ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES

ASSESSING THE IMPACT OF VARIATION ORDERS ON PUBLIC BUILDING PROJECTS IN ADDIS ABABA

BY

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A Thesis Submitted to the School of Graduate Studies of Addis Ababa University, Addis Ababa Institute of Technology in partial fulfillment of the requirements for the Degree of Master of Science in Civil Engineering (Construction Technology and Management)

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DECLARATION

"I declare that this research report entitled ***"Assessing the Impact of Variation Orders on Public Building Projects in Addis Ababa"*** is the result of my own work, it contains no materials previously published or written by another person except where due reference is made. This report has not been previously submitted for any degree at other higher education institutions."

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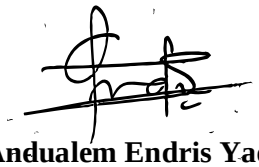

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DEDICATION

I dedicate this work for my teachers who nurtured me in my school life.

ACKNOWLEDGEMENTS

First of all may thankful honor return to God who sustained me during my research project! I accomplished everything through Him who strengthens me.

I would like to convey my truthful gratitude to my Advisor Associate Professor Wubishet Jekale Mengesha (Dr.-Ing) for his invaluable guidance and motivation throughout this research. I am truly lucky to have him as my advisor and I thank him for inspiring me on my research I had never dreamt of which afterwards became part of my life.

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LIST OF ABBREVIATIONS

AAHDCB	Addis Ababa Housing Development and Construction Bureau
BoQ	Bill of Quantities
CII	Construction Industry Institute
DB	Design-Build
DBB	Design-Bid-Build
FIDIC	Federation Internationale des Ingenieurs-Conseils: a French acronym interpreted in English as International Federation of Consulting Engineers
IPD	Integrated Project Delivery
JBCC	The Joint Building Contracts Committee
MUDC	Ministry of Urban Development and Construction
PPA	Public Procurement Agency
UNDP	United Nations Development Program

ABSTRACT

Variation is inevitable in construction projects due to the complex nature of the construction industry. It is common in all types of construction projects and it determines the time limits and anticipated budget of the projects. Variation order is observed as one of the most frequently occurring issues in construction projects in Ethiopia. Like other regions of the country, construction projects in Addis Ababa are suffering from variation orders. These variations are known to impact various aspects of the projects. This study assessed the impact of variation orders on public building projects in Addis Ababa to reduce them. The objectives of the study were firstly to determine the causes of variation orders; secondly to identify the impacts of variation orders; and lastly to recommend strategies to minimize variation orders. Through a comprehensive study of literature review, resulted in identification of 38 common causes of variation orders, 15 impacts of variation orders and 15 recommended strategies to minimize variation orders and these variables were mapped in frequency table. A desk study, interview and questionnaire survey were carried out to identify the causes of variation orders, their impacts on public building projects and to seek recommendations to reduce them. The desk study conducted on five selected projects and the causes of variation orders and their impacts on the projects were identified. Interviews were made with selected experienced public building project participants for expert opinion. The questionnaire responses were analyzed using the relative index method. A triangulation method on the desk study, survey and the literatures was done to improve the validity of the findings from the study. The results indicated that design changes, incomplete contract documents, and impediment in prompt decision making process were the most causes of variation orders. The results also showed that completion schedule delay, increase in project cost, and additional payments for contractor were the most impact of variation orders. The findings also suggested the most recommended strategies to minimize variation orders. These strategies were to produce a concluding design and contract document, to complete drawings at tender stage, and to supervise the works with experienced and dedicated supervisor to minimize variation orders on public building projects. The study concluded based on the findings of the research and recommendations for further studies were forwarded to minimize variation orders.

Key words: Variation order, cause, impact, public projects, Addis Ababa.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The construction industry in Ethiopia has been on fast growing mode which plays an instrumental role in the country development. Addis Ababa in the last ten years experienced a huge volume of work in the field of constructions. This resulted in a very rapid growth and transformation during this period. The city has generated many facilities and government buildings opportunities. The growth of the city is being accelerated due to the construction of private and government owned buildings. Large and complex government buildings have been built, attracting domestic contractors and construction companies from all over the world. This situation coupled with inexperienced consultants and the client has led to inadequate design resulting in many changes to plans, specifications, and contract terms which resulted in variation orders.

With the announcement of the government five years Growth and Transformation Plan (GTP) in 2010, the construction industry is said to be the most beneficial sector as there lots of projects being rolled out by the government and to be carried out in the five years plan. The implementation of government projects are expected to provide further thrust to the construction sector in the country. Therefore, it is important to ensure these projects are being implemented successfully without any major problems while minimizing the adverse impacts of variation orders on the project outcome.

As the number of variation orders on a project increases, so does the possibility of misunderstanding among the contracting parties. Such a misunderstanding may occur because one or more of the parties lacks full knowledge of the variation order process itself, the costs involved in implementing changes, or the delays, conflicts, and interruption of the construction sequence and schedule which can adversely impact project coordination.

Previous studies on variation orders are mainly focused on the sources and causes of variation orders. The sources of variations include the performance of construction parties, resources availability, environmental conditions, involvement of other parties, and contractual relation. Many times delays, cost overrun and quality defects of a construction can be attributed to variation at various stages of the project (Burati *et al.*, 1992). Variations and conflicts in

construction projects, at work, and even in our daily lives are very common (Arain and Low, 2006).

Variation orders involved alteration, addition, omission, and substitution in terms of quality, quantity and schedule of work (Adnan *et al*., 2010). Any addition, deletion, or any other revision to project goals and scope of work are considered to be variation, whether they increase or decrease the project cost or schedule (Ibbs *et al*., 2001). The work of Sun and Meng (2008) mentioned that a variation in construction projects refers to an alteration to design, building works, project programs or project aspects caused by modifications of preexisting conditions, assumptions, or requirements. Variation orders have an impact on overall project performance (Ruben, 2008). This is because variations can cause substantial adjustment to the contract duration, total direct and indirect cost, or both.

In most cities of the country like Addis Ababa where new infrastructure and buildings are being built, the occurrence of variation orders on public projects seems usual. Most public building projects in Addis Ababa were delayed with certain amount of variation orders increasing from the original value of the contract sum. According to the team leader of Addis Ababa Housing Development and Construction Bureau, Supervision and Follow-up department, variation is ordered for most of the projects. The projects were delayed and the cost of the projects increased. The focus of this study would be on public building projects being built in Addis Ababa from July 2010G.C to the end of June 2012G.C. Due to general background of the problem in the construction industry and the specific problem within the public buildings, there is a cause for a study to be made on assessment of the impact of variation orders on public building projects in Addis Ababa.

1.2 Statement of the Problem

Nowadays, variation orders have become a common problem in public building projects in Addis Ababa. Variation orders are issued to correct or modify the original scope of work because changes during construction of projects are unavoidable. The major causes of delay, disputes and sometimes generate significant cost and environmental impacts are variation orders issued during construction of projects. Yet, no unique method is available for minimizing variation orders effectively. However, their impact can be minimized with an appropriate study about the causes. Variation orders on public building projects have the potential to impact public building projects, and the identification of their causes might lead

to their reduction, possible elimination and subsequent improvement in overall performance of public building projects.

1.3 Aim and Objectives of the Study

Based on the problem statement above, the aim of this study is to assess the impact of variation orders on public building projects in Addis Ababa in order to take remedial measures to minimize them.

The objectives of the study are:

- To determine the causes of variation orders;
- To identify the impacts of variation orders; and
- To recommend strategies to minimize variation orders.

The following research questions pertain to offices consisting of public building project management teams in Addis Ababa. The overall purpose of this research is to minimize the impact of variation orders on public building projects, thereby increasing the effectiveness in both a project and a government. Thus formulating and answering the following research questions could define the overall purpose:

- What are the causes of variation orders?
- What are the impacts of variation orders?
- How can we minimize variation orders?

1.4 Scope of the Study

There are many projects which are currently under construction in Ethiopia. In order to achieve the stated objectives of the study, the scope would be too large to tackle. Therefore, the study will be limited to Addis Ababa city where many public building projects are under construction. This scope limitation is done due to limitation of budget and schedule of the research. Data to be used will include only G+3 and above with and without basement of public building projects which are under construction those issued from the commencement of work from July 2010 to the end of June 2012 G.C and more than 60% completed projects.

1.5 Significance of the Study

Since variation orders can have numerous negative impacts to projects cost and schedule, it will be important to identify the major causes those contribute to variation orders and to study the impacts of variation orders and possible strategies to minimize them during the implementation of public building projects. The study will be supportive for public building construction stakeholders in general and for Addis Ababa city government public building construction stakeholders specifically to take remedial measures to reduce the occurrence of the problem. The study will also be helpful for the government in general and most technical departments such as Housing Development and Construction Bureau (HDCB) in assessing and taking remedial measures for reducing the impact of variation orders.

1.6 Structure of the Research

Research writing is the final step of the study and it contains five main chapters. These are the introduction, literature review, the research methodology, data analysis and discussions, and conclusion and recommendations.

Chapter One: Introduction: This chapter comprised the background of the study, problem statement, aim and objectives, significance and limitations of the study, and structure of the research.

Chapter Two: Literature Review: The literature review started with literature exploration of the electronic and hard copy media in answering the research objectives. The causes and impact of variation orders as well as strategies to minimize variation orders on building projects were discussed.

Chapter Three: Research Methodology: This chapter discussed the tools and methods used for data collection.

Chapter Four: Data Analysis and Discussions: This chapter constituted the analysis of data gathered with the research instruments. It analyzed data from the desk studies, questionnaire and the interview.

Chapter Five: Conclusion and Recommendations: This is the final chapter of the research in which conclusions and recommendations were drawn based upon the analysis data, linking them to the problem statement and objectives of the study.

Generally, the research was written following a certain structure. Though step order may vary depending on the subject matter and researcher, the steps outlined in **Figure 1.1** below were followed in this study;

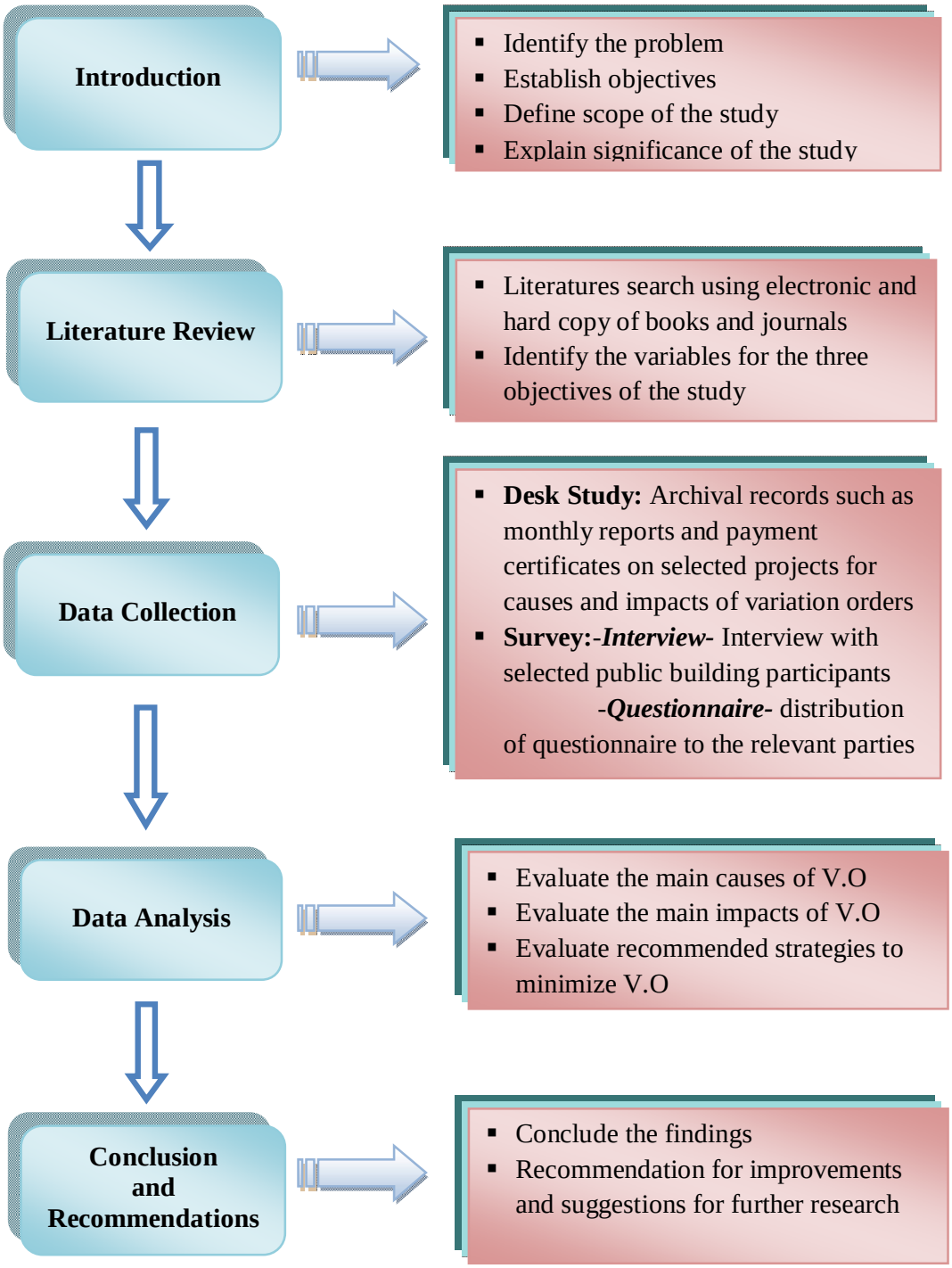

Figure 1.1: Structure of the research

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Construction project is a mission, undertaken to create a unique facility, product or service within the specified scope, quality, time and cost. In practice, however, some construction projects encounter variation, delay on completion time or poor workmanship upon completion.

The one thing certain on any project is that there will be variations occurring along the way sometimes even before the signing of the contract. Variations are inevitable in any construction projects (Ibbs *et al.,* 2001). Nothing is more constant than variation during the course of a construction project. Despite the best efforts of all concerned during the planning, implementation and administration of the contract, variation will almost certainly occur. The variations and variation orders can be detrimental in any project, if not considered collectively by all participants (Arain and Low, 2005). The most frequent type of variation met in building projects are variations to the original scope of work or those that arise from unexpected conditions in the field. Even two buildings of same design, that is very similar, have differences caused by the terrain, existing utilities, or other factors such as subsurface conditions. Basically variation orders are acceptable as part of the contract administration process.

This chapter reviews literatures related to variation orders; including: definition of variation order; nature and type of variation orders; contractual provisions relative to variation orders; variation orders and project delivery systems, management of variation orders, causes and impacts of variation orders; and recommended strategies to minimize variation orders on public building projects.

2.2 Definition of Variation

There is no single definition of what constitutes a variation. The term ‘variation’ as described and/or defined by various standard forms of contract differs from one to another but in principle the definition and/or meaning is more or less similar. Usually, any standard form of

building contract will contain a definition of a variation in terms of specific actions and activities.

The building contract dictionary defined variations as alterations, additions or omissions in work, materials, working hours, work space, etc.

As defined in PPA (2006), "variation" is an instruction given by the engineer, which varies the works.

According to FIDIC (1999), "variation" means any change to the works, which is instructed or approved as a variation.

Hayati (2006) described that each standard form of building contract has its own definition but clearly 'variation', in generic sense, refers to any alteration to the basis upon which the contract was let. This means the term embraces not only changes to the work or matters pertaining to the work in accordance with the provisions of contract, but also changes to the contract conditions themselves.

According to Hayati (2006) variation can be taken to be any, a combination of any or all of the following:

i. Variation in building projects may mean 'the alteration or modification of the design, quality or quantity of the works, as shown upon the contract drawings and described by or referred to in the contract bills, and includes the addition, omission or substitution of any work, the alteration of the kind or standard of any of the materials as goods to be used in the works, and the removal from the site of any work materials or goods executed or brought thereon by the contractor for the purposes of the works other than work or material or goods which are not in accordance with the contract'.

ii. Variations in building projects with instructions concerning the nature of the works which are not specifically termed as variation in the contract documents.

iii. Variation of contract in law, i.e. if both parties alter a contract document by agreement after execution of the original contract this is a variation of the contract terms or conditions.

iv. Variation of price clause which enables the contract sum to be adjusted for rises and falls in the cost of labour or materials.

Hibberd (1986) defined variation as any changes in the quality or quantity of the works as mentioned or spelled out in a contract document. Bin-Ali (2008) defined variation orders as any deviation i.e., alteration, addition or omission, from the contract with regard to contract drawings, specifications, and/or bills of quantities. Variation order was also defined as the alteration or modification of the design, quality of works, as agreed upon the contract drawings, bill of quantities, and/or specifications (Bin-Ali, 2008).

Popescu (1995) indicated that a contract variation order is when a change is made in the original contract that will affect the scope of work. Variation order is authorized by the owner and is often initiated by the contractor. Schexnayder *et al.* (2004) explained that the variation order directives issued by the owner to change the contract by adding or subtracting features within the scope of the work. Variations that are outside the scope of work require a supplementary agreement. Variation orders change the details or conditions of the work and they are used to add "extra" or delete work.

In general, the term 'Variation' usually means a change, modification, alteration, revision or amendment to the original intent of the contract and/or its works. A variation order is the formal document that is used to modify the original contractual agreement and becomes part of project's documents (Fisk, 1997). Furthermore, a variation order is a written order issued to the contractor after the contractual agreement by the owner, which authorize a change in the work or an adjustment in the contract sum or even the contract time.

2.3 Nature and Types of Variation Orders

2.3.1 Nature of Variation Orders

The research team Ming *et al.* (2004) reported that project variations can be classified as "anticipated variations" and "emergent variation". Anticipated variations are planned in advance and occur as intended. On the other hand, emergent variation arise spontaneously and are not originally anticipated or intended. Another way to view project variation is through its necessity. In this way, project variation can be classified as "elective variations" and "required variations". According to Ming *et al.* (2004) an elective variation is where one

may choose whether or not to implement; and a required variation is where there is no option but to make the variation.

No matter how carefully a project is planned and scheduled, it is almost certain that there will be variations before the project is completed. As sited in the works of Ruben (2008), the type of variation orders can be determined by referring to both the reasons for their occurrence and subsequent effects. (Arain & Pheng, 2005) distinguished two types of variation orders, namely: beneficial and detrimental variation orders.

2.3.1.1 Beneficial variation orders

As Arain & Pheng (2005) described, a beneficial variation order is one issued to improve the quality standard, reduce cost, schedule, or degree of difficulty in a project. This type of variation order eliminates unnecessary costs from a project as a result; it optimizes the client's benefits against the resource input by eliminating unnecessary costs. This means beneficial variation orders initiated for value analysis purposes to realize a balance between the cost, functionality and durability aspects of a project to the satisfaction of clients. Value analysis is an organized approach to the identification and elimination of unnecessary costs which are defined as costs which provide neither use, nor life, nor quality, nor appearance, nor customer features (Kelly & Male, 2002). Value analysis describes a value study of a project that is already built or designed and analyses the product to see if it can be improved (Zimmerman & Hart, 1982). Therefore, a variation order is beneficial if it is initiated to enhance the client's value. Among others, the client's value system elements include time, capital cost, operating cost, environment, exchange or resale, aesthetic/esteem and fitness for the purpose (Kelly & Duerk, 2002). A beneficial variation order, therefore, seeks to optimize the client's benefits against the resource input by eliminating unnecessary costs. These benefits are understood to be the satisfaction of perceived needs for public building projects that include social, economic and commercial aspects.

Additionally, a beneficial variation is initiated in the spirit of adding value to the project. However, it should be noted that regardless of how beneficial a variation order might be non value-adding costs are likely to accrue as a result (Ruben, 2008). For example a variation order to solve the discrepancies between contract documents involves the abortion of works that have already been executed. Cost for aborted works should not have been incurred if discrepancies were not found between contract documents.

2.3.1.2 Detrimental variation orders

According to Arain & Pheng (2005), a detrimental variation order is one that negatively impacts the client's value or project performance. For example a client who is experiencing financial problems may require the substitution of quality standard expensive materials to substandard cheap materials. Arguably, a detrimental variation order compromises the client's value system. For example, in marine construction, steel window frames result in steel oxidation if selected instead of timber or aluminum frames.

2.3.2 Types of Variation Orders

Variations in construction projects are very common and likely to occur from different sources, by various causes, at any stage of a project, and may have considerable negative impacts on items such as costs and schedule delays. A critical variation may cause consecutive delays in project schedule, re-estimation of work statement, and extra demands of equipment, materials, labor, and overtime. Variations, if not resolved through a formalized variation management process, can become the major source of contract disputes, which is a severe risk contributing to project failure.

Classifications of variations in general terms apply to changes in construction domain. Motawa et al. (2007) summarized variations as **Table 2.1** below:

Table 2.1: Types of variation (Motawa *et al*., 2007)

Bases of variation	Types of Variation
Time	Anticipated or Emergent, Proactive or Reactive, or Pre-fixity or Post-fixity
Need	Elective or Required, Discretionary or Nondiscretionary, or Preferential or Regulatory
Effect	Beneficial, Neutral or Disruptive

2.4 Contractual Provisions Relative to Variation Orders

Most standard forms of contract include a clause under which the employer or his representative is able to issue an instruction to the contractor to vary the works which are described in the contract. A change in shape of the scheme, the introduction of different materials, revised timing and sequence are all usually provided for by the variations clause. It will also usually include a mechanism for evaluating the financial effect of the variation and there is normally provision for adjusting the completion date. In the absence of such a clause the employer could be in a difficulty should a variation to the works be required. The contractor could either refuse to carry out the work or undertake the work or insist upon payment on a quantum merit or fair valuation basis. Calculation of the price for the extra work applying this method could involve payment in excess of the contract rates.

Among the different conditions of contract, the Federation Internationale Des Ingenieurs Conseils (FIDIC), Ministry of Urban Development and Construction (MUDC), and Public Procurement (PPA) are widely used in Ethiopian construction industry. These contract conditions clearly define the duties and responsibilities of the parties involved in the contract and it describes the guidelines for contract administration, they consequentially alter variation of construction works unless and otherwise they are deleted or replaced by other words or sentences in the specific conditions of contract for a project.

2.4.1 General Conditions of Contract for Procurement of Works (PPA, 2006)

Even though contract conditions include the usual variations clause there may be circumstances which could lead to additions or changes introduced by the employer which falls outside the variations clause. Variation related clauses as described under clause 38, 39 and 40 of Public Procurement Agency (PPA, 2006) concerning variations and payment of variations are as follows:

- *Clause 38.1:* If the final quantity of the work done differs from the quantity in the bill of quantities for the particular item by more than 25 percent, provided the change exceeds 5 percent of the initial contract price, the engineer shall adjust the rate to allow for the change. This clause is applied for admeasurements contract.

- *Clause 39.1*: All variations shall be included in updated programs (or in the case of lump sum contracts in updated programs and activity schedules) produced by the contractor.

- *Clause 40.1*: For both admeasurements and lump sum contracts, the contractor shall provide the engineer with a quotation for carrying out the variation when requested to do so by the engineer. The engineer shall assess the quotation, which shall be given within seven days of the request or within any longer period stated by the engineer and before the variation is ordered.

- *Clause 40.2*: For admeasurements contracts only, if the work in the variation corresponds with an item description in the bill of quantities and if, in the opinion of the engineer, the quantity of work above the limit stated in sub-clause 38.1 or the timing of its execution do not cause the cost per unit of quantity to change, the rate in the bill of quantities shall be used to calculate the value of the variation. If the cost per unit of quantity changes, or if the nature or timing of the work in the variation does not correspond with items in the bill of quantities, the quotation by the contractor shall be in the form of new rates for the relevant items of work.

- *Clause 40.3*: For both admeasurements and lump sum contracts, if the contractor's quotation is unreasonable, the engineer may order the variation and make a change to the contract price, which shall be based on the engineer's own forecast of the effects of the variation on the contractor's costs.

- *Clause 40.4*: For both admeasurements and lump sum contracts, if the engineer decides that the urgency of varying the work would prevent a quotation being given and considered without delaying the work, no quotation shall be given and the variation shall be treated as a compensation event.

- *Clause 40.5*: For both admeasurements and lump sum contracts, the contractor shall not be entitled to additional payment for costs that could have been avoided by giving early warning.

2.4.2 Standard Condition of Contract for Civil Works Project (MUDC, 1994)

According to Ministry of Urban Development and Construction (MUDC, 1994) conditions of contracts for construction of civil works project, variation related clauses are read as follows:

- *Clause 51, Variations:* The engineer shall make any variation of the form, quality or quantity of the works or any part thereof that may, in his opinion, be necessary and for that purpose, or if for any other reason it shall, in his opinion be desirable, he shall have power to order the contractor to do and the contractor shall do any of the following:

  (a) Increase or decrease the quantity of any work included in the contract,
  (b) Omit any such work,
  (c) Change the character or quality or kind of any such work,
  (d) Change the levels, lines, position and dimensions of any part of the works, and
  (e) Execute additional work of any kind necessary for the completion of the works and no such variation shall in any way vitiate or invalidate the contract, but the value, if any, of all such variations shall be taken into account in ascertaining the amount of the counteract price.

- *Clause 52, Valuation of variations:* All extra or additional work done or work omitted by order of the engineer shall be valued at the rates and prices set out in the contract if, in the opinion of the engineer, the same shall be applicable. If the contract does not contain any rates or prices applicable to the extra or additional work then suitable rates or prices shall be agreed upon between the engineer and the contractor. In the event of disagreement the engineer shall fix such rates or prices as shall, in his opinion, are reasonable and proper.

2.4.3 General Conditions of Contract for Civil Works (UNDP, 2000)

A construction contract condition which developed for United Nations Development Program (UNDP, 2000) projects described variation in the following clauses:

- *Clause 15a*: The engineer may instruct the contractor, with the approval of the employer and by means of change orders, all variations in quantity or quality of the works, in whole or in part, that are deemed necessary by the engineer.

- *Clause 48.1*: The engineer may within his powers introduce any variations to the form, type or quality of the works or any part thereof which he considers necessary and for that purpose or if for any other reasons it shall, in his opinion be desirable, he shall have power to order the contractor to do and the contractor shall do any of the following:

    (a) increase or decrease the quantity of any work under the contract;
    (b) omit any such work;
    (c) change the character or quality or kind of any such work;
    (d) change the levels, lines, positions and dimensions of any part of the works;
    (e) execute additional work of any kind necessary for the completion of the works, and no such variation shall in any way vitiate or invalidate the contract.

For an increase cost of contract or altering the works due to variations according to this condition is stipulated under clause 48.2 as follows.

- *Clause 48.2*: The engineer shall, however, obtain the written approval of the employer before giving any order for any variations which may result in an increase of the contract price or in an essential alteration of the quantity, quality or character of the works.

- *Clause 48.3*: No variations shall be made by the contractor without an order in writing from the engineer. Variations requiring the written approval of the employer under clause 48.2 shall be made by the contractor only upon written order from the engineer accompanied by a copy of the employer's approval. It is provided that, subject to the provisions of the contract, no order in writing shall be required for any increase or decrease in the quantity of any work where such increase or decrease is not the result of an order given under this clause but is the result of the quantities exceeding or being less than those stated in the bill of quantities.

2.4.4 Conditions of Contract for Construction (FIDIC, 1999)

The FIDIC (1999) under clause 3.3, it stipulates that the engineer may issue to the contractor instructions and additional or modified drawings which may be necessary for the execution of the works and the remedying of any defects, all in accordance with the contract. But, not all

instructions vary the contractual arrangements or the way the works are being undertaken. As stated under clause 13.1 of FIDIC (1999), variations may be initiated by the engineer at any time prior to issuing the taking-over certificate for the works, either by an instruction or by a request for the contractor to submit a proposal.

The contractor shall execute and be bound by each variation, unless the contractor promptly gives notice to the engineer stating (with supporting particulars) that the contractor cannot readily obtain the goods required for the variation. Upon receiving this notice, the Engineer shall cancel, confirm or vary the instruction.

As FIDIC (1999) stipulates, each variation may include:

(a) changes to the quantities of any item of work included in the contract (however, such changes do not necessarily constitute a variation).
(b) changes to the quality and other characteristics of any item of works.
(c) changes to the levels, positions and/or dimensions of any part of the works.
(d) omission of any work unless it is to be carried out by others.
(e) any additional work, plant, materials or services necessary for the permanent works, including any associated tests on completion, boreholes and other testing and exploratory work. or
(f) changes to the sequence or timing of the execution of the works.

The FIDIC (1999), under clause 13.2 states that the contractor may, at any time, submit to the engineer a written proposal which (in the contractor's opinion) will, if adopted, (i) accelerate completion, (ii) reduce the cost to the employer of executing, maintaining or operating the works, (iii) improve the efficiency or value to the employer of the completed works, or (iv) otherwise be of benefit to the employer.

Under clause 13.3 of FIDIC (1999), it stipulates that if the engineer requests a proposal, prior to instructing a variation, the contractor shall respond in writing as soon as practicable, either by giving reasons why he cannot comply (if this is the case) or by submitting:

(a) a description of the proposed work to be performed and a program for its execution
(b) the contractor's proposal for any necessary modifications to the program according to the program stated and to the time for completion, and

(c) the contractor's proposal for evaluation of the variation.

The engineer shall, as soon as practicable after receiving such proposal, respond with approval, disapproval or comments. The contractor shall not delay any work whilst awaiting a response. Each instruction to execute a variation, with any requirements for the recording of costs, shall be issued by the engineer to the contractor, who shall acknowledge receipt.

Each instruction to execute a variation, with any requirements for the recording of costs, shall be issued by the engineer to the contractor, who shall acknowledge receipt. Each variation shall be evaluated in accordance with clause 12 [Measurement and Evaluation: It states that the works shall be measured, and valued for payment], unless the engineer instructs or approves otherwise in accordance with this clause.

Even though the above contract conditions include the usual variations clause, there may be circumstances which could lead to additions or changes introduced by the employer which falls outside the variations clause. Contractors who find themselves with unattractive contract prices would find it to their advantage to be able to argue that a change introduced by the employer fell outside the variations clause thus leaving the way open to argue that payment for the change should be on a quantum merit or fair valuation basis. In the above different contractual provisions, all the contracts have stipulated the various methods by which the contractor will be reimbursed. The contracts have a specific procedure covering the process of handling variations to the work.

2.5 Variation Orders and Project Delivery Systems

A project delivery system is a system designed to achieve the satisfactory completion of a construction project from conception to occupancy. A project delivery method may employ any one or more contracting formats to achieve the delivery.

Every owner responsible for the implementation of a construction project must make an early and important decision regarding the method by which the project will be designed and constructed (Odabasi *et al.,* 2003). Because of financial, organizational and time constraints, various project delivery methods have evolved to fit particular project and owner needs.

Methods that have gained in popularity include Design-Bid-Build (DBB), Design-Build (DB), and the latest, Integrated Project Delivery (IPD). Proponents of particular alternative

methods advocate or promise improvements over the traditional system in terms of project schedule and cost control, and the number of disputes (Levy, 2006). The Integrated Project Delivery method, although to date only used on a negligible number of projects, is included here due to interest in understanding the concept.

2.5.1 Design-Bid-Build (DBB)

The Design-Bid-Build (DBB) approach is the most accepted traditional project delivery method today, especially for public projects in Addis Ababa. In DBB, the project is separated into a design phase and construction phase. With two well-defined phases, construction will start once the design is completed, while the drawings become the basis for the bidding documents. Because the owner is more certain about the finished product, usually a lump sum contract is implemented in a DBB project (Odabasi *et al.*, 2003).

The DBB system remains the most frequently used delivery method for construction projects (Levy, 2006). Using this method, the owner engages a designer to prepare the design of the project, including construction drawings, and specifications. Once completed, the bid document, including the design and bidder's information packet, is presented to interested contractors who prepare and submit their bids for the work. The owner will select a contractor, usually based on the lowest responsive and responsible bid (for most public works), or some hybrid of price and technical merit. The selected general contractor will then execute contracts with subcontractors to construct various specialty items. The contractor is responsible for constructing the facility in accordance with the contract documents. The designer typically maintains limited oversight of the work and responds to questions about the design on behalf of the owner (Levy, 2006).

2.5.2 Design-Build (DB)

Design-Build (DB) is the oldest approach that is regarded as an alternative project delivery method. During ancient times in Mesopotamia and Egypt, the master builder was responsible for the design and construction of the entire project. This continued to be the most commonly used project delivery method until the late 19th century, when advances in science and technology allowed the fields of architecture and engineering to become two different professions (Songer and Molenaar, 1996). The contractor usually has the task of assembling a group of designers and constructors to perform the job for this type of delivery method.

According to Levy (2006), the owner contracts with a DB team, which can be a joint venture of a contractor and a designer, a contractor with a designer as a sub-consultant, a designer-led team with a contractor as a subcontracted entity, or a single firm capable of performing both design and construction. Since contractors are most comfortable in the role of risking corporate capital in performing projects, they usually are the lead members of this sort of team. One variation of the typical DB team structure, known as fee-paid developer, involves the owner engaging a developer, which then selects its own designer and contractor partners. However formulated, the DB team performs the complete design of the facility, usually based on a preliminary scope or design presented by the owner.

At some point early in the process, through a prescribed process, the DB team will establish a fixed price to complete the design and construction of the facility. Once underway, the DB team is then responsible for construction of the project, and for all coordination between design and construction.

2.5.3 Integrated Project Delivery (IPD)

Integrated Project Delivery (IPD) contracts are a relatively new to our marketplace and no projects have been carried out using these contracts. Pure IPD, in its contractual sense, requires a multiparty agreement among the prime players in the design and construction process – at least the owner, the designer and the builder – but this agreement can include many of the important sub-consultants and subcontractors as well (Levy, 2006).

Regarding project delivery systems and variations, some researchers have examined and described some points. Ibbs *et al.* (2003), examines the relationship between impacts on project change as against the DBB and DB project procurement method. They also found out that, design, bid and build contracts experienced a higher number of changes and change in cost against design and build contracts. The results obtained were consistent with studies carried out earlier by Konchar and Sanvido (1998). Ibbs *et al.* (2003) also found that changes to the schedule effects the total project duration and the worst effect if the design, bid and build delivery system.

2.6 Management of Variation Orders

Construction contracts are complex both in nature and the process required to realize the finished product. So variation is common on construction projects. Variation orders are typically issued in the form of contract instructions.

Once a variation order has been instructed and works are carried out, the employer has to reimburse the contractor for the same. This obligation of the employer involves certain activities or stages for measurement of works, valuation of the varied works and payment for the varied works.

According to Ssegawa *et al.* (2002) contractual clauses state how variation orders should be initiated. In all cases, variation orders are issued by the consultant and must be given in writing or oral instruction should be subsequently confirmed in writing (Wainwright & Wood, 1983; FIDIC, 1999; Finsen, 2005; JBCC, 2005; Ssegawa *et al.*, 2002). Since the contractor is not bound to comply with the oral instructions, all oral instructions have to be confirmed in writing by either the consultant or the contractor. Where variation orders are confirmed in writing by the contractor, the consultant has to confirm by signature. If the contractor is agreeable with the variation order, the works should proceed. The contractor and the consultant agree upon which method of valuation of variation orders should be used.

The valuation of variation orders, while seen as an administrative step in the remuneration of changes effected to the contract, is in reality a rather complex matter involving a thorough understanding of contractual provisions, costing principles and an exercise of fair judgment on the part of the evaluators (Wainwright & Wood, 1983; JBCC, 2005).

According to Wainwright *et al.* (1983), the valuation of variation orders may be in the form of:

- Rates where contracted rates are adopted where the varied works are of similar character and extent and executed under similar conditions to items in the contract bills;
- Day works which consist of the payment of executed works on a basis calculating the prime cost of works including materials, labour, plant hire and transport plus a percentage addition as agreed between parties to the contract;
- Quotation where contractors submit a quotation to effect the work contained in a variation order; and

- *Quantum meruit* is a miscellaneous method where negotiated or agreed rates or payment are made on a reasonable sum.

Ming *et al.* (2004) defined a generic variation management process model **(Figure 2.1)**. The generic model consists of four stages, start up, identify & evaluation, approval, and implement & review (Ming *et al.,* 2004)

2.6.1 Start Up

This contains the proactive requirements that are essential for effective variation management. These requirements enable the project team to respond readily to variation, to manage variation effectively, and to facilitate contingency plans for any anticipated variation.

2.6.2 Identify and Evaluate

During a construction project, some variations can be anticipated while others may occur unexpectedly. The aim of the project team is to actively seek to identify potential variations at the earliest opportunity. This can be achieved by considering whether any of the potential variation causes are likely to be present in a project. Once a potential variation is identified, evaluation can be carried out in order to assist with the decision making process. Evaluation steps may include implications assessment and optimum selection of variation options.

2.6.3 Approval

Once the evaluation step has been completed it will need to be approved by appropriate member of the team (usually the project manager) and may be by the client depending on the nature of the variation. In order to approve a variation it is necessary for the people involved to see the impact that the variation will have on the project. There may be several iterations during the approval process.

2.6.4 Implement and Review

Once a variation is approved, it needs to be communicated to all team members whose work is affected by the variation. If necessary, schedule of work needs to be adjusted and new schedule needs to be agreed by the whole team. Finally, the project team should review and learn lessons from the process of the variation event.

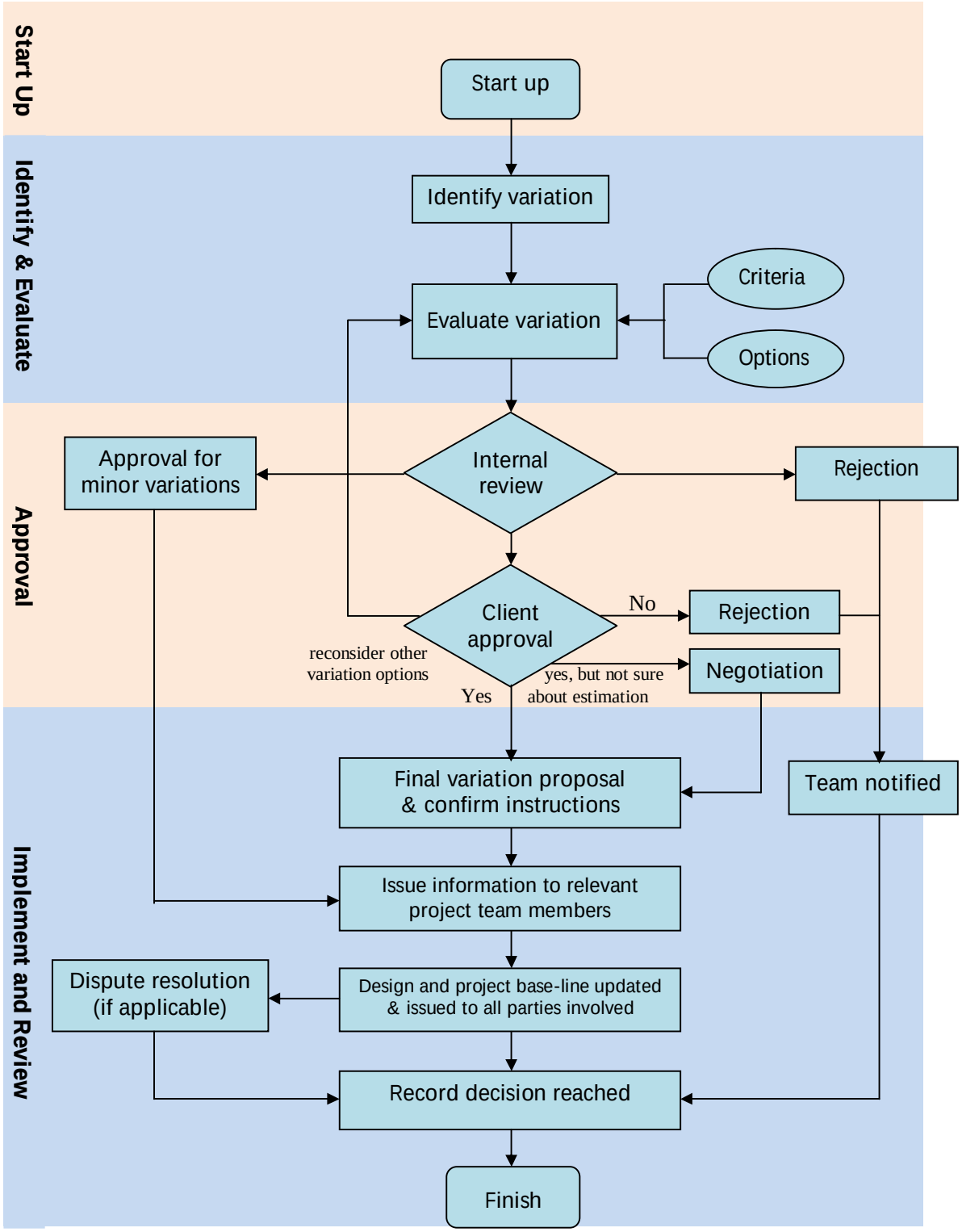

Figure 2.1: Variation management process (Ming *et al.*, 2004)

2.7 Causes of Variation Orders

Various authors had identified different causes of variation orders in construction projects both on the private and public projects. Contractual clauses relating to variation allows parties involved in the contract to freely initiate variation orders within the ambit of the scope of the work without alteration of the original contract (Ruben, 2008). But variation orders are common in construction projects, and improved understanding would require identifying their causes. The works of many researchers show that that variation has come to stay as part of the construction projects and it cut across various stakeholders.

The causes of project variation may originate from either external or internal pressures that are being applied to the project (Ming *et al.*, 2004). External causes may be due to technological changes, changes in the customer expectations and tastes, changes in competitor's activities, changes in government and policies, changes in the economy and finally demographic changes in the society. Internal causes may result from changes in management policy, changes in organizational objectives and changes in the long-term survival strategy of the organizations involved.

According to Sunday (2010), the main causes of variation orders on construction projects are inadequate working drawing details, design discrepancies, conflicts between contract documents, the change of plans or scope by owner, impediment in prompt decision making process, inadequate project objectives, and replacement of materials or procedures, differing site conditions, shortage of skilled manpower, contractor's desired profitability and contractor's financial difficulties.

Variation orders arise due to different causes. Some are foreseeable, others are not. Some result from a genuine change of circumstances and others from the design team's own inadequacies. Arain and Pheng (2006) categorized causes of variations in to four origin agents. These are client, consultant, contractor and others related changes. This means the owner, the consultant, the contractor or other s can directly initiate variations or the variations are required because one of the parties fails to fulfill certain requirements for carrying out the project. As Mohammad *et al.* (2010) identified, change of plan by the owner, substitution of materials by the owner, change in design by the consultant, errors and omissions in design, and owner's financial problems are the main causes of variation orders.

Ming *et al. (*2004) noted that at a more detailed level, the causes of construction project variation are usually generated from either design or construction activities. The design generated causes include design changes, design errors, omissions and operational improvements. Construction driven causes are often linked to the unsatisfactory site conditions that hinder good workmanship, material handling and plant operation. The design and construction issues must be considered in conjunction with how the team is managed, coordinated and communicated with to reduce problems resulting from insufficient work separation, insufficient construction planning and disturbance in personnel planning.

Ssegawa *et al*. (2002) investigated the opinion of project parties regarding the frequency of occurrence, causes, and originators of variation orders. The study found that additions and omissions are the most common cause of variations in projects, which represented about 45.7% of all variation orders in building projects. Substitutions were considered the third most important cause of variations. The study further revealed that restriction on working conditions (space, access), and replacement of employee were ranked very low occurrence. The main causes of omission related variations were lack of financial, design changes and feasibility of construction. The study results indicated that client and architect caused most of the omission due to financial reasons, design and changes of drawings, and feasibility of construction. As Ruben (2008) found out, the most frequent causes of variation orders were change of schedule, specifications and design and errors in design and inadequate working drawing details.

Lots of studies are conducted to identify the causes of variation orders (Mohammad *et al.*, 2010; Arain and Pheng, 2006; Sunday, 2010; Ssegawa *et al*. (2002); Gray and Hughes, 2001; Ruben, 2008; Al-Hammad and Assaf, 1992; Thomas and Napolitan, 1994; Clough and Sears, 1994; Assaf, *et al.*, 1995; Puddicombe, 1997; Fisk, 1997; O'Brien, 1998; Mokhtar, *et al.*, 2000; Kumaraswamy, *et al.*, 1998; O'Brien, 1998). List of causes of variation orders identified from the above discussed sources are shown in **Table 2.2** below.

Table 2.2: Causes of variation orders (Ruben, 2008)

S.N	Causes of variation orders
1	Change of plans or scope
2	Change of schedule
3	Change in specifications
4	Change in design
5	Errors and omissions in design
6	Inadequate working drawing details
7	Non-compliant design with government regulations
8	Impediment in prompt decision making process
9	Unforeseen problems
10	Replacement of materials or procedures
11	Inadequate shop drawing details
12	Lack of judgment and experience
13	Financial problems
14	Inadequate scope of work for one or more parties to the contract
15	Design complexity
16	Lack of communication
17	Defective workmanship
18	Design discrepancies
19	Inadequate project objectives
20	Long lead procurement
21	Lack of coordination
22	Fast track construction
23	Ambiguous design details
24	Unavailability of skills
25	Weather conditions
26	Lack of strategic planning
27	Lack of knowledge of available materials and equipment
28	Lack of involvement in design of one or more parties to the contract
29	Non-compliant design with owner's requirement
30	Health and safety considerations
31	Lack of a specialized construction management
32	Obstinate nature of one or more of the parties to the contract
33	Differing site conditions
34	Poor procurement process
35	Conflicts between contract documents
36	Value engineering
37	Change in economic conditions
38	Honest wrong beliefs of one or more parties to the contract
39	Lack of required data
40	Unavailability of equipment
41	Unfamiliarity with or unawareness of local conditions
42	Socio-cultural factors
43	Change in government regulations
44	Speculation on desired profitability
45	Technology change

2.8 Impact of Variation Orders on Building Projects

Impact is defined in electronic Webster dictionary as "the force of impression of one thing on another". In construction, variation orders can impact portions of the project directly or indirectly and result in reduced productivity. This is always a subjective issue as the contractor feel that the loss due to variation order is the fault of the designers and owners. Conversely, owners typically claim that the loss in productivity is due to poor management on the part of the contractors. However, not every variation order will impact the productivity of the project.

Variations in any planned activity will cause a disturbance and will require the rearrangement or review of the existing plan under the recent developments. Given the complex, multi-party and multi resource nature of the construction industry, it is not difficult to perceive the impacts of changes on projects.

Impacts of variations were observed by many researchers and its occurrence has an adverse impact on project performance. Ruben (2008) found that variation orders had an impact on overall project performance and the major adverse impact of variation orders are time and cost overruns and disputes between the parties to the contract. Thomas *et al.* (2002) suggest that variability generally impedes project performance. Ibbs (1997) concluded that variation orders affect project performance as they adversely affect productivity and project costs. According to Arain and Pheng (2005b) variation orders are an unwanted but inevitable reality of any construction project. Further, Hanna *et al.* (2002) found that projects with many variation orders cause the contractor to achieve lower productivity levels than planned. Variation orders adversely impact project performance in terms of cost overruns, time overruns, quality degradation, health and safety issues and professional relations. Numerous studies have been done to identify the impacts of variations, relationships between variation and its impacts (Hanna *et al.*, 2002; Hester *et al.*, 1991; Thomas and Napolitan, 1994; Osman *et al.*, 2009; Ibbs, 1997; Arain and Pheng, 2005b; Haldun, 1998; CII, 1990; Ibbs, 1995).

The 16 impacts identified from the literature review, as shown in **Table 2.3**: are discussed below.

Table 2.3: Impacts of variation orders (Hanna *et al.*, 2002)

S. N	Impacts of Variation Orders
1	Increase in project cost
2	Progress is affected but without any delay
3	Increase in overhead expenses
4	Delay in payment
5	Quality degradation
6	Productivity degradation
7	Procurement delay
8	Rework and demolition
9	Logistics delays
10	Blemish firm's reputation
11	Poor safety conditions
12	Poor professional relations
13	Additional payments for contractor
14	Disputes among professionals
15	Completion schedule delay

a. Increase in project cost

Construction projects involve recognized phases of which two are particularly important, namely the pre-construction and construction phases. The most common impact of variations during the construction phase is the increase in project cost (CII, 1990). However, all variation orders do not increase the costs of construction. Omissions in most cases reduce costs while additions increase costs (Ssegawa *et al.*, 2002). As Ruben (2008) found in his study variation orders adversely impact costs. In every construction project, a contingency sum is usually allocated to cater for possible variations in the project, while keeping the overall project cost intact. Arguably, the more the number of variation orders, the more they are likely to affect the overall construction delivery cost. In fact, variation orders have both a direct and indirect effect on cost. Direct costs constitute the additional costs incurred to perform the activities of the current variation orders. As Bower (2000) identified, the direct costs associated with variation orders are as follows:

- Time and material charges related to immediately affected tasks;
- Recalculation of network, increased time-related charges and overheads;
- Reworks and standing time;
- Timing effects for example winter time;
- Inflation, change to cash flow and loss of earnings; and

- Management time, head office and site charges.

Bower (2000) also pointed out that indirect costs are costs incurred as a result of variation orders, whether they are apparently linked to them or not. These include:

- Loss of productivity due to interruption where the gang has to familiarize with new working condition, tools and material;
- Rework and making good on affected trades other than the actual variation order
- Change in cash flow due to effect on inflation and financial charges;
- Cost for redesign and administration of the variation order; and
- Litigation-related costs in case disputes arise due to the variation order.

b. Progress is affected

Project progress may be impacted by variations (Assaf *et al.*, 1995). During execution of the project, time has an equivalent monetary value even if the professional team tries its best to keep the project completion schedule intact. However, only major variations during the project may affect the project completion time according to Arain and Pheng (2005). This means the contractor would usually try to accommodate the variations by utilizing the free floats in the construction schedules. Hence, the variations affect the progress but without any delay in the project completion if the free floats are utilized.

c. Increase in overhead expenses

Variations need to go through a few stages of processing procedures as mentioned earlier and require to be evaluated before they can even be implemented (O'Brien, 1998). The process and implementation of variations in construction projects would increase the overhead expenses for all the participants concerned. Normally these overhead charges are provided for from the contingency fund allocated for the construction project.

d. Delay in payment

Delay in payment occurred frequently due to variations in construction projects (CII, 1990). Variations may hinder the project progress, leading to delays in achieving the targeted milestones during construction (CII, 1995). Eventually, this may affect payment to the contractors. Occasionally this delay may cause severe problems that end up in delays in

payment to the subcontractors; this is because main contractors may not be able to pay the subcontractors unless they get paid by the owner first.

e. Quality degradation

Variations, if frequent, may impact the quality of work adversely (Fisk, 1997). Contracts with a significant degree of risk for unknown variables such for example, lump sum, contractors may cut corners on quality and quantity to maximize profits. According to CII (1995), the quality of work was usually poor because of frequent variations since contractors tended to compensate for the losses.

f. Productivity degradation

Interruption, delays and redirection of work that are associated with variation orders have a negative impact on labour productivity. These in turn can be translated into labour cost or monetary value (Ibbs, 1997b). Hester *et al.* (1991) argued that the productivity of workers was expected to be greatly affected in cases where they were required to work overtime for prolonged periods to compensate for schedule delays. Thomas and Napolitan (1995) concluded that variations normally led to disruptions and these disruptions were responsible for labour productivity degradation. The most significant types of disruptions were due to the lack of materials and information as well as the work out of sequence. Lack of material was reported as the most serious disruption. Hence, to manage variation, one needed to manage these disruptions. However, the disruptive effects could not be avoided in many instances.

g. Procurement delay

Variations which are imposed when construction is underway may require revised procurement requests (O'Brien, 1998). Procurement delays can be frequent due to variations that require new materials and specialized equipment. Hester *et al.* (1991) observed that procurement delays were common effects of variations related to new resources for construction projects.

h. Rework and demolition

Rework and demolition are frequent occurrences due to variations in construction projects (Clough and Sears, 1994). Variations which are imposed when construction is underway or even completed, usually lead to reworks and delays in project completion (CII, 1990a).

Rework and demolition are potential effects of variations in construction, depending on the timing of the occurrence of the variations. These effects are to be expected due to variations during the construction phase. This is because the variations during the design phase do not require any rework or demolition on construction sites.

i. Logistics delays

Logistics delays may occur due to variations requiring new materials and equipment (Fisk, 1997). Hester *et al*. (1991) observed that logistics delays were significant effects of variations in construction projects. Logistics delays were experienced in construction projects where variations in the construction phase required new materials, tools and equipments.

j. Blemish firm's reputation

Variations are referred to as a major source of construction claims and disputes (Fisk, 1997; Kumaraswamy *et al.*, 1998). The claims and disputes may affect the firm's reputation adversely, leading to insolvency in severe cases. Variations also increase the possibility of professional disputes. Conventionally, variations present problems to all the parties involved in the construction process.

k. Poor safety conditions

Variations may impact the safety conditions in construction projects (O'Brien, 1998; Arain *et al.,* 2004). This is because change in construction methods, materials and equipment may require additional health and safety measures (Arain & Pheng, 2005).

l. Poor professional relations

Construction changes are a major source of construction dispute (Fisk, 1997). Eventually, variations may impact professional relations, leading to disputes.

Clear procedures that are presented in the contract and fair allocation of risks can help in resolving disputes through negotiation rather than litigation (CII, 1995).

m. Additional payments for contractor

Additional payments for the contractor can be an impact of variations in construction projects. Variations are considered to be a common source of additional works for the

contractor (O'Brien, 1998). Due to additional payments, the contractor looks forward to variations in the project.

n. Disputes among professionals

Like poor professional relations, disputes among professionals are also impacts of frequent variations in construction projects. The disputes over variation orders and claims are inevitable and the variation clauses are often the source of project disputes (CII, 1995). Clear procedures presented in the contract and fair allocation of risks can help in resolving disputes through negotiation rather than litigation (CII, 1995). Frequent communication and strong coordination can assist in eliminating the disputes between professionals.

o. Completion schedule delay

Clients require their construction projects to be completed within minimum time limits. It is anticipated that projects finished within the shortest possible time achieve some monetary savings. Completion schedule delay is a frequent result of variations in construction projects (Ibbs, 1997). According to Koushki (2005) variation orders issued during various phases of construction projects impacted both the completion time and costs of projects. Hanna *et al.* (2002) stated that as the number of variation orders increases the more significant productivity losses become. Productivity is the amount of output over a unit of time. Therefore, loss in productivity implies loss of time and subsequent delays.

2.9 Recommended Strategies to Minimize Variation Orders

The potential impact of variation orders can be minimized if possible strategies are clearly suggested. As Arain (2005) suggested, variations can be reduced with due diligence during the design stages. Furthermore, it would assist professionals in taking proactive measures for reducing variation orders for building projects if strategies are suggested. In order to minimize variation orders control system should be established for the ultimate benefit of owners. Baharuddin (2005) concluded variation orders can be minimized if all the parties involved in projects are aware that preliminary work before tendering must be carried out, for example detailed site and soil investigations. While design errors and omissions cannot be completely avoided, they can be reduced especially if designers assessed their workloads before committing themselves to new contracts (Ruben, 2008). In another way, the designers should ensure enough time and experienced human resources to deliver a sound design within

the proposed time frames. Ruben (2008) identified recommendations to reduce the occurrence of variation orders. Among other recommendations, Baharuddin (2005) identified the following recommended strategies and suggestions to reduce the occurrences of variation orders. Many studies were conducted to find out possible strategies to minimize variation orders.

List of strategies that suggested by different researchers are identified as follows (Bower, 2000; Baharuddin, 2005; Chan and Yeong, 1995; Arain, 2005; Ruben, 2008; Bin-Ali, 2008; Willis, 1980; Ming *et al.*, 2004; Levy, 2006; Al-Hakim, 2005a; Sweeney, 1998; Formoso, 1999). These are:

- Adequate planning is required by all involved parties before works start on site;
- The consultant should produce a concluding design and contract;
- Drawings should be complete at tender stage;
- Adequate time should be spent on pre-tender planning phase;
- Clients should provide a clear brief of the scope of works;
- All parties should forecast to overview unforeseen situations;
- Closer consultant co-ordination is required at design stage;
- Enhance communication and all parties should be proactive all times;
- Works should be supervised with an experienced and dedicated supervisor;
- Consultant should ensure that the design/specifications fall within the approved budget and the budget team should participate during the design phase;
- Get accurate information and research with regard to procurement procedure, material and plant;
- Carry out detail site investigation including detail soil investigations and consider it during tendering stage;
- Have the underground cable route confirm by the local authorities;
- Have the land application or land purchase completed before awarding contracts;
- Once the tender is awarded, there should be no changes to the specifications; and
- Place experienced and knowledgeable executives in the engineering and design department.

2.10 Variable Identification

This chapter reviewed literatures on variation orders and their impacts on building projects. Based on their nature two types of variation orders are identified namely beneficial variation orders that lead to value improvement; and detrimental variation orders that lead to value degradation. Based on their bases like time, need and effect, different types of variation orders were identified namely anticipated or emergent, proactive or reactive, or pre-fixity or post-fixity, elective or required, discretionary or nondiscretionary, or preferential or regulatory, beneficial, neutral or disruptive. Based on the objectives of the study, the causes of variation orders and their impacts on building projects as well as recommended strategies to minimize them were identified from the literatures to be used in the research instrument.

From the literatures, the following causes of variation orders were identified:

- Change of plans or scope
- Change of schedule
- Change in specifications
- Change in design
- Errors and omissions in design
- Inadequate working drawing details
- Non-compliant design with government regulations
- Impediment in prompt decision making process
- Unforeseen problems
- Replacement of materials or procedures
- Inadequate shop drawing details
- Lack of judgment and experience
- Financial problems
- Inadequate scope of work for one or more parties to the contract
- Design complexity
- Lack of communication
- Defective workmanship
- Design discrepancies
- Inadequate project objectives
- Long lead procurement
- Lack of coordination
- Fast track construction
- Ambiguous design details
- Unavailability of skills
- Weather conditions
- Lack of strategic planning
- Lack of knowledge of available materials and equipment
- Lack of involvement in design of one or more parties to the contract

- Non-compliant design with owner's requirement
- Health and safety considerations
- Lack of a specialized construction management
- Obstinate nature of one or more of the parties to the contract
- Differing site conditions
- Poor procurement process
- Conflicts between contract documents
- Value engineering
- Change in economic conditions
- Honest wrong beliefs of one or more parties to the contract
- Lack of required data
- Unavailability of equipment
- Unfamiliarity with or unawareness of local conditions
- Socio-cultural factors
- Change in government regulations
- Speculation on desired profitability
- Technology change

The frequent occurrence of variation orders can impact building projects for example, by contributing to cost overruns. If not carefully managed, a variation order may give rise to disputes between parties to the contract. From the literatures a list of impact of variation orders were identified. These are:

- Increase in project cost
- Progress is affected
- Increase in overhead expenses
- Delay in payment
- Quality degradation
- Productivity degradation
- Procurement delay
- Rework and demolition
- Logistics delays
- Blemish firm’s reputation
- Poor safety conditions
- Poor professional relations
- Additional payments for contractor
- Disputes among professionals
- Completion schedule delay

Due to the nature of works, variations are unavoidable in construction projects. But their occurrence can be minimized if clear strategies are set. Recommended strategies to minimize variation orders were developed from the literatures to minimize variation orders. These are:

- Plan adequately before works start on site;
- Produce a concluding design and contract documents;
- Complete the drawings at tender stage;
- Spend adequate time on pre-tender planning phase;
- Provide a clear brief of the scope of works;
- Forecast to overview unforeseen situations;
- Coordinate closely at design stage;
- Enhance communication between all parties;
- Supervise works with an experienced and dedicated supervisor;
- Ensure that the design/specifications fall within the approved budget;
- Get information with regard to procurement procedure, material and plant;
- Carry out detail site investigation including detail soil investigations;
- Have the underground cable route confirm by the local authorities;
- Have the land application or land purchase completed before awarding contracts;
- Once the tender is awarded, make no changes to the specifications; and
- Place experienced and knowledgeable executives in the design department.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodology adopted and identifies the tools and techniques employed in conducting this study. The methodology describes the practical way in which the whole research project has been organized (Oliver, 2004). Methodology is a plan of action that shows how the problems will be investigated, what information will be collected using which methods, and how this information will be analyzed in order to arrive at conclusions and develop recommendations. Research follows some steps and procedures when conducted. Once the problem statement has been formulated, it should become evident what kind of data will be required to study the problem, and also what kind of analysis would be most appropriate to analyze the data (Walliman, 2005). The problem investigated in this study is the impact of variation orders on public building projects in Addis Ababa. It is anticipated that the identification of the causes of variation orders may lead to their reduction, possible elimination and improvement in overall performance of public building projects.

3.2 The Study Approach

The methods of data collection impact the analyses, the results, conclusions, values and validity of the study at the end. From the theoretical point of view, qualitative approach seeks to gain insights and understanding people's perceptions of the world. This research can be both qualitative and quantitative. It is qualitative, because the study focused to obtain the perceptions of public building construction stakeholders relative to the impact of variation orders. Desk studies were conducted on specific public building projects in Addis Ababa. The desk studies on the selected sites involved the observation of site documents project participants' opinion and the exploration of the physical works.

The study is also quantitative, because it focused on measurements (such as: high and low, often and seldom, similar and different) of the variables that identified from the literatures to get answers for the formulated questions.

In order to improve the validity of the findings of this research, the triangulation approach was adopted between the desk study, survey and the literatures. This approach consists of combinations of qualitative and quantitative methods strengthened with the literature review.

3.3 Population and Sampling

Due to the nature of data to be collected from the desk study and the expected participants for survey study, a non-probability sampling was preferred to be used. A purposive sampling method was adopted to select the population for the study.

In this study first a population of twenty eight (28) **(See Appendix B)** G+3 and above with and without basement public building projects, which were under construction in Addis Ababa from the commencement of work from July 2010 to the end of June 2012 G.C with more than 60% completed projects from different sectors were selected. The projects selected limiting their progress, work schedules and building height. All the twenty eight projects will be used in the study. The other populations were the stakeholders in the Addis Ababa city government public building projects namely clients (project owners), contractors and consultants to which the questionnaires were sent. These populations were selected depending on their direct exposure to the selected twenty eight public building project activities.

3.4 Data Collection

For a better understanding on the applicability of the various mechanisms used in assessing the impact of variation orders, data was collected using desk study and survey.

3.4.1 Desk Study

In order to have information on the stated problem, data was extracted from the project payment certificates and monthly progress reports. This helps to understand the relationship between the theories and actual practices in building projects. The data collected through the desk study was determined the worthiness of the topic for research.

3.4.2 Survey

3.4.2.1 Interviews

The interview was conducted face-to-face with the interviewee asking questions selected individuals. The interview is a useful technique for collecting data which would probably not be accessible using techniques such as observations and questionnaires. Semi-structured interview were conducted with senior project supervision and follow up team leader, a senior contract administrator, and a senior project manager to gather information on causes and

impacts of variation orders on public building projects as well as to look for recommendations if any to minimize them.

3.4.2.2 Questionnaire

Questionnaire is the simplest and time saving method to collect data effectively from a huge number of respondents. Formulating questions from the identified variables, the questionnaire was designed to gather data from professionals that were involved in public building projects in Addis Ababa. Closed-ended questions were formulated by allowing them to add other variables from their experience at the end of each section (**See Appendix A**). The respondents were asked to rate the questions on the five-point scale of ordinal measures as shown in **Figure 3.1** below. The questionnaire was structured in four sections as follows:

Section A: The category of organization in which the respondent serves, his/her role in the organization, and the respondent's working experience. Basically there were four questions in this section.

Section B: To obtain responses from respondents on the causes of variation orders on public building projects. The ranking of the responses was by using Likert's scale of five ordinal measures which arranged in ascending order from 1 to 5. This section included a total of 38 required responses.

Section C: To get responses from the respondents on the impact of variation orders on public building projects. The responses were ranked by using Likert's scale of five ordinal measures which arranged in ascending order from 1 to 5. A total of 15 required responses were included under this section.

Section D: To obtain responses from the respondents on the recommended strategies to minimize variation orders on public building projects. The responses were ranked by using Likert's scale of five ordinal measures which are arranged in ascending order from 1 to 5. This section included a total of 15 required responses.

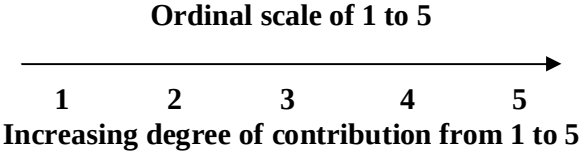

Figure 3.1: Five ordinal measures of agreement by Likert Scale

The questionnaires were hand-delivered to the respondents at their head offices and at project sites. The responses were received also by the same means. However, a face-to face delivery was preferred to motivate the respondents to participate and thereby improving the response rate for the study.

3.5 Method of Data Analysis

The responses to the questionnaire was based on Likert's scale of five ordinal measures which was from one 1 to five 5 arranged in ascending order according to the degree of contribution to each question.

The main approach used to analyze the data was by using the Relative Index (RI) technique. The responses are analyzed using the Microsoft Excel software package. The analysis included ranking the factors in terms of degree of effecting. In the computation of the relative index the following formula was used;

$$\mathbf{RI = \frac{(5n_5 + 4n_4 + 3n_3 + 2n_2 + n)}{5\,(n_5 + n_4 + n_3 + n_2 + n)}} \quad \ldots\ldots\ldots \quad \textbf{Equation 3.1}$$

Where:

RI: Relative Index

n5, n4, n3, … : number of responding indices.

The Spearman (rho) rank correlation coefficient is used for measuring the differences in ranking between two groups of respondents scoring for various factors (i.e. clients versus consultants, clients versus contractors, and consultants versus contractors).

The Spearman (rho) rank correlation coefficient for any two groups of ranking is given by the following formula:

$$\mathbf{Rho\ (\rho_{cal}) = 1 - \frac{6 \times (\sum d_i^2)}{N \times (N^2 - 1)}} \quad \ldots\ldots\ldots \quad \textbf{Equation 3.2}$$

Where:

Rho (ρ_{cal}): Spearman's rank correlation coefficient;

d_i: the difference in ranking between each pair of factors; and

N: number of factors (variables).

The value of the Spearman (rho) rank correlation coefficient varies between **-1** and **+1**. A correlation coefficient of ***+1*** implies perfect positive correlation, ***0*** implies no correlation and ***-1*** implies perfect negative correlation.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter analyses the data collected using questionnaires, desk study and interviews. The method used is discussed in Chapter 3. The collected data from the questionnaires were tabulated and analyzed according to their ranking on Relative Index (RI). Interviews from selected respondents are presented, together with observations from desk study. The objective of this chapter is to identify the highest ranked factors for discussion and to find correlation with findings from the interviews and desk study.

4.2 Analysis of Data from the Desk Study

During the study period, there were a total of thirty-eight (38) public building projects which were under execution in Addis Ababa and twenty-eight (28) project samples are taken for the study. From this number five (5) completed projects in which variation orders (VO) approved were selected for desk study in order to fully understand the causes and impacts of variation orders and to determine what recommendations or strategies could be taken to minimize variation orders on public building projects. These projects were 100% completed and selected as a representative to the occurrences of variation orders of each of the public building projects. The list of selected projects is as shown in **Table 4.1**.

Table 4.1: List of selected building projects

Project Code	Project Name	Contract Amount (Birr)	V.O (Birr)	Percent of V.O (%)
Project A	Sport Commission	51,931,227.89	8,284,485.09	15.95
Project B	Education Bureau	60,343,438.45	4,091,699.06	6.78
Project C	Police Commission	99,444,398.79	8,152,255.70	8.20
Project D	Credit & Savings Institution	36,914,578.87	7,234,368.3	19.60
Project E	Fire and Emergency Service	58,076,253.18	5,150,610.80	8.87

(Source: Addis Ababa Housing Development & Construction Bureau (2012))

4.2.1 Project A

The tender sum for Project A was 51,931,227.89Birr and the original planned works duration was 540 days. There were numerous additional works associated with design changes due to owner's requirement. During the observation of the project it was observed that additional partition walls were provided between the rooms. Items were missed on contract document for sanitary and electrical works. Due to these changes a variation of 8,284,485.09Birr was ordered. As the contractor could not finish on agreed time, the extension of time of 255 days was granted which was a time overrun of 47.22% over the schedule of works. No penalties were levied against the contractor.

4.2.2 Project B

Project B was awarded with a tender sum of 60,343,438.45Birr and the original planned works duration was 720 days. The project was exposed to variation due to design changes for the error made by the consultant. It was observed that civil site works were redesigned which incurred an extra cost. Items were missed on contract document for sanitary and electrical works. Due to these changes a variation of 4,091,699.06Birr was ordered. Due to lack of communication between the client and the consultant, dispute occurred between the client and consultant. Then the payment is delayed and the contractor was granted an extension time of 300 days which was a time overrun of 41.67% over the planned works duration.

4.2.3 Project C

The tender sum for Project C was 99,444,398.79Birr and the original planned works duration was 800 days. The project was exposed to variation order of 8,152,255.70Birr due to missed items on contract document, design modifications on civil site works, and design changes for roofing works. Modification of the civil site works took about five months to make decisions and submit the modified documents to the contractor. Due to this lack of decision making process by the client, the contractor was granted an extension time of 285 days which was a time overrun of 35.63% over the schedule of works.

4.2.4 Project D

Project D was awarded with a tender sum of 36,914,578.87Birr and the original planned works duration was 600 days. The project was exposed to variation order of 7,234,368.30Birr

due to additional works on civil site, missed items on contract document and design modifications on door and window works which caused by design errors made by the consultant. The client ordered the contractor to execute the additional works, the missed items and the works to be modified. Due to lack of decision making process, the client did not submit the modified deign at the right time to the contractor. The interim payment to the contractor is also delayed due to the additional works which totally affected payment for the other activities. Due to this reason the project was delayed which caused by the client and the contractor was granted an extension time of 245 days which was a time overrun of 40.83% over the schedule of works.

4.2.5 Project E

The tender sum for Project E was 58,076,253.18Birr and the original planned works duration was 540 days. A variation of 5,150,610.80Birr was ordered due to missed items on contract document. The client did not approve the variation at their earliest with the right decision. The contractor was granted an extension of time of 285 days which was a time overrun of 52.78% over the planned works duration. The client's records were silent relative to the reason for such an extension except the missed items on the contract document.

Table 4.2: Summary of causes and impact of variation orders data from the desk study

Project	Causes of V.O	Impact of V.O
Project A	• Design changes • Incomplete contract document	• Increase in project cost • Completion schedule delay
Project B	• Modification of design • Incomplete contract document and drawings • Lack of communication between parties	• Increase in project cost • Completion schedule delay • Disputes among the parties • Payment delay to the contractor
Project C	• Design changes • Incomplete contract document • Modification of design • Lack of decision making by the client	• Increase in project cost • Completion schedule delay
Project D	• Additional works • Incomplete contract document • Modification of design	• Increase in project cost • Completion schedule delay • Payment delay to the contractor
Project E	• Incomplete contract document • Lack of decision making by the client	• Increase in project cost • Completion schedule delay

4.2.6 Findings from the Desk Study

The desk study was applied to five selected documents of public building projects contract documents. The contract documents were massive with data, information, contract, bill of quantities and drawings. The studied documents were signed, stamped and legal documents at law.

4.2.6.1 Causes of Variation Orders

The desk study findings showed that fourteen (14) causes of variation orders in answering the first objective. Due to the repetition, it was further syntheses to eight (8) from the most to the least repetitive causes of variation orders to be used in questionnaire for the verification and validation process to evaluate their degree of important. But all the eight causes were already the domain of the variables which identified from the literatures review. Below is the document study finding of summary of causes of variation orders from the five projects contract documents as shown in **Table 4.3.**

Table 4.3: Causes of variation orders from the desk study

S.N	Causes of Variation Orders
1	Design changes
2	Incomplete contract documents
3	Incomplete working drawings
4	Errors in design by the consultant
5	Design modification
6	Non-compliant design with owner's requirement
7	Lack of communication between the parties
8	Lack of decision making process by the client

4.2.6.2 Impact of Variation Orders

From the document study findings, the following are summary of the impacts of variation orders shown in **Table 4.4**. Thirteen (13) impacts were identified in answering the second objective. And these variables were further syntheses to four (4) in ascending order of their prepetition which were be used in the questionnaire for the verification and validation process to evaluate their degree of important. But all the variables were in the literatures review.

Table 4.4: Impacts of variation from the desk study

S.N	Impacts of Variation Orders
1	Increase in project cost
2	Completion schedule delay
3	Payment delay to the contractor
4	Disputes among the involved parties

4.3 Interviews

4.3.1 Analysis of Data from the Interview

These interviews were made between selected construction industry practitioners who are currently involved in public building projects focusing on their perceptions on variations orders. In total three interviews were conducted, namely with a senior project supervision and follow up team leader (A) from the clients' group, a senior contract administrator (B) from the consultants', and a senior project manager (C) from the contractors' group as shown in **Table 4.5** below. The interview aimed at discovering the causes of variation orders and their impacts on public building projects and to seek recommendations to minimize their occurrence.

Table 4.5: Interview results

Questions	Interviewee A	Interviewee B	Interviewee C
From your experience, what are the causes of variation orders on public building projects?	▪ Incomplete BoQ ▪ Design changes and modification ▪ Errors in design ▪ Change in specifications ▪ Lack of communication between parties	▪ Design Changes ▪ Change in specification ▪ Incomplete BoQ ▪ Unforeseen conditions on site ▪ Lack of coordination	▪ Discrepancy between drawing and BoQ ▪ Non-compliant design with client's requirement ▪ Lack of experience ▪ Errors in design ▪ Design complexity ▪ Lack of judgment
What are the various impacts of variation orders on public building projects?	▪ Increase in project cost ▪ Completion schedule delay ▪ Degrades quality	▪ Disputes among the professionals ▪ Increase in project cost ▪ Completion schedule delay ▪ Rework and demolition	▪ Increase in contract and over head costs ▪ Disputes among parties ▪ Completion schedule delay
What do you suggest to minimize the variation orders on public building projects?	▪ Produce a complete design and contract document ▪ Prepare a completed detail drawings ▪ There should be communication between parties	▪ Designs should be complete at tender stage ▪ Carry out detail site investigation before tendering stage ▪ Forecast unforeseen situations before tendering	▪ Prepare a complete drawing and contract document before tendering stage ▪ Completed detail drawings should be submitted on time ▪ Works should be supervised with experienced supervisors

4.3.2 Findings from the Interview

From the interview sixteen (16) causes of variation orders in answering the first question, ten (10) impacts of variation orders for the second question and nine (9) strategies to minimize variation orders in answering the third question were identified. These variables were merged and checked if they were out of the literatures in order to include them in the questionnaire. But more of them with the same meaning were the domain of the variables identified from the literatures.

The findings from the interview revealed that incomplete contract document, design changes, change in specifications, errors in design, unforeseen conditions, design complexity, lack of communication and coordination between the parties, lack of experience and of judgment were the causes which contribute to the occurrence of variation orders.
As identified from the interview, the impacts of variation orders which frequently occur on public building projects were increase in project cost, most of the time which termed as cost overrun, completion schedule delay termed as time overrun, disputes among the parties, it degrades quality and it results in rework and demolition.

The interviewee suggested that it is possible to minimize the occurrence variation orders with the most common strategies which always pointed out by experienced construction practitioners. According to the interviewee, a complete design and contract documents should be produced, complete detail drawings should be submitted on time, a detail site investigation should be carried out and unforeseen conditions should be forecasted before the tendering stage and supervising the works with experienced supervisors can minimize variation orders on public building projects.

4.4 Analysis of Data from the Questionnaires

4.4.1 Rate of Response

The respondents were grouped into three major groups namely client, consultant and contractor. The returns from the three groups are tabulated in **Table 4.6** below which shows an average response rate. Out of 45 targeted responses, only 32 (71%) of them completed and returned the questionnaire. Thirty one questionnaires from 9 clients, 4 consultants and 19 contractors were received.

Table 4.6: Questionnaire return rate

Group	Number of Questionnaires distributed	Number of Questionnaires Returned	Response Rate (%)
Client	12	9	75
Consultant	5	4	80
Contractor	28	19	68
Total	**45**	**32**	**71**

4.4.2 Respondents' Background

Among the nine responses received from clients, seven (78%) of them were construction supervisors and follow-up engineers while two (22%) were contract administrators.

Among the four responses received from consultants, three (75%) of them were resident engineers and one (25%) was contract administrator. And among the nineteen responses received from contractors, eight (42%) of them were project managers, eight (42%) of them were office engineers, three (16%) were quantity surveyors. **Figure 4.1** below shows the composition of respondents by their position in their organization.

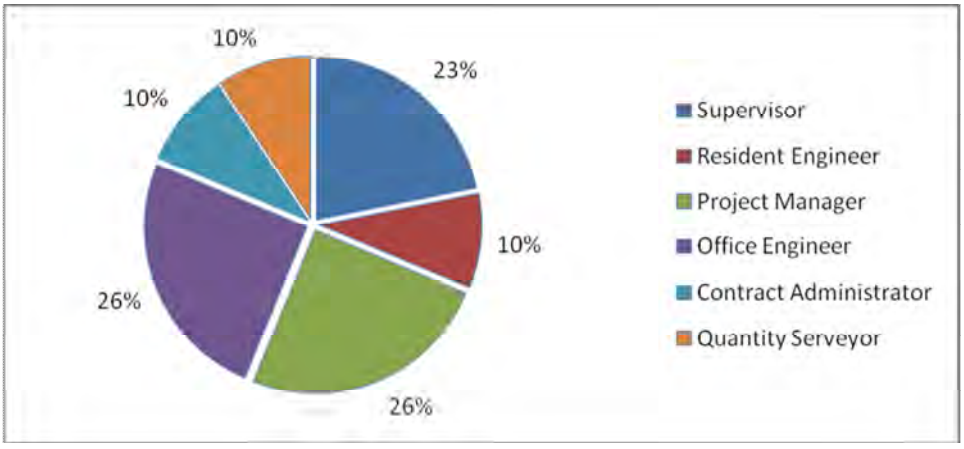

Figure 4.1: Position of respondents

4.4.3 Respondents' Experience

All the respondents have different levels of work experience in building projects. Proportions of the respondents in terms of number of years of involvement in building projects are tabulated in **Table 4.7.** It was observed that the majority of the respondents from the clients have between five to ten years of experience. Majority of the respondents from the consultants have also between five to ten years of experience. And about one half of the respondents from the contractors have less than five years of experience.

Table 4.7: Respondents' experience

Experience in Building Projects	Client	Consultant	Contractor	Total
Less than 5 years	3	1	12	16
5 to 10 years	4	2	3	9
10 years and above	2	1	4	7

4.4.4 Findings from the Questionnaires

In the structured part of the questionnaire, the respondents were asked to rate the degree of contribution of the variables drawn from the literature review. Furthermore, the respondents were also asked to add other variables or factors that contributed to the causes and impacts as well as recommendations that they perceived as being necessary. The responses were analyzed using the Microsoft Excel software package.

From the forty five (45) causes of variation identified from the literatures, only thirty-eight (38) mutually exclusive causes of variation orders, fifteen (15) impacts of variation orders and fifteen (15) strategies to minimize variation orders on building projects were used in questionnaire survey. All the impacts of variation orders and the suggested strategies to minimize them were used as identified from the literatures. The analysis was divided in to three groups the clients' point of view, the consultants' point of view and the contractors' point of view and a correlation test was done between the groups. A ranking system using the Relative Index (RI) method was calculated to find the most significant factor for each section. The value of RI ranges from 0.2 to 1. The value 0.2 represents the lowest strength and the value 1 representing the maximum strength.

4.4.4.1 Causes of Variation Orders on Public Building Projects

The frequency of the causes of variation orders were identified by using a 5 point Likert scale, namely Never = 1; Seldom = 2; Sometimes = 3, Often = 4; and Always = 5. The causes of variation orders were ranked by comparing their relative index.

I. Clients Group

From **Table 4.8** below, it was possible to rank the causes of variation orders by comparing their RI. According to the clients, impediment in prompt decision making process, change in design by the consultant, errors and omissions in design, inadequate working drawing details, and unforeseen problems were the most ranking causes of variation which dominate with equal value (RI=0.667) followed by change in specifications, conflicts between contract documents, and design discrepancies (RI=0.644). And health and safety consideration was the least ranked cause of variation orders.

Table 4.8: Frequency of causes of variation orders from the clients group

Causes of Variation Orders	RI of Client	Ranking
Impediment in prompt decision making process	0.667	1
Change in design by the consultant	0.667	2
Errors and omissions in design	0.667	3
Inadequate working drawing details	0.667	4
Unforeseen problems	0.667	5
Change in specifications	0.644	6
Conflicts between contract documents	0.644	7
Design discrepancies	0.644	8
Unavailability of skills	0.622	9
Contractor's desired profitability	0.622	10
Non-compliant design with owner's requirement	0.600	11
Lack of strategic planning	0.600	12
Change of schedule	0.578	13
Lack of coordination	0.578	14
Lack of consultant's knowledge of available materials and equipment	0.578	15
Lack of contractor's involvement in design	0.578	16
Poor procurement process	0.578	17
Consultant's lack of judgment and experience	0.556	18
Change of plans or scope	0.533	19
Technology change	0.533	20
Design complexity	0.533	21
Consultant's lack of required data	0.533	22
Honest wrong beliefs of contractor	0.533	23
Differing site conditions	0.511	24
Defective workmanship	0.511	25
Unfamiliarity with local conditions	0.511	26
Contractor's lack of required data	0.511	27
Non-compliant design with government regulations	0.489	28
Lack of communication	0.489	29
Inadequate project objectives	0.467	30
Lack of a specialized construction manager	0.467	31
Change in government regulations	0.467	32
Change in economic conditions	0.444	33
Fast track construction	0.422	34
Weather conditions	0.422	35
Honest wrong beliefs of consultant	0.400	36
Socio-cultural factors	0.400	37
Health and safety considerations	0.378	38

II. Consultants Group

As shown in **Table 4.9**, respondents of this group equally believed that change in economic conditions and unforeseen problems were the most ranking causes of variation orders (RI=0.800). Change of plans, change in specifications, and poor procurement process followed with equal value (RI=0.750) and then change of schedule (RI=0.700). According to the respondents of this category the least ranked cause of variation orders was honest wrong beliefs of consultant.

Table 4.9: Frequency of causes of variation orders from the consultants group

Causes of Variation Orders	RI of Consultant	Ranking
Change in economic conditions	0.800	1
Unforeseen problems	0.800	2
Change of plans or scope	0.750	3
Change in specifications	0.750	4
Poor procurement process	0.750	5
Change of schedule	0.700	6
Design discrepancies	0.700	7
Lack of contractor's involvement in design	0.700	8
Lack of communication	0.700	9
Honest wrong beliefs of contractor	0.700	10
Lack of strategic planning	0.700	11
Change in design by the consultant	0.650	12
Errors and omissions in design	0.650	13
Contractor's desired profitability	0.650	14
Differing site conditions	0.650	15
Unfamiliarity with local conditions	0.650	16
Contractor's lack of required data	0.650	17
Impediment in prompt decision making process	0.600	18
Design complexity	0.600	19
Unavailability of skills	0.600	20
Lack of a specialized construction manager	0.600	21
Weather conditions	0.600	22
Health and safety considerations	0.600	23
Inadequate project objectives	0.550	24
Conflicts between contract documents	0.550	25
Inadequate working drawing details	0.550	26
Consultant's lack of judgment and experience	0.550	27
Non-compliant design with government regulations	0.550	28
Non-compliant design with owner's requirement	0.550	29
Defective workmanship	0.550	30
Fast track construction	0.550	31
Socio-cultural factors	0.550	32
Technology change	0.500	33
Lack of coordination	0.500	34
Consultant's lack of required data	0.500	35
Change in government regulations	0.500	36
Lack of consultant's knowledge of available materials	0.450	37
Honest wrong beliefs of consultant	0.400	38

III. Contractors Group

From **Table: 4.10** below, the most cause of variation according to these respondents lack of communication (RI=0.726). The second ranked cause was inadequate working drawing details (RI=0.695), followed by impediment in prompt decision making process and poor procurement process (RI=0.684) and then change in design by the consultant (RI=0.674). Health and safety consideration was the least ranked cause of variation orders.

Table 4.10: Frequency of causes of variation orders from the contractors group

Causes of Variation Orders	RI of Contractor	Ranking
Lack of communication	0.726	1
Inadequate working drawing details	0.695	2
Impediment in prompt decision making process	0.684	3
Poor procurement process	0.684	4
Change in design by the consultant	0.674	5
Change of plans or scope	0.663	6
Lack of contractor's involvement in design	0.663	7
Contractor's desired profitability	0.663	8
Change in specifications	0.653	9
Errors and omissions in design	0.653	10
Contractor's lack of required data	0.653	11
Change of schedule	0.642	12
Consultant's lack of judgment and experience	0.642	13
Lack of consultant's knowledge of available materials	0.642	14
Consultant's lack of required data	0.642	15
Design discrepancies	0.642	16
Lack of a specialized construction manager	0.642	17
Lack of strategic planning	0.632	18
Unforeseen problems	0.621	19
Lack of coordination	0.611	20
Differing site conditions	0.600	21
Defective workmanship	0.600	22
Unfamiliarity with local conditions	0.600	23
Conflicts between contract documents	0.589	24
Change in economic conditions	0.579	25
Design complexity	0.568	26
Non-compliant design with owner's requirement	0.568	27
Honest wrong beliefs of contractor	0.547	28
Unavailability of skills	0.537	29
Weather conditions	0.526	30
Technology change	0.516	31
Honest wrong beliefs of consultant	0.516	32
Non-compliant design with government regulations	0.516	33
Inadequate project objectives	0.495	34
Socio-cultural factors	0.484	35
Fast track construction	0.474	36
Change in government regulations	0.442	37
Health and safety considerations	0.411	38

The spearman correlation coefficient is calculated using **Equation 3.2** and tabulated as shown below in **Table 4.11.**

Table 4.11: Summary of correlation test on the ranking of causes of variation orders

Respondents	**Rho(ρ_{cal}) = 1 – $\frac{6x(\sum d_i^2)}{N x (N^2 - 1)}$**	**Relation of the respondents**
Client Vs Consultant	0.999	strong
Consultant Vs Contractor	1.000	strong
Client Vs Contractor	1.000	strong

From the correlation table above, it can be concluded that there is a strong correlation between the attitudes of the respondents in all the three groups. This means that most of the respondents have the same perception about the causes of variation orders.

IV. Overall Responses

As sown in **Table: 4.12** below, it was possible to rank the causes of variation orders combining the responses of all respondents. The most raked causes of variation orders by all respondents were impediment in prompt decision making process, change in design by the consultant, and inadequate working drawing details dominate with the same value (RI=0.669). Change in specifications and poor procurement process came next with equal value (RI=0.663). Errors and omissions in design, lack of communication and unforeseen problems followed with the same value (RI=0.656) and then design discrepancies and contractor's desired profitability (RI=0.650). Change in government regulations (RI=0.456) and health and safety considerations (RI=0.425) were the least ranked causes of variation orders.

Table 4.12: Overall frequency of causes of variation orders

Causes of Variation Orders	Overall RI	Ranking
Impediment in prompt decision making process	0.669	1
Change in design by the consultant	0.669	2
Inadequate working drawing details	0.669	3
Change in specifications	0.663	4
Poor procurement process	0.663	5
Errors and omissions in design	0.656	6
Lack of communication	0.656	7
Unforeseen problems	0.656	8
Design discrepancies	0.650	9
Contractor's desired profitability	0.650	10
Lack of contractor's involvement in design	0.644	11
Change of plans or scope	0.638	12
Change of schedule	0.631	13
Lack of strategic planning	0.631	14
Contractor's lack of required data	0.613	15
Consultant's lack of judgment and experience	0.606	16
Conflicts between contract documents	0.600	17
Lack of consultant's knowledge of available materials	0.600	18
Consultant's lack of required data	0.594	19
Lack of coordination	0.588	20
Lack of a specialized construction manager	0.588	21
Differing site conditions	0.581	22
Unfamiliarity with local conditions	0.581	23
Non-compliant design with owner's requirement	0.575	24
Unavailability of skills	0.569	25
Defective workmanship	0.569	26
Change in economic conditions	0.569	27
Design complexity	0.563	28
Honest wrong beliefs of contractor	0.563	29
Technology change	0.519	30
Non-compliant design with government regulations	0.513	31
Weather conditions	0.506	32
Inadequate project objectives	0.494	33
Honest wrong beliefs of consultant	0.469	34
Fast track construction	0.469	35
Socio-cultural factors	0.469	36
Change in government regulations	0.456	37
Health and safety considerations	0.425	38

4.4.4.2 Impact of Variation Orders on Public Building Projects

The impact of variation orders on building projects was determined using a 5 point Likert scale, namely No impact = 1; Low impact = 2; Medium impact = 3; High impact = 4; and Very high impact = 5. The impact of variation orders were ranked by comparing their relative index.

I. Clients Group

From **Table: 4.13** below, the respondents of this group responded that the most impact of variation order was completion schedule delay (RI=0.822) followed by increase in project cost (RI=0.778).Additional payments for contractor was the third ranked impact (RI=0.733) and disputes among the parties was the forth. Fifthly progress is affected according to the clients followed by delay in payment and logistics delays with equal value (RI = 0.622). Productivity degradation and blemish firm's reputation were the least impact of variation orders on building projects with equal value (RI = 0.422).

Table 4.13: Frequency of impact of variation orders from the clients group

Impact of variation orders	RI of Client	Ranking
Completion schedule delay	0.822	1
Increase in project cost	0.778	2
Additional payments for contractor	0.733	3
Disputes among professionals	0.667	4
Progress is affected	0.644	5
Delay in payment	0.622	6
Logistics delays	0.622	7
Increase in overhead expenses	0.600	8
Procurement delay	0.578	9
Rework and demolition	0.556	10
Poor professional relations	0.511	11
Quality degradation	0.489	12
Poor safety conditions	0.444	13
Productivity degradation	0.422	14
Blemish firm's reputation	0.422	15

II. Consultants Group

As it can be seen **Table: 4.14** below, it was possible to rank the impacts of variation orders. The most raked impacts of variation orders by the consultants were increase in project cost, delay in payment, and completion schedule delay with equal value (RI=0.850). Progress affection came next (RI=0.800) and then increase in overhead expenses, rework and demolition, and logistics delays followed the rank (RI=0.700). Poor safety conditions and disputes among professionals with equal value (RI=0.600) were the least impacts of variation orders on public building projects.

Table 4.14: Frequency of impact of variation orders from the consultants group

Impact of variation orders	RI of Consultant	Ranking
Increase in project cost	0.850	1
Delay in payment	0.850	2
Completion schedule delay	0.850	3
Progress is affected	0.800	4
Increase in overhead expenses	0.750	5
Rework and demolition	0.750	6
Logistics delays	0.750	7
Procurement delay	0.700	8
Additional payments for contractor	0.700	9
Quality degradation	0.650	10
Productivity degradation	0.650	11
Blemish firm's reputation	0.650	12
Poor professional relations	0.650	13
Poor safety conditions	0.600	14
Disputes among professionals	0.600	15

III. Contractors Group

From the following **Table 4.15**, it was possible to rank the impacts of variation orders by comparing their RI. According to the contractors, completion schedule delay (RI=0.800) was the most ranked impact followed by increase in project cost (0.789). Progress affection (RI=0.768) and additional payments for contractor (RI=0.737) were the next most ranked impact (RI=0.768) and then increase in overhead expenses (RI=0.716). According to the contractors, poor safety conditions and poor professional relations were the least ranked impacts of variation orders with equal value (RI=0.579).

Table 4.15: Frequency of impact of variation orders from the contractors group

Impact of variation orders	RI of Contractor	Ranking
Completion schedule delay	0.800	1
Increase in project cost	0.789	2
Progress is affected	0.768	3
Additional payments for contractor	0.737	4
Increase in overhead expenses	0.716	5
Delay in payment	0.705	6
Procurement delay	0.705	7
Productivity degradation	0.674	8
Logistics delays	0.653	9
Disputes among professionals	0.653	10
Rework and demolition	0.642	11
Blemish firm's reputation	0.611	12
Quality degradation	0.600	13
Poor safety conditions	0.579	14
Poor professional relations	0.579	15

The spearman's correlation coefficient is calculated using **Equation 3.2** and tabulated as shown below in **Table 4.16.**

The summarized spearman correlation coefficient indicates that there is a strong correlation between all the three groups. This implies that most of the respondents have the same perception about the impact of variation orders.

Table 4.16: Summary of correlation test on the ranking of impact of variation orders

Respondents	$\text{Rho}(\rho_{cal}) = 1 - \frac{6x(\sum d_i^2)}{N x (N^2 - 1)}$	Relation of the respondents
Client Vs Consultant	0.994	strong
Consultant Vs Contractor	0.999	strong
Client Vs Contractor	0.997	strong

IV. Overall Responses

As it can be seen in **Table: 4.17** below, the most raked impacts of variation orders from the combined responses of all respondents were completion schedule delay (RI=0.794) followed by increase in project cost (RI=0.793). Additional payments for contractor (RI=0.742) and progress affection (RI=0.731) were the next and then increase in overhead expenses

(RI=0.697). Poor safety condition (RI=0.537) were the least ranked impact of variation orders as responded by all participants.

Table 4.17: Overall frequency of impact of variation orders

Impact of variation orders	Overall RI	Ranking
Completion schedule delay	0.794	1
Increase in project cost	0.793	2
Additional payments for contractor	0.742	3
Progress is affected	0.731	4
Increase in overhead expenses	0.697	5
Delay in payment	0.694	6
Procurement delay	0.679	7
Logistics delays	0.667	8
Disputes among professionals	0.661	9
Rework and demolition	0.642	10
Productivity degradation	0.594	11
Blemish firm's reputation	0.576	12
Quality degradation	0.566	13
Poor professional relations	0.560	14
Poor safety conditions	0.537	15

4.4.4.3 Recommended Strategies to Minimize Variation Orders

The frequency of recommended strategies to minimize variation orders on building projects was identified using a 5 point Likert scale, namely Unimportant = 1; Less important = 2; Important = 3; Very important = 4; and Very high important = 5.The impact of variation orders were ranked by comparing their relative index.

I. Clients Group

From **Table 4.18**, it was possible to rank the recommended strategies to minimize variation by comparing their RI. According to the client, the most ranked recommended strategy was drawings should be complete at tender stage (RI=0.933) followed by carry out detail site investigation including detail soil investigations and consider it during tendering stage (RI=0.867). Adequate planning in advance is required by all involved parties before works start on site come next (RI=0.844). The recommended strategy to have the land application or land purchase completed and finalized before awarding contracts and once the tender is

awarded, make no changes to the specifications with equal value (RI=0.667) were the least ranked recommendation to minimize variation orders.

Table 4.18: Frequency of recommended strategies from the clients group

Recommended Strategies to Minimize V.O	RI of Client	Ranking
Complete the drawings at tender stage	0.933	1
Carry out detail site investigation including detail soil investigations and consider it during tendering stage	0.867	2
All involved parties should plan adequately before works start on site	0.844	3
The consultant should produce a concluding design and contract documents	0.822	4
Spend adequate time on pre-tender planning phase	0.822	5
The consultant should co-ordinate closely at design stage	0.822	6
Supervise the works with an experienced and dedicated supervisor	0.822	7
Place experienced and knowledgeable executives in the engineering and design department	0.822	8
Consultants should ensure that the design/specifications fall within the approved budget	0.800	9
Clients should provide a clear brief of the scope of works	0.756	10
All parties should forecast unforeseen situations	0.756	11
Enhance communication between all parties	0.756	12
Get accurate information and research with regard to procurement procedure, material and plant	0.733	13
Once the tender is awarded, make no changes to the specifications	0.667	14
Have the land application or land purchase completed before awarding contracts	0.667	15

II. Consultants Group

From **Table: 4.19** below, the most ranked recommended strategy to minimize variation according to respondents of this category is adequate planning in advance is required by all involved parties before works start on site (RI=1.00). The next recommendations were to enhance communication between all parties, works should be supervised with an experienced and dedicated supervisor and carry out detail site investigation including detail soil investigations and consider it during tendering stage came next with equal value (RI=0.950).

Once the tender is awarded, there should be no changes to the specifications was the least ranked recommendation to minimize variation orders according to the consultants (0.650).

Table 4.19: Frequency of recommendations from the consultants group

Recommended Strategies to Minimize V.O	RI of Consultant	Ranking
All involved parties should plan adequately before works start on site	1.000	1
Enhance communication between all parties	0.950	2
Supervise the works with an experienced and dedicated supervisor	0.950	3
Carry out detail site investigation including detail soil investigations and consider it during tendering stage	0.950	4
The consultant should produce a concluding design and contract documents	0.900	5
Complete the drawings at tender stage	0.900	6
Spend adequate time on pre-tender planning phase	0.900	7
The consultant co-ordinate closely at design stage	0.900	8
Consultants should ensure that the design/specifications fall within the approved budget	0.900	9
Place experienced and knowledgeable executives in the engineering and design department	0.900	10
Clients should provide a clear brief of the scope of works	0.850	11
Get accurate information and research with regard to procurement procedure, material and plant	0.850	12
Have the land application or land purchase completed before awarding contracts	0.800	13
All parties should forecast unforeseen situations	0.750	14
Once the tender is awarded, make no changes to the specifications	0.650	15

III. Contractors Group

As shown in **Table: 4.20** below, the most ranked recommendation to minimize variation according to the contractors was adequate planning in advance is required by all involved parties before works start on site (RI=0.905) followed by the consultant should produce a concluding design and contract documents (RI=0.863) and then enhance communication between all parties (RI=0.842). According to these respondents, once the tender is awarded, there should be no changes to the specifications (RI=0.621) was the least ranked recommendation to minimize variation orders.

Table 4.20: Frequency of recommendations from the contractors group

Recommended Strategies to Minimize V.O	RI of Contractor	Ranking
All involved parties should plan adequately before works start on site	0.905	1
The consultant should produce a concluding design and contract documents	0.863	2
Enhance communication between all parties	0.842	3
The consultant should co-ordinate closely at design stage	0.832	4
Supervise the works with an experienced and dedicated supervisor	0.821	5
Consultants should ensure that the design/specifications fall within the approved budget	0.821	6
Place experienced and knowledgeable executives in the engineering and design department	0.821	7
All parties should forecast unforeseen situations	0.811	8
Get accurate information and research with regard to procurement procedure, material and plant	0.811	9
Complete the drawings at tender stage	0.789	10
Clients should provide a clear brief of the scope of works	0.789	11
Spend adequate time on pre-tender planning phase	0.779	12
Carry out detail site investigation including detail soil investigations and consider it during tendering stage	0.779	13
Have the land application or land purchase completed before awarding contracts	0.747	14
Once the tender is awarded, make no changes to the specifications	0.621	15

The spearman's correlation coefficient is calculated using **Equation 3.2** and tabulated as shown below in **Table 4.21.** The summarized spearman correlation coefficient indicates that there is a strong correlation between all the three groups. This means that most of the respondents have the same perception on the recommended strategies to minimize variation orders.

Table 4.21: Summary of correlation test on the ranking of recommendations

Respondents	$\text{Rho}(\rho_{cal}) = 1 - \frac{6x(\sum d_i^2)}{N \times (N^2 - 1)}$	Relation of the respondents
Client Vs Consultant	0.997	strong
Consultant Vs Contractor	0.998	strong
Client Vs Contractor	1.000	strong

IV. Overall Responses

From **Table: 4.22**, it was possible to rank the recommended strategy to minimize variation orders. The most raked strategy by all respondents were adequate planning in advance is required by all involved parties before works start on site (RI=0.900) followed by the consultant should produce a concluding design and contract documents (RI=0.856). Drawings should be complete at tender stage (RI=0.844) was the next. According to all the respondents, the least ranked strategy was once the tender is awarded, there should be no changes to the specifications (RI=0.638).

Table 4.22: Overall frequency of recommendations to minimize variation orders

Recommended Strategies to Minimize V.O	Overall RI	Ranking
All involved parties should plan adequately before works start on site	0.900	1
The consultant should produce a concluding design and contract documents	0.856	2
Complete the drawings at tender stage	0.844	3
The consultant should co-ordinate closely at design stage	0.838	4
Supervise the works with an experienced and dedicated supervisor	0.838	5
Enhance communication between all parties	0.831	6
Place experienced and knowledgeable executives in the engineering and design department	0.831	7
Consultants should ensure that the design/specifications fall within the approved budget	0.825	8
Carry out detail site investigation including detail soil investigations and consider it during tendering stage	0.825	9
Spend adequate time on pre-tender planning phase	0.806	10
Get accurate information and research with regard to procurement procedure, material and plant	0.794	11
Clients should provide a clear brief of the scope of works	0.788	12
All parties should forecast unforeseen situations	0.788	13
Have the land application or land purchase completed before awarding contracts	0.731	14
Once the tender is awarded, make no changes to the specifications	0.638	15

4.6 Discussion of Findings

This section presents the discussion of the study findings from the questionnaires, the desk study and the interview. The cause of variation orders, impact of variation orders and recommendations to minimize variation orders are discussed.

4.6.1 Causes of Variation Orders in Public Building Projects

From the questionnaires, the desk study and interview, the common causes of variation orders on public building projects were design changes and incomplete contract documents, which resulted from numerous additional works. The causes of variation orders were ranked in ascending order and the most frequent were identified.

As ranked on questionnaires response previously in **Table 4.12** it is clear that the first most causes of variation orders were impediment in prompt decision making process, change in design by the consultant, inadequate working drawing details, change in specifications, and poor procurement process.

The first major cause of variation orders was change in design by the consultant. This could also be caused due to the client change of mind. Design change is indeed one of the most causes of variation orders and this fact is supported by the interviewees and the observations in the desk study. This similarly confirms with the literature review that design change was one of the major causes of variation orders. As Ming *et al.* (2004) identified design change was the major causes of variation orders. The works of Ruben (2008) also listed that design change was one of the most causes of variation orders.

Incomplete contract document was the second major cause of variation orders. This occurs due to the client or the consultant work before tendering and it increases the project cost or schedule. Contract documents of most public projects done by the clients and it could be difficult to prepare a complete document because they are busy of work.

The third major cause of variation order was impediment in prompt decision making process, which is due to lack of judgment by the client or the consultant. There is no doubt that lack o decisions delay the project and causes the contractors to re-design the requirements, reschedule, their works and material procurement which would have an adverse impact on the project.

Inadequate working drawing details was the fourth major cause of variation order which is the out-come of the consultant. A well detailed working drawing is believed to decrease variation orders. Most professionals argue that a detailed working drawing should be prepared before the tender stage.

The fifth major cause of variation order was change in specifications which confirms with the literature review and the interview. In a design stage, it could be a failure to change the specification due to change of mind of the client or the consultant which results in variation orders. Consequently change in specifications can be the major cause. As reviewed in the literature part of this research Ruben (2008) listed that change in specifications among the major causes. Contrarily this was not the major causes in the desk study.

4.6.2 Impact of Variation Orders on Public Building Projects

According to the findings from the desk studies, completion schedule delay and increase in project cost are the most common impacts of variation orders. It was not unexpected for the project cost to increase due to frequent variations in the project. These impacts are also repeated on the questionnaire responses as shown and ranked previously in **Table 4.17**.

As it was found from the interview, completion schedule delay, increase in project cost, and disputes among parties were the most predominant impacts of variation orders.

From the responses of the questionnaire, completion schedule delay, increase in project cost, additional payments for contractor, progress is affected and increase in overhead expense were the most impacts of variation orders.

Completion schedule delay was the first major impact of variation orders in public building projects. According to the findings from the desk studies and the interview, completion schedule is the common impact on public building projects that increases the consistency of the response to conclude. Previously (Ibbs, 1997a) pointed out that completion schedule delay was a frequent result of variations in construction projects. This confirmed that variations impact the project adversely, leading to delays in the project completion.

The second major impact of variation orders was increase in project cost on public building projects which similarly confirms with the findings from the desk study and interview. Completion schedule delay and increase in project cost are also the major impacts as

reviewed in the literature part. For example Koushki (2005) found that variation orders impacted both the completion time and costs of projects. These impacts were due to detrimental variation orders since they negatively impacted the client's value. Any major additions or alterations in the design may eventually increase the project cost. It was not unexpected for the project cost to increase due to frequent variations in the project. This was because the variation orders may impact the project's total direct and indirect costs. Therefore, any major addition or alteration in the design may eventually increase the project cost. The findings from the respondents were also consistent with the observations from the desk study and interviews.

As the responses found from the questionnaire, additional payments for the contractor was the third major impact of variation orders. Additional payment for the contractor is the common impact when variation is ordered. As O'Brien (1998) described, variations are considered to be a common source of additional works for the contractor. This is because as the volume of work increases, payment to the contractor increases when the varied items are measured. This adds value to the contractor.

The fourth major impact was the effect on the progress. This impact was not uncommon that project progress can be affected due to variations. Since variation management passes through different processes, most clients do not approve variation orders on time and the contractor refuses to continue the work. The contractor can also need new materials, new equipments and specialized man power. These affect the project progress.

The fifth major impact of variation orders on public building projects was the increase in overhead expenses. This cost can be incurred directly or indirectly during the process and implementation of variation orders. Because the overhead expenses for all involved parities will increase as lots of professional and paper works need to be done. Arguably, the more the variation orders, the more likely they increase the overhead expenses especially to the contractor that impact public building projects.

4.6.3 Recommended Strategies to Minimize Variation Orders

According to the findings from the interview, the suggested recommendations by the interviewee were to carry out detail site investigation before tendering, to produce a complete design and contract documents, there should be communication between the parties, and

works should be supervised with a dedicated supervisor. These recommendations were also mostly ranked on the questionnaires response. As the interviewee pointed out, preparing complete detail drawings can reduce the risk of variation. Open communication among all parties involved in the project is the key to reduce variations. Experienced and dedicated supervisors can also reduce variation orders since they are not careless on the works they are assigned.

According to the findings from the questionnaires ranked previously in **Table 4.22** and the interview conducted, the first most recommended strategy was consultants should produce a concluding design and contract documents. The controls for the frequent change in design by consultant, and inadequate working drawing details would be through systematic detailing of design. This would provide an opportunity for the consultant to review and finalize the design during the design phase.

Completing drawings at tender stage was the second most recommended strategy to minimize variation orders. Any change or modification made later will result in an additional works which leads to variations. The design team should submit complete design for tendering. This would assist in reducing the occurrence of variations during the construction phase where the impact of variations can be severe on the project.

The third most recommended strategy was works should be supervised with an experienced and dedicated supervisor. This was because experienced supervisors can forecast what will happen on site through their past experience. They are also decision makers comparing the design and the actual site condition on the right time. Experienced supervisors are also responsible for their job and this surely helps to minimize variation orders on site.

Enhancing communication between all involved parties was the fourth most recommended strategy to minimize variation orders. Different parties involved in a project work differently, so a clear communication between the parties is necessary. This was because communication can increase project performance during the execution of a project.

The fifth most recommended strategy was to carry out detail site investigation including detail soil investigation and considering it during tendering. This was because the design and construction methodology varies from one site to the other. Even the same type of projects cannot be executed with the same cost and schedule due to difference in site conditions.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

5.1.1 Causes of variation orders on public building projects in Addis Ababa

The first objective of the study was to analyze the causes of variation orders on public building projects in Addis Ababa. The desk study of the five projects confirmed that the most frequent causes of variation orders on public building projects was design changes. According to the interview made between three selected construction practitioners involved in public building projects they pointed out that the main cause of variation orders was design changes.

Among 38 causes of variation orders, the responses received from the clients' showed that impediment in prompt decision making process, change in design by the consultant, errors and omissions in design, inadequate working drawing details, and unforeseen problems were the top five most frequent causes of variation orders on public building projects.

According to the consultants', the top five most frequent causes of variation orders on public building projects were change in economic conditions, unforeseen problems, change of plans or scope, change in specifications, and poor procurement process.

Regarding the contractors', the top five most frequent causes of variation orders on public building projects were lack of communication, inadequate working drawing details, impediment in prompt decision making process, poor procurement process, and change in design by the consultant.

From the overall responses, it was concluded that impediment in prompt decision making process, change in design by the consultant, inadequate working drawing details, change in specifications, and poor procurement process were the most important causes of variation orders on public building projects. And there was a strong correlation between ranking by client and consultant, client and contractor as well as consultant and contractor. This confirmed that most of the respondents have the same perception about the causes of variation orders on public building projects.

From the findings of the desk study, interview and questionnaire, change in design, incomplete contract documents, impediment in prompt decision making process, inadequate working drawing details, and change in specifications were the major causes of variations.

5.1.2 Impact of variation orders on public building projects in Addis Ababa

The second objective was to identify the various impacts of variation orders on public building projects in Addis Ababa. The study found that variation orders had an impact on public building projects. From the desk study of five projects, project A, project B, project C, project D and project E were exposed to variation orders amounting to 15.95%, 6.78%, 8.20%, 19.60% and 8.87% of the contract amount respectively. According to the data from the desk study, increase in project cost was the major impact on public building projects. The interviewee indicated that variation orders adversely impacted costs.

As it was analyzed from the desk study, project A, project B, project C, project D and project E experienced time overruns to 47.22%, 41.67%, 35.63%, 40.83% and 52.78% of the contract schedule respectively. The interviewee also pointed out that variation order also impacts the completion schedule of public building projects. It was argued that variation orders contributed to time overruns.

From the 15 impacts of variation orders, completion schedule delay, increase in project cost, additional payments for contractor, disputes among professionals, and effect on progress were the top five most frequent impacts of variation orders according to the responses of the clients'.

As consultants' responded, the top five most frequent impacts of variation orders were increase in project cost, delay in payment, completion schedule delay, effect on progress, and increase in overhead expenses.

According to the responses of the contractors', completion schedule delay, increase in project cost, effect on progress, additional payments for contractor, and increase in overhead expenses were the top five most frequent impacts of variation orders on public building projects.

From the overall responses received, it was concluded that the top most impacts of variation orders on public building projects were completion schedule delay, increase in project cost,

additional payments for contractor, effect on progress, and increase in overhead expenses. The correlation between ranking by client and consultant, client and contractor as well as consultant and contractor was strong. This indicated that most of the respondents have the same perception about the impact of variation orders on public building projects.

From the findings of the desk study, interview and the questionnaires, the major impacts of variation orders on public building projects were completion schedule delay, increase in project cost, additional payments for the contractor, effect on progress, and increase in overhead expenses.

5.1.3 Recommended strategies to minimize variation orders

The third objective was to suggest recommendations to minimize variation orders on public building projects in Addis Ababa. From the literatures, fifteen (15) strategies to minimize variation orders on building projects were identified. No recommended strategies were found from the document study and conclusion was based on the questionnaire survey and the interview to be able to suggest recommendations to minimize variation orders.

From the interview, it was repetitively suggested that designs and contract documents should be complete at the tender stage to minimize the occurrence of variation orders on public building projects.

The clients' responded that drawings should be complete at tender stage to minimize variation orders on building projects. Eventually, this may aid in eliminating the occurrence of variations, arising from errors and design discrepancies, during the construction stage where the impact of the variations can be severe.

The consultants' and the contractors' response argued on the strategy that states adequate planning in advance is required by all involved parties before works start on site to minimize variation orders. This was because a well planned project can eliminate variations that may arise due to lack of pre-project planning.

From the interview and overall responses received, it was therefore concluded that the following best five strategies were recommended to minimize variation orders on public building projects:

- The consultant should produce a concluding design and contract documents

- Drawings should be complete at tender stage
- Works should be supervised with an experienced and dedicated supervisor
- Enhance communication between all parties
- Carry out detail site investigation including detail soil investigations and consider it during tendering stage

5.2 Recommendations

This research focused on the assessment of variation orders in a few contracts of public building projects undertaken by city government of Addis Ababa. Based on the focused sector and how variation is minimized, the recommendations of this thesis are as follows:

- An understanding of the causes of variation orders would be helpful for building professionals in assessing variation orders.
- The client should allow sufficient time to prepare an elaborately detailed project brief. This will eliminate frequent variations to the original plan of the project due to client change of mind.
- Variations can be minimized if consultants produce a complete design as change of design was the major cause of variations in public building projects.
- Direct communication among the project team is a key to eliminate variations occur due to communication gap during design and execution phase.
- Consultants should give sufficient time for planning and design phase, this will assist in minimizing variation orders due design changes at construction stage.
- A detailed design would be able to exert control to unnecessary interference from consultants or other external influences.
- The consultants should prepare completed contract document before the tendering stage. This minimizes variation orders occur due to change of specifications.
- Contractors should identify and inform the varied item of work to the client before the activity starts to reduce variations. Because the client will have sufficient time to check the varied item in different perspectives to give work order at minimum variations.
- There should be improvement in project management, and improved decision making process on the part of the client during project execution stage so as to minimize the occurrence of variation orders.

- The study would assist professionals in taking proactive measures for minimizing variation orders in building projects.
- The results of this research should help construction practitioners, policy makers and researchers in the field of construction management.

Further areas of research recommended are as follows;

- Since this study focused on public building projects, it would be interesting to study the impact of variation orders in other building projects and compare the results.
- A more elaborative investigation into the contract conditions is needed with the view to minimizing impact of variation orders in public building projects.

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APPENDICES

APPENDIX A: QUESTIONNAIRE

AAiT
Addis Ababa University
Addis Ababa Institute of Technology
School of Graduate Studies
Department of Civil and Environmental Engineering

QUESTIONNAIRE

Assessing the Impact of Variation Orders on Public Building Projects in Addis Ababa

Detail of the Researcher:

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This research study titled **"Assessing the Impact of Variation Orders on Public Building Projects in Addis Ababa"** is undertaken by Andualem Endris at the Addis Ababa Institute of Technology, Civil and Environmental Engineering Department to assess the impact of variation orders on public building projects. Please answer **all** questions.

Thanks in advance for your co-operation and help!

Sincerely,

Andualem Endris

August 2013

SECTION A: ORGANIZATION AND RESPONDENT'S PROFILE

1. Which of the following best describes your company?

Company	**Tick one**
Client	
Consultant	
Contractor	
Other	

2. If your answer above was other, please specify:_____

3. Your current position in your organization:_____

4. Experience (please tick one):

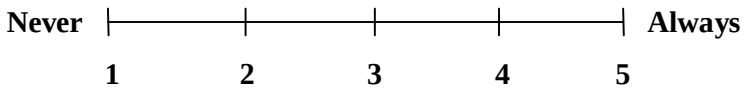
   ☐ Less than 5 years

   ☐ 5 to 10 years

   ☐ 10 years and above

SECTION B: CAUSES OF VARIATION ORDERS

Please indicate your level of agreement with the following questions on a scale 1 to 5.



Indicator: **1 = Never**

2 = Seldom

3 = Sometimes

4 = Often

5 = Always

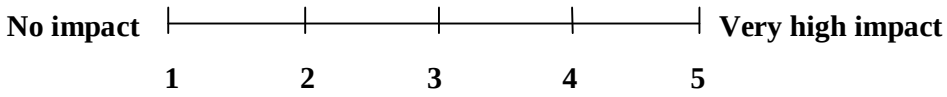
2. The following are examples of causes of variation orders. Based on your experience, indicate how frequently each of them occurs on public building projects.

S.N	Causes of Variation Orders	Never 1	2	3	4	Always 5
1	Change of plans or scope					
2	Change of schedule					
3	Inadequate project objectives					
4	Impediment in prompt decision making process					
5	Change in specifications					
6	Change in design by the consultant					
7	Errors and omissions in design					
8	Conflicts between contract documents					
9	Technology change					
10	Lack of coordination					
11	Design complexity					
12	Inadequate working drawing details					
13	Consultant's lack of judgment and experience					
14	Lack of consultant's knowledge of available materials					

S.N	Causes of Variation Orders *(continued)*	Never 1	2	3	4	Always 5
15	Honest wrong beliefs of consultant					
16	Consultant's lack of required data					
17	Design discrepancies					
18	Non-compliant design with government regulations					
19	Non-compliant design with owner's requirement					
20	Lack of contractor's involvement in design					
21	Unavailability of skills					
22	Contractor's desired profitability					
23	Differing site conditions					
24	Defective workmanship					
25	Unfamiliarity with local conditions					
26	Lack of a specialized construction manager					
27	Fast track construction					
28	Poor procurement process					
29	Lack of communication					
30	Honest wrong beliefs of contractor					
31	Lack of strategic planning					
32	Contractor's lack of required data					
33	Weather conditions					
34	Health and safety considerations					
35	Change in government regulations					
36	Change in economic conditions					
37	Socio-cultural factors					
38	Unforeseen problems					
	If any other causes of variation orders, please specify	**Never 1**	**2**	**3**	**4**	**Always 5**
41						
42						
43						
44						
45						
46						
47						
48						
49						
50						

SECTION C: IMPACT OF VARIATION ORDERS

Please indicate your level of agreement with the following questions on a scale 1 to 5.



Indicator: **1 = No impact**

2 = Low impact

3 = Medium impact

4 = High impact

5 = Very high impact

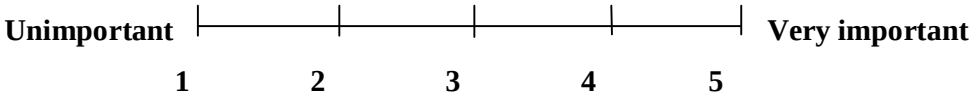
3. Following are list of impact variation orders. From your experience, what is the impact of variation orders on building projects?

S.N	Impact of Variation Orders	No impact 1	2	3	4	Very high impact 5
1	Increase in project cost					
2	Progress is affected					
3	Increase in overhead expenses					
4	Delay in payment					
5	Quality degradation					
6	Productivity degradation					
7	Procurement delay					
8	Rework and demolition					
9	Logistics delays					
10	Blemish firm's reputation					
11	Poor safety conditions					
12	Poor professional relations					
13	Additional payments for contractor					
14	Disputes among professionals					
15	Completion schedule delay					

	If any other impact of variation orders, please specify	**No impact**				**Very high impact**
		1	**2**	**3**	**4**	**5**
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

SECTION D: RECOMMENDATIONS TO MINIMIZE VARIATION ORDERS

Please indicate your level of agreement with the following questions on a scale 1 to 5.



Indicator: **1 = Unimportant**

2 = Less important

3 = Important

4 = Very important

5 = Very high important

4. Following are suggested strategies or recommendations used to minimize variation orders. From your experience, what is the best strategy action can be taken to minimize variation orders on building projects?

S.N	Recommendations to minimize variation orders	Un important				Very High important
		1	2	3	4	5
1	All involved parties should plan adequately before works start on site					
2	The consultant should produce a concluding design and contract documents					
3	Complete the drawings at tender stage					
4	Spend adequate time on pre-tender planning phase					
5	Clients should provide a clear brief of the scope of works					
6	All parties should forecast unforeseen situations					
7	The consultant should co-ordinate closely at design stage					
8	Enhance communication between all parties					
9	Supervise the works with an experienced and dedicated supervisor					
10	Consultants should ensure that the design/specifications fall within the approved budget					

S.N	ɔmmendations to minimize variation orders *(continued)*	Un important 1	2	3	4	Very high important 5
11	Get accurate information and research with regard to procurement procedure, material and plant					
12	Carry out detail site investigation including detail soil investigations and consider it during tendering stage					
13	Have the land application or land purchase completed before awarding contracts					
14	Once the tender is awarded, make no changes to the specifications					
15	Place experienced and knowledgeable executives in the engineering and design department					
	If you have any other recommendations to minimize variation orders, please specify	**Un important 1**	**2**	**3**	**4**	**Very high important 5**
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

Thank You!

APPERNDIX B: List of Public Building Projects for the Study

(Taken from Addis Ababa Housing Development and Construction Bureau (2012))

S.N	Projects	Building Height	Client	Consultant	Contractor	Remarks
1	Addis Ababa City Administration Education bureau	G+12	AAHDCB	MGM PLC	AMB Con. PLC	*Selected for desk study*
2	Addis Credit and Savings institution, HQ	G+7	AAHDCB	AAHDCB	AMB Con. PLC	*Selected for desk study*
3	Addis Ketema sub-city Administration office	G+10	AAHDCB	AAHDCB	Orbit Con. PLC	
4	Akaki-Kaliti TVET additional Block 1	G+4	AAHDCB	AAHDCB	Demera Con. PLC	
5	Akaki-Kaliti TVET additional Block 2	G+4	AAHDCB	AAHDCB	"	
6	Akaki-Kalitti sub-city Administration office	G+12	AAHDCB	MGM PLC	Yirgalem Con.	
7	Arada Sub-city Fire and Emergency service	G+7	AAHDCB	AAHDCB	GIGA Con. PLC	*Selected for desk study*
8	Bole sub-city Administration office	G+10	AAHDCB	AAHDCB	Rama Con. PLC	
9	Endode secondary school additional block	G+4	AAHDCB	AAHDCB	T/Haimanot BC	
10	Environmental Conservation Authority bureau	G+7	AAHDCB	AAHDCB	Pyramid Con. PLC	
11	Gandi hospital additional building	G+4	AAHDCB	AAHDCB	Etete Con. PLC	
12	Gandi Memorial hospital Maternity block	G+4	AAHDCB	AAHDCB	Etete Con. PLC	
13	Justice Bureau	G+12	AAHDCB	AAHDCB	Tewodros A, BC	
14	Kotebe teachers college additional block 1	G+4	AAHDCB	AAHDCB	Meven Con	
15	Kotebe teachers college additional block 2	G+4	AAHDCB	AAHDCB	Radar Con. PLC	
16	Kotebe teachers college additional block 3	G+4	AAHDCB	AAHDCB	"	
17	Kotebe teachers college additional block 4	G+4	AAHDCB	AAHDCB	"	
18	Menelik Hospital additional building	G+7	AAHDCB	AAHDCB	Afro-Tsion PLC	
19	Police Commission head office	G+7	AAHDCB	AAHDCB	GIGA Con. PLC	*Selected for desk study*
20	Ras Desta hospital Maternity block	G+4	AAHDCB	AAHDCB	Melaku con.	
21	Sport Commission	G+12	AAHDCB	AAHDCB	GIGA Con. PLC	*Selected for desk study*
22	Tegbareid TVET College building	G+7	AAHDCB	AAHDCB	Pyramid Con. PLC	
23	Ye Abeboch Fire elem. school additional block	G+4	AAHDCB	AAHDCB	T/Haimanot BC	
24	Yeka sub-city Administration office	G+12	AAHDCB	MGM PLC	Zamra Con. PLC	
25	Yekatit 12 Hospital building	G+7	AAHDCB	AAHDCB	GIGA Con. PLC	
26	Yekatit 12 hospital Maternity block	G+4	AAHDCB	AAHDCB	Tewodros B, BC	
27	Youths and children theatre	G+11	AAHDCB	MGM PLC	GIGA Con. PLC	
28	Zewditu Memorial hospital additional building	G+12	AAHDCB	AAHDCB	Safer Con. PLC	

APPERNDIX C: Clients' responses for causes of variation orders

Factor Description	Frequency Analysis (FA)				
	Never	Seldom	Some times	Often	Always
Change of plans or scope	1	2	5	1	0
Change of schedule	0	4	2	3	0
Inadequate project objectives	2	4	1	2	0
Impediment in prompt decision making process	0	3	1	4	1
Change in specifications	0	2	4	2	1
Change in design by the consultant	0	1	5	2	1
Errors and omissions in design	0	1	4	4	0
Conflicts between contract documents	0	2	3	4	0
Technology change	1	3	3	2	0
Lack of coordination	0	4	2	3	0
Design complexity	0	4	4	1	0
Inadequate working drawing details	0	1	4	4	0
Consultant's lack of judgment and experience	1	2	4	2	0
Lack of consultant's knowledge of available materials	0	3	4	2	0
Honest wrong beliefs of consultant	2	5	2	0	0
Consultant's lack of required data	0	4	4	1	0
Design discrepancies	0	1	5	3	0
Non-compliant design with government regulations	2	3	2	2	0
Non-compliant design with owner's requirement	0	1	7	1	0
Lack of contractor's involvement in design	1	2	4	1	1
Unavailability of skills	0	0	8	1	0
Contractor's desired profitability	0	2	4	3	0
Differing site conditions	1	2	6	0	0
Defective workmanship	2	2	3	2	0
Unfamiliarity with local conditions	1	4	2	2	0
Lack of a specialized construction manager	2	3	3	1	0
Fast track construction	2	4	3	0	0
Poor procurement process	2	0	4	3	0
Lack of communication	1	4	3	1	0
Honest wrong beliefs of contractor	1	3	3	2	0
Lack of strategic planning	1	2	2	4	0
Contractor's lack of required data	2	2	3	2	0
Weather conditions	1	6	2	0	0
Health and safety considerations	3	4	2	0	0
Change in government regulations	2	3	3	1	0
Change in economic conditions	1	5	3	0	0
Socio-cultural factors	3	3	3	0	0
Unforeseen problems	0	2	4	1	2

APPERNDIX D: Consultants' responses for causes of variation orders

Factor Description	Frequency Analysis (FA)				
	Never	Seldom	Sometimes	Often	Always
Change in economic conditions	0	0	1	2	1
Unforeseen problems	0	0	2	0	2
Change of plans or scope	0	0	2	1	1
Change in specifications	0	1	0	2	1
Poor procurement process	0	0	1	3	0
Change of schedule	0	0	2	2	0
Design discrepancies	0	0	2	2	0
Lack of contractor's involvement in design	0	0	2	2	0
Lack of communication	0	0	2	2	0
Honest wrong beliefs of contractor	0	0	2	2	0
Lack of strategic planning	0	1	0	3	0
Change in design by the consultant	0	1	1	2	0
Errors and omissions in design	0	1	1	2	0
Contractor's desired profitability	0	1	1	2	0
Differing site conditions	0	1	1	2	0
Unfamiliarity with local conditions	0	1	1	2	0
Contractor's lack of required data	0	1	1	2	0
Impediment in prompt decision making process	0	1	2	1	0
Design complexity	0	2	0	2	0
Unavailability of skills	0	1	2	1	0
Lack of a specialized construction manager	0	1	2	1	0
Weather conditions	0	1	2	1	0
Health and safety considerations	0	1	2	1	0
Inadequate project objectives	0	2	1	1	0
Conflicts between contract documents	0	1	3	0	0
Inadequate working drawing details	0	2	1	1	0
Consultant's lack of judgment and experience	0	2	1	1	0
Non-compliant design with government regulations	0	2	1	1	0
Non-compliant design with owner's requirement	0	3	0	0	1
Defective workmanship	0	2	1	1	0
Fast track construction	0	2	1	1	0
Socio-cultural factors	0	1	3	0	0
Technology change	1	1	1	1	0
Lack of coordination	0	3	0	1	0
Consultant's lack of required data	0	2	2	0	0
Change in government regulations	0	2	2	0	0
Lack of consultant's knowledge of available materials	1	2	0	1	0
Honest wrong beliefs of consultant	1	2	1	0	0

APPERNDIX E: Contractors' responses for causes of variation orders

Factor Description	Frequency Analysis (FA)				
	Never	Seldom	Some times	Often	Always
Lack of communication	0	2	6	8	3
Inadequate working drawing details	2	2	6	3	6
Impediment in prompt decision making process	0	3	9	3	4
Poor procurement process	0	3	6	9	1
Change in design by the consultant	0	3	9	4	3
Change of plans or scope	0	4	6	8	1
Lack of contractor's involvement in design	1	4	6	4	4
Contractor's desired profitability	1	4	5	6	3
Change in specifications	0	5	4	10	0
Errors and omissions in design	0	5	6	6	2
Contractor's lack of required data	1	3	6	8	1
Change of schedule	1	2	8	8	0
Consultant's lack of judgment and experience	3	1	7	5	3
Lack of consultant's knowledge of available materials	2	3	5	7	2
Consultant's lack of required data	0	3	9	7	0
Design discrepancies	1	3	7	7	1
Lack of a specialized construction manager	1	2	9	6	1
Lack of strategic planning	0	6	6	5	2
Unforeseen problems	1	3	10	3	2
Lack of coordination	2	4	7	3	3
Differing site conditions	1	4	8	6	0
Defective workmanship	1	6	6	4	2
Unfamiliarity with local conditions	0	5	10	3	1
Conflicts between contract documents	2	3	10	2	2
Change in economic conditions	3	5	4	5	2
Design complexity	3	4	6	5	1
Non-compliant design with owner's requirement	2	3	12	0	2
Honest wrong beliefs of contractor	3	5	5	6	0
Unavailability of skills	2	3	13	1	0
Weather conditions	2	6	9	1	1
Technology change	1	10	5	2	1
Honest wrong beliefs of consultant	4	4	8	2	1
Non-compliant design with government regulations	2	5	11	1	0
Inadequate project objectives	4	5	7	3	0
Socio-cultural factors	1	12	4	1	1
Fast track construction	3	7	8	1	0
Change in government regulations	6	7	3	2	1
Health and safety considerations	8	4	5	2	0

APPERNDIX F: Clients' responses for impacts of variation orders

Factor Description	Frequency Analysis (FA)				
	No	**Low**	**Medium**	**High**	**Very High**
Completion schedule delay	0	1	0	5	3
Increase in project cost	0	1	2	3	3
Additional payments for contractor	1	0	2	4	2
Disputes among professionals	1	1	3	2	2
Progress is affected	0	2	5	0	2
Delay in payment	1	3	1	2	2
Logistics delays	0	2	4	3	0
Increase in overhead expenses	0	2	5	2	0
Procurement delay	0	2	6	1	0
Rework and demolition	2	2	2	2	1
Poor professional relations	1	3	4	1	0
Quality degradation	1	4	3	1	0
Poor safety conditions	1	5	3	0	0
Productivity degradation	2	4	3	0	0
Blemish firm's reputation	1	6	2	0	0

APPERNDIX G: Consultants' responses for impacts of variation orders

Factor Description	Frequency Analysis (FA)				
	No	**Low**	**Medium**	**High**	**Very High**
Increase in project cost	0	0	1	1	2
Delay in payment	0	0	0	3	1
Completion schedule delay	0	0	1	1	2
Progress is affected	0	0	1	2	1
Increase in overhead expenses	0	0	1	3	0
Rework and demolition	0	0	1	3	0
Logistics delays	0	0	1	3	0
Procurement delay	0	0	2	2	0
Additional payments for contractor	0	1	1	1	1
Quality degradation	0	1	1	2	0
Productivity degradation	0	1	2	0	1
Blemish firm's reputation	0	1	1	2	0
Poor professional relations	0	1	1	2	0
Poor safety conditions	0	1	2	1	0
Disputes among professionals	0	1	2	1	0

APPERNDIX H: Contractors' responses for impacts of variation orders

Factor Description	Frequency Analysis (FA)				
	No	Low	Medium	High	Very High
Completion schedule delay	1	0	5	5	8
Increase in project cost	0	1	5	7	6
Progress is affected	1	1	2	11	4
Additional payments for contractor	0	2	7	5	5
Increase in overhead expenses	1	3	4	6	5
Delay in payment	1	5	2	5	6
Procurement delay	1	2	5	8	3
Productivity degradation	1	2	8	5	3
Logistics delays	1	2	7	9	0
Disputes among professionals	1	4	5	7	2
Rework and demolition	1	4	6	6	2
Blemish firm's reputation	1	4	8	5	1
Quality degradation	3	3	6	5	2
Poor safety conditions	3	5	4	5	2
Poor professional relations	3	4	6	4	2

APPERNDIX I: Clients' responses for strategies to minimize variation orders

Factor Description	Frequency Analysis (FA)				
	Un important	Less Important	Important	Very important	Very high important
Complete the drawings at tender stage	0	0	0	3	6
Carry out detail site investigation including detail soil investigations and consider it during tendering stage	0	0	1	4	4
All involved parties should plan adequately before works start on site	0	0	1	5	3
The consultant should produce a concluding design and contract documents	0	0	3	2	4
Spend adequate time on pre-tender planning phase	0	1	1	3	4
The consultant should co-ordinate closely at design stage	0	0	2	4	3
Supervise the works with an experienced and dedicated supervisor	0	0	1	6	2
Place experienced and knowledgeable executives in the engineering and design department	0	0	1	6	2
Consultants should ensure that the design/specifications fall within the approved budget	0	1	0	6	2
Clients should provide a clear brief of the scope of works	0	1	3	2	3
All parties should forecast unforeseen situations	0	0	3	5	1
Enhance communication between all parties	0	0	4	3	2
Get accurate information and research with regard to procurement procedure, material and plant	0	0	6	0	3
Once the tender is awarded, make no changes to the specifications	0	1	4	4	0
Have the land application or land purchase completed before awarding contracts	0	3	3	0	3

APPERNDIX J: Consultants' responses for strategies to minimize variation orders

Factor Description	Frequency Analysis (FA)				
	Un important	Less Important	Important	Very important	Very high important
All involved parties should plan adequately before works start on site	0	0	0	0	4
Enhance communication between all parties	0	0	0	1	3
Supervise the works with an experienced and dedicated supervisor	0	0	0	1	3
Carry out detail site investigation including detail soil investigations and consider it during tendering stage	0	0	0	1	3
The consultant should produce a concluding design and contract documents	0	0	0	2	2
Complete the drawings at tender stage	0	0	0	2	2
Spend adequate time on pre-tender planning phase	0	0	1	0	3
The consultant co-ordinate closely at design stage	0	0	0	2	2
Consultants should ensure that the design/specifications fall within the approved budget	0	0	1	0	3
Place experienced and knowledgeable executives in the engineering and design department	0	0	0	2	2
Clients should provide a clear brief of the scope of works	0	0	1	1	2
Get accurate information and research with regard to procurement procedure, material and plant	0	0	0	3	1
Have the land application or land purchase completed before awarding contracts	0	0	1	2	1
All parties should forecast unforeseen situations	0	0	2	1	1
Once the tender is awarded, make no changes to the specifications	0	0	3	1	0

APPERNDIX K: Contractors' responses for strategies to minimize variation orders

Factor Description	Frequency Analysis (FA)				
	Un important	Less Important	Important	Very important	Very high important
All involved parties should plan adequately before works start on site	0	1	2	2	14
The consultant should produce a concluding design and contract documents	0	1	3	4	11
Enhance communication between all parties	0	2	1	7	9
The consultant should co-ordinate closely at design stage	1	0	1	10	7
Supervise the works with an experienced and dedicated supervisor	2	1	1	4	11
Consultants should ensure that the design/specifications fall within the approved budget	0	1	4	6	8
Place experienced and knowledgeable executives in the engineering and design department	1	1	1	8	8
All parties should forecast unforeseen situations	0	1	3	9	6
Get accurate information and research with regard to procurement procedure, material and plant	0	1	5	5	8
Complete the drawings at tender stage	0	2	5	4	8
Clients should provide a clear brief of the scope of works	1	0	6	4	8
Spend adequate time on pre-tender planning phase	1	1	5	4	8
Carry out detail site investigation including detail soil investigations and consider it during tendering stage	1	2	3	5	8
Have the land application or land purchase completed before awarding contracts	1	2	6	2	8
Once the tender is awarded, make no changes to the specifications	3	5	3	3	5

APPERNDIX L: Thesis Proposal

ASSESSING THE IMPACT OF VARIATION ORDERS ON PUBLIC BUILDING PROJECTS IN ADDIS ABABA

by

Andualem Endris Yadeta

Thesis Proposal submitted to Addis Ababa University, Addis Ababa Institute of Technology in partial fulfillment of the requirements for the degree

Of

Master of Science

In

Civil Engineering
(Construction Technology & Management)

Under the Supervision of **Dr.-Ing Wubishet Jekale**

JANUARY 2012

A B S T R A C T

Many building projects are exposed to variations. This study will investigate the impact of variation orders on public building projects in Addis Ababa in order to take proactive measure to minimize or appropriately manage it. The study will have the following objectives, namely (1) to determine the causes of variation orders; (2) to determine the impacts of variation orders; and (3) to recommend strategies to minimize variation orders. Literatures relative to the research area will be extensively reviewed. The data gathering approaches will include desk study, interviews and questionnaire to collect both qualitative and quantitative data. Statistical data analysis and interpretations will be used and finally the result will be concluded and recommended to all stakeholders.

Background of the Study

Construction contract is a business agreement that is subjected to variability. Contractual clauses relating to changes allow parties involved in the contract to freely initiate variation orders within the ambit of the scope of the work without alteration the original contract (Adnan *et al*., 2010) sited in Harbans (2003). Even if carefully planned, it is likely that there will be changes to the scope of the contract as the work progresses (Adnan *et al.*, 2010).

Variations and conflicts in a construction projects, at work, and even in our daily lives are very common. Any addition, deletion, or any other revision to project goals and scope of work are considered to be variation, whether they increase or decrease the project cost or schedule (Adnan, 2010). A change in construction projects refers to an alteration to design, building works, project programs or project aspects caused by modifications of preexisting conditions, assumptions, or requirements (Adnan, 2010).

Various studies have revealed that variation orders contribute to cost overruns. A study of the effects of variation orders on institutional building projects revealed that variation orders contributed substantially to increase in construction project costs (Ruben and Theo, 2008). It was found that variation orders issued during various phases of construction projects negatively affected both the completion time and costs of projects (Ruben and Theo, 2008).

In developing countries like Ethiopia, its potential impact leads to unnecessarily increase the cost of construction without adding value to the project. The construction sector in Ethiopia is considered one of the crucial economical sectors. This sector is subjected to a very difficult situation since the increase of the sector. There are many public building projects in Addis Ababa and they have been constructing now. Many of the projects are either on hold or subjected to major variations due to shortage of construction materials, increase in construction materials cost, shortage of modern construction equipment, lack of skilled manpower. So this thesis aims to assess the impact of variation orders on Addis Ababa public building projects.

Statement of the Problem

Nowadays, variation orders have become a common problem in public building projects in Addis Ababa. Variation orders are issued to correct or modify the original scope of work because changes during construction of projects are unavoidable. The major causes of delay, disputes and sometimes generate significant cost and environmental impacts are variation orders issued during construction of projects. Yet, no unique method is available for minimizing variation orders effectively. However, their impact can be minimized with an appropriate study about the causes. Variation orders on public building projects have the potential to impact public building projects, and the identification of their causes might lead to their reduction, possible elimination and subsequent improvement in overall performance of public building projects.

Review of Literatures

Construction project is a mission, undertaken to create a unique facility, product or service within the specified scope, quality, time and cost. In practice, however, some construction projects encounter variation, delay on completion time or poor workmanship upon completion.

The one thing certain on any project is that there will be variations occurring along the way sometimes even before the signing of the contract. Variations are inevitable in any construction projects (Ibbs *et al.*, 2001). Nothing is more constant than variation during the course of a construction project. Despite the best efforts of all concerned during the planning, implementation and administration of the contract, variation will almost certainly occur. The variations and variation orders can be deleterious in any project, if not considered collectively by all participants (Arain and Low, 2005). The most frequent type of variation met in building projects are variations to the original scope of work or those that arise from unexpected conditions in the field. Even two buildings of same design, that is very similar, have differences caused by the terrain, existing utilities, or other factors such as subsurface conditions. Basically variation orders are acceptable as part of the contract administration process.

Further, the human behavior of parties to the contract cannot be predicted. Variation orders may arise from changes in the minds of parties involved in the contract. Variation orders may

be initiated either by clients or by contractors (Adnan, *et al.*, 2010). A study that focused on the points of view of developers of potential causes of variation orders suggested four main root agents of variation orders (Arain and Pheng, 2006). These agents included clients, consultants, contractors and unspecified "others".

If variation orders are frequent, they may potentially affect the quality of works. Hanna *et al.* (2002) indicated that contracts with a significant degree of risk for unknown variables such for example lump sum, contractors may cut corners on quality and quantity to maximize profits. Quality of works may be compromised as contractor may try to compensate for the losses as they are not optimistic at about cost recovery. Moreover; variation order occurrence can lead to revision of health and safety considerations.

Ruben and Theo (2008) remarked that disputes between the client and the contractor can occur if variation orders are not managed carefully. Harbans (2003) warned that unless a mutually acceptable solution is agreed by the parties, valuation of variations in the form of variation orders will continue to remain at the forefront of disputes and claims making their way ultimately to arbitral tribunals or the corridors of justice. Ssegawa *et al.* (2002) found that a large proportion of current arbitrations were on claims for additional time and additional expenses. He reported that more than one-third of disputes pertained to how to determine losses that stem from variation orders.

Research Objectives

The objectives of the study will be:

- To determine the causes of variation orders;
- To identify the impacts of variation orders; and
- To recommend strategies to minimize variation orders.

Research Questions

From the objectives of the study, formulating and answering the following research questions will define the overall purpose:

- What are the causes of variation orders?
- What are the impacts of variation orders?

- How can we minimize variation orders?

Research Methodology

The research methodology is structured as follows:

- Literature and previous studies related to the area of research will be extensively reviewed.
- The research design is based on a purposive sampling selection process in terms of which a representative sample of stakeholders/participants in the construction process of public building will be surveyed and a selection of similar public building projects from which to derive further data on variation orders. In particular, case studies, interviews with relevant parties such as site and head office management of public institutions, self-administered surveys and examination of public project documentation and records will form the basis of the research methodology.
- The gathered data will be analyzed using the appropriate statistical analysis tools. Both quantitative and qualitative methods will be used.

Then conclusions will be drawn from the analyzed data and recommendations for improvement and future study will be formulated.

Work Schedule

No	Task	Duration (in weeks): February- July																					
		Feb 2012				Mar 2012				April 2012				May 2012				June 2012				July 2012			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Literature review																								
2	Questionnaire preparation																								
3	Data collection																								
4	data analysis																								
5	Report preparation																								
6	Report compilation																								

Budget

S.N	Item	Unit	Qty	Rate	Amount(ETB)
1	**Stationeries**				
1.1	Photo copy	Pcs	800	0.4	320
1.2	Flash Disk(2GB)	Pcs	1	200	200
1.3	Blank CDs and DVD	Pcs	20	5	100
1.4	Typing and Printing	Pcs	300	3	900
	Sub-total (1)				***1520***
2	**Transportation and Daily expense**				
2.1	Transportation	-			1000
2.2	Daily expense	Days	30	50	1500
	Sub-total (2)				***2500***
3	**Others**	-			**1000**
	Sub-total(3)				***1000***
	Total (1+2+3)				**5020**
4	**Contingency (10%)**				**780**
5	**Grand Total**				**5800(ETB)**

Submitted by

Andualem Endris Yadeta	……..…	……
Student	Signature	Date

Approved by

1. **Wubishet Jekale (Dr.Ing)**	…….	……..
Advisor	Signature	Date
2. _____	……	..……
Chair man, Dep.'s Graduate Committee	Signature	Date
3. _____	…….	……
Chair man, Faculty's Graduate Committee	Signature	Date
4._____	……	……
Dean, Graduate School	Signature	Date