ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

CAUSES AND EFFECTS OF VARIATION ORDERS IN ROAD CONSTRUCTION PROJECTS: **The case of national works contract administered by Addis Ababa city roads authority.**

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CHAIRMAN

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Abstract

This thesis assesses variation orders in national works contract of Addis Ababa City Road projects by investigating the predominant causes, studying their effects on the project, identifying initiating parties, and suggesting controlling remedies to alleviate such related problems. The main purpose of this study was to study, identify and mitigate those common and frequent variation orders encountered in Addis Ababa City Road projects which are being reflected in the projects delay, cost overrun, and disputes.

In order to obtain the view of many role players such as employer, consultants and contractors in the industry on these phenomena a concept study was developed through literature survey. Following a survey was conducted and analyzed using a questionnaire and desk study assessment. Based on the analyzed data the most predominant causes, origin agent, consequential effects were identified and controlling methods were also proposed.

The results revealed that inadequate design, error and omission in design and ambiguous design were the main causes of consultant originated variations while Right of way (access to site) problem, change of plans or scope and inadequate objectives were the main causes of client originated variations. The study further revealed that in most situations variations have resulted in cost overrun, time overrun and disputes. The finding indicated that consultant is the major source of variation orders. It is also recognized that the issue of variation order in road construction projects of Addis Ababa City is serious and could be managed by applying proper construction management tools at design, construction and design-construction interface stages. Finally remedial recommendations are forwarded based on the findings of the results.

Key words: cause, change, cost overrun, effect, time overrun, origin agent, variation, variation order.

Abbreviations

AACRA: Addis Ababa City Roads Authority

AAWSA: Addis Ababa City Water and Sewerage Authority

APMP: Association of Project Management

BOFED: Bureau of Finance and Economic Development of Addis Ababa

CII: Construction Industry Institute

EEPCo: Ethiopian Electric Power Corporation

ETC: Ethiopian Telecommunication Corporation

GDP: Gross Domestic Product

LRT: Light Rail Transit

MoWUD: Ministry of Works and Urban Development

NBE: National Bank of Ethiopia

ROW: Right of way

UNEP: United Nations Environmental Program

PMC: Project Management Consultant

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CHAPTER ONE

1.0 INTRODUCTION

1.1 RESEARCH OVERVIEW

Construction industry makes significant contributions to the socio-economic development process of a country. Its importance emanates largely from the direct and indirect impact it has on all economic activities. It contributes to the national output and stimulates the growth of other sectors through a complex system of linkages (UNEP, 1996). UNEP further observes that the industry consumes one-sixth to one half of the world's wood, minerals, water and energy. It contributes to employment and creates income for the population and has multiplier effects on the economy.

Road construction, in particular, plays a significant role in realizing economic development and for the expansion of investment. The role of construction of roads is crucial for sustainable development. Road development is also essential with the perspective of saving of time, minimizing traveling expenses and improving services in trade, education and health sectors. For the realization of sustainable social and economic development, building new roads, maintaining and upgrading of the existing ones is vital (BOFED, 2002).

Likewise, the construction industry has important contributions to the Ethiopian economy, as demonstrated by its share in the GDP. For instance it can be seen from Table 1.1 below that the share of the Construction sector in the total national GDP has been increasing and averaged at about 5.4 percent in the period 2000/01- 2009/10 (NBE, 2013).

Table 1.1 Sectorial contributions (Value added % GDP) for the period 2000/01- 2009/2010

Year	Agriculture Value added (%GDP)	Service Value added (%GDP)	Industry Value added(%GDP)				
			Manufacturing	Construction	Electricity	Mining	Industry total
2000/01	50.9	38.0	5.3	4.3	2.1	0.5	12.1
2001/02	49.1	38.6	5.3	4.9	2.2	0.5	12.9
2002/03	44.9	41.7	5.4	5.7	2.4	0.5	14.0
2003/04	47.0	39.7	5.2	6.1	2.3	0.5	14.0
2004/05	47.4	39.7	5.2	5.8	2.2	0.4	13.6
2005/06	47.1	40.4	6.1	4.3	2.5	0.5	13.4
2006/07	46.1	41.7	5.0	5.7	2.2	0.4	13.2
2007/08	44.6	43.5	4.8	5.6	2.2	0.4	13.0
2008/09	43.2	45.1	4.9	5.8	1.9	0.4	13.0
2009/10	42.0	46.1	4.9	5.8	1.8	0.5	13.0

Source: [National bank of Ethiopia, July 2013(at various years),http//www.nbe.gov.et]

According to a report by the Addis Ababa City Roads Authority 2014, it is indicated that the total length of road constructed in the city before the establishment of the Authority in March 15, 1998 was only 1,300 km with road network coverage of 5.52%. In January 2015, the city road length has reached 4,671 kms with the road network coverage of 17.50% as compared with the developed area of the city. The total expended budget during the last 15 years was 14.88 billion birr and the targeted city road network coverage of the authority by the year 2019/2020 is 25%. Table 1.2 shows total budget allocated for capital and regular expenses in consecutive 8 years in the period 2004/05- 2012/13.

Table 1.2 Capital and regular expenses of Addis Ababa City Roads Authority
(From 2004/2005 to 2012/2013)

No.	Year	From city adminstration for Capital project		From city adminstration for regular expense		From federal road fund for maintenance		Sum From city adminstration and road fund	
		Planned	Expended	Planned	Expended	Planned	Expended	Planned	Expended
1	2004/2005	303,620,000.00	227,802,584.00	20,095,082.00	18,857,848.00	19,922,867.00	16,911,361.00	323,542,867.00	244,713,945.00
2	2005/2006	700,071,638.00	532,933,329.00	22,436,443.00	20,753,431.00	24,150,000.00	25,020,000.00	724,221,638.00	557,953,329.00
3	2006/2007	1,121,427,638.00	921,587,928.00	25,460,226.00	25,242,089.00	32,500,000.00	33,261,981.00	1,153,927,638.00	954,849,909.00
4	2007/2008	1,507,915,880.00	1,039,274,356.00	37,043,614.00	33,758,970.00	37,500,000.00	36,638,445.00	1,545,415,880.00	1,075,912,801.00
5	2008/2009	1,545,050,568.00	1,307,392,599.00	42,572,091.00	38,699,758.00	37,500,000.00	37,600,000.00	1,582,550,568.00	1,344,992,599.00
6	2009/2010	1,027,414,794.00	1,443,615,649.00	40,187,310.00	37,476,522.00	35,000,000.00	38,900,000.00	1,062,414,794.00	1,482,515,649.00
7	2010/2011	1,077,870,000.00	1,295,062,249.00	44,403,884.00	40,493,845.00	41,630,000.00	41,200,000.00	1,119,500,000.00	1,336,262,249.00
8	2011/2012	1,134,878,400.00	1,381,031,651.00	48,564,890.00	46,359,200.00	45,793,013.00	46,547,195.00	1,180,671,413.00	1,427,578,846.00
9	2012/2013	1,369,184,324.00		57,707,103.00		50,372,300.00	63,947,657.00	1,419,556,624.00	1,427,578,846.00
	2012/2013 corrected budget	4,208,986,316.00	4,083,864,982.00	70,606,039.00	66,159,828.00				
	Total Sum	**12,627,235,234.00**	**12,232,565,327.00**	**351,369,578.00**	**327,801,491.00**	**324,368,180.00**	**340,026,639.00**	**10,111,801,422.00**	**8,424,779,326.00**

[Source: Addis Ababa City Roads, special edition (March, 2014)]

However, the complexity of the construction industry due to different stakeholders' involvement makes it different from other industry. This complexity gives rise mostly to unwanted situation like variations with their attached effects, and the more variation orders on a project, the greater the likelihood that they become time consuming and costly in construction projects (Mohamed, 2001).

Road projects of Addis Ababa City are commonly characterized by cost and time overrun due to variation orders. There are many reasons for issuing construction variation orders in Addis Ababa City Road Construction contracts. It might be a result of further development of the Employer's requirements or the consultant may make an error in the plans or a specification that has to be overcome or the contractor may find something that was hidden that could not have been reasonably planned for. Identifying and quantifying the predominant causes, effects and origin agents of variation orders is therefore essential for the road construction of the city in order to mitigate the consequential impact.

1.2 RESEARCH PROBLEM

Most of the road projects of Addis Ababa City are not completed within the original contract price and original contract time due to issuance of variation orders during construction period which is becoming a common practice that reflects the improper management of variation orders in the road projects of the city. The employer and the contractors are not beneficial from this scenario and at large the end users of the road project. Variation orders are issued frequently and projects are subject to delay, additional cost and disputes. The employer is forced to accept those changes with their consequential additional costs during construction though it could have been managed or minimized during the design and construction stages. Most importantly, consultants make frequent review of the design during construction time and contractors do suffer from the resulted delay of the review and employer's approval.

Therefore, it is clear that stakeholders are not beneficial from the negative effects of such variation orders. Thus, it is important to explore the extent of variation order in the national contracts of road projects of Addis Ababa City and better understand their influences.

1.3 OBJECTIVE OF THE RESEARCH

The main objectives of this research study are:-

- To identify the predominant causes of variation orders that are prevalent in national works contract of Addis Ababa City Road projects.
- To identify the main origin agents for the predominant causes of variation orders
- Investigate the potential effects of variation orders in national works contract of Addis Ababa City Road projects and
- To recommend how to control or minimize variation orders in national works contract of Addis Ababa City Road projects.

1.4 RESEARCH QUESTIONS

In order to achieve at credible conclusion, the research study was guided by the following questions:

i. What are the predominant causes of variation orders in the national contract road projects of Addis Ababa?

ii. Which contacting party is mostly initiating the predominant causes of variation orders?

iii. What are the most consequential effects of variation orders in the national contract road projects of Addis Ababa?

iv. How can variation orders be controlled or minimized in the national contract road projects of Addis Ababa?

1.5 SIGNIFICANCE OF THE STUDY

Generally the study is envisaged to provide valuable relevant information for all contracting parties based on the findings of the study on Variation orders in the road construction projects of Addis Ababa city. Particularly, this study will assist both employer (AACRA) and road contractors to identify the potential causes and effects at design and construction stages to minimize and control variation orders and its consequential impacts. The study will also lay the foundation for further research on the subject matter.

1.6 BRIEF METHODOLOGY

The study has used both primary and secondary data. The primary data for the study was obtained through distribution of questionnaires to professionals involved in the construction of the city road projects. In order to enrich the questionnaire for the research, a review of books and journals were used to identify the various efforts that have been made in the past to evaluate and examine the causes, effects and controls of variation orders on road construction projects. Simple statistical analysis involving tables, rankings and percentages were used in analyzing the results from the questionnaire. Descriptive explanations were also employed in making the analysis more meaningful. Secondary sources of data were obtained from relevant literatures that covered research and publication on the subject matter.

1.7 LIMITATION OF THE STUDY

Construction of road projects in the public sector has assumed significant functions, hence the need for assessment on the causes, effects and controls of variation orders in Addis Ababa City Road projects is therefore in order to achieve overall project objectives. Historical data related to variation order is not well recorded hence getting data for this study was very difficult. Data collection and analysis was therefore mostly limited to the data received from project supervisors, colleagues and volunteer professionals who are participating in the city road construction projects.

1.8 RESEARCH OUTLINE

This research will have the following broad categories.

Chapter I: Introduction/ Research Overview
Chapter II: Literature review
Chapter III: The research design and methodology
Chapter IV: The research analysis and discussions
Chapter V: The research conclusions and recommendations

Each of the above chapters will contain the following contents as stipulated bellow.

Chapter I: describes the research overview, its initiation and purposes. It also indicates the research objectives, how the research process is conducted and the contents of the research.

Chapter II: covers the literature review part of the thesis; the literature review will include general information about causes, effects, origin agent and controls of variation orders.

Chapter III: covers the research methodology. The methodological approach consists of the overall research strategy; the study approach, data source and collection, method of analysis and writing of the research paper.

Chapter IV: Contains the analysis and discussion part. It contains the findings on causes and effects, origin agents and possible controls of variation orders.

Chapter V: in this part based on the findings of the study, conclusions and recommendations are presented.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter a comprehensive literature review has been made focusing on the possible causes of variation orders, their effects, origin agents and methods that should be adopted in controlling potential variation orders on road construction projects.

The need to make changes in a construction project is a matter of practical reality. Even the most thoughtfully planned projects may necessitate changes due to various factors (O'Brien, 1998). Likewise, Ssegawa *et al.*, (2002) elaborated due to its compartmentalization the construction industry has made variation almost an inevitable element and has become so prevalent that it is hardly possible to complete a project without changes to the plans or the construction process itself. This complexity gives rise mostly to unwanted situation like variations with their attached effects, and the more variation orders on a project, the greater the likelihood that they become time consuming and costly in construction projects (Mohamed, 2001).

Thus, construction projects are bound to encounter variation orders; the goal of the owner, design or construction manager is to limit the number of such changes (CII, 1994b). Variations in drawings and contract documents usually lead to a change in contract price or contract schedule. Conventionally, variations present problems to all parties involved in the construction process. Proper management of variation orders is therefore very significant for all types of construction projects.

Chan and Yeong (1995) also indicated that a variation order often involves additional cost and disruption to work already underway, leading to cost and time overruns, quality degradation, and loss in productivity on construction projects.

On the other hand, Fisk (1997) described that the contract provision seems to support the variation orders in construction project and being misunderstood by the stakeholders both on its application and limit. A variation is then explained as an unwanted situation in a project

but with stand-by defense in the contract condition as it is a common phenomenon in all types of construction projects (Fisk, 1997; O'Brien, 1998).

It was asserted that variation orders cannot be avoided completely (Mohamed, 2001) and Ssegawa *et al.* (2002) further added that the presence of variation clauses in contracts amounts to admitting that no project can be completed without changes. Even if carefully planned, it is likely that there will be changes to the scope of the contract as the work progresses (Harbans, 2003). In the study "Quantitative definition of projects impacted by change orders" Hanna *et al.* (2002) indicated that variations occur given the uniqueness of each project and the limited resources of time and money available for planning. And also the inevitable changes arising from variation that has impacts on a project are changes that may lead to disruptions and changes in work condition which eventually leads to loss of productivity.

According to Arain and Pheng, (2005) variations could be perceived as positive or negative to the preconceived goals of the professionals involved in a project. Therefore, a major variation must be managed and handled professionally in order to minimize its cost, schedule and other consequential impacts that may divert the project away from its targeted goals.

Tadesse Ayalew (2009) has indicated that variation is one of the major problems in Ethiopian Federal Road construction projects. He has identified the major causes of variations as Right of way problem, change in defined scope, lack of proper planning, lack of contractor's proper evaluations of tender documents at tendering phase and contractor's financial problems. The major effects identified are delay in completion time, increase in project cost, suspension (hold on) of work, decrease in productivity and dispute between parties. Based on his survey result, contractors are more responsible in initiating the majority of the specified variation causes and also the most affected party due to the consequential effects.

Semere Jelalu (2013) indicated that ROW problem is the dominant challenge in Addis Ababa City Road construction projects. In addition to ROW most variation orders arise due to design changes as a result of errors and incomplete data at initial stages and change of scope by the client as a result of community request and client interest. He added further, variation

orders are up to 60% of the project cost and time extension are up two years are observed in some of Addis Ababa City Road construction projects.

On the other hand, Abebe Dinku and Girmay Kahsay (2003) studied on claims in international construction projects in Ethiopia and found out that variations due to Right of way, design changes, modifications and lack of sufficient data are main causes for the delay of Addis Ababa Ring Road construction. In agreement to their study, Liu yi (2009) in his study of claims in international construction contracts of Ethiopia has identified most of the claims arise from R.O.W problem, design related issues which take 18.12% and 12.9% proportion respectively in time extension claims during the contract execution. Claims due to contract administration problem like ambiguities in contract document, showing decision making and inadequate communication, etc. takes 51.9% of the contact claim. Others like default of the employer, changed circumstance and unforeseen or uncertain condition during the execution of contract takes 17.08% of the total. He has then concluded the key problem to the contract claim in Ethiopian road projects is lack of experience in contract administration.

To identify and analyze potential variations in a project as early as possible would therefore enhance the management of a project. Learning from these variations is imperative because professionals in the construction sector can improve and apply their experience in the future. Thus the following subchapters review the definition of variation, possible causes, effects and controls of variation orders in road construction projects in such a way that the objectives are well addressed.

2.2 VARIATION AND VARIATION ORDER DEFINITIONS:

Notwithstanding the most advanced tools and techniques available for project management, variations have come to be considered as an expected occurrence in any project. Accordingly, significant work has been done by researchers to define, analyze and recommend appropriate solutions to manage variations in different project environments.

According to the Association of Project Management, APMP Syllabus (2000), variation is described in very simple terms as “A change in scope or timing of work which a supplier is obliged to do under a contract”.

However, a more detailed definition is provided by John Molloy (1999) as 'any alternation of the work whether by way of addition, modification or omission to the work to be done under the contract by the contractor. Such changes may cover but are not limited to the work required but excluded from the contract, work not required but included in the contract, additional work requested by the client, changes to the written scope requested by the client, changes to the character or quality of materials or construction methods and changes applicable to site conditions, location, etc.'.

A different type of definition is also provided by Harrell Remodeling Inc (HR) which refers to the actual work measured after project completion and may turn out to be more or less than the estimated value included in the tender. Such changes are managed by using a change order or variation.

Another definition of variation is presented by Moonseo Park (2003) who defines construction changes as referring to 'work state, processes, or methods that deviate from the original construction plan or specification. They usually result from work quality, work conditions or scope changes.

Similarly Fisk (1997) and O'Brien (1998), defined variation as any deviation from an agreed well-defined scope and schedule. Stated differently, this is a change in any modification to the contractual guidance provided to the contractor by the owner or owner's representative. This includes changes to plans, specifications or any other contract documents. A variation order is the formal document that is used to modify the original contractual agreement and becomes part of a project's documents.

Furthermore Clough and Sears (1994) indicated that a variation order is a written order to the contractor signed by the owner and issued after execution of the contract, authorizing a change in the work or an adjustment in the contract sum or the contract time.

Similarly, Clause 51(1) of AACRA's General conditions of contract provision (MOWUD Dec 1994), describes variations as alterations, additions or omissions of any part of the work to the contract documents.

Variation is used interchangeably with the word change, for the purpose of this research, and is defined as any event that results in formal modification of the original scope, execution

time, construction methodology cost and/or quality or quantity of work as well as contract provisions. And a variation order is the formal document that is used to modify the original contractual agreement and becomes part of a project's documents.

Thus, it would be worth noting to understand the nature of variations and factors affecting the occurrence of variation orders before reviewing the causes, effects and controls of Variation orders in road construction projects.

2.3 NATURE OF VARIATION ORDER

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

2.3.1 Beneficial variation orders

A beneficial variation order is one issued to improve the quality standard, reduce cost, schedule, or degree of difficulty in a project (Arain & Pheng, 2005b). A beneficial variation order eliminates unnecessary costs from a project. As a result it optimizes the client's benefits against the resource input by eliminating unnecessary costs. It is a variation order initiated for value analysis purposes to realize a balance between the cost, functionality and durability aspects of a project to the satisfaction of clients.

2.3.2 Detrimental variation orders

A detrimental variation order is one that negatively impacts the client's value or project performance (Arain and Pheng, 2005). For example a client who is experiencing financial problems may require the substitution of quality standard expensive materials to substandard cheap materials.

2.4 FACTORS INFLUENCING THE OCCURRENCE OF VARIATION ORDERS

Unfortunately, variation orders are typically expected to occur in all construction projects. However, the frequency of their occurrence varies from one project to another depending on various factors (Arain & Pheng, 2005b). Factors influencing the occurrence of variation orders include the nature of the works, the complexity of the project and the procurement method.

2.4.1 Nature of the works

Construction works involve building, civil and/or specialist works. Building works include, for example, the construction of residential houses, commercial premises and offices. Civil works include, for example, the construction of roads and infrastructural installations. 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. According to Uyun (2007), the 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. The presence of provisional quantities or sums in a contract is a clear indication of the likely occurrence of variation orders in a project.

2.4.2 Complexity of the project

Project complexity is a result of continuous demands for speed in construction, cost and quality control, health and safety in the work place and avoidance of disputes, together with technological advances, economic liberalization and globalization, environmental issues and fragmentation of the construction industry (Gidado, 1996). Project complexity consists of many varied interrelated parts (Baccarini, 1996). Ireland (2007) indicated that complexity involves an item having two or more components or two or more variables.

The degree of project complexity is classified as low, medium and high complexity (Ireland, 2007). The greater the project complexity, the greater the likelihood of variation order occurrence. A 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.

2.4.3 Procurement method

The participants in a construction project constitute a multi-organizational body generally including a client, designers, specialist consultants, project managers and constructors. 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, Love (2002) indicated that non-traditional procurement methods are subject to greater occurrence of errors, omissions and changes than the traditional methods.

2.4.3.1 Traditional method

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 (Ashworth, 1998). Since the works commence on site when the design is complete, the occurrence of variation orders in this arrangement is minimized. Koushki *et al.* (2005) revealed 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. 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. Turner (1990) indicated that since clients and their consultants control the origin of variations, variations should not occur if pre-construction design has been good.

2.4.3.2 Non-traditional methods

Over the years other forms of procurement have emerged, namely, nontraditional methods. Ashworth (1998) indicated 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 industrialized 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. The involvement of contractors into the design is an opportunity for them to use specialized 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 (Ashworth, 1998).

2.5 CAUSES OF VARIATION ORDERS

Variation orders occur due to a number of reasons ranging from finance, design, aesthetic, geological, weather conditions to feasibility of construction, statutory changes, product improvement, discrepancies between contract documents (Hanna *et al.*, 2002; Ssegawa *et al.*, 2002; Harbans, 2003; Uyun, 2007). The nature and frequency of variation occurrences vary from one project to another depending on various factors (Kaming, *et al.*, 1997).

Various authors had identified different causes of variation orders in construction project both on the private and public projects. The enormity of the various causes of 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 various stakeholders. Arain and Pheng (2005) identified four origin agents of variation orders. It has been categorized into consultant related, owner related, contractor related changes and the other changes.

2.5.1 Client related changes

Client related changes are the causes of variations that are initiated by the owner. In some cases, the owner directly initiates variations or the variations are required because the owner fails to fulfill certain requirements for carrying out the project. The changes initiate by client are:

Change of plans or scope: Change of plan or scope of project is one of the most significant causes of variation in construction projects (CII, 1990b) and is usually the result of insufficient planning at the project definition stage, or because of lack of involvement of the owner in the design phase (Arain *et al*., 2004). This cause of variations affects the project severely during the later phases.

Change of schedule: A change of schedule during the project construction phase may result in major resource reallocation (Fisk, 1997; O'Brien, 1998). Time has an equivalent money value. A change in schedule means that the contractor will either provide additional resources, or keep some resources idle. In both cases additional cost is incurred.

Owner's financial problems: The owner of the facility may run into difficult financial situations that force him to make changes in an attempt to reduce cost. Owner's financial problems affect project progress and quality (Clough and Sears, 1994; O'Brien, 1998). Proper planning and review of project cash flow would be effective in eliminating this problem.

Right of way (access to site) problem: According to Mark T. and Murray F. (2004), the issue of right of way in road construction is complex and time consuming as well as expensive. The authors also indicated that, in many cases, the costs related to right of way issues exceed the actual cost for Construction.

According to the report by Indiana road system, Right of way problem is not only related to land acquisition issues but also utility facilities which are responsible too for problems with regard to highway upgrading and improvements. A study by penn state university of American association of state highway and transportation officials cited in this report indicated that, road construction projects generally takes longer and costs more when utility facilities need to be relocated. The study indicated that the reconstruction of road in Michigan was delayed more than a year by a number of problems including relocation problems of utility facilities. One of the common problems which make relocating utility facility difficult is obtaining information about the location of utility facilities during design phase. After an in-depth study, the utility task forces organized by Indiana highway systems forwarded a recommendation which includes; improving awareness and better communication, new procedures to better coordinate relocation of utility facility and clarifying responsibility and to establish accountability to improve the situation.

Inadequate project objectives: Inadequate project objectives are important causes of variation in construction projects (Ibbs, 1997). Due to inadequate project objectives, the designer would not be able to develop a comprehensive design which leads to numerous variations during the project construction phase.

Replacement of materials or procedures: Replacement of materials or procedures may cause major variations during the construction phase. The substitution of procedures includes variations in application methods (Chappell and Willis, 1996). Therefore, an adjustment to the original contract value is required if there is a change in procedures.

Impediment in prompt decision making process: Prompt decision making is an important factor for project success (Sanvido et al., 1992; Gray and Hughes, 2001). A delay in decision making may hinder subsequent construction activities that may eventually delay the project progress.

Change in specifications by owner: Changes in specifications are frequent in construction projects with inadequate project objectives (O'Brien, 1998). In a multi-player environment like any construction project, change in specifications by the owner during the construction phase may require major variations and adjustments in project planning and procurement activities.

2.5.2 Consultant related changes

In some cases, the consultant directly initiates variations or the variations are required because the consultant fails to fulfill certain requirements for carrying out the project. The changes initiate by consultant are as follows:

Change in design by consultant: 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.

Differing site Conditions: Assaf et al., (1995) has indicated that differing site condition can be an important cause of delays in large Construction projects. The contractor may face different soil conditions than those indicated in the tender documents. Eventually this may affect his cost estimates and schedule adversely.

Errors and omissions in design: 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.

Conflicts between contract documents: 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.

Inadequate scope of work for contractor: In a multi-player environment like construction, the scope of work for all the players must be clear and unambiguous for successful project completion (Fisk, 1997; Arain *et al*., 2004). Inadequate scope of work for the contractor can cause major variations that may adversely affect the project, leading to changes in construction planning.

Lack of coordination: A lack of coordination between parties may cause major variations that could eventually impact the project adversely (Arain *et al*., 2004). Detrimental variations, which affect the projects adversely, can usually be managed at an early stage with due diligence in coordination.

Design complexity: Complex designs require unique skills and construction methods (Arain *et al*., 2004). Complexity affects the flow of construction activities, whereas simple and linear construction works are relatively easy to handle (Fisk, 1997). Hence, complexity may cause major variations in construction projects.

Inadequate working drawing details: To convey a complete concept of the project design, the working drawings must be clear and concise (Geok, 2002). Insufficient working drawing details can result in misinterpretation of the actual requirement of a project (Arain *et al*., 2004). Thorough reviewing of design details would assist in minimizing variations.

Design discrepancies (inadequate design): Inadequate design can be a frequent cause of variations in construction projects (CII, 1990a; Fisk, 1997). Design discrepancies affect the project functionality and quality. Eventually, this can affect a project adversely depending on the timing of the occurrence of the variations.

Ambiguous design details: A clearer design tends to be comprehended more readily (O'Brien, 1998). Ambiguity in design is a potential cause of variations in a project. This is because ambiguity in design can be misinterpreted by project participants, leading to rework and delay in the project completion. Eventually, this may affect the project adversely.

Lack of consultant's knowledge of available materials and equipment: Knowledge of available materials and equipment is an important factor for developing a comprehensive design (Geok, 2002). In the construction industry where material standardization is not common, the consultant's lack of knowledge of available materials and equipment can cause numerous major variations during various project phases.

Noncompliance of design with owner's requirements: A comprehensive design is one that accommodates the owner's requirements (Cox and Hamilton, 1995). A noncompliance design with the owner's requirements is considered an inadequate design (Fisk, 1997). Eventually, this may cause variations for accommodating the owner's requirements. This may affect the project adversely during the construction phase.

Change in specifications by consultant: Changes in specifications are frequent in construction projects with inadequate project objectives (O'Brien, 1998). As mentioned earlier with respect to changes in specifications by the owner, this is also a potential cause of variations in a project, leading to reworks and delays in the project completion

2.5.3 Contractor related changes

In some cases, the contractor may suggest variations to the project or the variations may be required because the contractor fails to fulfill certain requirements for carrying out the project. The contractor related changes are as follows:

Lack of contractor's involvement in design: Involvement of the contractor in the design may assist in developing better designs by accommodating his creative and practical ideas (Arain *et al*., 2004). Lack of contractor's involvement in design may eventually cause variations. Practical ideas which are not accommodated during the design phase will eventually affect the project adversely.

Unavailability of equipment: Unavailability of equipment is a procurement problem that can affect the project completion (O'Brien, 1998). Occasionally, the lack of equipment may cause major design variations or adjustments to project scheduling to accommodate the replacement.

Unavailability of skills (shortage of skilled manpower): Skilled manpower is one of the major resources required for complex technological projects (Arain *et al*., 2004). Shortage of

skilled manpower is more likely to occur in complex technological projects. This lack can be a cause for variations that may delay the project completion.

Contractor's financial difficulties: Construction is a labor intensive industry. Whether the contractor has been paid or not, the wages of the worker must still be paid (Thomas and Napolitan, 1994). Contractor's financial difficulties may cause major variations during a project, affecting its quality and progress.

Defective workmanship: Defective workmanship may lead to demolition and rework in construction projects (Fisk, 1997; O'Brien, 1998). Defective workmanship results in low quality in construction projects (Arain *et al*., 2004). Eventually, this cause may affect the project adversely, leading to rework and delay in the project completion.

Lack of a specialized construction manager: The construction manager carries out the construction phase in an organized way to eliminate the risks of delays and other problems. Lack of a specialized construction manager may lead to defective workmanship and delay in the construction project.

Poor procurement process: Procurement delays have various adverse effects on other processes in the construction cycle (Fisk, 1997). Occasionally, the procurement delay may cause an entire change or replacement for originally specified materials or equipment for the project (Arain *et al*., 2004). This may therefore cause a need for project activities to be reworked.

Lack of communication: Detrimental variations, which affect the projects adversely, can usually be managed at an early stage with strong and incessant communication. A lack of coordination and communication between parties may cause major variations that could eventually impact the project adversely (Arain *et al*., 2004).

Contractor's lack of judgment and experience: The Contractor's lack of professional experience increases the risk of errors during construction (O'Brien, 1998). This lack may cause major construction variations in a project. Eventually, this may affect the project quality and delay the project completion.

Complex design and technology: Complex design and technology require detailed interpretations by the designer to make it comprehensible for the contractor (Arain, 2002). A complex design may be experienced for the first time by the contractor. Eventually, the complexity may affect the flow of construction activities, leading to delays in the project completion.

Contractor's lack of required data: A lack of required data may affect the contractor's strategic planning for successful project completion, leading to frequent disruptions during the construction process. This is because a lack of data can result in misinterpretation of the actual requirements of a project (Assaf *et al*., 1995; Arain *et al*., 2004).

2.5.4 Other changes

Other variations beyond the control of the contractual parties that give rise to variation orders include the following:

Weather conditions: 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. Occasionally, this may affect the project progress adversely, leading to delays in construction.

Safety considerations: Safety is an important factor for the successful completion of a building project (Clough and Sears, 1994). Noncompliance with safety requirements may cause major variations in design. Lack of safety considerations may affect the project progress adversely, leading to serious accidents and delays in the project completion.

Change in government regulations: Local authorities may have specific codes and regulations that need to be accommodated in the design (Arain *et al*., 2004). Change in government regulations during the project construction phase may cause major variations in design and construction. This can affect a project adversely depending on the timing of the occurrence of the changes.

Change in economic conditions: Economic condition is one of the influential factors that may affect a construction project (Fisk, 1997). The economic situation of a country can affect the whole construction industry and its participants. Eventually, this may affect the project adversely, depending on the timing of the occurrence of the variations.

Unforeseen problems: Unforeseen conditions are usually faced by professionals in the construction industry (Clough and Sears, 1994; O'Brien, 1998). If these conditions are not solved spontaneously, they may cause major variations in the construction projects. Eventually, this may affect the project adversely, leading to reworks and delays in the project completion.

Researchers have identified a large number of factors which may be responsible for affecting construction projects and leading to delays, variations and cost impacts. A principal attention is therefore given to the most highly rated factors from each researcher and developed the following table that shows causes of variation orders stemming from the above discussed origin agents.

Table 2.1 Origin and Causes of variation orders [Adapted from Arain and pheng (2006)]

No	Causes of variation orders	Client	Consultant	contractor	others
1	Change of plans or scope	○			
2	Change of schedule	○			
3	Financial problems	○		○	
4	Inadequate project objectives	○			
5	Replacement project objectives	○			
6	Impediment of materials or procedures	○			
7	Obstinate nature of one or more of the parties to the contract	○	○	○	
8	Change in specification	○	○		
9	Change in design		○		
10	Errors and omissions in design		○		
11	Conflicts between contract documents		○		
12	Inadequate scope of work for one or more parties to the contract		○		
13	Technology change		○		
14	Value engineering		○		
15	Lack of coordination		○		
16	Design complexity		○	○	
17	Inadequate shop drawing details		○		
18	Inadequate working drawing details		○		
19	Lack of judgment and experience		○	○	
20	Lack of knowledge of available materials and equipment		○		
21	Honest wrong beliefs of one or more of the parties to the contract		○		
22	Lack of required data		○		
23	Ambiguous design details		○		

24	Design discrepancies		○		
25	Non -compliant design with government regulations		○		
26	Non – Compliant design with owner's requirement		○		
27	Lack of involvement in design of one or more parties to the contract			○	
28	Unavailability of equipment			○	
29	Unavailability of skills			○	
30	Speculation on desired profitability			○	
31	Differing site conditions			○	
32	Defective workmanship			○	
33	Unfamiliarity with or unawareness of local conditions			○	
34	Lack construction			○	
35	Fast track construction			○	
36	Poor procurement process			○	
37	Lack of communication			○	
38	Long lead procurement			○	
39	Honest wrong belief of Contractor			○	
40	Lack of strategic planning			○	
41	Contractor's Lack of required data			○	
42	Weather conditions				○
43	Health and safety considerations				○
44	Change in government regulations				○
45	Change in economic conditions				○
46	Socio- cultural factors				○
47	Unforeseen problems				○

2.6 EFFECTS OF VARIATION ORDERS

The most important effects of variation orders from the perspective of the employer, consultants and contractors are delay in schedule, increase in project cost and disputes between owner and contractor (Research Journal of Applied Sciences, 2012).

Given a well-structured schedule of works, maximum project performance would be achieved if the work invariably flows smoothly within time limits and anticipated budget constraints. However, it is rare that projects perform precisely in line with their original schedule due to reasons such as, for example, business condition changes, delivery slips, and corrections to design (Al-Hakim, 2005b). The occurrence of variation orders has an adverse impact on project performance. Thomas et al. (2002) suggest that variability generally impedes project performance. Ibbs (1997) concluded that variation orders affect project performance as they adversely affect productivity and project costs. According to Arain and Pheng (2005b) variation orders are an unwanted but inevitable reality of any construction project. Further, Hanna *et al.* (2002) found that projects with many variation orders cause the contractor to

achieve lower productivity levels than planned. Variation orders adversely impact project performance in terms of cost overruns, time overruns, quality degradation, disputes and professional relations.

2.6.1 Cost overruns

Construction projects involve recognized phases of which two are particularly important, namely the pre-construction and construction phases. Given that the construction phase typically consumes more resources than the pre-construction phase, attention to cost planning is focused on the construction phase. Clients desire to know in advance the total cost of their finished construction projects. Clients prefer final construction costs to equate to the originally forecast tender figure. Unfortunately, many construction projects incur cost overruns. However, all variation orders do not increase the costs of construction. Omissions in most cases reduce costs while additions increase costs (Ssegawa *et al.,* 2002). Various studies have revealed that variation orders contribute to these cost overruns. Arguably, the more the number of variation orders, the more they are likely to affect the overall construction delivery cost.

2.6.2 Time overruns

Clients require their construction projects to be completed within minimum time limits. It is anticipated that projects finished within the shortest possible time achieve some monetary savings. In most cases, contractors pay liquidated damage when they exceed the original project delivery date that is meant to compensate damages suffered by the client owing to the prolonged delivery period. Several authors agree that variation orders present as one of the reasons for project time overruns (Chan & Yeong, 1995, Mohamed 2001). It was found that variation orders issued during various phases of construction projects negatively affected both the completion time and costs of projects (Koushki, 2005). Hanna *et al.* (2002) found that as the number of variation orders increases the more significant productivity losses become. Productivity is the amount of output over a unit of time. Therefore, loss in productivity implies loss of time and subsequent delays. Yogeswaran *et al.* (1997) classified delays into 'excusable' and 'non-excusable', where the former category relieves the contractor of liability for liquidated damages and the latter is due to the contractor's culpable delay.

2.6.3 Quality degradation

Patrick and Toler (July 17, 2008) indicated that contracts with a significant degree of risk for unknown variables such for example, lump sum, contractors may cut corners on quality and quantity to maximize profits. If variation orders are frequent, they may potentially affect the quality of works. Quality may be compromised as contractors try to compensate for losses they are not optimistic about recovering.

2.6.4 Disputes

Disputes may arise between parties to the contract due to variation orders. Charoenngam *et al.* (2003) remarked that disputes between the client and the contractor can occur if variation orders are not managed carefully. Misunderstandings may arise when contractors are not satisfied with the determination of the valuation of variation orders by the client's consultant. Parties to a contract are left to argue over the cost, time effects and due compensation of a variation order (Bower, 2000). Possibly because contractors are not confident about the outcome of such negotiations, they usually request higher values for variation orders than the actual cost incurred. Bower (2000) opined that consequently there is tension between parties as the contractor continually pushes the client to settle claims for additional costs while invariably feeling that the reimbursement has been insufficient.

Harbans (2003) warned that unless a mutually acceptable solution is agreed by the parties, valuation of variations in the form of variation orders will continue to remain at the forefront of disputes and claims making their way ultimately to arbitral tribunals or the corridors of justice. Finsen (2005) found that a large proportion of current arbitrations were on claims for additional time and additional expenses. Ssegawa *et al.* (2002) reported that more than one-third of disputes pertained to how to determine losses that stem from variation orders.

2.6.5 Professional relations

A construction project creates professional relationships between parties to the contract. Each project successfully completed constitutes an added experience to participants and their reputation builds up. Frequent variation orders can be very damaging to the relationship between the representatives of all parties (Bower, 2000). The excessive occurrence of variation orders due to design errors or omission may undermine the professionalism of the designer.

2.7 CONTROLS FOR VARIATION ORDERS

Controls for variations and variation orders have been suggested by many researchers (Mokhtar *et al.*, 2000; Ibbs *et al.*, 2001). The controls were grouped under three categories: Design stage, Construction stage and Design- Construction interface stage. These groups assisted in developing a comprehensive enumeration of potential controls for variation orders.

2.7.1 Design Stage Controls for Variation Orders

According to Arian and Pheng (2005) design stage controls of variation orders are the following:

Review of contract documents: Contract documents are the main source of information for any project. Comprehensive and balanced variation clauses would be helpful in improving coordination and communication quality (CII, 1994a). Conflicts between contract documents can result in misinterpretation of the actual requirement of a project.

Freezing design: Variations in design can affect a project adversely depending on the timing of the occurrence of the changes. Therefore, freezing the design is a strong control method. Many owners freeze the design and close the door for variations after the completion of the drawings (CII, 1990a). However, this control requires that the design of the construction project should be comprehensive; otherwise, it may affect the project objectives adversely.

Value engineering at conceptual phase: During the design phase, value engineering can be a cost saving exercise, as at this stage, variation in any design element would not require rework or demolition at the construction site. Value engineering at the conceptual stage can assist in clarifying project objectives and reducing design discrepancies (Dell'Isola, 1982).

Involvement of professionals at initial stages of project: Involvement of professionals in design may assist in developing better designs by accommodating their creative and practical ideas (Arain *et al.*, 2004). This practice would assist in developing a comprehensive design with minimum discrepancies (O'Brien, 1998). Practical ideas that are not accommodated during the design phase may affect the project adversely. Variation during the construction phase is a costly activity as it may initiate numerous changes to construction activities.

Owner's involvement at planning and design phase: Involvement of the owner at the design phase would assist in clarifying the project objectives and identifying noncompliance with their requirements at the early stage (Fisk, 1997). Hence, this may help in eliminating variations during the construction stage where the impact of the variations can be severe.

Involvement of contractor at planning and scheduling process: Involvement of the contractor at planning and scheduling may assist in developing better plans and schedules by accommodating practical ideas suggested by the contractor (Arain *et al.,* 2004). Eventually, this may eliminate the major variations in the later stages of the construction project where the impact of the variations can be severe.

Thorough detailing of design: A clearer design tends to be comprehended more readily (O'Brien, 1998). This would also assist in identifying the errors and omissions in design at an early stage. Eventually, thorough detailing of design can eliminate variations arising from ambiguities and errors in design.

Clear and thorough project brief: A clear and thorough project brief is an important control for variations in construction projects (O'Brien, 1998) as it helps in clarifying the project objectives to all the participants. Eventually, this may reduce the design errors and noncompliance with the owner's requirements.

Reducing contingency sum: The provision of a large contingency sum may affect the participants' working approaches. This is because the designer may not develop a comprehensive design and would consequently carry out the rectifications in design as variation orders during the later stages of the construction project. Therefore, reducing the contingency sum would be helpful in ensuring that the professionals carry out their jobs with diligence.

2.7.2 Construction Stage Controls for Variation Orders

Arian and Pheng (2005) have also classified construction stage controls of variation orders as following:

Clarity of variation order procedures: Clarity of variation order procedures is an integral part of effective management of variation orders (Mokhtar *et al.*, 2000). Early in the project life, the procedures should be identified and made clear to all parties. Clarity of variation order procedures would help in reducing the processing time and other mishandling issues (Ibbs *et al.*, 2001).

Written approvals: Any variation in the work that involves a change in the original price must be approved in writing by the owner before a variation order can be executed (CII,1990a; Hester *et al*., 1991; Cox, 1997). Any party signing on behalf of the owner must have written authorization from the owner. It is difficult to prove the right for compensation if there is no such authorization from the owner. In the hectic environment of construction, many verbal agreements can be forgotten, leaving the contractor without any legal proof to get compensation for the variations.

Variation order scope: A well-defined scope can assist the professional team in recognizing and planning appropriately to minimize the negative impact of the variation (Ibbs *et al.* 2001). The original scope should be clear and well defined to distinguish between a variation of scope and a variation due to design development. CII (1994b) pointed out that a common disagreement between parties in a project was about defining the variation scope. Thus, the effective definition of the scope of work is of paramount importance to identify and manage variations.

Variation logic and justification: Variation logic and justification for implementation was one of the principles of effective change management proposed by Ibbs *et al.* (2001). This principle required a change to be classified as **required** or **elective**. Required changes were required to meet original objectives of the project while elective changes were additional features that enhanced the project. Knowing the logic and justification behind the proposed variations assists the professionals in promoting beneficial variations and eliminating detrimental variations.

Project manager from an independent firm to manage the project: Involvement of a project manager from an independent firm would assist in eliminating variations that arise due to the lack of coordination among professionals (Arain *et al.*, 2004). This practice may

assist in reducing design discrepancies through early reviews of the contract documents and drawings.

Restricted pre-qualification system for awarding projects: A restricted pre-qualification system for awarding projects would act as a filter to select only the capable parties for project bids (Chan and Yeong, 1995; Fisk, 1997). However, the lack of a restricted pre-qualification system may allow incapable parties to bid. This may eventually lead to numerous problems in the later stages of a construction project.

Owner's involvement during construction phase: Involvement of the owner during the construction phase would assist in identifying noncompliance with the requirements and in approving the variations promptly (Ibbs *et al.*, 2001). Eventually, the involvement of the owner during the construction phase may keep him aware of ongoing activities and assist in prompt decision making.

Avoid use of open tendering: Competitive open tendering usually encourages the main contractor to price very low to win the contract, especially in bad times when they are in need of jobs. This practice would give rise to the contractor trying to claim more to compensate for the low price (Chan and Yeong, 1995). Avoiding the use of open tender would assist in eliminating the risks of unfair bids. This may eventually help in eliminating variations that may arise due to the contractor's bidding strategy.

Use of project scheduling/management techniques: To manage a variation means being able to anticipate its effects and to control, or at least monitor, the associated cost and schedule impact (Hester *et al.*, 1991). The most known scheduling techniques in the construction industry are CPM, PERT and Gantt chart (Clough and Sears, 1994). These techniques are helpful in identifying the downstream effects of any variations on subsequent construction activities (Mokhtar *et al.*, 2000). Eventually, these may assist in eliminating detrimental variations.

Comprehensive documentation of variation order: Through timely notification and documentation of variation orders, participants will have kept their rights and thereby their option to pursue a subsequent claim or to defend against a claim (Cox, 1997; O'Brien, 1998).

One of the most aggravating conditions is the length of time that elapses between the time when a proposed contract modification is first announced and when the matter is finally rejected or approved as a variation order (Fisk, 1997). Cox (1997) suggested that the documentation of variation orders and claims had assisted in tracking the effects of the variation and claim events on time and cost. A documented source of knowledge about previous variation orders would be helpful in making decisions concerning the appropriate handling of variation orders.

2.7.3 Design-Construction Interface Stage Controls for Variation Orders

According to Arian and Pheng (2005) design-construction stage controls of variation orders are the following:

Prompt approval procedures: One of the most aggravating conditions is the length of time that elapses between the time when a proposed contract modification is first announced and when the matter is finally rejected or approved as a variation order (Fisk, 1997). However, the longer the period between recognition and implementation, the more costly the change will be. Hence, prompt approval procedures would assist in reducing the adverse effects of variations in the construction project.

Ability to negotiate variation: Ability to negotiate variation is an important factor for the effective control of variation orders (Clough and Sears, 1994). Effective negotiation can assist the professional team in minimizing the negative impacts of the variation (Cushman and Butler, 1994). There are certain skills required for effective negotiation of variation orders, i.e., the knowledge of contract terms, project details, technology, labour rates, equipment, methods and communication skills.

Valuation of indirect effects: Consequential effects can occur later in the downstream phases of a project. Therefore, it is essential to acknowledge this possibility and establish the mechanism to evaluate its consequences (Ibbs *et al.*, 2001). Indirect effects of variations can be substantial in the downstream phases of a complex project (Fisk, 1997). Professionals should thus evaluate the total overall effects a change may have on the downstream phases of a project, to manage the variation order effectively.

Utilize work breakdown structure: A work breakdown structure (WBS) is a management tool for identifying and defining work (Hester *et al.*, 1991; Mokhtar *et al.*, 2000). A contractor should consider using the WBS as an evaluation tool, especially on large projects. If a variation involves work not previously included in the WBS, it can be logically added to the WBS and its relationship with the other WBS element can be easily checked. Ripple effects can also be traced by the use of WBS (Hester *et al.*, 1991).

Continuous coordination and direct communication: Coordination and communication are important in a multi-participant environment as in most construction projects (Assaf *et al.*, 1995). Detrimental variations, which affect the projects adversely, can usually be managed at the early stage with due diligence in coordination, and frequent communication.

Control the potential for variation orders to arise through contractual clauses:

Selection of the appropriate contract form with the necessary and unambiguous variation clauses would be helpful in the management of variation orders (Cox, 1997). Shifting risks and improved communication channels could result from properly prepared variation clauses (CII, 1990a). Clear procedures presented in the contract and fair allocation of risks can help in resolving disputes through negotiation rather than litigation.

Comprehensive site investigation: Comprehensive site investigations assist in proper planning for construction activities (Fisk, 1997). As mentioned earlier, differing site conditions are an important cause of delays in large Construction projects (Assaf *et al.*, 1995). Therefore, a comprehensive site investigation would help in reducing potential variations in a project.

Use of collected and organized project data compiled by owner, consultant and contractor: The variation orders should always be documented for future references (Fisk, 1997). In a research study by CII (1994b) on the control of project changes, the research team concluded that better controls for variation orders were achievable by sharing a database compiled by all the participants.

Knowledge-base of previous similar projects: A knowledge-base would facilitate an effective management process (CII, 1994b; Miresco and Pomerol, 1995; Ibbs *et al.*, 2001).

From the outset, project strategies and philosophies should take advantage of lessons learned from past similar projects (CII, 1994b). If professionals have a knowledge-base established on past similar projects, it would assist the professional team to plan effectively before starting a project, both during the design phase as well as during the construction phase, minimize and control variations and their effects.

Comprehensive analysis and prompt decision making through computerized knowledge-based decision support system: A Decision Support System (DSS) approach for management decisions seems to be the most natural idea to follow (Miresco and Pomerol, 1995). The knowledge-based system would be helpful in presenting a comprehensive scenario of the causes of variations, their relevant effects and potential controls that would assist in decision making at the early stage of the variations occurring.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter discusses method adopted in carrying out the data collected for the survey. Specific areas covered are study approach, instruments for data collection, research scope and limitations, sample and sampling procedure, and the procedure for analyzing the data. In order to obtain the relevant data both primary and secondary data were used to address the specific details under the study.

The primary data for the study was obtained through distribution of questionnaires from professionals involved in road construction projects of Addis Ababa. In order to enrich the questionnaire for the research, a review of text books and journals were used to identify the various efforts that have been made in the past to evaluate and examine the effects of variation orders on road construction projects. Secondary sources of data were obtained from relevant literature that covered research and publication on the subject matter.

Data collection was done by means of questionnaires which were completed by a selected group of 32 professionals from the client, consultant and contractors participating in the city road projects. The questionnaires tested respondents' views and knowledge regarding issues relating to variation order in road construction projects of Addis Ababa City.

3.2 THE STUDY APPROACH

The research was initiated from the prevailing practical problems and discovers whether there is a cause and effect of variation orders in the road construction projects of Addis Ababa. Once research problem is identified an in-depth literature review has been done to have an understanding on the causes, effects, origin agents and how to control or minimize the consequential impacts. The review includes books, journals, internet sources and archival documents such as progress reports, contract documents and supplementary agreements of Addis Ababa City Road Authority.

After an in depth review of the literature a questionnaire was designed and distributed to contractors, consultants and client (AACRA) staffs to obtain their professional opinion out of their experience.

After the required data are collected, checked and sorted analysis of data will follow to get the results and based on that discussions are made to draw conclusions and forward recommendations.

3.3 DATA SOURCE AND COLLECTION

The questionnaires were series of structured questions which were related to the research work and directed to respondents of stockholders from the client, the contractor and the consultant who are the major participants of the city road projects. The questionnaire is divided in to two sections namely respondents profile and prevalence of variation. The questionnaire consisted of both open ended and close-ended questions. Thus, in some cases, respondents were to choose the option that best reflected their options. Respondents were required to respond to a number of questions. The respondents were asked to respond Twenty (20) questions.

The answers for the structured part of the questionnaire are based on Likert's-scale of ordinal measures of agreement towards each statement as shown in the following sections. The reasons for adopting this simple scale are:

- To provide simplicity for the respondent to answer, and
- To make evaluation of collected data easier

Likert's-scale is important to know respondents' feelings or attitudes about something and is utilized for the data analysis. The respondents must indicate how closely their feelings match with the question or statement on a rating scale.

After the possible causes, effects and controls of variation orders are identified; respondents are asked the frequency of occurrence for each variable. Accordingly, the respondents choose one of the following based on their opinion and experience.

1- Never
2- Seldom
3- Sometimes
4- Always

For possible effects of variation orders respondents were asked for the chances of occurrence of impacts of effects Variation based on the following choices.

1- Major impact
2- Slight impact
3- No impact

3.4 METHOD OF ANALYSIS

Both descriptive and inferential statistics are employed in the data analysis. In the analysis the "Mean Score" method is adopted to establish the relative importance of the causes, effects and controls of variation orders in road projects in Addis Ababa. As discussed earlier Likert's scale of three to five ordinal measures of agreement towards each statement is used to calculate the mean score for each factor that is used to determine the relative ranking.
The mean score (MS) for each variables of variation order is computed by using the following formula;

$$MS = \frac{\sum (\mathbf{f} \times \mathbf{S})}{\mathbf{N}} \quad \text{---------- [3.1]}$$

Where:

MS – Mean Score

f – Frequency of responses for each score
S – Scores given to each factor (from 1 to 4)
N – Total number of responses concerning each factor

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

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

$$\text{Rho } (\rho_{cal}) = 1 - \frac{6 \times (\Sigma d_i^2)}{N \times (N^2 - 1)} \quad \text{---------- [3.2]}$$

Where:

Rho (ρ_{cal}) – Spearman rank correlation coefficient

d_i – The difference in ranking between each pair of factors

N – Number of factors (variables)

Procedure for hypothesis testing:

1. Define the null hypothesis (H_0) and the alternative hypothesis (H_A)
2. Choose a value for P. (i.e. choose the significance level)
3. Calculate the value of the test statistic, Rho (ρ_{cal}).
4. Compare the calculated value with a table of the critical values of the test statistic.
5. If the calculated value of the test statistic is less than the critical value from the table, accept the null hypothesis (H_0). If the absolute (calculated) value of the test statistic is greater than or equal to the critical value from the table, reject the null hypothesis (H_0) and accept the alternative hypothesis (H_A).

3.5 THE RESEARCH SCOPE AND LIMITATIONS

Despite the fact that variation orders are affecting seriously the road construction projects of Addis Ababa it has never been properly studied. This brings a great shortage of reference materials on the subject matter.

3.6 WRITING THE RESEARCH

This research has four major stages:

- The research proposal
- Literature review
- Research methodology and analysis
- Final research writing

The research was started by creating a conceptual framework of the research together with collecting and organizing various related literatures. After the literature review data survey were conducted and research instrument development was done. Following this, discussion and analysis of the responses from the research population is undertaken and the conclusion and recommendation are presented at last.

CHAPTER FOUR

4.0 DATA ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

This Chapter examines and analyses the results of data gathered from desk study and questionnaire survey which was distributed among professionals working in the national works contract of road projects administered by Addis Ababa City Roads Authority.

This chapter consists of two major parts. The first part describes and analyses the data related to the respondents' experience and response rate. The second part focuses on the main objectives of this survey, ranks and discusses the major causes of Variation orders, identifying the most origin agents, consequential effects and proposed controls of variation orders based on the opinions of the professional respondents from the Contracting parties i.e. the Consultant, Contractor and Client. Each ranking is made using mean score data analysis method based on the importance of frequencies of occurrence for the causes, origin agents, effects and proposed controls of Variation orders to identify the most important factors in the national contract road constructions of Addis Ababa City Road projects. Agreements of the respondents on the rankings of the causes, effects and controls of variation orders, i.e. between Contractor and consultant, between client and contractor, and between consultant and Client were also tested using a Spearman correlation coefficient.

A desk study survey was also conducted to evaluate the existence and extent of variation orders for randomly selected completed and undergoing Road projects of the Addis Ababa City. Documents surveyed include project progress reports, Contract documents, supplementary agreements, variation orders, correspondence letters and other complementary documents. Based on the data collected, the total amount of variation was compared to their corresponding original contract amount and time, also the number of variation orders was identified with their corresponding reasons for the changes.

4.2 FINDINGS

The questionnaire involved both closed and open-ended questions and distributed to the respondents. Closed-ended questions were formulated such that respondents choose one

option from a limited list of possible answers. Data was captured and analyzed using mean score method of ranking. The open-ended questions allowed respondents to answer the same questions without restricting the manner in which they answered them. These questions sought clarifications to various responses. These responses were analyzed using descriptive analysis. They were recorded and categorized such that similar reasons were grouped together and subsequently quantified.

4.2.1 Profile of respondent and Questionnaire Response Rate

Out of a total of 38 questionnaires 14 were distributed to Contractors, 14 to Consulting Engineers and the remaining 10 to staffs of the client. 32(84.2%) professionals duly completed and returned the questionnaires. As depicted in Table 4.1, respondent professionals in the survey included are contractors (29%), Consulting Engineers (34%) and clients (21%).The survey was conducted between September 2014 and November 2014.

Table 4.1 Summary of questionnaire distribution and response rate

No	Respondent	Total questionnaire Distributed		Total questionnaire Responded		Response rate (%)
		No	(%)	No	(%)	
1	**Contractor**	14	36.84	11	34.38	78.6
2	**Consulting engineers**	14	36.84	13	40.63	92.9
3	**Client(AACRA)**	10	26.32	8	25.00	80.0
	Total	**38**	**100.00**	**32**	**100.00**	**84.2**

The positions held by respondents include Project managers, Resident Engineers, Supervision head Engineers, Contract Engineers, Project counterpart Engineers and Senior Engineers of head staffs of the client having a total work experience ranging from 2 years to 28 years in the road construction industry.

4.2.2 Impact of variation orders on construction works

Variation orders involve additions, omissions and substitutions to the construction works. The frequency of their impact on construction works were ranked from the most frequent to the least frequent where 1st (most frequent) = 1, 2nd = 2 and 3rd (least frequent) = 3 by

comparing the means as shown in Table 4.2. Additional works was reported to be the most frequent consequence with a mean of 1.2. Substitution works were ranked second with a mean score of 2.1 and omissions third with a mean score of 2.5. Respondents were also asked to clarify their ranking orders and their responses were set out in Table 4.3.

Table 4.2 Ranking of work impacts of Variation orders (N=3)

No	Impact	Contractors MS	Consultants MS	Client MS	Average MS	Ranking
1	Additional works	1.2	1.3	1.1	1.2	1
2	Omissions of works	2.5	2.6	2.5	2.5	3
3	Substitution of works	2.3	2.1	1.9	2.1	2

Table 4.3 Reasons to the work impacts of variation orders (N=82)

Work impact	Reason	Clarifications
Additional works	Unforeseen site condition	Additional works due to unforeseen ground condition
	Design problem	Works changed by consultant during construction stage due to inadequate design period given
	works Scope change	Scope change by clients during Construction stage
Omissions of works	Incomplete design	works can be omitted because plans were incomplete at design stage or quantities are estimated in excess
	unforeseen site condition	works can be omitted due to unforeseen ground condition
	Right of way issues	works can be omitted due to ROW obstruction
	Technological changes	Improved design inputs on the already designed works which are under construction
Alteration of works	unforeseen site condition	fill or borrow materials are substituted due to the lesser bearing Capacity of existing soil
	Incomplete Design	substitutions are made to errors on Design/plans
	Right of way problems	works can be substituted due to ROW obstructions
	Project time pressure	works or materials are substituted because clients want the work to be done quickly then need for alternative materials
	non availability of construction material	when better or equal material is proposed and replaced to the original contract requirement
	Budgetary considerations	Alteration of works by the client to cut project cost and create job for SMS
	Late changes	Changing the work type by the client/stack holders lately during construction stage

It is evident that respondents suggested various reasons for additional works, substitution works and omission works as indicated on Table 4.3

4.3 CAUSES AND ORIGIN AGENTS OF VARIATION ORDERS

4.3.1 Factors influencing variation orders

The factors that influenced the occurrence of variation orders were ranked from those that were the most dominant (1) to those that were the least dominant (3). The results are shown in Table 4.4 by the means of responses. The nature of works was the most dominant influence with a mean score of 1.6, followed by complexity of works with a mean score of 1.8 and then procurement method with a mean score of 2.5.

Table 4.4 Ranking of the factors influencing variation orders (N=3)

No	Factors influencing variation orders	Contractors MS	Consultants MS	Client MS	Average MS	Ranking
1	Nature of works	1.5	1.5	1.8	1.6	1
2	Complexity of works	2.2	1.8	1.4	1.8	2
3	Procurement method	2.3	2.8	2.4	2.5	3

4.3.2 Frequency of involvement of origin agents

The frequency of the involvement of four origin agents of variation orders, namely clients, consultants, contractors and unspecified "others" were investigated. The following ranking order was used, namely 1st (most frequent involvement) = 1; 2nd = 2; 3rd = 3; 4th (least frequent involvement) = 4. As shown in Table 4.5, the Consultant was the origin-agent most frequently involved with a mean score of 1.4, followed by the client and a contractor with a mean score of 2.3 and 2.6 respectively.

Table 4.5 Ranking of origin agents of variation orders (N=4)

No	Origin agent	Contractors MS	Consultants MS	Client MS	Average MS	Ranking
10.1	Contractor	2.4	3.0	2.5	2.6	3
10.2	Consultant	1.6	1.2	1.3	1.4	1
10.3	Client	2.5	2.0	2.5	2.3	2
10.4	Others	3.0	3.7	3.4	3.4	4

4.3.3 Origin agents versus causes

Table 4.6 shows the contribution of the origin agents to the occurrence of variation orders versus a given list of causes of variation orders where Client = 1; Consultant = 2; Contractor =3; "Others" = 4. Major findings of origin agent versus the causes are highlighted. Most predominantly, it was revealed that clients initiated variation orders due to Right of way problem (81%), change of plans or scope (74%) and inadequate scope of work for one or more parties to the contract (66%).

Table 4.6 Origin agents versus causes (N=35)

Causes of variation orders	1	2	3	4
	%	%	%	%
Change of plans or scope	74	20	6	0
Change of schedule	18	5	77	0
Financial problems	39	0	61	0
Right of way (access to site) problem	81	8	3	8
Inadequate project objectives	57	30	3	10
Replacement of materials or procedures	3	48	48	0
Impediment in prompt decision making process	53	43	4	0
Change in specification	17	63	17	3
Change in design	13	84	3	0
Errors and omissions in design	0	95	5	0
Conflicts between contract documents	27	58	16	0
Inadequate scope of work for one or more parties to the contract	66	20	3	11
Complex design and Technology	8	82	4	7
Lack of coordination	23	22	52	3
Design complexity	0	100	0	0
Inadequate working drawing details	0	69	31	0
Lack of judgment and experience	14	51	35	0
Lack of knowledge of available materials and equipment	0	18	83	0
Ambiguous design details	0	93	8	0
Design discrepancies(inadequate design)	0	96	4	0
Non – Compliant design with owner's requirement	12	81	7	0
Lack of involvement in design of one or more parties to the contract	63	30	4	4
Unavailability of equipment	0	3	97	0

Unavailability of skills(shortage of skilled manpower)	4	10	83	3
Differing site conditions	14	26	43	18
Defective workmanship	0	8	92	0
Lack of specialized construction manager	3	8	81	7
Poor procurement process	54	8	34	4
Lack of communication	29	28	40	3
Lack of required data	4	76	20	0
Weather conditions	3	3	21	72
Health and safety considerations	18	0	44	38
Change in government regulations	41	0	8	50
Change in economic conditions	21	0	22	57
Unforeseen problems	13	7	3	76

Keys: 1. Client, 2. Consultant, 3 Contractor, 4. Others

Consultants initiated variation orders due to design discrepancies/inadequate design (96%), errors and omissions in design and design complexity accounts (95.0%) while ambiguous design details (93.0%) and change in design (84%) are following. On the other hand, contractor originated variation orders were mainly due to unavailability of equipment (97%), defective workmanship (92%) and shortage of skilled manpower (83%). It was also revealed that unspecified "others" origin agents were caused by unforeseen problems (76%), weather conditions (72%) and change in economic conditions (57%).

4.3.4 Frequency of occurrence of causes of variation orders

The frequency of the occurrence of causes of variation orders were identified by using the following scale, namely Never = 1; Seldom = 2; Sometimes = 3; Always = 4. From Table 4.7, it was possible to rank the causes of variation orders by comparing their means. Right of way (access to site) problem (3.6), change in design (3.4) and errors and omissions in design (3.3) were most ranking causes of variation orders.

Table 4.7 Frequency of occurrence of causes of variation orders (N=35)

Causes of variation orders	Contractor MS	Consultant Ms	Client Ms	Weighted Average Ms	Rank
Right of way (Access to site) problem	3.8	3.5	3.6	3.6	1
Change in design	3.3	3.5	3.5	3.4	2
Errors and omissions in design	3.3	3.4	3.3	3.3	3
Lack of coordination	3.3	3.2	3.0	3.2	4
Change of plans or scope	2.8	3.1	3.3	3.1	5
Financial problems	3.1	3.2	2.5	2.9	6
Design discrepancies(inadequate design)	2.6	3.2	3.0	2.9	6
Change of schedule	2.7	3.0	2.9	2.9	6
Lack of judgment and experience	2.8	2.7	3.3	2.9	6
Differing site conditions	2.7	2.8	3.3	2.9	6
Lack of communication	2.9	2.8	2.8	2.8	11
Inadequate working drawing details	2.6	2.8	3.0	2.8	11
Poor procurement process	3.1	2.5	2.8	2.8	11
Replacement of materials or procedures	3.0	2.8	2.4	2.7	14
Lack of involvement in design of one or more parties to the contract	2.7	2.9	2.6	2.7	15
Impediment in prompt decision making process	2.9	2.6	2.5	2.7	15
Defective workmanship	2.8	2.9	2.3	2.7	15
Lack of specialized construction manager	2.9	2.6	2.5	2.7	15
Unavailability of skills(shortage of skilled manpower)	2.6	2.6	2.8	2.7	15
Ambiguous design details	2.5	2.7	2.5	2.6	20
Unavailability of equipment	2.8	2.5	2.5	2.6	20
Lack of required data	2.5	2.5	2.8	2.6	20

Lack of knowledge of available materials and equipment	2.2	2.5	3.1	2.6	20
Unforeseen problems	3.0	2.3	2.5	2.6	20
Weather conditions	3.0	2.3	2.4	2.6	20
Inadequate project objectives	2.4	2.5	2.8	2.6	20
Conflicts between contract documents	2.6	2.6	2.4	2.5	27
Change in specification	2.7	2.3	2.5	2.5	27
Non – Compliant design with owner's requirement	2.2	2.2	2.8	2.4	29
Inadequate scope of work for one or more parties to the contract	2.3	2.5	2.3	2.4	29
Complex design and Technology	2.0	2.1	2.5	2.2	31
Design complexity	2.0	2.1	2.5	2.2	31
Change in economic conditions	2.3	1.6	2.4	2.1	33
Change in government regulations	2.0	1.7	2.5	2.1	33
Health and safety considerations	2.4	1.8	1.9	2.0	35

To supplement the results of the questionnaire survey and to have an over view of the extent of variation order a desk study was conducted. Documents surveyed include project progress reports, contract documents, supplementary agreements, variation orders, corresponding letters and other complementary documents.

According to the desk study some of the major causes for the variation order were geometric design change (horizontal and vertical alignment changes), revision of typical cross section, additional works to the project(supplementary agreement), design change of at grade junctions to round about or underpass/overpass or interchange junctions, road width widening due to master plan modification, additional provisions of drainage facilities and bridge elevation modification due to change in grade.

Table 4.8 below shows summary of results of the desk study for the original amounts of projects, revised and contract time, number of variation orders, variation amount and major reasons for the variation in randomly selected sixteen (16) road projects of Addis Ababa City.

Table 4.8 Summary of variation order results from desk study

Project	Origional Contract amount (Birr)	Project status(%)	Contract commencement date	Contract completion date	Revised completion date	No. of VO.	Amount of variations(Birr)	Major reasons for the variation
A	**146,890,587.61**	Completed	2-Jun-06	2-Nov-08	30-Jun-10	5	**66,500,000.00**	Horizontal alignment and grade change,Typical cross section change,addition of new underpass bridge, Revision of bridge elevation and additional side interceptor ditch
B	**150,032,280.31**	Completed	4-Apr-12	3-Apr-13	12-Mar-13	2	**24,621,369.25**	Horizontal alignment chage, additional down stream drainage facility and replacing double outreach electic poles by singl one
C	**189,216,770.04**	35% Completed	24-May-13	24-Oct-14	12-Jul-15	1	**3,358,392.09**	Provision of additional culvert
D	**50,365,079.79**	Completed	28-Mar-06	29-Mar-07	24-Nov-09	1	**18,036,507.00**	Design Change(Typical crosssection change for split grade)
E	**87,384,461.33**	Completed	28-Mar-06	29-Mar-07	30-Jun-09	1	**11,346,000.00**	Additional works to the project (Supplementary agreement)
F	**43,576,867.00**	Completed	2-May-06	30-Jun-09	31-Oct-10	1	**8,948,394.00**	Design change of at grade junction to round about(Overpass/underpass)
G	**89,490,473.00**	Completed	6-Jul-07	31-Dec-08	31-Dec-10	1	**17,000,000.00**	Design change of at grade junction to Round about and road width widening due to masterplan modification
H	**326,506,025.00**	Completed	8-May-06	20-Nov-08	30-Jun-12	1	**264,000,000.00**	Design change (Addition of frontage road,change of simple junction to interchange junction)
I	**283,652,248.00**	Completed	6-Jul-07	5-Jul-10	31-Mar-12	7	**67,217,870.00**	Additional works to the project (supplementary agreement),addition of New interceptor ditch, additional drainage channel and Median widening and paving with asphalt wearing surface.
J	**49,587,265.63**	95% Completed	10-May-06	10-Nov-07	31-Dec-14	5	**66,497,642.00**	Design change of at grade junction to interchange(supplementary agreement),Bridge elevation modification and redesign of retaining walls
K	**62,346,103.45**	Completed	2-May-06	16-May-07	30-Jun-09	1	**4,082,219.71**	Design change of typical cross section to split grade
L	**36,213,579.11**	Completed	27-Jul-06	27-Sep-07	31-Dec-09	2	**21,822,854.40**	Typical cross section design and width change, Addition of Retaining walls,modification of bridge elevation and change of road width.
M	**115,539,588.00**	Completed	6-Jul-07	6-Apr-09	15-Jan-11	1	**11,800,000.00**	Design Change, Typical crosssection change for split grade for access
N	**143,986,784.00**	Completed	9-Jun-06	8-Jan-08	30-Jun-12	1	**21,500,000.00**	Horizontal alignment and grade change, Revision of bridge elevation and addition of side interceptor ditch
O	**224,055,813.00**	Completed	14-May-09	8-Aug-10	11-Jan-11	1	**7,841,899.96**	Design change (Typical cross section and road width changeand Addition of Retaining walls)
P	**306,413,159.00**	Completed	7-Jul-08	23-Jun-10	12-Jun-12	2	**29,354,380.63**	provision of New interceptor ditch, additional drainage channel out of the project coridor.

4.3.5 Reduction of occurrence of variation orders

It was suggested by respondents that the occurrence of variation orders could also be reduced. Various opinions were categorized into 7 groupings as shown in Table 4.9. Several respondents suggested the occurrence of variation orders could be reduced if the design is complete after ROW obstructions are cleared (30%), time for design and site investigation works shall be adequate and fair (20%), lack of Proper project management (16%) and proper communication and coordination (14%).

Table 4.9 How to reduce the occurrence of variation orders (N=44)

Reason	percentage	Clarifications
Completeness of the design	30%	Detail Design and site investigations should be done after all ROW obstructions are cleared based on the actual site condition
Professional experience and accountability	7%	The client shall thoroughly check the submitted design by incorporating a jury of experienced professionals and make accountable the professional if the design fails
Adequate time for design and site investigation works	20%	Time allocated during the design stage including proper site investigation shall be fair and adequate
Adequate Money for design	7%	adequate money shall be allocated for proper investigations during design period
proper Communication and Coordination	14%	Proper communication channel should be proactive by all concerned stockholders at all stages
Procurement method	7%	The selection criteria of consultant and contractor shall be improved and transparent
Lack of Proper project management	16%	Good project management and defining project objective is required by the client and all stockholders

Table 4.10 below reveals that there is a relatively strong correlation between the attitudes of the respondent from the contractor to consultant and consultant to client. This indicates that most of the respondents do agree on the ranking of possible dominant causes of variation orders. However, from table 4.10 it is evident to understand the correlation between the contractors to client is relatively weak. Possible reason for the weak agreement could be one party does not want to be responsible for the cause of variation and take the blame to the other party instead.

Table 4.10 Summary of correlation test on the ranking of causes of Variation order

Respondent	$\rho = 1 - \frac{6 \times (\sum d_i^2)}{N \times (N^2 - 1)}$	Critical value of ρ (Appendix A-2)	Significance for P < 0.05	Reject/don't reject the Null Hypothesis
Contractor/Consultant	0.652	0.335	Significant	Reject
Consultant/Client	0.595	0.335	Significant	Reject
Contractor/Client	0.338	0.335	Significant	Reject

4.4 EFFECTS OF VARIATION ORDERS

4.4.1 Nature of variation orders

Variation orders are classified as either beneficial or detrimental variation orders. A 5 point Likert scale was used to determine how frequently these occurred on construction projects, namely Never = 1; Seldom = 2; Sometimes = 3; Often = 4; and Always = 5. As shown in Table 4.11, respondents believed detrimental (mean 3.2) variation orders and beneficial variation orders (mean 3.0) occur on construction projects.

Table 4.11 Frequency of occurrence of variation orders by nature

Nature of variation orders	Contractors MS	Consultants MS	Client MS	Average MS	Ranking
Beneficial variation	2.7	3.3	3.0	3.0	2
Detrimental variation	3.1	3.6	2.9	3.2	1

4.4.2 Problems encountered when negotiating variation orders

There are problems encountered when dealing with variation orders. These problems were categorized as shown in Table 4.12. Respondents reported that they mostly encountered problems associated with the genuine determination of the unit prices involved (25%). There was conflict of interest between the contractor and the consultant/client with regard to determination of unit rates.

Table 4.12 Problems encountered when negotiating variation orders (N=40)

Problems	Percentage	Clarifications
Time taking procedure for approval	18%	It takes lengthy time by the client for approval of Variation orders
unit price determination	25%	Conflict of interest between the Contractor and the Consultant/client with regard to determination of unit rates
Reluctant nature of the client	5%	The client is reluctant to accept the order because in most cases variation orders involve additional budget and client does not want to compensate related expenses
Lack of decision making by client	15%	The client do not want to make decision due to lack of capacity and in fear of utilizing additional public money and thereby influencing Contractors
compromising the design	3%	The design quality is compromised to minimize the effect of variation orders
Disputes	5%	A variation order is a source of conflict and disputes between parties to the contract
Budget shortage	13%	it is difficult to convince the client to allocate additional budget for Variation orders
Lack in estimating the actual quantity	5%	Consultants fail in quantifying the actual volume varied
Scope of variation	3%	Lack in understanding the scope of variation by parties involved in the contract
Biasness of the Consultant	3%	Consultants tend to be by the employers side
Missing base price in the contract document	5%	Base prices are missed in most contracts to fix applicable unit rates
Contractors excuse due to VO	3%	Contractors mostly use Variation order as an excuse for their delay

It takes also lengthy time by the client for approval of variation orders (18%), the client do not want make decision due to lack of capacity and in fear of utilizing additional public money and thereby influencing contractors(15%) and it is difficult to convince the client to allocate additional budget for variation orders(13%).

4.4.3 Effects of variation orders on project performance

The frequency of outcomes of variation orders with regards to project performance were ranked using a 5 point Likert scale where Never = 1; Seldom = 2; Sometimes = 3; Often = 4;

and Always = 5. From Table 4.13, it is evident from the ranking of the means of responses that cost overrun dominates with mean score of 4.28. Then time overrun with a mean score of 4.25 follow and then disputes and impact on relationship between professionals scored with a mean of 3.06 and 2.98 respectively.

Table 4.13 Outcomes of variation orders (N=5)

No	Outcome	Contractors MS	Consultants MS	Client MS	Average MS	Ranking
1	Cost overrun	4.08	4.33	4.43	4.28	1
2	Time overrun	4.20	4.25	4.29	4.25	2
3	Quality degradation	2.40	2.50	2.29	2.40	5
4	Disputes	2.73	3.17	3.29	3.06	3
5	Professional relations	2.55	3.22	3.17	2.98	4

4.4.4 Adverse impact of variation orders

The adverse impact of variation orders on construction projects was established using a 3 point Likert scale where Major impact = 1; Slight impact = 2; and No impact = 3. By comparing the means shown in Table 4.14, cost overrun dominated (1.16), followed by time overrun (1.25) and then disputes between parties to the contract (1.85).

Table 4.14 Adverse impact of variation orders on project performance (N=5)

No	Outcome	Contractors MS	Consultants MS	Client MS	Average MS	Ranking
1	Cost overrun	1.25	1.23	1.00	1.16	1
2	Time overrun	1.30	1.31	1.14	1.25	2
3	Quality degradation	2.00	2.00	1.86	1.95	4
4	Disputes	2.09	1.75	1.71	1.85	3
5	Professional relations	2.27	2.09	2.00	2.12	5

Table 4.15 below also shows summary of the desk study survey for percentage and amounts of variation orders in randomly selected fifteen (15) road projects of Addis Ababa city after the survey data is checked and sorted. Accordingly, the peak values of project J are exceptionally excluded not to affect other survey data. Therefore, the mean average

percentage of variation value is 24.11 %, which ranges from 2% to 80.86% that is much more than the tolerable provisions of the contract. The result shows the client is expending more money due to variations in the city road projects.

Table 4.15 Summary of variation order amounts and percentages

Project	Origional Contract amount (Birr)	Project status(%)	No. of VO.	Amount of variations(Birr)	Percentage of Variation(%)
A	146,890,587.61	Completed	5	66,500,000.00	45.27
B	150,032,280.31	Completed	2	24,621,369.25	16.41
C	189,216,770.04	35% Completed	1	3,358,392.09	2.00
D	50,365,079.79	Completed	1	18,036,507.00	35.81
E	87,384,461.33	Completed	1	11,346,000.00	12.98
F	43,576,867.00	Completed	1	8,948,394.00	20.53
G	89,490,473.00	Completed	1	17,000,000.00	19.00
H	326,506,025.00	Completed	1	264,000,000.00	80.86
I	283,652,248.00	Completed	7	67,217,870.00	23.70
K	62,346,103.45	Completed	1	4,082,219.71	6.55
L	36,213,579.11	Completed	2	21,822,854.40	60.26
M	115,539,588.00	Completed	1	11,800,000.00	10.21
N	143,986,784.00	Completed	1	21,500,000.00	14.93
O	224,055,813.00	Completed	1	7,841,899.96	3.50
P	306,413,159.00	Completed	2	29,354,380.63	9.58
Total	2,255,669,818.64			577,429,887.04	24.11

On the other hand, Table 4.16 shows the corresponding percentages of variation associated time overrun for the randomly selected road projects. The mean average percentage of time overrun value is 126.50%.

Table 4.16 Percentage of Variation associated time overrun

Project	Contract commencement date	Contract complition date	Revised complition date	Original Contract period(Days)	Time extension (Days)	Percentage of time overrun(%)
A	2-Jun-06	2-Nov-08	30-Jun-10	884	605	68.44
B	4-Apr-12	3-Apr-13	12-Mar-13	365	-22	-6.04
C	24-May-13	24-Oct-14	12-Jul-15	518	261	50.39
D	28-Mar-06	29-Mar-07	24-Nov-09	365	971	265.30
E	28-Mar-06	29-Mar-07	30-Jun-09	365	824	225.14
F	2-May-06	30-Jun-09	31-Oct-10	1155	488	42.25
G	6-Jul-07	31-Dec-08	31-Dec-10	544	730	134.19
H	8-May-06	20-Nov-08	30-Jun-12	927	1318	142.18
I	6-Jul-07	5-Jul-10	31-Mar-12	1095	635	57.99
K	2-May-06	16-May-07	30-Jun-09	379	776	204.75
L	27-Jul-06	27-Sep-07	31-Dec-09	427	826	193.44
M	6-Jul-07	6-Apr-09	15-Jan-11	640	649	101.41
N	9-Jun-06	8-Jan-08	30-Jun-12	578	1635	282.87
O	14-May-09	8-Aug-10	11-Jan-11	451	156	34.59
P	7-Jul-08	23-Jun-10	12-Jun-12	716	720	100.56
					Average	126.50

Table 4.17 below generally shows there is a relatively strong correlation between the attitudes of the respondents from the contractor to consultant, consultant to client then contractor to client. However, the correlation is marginal when we see the correlation between the contractor to consultant and the contractor to client. The main reason could be each party would like to pronounce effects only related to the party he representing is suffering from. This is also supported by the strong correlation between the consultants to client that consultants usually would like to keep the interest of the client in most cases.

Table 4.17 Summary of correlation test on the ranking of impacts of variation orders

Respondent	$\rho = 1 - \frac{6 \times (\sum d_i^2)}{N \times (N^2 - 1)}$	Critical value of ρ (Appendix A-2)	Significance for P < 0.05	Reject/don't reject the Null Hypothesis
Contractor/Consultant	**0.9**	**0.9**	**Significant**	**Reject**
Consultant/Client	**1**	**0.9**	**Significant**	**Reject**
Contractor/Client	**0.9**	**0.9**	**Significant**	**Reject**

4.5 CONTROLS OF VARIATION ORDERS

The frequency of controls of variation orders were ranked using a 4 point Likert scale where Never = 1; Seldom = 2; Sometimes = 3; and Always = 4. From Table 4.18, it is evident from the ranking of the means of responses that written approval during construction stage dominate with mean score of 3.5. Then owner's involvement during construction phase and review of contract documents during design stage scored with a mean of 3.3 and 3.2 respectively and then owner's involvement at planning and design phase, clarity of variation order procedures at construction stage, continuous coordination and direct communication and utilize work breakdown structure at design-construction interface stage all equally scored with a mean of 3.1.

Table 4.18 Controls of variation orders and its frequency (N=28)

NO	Controls of variation orders	Contractor MS	Consultant MS	Client MS	Weighted Average MS	Rank
	A. Design Stage Controls for Variation Orders					
1	Review of contract documents	3.6	2.8	3.3	3.2	3
2	Freezing design	2.9	2.0	2.8	2.6	21
3	Value engineering at conceptual phase	2.9	2.4	2.7	2.7	20
4	Involvement of professionals at initial stages of project	2.9	2.8	3.1	2.9	13
5	Owner's involvement at planning and design phase	3.0	2.5	3.7	3.1	6
6	Involvement of contractor at planning and scheduling process	2.0	1.8	2.4	2.1	27
7	Thorough detailing of design	2.8	2.7	3.1	2.9	15
8	Clear and thorough project brief	2.8	2.5	2.7	2.7	19
9	Reducing contingency sum	2.6	2.0	2.9	2.5	24
	B. Construction Stage Controls for Variation Orders					
10	Clarity of variation order procedures	3.1	3.1	3.0	3.1	7
11	Written approvals	3.5	3.5	3.4	3.5	1
12	Variation order scope	3.3	2.9	2.7	3.0	11
13	Project manager from an independent firm to manage the project	2.2	1.4	2.3	2.0	28
14	Restricted pre-qualification system for awarding projects	2.2	2.4	3.1	2.6	22
15	Owner's involvement during construction phase	2.8	3.2	3.9	3.3	2
16	Avoid use of open tendering	2.2	1.9	2.1	2.1	26
17	Use of project scheduling/management techniques	2.8	2.5	2.9	2.7	18
18	Comprehensive documentation of variation order	3.0	3.0	2.9	3.0	12
	C. Design-Construction Interface Stage Controls for Variation Orders					
19	Prompt approval procedure	3.2	3.2	2.7	3.0	10
20	Ability to negotiate variation	3.2	2.9	3.0	3.0	8
21	Valuation of indirect effects	2.8	2.2	2.5	2.5	23
22	Utilize work breakdown structure	3.2	3.2	3.0	3.1	4
23	Continuous coordination and direct communication	3.1	2.6	3.7	3.1	5

24	Control the potential for variation orders to arise through contractual clauses	3.1	2.7	2.8	2.9	16
25	Comprehensive site investigation	3.2	2.4	3.5	3.0	9
26	Use of collected and organized project data compiled by owner, consultant and contractor	3.0	2.3	3.2	2.8	17
27	Knowledge-base of previous similar projects	3.0	2.6	3.2	2.9	14
28	Comprehensive analysis and prompt decision making through computerized knowledge-based decision support system	2.7	1.5	2.8	2.3	25

Table 4.19 below generally shows there is a strong correlation between the attitudes of the respondents from the contractor to consultant. However, the correlation is relatively less when we see the consultant to client and contractor to client. The main reason might be a difference in understanding the basic concepts of the contract provisions and experience.

Table 4.19 Summary of correlation test on the ranking of control of variation orders

Respondent	$\rho = 1 - \frac{6 \times (\sum d_i^2)}{N \times (N^2 - 1)}$	Critical value of ρ (Appendix A-2)	Significance for P < 0.05	Reject/don't reject the Null Hypothesis
Contractor/Consultant	**0.72**	**0.377**	**Significant**	**Reject**
Consultant/Client	**0.43**	**0.377**	**Significant**	**Reject**
Contractor/Client	**0.43**	**0.377**	**Significant**	**Reject**

Further comments and suggestions given by respondents about variation orders include:

- √ The client should, as much as possible, allow the design consultant do a comprehensive design revision and site investigation work after all the ROW obstructions are cleared and before floating the tender for Construction.
- √ The client should also thoroughly check and approve the designs submitted by the consultants
- √ Consultants should be given ample time for detail designing, involve experienced and qualified experts and should be held accountable for faulty designs, if any.
- √ Consultants' fee for design and supervision shall be revised to avoid the brain drain of experienced and qualified engineers to neighboring African counties. Consequently, all design works are on the burdens of less experienced junior Engineers which would

also affect the quality of the design output, reflected in cost and time overrun implications to the projects.

- √ Proper technical procurement emphasize should be given during the selection of contractors and consultants.
- √ The client should implement effective project management and contract administration procedures at all stages of the project.
- √ Proper communication channel is required among all parties to the contract and stakeholders such as EEPCO, AAWSA and ETC, LRT.

4.6 DISCUSSION

This section discusses the study findings of both the questionnaire survey and desk study results. Based on the findings the most prevalent causes, origin agents, adverse effects and effective controls for variation orders are discussed.

4.6.1 Prevalence of variation order

The prevalence of variation order in national works contracts that is administered by AACRA has been checked through both desk study of randomly selected completed and undergoing national works contract road projects of AACRA and questionnaire survey of various professional engineers who have been participating in the road projects of the city. Both sources revealed that variation order is a common problem which nearly every project is suffering- from and showed that it is a serious problem in the national works contracts of the road projects that are administered under AACRA. Therefore, at this point, it is vital to identify what that real causes are, which party is dominantly originating each cause, what are the consequential effects and also remedial measures in controlling the variation orders.

4.6.2 Causes of variation orders and origin agents

Based on the findings of the desk study survey, some of the major causes for the variation order were geometric design change (most geometric design revisions were due to new ground condition after ROW obstructions are cleared), revision of typical cross section, additional works to the project(supplementary agreement), design change of at grade junctions to round about or underpass/overpass or interchange junctions, road width widening

due to master plan modification, additional provisions of drainage facilities and bridge elevation modification due to change in grade.

The causes of variation orders from the questionnaire were also ranked in ascending order and the most frequent subsequent origin agent were identified. From Table 4.20, it is evident that the most frequent causes of variation orders which were originated by the consultant are design complexity, inadequate design, error and omission in design, ambiguous design details and change in design during the construction stage. Lack of experienced professional engineers, submission of inadequate design details due to lack of experience and short design time given by the client and inefficient contract administration during construction stage are identified to be contributing predominantly.

Table 4.20 causes of variation orders versus most origin agents

Causes of variation orders	Ranking	Origin agent
Design complexity	1	Consultant
Unavailability of equipment	2	Contractor
Design discrepancies(inadequate design)	3	Consultant
Errors and omissions in design	4	Consultant
Ambiguous design details	5	Consultant
Defective workmanship	6	Contractor
Change in design	7	Consultant
Unavailability of skills(shortage of skilled manpower)	8	Contractor
Lack of knowledge of available materials and equipment	9	Contractor
Complex design and Technology	10	Consultant
Lack of specialized construction manager	11	Contractor
Right of way (access to site) problem	12	Client
Non – Compliant design with owner's requirement	13	Consultant
Change of schedule	14	Contractor
Lack of required data	15	Consultant
Unforeseen problems	16	Others
Change of plans or scope	17	client
Weather conditions	18	Others
Inadequate working drawing details	19	Consultant
Inadequate scope of work for one or more parties to the contract	20	Client
Change in specification	21	Consultant
Lack of involvement in design of one or more parties to the contract	22	Client
Financial problems	23	Contractor
Conflicts between contract documents	24	Consultant
Change in economic conditions	25	Others
Inadequate project objectives	26	Client
Poor procurement process	27	Client
Impediment in prompt decision making process	28	Client
Lack of coordination	29	Contractor
Lack of judgment and experience	30	Consultant
Replacement of materials or procedures	31	Consultant
Health and safety considerations	32	Contractor
Differing site conditions	33	Contractor
Change in government regulations	34	Client
Lack of communication	35	Contractor

The consultant and the client were found to be the most frequent origin agents of variation orders. It was reported by respondents that a failure to produce detailed drawings by the consultant together with change of mind by client resulted in variation orders. Stated differently, the occurrence of variation orders was a consequence of the behavior of the consultant and the client during the pre-tender stage for construction. Moreover, this could have been the reason to find that the contractor had least influence on variation orders during the construction stage.

By comparing the findings regarding the work impact and the origin agent of variation orders, there appears to be a relationship between the most predominant rankings shown in Table 4.21.

Table 4.21 Relationships between the origin agents and the work impact.

ORIGIN AGENT	CAUSE	WORK IMPACT
Consultant	Incomplete design /pre-tender stage /	Additional works /Construction stage/
	No detailed design /during construction/	
Client	Inadequate scope of work and project objectives /pre-tender stage/	
	Impediment in prompt decision making process /during construction/	

These relationships are discussed as follows:

- ☐ Additional works are the result of the failure of the consultant to produce a complete design resulting in more details being required during the construction stage;
- ☐ Additional works are the result of the failure of client to provide a clear and comprehensive brief with the result that client changes emerge during the construction stage;

The contractor initiated causes of variation orders were unavailability of equipment, shortage of skilled manpower, lack of knowledge of available material and equipment and change of schedule. This indicates an experienced contractor who is well equipped with required machineries and skilled manpower would enhance the value of the project by proposing

replacement of materials or construction procedures. From the finding it is learnt that the contractors involving in the city road project works lack experience and capacity which have a potential contribution in increasing the number of variation orders on a project.

Respondents also suggested the most predominant causes of variation orders originated from the client were Right of way (access to site) problem, change of plans or scope, inadequate project objectives and poor procurement process. On the other hand, respondents indicated that some of client initiated variation orders like Right of way (access to site) problem, change of scope and project objectives are main reasons that encompass most of the changes initiated from the consultant.

The fact that respondents suggested the reduction of the occurrence of variation orders could be admittance by the construction industry that excessive variation orders had some adverse impact on the project. Respondents suggested that adequate time should be spent on design and accurate information should be disseminated between parties to the contract.

4.6.3 Most frequent effects of variation orders

Adverse impacts of Variation orders in the national road construction projects of Addis Ababa City Roads were suggested by the respondents and therefore cost and time overruns and disputes between parties to the contracts were the most predominant adverse impacts of variation orders on project performance. Likewise, the desk study revealed that the cost overrun due to variation orders in surveyed city road projects of Addis Ababa resulted in average percentage increase of 24.11 % of the original project contract amount and the corresponding associated average time overrun is 126.50% of the original contract period. Further desk study exceptionally revealed that variation orders of up to 134% of the project cost and time extension of up Seven(7) years were observed in one of the surveyed road construction project of Addis Ababa City.

Although the degree of effects of cost overrun varies on the stakeholders in the construction industry, both the client and the contractor are affected by cost overrun. The primary victim of cost overrun would be the project owner since he has envisaged his construction project to be realized within an allocated cost and time frame. Anything outside these stated frames are cost overrun and time overrun to the client.

Difficulties were common in negotiating and valuation of variation orders. There appear to have conflict of interest between the contractor and consultant in determination of unit rates and could be the source of disagreement or dispute and poor professional relationships. The main reasons behind is that the consultants lack impartiality and would like only to keep the clients' interest and also the contractors' submit exaggerated figures. On the other hand, the client takes longer time to approve any variation order due to lack of capacity in contract administration and implementing applicable procedures thereby resulted in project delay for a long period of time and is subjected to market inflationary pressure and financial interests.

4.6.4 Effective Controls of variation orders

Respondents reported that with respect to the actual prevailing experience of controls of variation orders, there is weak application to avoid or minimize the effects of variation orders in AACRA projects before it became a serious project issue. On the other hand, they have suggested timely written approvals and owners' involvement during construction stage are rated most.

Review of contract documents and owners involvement at planning and design phase were rated most to be implemented at design stage. This was because the involvement of the owner in the design phase would assist in clarifying the project objectives and in identifying noncompliance with their requirements at an early stage. Eventually, this may help in eliminating the occurrence of variations during the construction stage where the impact of the variations can be more severe. The survey results indicated that the involvement of owner not only in the design phase but also in the construction phase is highly appreciated by the professionals. Hence, the professionals strongly recommended the involvement of owner at planning and design phases would eventually assist in reducing potential variations in the construction projects.

On the other hand, utilizing of work breakdown structure and continuous coordination and direct communication among parties were also rated most to be implemented during the design-construction interface stage. Detrimental variations, which affect the projects adversely, can usually be managed at an early stage with due diligence in coordination. Continuous coordination and direct communication was perceived as an effective control for variation orders in national contract road projects administered by AACRA.

This was because coordination and communication are integral for the successful completion of a construction projects, in the case of road projects of Addis Ababa, where many stockholders are involved. These also assist in managing variations, which can affect the projects adversely, at an early stage where the impact of the variations would be less severe than during the construction phase.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Road projects play a significant role in the economy of a country particularly in developing countries like Ethiopia. Thereby, nowadays the number and complexity of city road construction projects is increasing in the capital city of Ethiopia, Addis Ababa. However, many construction management problems are beset during construction stage. Among those, variation order is a considerable issue which this research paper is trying to address briefly. This study therefore aimed to identify main causes of variation orders, predominant origin agents to the causes, identify consequential effects and propose controls for variation orders in the national contracts of city road construction projects of Addis Ababa. Thus in accordance to the study objectives, a comprehensive literature review, questionnaire survey among construction professionals and desk study were conducted for national contract road construction projects of Addis Ababa City.

Both the questionnaire survey and desk study confirmed the existence and extent of variation order in national contract road construction projects of Addis Ababa. The questionnaire survey indicated all of the respondents have been involved in the administration of variation orders of the city road projects. This was later reinforced by the findings of the desk study for 16 randomly selected city road projects and all projects faced variation orders ranging from 1 to 7 and average percentage increase of 24.11 % of the original project contract amount and the corresponding associated average time overrun is 126.50% of the original contract period.

The findings of the analyzed survey results have been thoroughly discussed in the previous chapter and therefore the following conclusions are drawn in accordance with the objectives of the study.

1) The most frequent causes of variation orders in road projects of Addis Ababa were identified based on the ranking for the occurrence of frequency of 35 identified possible causes of variation orders from the review of the literature. The most ranked common causes of variation orders identified are Right of way (access to site) problem, change in

design, errors and omissions in design, lack of coordination between contracting parties/stakeholders and change of plans or scope of the project. The result revealed that inadequate design, error and omission in design and ambiguous design were the main causes of consultant initiated variations while Right of way (access to site) problem, change of plans or scope and inadequate objectives were the main causes of client initiated variations. In agreement to the above, a study by Sunday, O.A (2010) on public construction projects indicated inadequate working drawings, design discrepancies and conflicts between contract documents are the most prevalent sources of variations due to consultants while change of plans or scope, impediment in prompt decision making and inadequate project objectives contributed mostly to variations by the owner. The findings of this thesis indicated that an involvement of the client is required at all project management stages and have proper project scope and objectives.

2) The survey analysis indicated that consultant is the most frequently involving party as an origin agent of predominant causes of variation orders in Addis Ababa City Road constructions projects. The client is ranked 2nd as an origin agent of variation orders. On the contrary, a thesis by Tadesse Ayalew (2009) concludes that contractors are the most common variation order initiators on Federal road projects of Ethiopia. However, Arian and pheng (2005), in agreement to this study, clearly showed that consultants and clients respectively are the most predominant initiators of variations on public construction projects. The occurrence of variation orders was identified to be a consequence of the behavior of the consultant and the client during the pre-tender stage of construction. This could be the main reason that the contractor had least influence on variation orders during the construction stage of the city roads. Nevertheless, in all such cases the consultants were not held accountable rather they have got additional payments as their supervision contract is a time based contract.

3) The most identified predominant ranked adverse effects of variation orders in Addis Ababa City Road construction projects are cost overrun, time overrun and disputes between contracting parties in agreement to the findings of researchers Arian and pheng (2005) and Aldubaisi A.H. (2000).On the other hand, survey results also indicated that the client is the most affected party.

4) As per the respondents' survey data, application of proper controlling tools for work variations in Addis Ababa city road projects is weak. As per the survey result finding, the following are the most applied three stage controlling mechanisms of variation orders during the road construction project management. Timely written approvals and owners' involvement during construction stage were rated most. During design stage, review of contract documents and owners' involvement at planning and design phase were rated next. Likewise, utilizing of work breakdown structure and continuous coordination and direct communication among parties were also rated most during the design-construction interface stage.

5.2 RECOMMENDATIONS

Recommendations forwarded from this thesis are a set of remedies to minimize variations in construction projects and minimize their impacts in future road construction projects of Addis Ababa City. Based on the findings of this research discussed in chapter four with main conclusion listed above and the referring to findings of previous studies discussed in the literature review, the following recommendation are made:

1) A clear and thorough project brief by the client would assist in eliminating variations that may arise due to unclear project objectives. Eventually, this may assist in developing a clear scope of work for the professionals.

2) The involvement of the owner/client in the design phase would assist in clarifying the project objectives and in identifying the noncompliance with their requirements at an early stage. Eventually, this may help in eliminating the occurrence of variations arising from errors and design discrepancies during the construction stage where the impact of the variations can be severe.

3) The establishment of an independent organization, who has the authority to command and coordinate all stakeholders participating in the city road construction and infrastructure development program, is vital in order to alleviate right of way and related problems. Unless there is some organization that is capable of coordinating and guiding all stakeholders, ROW problem continue to be a dominant problem. On the other hand, an integrated design manual which includes all utility facility under

walkway shall be prepared by the client for the typical sections of the city roads to be adopted by the design consultants.

4) Another justified recommendation for the client is to review the original design by an independent design consultant to avoid most of the consultant related predominant causes of variations. In addition to this, the client need to get a project management consultant firm (PMC) to supervise both the design and construction activities to insure that the owners' needs and expectations are met by the design. The practice of appointing PMC is rarely adopted currently.

5) Thorough detailing of design was perceived as one of the most effective controls for variation orders for city road projects. The controls for the errors and omissions in design, design discrepancies and frequent change in design, would be minimized through detailing of design only by having staged offices that shall overlook in to designs made by juniors who are inexperienced. This will provide an opportunity for the consultant to review and finalize the design during the design phase. This would assist in reducing the variation occurrences during the construction phase where the impact of variations can be severe.

6) As discussed in the previous sections, the most important causes of variation orders were mostly consultant related variations and client related variations respectively. Hence, the study suggested that variations can be reduced with due diligence during the design stages and project defining moments if there exist a proper channel of communication. Furthermore, the suggested controls also emphasized the proper involvement of all parties for a collaborative effort in reducing variations.

7) The identification, analysis and documentation of potential variations in a project as early as possible can enhance the management of variations in the projects. Learning from these variations is imperative because the professionals can improve and apply their experience in the future.

8) Finally I recommend my fellow researchers for further studies on variation order management in city road construction projects as it is proven to be a potential study area during this study process.

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DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university. All sources of materials used for the thesis have been duly acknowledged.

NAME: TEWODROS ZEWDU

Place: Addis Ababa, Ethiopia

Date of submission: _____

Signature: _____

Title of the thesis:

"Causes and effects of Variation orders in road construction projects. The case of national works contract administered by Addis Ababa City Roads Authority."

This thesis has been submitted for examination with my approval as a university advisor

Name: Professor Dr.-Ing Abebe Dinku

Signature: _____

Date: _____

Appendix: A-1

Causes and effects of Variation orders in road construction projects. The case of National works contract administered by Addis Ababa City Roads Authority.

Questionnaire

- Since this survey is required for academic research, the data obtained will be held confidential. Your prompt response is highly essential for the fulfillment of the study.
- Please answer all questions.
- If you have any query on this survey, you are kindly requested to contact me directly on tel. **0911–120530.**

Objective of the Research

The goal of this research is to examine the critical causes and effects of variation orders in selected national works contract of Addis Ababa City Road projects. By understanding the causes and effects the Employer, Consultants and Contractors will be able to recognize the focus point to minimize such related variation orders in future city road projects. The research will help the main contracting parties and stakeholders save time, money and avoid disputes on upcoming road projects of the city.

The main objectives of this research study are:-

- To identify the predominant causes of variation orders that is prevalent in national works contract of Addis Ababa City Road projects.
- Investigate the potential effects of variation orders in national works contract of Addis Ababa City Road projects.
- To identify the main origin agents for the predominant causes of variation orders and
- To recommend how to control variations in national works contract of Addis Ababa City Road projects.

SECTION A: PROFILE

1. Which of the following best describes your company?

No	Company description	Tick only one box
1.1	Contractor	
1.2	Consulting engineering	
1.3	Client(AACRA)	

2. How long have you worked in the construction industry? ……..years……..months

3. How long have you worked for your present company? ……...years……..months

4. What is your current position in your organization? ……

5. How long have you been in your present position? ……years…..….months

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

Yes □ No □

SECTION B: THE PREVALENCE OF VARIATION ORDERS

7. From your own experience, from the 1st (most frequent) to the 3rd (least frequent) **rank** the following impacts of variation orders on National works contract of Addis Ababa City road projects you were involved.

No	Impact	1st	2nd	3rd
7.1	Additional works			
7.2	Omissions of works			
7.3	Alteration of works			

8. Please explain the ranking order you suggested above.

8.1 Additional works:

_____

_____

8.2 Omissions from works:

_____

_____

8.3 Substitution of works:

_____

_____

SECTION C: ORIGIN AGENT AND CAUSES OF VARIATION ORDERS

9. From your experience in national works contract of Addis Ababa City Road projects, please indicate the frequency of each of the factors influencing the occurrence of variation orders by **ranking** from 1st (most frequent) to 3rd (least frequent).

No	Factors influencing variation orders	1st	2nd	3rd
9.1	Nature of works			
9.2	Complexity of works			
9.3	Procurement method			

10. Please indicate the frequency of each as an origin agent by **ranking** from 1st (most frequent) to 4th (least frequent). NB**: "Others"** include situations beyond the control of the contractual parties that give rise to variation orders such as for example weather conditions, health and safety considerations, change in government regulations, change in economic conditions and unforeseen problems.

No	Origin agent	1st	2nd	3rd	4th
10.1	Contractor				
10.2	Consultant				
10.3	Client				
10.4	Others				

11. Please explain your **choice of ranking** relative to **each** of the origin agents.

11.1 Contractor:

_____

_____

11.2 Consultant:

_____

_____

11.3 Client:

_____

_____

11.4 Others:

_____

12. The following are possible causes of variation orders; tick the **most frequent** origin agent corresponding to **each** of them from your experience in national works contract of Addis Ababa City Road projects that you were involved.

No	Causes of variation orders	Client	Consultant	contractor	others
12.1	Change of plans or scope				
12.2	Change of schedule				
12.3	Financial problems				
12.4	Right of way (access to site) problem				
12.5	Inadequate project objectives				
12.6	Replacement of materials or procedures				
12.7	Impediment in prompt decision making process				
12.8	Change in specification				
12.9	Change in design				
12.10	Errors and omissions in design				
12.11	Conflicts between contract documents				
12.12	Inadequate scope of work for one or more parties to the contract				

12.13	Complex design and Technology				
12.14	Lack of coordination				
12.15	Design complexity				
12.16	Inadequate working drawing details				
12.17	Lack of judgment and experience				
12.18	Lack of knowledge of available materials and equipment				
12.19	Ambiguous design details				
12.20	Design discrepancies(inadequate design)				
12.21	Non – Compliant design with owner's requirement				
12.22	Lack of involvement in design of one or more parties to the contract				
12.23	Unavailability of equipment				
12.24	Unavailability of skills(shortage of skilled manpower)				
12.25	Differing site conditions				
12.26	Defective workmanship				
12.27	Lack of specialized construction manager				
12.28	Poor procurement process				
12.29	Lack of communication				
12.30	Lack of required data				
12.31	Weather conditions				
12.32	Health and safety considerations				
12.33	Change in government regulations				
12.34	Change in economic conditions				
12.35	Unforeseen problems				

13. Following are possible causes of variation orders; indicate how frequently each of them occurs on national works contract of Addis Ababa City Road projects that you were involved.

No	Causes of variation orders	Never	Seldom	Sometimes	Always
13.1	Change of plans or scope				
13.2	Change of schedule				
13.3	Financial problems				
13.4	Right of way (Access to site) problem				
13.5	Inadequate project objectives				
13.6	Replacement of materials or procedures				
13.7	Impediment in prompt decision making process				
13.8	Change in specification				
13.9	Change in design				
13.10	Errors and omissions in design				
13.11	Conflicts between contract documents				
13.12	Inadequate scope of work for one or more parties to the contract				
13.13	Complex design and Technology				
13.14	Lack of coordination				
13.15	Design complexity				
13.16	Inadequate working drawing details				
13.17	Lack of judgment and experience				
13.18	Lack of knowledge of available materials and equipment				
13.19	Ambiguous design details				
13.20	Design discrepancies(inadequate design)				
13.21	Non – Compliant design with owner's requirement				

13.22	Lack of involvement in design of one or more parties to the contract				
13.23	Unavailability of equipment				
13.24	Unavailability of skills(shortage of skilled manpower)				
13.25	Differing site conditions				
13.26	Defective workmanship				
13.27	Lack of specialized construction manager				
13.28	Poor procurement process				
13.29	Lack of communication				
13.30	Lack of required data				
13.31	Weather conditions				
13.32	Health and safety considerations				
13.33	Change in government regulations				
13.34	Change in economic conditions				
13.35	Unforeseen problems				

14. How can the occurrence of variation orders be reduced?

_____

_____

D. EFFECTS AND CONTROLS OF VARIATION ORDERS

15. A beneficial variation order is one issued to improve the quality standards, reduce cost, schedule, or degree of difficulty in a project to the satisfaction of the client. A detrimental variation order is one that negatively impacts the client's value or project performance.

Based on your past experience, indicate how frequently beneficial and detrimental variation orders occur on projects you were involved in national works contract of Addis Ababa City Road projects.

No	Nature of variation orders	Never	Seldom	Sometimes	Often	Always
15.1	Beneficial variation					
15.2	Detrimental variation					

16. When negotiating a variation order with the client/contractor, what kind of problems do you encounter?

_____

_____

_____

_____

17. From your experience with variation orders in national works contract of Addis Ababa City Road projects, indicate how frequently variation orders resulted in the following effects:

No	Outcome	Never	Seldom	Sometimes	Often	Always
17.1	Cost overrun					
17.2	Time overrun					
17.3	Quality degradation					
17.4	Disputes					
17.5	Professional relations					

18. From your experience with variation orders in national works contract of Addis Ababa City Road projects, what was the impact of effect of variation orders on AACRA road projects?

NO	Outcome	Major impact	Slight impact	No impact
18.1	Cost overrun			
18.2	Time overrun			
18.3	Quality degradation			
18.4	Disputes			
18.5	Professional relations			

19. Following are tools for Controls of variation orders, indicate how frequently each of them are being applied on national works contract of Addis Ababa City Road projects that you were involved.

NO	Controls of variation orders	Never	Seldom	Sometimes	Always
	A. Design Stage Controls for Variation Orders				
19.1	Review of contract documents				
19.2	Freezing design				
19.3	Value engineering at conceptual phase				
19.4	Involvement of professionals at initial stages of project				
19.5	Owner's involvement at planning and design phase				
19.6	Involvement of contractor at planning and scheduling process				
19.7	Thorough detailing of design				
19.8	Clear and thorough project brief				
19.9	Reducing contingency sum				
	B. Construction Stage Controls for Variation Orders				
19.10	Clarity of variation order procedures				
19.11	Written approvals				
19.12	Variation order scope				
19.13	Project manager from an independent firm to manage the project				
19.14	Restricted pre-qualification system for awarding projects				
19.15	Owner's involvement during construction phase				
19.16	Avoid use of open tendering				
19.17	Use of project scheduling/management techniques				
19.18	Comprehensive documentation of variation order				

	C. Design-Construction Interface Stage Controls for Variation Orders				
19.19	Prompt approval procedure				
19.20	Ability to negotiate variation				
19.21	Valuation of indirect effects				
19.22	Utilize work breakdown structure				
19.23	Continuous coordination and direct communication				
19.24	Control the potential for variation orders to arise through contractual clauses				
19.25	Comprehensive site investigation				
19.26	Use of collected and organized project data compiled by owner, consultant and contractor				
19.27	Knowledge-base of previous similar projects				
19.28	Comprehensive analysis and prompt decision making through computerized knowledge-based decision support system				

20. Do you have any further comment, suggestion or contribution relative to variation orders?

_____

_____

_____

_____

_____

Thank you!!

Appendix: A-2

[Source: Dissertation Research & Writing for Construction Students (2013)]

Table C *Critical values of ϱ (rho) at various levels of probability (Spearman rank correlation coefficient)*

For any *N* the observed value of ρ is significant at a given level of significance if it is *equal* to or *larger* than the critical values shown in the table.

	Level of significance for one-tailed test			
	0.05	0.025	0.01	0.005
N (number of subjects)	Level of significance for two-tailed test			
	0.10	0.05	0.02	0.01
5	0.900	1.000	1.000	–
6	0.829	0.886	0.943	1.000
7	0.714	0.786	0.893	0.929
8	0.643	0.738	0.833	0.881
9	0.600	0.683	0.783	0.833
10	0.564	0.648	0.746	0.794
12	0.506	0.591	0.712	0.777
14	0.456	0.544	0.645	0.715
16	0.425	0.506	0.601	0.665
18	0.399	0.475	0.564	0.625
20	0.377	0.450	0.534	0.591
22	0.359	0.428	0.508	0.562
24	0.343	0.409	0.485	0.537
26	0.329	0.392	0.465	0.515
28	0.317	0.377	0.448	0.496
30	0.306	0.364	0.432	0.478

Note: When there is no exact number of subjects use the next lowest number.