Modified Variation Order Management Model for Civil Engineering Construction Projects

David Dickson Oloo

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

Signature: _____ Date: _____

David Dickson Oloo

This thesis has been submitted for examination with our approval as the university supervisors.

Signature: _____ Date: _____

Dr. Gerryshom Munala

JKUAT, Kenya

Signature: _____ Date: _____

Dr. Githae Wanyona

JKUAT, Kenya

DEDICATION

To my wife Judith Akinyi, ‘Thank you’.

To my son Adrian Jesse Oloo, who has since gone to be with the lord ‘Daddy loves you’.

To my youngest son Casey Ethan Otunga, ‘welcome to the world and may you be a better man than your dad’.

Last but not least, to my parents Mr. Francis Otunga Nyamngero and Mrs. Dorcas Akinyi Oloo for the firm foundation they laid for me and their prayers during the course of this work. To them, I will be forever indebted.

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I am greatly indebted to staff in the Department of Construction Management who out of their busy schedule found time to organise meetings with our research co-ordinators and JKUAT library staff who allowed me to access the electronic journal database regularly and on a short notice, contrary to the regulations of the library.

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LIST OF ABBREVIATIONS

ACEK	Association of Consulting Engineers of Kenya
ADB	African Development Bank
CIRIA	Construction Industry Research and Information Association
CII	Construction Industry Institute
DAB	Dispute Adjudication Board
FIDIC	International Federation of Consulting Engineers
FPC	Finite Population Correction
KRB	Kenya Roads Board
MoPW	Ministry of Public Works
NWCPC	National Water Conservation and Pipeline Cooperation
PPOA	Public Procurement and Oversight Authority
PVO	Potential Variation Order
VO	Variation Order
RFI	Request for Information
RFP	Request for Proposal
SPSS	Statistics Package for Social Sciences
TC	Tender Committee
TOC	Taking Over Certificate

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ABSTRACT

Variations are almost inevitable in construction projects and play important role in determining the closing cost and time of the projects. In civil engineering construction projects in Kenya, variations are incessant and excessive in magnitude. This study therefore investigated the factors contributing to variation orders and their effects on civil engineering construction projects in Kenya and proceeded to recommend an effective variation order management system.

The study was conducted through survey method. Data was collected using a total of 95 questionnaires. The survey achieved a 78% rate of return. The data was analysed using percentages, Relative Importance Index (RII), and Kendall's coefficient of concordance. The results were presented in tables and pie-chart diagrams.

The results suggest that in civil engineering construction projects in Kenya, the client is the most predominant origin agent of variations at 55%, while additional work is the most common aspect of variations at 58%. Using RII, the five most important factors causing variation orders were found to be: delay in land acquisition/compensation (0.859); differing site conditions (0.832); change of plans or scope by client (0.762); change of schedule by the client (0.751); and lack of coordination between overseas and local designers (0.741). In addition, the three most important effects of variation orders were found to be: cost overruns (0.903); contractual claims and disputes (0.814); and time overruns (0.811). The study also established that there is no existing variation management system for civil engineering construction projects in Kenya and consequently developed an effective model that if adopted, would help reduce the occurrence of variations and ensure that those that are inevitable do occur in a controlled manner.

To minimise the occurrence of variation orders in civil construction in Kenya, the study recommended the following: conclusion of design before tendering; thorough feasibility study; clear and precise project brief devoid of ambiguities; and proper coordination between overseas and local designers.

The study concludes that the success of variation management depends not only on the diligence of the client and consultant during the preconstruction stage but also upon effective communication and collaboration between project team members throughout the project life cycle.

CHAPTER ONE

1.0 INTRODUCTION

1.1Background of the Study

The complexity of construction works means that it is hardly possible to complete a project without changes to the plans or the construction process itself. Construction plans exists in form of designs, drawings, quantities and specifications earmarked for a specific construction site. According to Ssegawa *et al.* (2002), changes to the plans are often effected by means of a variation order initiated by a consultant on behalf of the client or as raised by the contractor.

Worldwide, variation orders are the main cause of cost and time overruns in construction contracts. CII (1990); Hsieh *et al.* (2004); Mohamed (2001); Randa *et al.* (2009); Zeitoun and Oberlender (1993) concur that variation orders contribute to 6-17% cost overruns in construction projects. CII (1990); Kumaraswamy *et al.* (1998); Zeitoun and Oberlender (1993) reported that time overruns due to variation orders are in the magnitude of 10-50%. Moreover, Assaf *et al.* (1995) reckoned that variation orders are the major cause of contractual claims, with a staggering 60% of all claims being attributed to variation orders.

Regionally, Ndihokubwayo (2008) observed that construction projects have a prevalence of variation orders of 85% of the total site instructions with clients being the origin of 49%, consultants 47% and contractors 4% of the variations. Further, Oladapo (2007); Sunday (2010) believed that variation orders are to blame for cost overruns of between 25-78% and time overruns of between 27- 68%. However, according to Ndihokubwayo and Haupt (2009), 95% of the variation occurring are considered beneficial to the project objectives.

In a developing country like Kenya, where a boom in construction is currently being experienced due to increased investment in infrastructure development, the occurrence and impact of variation orders cannot be overlooked. This is because past projects have been marred by variations, resulting in cost and time overruns. Locally, ADB (1998); Andrew (2013); KRB (2002) reported that variation orders in construction projects have been associated with cost and time overruns in the magnitude of 70 - 151% and 32 - 179% respectively. Separately, Msafiri (2006)

noted that design changes by engineers is a major cause of schedule delays in road construction projects. In addition, KACC (2007) cautioned that the rampant occurrence of variations has been revealed as an avenue through which unscrupulous contractors, engineers and government officials collude to escalate project cost resulting into wastage of public funds.

Attempts have been made to solve the problem of variations by restricting their magnitude. FIDIC (1999) allows for up to 10% while FIDIC (2006) stipulates 25% of the contract sum. Whereas in Kenya, the PPOA (2006); PPOA (2013) impose ceiling of 15% and 25% of the original contract sum respectively. Despite of these attempts, construction projects are still dogged by cost and time overruns; contractual claims and disputes; degradation of labour productivity and strained professional relationship attributable to variations orders.

1.2 Statement of the Problem

Ashworth (1998) posit that the existence of variation clauses in various standard forms of contracts is not a bad idea per se. It somewhat improves the clients' potential for securing a superior end product, but at a price, for the clients then have less certainty about the completion cost and time for their projects. Further, these clauses impose limits to the magnitude of variations so that the clients' right to vary is not mismanaged. However, in civil engineering construction projects in Kenya, variation orders are *incessant and excessive in magnitude*. According to KACC (2007), the limits of variation are never adhered to as stipulated in the public procurement and disposal act (PPOA). This creates a loophole that is often exploited by unscrupulous personnel leading to unwarranted variations and eventually embezzlement of public funds. Therefore, the purpose of this study is to investigate the underlying factors contributing to variation orders and their downstream effects on civil construction projects in Kenya, with a view of making recommendations that are geared towards effective variation order management.

1.3 Objectives of the Study

The main objective of this research is to determine the factors contributing to variation orders and their effects in civil engineering construction project in Kenya, with a view to recommending a management model that is geared towards effective variation management.

The specific objectives of this research study are:

(i) To examine the nature of variation orders in civil engineering construction projects in Kenya;

(ii) To determine the factors that contribute to variation orders in civil engineering construction projects in Kenya;

(iii) To investigate the effects of variation orders in civil engineering construction projects in Kenya.

(iv) To recommend an effective variation order management system for civil engineering construction projects in Kenya.

1.4 Research Questions

1. Objective 1:

   a) Who are the origin agents of variation orders in civil engineering construction projects in Kenya?

   b) What are aspects of variations in civil engineering construction projects in Kenya?

2. Objective 2:

   a) What are the most important factors that contribute to variation orders in civil engineering construction projects in Kenya?

   b) Which origin agent is responsible for the most important factors causing variation orders in civil engineering construction projects in Kenya?

3. Objective 3:

   a) What are the most important effects of variation orders in civil engineering construction projects in Kenya?

   b) What do the most important effects of variation orders imply on the problem statement of this study?

4. Objective 4:

   a) Is there a system in place for variation order management in civil construction projects in Kenya?

   b) What steps can be taken to ensure that variation orders in civil construction projects in Kenya are effectively managed?

1.5 Justification of the Study

Variation orders are an all too common part of construction projects. This is because; the need to make changes in a construction project is a matter of practical reality. However, variations can be extremely expensive and may negatively impact a project's schedule. In addition, they can potentially sour the business relationships on a project. It is therefore a desirable outcome for project stakeholders to reduce the occurrence of avoidable variation orders and to mitigate the effect of the unavoidable ones. CII (1994); Hester *et al.* (1991), concede that to overcome the problems associated with variations to a project, the project team must be able to comprehensively understand the root causes of variations and their immediate downstream effects so as to control, or at least monitor the associated cost and schedule impact.

1.6 Significance of the Study

Firstly, the literature is awash with probable factors that could cause variations in construction projects and their effects. However, the levels of significance of these factors vary from one country to the other and depend on the uniqueness of the challenges faced in each country. Hence the need to put into perspective the most important causes and effects of variations in the Kenyan context.

Secondly, the findings of this study contribute valuable knowledge to the field of construction management in general. To the best of the author's knowledge, it is one of the few if not the only study that has focused on developing variation order management model for civil engineering construction projects in Kenya, and as such; it is to produce hitherto unavailable knowledge on this subject. It should therefore form a useful material for reference to other researchers and readers in general.

Thirdly, the study suggests significant policy statement through its recommendations. The study makes recommendations on ways of reduce the occurrence of variations in civil construction projects. Such recommendations could inform procurement policy formulation in the construction industry in general because they are originated through valid research data.

Last but not the least, the study also influences the practice of management of public construction projects in Kenya. In the attempt to deal with adverse effects of variation

orders such as cost overruns, time overruns and contractual claims and disputes, the management of public funded construction projects will focus on specific issues of causes of construction variations generated through this research. Henceforth, they need to follow theories, rules and traditions that are remote and without specific relevance to them but, but base their practices, decisions and other managerial behaviors on products of research that are specific to their situations. The use of such specific knowledge will improve the quality of management of construction projects and raise the performance of construction projects in the country.

1.7 Scope of the Study

This study on causes and effects of variation orders in civil construction projects in Kenya was confined to participant companies with their headquarters in Nairobi County geographical area within the republic of Kenya. However, the participant companies are assumed to be experienced in civil engineering construction projects spread across the breadth and width of the republic of Kenya.

The participant companies considered in this study were those involved in either complete or ongoing public funded roads, bridges, water, sewerage, ports, airports and electricity generation and transmission infrastructure projects in Kenya with contract sum of at least KS. 500,000,000.

The study was conducted between January 2013 and January 2014 through survey design, where the opinion of 95 construction professionals working with engineering consultants, clients and contractors were sought using questionnaires.

1.8 Limitations of the Study

First and foremost, the ideal study would have been a combination of questionnaire surveys and case studies where actual project documents, records and variation orders would be examined. However, due to budgetary and time constraints, only professionals' opinions were sort. In adopting this methodology for the study, the actual magnitude of factors causing variations and their effects could not be established.

Secondly, the study assumed that civil engineering construction projects in Kenya are undertaken through the design bid and build (traditional) procurement model where the design responsibilities rest with the client. However, a significant proportion of

mega construction projects are adopting the design build (turnkey) procuring model where design responsibilities are with the contractor.

Nevertheless, the above limitations do not render the observations made in this study incomplete or invalid. In addition, while the findings may not be broadly generalized, they are indicative of the causes and effects of variation orders on civil construction projects in Kenya, given that most of the key findings confirmed the findings of the literature review.

1.9 Assumptions of the Study

The study made the following assumptions during the course of execution;

1) Civil engineering construction projects in Kenya adopt the traditional design bid and build procurement system where construction risks are almost equally shared between the client and contractor and the consultant is the client's agent.
2) The frequency of occurrence of variation orders and their magnitude vary from one type of civil work to the other. For the purpose of this study, it was assumed that civil works experience more or less the same frequency and magnitude of variations.
3) The respondents for the questionnaire survey are engaged in public construction projects which are subject to the provisions of the Public Procurement and Disposal Act of 2005.

1.10 Definition of Terms

The following are the definitions of the basic technical terms used in this study: -

1.10.1 Civil Engineering Construction: A discipline which includes all techniques concerning the civil constructions of bridges, buildings, transportation systems, tunnels, viaducts, airports, dams, harbors, water distribution, transmission lines etc. (Jean-Paul, 2004).

1.10.2 Variation: The change in the contractual terms upon which the relevant work is to be performed (Akinsola et al., 1994). This study will interchangeably use "variation" and "change" to refer to the same thing.

1.10.3 Variation Order: A written instruction issued to the contractor by the owner, which authorize a change in the work or an adjustment in the contract sum or even the

contract time (Clough & Sears, 1994). This study will interchangeably use “variation order” and “change order” to refer to the same thing.

1.11 Study Outline

The study report is organised in five chapters:

Chapter One: Introduction- This chapter is an introduction to the study comprising the background, statement of the problem, objectives of the study, research questions, study justification, scope and limitations, assumptions of the study, definition of terms, and study outline.

Chapter Two: **Literature Review-**This chapter explored previous studies related to variation orders. The origin causes and impact of variation orders on projects performance were discussed.

Chapter Three: Research Design and Methodology -This chapter discussed the research approach, tools and methods used for data gathering and analysis.

Chapter Four: Data Analysis and Discussions –This chapter constituted the presentation and analysis of data gathered at the survey stage of the research. Guided by the methodology, the raw data captured by the research instrument are analysed and the findings discussed based on research questions or objectives.

Chapter Five: Summary, Conclusions and Recommendations - Conclusions and recommendations were drawn based upon data analysis, linking them to the problem statement, research questions and objectives of the subject under investigation.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature related to variation orders in construction projects. The review is conceptualised under the objectives of the study and focuses mainly on four major topics namely: the origin agents of variations, the aspects of variations, the potential causes of variation orders and the potential effects of variation orders. A theoretical and conceptual framework is then developed to help identify the variation order variables.

2.2 The Legal Framework

This sub-section outlines the existing regulatory framework that guide the management of variations in civil engineering construction projects both in Kenya and in the international scene. It begins by exploring the genesis and provisions of the local public procurement regulations under PPOA and proceeds to shed light on the requirements of FIDIC Redbook 1999 for the administration of contracts in the civil works designed by the client.

2.2.1 Variations under PPOA

In Kenya, variation to works in public projects is administered by the Public Procurement and Disposal Act of 2005. Under this legal dispensation, the Public Procurement Oversight Authority (PPOA) was created to oversee public procurement system with its principal function of ensuring that the public procurement law is complied with. According to PPOA (2006) clause 31, variations to work shall be effective provided; the quantity variation for works does not collectively exceed fifteen percent (15%) of the original contract quantity; and quantity variation is to be executed within the period of the contract. This regulation has since been amended via PPOA (2013) which limits cumulative variations to 25% of the contract sum for works. Further, PPOA (2009) instructs that all variation must be approved by the tender committee within the procuring entity and instruction issued in writing in form of Variation Instruction or Variation Order.

2.2.2 Variations under FIDIC Redbook 1999

FIDIC (1999) empowers the engineer to initiate variations either by instruction (sub-clause 3.3) or by a request for the contractor to submit a proposal (sub-clause 13.1). An instruction can be issued at any time to the extent that it is necessary for the execution of the works (sub-clause 3.3). However, FIDIC (1999) limits the power of the engineer to give an instruction which constitutes a variation until the engineer has issued the Taking-Over Certificate (TOC). Any variation order instructed after the issuance of the TOC to the contractor is therefore null and void.

In order to avoid non intended variation orders or variation orders without having a full appraisal of its consequences, the engineer will usually request a proposal from the contractor according to sub-clause 13.3 of (FIDIC 1999). The latter will then respond in writing as soon as practicable, either by giving reasons why he cannot comply or by submitting a detailed proposal in accordance with sub-clause 13.3. Such kind of proposal will not constitute a firm offer to carry out the variation. Thus the engineer will not accept an offer but simply give the instruction to execute the proposed variation. If instructed, payment will be made either by measurement and evaluation and subsequent determination. Moreover extension of time for completion would be determined under the procedures at sub-clause 20.1, 3.5 and subject to sub-clause 8.4.

Jaeger and Hok (2010) argue that the contractor is bound to execute each variation, unless he promptly gives reasons with supporting particulars stating the grounds for which he is not willing to do so. However, FIDIC (1999) gives little scope for excuses. The extent to which variations are admissible is covered in sub-clause 13.1. The consultant is not permitted to omit work in order to have it done by others. He is also not permitted to amend the contract. Thus variations must not differ radically from what the contractor has already undertaken to carry out (Jaeger & Hok, 2010).

According to sub-clause 13.2 the contractor is also entitled to initiate variations on special grounds. This kind of variation has been named value engineering. The types of variations which fall under sub-clause 13.2 are clearly defined in sub- clause 13.2. However, if the consultant approves a proposal of the contractor which did not meet the requirements of sub-clause 13.2 this will nevertheless constitute a variation order.

But only if the requirements of sub-clause 13.2 are met, will the contractor be entitled to an additional fee pursuant to sub-clause 13.2.

For both the parties to the contract and the consultant, it is critical to know whether an instruction from the engineer should be treated as a variation or a simple site instruction (compare sub-clause 3.3 where it is said, that if an instruction constitutes a variation, clause 13 applies).

According to Jaeger and Hok (2010), under the terms of FIDIC (1999) the consultant is required to give instructions for a number of different purposes. He may instruct to make good defects, to recover work and to test work. According to sub-clause 1.5, he is entitled to issue instructions if an ambiguity or discrepancy is found in the documents. If any of his instructions change the order of priority of the documents which is ruled in sub-clause 1.5 it is suggested that the instruction according to which a document of less priority overrules a document of higher priority should constitute a variation. Some of his instructions may have the nature of a variation; some remain simple site instructions without any impact on time and money. Some of those instructions deemed to constitute a variation, would include an instruction under sub-clause 4.6 (instructions to allow opportunities for carrying out work to the client's personnel, any other contractors or personnel of any legally constituted public authority) or one under sub-clause 11.2 (instruction to remedy defects which are not attributable to the contractor).

2.3 Taxonomy of Variations

The nature of a variation order can be determined by referring to both the reasons for their occurrence and subsequent effects. According to Arain and Pheng (2005b) there are two types of variation orders namely: beneficial and detrimental variation order.

2.3.1 Beneficial Variation Orders

Arain and Pheng (2005b) believe that a beneficial variation order is one issued to improve the quality standard, reduce cost, schedule, or degree of difficulty in a project and as a result; it optimizes the client's benefits against the resource input by eliminating unnecessary costs from a project. In addition, Kelly (2002) argued that 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.

2.3.2 Detrimental Variation Orders

Arain and Pheng (2005b) are of the opinion that 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.

Ndihokubwayo and Haupt (2009) investigated the nature of variation orders in building construction projects in South Africa using questionnaire survey. Their study found that 95% of variation orders issued were beneficial to the projects performance. Apparently, there was no variation order issued that negatively affected the quality of the end product.

2.4 Origin Agents of Variation Orders

Arain and Pheng (2006a) identified four main origin agents of variation orders. These agents include clients, consultants, contractors and the unspecified “others” as depicted in Figure 2-1.

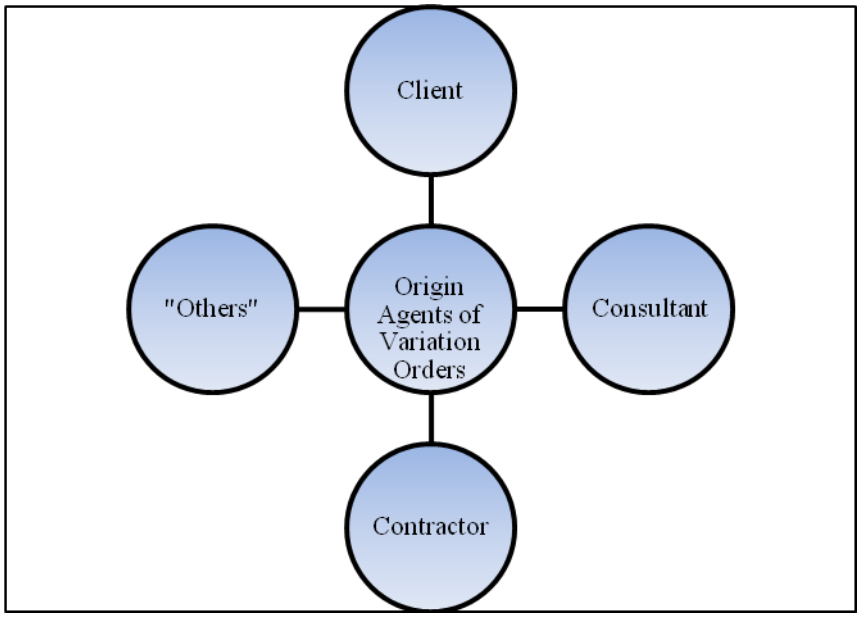

Figure 2-1: Origin Agents of Variation Orders

Source: Arain and Pheng (2006b)

2.4.1 Client

Arain and Pheng (2006a) noted that the client as the project initiator plays a major role in the construction project from the inception to the completion. As a result, clients influence the likelihood of the occurrence of variation orders. Clients anticipate the needs and objectives of projects, establish the scope of works and the required quality standards.

2.4.2 Consultant

Ndihokubwayo and Haupt (2008) observed that the consultant team includes architects, designers, specialist engineers, project managers, surveyors, quantity surveyors and construction economists. Members of the consultant team have power to effect variation orders upon delegation by the client or on their behalf.

2.4.3 Contractor

Sweeney (1998) stated that it is the contractor's responsibility to advise the consultant to issue a variation order when a technical problem is discovered. According to Sweeney (1998) a contractor may propose alternative construction methods where his experience shows that the proposed technology will not fulfil the desired fitness and function of a design.

2.4.4 'Other' Variations

Arain and Pheng (2006a) observed that situations beyond the control of the contractual parties may give rise to variation orders, These include; weather conditions, certain health and safety considerations, change in government regulations, change in economic conditions, socio-cultural factors and unforeseen problems.

Awad (2001) analyzed the variation orders occurrence in combined sewer flow construction projects in Michigan, USA. The study found that the most frequently project parties generating variation orders were: the engineer (consultant) generating about 47.1% of total cost escalation; and the owner (client) generating 43.1%. The study further found that about 55.4% of the variation orders causing total time extension were generated by the owner group.

Bromilow (1970) in his research based on analysis of data collected on 248 projects in Australia, identified seven sources of variations. From the report, the client was

identified as the most prolific source of variations on construction works (49%) with the second major source being the design team (26%).

2.5 Aspects of Construction Variations

According to FIDIC (2006),each variation may include:

1) Changes to the quality and other characteristics of any item of work,
2) Changes to the levels, positions and/or dimensions of any part of the Works,
3) Omission of any work unless it is to be carried out by others,
4) 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
5) Changes to the sequence or timing of the execution of the Works.

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 aspects 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.

2.6 Potential Causes of Variation Orders

The enormity of the various factors causing variations identified over the years by various author shows that variation has come to stay as part of the construction projects and it cut across all contracting parties. Table 2-1 shows various causes of variation order and their categorization according to origin agents. The causes of variation orders were categorized into consultant related, client related, contractor related variation order and the other changes that can be referred to as force majeure.

Table 2-1: Potential Causes of Variation Orders

Category of variation	Cause of Variation	Identified Author (s)
Consultant related variations	Change in design by consultant; Errors and omissions in design; Conflicts between contract documents; Inadequate scope of work for contractor; Technology change; Lack of coordination; Design complexity; Inadequate working drawing details; Inadequate shop drawing details; Consultant's lack of judgment and experience; Lack of consultant's knowledge of available materials and equipment; Consultant's lack of required data; Obstinate nature of consultant; Ambiguous design details;	Al-Hammad and Assaf (1992); Assaf *et al.* (1995); Chappel and Willis (1996); CII (1994); Fisk (1997); O'Brien (1998); Wang (2000)
Client related variations	Change of plans or scope by owner; Change of schedule by owner; Owner's financial problems; Inadequate project objectives; Replacement of materials or procedures; Impediment in prompt decision making process; Obstinate nature of owner; Change in specifications by owner.	Arain and Pheng (2005a); Fisk (1997); Gray and Hughes (2001); O'Brien (1998); Wang (2000)
Contractor related variations	Complex design and technology; Lack of strategic planning; Contractor's lack of required data; Lack of contractor's involvement in design; Lack of modern equipment; Unfamiliarity with local conditions; Lack of a specialized construction manager; Fast track construction; Poor procurement process; Lack of communication; Contractor's lack of judgment and experience; Shortage of skilled manpower; Contractor's financial difficulties; Contractor's desired profitability; Differing site conditions; Defective workmanship; Long lead procurement	Al-Hammad and Assaf (1992); Arain and Pheng (2005a); Assaf *et al.* (1995); Clough and Sears (1994); Fisk (1997); O'Brien (1998); Thomas and Napolitan (1994); Wang (2000)
'Other' variations	Weather conditions; Safety considerations; Change in government regulations; Change in economic conditions; Socio-cultural factors; Unforeseen problems.	Arain and Pheng (2005a); Fisk (1997); Kumaraswamy *et al.* (1998); O'Brien (1998); Wang (2000)

Source: Sunday (2010)

Wu *et al.* (2005) analyzed the causes and effects of 1038 variation orders authorized by project management in a highway construction project in Taiwan. The study found that changes made in response to legislative or policy changes were significant in embankment roads on northern section. It was also revealed through this research that design changes in response to complaints of civilians and geological conditions were significant causes of variation orders.

Arain and Pheng (2006a) studied 53 factors that caused variation orders in institutional buildings in Singapore. The study divided these factors into four categories based on the origin of variation orders; i) owner related factors; ii) consultant related factors; iii) contractor related factors; and iv) other factors. The study results indicated that errors and omission in design, change in specification by owner, design discrepancies, change in specifications by consultant, and noncompliance design with governmental regulation considered were the most significant causes of variation orders.

Amiruddin *et al.* (2012) examined the 26 factors that cause variation orders in road construction projects in Iran. Using the mean score method to rank the causes on a 5 point Likert scale of 1-Strongly disagree to 5-Strongly agree, the results of the study disclosed that change of plans or scope by the owner was identified as the greatest cause of variation orders from all the viewpoints. Errors and omissions comes second under the ranking while both differing site conditions and contractor's financial difficulties jointly take the third position in the order of the causes of variation orders. Jointly following this on the same ranking scale are weather condition and conflict in the project site, these two occupy the fourth ranked cause of variation order. Following this is the owner's financial problem which occupies the 5th rank. Value engineering and quality improvement jointly occupy the 6th most important factor causing variation order. The least factor responsible for variation order from the perspective of all the groups is acceleration of work.

2.7 Potential Effects of Variation Orders

Various authors have identified different effects of variation orders in construction projects in the literature that was reviewed for this study. There are 16 major potential effects of variation orders on construction projects. The effects that were determined are as tabulated in Table 2-2;

Table 2-2: Potential Effects of Variation Orders

S/N	Effects of Variation	Identified Author
1	Progress Degradation	Arain and Pheng (2005b); Assaf *et al.* (1995)
2	Cost Overrun	Assaf *et al.* (1995); CII (1990); Clough and Sears
3	Hiring new professional	Arain and Pheng (2005b); CII (1995); Fisk (1997)
4	Increases in Overhead Expenses	Arain and Pheng (2005b); O'Brien (1998)
5	Delays in Payment	CII (1990, (1995)
6	Quality Degradation	Fisk (1997)
7	Productivity Degradation	Hester *et al.* (1991); Moselhi *et al.* (2005); Reichard and Norwood (2001); Thomas and Napolitan (1994)
8	Procurement Delay	Arain and Pheng (2005b); Hester *et al.* (1991); O'Brien (1998)
9	Rework and Demolition	Arain and Pheng (2005b); Clough and Sears (1994)
10	Logistics Delays	Arain and Pheng (2005b); Fisk (1997); Hester *et al.* (1991)
11	Damage to Firm's Reputation	Arain and Pheng (2005b); Fisk (1997); Kumaraswamy *et al.* (1998)
12	Poor Safety Conditions	Arain *et al.* (2004); Arain and Pheng (2005b)
13	Poor Professional Relations	Fisk (1997)
14	Disputes among Professionals	Arain *et al.* (2004); CII (1986b)
15	Additional Payments for Contractor	Arain (2005); O'Brien (1998)
16	Time Overrun	Ibbs (1997); Kumaraswamy *et al.* (1998); Reichard and Norwood (2001); Zeitoun and Oberlender (1993),

Source: Author (2013)

Koushki *et al.* (2005) studied delays and cost increases in the construction of private residential projects in Kuwait and revealed that a number of variation orders issued during the construction phase led to both delays and cost increases. The projects that experienced variation orders incurred more than 58% time delay and cost increases when compared to those with no variation orders. In his study of causes, effects and control of variation orders in large building constructions projects in Malaysia, Randa *et al.* (2009) indicated that cost overruns due to variations were in the magnitude of 5-10% of the original contract sum and that the schedule slippage was less than 10% of the original contract duration. According to Hsieh *et al.* (2004), 10-17% ratio of change order cost to total project cost is related to metropolitan public works in Taiwan.

Assaf and Al-Hejji (2006) studied the causes of delay in large construction projects in Saudi Arabia, the results of the study indicated that most common cause of delays identified by all three parties of the project was variation orders. Zaneldin (2006) studied the types, causes, and frequency of construction claims in Dubai and Abu Dhabi in the UAE using data from 124 claims for a variety of projects. The study

results indicated that the "variation order" claims were the most frequent type of claims with an important index of 60.5% and variation order was the most frequent cause of claims with an important index of 55%. Kumaraswamy *et al.* (1998) studied claims for extension of time due to excusable delays in Hong Kong's civil engineering projects. Their findings suggested that 15-20% time over run was mainly caused by inclement weather, 50% of the projects surveyed were delayed because of variations.

Ndihokubwayo and Haupt (2009) studied effects of variation orders in building projects in the Western Cape Province of South Africa and using a 5 point Likert scale of 1- Never to 5- Always to rank the most important impacts of variations, revealed that time and cost overruns ranked the highest with a mean score of 4.0. Even as dispute between parties to the contract ranked the third most important effect of variation orders with a score of 3.7. Amiruddin *et al.* (2012) also used 5 point Likert scale method to rank the effects of variation orders in road construction projects in Iran. The scale he adopted was 1- strongly disagree to 5- strongly agree. Accordingly, it was revealed that delay in completion schedule is the most visible effect of variation orders with a mean score of 4.2 whereas, increase in project cost and disputes between owner and contractor were, the second and third important effects of variation orders in Iran with mean scores of 3.9 and 3.8 respectively.

In Kenya, Msafiri (2006), attributed delays in road construction projects to change in design by engineers among other factors. Separately, Choge and Muturi (2014) studied the factors affecting adherence of cost estimates in projects of Kenya National Highways Authority and disclosed that among the five factors considered, design variations was the most critical one. Moreover, individual projects' completion reports provided an insight into the extent of the effects of variation orders on construction projects. According to ADB (1998), in the Third Nairobi Water Supply Project, the Thika Dam component was a subject of major design and construction modification due to the unexpected geological conditions encountered during the construction. These modifications led to variation orders and subsequently quantity increases with associated cost and time overruns of 70% and 32% respectively. Elsewhere, KRB (2002) reported that the repair and resealing of Timboroa-Meteitei-Sanghor-Awasi road contract RD 0330 was awarded in 1997 and schedule for completion in 1999. The initial scope of work was based on design data collected in

1994.However, the commencement of this project coincided with El-Nino rains that caused further deterioration of the road. The scope of the works was on these grounds revised to repair and construction. Thus, the contract sum was revised upwards by 151% while the contract period revised by 43 months (179%) through a variation order dated June 2001. Last but not least, Andrew (2013) reported that, the NWCPC through a letter referenced NWCPC/CON/FIL/444/VOL.V11/81 varied the works at Badasa Dam in Marsabit County, which is a Vision 2030 flagship project tendered for KS. 1.7 billion in 2009 by KS. 1.9 billion (112%) due to original design flaws and unexpected geological conditions. The project was due for completion by 2011but has stalled and the contractor has moved to court to seek redress on the pending fees and liquidated damages levied by NWCPC.

2.8. Valuation of Variations

Singh Harbans (2003); Wainwright and Wood (1983) concur that the valuation of variation orders may be in the form of:

1) 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
2) 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
3) Quotation where contractors submit a quotation to effect the work contained in a variation order; and
4) *Quantum meruit* is a miscellaneous method where negotiated or agreed rates or payment are made on a reasonable sum.

2.9 Factors Influencing the Occurrence of Variations

Arain and Pheng (2005a) contend that the frequency of occurrence of variations vary from one project to another depending on various factors. Ndihokubwayo and Haupt (2008) identified the factors influencing the occurrence of variation orders as; the nature of the works, the complexity of the project and the procurement method.

2.9.1 Nature of the Works

According to Ndihokubwayo and Haupt (2008), construction projects that involve extensive unforeseen conditions are likely to generate variation orders. For example, civil works involving bulk earth excavation and building works that include specialist works beyond the expertise of the designer cannot accurately be determined before works commence on site. Drawings and specifications do not always show the real site conditions nor do preliminary investigations. Despite this situation, it is common that works commence on site while some trades and building elements still need to be completely designed or detailed. Consequently, contracts contain provisional quantities and sums that will be subject to future adjustment. Uyun (2007) concedes that the presence of provisional quantities or sums in a contract is a clear indication of the likely occurrence of variation orders in a project.

Gidado (1996) points out that there are four major possible causes of project uncertainty, namely:

1) Lack of complete specification for the activities to be executed;
2) Unfamiliarity with the inputs and/environment by management;
3) Lack of uniformity, such as when material to be worked with varies with place and time or teams working together vary with place and time or the role of the teams keeps varying with place and time.
4) Unpredictability of the environment, such as the effect of weather and refurbishment of very old buildings having no record drawings.

2.9.2 Complexity of the Project

Gidado (1996) asserted that project complexity is attributed to the continuous demand for speed in construction, cost and quality control, health and safety in the work place and avoidance of disputes, together with technological advances, economic liberalisation and globalisation, environmental issues and fragmentation of the construction industry. Baccarini (1996); Ireland (2007) concurred that two types of project complexity are distinguished, namely organisational or management complexity and technological or technical complexity.

According to Ireland (2007) the degree of project complexity is classified as low, medium and high complexity. The greater the project complexity, the greater the

likelihood of variation order occurrence. Ndihokubwayo and Haupt (2008) noted that variation order issued due to the complexity of the design may take time for the design team to understand the required change and redesign while works on site are put on hold.

2.9.3 Procurement Method

According to Love (2002), the path followed to deliver the project differs from one project to another. Typically, this is a procurement method that stipulates the form of contractual arrangement between participants or parties to the contract. One type of procurement method may result in more variation orders than another. For example, non-traditional procurement methods are subject to greater occurrence of errors, omissions and changes than the traditional methods.

2.9.3.1 Traditional Method

Ashworth (1998) contended that traditionally, an employer who wished a project to be constructed would invariably commission a designer or design team to prepare drawings of the proposed scheme and, if the scheme was sufficiently large, employ a quantity surveyor to prepare documentation, such as bills of quantities, from which the contractor could prepare a bid price. Since the works commence on site when the design is complete, the occurrence of variation orders in this arrangement is minimised. Koushki *et al.* (2005) concurred that clients who spent more time and money on the design phase issued less variation orders than those who allocated insufficient money and time to this phase. Turner (1990) was of the view that the more time spent on completing the contract documents before commencement of works, the more likely the avoidance of discrepancies between the contract documents, errors and omissions into the design. Consequently, there is less variation orders. Since clients and their consultants control the origin of variations, variations should not occur if pre-construction design has been good.

2.9.3.2 Non-traditional Methods

Ashworth (1998) noted that changes in procurement methods are the result of a move away from the craft base to the introduction of off-site manufacture, the use of industrialised components, the wider application of mechanical plant and equipment, the improved knowledge of production techniques, the recognition that involvement of the contractor into both the design and the way works are carried out on site will

result into quality of finished works. For example, design and construct procurement methods where the contractor is responsible for the design and construction are deemed to overcome the problem of variation order occurrence.

Ashworth (1998) further stated that the involvement of contractors into the design is an opportunity for them to use specialised knowledge and methods of construction evolving from their own design and as a result, there is less scope for variations than with the design and construct approach. The package deal procurement method requires the client to view completed projects of a specific design and choose a suitable project or design from the catalogue. Owing to the completeness of the design, this procurement method is less prone to variation orders.

Ashworth (1998) recommended that the fast track procurement method is appropriate for situations where the client targets the shortening of the overall design and construction process. When the design for the whole section of the works, such as foundations, is completed the work is then let to the contractor, who will start this part of the construction work on site while the remainder of the project is still being designed. Turner (1990) warned that variations should be expected on construction projects that lack pre-design. Variation orders resulting from design errors and omissions can be problematic where construction overlaps the design.

2.10 Theoretical Framework

This study was modelled on the Deming's theory of Profound Knowledge which is a management philosophy grounded on the system theory. It is based on the principle that each organization is composed of a system of interrelated processes and people which make up system's components. According to Berry (2013), the success of all workers within the system is dependent on management's capability to orchestrate the delicate balance of each component for optimization of the entire system.

Berry (2013) stated that the Deming's theory of Profound Knowledge is made up of four interrelated components:

1. Appreciation of a system
2. Theory of knowledge
3. The psychology of change
4. Knowledge about variation

Berry (2013) emphasized that the four components cannot be separated. Knowledge of psychology, variation, theory of knowledge and appreciating the processes of a system must be managed with a delicate balance. They make up systems.

Berry (2013) noted that variation is a natural, inevitable part of life. The goal of quality or continuous improvement is to reduce the range of variation over time, in addition to adjusting the process level to the desired level. Almost all variation within a process is due to chance causes, inherent in the design of the process. Management controls the design of the process. People within the system are limited by that design.

According to EdwardDemingInstitute (2014), in any business, there are always variations, between people, in output, in service and in product. Drawing on his training as a statistician and the ground-breaking statistical theories of his mentor, Walter Shewhart of Bell Laboratories, Dr Deming located two types of variations within a system—common cause and special cause. Common cause variations are problems built right into the system, such as defects, errors, mistakes, waste and rework. In a stable system, common cause variation will be predictable within certain limits. On the other hand, special cause variations represent a unique event that is outside the system, such as a natural disaster, or an unexpected strike by public transportation workers.

EdwardDemingInstitute (2014) observed that distinguishing the difference between variations, as well as understanding its causes and predicting behaviour, is key to management's ability to properly remove problems or barriers in the system. However, without knowledge of variation, management might very well (with the very best intention) take action that actually makes things worse. Just as important, through knowledge of variation, management realizes that attributing a problem to a person, instead of the system, is misguided and misleading.

As adopted in this study, the civil construction industry in Kenya is a system, while the client, consultants, contractor are components of the system. Therefore, the causes of variation attributable to the three parties are considered to be common causes that are inherent within the system, even as the causes of variations that cannot be attributed to the tree parties such as inclement weather, differing site conditions, technology changes, socio-cultural factor, environmental factors, change in

government regulations, economic change etc. are considered to be special causes from outside the system but influencing it.

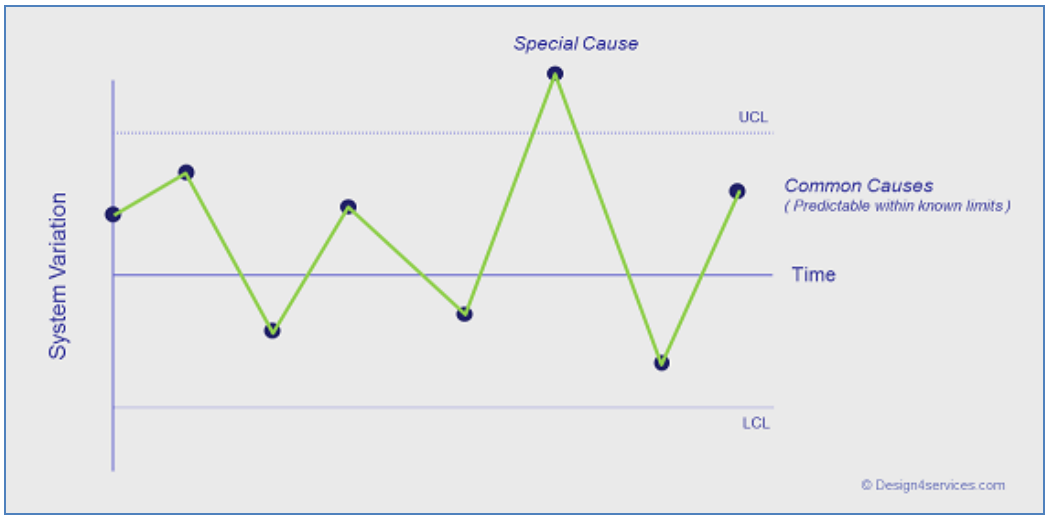

Figure 2-2: Variation Control Chart

Source: Design4service.com (2014)

However, in adopting the theory of profound knowledge grounded on the systems theory, the researcher is not ignorant of its shortcomings in the civil construction industry. This theory requires a shared vision and a common goal where all the parties i.e. the client, contractor and consultant to work cohesively for the benefit of all. This is a task that is not easy to achieve in civil construction projects where most often, the client and contractor adopt an antagonistic approach to issues and the consultant as the client's agent seldom plays an impartial role in this relationship.

2.11 Conceptual Framework

Mugenda and Mugenda (1999) define conceptual framework as a concise description of the phenomenon under study accompanied by a graphical or visual depiction of the major variables of the study. Conceptual frameworks play an important role in understanding social phenomena and therefore can also play a role in policy research analysis. Conceptual frameworks can also be useful for understanding the nature of a policy problem, the important elements and relationships and the hidden assumptions embedded in the policy problem definition and solutions.

In this study, the origin agents of variations namely, clients, consultants, contractors and the "other'' are the independent variables. From the origin agents, different types of variations namely additional work, omission from work, change to sequence and

timing of work, change to quality/characteristics of the work and change to levels/position / dimension of the work arise. In this study, these types of variations are the intervening variables.

Depending on the type of variation that occurs in a project, one or a combination of the following effects could be experienced; cost overruns, contractual disputes and claims, time overruns, increase in overhead costs, progress degradation, quality degradation, demolition and rework, productivity degradation, procurement delays, and delays in payment are considered dependant variables.

The moderating variables for the study were considered to be procurement method, project complexity, and nature of work. These variables influence the occurrence of different types of variation in a project.

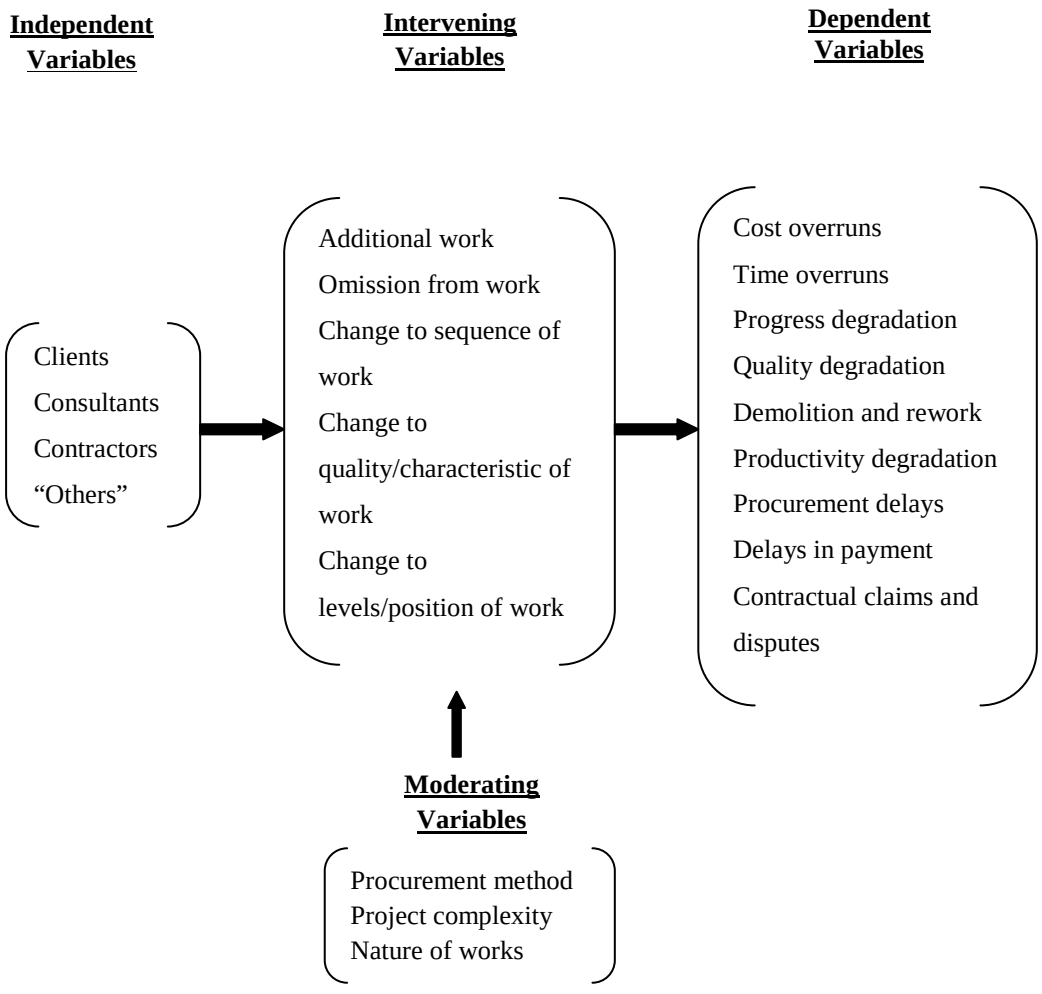

Figure 2-3: Conceptual Framework
Source: Author, (2013)

CHAPTER THREE

3.0 RESEARCH DESIGN & METHODOLOGY

3.1 Introduction

Chapter three outlines plan of action that shows how the problem was investigated, what information was collected using which methods, and how this information was analysed in order to accomplish the study objectives. The chapter is organized around five major topics, namely: research design, population and sample, pilot study, data collection and instruments, and data analysis.

3.2 Research Design

This study was conducted through a survey research design with a combination of both quantitative and qualitative research strategies. According to Geoffrey *et al.* (2005) survey studies ask large numbers of people questions about their behaviours, attitudes, and opinions. Some surveys merely describe what people say they think and do.

Geoffrey *et al.* (2005) argues that the principal advantage of survey studies is that they provide information on large groups of people, with very little effort, and in a cost-effective manner. Surveys allow researchers to assess a wider variety of behaviours and other phenomena than can be studied in a typical naturalistic observation study.

According to Mugenda and Mugenda (1999), the combination of qualitative and quantitative methods is advantageous because they supplement each other in that qualitative methods provide the in-depth explanations while quantitative methods provide the hard data needed to meet required objectives. Moreover, since both methods have some bias, using both types of research helps to avoid such bias in that each method can be used to check the other. For example, the subjectivity associated with qualitative analysis research is minimized by the objectivity of quantitative research. The finding derived from derived from one approach validates the other.

3.3 Population and Sample

3.3.1 Population

Mugenda and Mugenda (1999) defined target population as an entire group of individuals, events, or objects having a common observable characteristics. For this questionnaire survey study the target population included;

1. All civil engineering consultants registered with the Association of Consulting Engineers of Kenya (ACEK) and located in Nairobi. According to ACEK, there are thirty two (32) engineering consultant firms registered under the category of civil and infrastructure by April 2013. These consulting companies are involved in road works, bridges, hydropower plants, overhead transmission lines and substations, water and sanitation, and ports and harbours.
2. All civil construction contractors registered with the ministry of public works of Kenya (MoPW) under class A and B, and located in Nairobi. Data from MoPW showed that there are fifty one (51) registered civil contractors under category A and B as of April 2013.
3. All clients in the public sector involved in civil construction projects, with their headquarters in Nairobi. A perusal of the government ministries' websites showed that there are at least twelve (12) government parastatals and corporations based in Nairobi that are involved in civil construction projects currently underway or completed.

This target population was chosen because of time and financial limitations of the study.

3.3.2 Sample and Sampling Technique

The rule of thumb is to obtain as big a sample as possible. However, resources and time are major constraints in deciding on the sample size to be used. Mugenda and Mugenda (1999) provided the following formula for determination of the sample size;

$$n_f = \frac{n}{1 + \frac{n}{N}}$$ **……Equation 1**

Where: $\boldsymbol{N}$ – total number of population; $\boldsymbol{n_f}$ – sample size from finite population; n – sample size from infinite population = $\mathbf{S^2/V^2}$; where $\mathbf{S^2}$ is the variance of the population elements and **V** is a standard error of sampling population (Usually S = 0.5 and V = 0.1 for 90% confidence interval).

James (2008) clarifies that the finite population correction (fpc) factor which in this study is denoted *n* is used to adjust a variance estimate for an estimated mean or total, so that this variance only applies to the portion of the population that is not in the sample. That is, variance is estimated from the sample, but through the fpc it is used to assess the error in estimating a mean or a total, which is due to the fact that not all data from the finite population are observed.

The target population, $\boldsymbol{N}$ was 12 for clients, 32 for consultants, and 51 for contractors. Therefore, the minimum sample size was 11, 25, and 34 for clients, consultants, and contractors respectively. However, Mugenda and Mugenda (1999) recommended that a representative sample needs to be a minimum of 30 items. Therefore, taking that into consideration and also to carter for the would-be nonresponsive respondents, this study sampled the entire target population of 12 clients, 32 consultants, and 51contractors.

3.4 Data Collection Instruments

In this study, questionnaires were used as the main instrument for collecting data. Kumar (2006) describes a questionnaire as a form which is prepared and distributed for the purpose of securing responses. Generally these questions are factual and designed for securing information about certain conditions or practices, of which recipient is presumed to have knowledge. The selection of this tool was guided by the nature of data to be collected, the time available as well as by the objectives of the study. The overall aim of the study was to evaluate the causes and effects of variation orders in civil construction projects in Kenya. Willis and Onen (2009) recommend that when the researcher is mainly concerned with the views, opinions, perceptions, feelings and attitudes of the respondents, such information can be best collected through the use of questionnaires.

According to Kothari (2004) the merits of questionnaire method are as follows; 1)There is low cost even when the universe is large and is widely spread geographically; 2) It is free from the bias of the interviewer; answers are in

respondents' own words; 3) Respondents have adequate time to give well thought out answers; 4) Respondents, who are not easily approachable, can also be reached conveniently and 5) Large samples can be made use of and thus the results can be made more dependable and reliable.

3.4.1 Questionnaire Format

In this study three sets of questionnaires, X, Y and Z were administered to collect data from consultants, clients and contractors respectively and are listed in Appendices A,B and C correspondingly. However, the three sets of questionnaires are similar in structure except for the open ended question section i.e. *Section D*, where the client, consultant and the contractor were required to answer different sets of questions. Each questionnaire was divided into four sections. Section *A* sought background information about respondents; section *B* focused on origin agents and causes of variation orders; section *C* examined the effects of variation orders while section *D* was an open ended section were the respondents were prodded to give more details on their respective experiences with variations .

Structured or Closed-ended questions: In section *A* through to section *C*, of the questionnaires, the respondents were restricted in the way they answered the questions as they were required to select one answer from among the given ones. These types of items refer to questions which are accompanied by a list of all possible alternatives from which a respondents select the answer that best describes their situation. Mugenda and Mugenda (1999) notes that in many cases it is impossible to exhaust all the categories since a researcher may not know all possible answers. In such cases it is customary to include a category called 'others' to take care of all those responses which may not fit in the given categories.

Unstructured or Open-ended questions: In section *D* of the questionnaire, unstructured questions were asked. Mugenda and Mugenda (1999) noted that these are questions which give the respondent complete freedom of response, hence permit an individual to respond in his or her own words.

According to Ranjit (2005), an open-ended question is a qualitative enquiry aiming at minimising the imposition of predetermined responses when gathering data whereby people can respond in their own words.

Ranjit (2005) argues that open-ended questions provide a wealth of information provided respondents feel comfortable about expressing their opinions; provide the respondents an opportunity to express themselves freely resulting in a greater variety of information; virtually eliminate the possibility of the investigator's bias.

3.5 Data Collection Procedure

Once the questionnaires had been finalized, they were subjected to pre-testing. Mugenda and Mugenda (1999); Walliman (2005) concur that pre-testing must be done on a selected sample that is similar in characteristic to that of the actual sample intended for the study. The procedures for pretesting were identical to those that were used during the actual data collection so as to anticipate any problem of comprehension or other sources of confusion, thus enhancing the reliability of the instrument. According to Mugenda and Mugenda (1999) the number of cases in the pre-test should not be very large. It should be between 1% and 10% depending on the sample size. This study adopted 5% of the sample size for the pilot study. A total of nine questionnaires were distributed to the likely respondents in the actual survey between 3rd and 20th July 2013. The objective of the pilot study was to verify the completeness of the questionnaires.

The following items are a summary of the major observations and modifications based on the pilot study:

1. The following factors were added to the causes: Lack of coordination between international and local designer; Interference of donors in project requirements; delay in land acquisition/ compensation and environmental considerations.

2. Some questions were omitted from questionnaire as suggested by the respondents. These questions were considered impractical or unrealistic with respect to the unique situation of construction projects in Kenya: Fast track construction; honest wrong belief of consultant; honest wrong belief of contractor; obstinate nature of the consultant; long lead procurement; obstinate nature of client.

3. The following questions were omitted from the effects of variation orders: Damage to firm’s reputation; hiring new professionals; and poor safety conditions.

4. Some factors were merged or rearranged in order to give more suitable and consistent meaning.

Subsequently, a few amendments were necessary as a result of either non-responses or improperly answered questions. A final version of the questionnaires were produced as listed in Appendices A, B and C.

A brief covering letter was prepared for every questionnaire. The letter contained a brief about the research, explaining the purpose of the study and assuring the respondents of anonymity and signed personally. To encourage the respondents to complete the questionnaires and mail them back, a stamped, addressed envelope was mailed together with the questionnaire. The name of participant organisations and individuals was not recorded on research instruments. However, the questionnaires were coded so as to know from which respondent the returned questionnaires are from. No compensation was paid to any respondent or participant in the study. The questionnaires were dispatched on the 6th August 2013 through postal mail.

3.6 Data Analysis Procedure

Using two software packages namely, Microsoft Excel 2007 and Statistical Package for Social Sciences (SPSS) v20, the data collected was analysed both qualitatively and quantitatively.

3.6.1 Qualitative Analysis

Qualitative analysis was used to analyse data captured in Section *D* of the questionnaire. According to O'Leary (2004), the analysis of qualitative data consists of abstracting from the raw data all points that a researcher considers to be relevant to the topic under investigation. Qualitative data is analysed thematically. Thematic analysis can include analysis of words, concepts, literary devices, and/or non-verbal cues. The responses to the open ended questions were recorded in Microsoft Excel and categorised such that similar reasons were grouped together.

3.6.2 Quantitative Analysis

In this study, quantitative analysis was used to analyse data captured in sections *A*, *B*, and *C* of the questionnaire. Walliman (2005) noted that quantitative analysis uses the syntax of mathematical operations to investigate the properties of data. Quantitative data is analysed statistically. Statistical analysis can be:

3.6.2.1Descriptive

Walliman (2005) states that descriptive statistics provide a method of quantifying the characteristics of the data, where their centres is, how broadly they spread and how one aspect of the data relates to another aspect of the same data. In this study, frequency (percentages) was adopted as the method of analysis to address objective 1 as stated in section 1.6 of Chapter One.

To address objectives 2 and 3 as stated in section 1.6 of Chapter One, the data from Section B and C were analysed using the Relative Importance Index (RII). Sambasivan and Soon (2007) recognizes that the RII method was adopted for similar studies to determine the relative importance of various factors. The RII method adopted for this study to determine the relative importance of the various causes and effects of variation orders based on responses from various groups; clients, consultants, and contractors. The five point Likert scale ranged from 1 (Least Frequent) to 5 (Extremely Frequent) for causes of variation orders and from 1 (Never) to 5 (Always) for effects of variation orders was adopted and transformed to relative importance index using the following equation:

$$RII = \frac{\sum W}{AN} \quad \text{…… Equation 2}$$

Where: W = the weight given to each factor by the respondents, ranges from 1 to 5;

A = the highest weight = 5;

N = the total number of respondents.

3.6.2.2 Inferential

In this study, Kendall's coefficient of concordance was used to test the correlation of consultants', clients' and contractors' opinion on the causes and effects of variation orders on civil construction projects in Kenya.

Kothari (2004) argues that Kendall's coefficient of concordance is an important non-parametric measure of relationship used for determining the degree of association among several sets of ranking of objects or individuals. When there are only two sets of rankings of objects, Spearman's coefficient of correlation is applicable, but

Kendall's coefficient of concordance is considered an appropriate measure of studying the degree of association among three or more sets of rankings.

The procedure for computing and interpreting Kendall's coefficient of concordance **(*W*)** is as followsKothari (2004):

$$W = \frac{s}{\left[\frac{k^2(N^3-N)}{12}\right]}$$ **……..Equation 3**

Where: $s = \sum(R_j - \overline{R_j})^2$

N = number of objects ranked;

K= number of sets of rankings i.e., the number of judges;

R_j= ranks assigned by k judges and $\overline{R_j}$ = Absolute mean of ranks

3.7 Quality Control

3.7.1 Validity

Mugenda and Mugenda (1999) define validity as the accuracy and meaningfulness of inferences, based on the research results. In other words, validity is the degree to which results obtained from the analysis of the data actually represent the phenomenon under study.

Validity was achieved in this study by adopting the random sampling method. Mugenda and Mugenda (1999) state that external validity of a study has to do with representativeness of the sample with regard to the target population. External validity refers to degree which research findings can be generalized to populations and environments outside the experimental setting.

3.7.2 Reliability

Mugenda and Mugenda (1999) reckon that reliability is a measure of the degree to which a research instrument yields consistent results or data after repeated trials. Reliability in research is influenced by random errors. As random error increases, reliability decreases.

Mugenda and Mugenda (1999) reiterate that there are four different methods of assessing reliability in data and these four are: test-retested, equivalent form, split-half and internal consistency. In this study, the internal consistency method was used. The Cronbach's Coefficient Alpha was computed to determine how items correlate among themselves. The Cronbach's alpha coefficient is calculated as follows:

$$\alpha = \left\{ \frac{Kr}{[1 + (K-1)r]} \right\}$$ **……...……Equation 4**

Where: α = Cronbach's Coefficient Alpha,

K = the number of items considered, and

r = the mean of the inter-item correlations the size of alpha is determined by both the number of items in the scale and the mean inter-item correlations.

George and Marllery (2003) provided a commonly accepted rule of thumb for describing internal consistency using Cronbach's alpha is as follows:

Table 3-1: Cronbach's Consistency Alpha

Cronbach's Coefficient Alpha	Internal Consistency Remarks
$\alpha \geq 0.9$	Excellent
$0.7 \leq \alpha < 0.9$	Good
$0.6 \leq \alpha < 0.7$	Acceptable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

Source: George and Marllery (2003)

The Cronbach's alpha coefficient was calculated and the subsequent relationship between the individual items and the overall scale was examined. Table 3-2 shows the results obtained.

Table 3-2: Cronbach's Alpha Results

Question	Q7	Q8	Combined
Number of Items	30	10	40
Cronbach's Alpha	0.81	0.63	0.77

Source: Author (2013)

3.8 Ethical Considerations

Precautions were taken to ensure that the study was carried out in an ethical manner. First and foremost the study was carried out with the full consent of the board of postgraduate studies of the Jomo Kenyatta University of Agriculture and Technology.

Secondly, the study ensured that there was informed consent by the potential participant by drafting a cover letter that explained the aim of the study and went further to provide the authors contacts for further clarification.

Thirdly, the study ensured that the participants' anonymity and confidentiality were preserved by not requesting for information that would reveal their identity. Moreover, the information provided was used for academic purposes only.

Last but not least, the study encouraged voluntary participation and respondents were not coerced or enticed to participate in the study.

3.9 Field Study Constraints

Despite the fact that the respondents were provided with stamped envelopes to encourage response, the initial rate of return was low (about 35%). Six weeks after the questionnaires had been dispatched it was concluded that no more response would be forthcoming through the postal mail, hence a process of identifying the nonresponsive companies commenced. This was possible because all the questionnaires had been coded according to the intended respondent. Based on this list, the companies were phoned to inquire about their willingness to participate after which appointments were booked to self-administer the questionnaires. Through this intervention the rate of return rose to 78%. It is worth noting that some nonresponsive respondent companies could not grant an appointment for self-administration of questionnaires hence their opinions could not be captured in this study. However, this does not affect the outcome of the study since the achieved rate of rate was sufficient to arrive at reliable conclusions.

CHAPTER FOUR

4.0 DATA ANALYSIS AND DISCUSSIONS

4.1 Introduction

This study investigated the causes and effects of variation orders in civil engineering construction projects in Kenya. The data collected was analysed using Microsoft Excel 2007 and the Statistical Package for Social Scientists (SPSS) version 20. The data analysis and discussion was carried out and organised according to the research objectives of the study. The analysis output was presented in form of figures and tables. The major findings were inferred and the results compared to the literature review.

4.2 Nature of Variation Orders in Civil Engineering Construction Projects in Kenya

The first objective of this study was to examine the nature of variation orders in civil engineering construction projects in Kenya. To achieve this objective, the study sought to establish who the origin agents of variation orders are and what aspects of variations exist in civil construction projects in Kenya.

4.2.1 The Origin Agents of Variation Orders in Civil Engineering Construction Projects in Kenya.

The respondents were asked to select one origin agent of most of the variation orders in their projects from a list of four choices namely; Client, Consultant, Contractor and "Other", where "other" meant agents that are not related to the three contracting parties in a construction project. The results in Figure 4-1 suggest that the client is the most predominant origin agent of most variation orders at 55% whiles the least predominant was the category of "other" at only 5%.

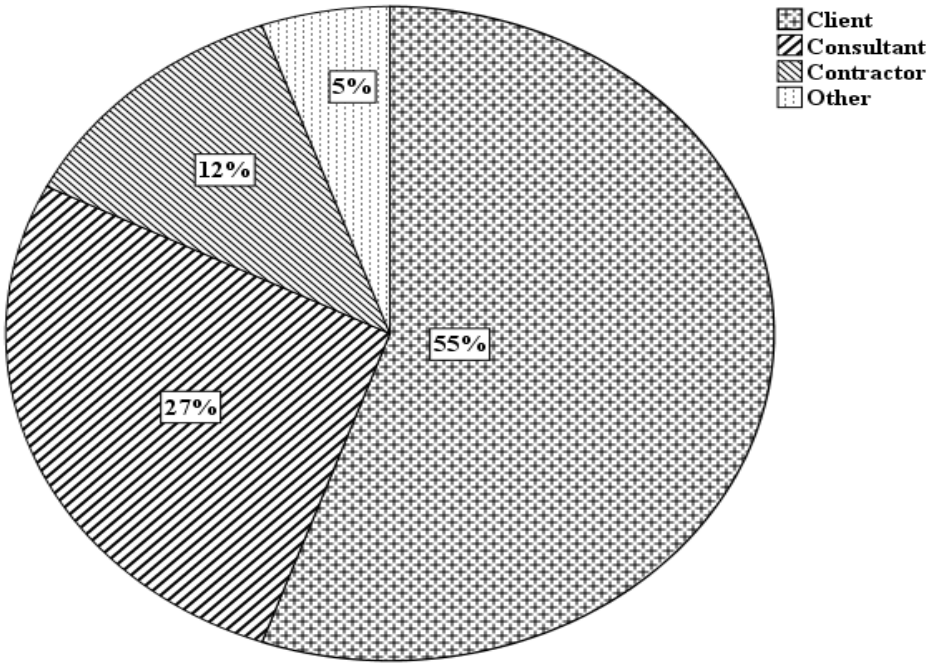

Figure 4-1: Origin Agents of Variation Orders in Kenya.

Source: Author (2014)

This finding indicates that the client is the major origin agent of variation orders in civil engineering construction projects in Kenya. This is because despite the involvement of the client in the pre-construction planning stage of a project it is at times difficult to determine the exact requirements of the client. If the objectives of the project are inadequately defined in the project brief, it is common that clients will tend to change their mind along the way. These changes may include replacement of materials, change of design, scope and schedule of works. Moreover, according to KACC (2007) the responsibility of the client during the preconstruction stage such as the acquisition of right of way if left to spill into the construction stage always lead to corridor realignment, necessitating redesign and subsequently variations.

This finding that the client is the most predominant origin agent could also mean that despite the presence of the consultant as the overseer of construction project on behalf of the client, the client seems to be wielding more powers when it comes to issuance of site instructions on technical issues and not letting the consultant execute his mandate.

The fact that most clients for civil construction projects in Kenya are government ministries and authorities with fully operational design departments where project

designs are issued instead of outsourcing the services of consultants for the same could be an explanation to the high score of the client as an origin agent of variation orders. This is because since the client assumes the design role, discrepancies in design leading to variations are blamed on the client rather than consultant.

On the other hand, in case errors, omissions or discrepancies are found in the design or a conflict is discovered between the contract documents, it is the duty of the consultant to provide a remedial solution. A contractor who finds a problem to interpret ambiguous design details and inadequate working drawings notifies the concerned consultant as soon as possible. A contractor cannot proceed with work where ambiguous situations arise unless the consultant issues an instruction which might at times constitute a variation order. This explains the reason behind contractor's dismal contribution towards variations with a score of 12%.

The least contributor to variations was under the category of 'other' with a score of 5%. In this category are factors that are not under the control of any of the contracting parties namely; client, consultant and contractor. In this category, the respondents listed inclement weather conditions and socio-cultural factors as the origins of variations.

The finding the client is the most predominant origin of variations is in concurrence with the views of previous researchers Al-Dubaisi (2000); Ndihokubwayo (2008); Oladapo (2007); Randa *et al.* (2009) who in their various studies revealed that indeed the client is the major origin agent of variation orders. However, this finding is contrary to that of Olsen *et al.* (2012) who found that the designer (consultant) is the major origin agent of variation orders by contributing 67%, while the client contributed 29%.

4.2.2 The Aspects of Variation Orders in Civil Construction Projects in Kenya

The respondents were asked to select the most common aspect of variation orders in their projects from a list of five, namely additional work; omission from work; change to the quality or other characteristic of any item of the work; change to the sequence or timing of execution of the work; and change to the levels, positions and/or dimensions of any part of the work.

The Figure 4-2 records the aspects of variation orders. The majority of the variation orders issued involved additional work with a score of 58%, even as change to the levels, positions and/or dimensions of any part of the work recorded only 1%.

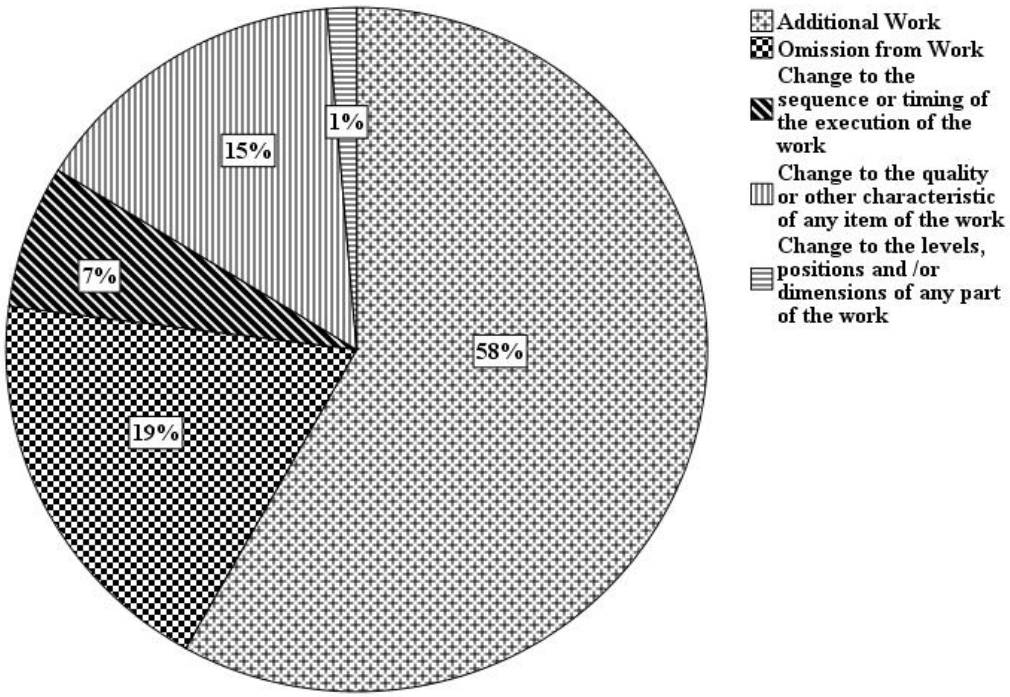

Figure 4-2: Aspects of Variation Orders in Kenya

Source: Author (2014)

Additional works are the result of the failure by client to provide a clear and comprehensive brief with the result that client changes emerge during the construction stage. In addition, additional works are also the result of the failure by the consultant to produce complete design resulting in more details being required during the construction stage.

Omission from work is the second largest contributor to variation orders in civil construction projects in Kenya at 19%. Due to budgetary constraints the client may choose to reduce the scope of his project to meet the shrinking financial capability. Further, during the construction phase of a project, some project objectives might be rendered irrelevant hence necessitating the reduction of scope by the client.

Change to the quality and other characteristics of any item of work occupies the third position as the most common aspect of variation, contributing to 15% of variation orders civil construction projects in Kenya. Substituting materials during construction

phase is a common occurrence in the construction industry. This could be as a result of new and superior materials becoming available in the market, or due lack of the specified material in the market or simply due to the change of mind on part of the client or the consultant.

This finding is in agreement with that of Ndihokubwayo (2008) who found that additional work is the major aspect of variation orders, contributing to 71% of all the variations. Compared to 58% for the case of additional work in civil construction projects in Kenya, it give the impression that though projects in Kenya experience scope creep, they do at slightly controlled environment than in South Africa.

4.3 Factors that Contribute to Variation Orders in Civil Engineering Construction Project in Kenya.

The second objective of this study was to determine the factors that contribute to variation orders in civil construction projects in Kenya. In order to achieve this objective, the study set out to determine what the ten most important factors contributing to variation orders are and to compare the clients', consultants,' and contractors' perspective on the factors causing variations.

4.3.1The Most Important Factors Causing Variation Orders in Civil Engineering Construction Projects in Kenya.

The respondents were asked to rate each potential cause based on his/her professional judgment and using the following scale, Least frequent = 1; Slightly frequent = 2; Moderately frequent = 3; Very frequent = 4; Extremely frequent = 5. As illustrated in Table 4-1, it was possible to rank the causes of variation orders by way of the Relative Importance Index (RII).

The ten most important causes of variation orders in civil construction projects in Kenya were found to be: 1) Delay in land acquisition/compensation, 2) Differing site conditions, 3) Change of plans or scope by client, 4) Change of schedule by the client, 5) Lack of coordination between overseas and local designers, 6) Change in design by consultant, 7) Inclement weather conditions, 8) Errors and omissions in design, 9) Unavailability of materials and equipment, and 10) Conflict between contract documents.

On the other hand, the five least important causes of variation orders were revealed to be: 1) Technology changes, 2) Value engineering, 3) Change in government regulations, 4) Contractors financial difficulties, 5) Inadequate project objectives and 6) Change in economic conditions.

Table 4-1: The Most Important Causes of Variation Orders in Kenya

Causes of Variation Orders	Overall		Client		Consultant		Contractor	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Delay in land Acquisition/ Compensation	0.859	1	0.900	1	0.850	1	0.853	1
Differing Site Conditions	0.832	2	0.767	2	0.842	2	0.847	2
Change of Plans or Scope by Client	0.762	3	0.567	12	0.792	3	0.805	3
Change of Schedule by Client	0.751	4	0.717	3	0.783	4	0.742	6
Lack of Coordination between Overseas and Local Designers	0.741	5	0.667	6	0.758	5	0.753	4
Change in Design by Consultant	0.735	6	0.650	8	0.750	6	0.753	4
Inclement Weather Conditions	0.727	7	0.650	8	0.742	7	0.742	6
Errors and Omissions in Design	0.711	8	0.717	3	0.708	8	0.711	8
Unavailability of Materials and Equipment	0.651	9	0.417	21	0.700	9	0.695	9
Conflict between Contract Documents	0.651	9	0.717	3	0.633	11	0.642	10

Source: Author (2014)

The entire ranking of factors contributing to variations in civil engineering construction projects in Kenya is as attached in Appendix H. Nonetheless, the discussion of the ten most important factors causing variation orders are amplified as follows:

4.3.1.1 Delays in Acquisition of Right of Way

Delay in acquisition of right of way is the most important cause of variation orders in civil engineering construction projects in Kenya. It was ranked first, according to overall correspondents with RII of 0.859.According to Steven and Daniel (2008), at the outset of construction, the owner has an implied obligation to provide adequate and timely access to the construction site. This implied obligation requires both acquiring the property, whether by purchase or lease, and providing access to the property for the delivery of contractor's equipment and materials.

This finding shows that due to government bureaucracy, the clients who in the case of Kenya are mostly government parastatals and corporations, issue premature notice to proceed at the beginning of the contract and that the contractor commences work while the right of way is progressively resolved alongside the works. This is a common phenomenon in infrastructure projects in Kenya such as roads, water distribution and transmission lines. In most cases this causes delays and disruption of work which are responsible for variation in project schedule. In extreme cases, right of way problems could necessitate rerouting of projects so as to avoid contentious areas.

4.3.1.2 Differing Site Conditions

Differing site conditions was found to be the second most important cause of variation order in civil engineering construction projects in Kenya. It was ranked second overall with RII of 0.832. Samantha (2002) contends that during the construction of a project, contractors often encounter subsurface or hidden conditions which were not anticipated and which may have a major impact on the time and cost of performing their work. However, Steven and Daniel (2008) argue that the owner has an implied obligation to provide the contractor with complete and accurate information regarding conditions at the construction site. If the owner has information in its possession regarding adverse conditions at the site, such as unanticipated geological conditions, water intrusion, underground pipe or cable, and other types of impediments to the clearing, grubbing and grading of the site, the owner has a duty to provide that information to the contractor. An owner can be liable for a “differing site condition” claim by the contractor even when the nondisclosure is unintentional.

This finding implies that in civil engineering construction projects in Kenya, the owners do not learn as much about the site conditions as possible before entering into the contract (generally in the planning stages) by conducting adequate site or subsurface investigations through its geotechnical consultant. Moreover, this finding could be a pointer to the fact that the contractors do not conduct their own investigations if necessary to confirm the information provided by the owners and its consultants so as to ensure accuracy.

4.3.1.3 Change of Plans or Scope by Client

Change of plans or scope by client was ranked the third most important cause of variation orders in civil engineering construction projects in Kenya with an RII of 0.762. Samantha (2002) noted that having adequate plans is a fundamental requirement for construction project. Insufficient plans result in uncertainties in the work which generally lead to remedial work prior to completion and an increase in the number of variations in the work. Increased variations in a construction project generally reduce productivity and efficiency, and increase the chances of construction claims, especially delay claims.

According to Wally (2012), *Spearin* doctrine holds that a contractor will not be liable to an owner for loss or damage that results solely from defects in the plan, design, or specifications provided to the contractor. Effectively, *Spearin* created a doctrine whereby the owner impliedly warrants that the plans and specifications, if followed, will result in a functioning system. *Spearin* holds that if a contractor is required to build according to plans and specifications prepared by the owner (or the owner's representative), then the contractor will not be responsible for the consequences of defects in the plan.

This finding suggests that in civil engineering construction projects in Kenya, cases of insufficient plans and lack of scope control is the order of the day. This often leads to frequent change of plans and scope creep further resulting into additional work, disruptions or defective workmanship. This finding could also be a suggestion that contractors do not adequately review plans submitted by the client or his representative for obvious deficiencies so as to alert the owner and consultant in respect of any such defects.

4.3.1.4 Change of Schedule by the Client

The fourth most important cause of variation orders in civil engineering construction projects in Kenya was found to be change of schedule by the client, with an RII of 0.751. Improper scheduling and coordination of the works leads to a disorganized construction project prone to disputes, claims and considerable losses for all involved. Proper scheduling and coordination is thus required for a successful and profitable construction project Samantha (2002).

This finding is an indicator that in Kenya, the owners do not give much attention to scheduling during the planning phase of their projects and thus schedules issued for construction are always unrealistic leading to acceleration of work where a contractor must complete its work faster than it had originally planned in the construction schedule. This has the potential of precipitating claims for additional cost from the need to replay and re-sequence the work, hire additional workers, work overtime, accelerate material delivery, obtain additional supervision, or use additional equipment.

4.3.1.5 Lack of Coordination between Overseas and Local Designers

With an RII of 0.741, lack of coordination between overseas and local designer was revealed to be the fifth most important cause of variation orders in civil engineering construction projects in Kenya. According to Alarcón and Mardones (1998), in construction projects clients requirements, constructive aspects and quality standards are defined during the design phase. However, this important phase is usually carried out with little interaction between the construction and design teams causing many problems during construction such us: incomplete designs, variation orders, rework, construction delays, etc.

This finding suggest that in large infrastructure projects in Kenya where the design consultants are foreign based, designs are often done on the basis of foreign standards and later reviewed locally to conform with the requirements of the local standards and site conditions. Poor or lack of proper coordination of this process could be responsible for design deficiencies/omissions and lack of constructability of the designs leading to high number of variations to suit the local clients requirements.

4.3.1.6 Change in Design by Consultants

The sixth most important cause of variation orders in civil engineering construction projects in Kenya was discovered to be change in design by consultants, with an RII of 0.735. Change in design for improvement by the consultant is a norm in contemporary professional practice Arain *et al.* (2004). The changes in design are frequent in projects where construction starts before the design is finalized Fisk (1997). Design changes can affect a project adversely depending on the timing of the occurrence of the changes.

This finding reveals that indeed projects in Kenya are commenced before the designs are finalized and approved for construction. This notion was captured by KACC (2007) who reported that many road projects have commenced on the basis of preliminary design that turn out to be inadequate leading to redesign as construction progresses. This further leads to the works progressing without adequate drawing to guide the construction process and inability of supervisors to control progress and quality of the works due to frequent design changes. These create an avenue for abuse by the supervisors and contractors during the implementation process, which may be in the form of unwarranted variations.

4.3.1.7 Inclement Weather Conditions

Inclement weather conditions was established to be the seventh most important cause of variation orders in civil construction projects in Kenya, with RII of 0.727. Adverse weather conditions can affect outside activities in construction projects Fisk (1997); O'Brien (1998). When weather conditions vary, the contractor needs to adjust the construction schedule accordingly. According to Mark (2012), this is particularly the case in situations where the timing or sequence of works can be varied to avoid likely inclement weather periods where weather patterns can be predicted with reasonable certainty.

This finding indicate that weather conditions of a particular project locality is never taken into consideration during the feasibility study or feasibility studies are never undertaken at all. Though it is compulsory for feasibility studies to be carried out for public funded projects in Kenya KACC (2007) reported that for some roads projects no such requirements were met and thus some technical, economic, environmental and time frame options adopted in the designs turn out to be non-feasible at the implementation stage leading to negotiations and unjustifiable variation.

4.3.1.8 Errors and Omissions in Design

At the eighth position as the most important causes of variation in civil engineering construction projects in Kenya was errors and omission in design with RII of 0.711. Errors and omissions in design are an important cause of project delays Arain *et al.* (2004). Design errors and omissions may lead to loss of productivity and delay in project schedule Assaf *et al.* (1995). Hence, errors and omissions in design can affect a project adversely depending on the timing of the occurrence of the errors.

This finding suggests that design problems arising from errors and omissions are common in civil engineering construction projects in Kenya. This fact was reported by KACC (2007) that in Kenya road design take long to be implemented. As a result, at the time of implementation, the road conditions are found to have changed substantially necessitating design reviews. In such cases, consultants are commissioned to review designs. However, the reviews are open to errors and omissions through over or under-design or replicating the previous designs which do not address the prevailing conditions. This necessitates redesign during the implementation stage, which leads to delays, variations and wastage of public funds.

4.3.1.9 Unavailability of Materials and Equipment

The ninth most important cause of variation orders in civil engineering construction projects in Kenya was discovered to be unavailability of materials and equipment. This was ranked ninth with RII of 0.651. According to O'Brien (1998), unavailability of equipment is a procurement problem that can affect the project completion. Occasionally, the lack of equipment may cause major design variations or adjustments to project scheduling to accommodate the replacement.

This finding suggests that feasibility studies are not done hence the design team proceed to finalize projects designs without knowledge on the availability of equipment or materials needed for construction in the market. This always leads to substitution of materials or equipment with the available options through a variation order. On the other hand, if materials approved are found to be of inferior quality after testing, a variation is effected to replace them with superior quality materials that are readily available.

4.3.1.10 Conflict between Contract Documents

Also in the ninth position as the most important cause of variation orders in civil engineering construction projects in Kenya is conflict between contract documents, with RII of 0.651. Conflict between contract documents can result in misinterpretation of the actual requirement of a project CII (1986a). To convey complete project scope for participants, the contract documents must be clear and concise. Insufficient details in contract documents may adversely affect the project, leading to delay in project completion.

This finding elaborates the challenge of tender documentation in civil engineering construction projects in Kenya. Tender documentation is not carried out meticulously to include comprehensive tender drawings, specifications, conditions of contract, and bills of quantities that are responsive to the proposed works with a view to minimize variations later in the contract and to improve contract management.

Table 4-2: The Five Most Important Causes of Variation and their Origin Agents

Factors Causing Variation	Origin Agent
1. Delay in Land Acquisition/ Compensation.	Client
2. Differing Site Condition	Client
3. Change of Plans and Scope by Client.	Client
4. Change of Schedule by Client.	Client
5. Lack of coordination between overseas and local designer.	Consultant

Source: Author (2004)

In retrospect, a critical look at the top five most important factors causing variation in civil engineering construction projects in Kenya reveal that the majority of these factors are client related as illustrated in Table 4-2. This finding further reinforces the argument that the client is indeed the most predominant origin agent of variation in civil construction projects in Kenya.

4.3.2 Test of Level of Agreement on Factors Causing Variation Orders

To test the level of agreement between the client, consultant and contractor, the Kendall's coefficient of concordance was used and the results were as shown in Table 4-3. It was revealed that there was a weak correlation (0.577) between clients and consultants and between clients and contractors too. Nonetheless, a strong correlation (0.965) was found between consultants and contractors.

Table 4-3: Kendall's Coefficient of Correlation for Causes of Variation Orders

Correlations					
			Client	Consultant	Contractor
Kendall's tau_b	Client	Correlation Coefficient	**1.000**	**.577****	**.577****
		N	30	30	30
	Consultant	Correlation Coefficient	**.577****	**1.000**	**.965****
		N	30	30	30
	Contractor	Correlation Coefficient	**.577****	**.965****	**1.000**
		N	30	30	30
**.Correlation is significant at the 0.01 level (2-tailed)					

Source: Author (2014)

This finding on strong correlation of the views of the consultant and those of the contractor regarding the causes of variation orders in civil construction projects in Kenya is baffling given the often perceived adversarial relationship between the two parties in any given construction project. However, the most striking is the low correlation between the views of the client and both consultant and the contractor. This could be interpreted to mean that the client does not fully appreciate the factors that give rise to variation in his project, hence his immense contribution to the occurrence of variation orders.

4.3.3 Comparison with Previous Results on Causes of Variation Orders

Table 4-4 shows comparison of causes of variation order between the results of this study and those of other researchers such as Amiruddin *et al.* (2012); Halwatura and Ranasinghe (2013); Ndihokubwayo and Haupt (2008) from the literature reviewed from Iran, Sri Lanka, and South Africa respectively.

Table 4-4: The Most Important Factors Causing Variation Orders; Comparison of Kenya, South Africa, Seychelles and Iran.

Rank	Kenya	South Africa Ndihokubwayo (2008)	Sri Lanka Halwatura and Ranasinghe (2013)	Iran Amiruddin *et al.* (2012)
1	Delay in land Acquisition/ Compensation	Change of plans or scope	Poor estimation	Change of plans or scope by employer
2	Differing Site Conditions	Change of schedule	Poor investigation	Errors and omissions in design
3	Change of Plans or Scope by Client	Change in specifications	Unforeseen site conditions	Differing site conditions

Rank	Kenya	South Africa Ndihokubwayo (2008)	Sri Lanka Halwatura and Ranasinghe (2013)	Iran Amiruddin *et al.* (2012)
4	Change of Schedule by Client	Change in design	Change in design by consultant/design changes	Contractor's financial difficulties
5	Lack of Coordination between Overseas and Local Designers	Errors and omissions in design	Additional preliminaries due to time extension	Weather condition
6	Change in Design by Consultant	Inadequate working drawing details	Client-initiated variations	Conflict in the project site
7	Inclement Weather Conditions	Design discrepancies	Other organizations	Employer's financial problems
8	Errors and Omissions in Design	Impediment in prompt decision making process	Errors and omissions in design	Value engineering
9	Unavailability of Materials and Equipment	Unforeseen problems	Inadequate scope of work for contractor	Quality improvement
10	Conflict between Contract Documents	Replacement of materials or procedures	Inadequate planning	Acceleration of work

Source: Author (2014)

It is clear that the ranking of causes of variation in these four countries are different. This was not completely unexpected because each country has different challenges in her construction industry. However, factors such as change in design by consultant, errors and omissions in design, differing site conditions, change of plans or scope by client, inclement weather conditions and conflict between contract documents appear in top ten of all these rankings. This revelation indicates that these factors can indeed be accepted as the most important causes of variation orders globally.

4.4 The Effects of Variation Orders in Civil Engineering Construction Projects in Kenya.

The third objective of this study was to investigate the effects of variation orders in civil engineering construction projects in Kenya. In order to achieve this objective, the sought to determine what the top five most important effects of variation orders are and compare the clients', consultants', and contractors' perspective on the effects of variation orders in civil construction projects in Kenya?

4.4.1 The Most Important Effects of Variation Orders in Civil Engineering Construction Projects in Kenya.

The respondents were requested to rank the frequency of occurrence of effects of variation orders in civil construction projects in Kenya using a 5 point Likert scale where Never = 1; Seldom = 2; Sometimes = 3; Often = 4; and Always = 5. From Table 4-5, it is evident that cost overruns, contractual claims and disputes and time overruns were the top three most important effects of variation orders in civil construction projects in Kenya. In contrast, delays in payment, procurement delays and quality degradation were the top three least important effects of variation orders.

Table 4-5: The Most Important Effects of Variation Orders in Kenya

Effects of Variation Orders	Overall		Client		Consultant		Contractor	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Cost Overruns	0.903	1	0.917	1	0.875	1	0.916	1
Contractual Disputes and Claims	0.814	2	0.733	3	0.842	2	0.821	2
Time Overruns	0.811	3	0.817	2	0.800	3	0.816	3
Increased Overhead Costs	0.786	4	0.717	5	0.792	4	0.805	4
Progress Degradation	0.724	5	0.733	3	0.758	5	0.700	5

Source: Author (2014)

The entire ranking of the effects of variations in civil engineering construction projects in Kenya is as attached in Appendix I. Nevertheless, the discussions on the five most important effects of variation orders in civil engineering construction projects in Kenya are amplified as follows;

4.4.1.1Cost Overruns

This study revealed that cost overruns is the first most important effect of variation orders in civil engineering construction projects in Kenya, with RII of 0.903. It not entirely unexpected for the project cost to increase due to frequent variations in the project. According to Arain and Pheng (2006b), this is because variation orders may affect the project's total direct and indirect costs. Therefore, any major addition or alteration in the design may eventually increase the project cost. 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. However, frequent major variations may lead to cost overrun in the contingency sum.

This finding that cost overruns is the most important effect of variations orders in civil engineering construction projects in Kenya is therefore, a submission that variations are incessant and indeed huge in magnitude contrary to the requirement of the public procurement and oversight authority stipulation of 15%. This is informed by the fact that most civil contracts have a contingency sum of 15% of the contract sum which is often exhausted by incessant and humongous variations.

4.4.1.2 Contractual Disputes and Claims

Contractual disputes and claims was found to be the second most important effect of variation orders in civil engineering construction projects in Kenya, scoring RII of 0.814. According to Singh Harbans and Sri (2004) the common areas of contention involving variation that usually lead to claims and disputes can be narrowed down to the following stages of a typical variation cycle, namely:

1. Ordering of variations;
2. Measurement of variations undertaken;
3. Valuation of varied work; and
4. Payment for the variation ordered

The revelation that contractual disputes and claims is the second most important effect of variation orders in civil engineering construction projects in Kenya could signify the notion that there is lack of clear variation order protocol in most construction projects in Kenya. Such protocol would entail; the procedures for initiating variation; approval of variations; timing of the issuance of variation order; procedure for measuring varied works; method for valuation of the varied works; and time limits within which payments have to be made to the contractor.

4.4.1.3 Time Overruns

The third most important effect of variation orders in civil engineering construction projects in Kenya was found to be time overruns, with RII of 0.811. Arain and Pheng (2006b) noted that the contractors are usually compelled to accommodate the implementation time for variations by utilizing the free floats in the construction schedules. Hence, minor variations affect the progress but without any delay in the

overall project completion. However, major variations may affect the project adversely, leading to delays in the project completion. Furthermore, frequent minor variations can also affect the project adversely depending on the timing of the occurrence of the variations. This is because the impact of variations during the construction phase can be more severe than in the design phase.

Therefore, this finding that time overruns is the third most important effect of variation orders in civil engineering construction projects in Kenya is a demonstration that indeed variations orders in Kenya are incessant and large in magnitude to the extent that they cannot be accommodated within the floats in the construction schedules.

4.4.1.4 Increased Overhead Cost

The fourth most important effect of variation orders in civil engineering construction projects in Kenya was found to be increase in overhead cost with RII of 0.786. Variations require processing procedures, paper work and reviews 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.

This finding mirrors the difficulty that contractors in Kenya experience in cases where variations instructed give rise to extension of time. The prolonged project period does not entitle the contractor to monetary compensation and thus contractors have to stretch their resources to meet overhead costs.

4.4.1.5 Progress Degradation

Progress degradation was revealed to be the fifth most important effect of variations in civil engineering construction projects in Kenya, scoring RII of 0.724. 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 equipment.

This finding implies that construction projects in Kenya do experience progress slow down which do not eventually lead to time overruns due to utilization of floats in the schedule or constructive acceleration to recover lost time.

4.4.2 Test of Level of Agreement on Effects of Variation Orders in Kenya

To further test the level of agreement between the client, consultant and contractor on the effects of variation orders in civil engineering construction projects in Kenya, the Kendall's coefficient of concordance was computed. As indicated in Table 4-6, there was a strong correlation (0.809) between clients and contractors. A stronger correlation (0.854) was reported between clients and consultants, even as a near perfect correlation (0.956) was found between consultants and contractors.

Table 4-6: Kendall's Coefficient of Correlation for Effects of Variation Orders

Correlations					
			Client	Consultant	Contractor
Kendall's tau_b	Client	Correlation Coefficient	**1.000**	**.854****	**.809****
		N	10	10	10
	Consultant	Correlation Coefficient	**.854****	**1.000**	**.956****
		N	10	10	10
	Contractor	Correlation Coefficient	**.809****	**.956****	**1.000**
		N	10	10	10
******.Correlation is significant at the 0.01 level (2-tailed)					

Source: Author (2014)

This revelation is almost a replication of the previous one on level of agreement on causes of variation orders in section 4.3.2 where the client registered lower level of agreement with both the consultant and contractor while the consultant and the contractor seem to be in near prefect agreement. Indeed it confirms that the clients fail to appreciate the impact of variation orders in their projects and hence majorly contribute to their occurrence.

4.4.3 Comparison with Previous Results on Effects of Variation Orders

Table 4-7 illustrates comparison of effects of variation order between the results of this research and with those of Ndihokubwayo (2008); Arain and Pheng (2005b); Amiruddin *et al.* (2012) from south Africa, Singapore, and Iran respectively. Though the ranking is different for individual countries, it is evident the effects such as time overruns, cost overruns and dispute between parties cut across all the jurisdictions.

This finding could be understood to mean that the above three effects of variation orders are the most important globally in the construction industry.

Table 4-7: The Most Important Effects of Variation Orders; Comparison of Kenya, South Africa, Singapore and Iran

Rank	Kenya	South Africa Ndihokubwayo (2008)	Singapore Arain and Pheng (2005b)	Iran Amiruddin *et al.* (2012)
1	Cost Overruns	Time overrun	Increase in project cost	Delay in completion schedule
2	Contractual Disputes and Claims	Cost overrun	Additional payment for contractor	Increase in project cost
3	Time Overruns	Disputes between parties to the contract	Progress is affected but without any delay	Disputes between owner and contractor
4	Increased Overhead Costs	Additional specialist equipment/personnel	Completion schedule delay	Decrease in quality of work
5	Progress Degradation	Complaints of one or more of the parties to the contact	Increase in overhead expenses	Additional revenue for contractor

Source: Author (2014)

4.5 Effective Variation Management System

The fourth objective of this study was to recommend an effective variation order management system for civil engineering construction projects in Kenya. To achieve this objective, the study set out to inquire if there is a system in existence for managing construction variations in civil engineering construction projects in Kenya.

4.5.1 Non-existence of Variation Management System for Civil Engineering Construction Projects in Kenya.

The respondents were asked if they have a system for managing variations in their respective construction projects .The majority of the responded alluded to the fact that there is no well-defined variation management system for their construction projects. Most of the clients clarified that generally, their variation orders are managed by intuition, with the hope that no disputes shall arise and that the contractors do not file claims. The contractors maintained that they have no problem with lack of clear variation management system so long as their claims are processed and they do not suffer losses due to unpaid extra work or overheads. However the contractors

complained that they have a problem with filing variation claims due to lack of contemporary records to support their course.

The perusal of existing literature indeed revealed that there is no variation management system that is generally adopted for civil engineering construction projects in Kenya. Though PPOA (2009) provides conditions for variations, it steers clear of providing a variation management system for works.

According to Gharaee (2012), variation management system is a combination of procedures, job descriptions and toolkits with the aim of:

1. Anticipating possible variations in the basic engineering and detailed engineering stages.
2. Recognizing variations, in design or construction, that have already occurred.
3. Providing preventive actions and (in case of not being avoidable) mitigation plans.
4. Coordinating both variations and subsequent compensation actions across the entire project team.

Construction decision-making takes place in a team setting. Therefore effective project change management should not rely solely on the project manager; it should integrate input from all the relevant team players.

4.5.2 Proposed Variation Management System for Civil Engineering Construction Projects in Kenya.

This section proposes an effective variation management system in light of the revelation of non-existence of a variation management system for civil engineering construction projects in Kenya as discussed in section 4.5.1. It proceeds to develop a model that would assist not to totally eliminate variations, but to minimize their occurrence and to ensure that variations that do occur, take place in a controlled environment so that viable alternatives are identified developed and their impact assessed before implementation. Gharaee (2012) reckons that using a practical model for variation management can help the project team considerably in identifying variations and evaluating their impacts as early and accurately as possible.

After perusal of previous work relating to variation management, the author identified a generic change management process by CIRIA (2001) as cited in Gharaee (2012)

that could be modified to suit the Kenyan scenario. The original model comprised of four steps namely; 1) Start up, 2) Variation identification and evaluation, 3) Variation approval and, 4) Variation implementation and review. The author noted the above four steps fall under the project life cycle stage of project execution. This research proposes to modify the above model to include elements that are relevant to the finding of sections 4.2, 4.3 and 4.4 that fall under the project initiation, project planning and project closure stages of the life cycle and also the unique challenges within which civil engineering construction projects in Kenya are undertaken as discussed in the preceding study findings. However, it should be noted that the proposed model, particularly under the project execution stage borrows heavily from the work of CIRIA (2001) as cited in Gharaee (2012).

The effective variation management model for civil engineering construction projects in Kenya was formulated by taking into account the following preceding works.

1. The finding of the study as derived from objectives one, two and three and discussed in sections 4.2, 4.3 and 4.4. These findings provide deficiency within civil construction projects that need to be bridged.
2. A Guide to the Project Management Body of Knowledge (PMBOK): Project Lifecycle Management fifth edition (2013). This work provided the project life cycle stages on which the proposed variation management model is grounded.
3. PPOA (2013) provided corruption prevention guidelines and ceiling on variation to works in public funded construction projects in Kenya.
4. FIDIC Red Book (1999) provided the contractual provisions for contract administration.
5. Change Management Best Practices for the Engineering and Construction Industry by Oracle (2009) which illustrated significant steps for variation management during the project execution stage.
6. Generic Project Management Process by CIRIA (2001) as cited in Gharaee (2012) , which presented the original model which was modified and adopted for the project execution stage.

The following assumptions have been made:

1. Extraneous factors such as political interference in the tendering process and final execution of construction projects shall not be experienced.
2. Clients in public funded construction projects shall adhere to PPOA's corruption prevention guidelines which require all variations to be approved by the tender committee.
3. Clients for civil engineering construction projects shall adopt a design bid build (DBB) procurement strategy. Shunji (2006) contends that this is the type of project delivery system that is most commonly used for infrastructure projects in the international construction market place.
4. FIDIC Redbook, 1999 shall be adopted as the conditions of contract for civil engineering construction projects in Kenya. Yukinobu (2006), observed that FIDIC conditions of contract is the most accepted standard conditions in use for international construction contracts. FIDIC is recommended by Multilateral Development Banks e.g. World Bank, AfDB, JBIC etc. for use in tender documents, and it is therefore the conditions which are most likely to be adopted for mega infrastructure projects.

The modified model is grounded on the four stages of project lifecycle as described in (PMBOK, 2013) namely:

1. **Project Initiation Stage: -** Preparation of clear project brief and conducting of credible feasibility study.
2. **Project Planning Stage: -** Way-leave acquisition, project design, project scheduling, contract documentation and project cost estimation.
3. **Project Execution Stage: -** Identify the contract requirements, identify the potential variation and create a potential variation order file, evaluation of PVO, approval of variation by tender committee, execution of VO and documentation of VO.
4. **Project Closure Stage: -** Production of as-built drawings, project completion reports and lessons learned log.

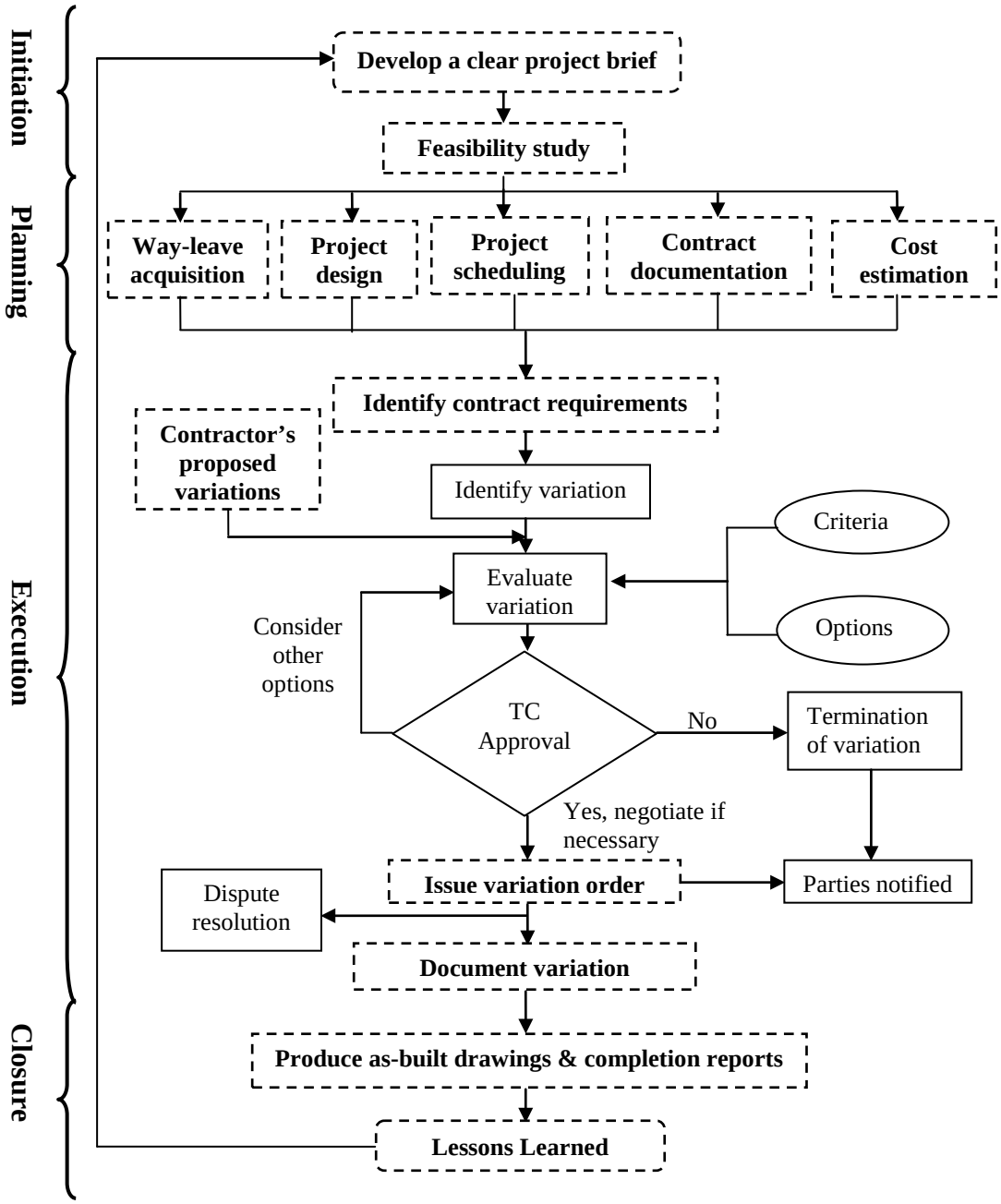

Figure 4-3: Modified Effective Variation Management Model

Source: Adopted, modified from Lazarus and Clifton (2001) as cited in Gharaee (2012), (Author's contributions are in **bold**)

The above stages are discussed more thoroughly in the subsequent paragraphs.

4.5.2.1 Stage One: Project Initiation

As revealed in section 4.2, where additional work is the most common aspect of variations and section 4.3, where change of scope by the client is the third most important factor contributing to variations in civil engineering construction projects in Kenya, it is clear that scope creep is a major bottleneck in civil construction projects. This is attributable to unclear project brief by the client at the initiation stage leading to variations during the subsequent stages. Additionally, section 4.3.1 of this study revealed that differing site conditions, change of plans and scope by client, change of schedule by the client, change of design by consultants, inclement weather conditions and unavailability of materials and equipment are the second, third, fourth, sixth, seventh and ninth most important factors contributing to variations in civil construction projects in Kenya respectively. All these six factors are attributable to lack of feasibility study or adoption of feasibility study that has been overtaken by time.

PMBOK (2013), outlined that at the project initiation stage, the initial project scope is defined. The expectations of the client in relation to factors such as time, cost and quality objective are to be made explicit at the crucial initiation phase of the project in form of a project brief, as these factors, when combined together, form the framework by which eventual project risks and performance can be evaluated. KACC (2007) observed that in most road projects in Kenya, feasibility studies are hardly conducted and as a result some of the technical, economic and time frame options are rendered non-feasible at the projects' execution stage, hence leading to negotiations and unjustifiable variations.

These therefore necessitate that at this critical stage in variation management, the client should ensure that his project brief is meticulously drafted and devoid of ambiguities. Moreover, a feasibility study ought to be used to justify what is developed and at what cost (the investment decision), it should also be used throughout the procurement phase to check that the project is being developed in accordance with the original assumptions and, where variation is necessary, it must be used to manage the variation by providing options. The above steps if undertaken during the project initiation stage would go a long way in minimizing variations in civil construction projects in Kenya.

4.5.2.2 Stage Two: Project Planning

The findings in section 4.3 indicating that delay in acquisition of way-leave, change of schedule by the client, lack of coordination between overseas and local designers, change of design by consultant, errors and omissions in design and conflict between contract documents are the first, fourth, fifth, sixth, eighth and ninth most important factors contributing to variation orders in civil construction projects in Kenya respectively.

According to PMBOK (2013), the project planning stage consists of those processes performed to establish the total scope of the effort, define and refine the objectives, and develop the course of action required to attain those objectives. The Planning processes develop the project management plan and the project documents that will be used to carry out the project. In construction, the contract documents prepared during the planning stage typically include the following components:

1. Contract Agreement and addenda to the contract,
2. Letter of Acceptance,
3. Letter of Tender,
4. Particular Conditions,
5. General Conditions,
6. Specifications,
7. Design drawings, and
8. Price schedules.

At the project planning stage, it is important that the client and consultant review the above listed contract documents to ensure that they are devoid of errors, omissions and ambiguities, so that construction variations emanating from the same could be minimized. It is also equally important that the order of precedence of the above documents is clearly set at this stage, so that future conflicts between contract documents are resolved without difficulty.

Consultant's design responsibilities are implemented at this stage of project life cycle. The detailed designs are expected to take into consideration the local standards, the recommendations of the feasibility study and the site conditions to ensure that the

designs are not only free of errors and omission but also constructible. In case there is involvement of overseas designers, the design team's activities should be well coordinated so that no miscommunication arises, leading to discrepancy in design data hence errors in design output. Before proceeding to the execution stage, all the design activities ought to be completed and frozen to avoid variations due to change in design by consultant.

Upon the finalization of detailed design and project specifications, the project cost estimation should be accurately done by performing quantity take off and multiplying by the unit price to get the total cost of work for the project. In order to take care of unforeseen changes during the construction, a markup of approximately 15% should be added to the total cost of work as a contingency sum.

Construction projects require realistic scheduling so as to avoid the last minute acceleration of works to achieve completion within an overly unrealistic time frame. Borrowing from feasibility study's recommendations on the climatic conditions of the project's locality, the client and consultant should be in a position to estimate the workable days in a calendar year and schedule the project on that basis rather than to assume that the entire 365 days in a year would be workable. This is critical for civil works given that they are majorly outdoor activities often dictated by site moisture conditions. This step would greatly minimize variations due to change of schedule by client.

Last but not least, in the project planning stage, the client has got a cardinal responsibility to provide access to site. This could be interpreted to mean full acquisition of way-leave for the infrastructure projects so that the contractor does not only have the working space for construction but also corridor for transporting equipment and materials. Any delay in provision of way-leave by client could cause variation in schedule or design of parts of the projects or even the entire project in extreme cases. Way-leave acquisition is a requirement that must therefore be met by the client before the contractor moves to site to commence work.

4.5.2.3 Stage Three: Project Execution

The findings of section 4.4 which disclosed that cost overruns, contractual disputes and claims, time overruns, increased overhead cost and progress degradation are the five most common effects of variation orders in civil construction projects in Kenya.

These effects begin to manifest themselves during this project execution stage and therefore need to be managed alongside the construction process.

PMBOK (2013) noted that the project execution stage consists of those processes performed to complete the work defined in the project management plan to satisfy the project specifications. This stage involves coordinating people and resources, managing stakeholder expectations, as well as integrating and performing the activities of the project in accordance with the project management plan. In construction projects, this stage commences with the issuance of the notice to commence according to clause 8.1 of (FIDIC, 1999).

The first and most important step for successfully managing variations at this stage entails identification and understanding of contract requirements and provisions by the respective parties before the project starts. The contract documents as prepared in the planning stage, spell out the requirements for the project in terms of its scope, schedule, and budget. The contract requirements must first be identified so that any variation (that is, a change) can be recognized, because a variation is essentially a requirement that deviates from the requirements set forth in the contract documents. This step should come in handy in averting potential contractual disputes and claims arising from construction variations, found to be the second most important effect of variation orders in civil construction projects in Kenya in section 4.4 of this study.

As logical starting points for the identification and administration of variations the client, consultant and contractor should pay particular attention to the contract clauses related to the following:

1. Variation: - FIDIC (1999) clause 13,
2. Contractor Notice: - FIDIC (1999) clause 20.1
3. Claims, dispute and arbitration: FIDIC (1999) clauses 20.2-20.8
4. Site evaluation: FIDIC (1999) clause 4.10
5. Unforeseeable physical conditions: FIDIC (1999) clause 4.12
6. Force majeure: FIDIC (1999) clause 19
7. Extension of time for completion: FIDIC (1999) clause 8.4.

The second step in effective variation management at this stage is to identify the possible variations that might occur in the future activities of the project. This can be accomplished by adopting the findings of sub-section 4.2.2 of this study which among others indicated that additional work comprise 58% of the variations in civil engineering construction projects in Kenya. Timing is of great importance here, in other words the earlier a variation is identified the lower the impacts will be. However, one of the major problems at the project execution stage is the failure of the clients, consultants or the contractors to recognize project variation. Once a potential variation is identified, it will be classified among the different types of variation provisions that are defined by the contract. According FIDIC (1999) clause 13, variation may include:

1. Additional work,
2. Omission from work,
3. Change to the quality or other characteristic of any item of the work,
4. Change to the sequence or timing of execution of the work, and
5. Change to the levels, positions and/or dimensions of any part of the work.

A potential variation order (PVO) file should be created for every identified variation in order to track the issue. Creation of the PVO file should be performed before entitlement for the potential variation is determined. Alternatively, FIDIC (1999) clause 13.2 allows the contractor at his own cost to propose in writing, a variation that could be of benefit to the client.

The third step of successful variation order management at the project execution stage is to evaluate the PVO. The aim of this step is to be able to ascertain the impact of the potential variation on the project's budget and schedule. This is done keeping in mind that in section 4.4 of this study, cost and time overruns were found to be the first and third most important effects of variations in civil construction projects in Kenya respectively. The client must, in a timely fashion, evaluate the PVO and determine whether the potential variation shall be beneficial or detrimental to the project's performance. Using cost analysis and duration analysis techniques, the client and his representative will be able to reach an informed decision whether to adopt or reject the proposed variation in totality or to consider other options. PPOA and KACC

(2009) provide corruption prevention strategies that require all variations to be approved by the clients' tender committee and must adhere to the stipulated limit of 25% of the contract sum for works. Once a decision has been made by the tender committee, it is important to notify the project team members, both internal and external on the approval or rejection of variation by the client. In order to keep a record of who has been informed, the project team must prepare a list of all the people who are going to be contacted. It is a very crucial task, as any ignorant in this stage may lead to irreversible damages. Early notification allows both the client and the contractor an opportunity to more effectively control the cost and mitigate schedule impact of variation.

The fourth element in effective variation management at the project execution stage is the execution of variation. This entails the issuance of a written variation order for implementation by the contractor and thereafter, valuation of the variation in accordance with FIDIC (1999), clauses 12.3 and 13.6. Even though FIDIC (1999) clause 13.1 expressly provides for the clients right to vary works, it is advisable for the contractor and client to work together as diligently as possible and to agree upon the cost and time adjustment for the varied work. Extension of time and financial compensation for the execution of the varied works are the stickiest issues likely to lead to contractual claims and disputes. However, if the parties have been working together throughout the course of the project, then their collaboration might allow them to find a middle ground during the negotiation process based on effective communication and trust. It is always possible that the two parties might not come to an agreement. If the parties are unable to negotiate a mutually agreed upon cost or time extension for the variation, and if the contractor disagrees with performing the work included in a VO after a final decision has been made by the client, then the contractor's only remedy might be to continue its dispute through the channels identified by the contract.

There are several different methods for resolving variation-related construction disputes to avoid costly arbitration or litigation. FIDIC (1999), clause 20.4 provides for Dispute Adjudication Boards (DABs), a neutral authority consisting of three members, is one preferred method. Selection of the board members can be performed in a number of ways; however, it is crucial that the individuals are neutral and both the client and the contractor view each board member as being impartial.

The fifth and the last step in a successful variation management process at the project execution stage is the documentation of variation. This step is important given the sentiments of the interviewed contractors who said that they have a problem with logging variation claims due to lack of records. This is a vital construction management function that needs to be undertaken consistently and systematically throughout the entire variation process of variation identification to execution. A comprehensive documentation system provides contemporary records for the contractor to substantiate claims and enables the client to effectively asses the contractor's claims.

4.5.2.4 Stage Four: Project Closure

PMBOK (2013) observes that the project closure stage consists of those processes performed to conclude all activities across all project management stages to formally complete the project, phase, or contractual obligations. This stage, when completed, verifies that the defined processes are completed within all of the stages to close the project or a project phase, as appropriate, and formally establishes that the project or project phase is complete.

In construction projects, this stage commences after substantial completion has been achieved and a TOC is issued according to FIDIC (1999) clause 10. In other words, it is the starting point of the defect liability period as provided for under clause 11 of (FIDIC, 1999). After TOC is issued, any variation order issued is not contractually binding and the contractor is under no obligation to execute such an order. However, during this stage, the contractor has an obligation to produce and submit to the client the as-built drawings reflecting the changes made to the specifications and/or design during the construction process, and showing the exact levels, dimensions, geometry and location of all elements of the work as completed under the contract.

At this stage, the consultant has an obligation to the client to produce the project completion reports which among others shall include the technical report on the work done while highlighting the varied sections of the work and the financial statement of the project, showing the financial impact of the varied works.

The clients' in-house project team should be able to draw up the lessons learned by capturing and considering the tacit knowledge and experiences of team members gained during variation events. Preparing a lessons-learned log at this stage can help

implementing the future projects in a better way and will create a priceless piece of knowledge for future reference.

4.6 Conclusion

In conclusion, four major observations were made from data analysis and discussions in this chapter. Firstly, the majority of variations originate from the clients resulting into additional work, which is an indication of the clients' inability to effectively execute scope management. Secondly, the first five most important factors contributing to variation orders are mostly attributable to the client. Thirdly, time and cost overruns and contractual claims and disputes arising from variations have a major impact on civil construction projects in Kenya. Lastly, there is no effective variation management system for civil construction projects in Kenya. The next chapter summarizes the study, draws conclusions, makes recommendations and suggests area(s) of further research.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the research work undertaken, and on the basis of the study findings draws conclusions about the study's aim and objectives, and makes recommendations as an outgrowth of the study. Additionally, it discusses the implication(s) of the findings for policy in the Kenyan construction industry and concludes by suggesting area(s) for further research.

5.2 Summary of the Findings

5.2.1 Nature of Variations in Civil Engineering Construction Projects in Kenya.

The first objective if this study was to determine the nature of variation orders in civil construction projects in Kenya. To achieve this objective, the research sought to find out the origins of variations and aspects that the variations assume upon implementation.

5.2.1.1 Origin Agents of Variation Orders in Civil Engineering Projects in Kenya

The respondents were requested to identify the origins of most of their variations in terms of the contracting parties namely; clients, consultants, contractors or any other source not attributable to the three parties and thereafter referred to as the "others".

The study revealed that the client is the most predominant origin agent of variation orders, with 55% of the respondents attributing variation orders to him. Moreover, 82% of the respondents believed that variation orders in their projects are blamed on the combined involvement of both the client and consultant.

5.2.1.2 Aspects of Variations in Civil Engineering Construction Projects in Kenya

The respondents were asked to identify the most common aspect of variation orders in their projects from a list of four possible aspects namely; additional work, omission from work, change to the sequence or timing of the execution of the work, change to the quality or other characteristic of any item of the work, and change to the levels, positions and /or dimensions of any part of the work.

The results study indicated that 58% of the respondents interviewed are of the opinion that additional work is the most common aspect of variation orders in civil engineering construction projects in Kenya. At the second place was omission from work which scored 19% of the respondents interviewed.

5.2.2 Factors Contributing to Variation Orders in Civil Engineering Construction Projects in Kenya.

The second objective of this study was to investigate the factors that contribute to variation orders in civil construction projects in Kenya. From the literature review, fifty four factors were identified to be contributing variation orders in construction projects globally. Through a pilot study, it was possible to isolate thirty factors unique to civil engineering construction projects in Kenya.

5.2.2.1 The Most Important Factors Contributing to Variation Order in Civil Engineering Construction Projects in Kenya.

The respondents were requested to rank the thirty factors that contribute to variation orders using the five point Likert scale of 5- extremely frequent through to 1-Least frequent according to their experience. The Likert scale was transformed into a relative importance index (RII). Using the RII, it was possible to isolate ten most important factors contributing to variation orders from an original list of thirty factors. The study findings indicated the ten most important factors causing variation orders in civil construction projects are; 1) Delay in land acquisition/compensation, 2) Differing site conditions, 3) Change of plans or scope by client, 4) Change of schedule by the client, 5) Lack of coordination between overseas and local designers, 6) Change in design by consultant, 7) Inclement weather conditions, 8) Errors and omissions in design, 9) Unavailability of materials and equipment, and 10) Conflict between contract documents.

5.2.2.2 Comparison of the Clients', Consultants' and Contractors' perspective on Factors Contributing to Variation Orders.

The Kendall coefficient of concordance was applied to compare the perception of the three contracting parties namely; client, consultant and contractor on the factors contributing to variation orders in civil engineering construction projects in Kenya. The findings of the study suggest that there is a strong correlation of 0.965 between

the consultant and the contractor. However, a weak correlation of 0.577 was reported between the client and both consultants and contractors.

5.2.3 Effect of Variations in Civil Engineering Construction Projects in Kenya.

The third objective of the study was to investigate the effects of variation orders in civil engineering construction projects in Kenya. A total of sixteen effects of variations were identified through the literature review and later condensed to ten effects unique to the Kenyan civil construction industry by means of a pilot study.

5.2.3.1 The Most Important Effects of Variations in Civil Engineering Construction Projects in Kenya.

The respondents were invited to rank the frequency of occurrence of effects of variation orders in their construction projects and according to their experience using a 5point Likert scale of 5-Always to 1- Never. The Likert scale was transformed into a relative importance index (RII). From an initial list of ten potential effects of variation orders, it was possible to isolate the most important effects using RII. The outcome of the study disclosed that the three most important effects of variation orders in civil engineering construction projects in Kenya are; cost overruns, contractual disputes and claims and time overruns in that order.

5.2.3.2 Comparison of the Clients', Consultants' and Contractors' Perception on the Effects of Variation Orders in Civil Engineering Construction Projects in Kenya.

The comparison of the perception of clients', consultants' and contractors' on the effects of variation orders on civil engineering construction projects in Kenya was done using the Kendall coefficient of concordance. The study found that there is a strong correlation of 0.809 between the clients and contractor and an even stronger correlation of 0.854 between clients and consultants. In addition, a near perfect correlation of 0.956 was reported between the consultants and contractors.

5.2.4 Model for Variation Management

The fourth objective of the study was to recommend a model for effective variation order management for civil engineering construction projects in Kenya. To achieve this objective, the study sought to inquire whether there is an existing system in place

for managing variations during projects' life cycle so that improvements to the system could be recommended or an entirely new system is proposed.

5.2.4.1 Non-existence of a Variation Management System in Civil Engineering Construction Projects in Kenya.

The respondents were asked if they have adopted any system for managing variations in their projects. The study revealed that despite the fact that civil engineering construction projects in Kenya experience variation orders that are incessant and excessive in magnitude, there exist no clear systems for managing them, a further indication that these variations are indeed uncontrolled and unjustifiable.

5.2.4.2 Proposed Variation Management Model for Civil Engineering Construction Projects in Kenya.

Due to lack of an effective variation management model in place, the study recommended a four stage management model that comprised;

1. **Project Initiation Stage: -** Preparation of clear project brief and conducting of credible feasibility study.
2. **Project Planning Stage: -** Way-leave acquisition, project design, project scheduling, contract documentation and cost estimation.
3. **Project Execution Stage: -** Identify the contract requirements, identify the potential variation and create a potential variation order file, evaluation of PVO, execution of VO and documentation of VO.
4. **Project Closure Stage: -** Production of as-built drawings, project completion reports and lessons learned log.

The proposed system is pegged on close cooperation and consultation between the projects teams of the client and contractor at the project execution stage to ensure that decisions reached at every stage are bilateral and informed by the contractual provisions to lessen the chances of disputes and to ensure no prejudice to either of contracting parties.

5.2.5 Methodology Adopted.

The study adopted survey research design method. This choice was settled on out of the necessity to sample the opinion of a large number of professionals cost effectively

and within a limited period of time. The target population was comprised of 12 clients, 32 consultants and 51 contractors. This translated to minimum sample size of 11 clients, 25 consultants, and 34 contractors. However, the entire population was sampled to keep with Mugenda and Mugenda (1999) recommendation of minimum sample size of 30 items and also to carter for the nonresponsive respondents. The rate of return was 78% of the questionnaires sent out and as a result exceeding the required threshold of 30-80% reported in preceding studies and can actually be generalized in order to arrive to an informed conclusion. Further, according to the participants' profile in appendix E**,** 82% of the respondents had experience of over ten years and 96% of the respondents had experience with variation orders. This validated the reliability of their opinions and hence the effectiveness and adequacy of the methodology adopted to arrive at the conclusions of this research.

5.3 Conclusions

The aim of this research study was to investigate the causes and effects of variation orders in civil construction projects in Kenya with a view of making recommendations geared towards an effective variation order management system. Based on the study findings, the following conclusions were drawn:

1. The study findings are an indictment of the client as the most predominant origin agent of variations in civil engineering construction projects in Kenya. As further revealed, the variations culminate into additional work which brings to the fore the difficulty that is scope management in construction projects. Generally, these findings are similar to several findings from developing countries. Clients therefore need to be at the forefront of interventions geared towards variation management in civil construction projects in Kenya, if these interventions have to be successful.
2. The five most important factors that contribute to the occurrence of variation orders in civil engineering construction projects in Kenya are 1) delay in land acquisition/compensation, 2) differing site conditions 3) change of plans or scope by client 4) change of schedule by the client and 5) lack of coordination between overseas and local designers in that order. All the above factors are attributable to either the client or the consultant, hence further magnifying the important role of the two parties in variation order minimization.

3. The three most important effects of variation orders in civil engineering construction projects in Kenya are; 1) contractual disputes and claims 2) cost overruns and 3) time overruns respectively. The results obtained are very relevant to the construction industry in Kenya because whenever there are variations or additional works during the construction phase, it usually brings about extra work to be carried out by the contractor which means more money for the contractor which in turn will result in project cost increase and may eventually affect the entire project's schedule.
4. Last but not least, the study revealed that there exist no comprehensible variation order management systems for civil engineering construction projects in Kenya. This has a potential of permitting uncontrolled and unjustifiable variations that add no value to the project performance hence detrimental to overall project performance. However, it shall be noted that the success of variation management system depends on how effectively the project team communicates and collaborates during entire project life cycle and that the system is as effective as the implementation team.

5.4 Recommendations

Based on the findings of this research discussed in chapter four, with main conclusion listed above the following recommendation are hereby made with the view of minimizing the occurrence and mitigating the effects of variation orders in civil engineering construction projects in Kenya:

Table 5-1: Recommendation for Variation Management

	Finding	Section	Recommendation
1	Client is the most predominant origin agent of variation orders in civil construction projects in Kenya.	Section 4.2 and Figure 4-1	During preconstruction phase the client should provide a clear and concise project brief devoid of ambiguities.
2	Additional work is the most frequent aspect of variation in civil construction projects in Kenya.	Section 4.3 and Figure 4-2	Conclusion of design prior to commencement of construction to avoid scope creep during the construction stage.
3	The study showed that the top five most important causes of variation	Section 4.4 and	• As part of preconstruction planning, the client should acquire the right of

	Finding	Section	Recommendation
	orders in civil construction projects in Kenya are; • Delay in land acquisition/compensation, • Differing site conditions, • Change in plans or scope by client, • Inclement weather conditions and, • Lack of co-ordination between overseas and local designers.	Table 4-1	way for the entire corridor before the contractor moves in to commence works. • A conclusive feasibility study that entails thorough geotechnical investigation that brings to the fore all subsurface conditions necessary for design. • Clients should provide a clear brief of the scope of works. • Past weather patterns of the construction area should be evaluated so as to come up with a realistic schedule that takes into account the non-workable days in a calendar year. • Proper coordination between the overseas and local designers so that the local design standards and requirements are adhered to and the actual site conditions are taken into consideration during design.
4	The study revealed that the top three most important effects of variation orders in civil construction projects in Kenya are; • Cost overruns, • Contractual claims and disputes and, • Time overruns.	Section 4.5 and Table 4-4	• Provision of contingencies in the contract sum of about 7.5-15% of the value of works. • Strict variation management protocol in construction contracts with respect to the following aspects; (1) Ordering of variations; (2) Measurement of variations undertaken; (3) Valuation of varied work; and (4) Payment for the variation ordered. • Use of Work Breakdown Structure (WBS) to track changes made so that were possible variations are made on non-critical path items.

Source: Author (2014)

5.5 Implication for Theory

Observations made in this study have two major implications for theory in construction project management. First and foremost, the observation that while there is near perfect concurrence between the consultant and the contractor on causes of variations and their effects, there is a very low level of agreement between either the consultants or contractors and clients with regard to the same. In line with the system thinking, construction projects need to be managed the way a business organization is managed i.e. with common goals and objectives. In construction projects these objectives would be to deliver a project within time and budget. However, a construction project is hardly viewed as a 'managed system' the way an organization is viewed and according to Larson (1997) the tendency for both owners and contractors to assume an adversarial posture with each other is based on the inherent conflict between owners' costs and contractors' profits. This is essentially a zero-sum game in which one party's gain is the other party's loss. This dynamic is even more complicated when one recognizes that it permeates the chain of relationships between contractors and subcontractors necessary to complete a significant construction project.

The apparent conflict of interest predisposes owners and contractors to be naturally suspicious of the motives and actions of each other. For the owners, this suspicion is often manifested by oppressively monitoring the contractor's performance, challenging each and every request to make an adjustment in plans or budget, and forcing compliance by withholding funds. Contractors respond by exploiting loopholes in the contract to their own advantage and withholding or manipulating information.

Finally, the adoption of Deming's theory of Profound Knowledge founded on the system thinking could help professionals in the construction industry to distinguishing the difference between the origins of variations, as well as understanding its causes and predicting behaviour, which is imperative to management's ability to properly remove problems or barriers in the system. However, without knowledge of variation, management might very well (with the very best intention) take action that actually makes things worse. Just as important, through knowledge of variation, management

realizes that attributing a problem to a person, instead of the system, is misguided and misleading.

5.6 Implication for Policy

Construction variation in civil engineering construction projects in Kenya is a procurement concern and therefore all public funded construction projects have to adhere to the existing public procurement regulations. In Kenya, The Public Procurements Oversight Authority (PPOA) was created by an Act of Parliament in January, 2007. The Authority is mandated to among others, ensure that procurement procedures established under the Public Procurement and Disposal Act are complied with and to monitor the procurement system and report to the Government on its overall functioning. PPOA's other roles include initiating public procurement policy as well as assisting in the implementation and operation of the public procurement system by preparing and distributing manuals and standard tender documents.

According to PPOA (2009) all variations must collectively not exceed 10% of the original contract quantity for goods and services and 15% of the original contract quantity for works and provided that any price or quantity variation is to be executed within the period of the contract. However, these thresholds are never adhered to if the completion reports of various projects in Kenya are anything to go by. Case in point is the Badasa dam in Marsabit County, where according Andrew (2013), the project tendered for KS. 1.7 billion in 2009 was varied by KS. 1.9 billion (112%). This was in gross violation of the public procurement policy.

Furthermore, KACC (2007) reported that even though the Manual for Procurement and Management of Projects by PPOA requires that feasibility studies be done for donor funded projects, for some of the road construction projects fully funded by the government this is never carried out. As a result, some of the technical, economic and time frame options adopted in the design turn out to be non-feasible at the implementation leading to negotiation and unjustifiable variations in the contracts. This creates a loophole that can be exploited by unscrupulous contractor and ministry personnel. In addition, the anomalies lead to delay in the implementation of the road works.

Therefore, in Kenya the most realistic starting point would be stringent adherence to the existing policy, where all public funded civil construction projects are closely

supervised by the regulatory authority to ensure compliance. The cases of non-compliance could be attributed to either lethargy or incapacity on the side of PPOA. It is for that reason that capacity building is necessary at the regulatory body and that the functions of PPOA be devolved from the capital Nairobi to all the 47 counties in the country so that they can effectively execute their mandate.

5.7 Areas of Further Study

This study adopted a survey research design where the findings are based on the opinion of professionals in civil construction projects in Kenya. There is a need for case study design where project documents from selected civil construction projects are scrutinized to quantify the actual extent of the causes and effects of variation orders so as to compliment the opinion of the construction professionals.

Since this study addressed the subject of variation orders in civil construction projects, it would be interesting to study the subject of building construction or mechanical construction or even electrical construction projects and compare the results.

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APPENDICES

Appendix A: Questionnaire X

JOMO KENYATTA UNIVERSITY

OF

AGRICULTURE AND TECHNOLOGY

P.O. BOX 62000-00200, NAIROBI, KENYA, TEL: +254-20-08008488, FAX: (67) 52437

SCHOOL OF ARCHITECTURE AND BUILDING SCIENCES

DEPARTMENT OF CONSTRUCTION MANAGEMENT

This research titled, **'Evaluation of the Causes and Effects of Variation Orders in Civil Engineering Construction Projects in Kenya'** is being conducted by **David Dickson Oloo,** a student of Masters of Construction Project Management at Jomo Kenyatta University of Agriculture and Technology (JKUAT).

The objective of the study is to evaluate the causes and effects of variation orders in civil construction project in Kenya, with a view to making recommendations that are geared towards proper variation order management.

This survey has been approved by the Board of Postgraduate Studies of JKUAT. All of the responses in the survey will be recorded anonymously and with utmost confidentiality. Thus, there are no risks associated with participating in this study. Moreover, the findings of this study shall be used for academic purposes only.

If you have any questions regarding the survey or this research project in general, please contact **David Dickson Oloo** at email: davoloo@yahoo.com or phone 0721360743. Thank you for accepting to participate in this study. Please kindly answer **all** questions.

SECTION A: RESPONDENT'S PROFILE

1. Which of the following best describes your company?

Client ☐ **Consultant** ☐ **Contractor** ☐ **Other (Specify).....** ☐

2. For how many years have you worked in the construction industry?

Below 5 ☐ **6 - 10** ☐ **11 - 15** ☐ **16 - 20** ☐ **Over 20** ☐

3. What is your current position in your company? .....

4. Have you ever been involved with the administration of variation orders?

Yes ☐ **No** ☐

SECTION B: ORIGIN AGENT AND CAUSES OF VARIATION ORDERS

5. What is the origin agent of most your variation orders?

Client ☐ **Consultant** ☐ **Contractor** ☐ **Other (Specify).....** ☐

6. Which of the following aspects of variations most frequently constitute varied works in civil construction projects?

☐ Additional work

☐ Omission from work

☐ Change to the sequence or timing of the execution of the works

☐ Change to the quality and other characteristics of any item of work

☐ Change to the levels, positions and /or dimensions of any part of the work

7. By ranking from **5 (extremely frequent), 4 (very frequent), 3 (moderately frequent), 2 (slightly frequent) to 1 (least frequent),** how frequently do you encounter the following causes of variation orders in your projects?

S/N	Causes of Variation Orders	5	4	3	2	1
1	Change in Design by Consultant					
2	Errors and Omissions in Design					
3	Conflict between Contract Documents					
4	Technology Changes					

S/N	Causes of Variation Orders	5	4	3	2	1
5	Value Engineering					
6	Lack of communication between contracting parties					
7	Consultants lack of Judgement and Experience					
8	Change in Specifications by consultant/client					
9	Change of Plans or Scope by client					
10	Change of Schedule by client					
11	Client's Financial Problems					
12	Inadequate Project Objectives					
13	Lack of Contractor's Involvement in Design					
14	Unavailability of Materials and Equipment					
15	Contractor's Financial Difficulties					
16	Contractor's Desired Profitability					
17	Differing Site Conditions					
18	Unfamiliarity with Local Conditions					
19	Contractor's Poor Procurement Process					
20	Contractor's Lack of Judgment and Experience					
21	Complex Design and Technology					
22	Inclement Weather Conditions					
23	Change in Government Regulations					
24	Change in Economic Conditions					
25	Socio-cultural factors					
26	Unforeseen Problems/ force majeure					
27	Lack of Coordination between Overseas and Local					
28	Interference of Donors in Project Requirements					
29	Delay in Land Acquisition/Compensation					
30	Environmental Considerations					

SECTION C: EFFECTS OF VARIATION ORDERS

8. By ranking from **5 (Always), 4 (Often), 3 (Sometimes), 2 (Seldom), to 1 (Never),** how frequently do variation orders result in the following in your projects?

S/N	Effects of Variation Orders	5	4	3	2	1
1	Cost Overruns					
2	Time Overruns					
3	Progress Degradation					
4	Delays in Payment					
5	Quality Degradation					
6	Productivity Degradation					
7	Procurement Delay					
8	Rework and Demolition					
9	Contractual Claims and Disputes					
10	Increased Overhead Costs					

SECTION D: VARIATION ORDER MANAGEMENT

9. How do you valuate variations in you civil construction projects?

10. What key considerations do you make when assessing contractor's claims on variation orders? List them in the order of importance.

11. How best can the occurrence of variations be reduced in civil construction project?

'THANK YOU FOR COMPLETING THIS QUESTIONNAIRE'

Appendix B: Questionnaire Y

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SECTION A: RESPONDENT'S PROFILE

3. Which of the following best describes your company?

Client ☐ **Consultant** ☐ **Contractor** ☐ **Other (Specify).....** ☐

4. For how many years have you worked in the construction industry?

Below 5	**6 - 10**	**11 - 15**	**16 - 20**	**Over 20**
☐	☐	☐	☐	☐

3. What is your current position in your company? .....

4. Have you ever been involved with the administration of variation orders?

Yes ☐ **No** ☐

SECTION B: ORIGIN AGENT AND CAUSES OF VARIATION ORDERS

5. What is the origin agent of most your variation orders?

Client	**Consultant**	**Contractor**	**Other (Specify).....**
☐	☐	☐	☐

6. Which of the following aspects of variations most frequently constitute varied works in civil construction projects?

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☐ Change to the sequence or timing of the execution of the works

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7. By ranking from **5 (extremely frequent), 4 (very frequent), 3 (moderately frequent), 2 (slightly frequent) to 1 (least frequent),** how frequently do you encounter the following causes of variation orders in your projects?

S/N	**Causes of Variation Orders**	**5**	**4**	**3**	**2**	**1**
1	Change in Design by Consultant					
2	Errors and Omissions in Design					
3	Conflict between Contract Documents					
4	Technology Changes					
5	Value Engineering					

S/N	Causes of Variation Orders	5	4	3	2	1
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7	Consultants lack of Judgement and Experience					
8	Change in Specifications by consultant/client					
9	Change of Plans or Scope by client					
10	Change of Schedule by client					
11	Client's Financial Problems					
12	Inadequate Project Objectives					
13	Lack of Contractor's Involvement in Design					
14	Unavailability of Materials and Equipment					
15	Contractor's Financial Difficulties					
16	Contractor's Desired Profitability					
17	Differing Site Conditions					
18	Unfamiliarity with Local Conditions					
19	Contractor's Poor Procurement Process					
20	Contractor's Lack of Judgment and Experience					
21	Complex Design and Technology					
22	Inclement Weather Conditions					
23	Change in Government Regulations					
24	Change in Economic Conditions					
25	Socio-cultural factors					
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30	Environmental Considerations					

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4	Delays in Payment					
5	Quality Degradation					
6	Productivity Degradation					
7	Procurement Delay					
8	Rework and Demolition					
9	Contractual Claims and Disputes					
10	Increased Overhead Costs					

SECTION D: VARIATION ORDER MANAGEMENT

9. When preparing project cost estimates and budget, how do you take care of unforeseen variations in your projects?

10. Do you have a variation order management system in place in your organization? If yes, please elaborate on the benefits of such a system to your organization.

11. How do you resolve disputes resulting from variation orders between you and the contractor?

'THANK YOU FOR COMPLETING THIS QUESTIONNAIRE'

Appendix C: Questionnaire Z

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Client ☐ **Consultant** ☐ **Contractor** ☐ **Other (Specify).....** ☐

6. For how many years have you worked in the construction industry?

Below 5 ☐ **6 - 10** ☐ **11 - 15** ☐ **16 - 20** ☐ **Over 20** ☐

3. What is your current position in your company? .....

4. Have you ever been involved with the administration of variation orders?

Yes ☐ **No** ☐

SECTION B: ORIGIN AGENT AND CAUSES OF VARIATION ORDERS

5. What is the origin agent of most your variation orders?

Client ☐ **Consultant** ☐ **Contractor** ☐ **Other (Specify).....** ☐

6. Which of the following aspects of variations most frequently constitute varied works in civil construction projects?

☐ Additional work

☐ Omission from work

☐ Change to the sequence or timing of the execution of the works

☐ Change to the quality and other characteristics of any item of work

☐ Change to the levels, positions and /or dimensions of any part of the work

7. By ranking from **5 (extremely frequent), 4 (very frequent), 3 (moderately frequent), 2 (slightly frequent) to 1 (least frequent),** how frequently do you encounter the following causes of variation orders in your projects?

S/N	Causes of Variation Orders	5	4	3	2	1
1	Change in Design by Consultant					
2	Errors and Omissions in Design					
3	Conflict between Contract Documents					
4	Technology Changes					

S/N	Causes of Variation Orders	5	4	3	2	1
5	Value Engineering					
6	Lack of communication between contracting parties					
7	Consultants lack of Judgement and Experience					
8	Change in Specifications by consultant/client					
9	Change of Plans or Scope by client					
10	Change of Schedule by client					
11	Client's Financial Problems					
12	Inadequate Project Objectives					
13	Lack of Contractor's Involvement in Design					
14	Unavailability of Materials and Equipment					
15	Contractor's Financial Difficulties					
16	Contractor's Desired Profitability					
17	Differing Site Conditions					
18	Unfamiliarity with Local Conditions					
19	Contractor's Poor Procurement Process					
20	Contractor's Lack of Judgment and Experience					
21	Complex Design and Technology					
22	Inclement Weather Conditions					
23	Change in Government Regulations					
24	Change in Economic Conditions					
25	Socio-cultural factors					
26	Unforeseen Problems/ force majeure					
27	Lack of Coordination between Overseas and Local					
28	Interference of Donors in Project Requirements					
29	Delay in Land Acquisition/Compensation					
30	Environmental Considerations					

SECTION C: EFFECTS OF VARIATION ORDERS

8. By ranking from **5 (Always), 4 (Often), 3 (Sometimes), 2 (Seldom), to 1 (Never),** how frequently do variation orders result in the following in your projects?

S/N	Effects of Variation Orders	5	4	3	2	1
1	Cost Overruns					
2	Time Overruns					
3	Progress Degradation					
4	Delays in Payment					
5	Quality Degradation					
6	Productivity Degradation					
7	Procurement Delay					
8	Rework and Demolition					
9	Contractual Claims and Disputes					
10	Increased Overhead Costs					

SECTION D: VARIATION ORDER MANAGEMENT

9. What challenges do you encounter when compiling claims related to variation orders in your projects?

10. How do you overcome the above challenges?

11. Do you have a variation order management system in the projects that you undertake? If yes, please elaborate how the system functions.

'THANK YOU FOR COMPLETING THIS QUESTIONNAIRE'

Appendix D: Rate of Return for Questionnaires

	Target Population	Minimum Sample Size	Number Sent	Number Returned	Rate of Return %
Client	12	11	12	12	100%
Consultant	32	25	32	24	75%
Contractor	51	34	51	38	75%
Total	95	70	95	74	78%

Appendix E: Participants Profile

General Information	Frequency	Percentage
Company Description		
Client	12	16
Consultant	24	32
Contractor	38	52
Position in Respective Company		
Director	8	11
Site Engineer	25	34
Project/ Construction Manager	16	22
Quantity Surveyor	8	11
Project Engineer	5	7
Design Engineer	6	8
Resident Engineer	2	3
Contracts Engineer	1	1
Clerks of Work	3	4
Participants Years' of Experience		
Below 5	3	4
5-10	10	14
11-15	12	16
16-20	20	27
Over 20	29	39
Experience with Variation Orders		
Yes	71	96
No	3	4

Appendix F: RII Calculation for Factors Contributing to Variation Orders

Question	Causes of Variation Orders	Scale						Overall			Client			Consultant			Contractor		
		1	2	3	4	5	∑W	A x N	RII	Rank	A x N	RII	Rank	A x N	RII	Rank	A x N	RII	Rank
Q7.1	**Change in Design by Consultant**	**2**	**7**	**16**	**32**	**16**	**272**	**370**	**0.735**	**6**									
	Client	0	3	1	5	2	39				60	0.650	8						
	Consultant	0	1	7	13	3	90							120	0.750	6			
	Contractor	2	3	8	14	11	143										190	0.753	4
Q7.2	**Errors and Omissions in Design**	**4**	**9**	**17**	**30**	**14**	**263**	**370**	**0.711**	**8**									
	Client	1	2	1	5	3	43				60	0.717	3						
	Consultant	2	1	7	10	4	85							120	0.708	8			
	Contractor	1	6	9	15	7	135										190	0.711	8
Q7.3	**Conflict between Contract Documents**	**9**	**10**	**14**	**35**	**6**	**241**	**370**	**0.651**	**9**									
	Client	1	1	1	8	1	43				60	0.717	3						
	Consultant	2	7	3	9	3	76							120	0.633	11			
	Contractor	6	2	10	18	2	122										190	0.642	10
Q7.4	**Technology Changes**	**46**	**22**	**3**	**1**	**0**	**103**	**370**	**0.278**	**30**									
	Client	10	2	0	0	0	14				60	0.233	30						
	Consultant	14	8	2	0	0	36							120	0.300	29			
	Contractor	22	12	1	1	0	53										190	0.279	30
Q7.5	**Value Engineering**	**40**	**22**	**7**	**3**	**0**	**117**	**370**	**0.316**	**29**									
	Client	9	1	2	0	0	17				60	0.283	27						
	Consultant	11	6	4	1	0	39							120	0.325	28			
	Contractor	20	15	1	2	0	61										190	0.321	27
Q7.6	**Lack of communication between contracting parties**	**25**	**21**	**17**	**7**	**3**	**161**	**370**	**0.435**	**18**									
	Client	8	1	3	0	0	19				60	0.317	25						
	Consultant	5	7	8	3	0	55							120	0.458	17			
	Contractor	12	13	6	4	3	87										190	0.458	17
Q7.7	**Consultants lack of Judgment and Experience**	**32**	**23**	**12**	**6**	**0**	**138**	**370**	**0.373**	**22**									
	Client	3	3	1	4	0	28				60	0.467	18						
	Consultant	13	6	3	2	0	42							120	0.350	23			
	Contractor	16	14	8	0	0	68										190	0.358	22
Q7.8	**Change in Specifications by consultant/client**	**9**	**12**	**19**	**27**	**5**	**223**	**370**	**0.603**	**12**									
	Client	1	3	4	3	0	31				60	0.517	16						
	Consultant	3	4	5	7	4	74							120	0.617	12			
	Contractor	5	5	10	17	1	118										190	0.621	12
Q7.9	**Change of Plans or Scope by client**	**4**	**7**	**15**	**21**	**27**	**282**	**370**	**0.762**	**3**									
	Client	1	4	4	2	1	34				60	0.567	12						
	Consultant	1	1	4	10	8	95							120	0.792	3			
	Contractor	2	2	7	9	18	153										190	0.805	3
Q7.10	**Change of Schedule by client**	**4**	**9**	**17**	**15**	**29**	**278**	**370**	**0.751**	**4**									
	Client	1	1	3	4	3	43				60	0.717	3						
	Consultant	1	2	6	4	11	94							120	0.783	4			
	Contractor	2	6	8	7	15	141										190	0.742	6

Question	Causes of Variation Orders	Scale					∑W	Overall			Client			Consultant			Contractor		
		1	2	3	4	5		A x N	RII	Rank	A x N	RII	Rank	A x N	RII	Rank	A x N	RII	Rank
Q7.11	**Client's Financial Problems**	**21**	**30**	**17**	**6**	**0**	**156**	**370**	**0.422**	**19**									
	Client	6	3	0	3	0	24				60	0.400	24						
	Consultant	4	14	5	1	0	51							120	0.425	20			
	Contractor	11	13	12	2	0	81										190	0.426	20
Q7.12	**Inadequate Project Objectives**	**34**	**23**	**11**	**2**	**1**	**126**	**370**	**0.341**	**26**									
	Client	9	3	0	0	0	15				60	0.250	29						
	Consultant	8	7	4	1	1	43							120	0.358	22			
	Contractor	17	13	7	1	0	68										190	0.358	22
Q7.13	**Lack of Contractor's Involvement in Design**	**12**	**19**	**26**	**13**	**4**	**200**	**370**	**0.541**	**15**									
	Client	4	3	3	1	1	28				60	0.467	18						
	Consultant	4	3	13	3	1	66							120	0.550	14			
	Contractor	4	13	10	9	2	106										190	0.558	14
Q7.14	**Unavailability of Materials and Equipment**	**9**	**9**	**20**	**26**	**10**	**241**	**370**	**0.651**	**9**									
	Client	4	5	1	2	0	25				60	0.417	21						
	Consultant	2	1	8	9	4	84							120	0.700	9			
	Contractor	3	3	11	15	6	132										190	0.695	9
Q7.15	**Contractor's Financial Difficulties**	**38**	**29**	**5**	**2**	**0**	**119**	**370**	**0.322**	**27**									
	Client	5	3	2	2	0	25				60	0.417	21						
	Consultant	13	10	1	0	0	36							120	0.300	29			
	Contractor	20	16	2	0	0	58										190	0.305	29
Q7.16	**Contractor's Desired Profitability**	**37**	**24**	**3**	**7**	**2**	**132**	**370**	**0.357**	**24**									
	Client	4	3	0	4	1	31				60	0.517	16						
	Consultant	11	12	0	1	0	39							120	0.325	26			
	Contractor	22	9	3	2	1	62										190	0.326	25
Q7.17	**Differing Site Conditions**	**1**	**4**	**13**	**20**	**36**	**308**	**370**	**0.832**	**2**									
	Client	1	1	2	3	5	46				60	0.767	2						
	Consultant	0	1	4	8	11	101							120	0.842	2			
	Contractor	0	2	7	9	20	161										190	0.847	2
Q7.18	**Unfamiliarity with Local Conditions**	**14**	**14**	**21**	**22**	**2**	**203**	**370**	**0.549**	**14**									
	Client	3	2	3	4	0	32				60	0.533	15						
	Consultant	3	6	6	7	1	66							120	0.550	14			
	Contractor	8	6	12	11	1	105										190	0.553	15
Q7.19	**Contractor's Poor Procurement Process**	**18**	**19**	**16**	**11**	**10**	**198**	**370**	**0.535**	**16**									
	Client	5	1	0	2	4	35				60	0.583	11						
	Consultant	4	10	4	3	3	63							120	0.525	16			
	Contractor	9	8	12	6	3	100										190	0.526	16
Q7.20	**Contractor's Lack of Judgment and Experience**	**35**	**18**	**11**	**7**	**1**	**137**	**370**	**0.370**	**23**									
	Client	2	2	2	4	1	33				60	0.550	13						
	Consultant	13	7	3	1	0	40							120	0.333	24			
	Contractor	20	9	6	2	0	64										190	0.337	24

Question	Causes of Variation Orders	Scale					∑W	Overall			Client			Consultant			Contractor		
		1	2	3	4	5		A x N	RII	Rank	A x N	RII	Rank	A x N	RII	Rank	A x N	RII	Rank
Q7.21	**Complex Design and Technology**	**19**	**30**	**17**	**3**	**2**	**152**	**370**	**0.411**	**20**									
	Client	6	4	1	0	0	17				60	0.283	27						
	Consultant	3	11	6	1	1	52							120	0.433	19			
	Contractor	10	15	10	2	1	83										190	0.437	19
Q7.22	**Inclement Weather Conditions**	**4**	**9**	**20**	**18**	**23**	**269**	**370**	**0.727**	**7**									
	Client	1	3	3	2	3	39				60	0.650	8						
	Consultant	1	3	6	6	8	89							120	0.742	7			
	Contractor	2	3	11	10	12	141										190	0.742	6
Q7.23	**Change in Government Regulations**	**35**	**32**	**5**	**1**	**0**	**118**	**370**	**0.319**	**28**									
	Client	6	5	1	0	0	19				60	0.317	25						
	Consultant	10	10	2	1	0	40							120	0.333	24			
	Contractor	19	17	2	0	0	59										190	0.311	28
Q7.24	**Change in Economic Conditions**	**33**	**31**	**8**	**2**	**0**	**127**	**370**	**0.343**	**25**									
	Client	2	7	2	1	0	26				60	0.433	20						
	Consultant	11	11	2	0	0	39							120	0.325	26			
	Contractor	20	13	4	1	0	62										190	0.326	25
Q7.25	**Socio-cultural factors**	**27**	**25**	**15**	**7**	**0**	**150**	**370**	**0.405**	**21**									
	Client	5	3	2	2	0	25				60	0.417	21						
	Consultant	9	8	5	2	0	48							120	0.400	21			
	Contractor	13	14	8	3	0	77										190	0.405	21
Q7.26	**Unforeseen Problems/ force majeure**	**9**	**13**	**23**	**18**	**11**	**231**	**370**	**0.624**	**11**									
	Client	2	3	4	2	1	33				60	0.550	13						
	Consultant	2	4	8	7	3	77							120	0.642	10			
	Contractor	5	6	11	9	7	121										190	0.637	11
Q7.27	**Lack of Coordination between overseas and local designers**	**3**	**9**	**19**	**19**	**24**	**274**	**370**	**0.741**	**5**									
	Client	0	1	3	6	1	40				60	0.667	6						
	Consultant	0	3	7	6	8	91							120	0.758	5			
	Contractor	3	5	9	7	15	143										190	0.753	4
Q7.28	**Interference of donors in project requirements**	**16**	**22**	**25**	**5**	**5**	**180**	**370**	**0.486**	**17**									
	Client	0	2	6	2	2	40				60	0.667	6						
	Consultant	8	4	8	1	2	54							120	0.450	18			
	Contractor	8	16	11	2	1	86										190	0.453	18
Q7.29	**Delay in land acquisition/ compensation**	**0**	**3**	**11**	**26**	**35**	**318**	**370**	**0.859**	**1**									
	Client	0	0	2	2	8	54				60	0.900	1						
	Consultant	0	0	4	10	10	102							120	0.850	1			
	Contractor	0	3	5	14	17	162										190	0.853	1
Q7.30	**Environmental considerations**	**11**	**22**	**16**	**11**	**13**	**212**	**370**	**0.573**	**13**									
	Client	0	3	4	2	2	36				60	0.600	10						
	Consultant	4	7	6	3	4	68							120	0.567	13			
	Contractor	7	12	6	6	7	108										190	0.568	13

Appendix G: RII Calculation for Effects of Variation Orders

Question	Effects of Variation Orders	Scale						Overall			Client			Consultant			Contractor		
		1	2	3	4	5	∑W	A x N	RII	Rank	A x N	RII	Rank	A x N	RII	Rank	A x N	RII	Rank
Q8.1	**Cost Overruns**	**2**	**1**	**4**	**17**	**50**	**334**	**370**	**0.903**	**1**									
	Client	0	0	0	5	7	55				60	0.917	1						
	Consultant	1	1	2	4	16	105							120	0.875	1			
	Contractor	1	0	2	8	27	174										190	0.916	1
Q8.2	**Time Overruns**	**2**	**8**	**11**	**16**	**37**	**300**	**370**	**0.811**	**3**									
	Client	0	1	1	6	4	49				60	0.817	2						
	Consultant	1	3	3	5	12	96							120	0.800	3			
	Contractor	1	4	7	5	21	155										190	0.816	3
Q8.3	**Progress Degradation**	**6**	**8**	**15**	**24**	**21**	**268**	**370**	**0.724**	**5**									
	Client	2	0	2	4	4	44				60	0.733	3						
	Consultant	0	2	8	7	7	91							120	0.758	5			
	Contractor	4	6	5	13	10	133										190	0.700	5
Q8.4	**Delays in Payment**	**45**	**14**	**9**	**3**	**2**	**122**	**370**	**0.330**	**10**									
	Client	5	2	3	2	0	26				60	0.433	10						
	Consultant	16	5	1	1	0	33							120	0.275	10			
	Contractor	24	7	5	0	2	63										190	0.332	10
Q8.5	**Quality Degradation**	**15**	**15**	**32**	**8**	**4**	**193**	**370**	**0.522**	**8**									
	Client	2	4	4	1	1	31				60	0.517	8						
	Consultant	3	4	10	5	2	71							120	0.592	8			
	Contractor	10	7	18	2	1	91										190	0.479	9
Q8.6	**Productivity Degradation**	**9**	**13**	**16**	**33**	**3**	**230**	**370**	**0.622**	**6**									
	Client	1	3	3	4	1	37				60	0.617	7						
	Consultant	3	5	4	11	1	74							120	0.617	6			
	Contractor	5	5	9	18	1	119										190	0.626	6
Q8.7	**Procurement Delay**	**15**	**30**	**12**	**11**	**5**	**180**	**370**	**0.486**	**9**									
	Client	2	5	3	2	0	29				60	0.483	9						
	Consultant	6	11	3	3	0	49							120	0.408	9			
	Contractor	7	14	6	6	5	102										190	0.537	8
Q8.8	**Rework and Demolition**	**5**	**14**	**36**	**13**	**6**	**223**	**370**	**0.603**	**7**									
	Client	0	2	7	1	2	39				60	0.650	6						
	Consultant	1	5	11	7	0	72							120	0.600	7			
	Contractor	4	7	18	5	4	112										190	0.589	7
Q8.9	**Contractual Disputes and Claims**	**1**	**9**	**10**	**18**	**36**	**301**	**370**	**0.814**	**2**									
	Client	0	3	2	3	4	44				60	0.733	3						
	Consultant	0	3	2	6	13	101							120	0.842	2			
	Contractor	1	3	6	9	19	156										190	0.821	2
Q8.10	**Increased Overhead Costs**	**1**	**6**	**8**	**41**	**18**	**291**	**370**	**0.786**	**4**									
	Client	1	2	1	5	3	43				60	0.717	5						
	Consultant	0	2	2	15	5	95							120	0.792	4			
	Contractor	0	2	5	21	10	153										190	0.805	4

Appendix H: Ranking of Factors Contributing to Variation Orders Using RII

Causes of Variation Orders	Overall		Client		Consultant		Contractor	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Delay in land Ccquisition/ Compensation	0.859	1	0.900	1	0.850	1	0.853	1
Differing Site Conditions	0.832	2	0.767	2	0.842	2	0.847	2
Change of Plans or Scope by Client	0.762	3	0.567	12	0.792	3	0.805	3
Change of Schedule by Client	0.751	4	0.717	3	0.783	4	0.742	6
Lack of Coordination between Overseas and Local Designers	0.741	5	0.667	6	0.758	5	0.753	4
Change in Design by Consultant	0.735	6	0.650	8	0.750	6	0.753	4
Inclement Weather Conditions	0.727	7	0.650	8	0.742	7	0.742	6
Errors and Omissions in Design	0.711	8	0.717	3	0.708	8	0.711	8
Unavailability of Materials and Equipment	0.651	9	0.417	21	0.700	9	0.695	9
Conflict between Contract Documents	0.651	9	0.717	3	0.633	11	0.642	10
Unforeseen Problems/ Force Majeure	0.624	11	0.550	13	0.642	10	0.637	11
Change in Specifications by consultant/client	0.603	12	0.517	16	0.617	12	0.621	12
Environmental Considerations	0.573	13	0.600	10	0.567	13	0.568	13
Unfamiliarity with Local Conditions	0.549	14	0.533	15	0.550	14	0.553	15
Lack of Contractor's Involvement in Design	0.541	15	0.467	18	0.550	14	0.558	14
Contractor's Poor Procurement Process	0.535	16	0.583	11	0.525	16	0.526	16
Interference of donors in Project Requirements	0.486	17	0.667	6	0.450	18	0.453	18
Lack of communication between contracting parties	0.435	18	0.317	25	0.458	17	0.458	17
Client's Financial Problems	0.422	19	0.400	24	0.425	20	0.426	20
Complex Design and Technology	0.411	20	0.283	27	0.433	19	0.437	19
Socio-cultural Factors	0.405	21	0.417	21	0.400	21	0.405	21
Consultants lack of Judgment and Experience	0.373	22	0.467	18	0.350	23	0.358	22
Contractor's Lack of Judgment and Experience	0.370	23	0.550	13	0.333	24	0.337	24
Contractor's Desired Profitability	0.357	24	0.517	16	0.325	26	0.326	26
Change in Economic Conditions	0.343	25	0.433	20	0.325	26	0.326	25
Inadequate Project Objectives	0.341	26	0.250	29	0.358	22	0.358	22
Contractor's Financial Difficulties	0.322	27	0.417	21	0.300	29	0.305	29
Change in Government Regulations	0.319	28	0.317	25	0.333	24	0.311	28
Value Engineering	0.316	29	0.283	27	0.325	26	0.321	27
Technology Changes	0.278	30	0.233	30	0.300	29	0.279	30

Appendix I: Ranking of Effects of Variation Orders Using RII

Effects of Variation Orders	Overall		Client		Consultant		Contractor	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Cost Overruns	0.903	1	0.917	1	0.875	1	0.916	1
Contractual Disputes and Claims	0.814	2	0.733	3	0.842	2	0.821	2
Time Overruns	0.811	3	0.817	2	0.800	3	0.816	3
Increased Overhead Costs	0.786	4	0.717	5	0.792	4	0.805	4
Progress Degradation	0.724	5	0.733	3	0.758	5	0.700	5
Productivity Degradation	0.622	6	0.617	7	0.617	6	0.626	6
Rework and Demolition	0.603	7	0.650	6	0.600	7	0.589	7
Quality Degradation	0.522	8	0.517	8	0.592	8	0.479	9
Procurement Delay	0.486	9	0.483	9	0.408	9	0.537	8
Delays in Payment	0.330	10	0.433	10	0.275	10	0.332	10