, less number of designers, complexity of the project. The statistical testing, Spearman's correlation coefficient, of the degree of agreement among the three respondents i.e. clients contractors and consultant participated in the survey, indicated that there is a good agreement on the rank on the causes of errors in the design of public building construction projects.

The cost wise effect of the design errors on the performance of public building construction projects in Ledeta sub-city. Results from this study reveals that cost due to design errors in the public building projects is 16.20% of contract sum, that is, if there is no design error in the design documents of the projects there must be a saving of 16.20% of the construction cost of the projects.

5.2 Recommendations

Based on the research findings finally, the study provides different measures that should be taken so as to eliminate design errors in public building projects of Ledeta sub-city.

These measures are;

- ❖ Ensure proper feasibility study before design and undertaking detailed underground investigation of projects,
- ❖ Provision of clear brief by the client, discouraging activity of concurrent design of consultants,
- ❖ Provision of proper or sufficient design time, ensure sufficient budget for the project, involvement of experienced technical personnel,
- ❖ Good communication among project participants,
- ❖ Effective project management and design reviews.

In addition there should be greater accuracy and investment by the clients on preparation and analysis in the preliminary phases of projects with a view to make available as soon as possible more and better information to designers. Many of the design errors occurred in the projects can be prevented through adherence to proper quality assurance system through design review/ check system by the responsible bodies.

Finally, undertaking of further research recommended is further investigation on design errors in construction projects, since this study focuses only on public building construction projects in the sub-city.

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APPENDICES

Appendix 1: Structured Questionnaire

Dear Sir/Madam,

I am MSC student in Addis University College, currently carrying out a research work titled “A study on design errors and its effect on the cost of public building projects in Ledeta sub-city”. The objectives of the research are to determine the types, causes the cost wise effect of design errors on the performance of public building construction projects in Ledeta sub-city, and also it will help in developing a way of minimizing the occurrence of such errors on the design of projects. Literatures have shown that huge amount of money, time and quality have been lost because of design errors in our construction industry. This study will help in eradicating such losses. Expected respondents/participants includes: clients, consultants and Contractors.

My request is that you kindly help me complete the questionnaire as it relates to your professional work experience. The information you supply will be collated and analyzed along with other respondents/participants, and will constitute your valuable; immeasurable and positive contributions to the Construction Industry.

I sincerely appreciate your valuable time and other contributions to promote this research.

Thank you!

Yours faithfully, Nahom Nigussie

Email:

[nigussienahom2@gmail.c](mailto:nigussienahom2@gmail.com)

om Phone no.:

+251910885804

PART A: General Information of Respondent / Firm / Company /

1. Name and Telephone No (optional):

.....

2. How old is your professional practice in your firm/company (Please circle as appropriate). (A) 1-5 yrs. (b) 6-10yrs (c) 11-15yrs (D) 16-20yrs
(e) Above 20yrs

3. What is your academic background (please circle as appropriate).

(A) MSc (b) Degree (c) Diploma (d) Primary & Secondary (e) No Education

4. Your Profession/Firm (Please circle as appropriate)

- a) Architecture
- b) Civil Engineering
- c) Electrical Engineering
- d) Mechanical Engineering

5. Types of project handled

- a) Health
- b) Sport filed
- c) Educational
- d) others –

PART B: Information on Types of Design Errors in Ledeta sub-city

The following (items 1 -10) are the types of design errors that are usually occurring in the design of public building projects in Ledeta sub-city. Please assess the importance of each of them based on your experience on construction projects; using 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree, 5 for strongly agree. Please tick where appropriate.

No.	Types of design errors in the construction of the regions public building projects	1	2	3	4	5
1	Omission of necessary items/ incompleteness of design					
2	Poor Coordination (between discipline)					
3	Discipline coordination problems (within the same discipline)					
4	Inaccuracy of details					
5	CAD related problem					
6	Non-Conformance to design Code					
7	Incorrect or missing notes					
8	Error in project contextual factors					
9	Dimensional errors					
10	Error in design calculation					

PART C: Information on the Causes of Design Errors in Ledeta sub-city

The following are the causes of design errors that occur in the design of the public building projects in Ledeta sub-city. Please assess the importance of each factor, based on your experience on construction projects using 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree, 5 for strongly agree. Please tick where appropriate:

Classification	Causes of Design Errors	1	2	3	4	5
Project related factors	1. Uniqueness of the project					
	2. Time schedule pressure					
	3. Project budgeted cost					
	4. Complexity of the project					
Client related factors	5. Poor briefing of project scope					
	6. lack of experience of the client					
	7. Construction time constraint imposed by the client					
	8. Minimum client point of contact with consultants					
	9. Inadequate financial provision					
Organizational structure	10. Poor management					
	11. Shortage of technical knowledge of designers					
	12. Lack of designer experience					
	13. Insufficient overall design time					

Consultant /Designer related	14. Lack of proper field investigation and inspection					
	15. Inefficiency of design team					
	16. Unavailability of quality management/ quality control					
	17. Lack of effective consulting team					
	18. Lack of information					
	19. Lack of coordination and communication in design team					
	20. Lack of transfer of knowledge between consultants					
	21. High work load of the consultants					
	22. Concurrent design activities of designers					
	23. Poor consultancy fees					
	24. unsatisfactory reputation of consultants					
	25. Less number of designers					

Appendix 2: Interview Questions for Case Study Projects

1. Name and Telephone No (Optional):

2. What was the project initial contract amount?

3. Does the client impose any time pressure on the consultant / design team?

4. What is the level of quality of the project brief?

5. Was the Design time sufficient?

6. How do you describe the level of coordination between design team members

7. Do you have all the information needed for the project?

8. What was the composition of the design team/ number of designers?

9. What type of design errors actually happened in the project?

10. What was the amount of cost incurred because of the design error?

Appendix 3: Data of Selected sample Projects

No	Project name	Contract amount of projects	Contract period	Date of agreement	Physical progress
1	Karamara school toilet work	1,127,939.56	30	1/10/2012	100%
2	Ferhiwot kg tilet work	1,330,006.3	30	1/10/2012	100%
3	Selam kg tilet work	1,288,513.53	30	1/10/2012	100%
4	Selam kg Dining room work	2,155,024.22	45	29/01/13	100%
5	M/G/Haylom school Dining room work	1,518,075.91	45	29/01/13	96%
6	Alemaya school Dining room work	1,690,173.32	45	29/01/13	96%
7	Africa Berhan school Dining room work	2,105,103.37	45	2/2/2013	100%
8	Edget Besera school fence work	6,722,433.75	120	7/11/2012	100%
9	Ledeta TVET	4,168,415.39	150	18/10/2012	95%
10	Meskerm 1 school 2 in 1 sport filed	1,949,389.38	120	6/11/2012	100%
11	Tesfakokeb school 3 in 1 sport filed	5,366,474.07	120	6/11/2012	100%
12	Alemu football sport filed	2,551,632.93	120	6/11/2012	100%
13	Kebele 37 school 2 in 1 sport filed	3,388,775.67	120	6/11/2012	70%
14	Edget Besera school 3 in 1 sport filed	3,964,024.77	120	29/10/12	80%
15	Karamara school 3 in 1 sport filed work	2,865,480.93	120	27/4/12	90%
16	Daget meda football filed & fence work	6,886,611.34	150	7/11/2012	100%
17	Africa hibret school 2 in 1 sport filed	2,418,662.2	120	24/4/12	100%
18	Wereda 3 library maintenance	1,588,259.7	90	6/11/2012	95%
19	Wereda 7 library maintenance	2,222,219.7	90	25/12/12	100%

20	Wereda 8 youth center maintenance	1892195.97	90	6/11/2012	100%
21	Wereda 1 youth center maintenance	1,209,296.3	90	6/11/2012	100%
22	Wereda 5 youth center maintenance	1,266,479.53	90	25/02/13	65%
23	Abent Health center maintenance work	3,453,907.27	120	18/10/12	100%
24	w/ro Beletshachew center APTS renovation work	1,082,223.42	120	14/11/12	100%
25	Tekelehaymanot Health center maintenance work	2,471,472.25	90	30/10/2012	100%
26	Dagim Hedase Health center maintenance work	4,192,311.43	90	30/10/2012	93%
27	Wereda 7 administration office fence work	648,452.5	60	3/2/2013	100%
28	Gandi memorial hospital cafeteria sanitary and electrical work	4,102,634.08	150	14/12/12	100%
29	Mezegebe Berhan school G+4 structural and finishing	25,973,643.25	270	5/5/2013	71%
30	L/K/Abedisa aga Kg G+3 structural and finishing	17,228,635.60	240	29/08/2013	20%

Table for sample selection from the Population of projects

Appendix 4: Critical Values of Spearman's Rank Correlation Coefficients
For Different Number of Data Set:

Number of Subjects (data set)	Level of significance for one-tailed test			
	0.05	0.025	0.01	0.005
	Level of significance for two-tailed test			
	0.1	0.05	0.02	0.01
5	0.9	1	1	-
6	0.829	0.886	0.943	1
7	0.714	0.786	0.893	0.929
8	0.643	0.738	0.833	0.881
9	0.6	0.683	0.783	0.833
10	0.564	0.648	0.746	0.794
12	0.506	0.591	0.712	0.777
14	0.456	0.544	0.645	0.715
16	0.425	0.506	0.601	0.665
18	0.399	0.475	0.564	0.625
20	0.377	0.45	0.534	0.591
22	0.359	0.428	0.508	0.562
24	0.343	0.409	0.485	0.537
26	0.329	0.392	0.465	0.515
28	0.317	0.377	0.448	0.496
30	0.306	0.364	0.432	0.478

Note: When there is no exact number of subjects, use the next lowest number Source: (Naoum, 2001)