

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
FACULTY OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING
(CONSTRUCTION TECHNOLOGY AND MANAGEMENT STREAM)

Causes and Effects of Variations in Ethiopian Federal Road Projects

By
Tadesse Ayalew

July 2009
Addis Ababa, Ethiopia

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Advisor: Professor Dr.-Ing. Abebe Dinku

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ABSTRACT

Construction industry is a major player in economy of any countries by generating employment and wealth to the nations. However many projects in developing countries experienced extremely low performance in terms of time cost. One of the contributing factors to this low performance among others is variation. This is because variation can affect project cost, schedules.

With this background, this study tries to identify whether variation exists or not, what causes these variations, what is their consequences, which contracting party is the more responsible in initiating these variation and which is most affected as a consequences of these causes.

Based on this a questionnaire which consists of 35 potential causes, 12 possible effects and other questions which enables to achieve the objectives of the research were developed. Accordingly the study concludes that variation as one major problem in Ethiopian Federal road construction projects. Right of way or accesses to site problems, change in defined scope, lack of proper planning, lack of proper evaluations of tender documents by contractors at tendering phase and contractor's financial problems were identified as major causes which results these variations and client/employer were identified more responsible in initiating most of the variation issues. The study also investigated; delay in project completion time, increase in project cost, suspension or hold on works, decrease in productivity and dispute among parties as a major effects and contractors as the most affected contracting party as a result of effects of variations.

ABBREVIATIONS

GDP	=	Gross Domestic Product
MoWUD	=	Ministry of Works and Urban Development
MoFED	=	Ministry of Finance and Economic Development
DCI	=	Domestic Construction Industry
ADLI	=	Agricultural Development led industrialization
RSDP	=	Road sector development program
ERA	=	Ethiopian Roads Authority
AACRA	=	Addis Ababa City Roads Authority
ETB	=	Ethiopian Birr
ADB	=	Africa Development Bank
U.K	=	United Kingdom
EU	=	European Union
CII	=	Construction Industry Institute
CPM	=	Critical Path Method,
FIDIC	=	Federation International Des Ingenieurs Councils
BoEPDM	=	Bureau of Engineering Project Delivery Manual
MS	=	Mean score
CL	=	Client/Employer
DSC	=	Design Consultants
SCS	=	Supervision Consultants
CT	=	Contractors
FoT	=	Faculty of Technology
AAU	=	Addis Ababa University

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CHAPTER ONE

1. INTRODUCTION

1.1 General Introduction

Construction industry has significant contribution to the national economy of any country (Chitkara, 2004). This concept is also shared by many other researchers; Liening (2001) quoted in Fetene (2008) for example indicated that the sector has a crucial contribution for economic development. According to Chitkara (*Ibid*), the contribution of the industry to the gross domestic product (GDP) of many countries ranges between 6-9%. On the other hand Fetene (2008) quoting Bhimaraya (2001) pointed out that the contribution goes up to 10%. The contribution of Ethiopian construction industry as reported by Ministry of Works and Urban Development (MoWUD, 2006) is estimated to be 3% which is much lower than sub-Sharan average of 6%. The six years data shown in Table 1.1 below from Ministry of Finance and Economic Development (MoFED, 2007), however showed different figure which by far exceeds the report by MoWUD (2006). According to MoFED the contribution of the construction industry to the GDP is more than 5.7% during the years 2002/2003 up to 2007/08 (see Table 1.1).

Table 1.1; Contribution of some selected industries to the national GDP

	1995	1996	1997	1998	1999	2000
Industry/Year	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Agriculture, Hunting and Forestry	44.9	47.0	47.4	47.1	46.3	44.6
Animal Farming and Hunting	14.8	14.3	13.5	12.7	12.3	11.8
Manufacturing	5.5	5.2	5.2	5.2	5.0	4.8
Electricity and Water	2.4	2.3	2.2	2.1	2.2	2.2
Construction	5.7	6.1	5.8	5.7	5.7	5.7
Whole Sale and Retail Trade	12.5	11.8	11.8	12.5	13.1	13.4
Hotels and Restaurants	2.4	2.3	2.3	2.4	2.7	3.0
Transport and Communications	5.9	5.7	6.1	5.8	5.6	5.8
Public Administration and Defense	4.8	4.3	4.2	4.0	3.7	4.2
Education	2.8	2.8	2.8	2.8	3.0	3.1
Health and Social Work	0.9	0.9	1.0	1.0	0.9	1.0

(Source MoFED, 2007)

With such a high contribution, the construction industry has a major influence on the economic growth of the country, Conversely it is highly dependent on the state of the economy to realize its potential (DCI, 2005). An inefficient and ineffective performance of the construction industry on the other hand will adversely affect all other sectors of the economy.

The performance of construction industry is one of the major development constraints in developing countries since their development highly depends on the growth of their physical infrastructures (Wubshet, 2004). As a matter of this fact, developing countries allocate a considerable amount of their scarce financial resources towards the development of their infrastructure needs. However, most of these infrastructure projects in developing countries encounter considerable low performance in terms of time, cost and quality etc.

Ogulana *et al.* (2004) and Wubshet (2004) described that many of these performance related problems are recurrent and serious. Because of this, many researchers in developing as well as developed countries undertake several studies on specific aspects of performance related problems such as time, cost and quality in many countries.

Most of these studies conducted on specific performance issues like cost, time and quality indicate that although the degree of impact varies from project to project it is generally accepted that variations can affect construction projects with unpalatable consequences in time and cost (Ibbs *et al.*, 2001). For example, Kumaraswamy *et al.* (1998a) shows that a total of 50 percent of the projects surveyed were delayed because of variations. Kaming *et al.* (1997) also pointed out that for time over run; the most important factors that caused delay were design changes, poor labor productivity, inadequate planning, and resource shortage. In this study, the magnitude of average schedule slippage due to variations was reported to be as high as 18 percent (Zeitoun & Oberlender, 1993) cited in Arian and Pheng (2005a).

Apart from the studies on specific performance issues, Ogulana *et al.* 2004 studied common problems of large construction projects in developing countries considering the cases of Vietnam to identify the major problems in these countries. They identified sixty two problems from literature and asked the respondent of the research to rate them based on frequency of occurrence

and their influences. Their findings indicate that in both criteria which are frequency of occurrences and influence, excessive change order is listed among the top twenty problems. It takes the third and thirteenth rank based on the frequency of occurrence and their influence respectively. This indicates that variation or change is one of the major problems of construction projects in developing countries.

1.2 Background of the Study

The Ethiopian government has been implementing a number of policies and strategies to alleviate poverty enhance economic development and social well being of its people. One of such policies which has been started in the early nineties recognizing the potential resources of the country is the Agricultural Development Led Industrialization (ADLI) program.

The success of this strategy and consequent economic recovery and development of the country is highly dependent on the restoration and expansions of the country's road transport sector which has one of the lowest road densities in Africa that deserves massive expansion and restoration. According to Ethiopian Roads Authority midterm review of the Road Sector Development Program (RSDP, 2005), Ethiopia has a very limited size and population of road network, currently about 36,496km that hampers economic development, especially in the rural areas. Besides this, the overall condition of the classified network is also in a poor condition; according to the above report, currently only 37 percent are identified to be in good condition.

Recognizing the crucial role of the road sector for the economic development of the country, the government with the support of these development partners has commenced a comprehensive program aimed at the development of the road sector in mid 1994, which resulted in the formulation of the RSDP in 1997(ERA midterm report, 2005). The objective of RSDP is to restore Ethiopia's road network, which is identified as an obstacle to sustainable economic development of the country, and to build institutional capacity of the road implementing agencies in order to properly manage the implementation processes.

The program was scheduled for a period of ten years (1997-2007) and was divided into two phases (RSDP I and RSDP II). The first phase of the RSDP ended in June 2002 which the second phase RSDPII started in the same year 2002. To implement this program, Ethiopian government

with the assistance of various donors such as the World Bank, European Union, ADB, Governments of Japan, Germany, U.K., Ireland and Sweden etc. spent considerable amount of money. Table 1.2 shows three consecutive years' government expenditures (ETB) for road sector development between 1999 and 2001.

Table 1.2; General Government Capital Expenditure Consolidated Budget [Millions of Birr]

Category and year	1999(2005/06)			2000 (2006/07)			2001 (2007/08)		
	% of road budget in comparison with			% of road budget in comparison with			% of road budget in comparison with		
	Budget	ED	TCE	Budget	ED	TCE	Budget	ED	TCE
Economic Development (ED)	13760.4			17325.9			21291.3		
Agriculture	4043.5			4818.7			5496.9		
Natural resources	2055.7			2607.4			3372.5		
Mining & energy	1300.0			1379.1			1386.6		
Trade Industry & tourism	247.9			369.9			10053.0		
Road construction	5897.3	42.86	26.13	7866.1	45.40	28.45	10053.0	47.22	28.74
Transport & communications	216.0			284.7			468.7		
Social development	7814.0			9190.1			12102.9		
Education	3628.0			3700.1			5711.0		
Health	1662.5			2276.2			2678.5		
Urban dev't & housing	2379.2			2987.0			3540.2		
Social welfare	22.9			12.4			11.1		
Culture & sport	121.5			214.4			162.1		
General development	992.0			1136.5			1579.3		
Total capital expenditure (TCE)	22566.5			27652.5			34973.5		

(Sources MoFED, 2007)

The above Table indicates 42.86, 45.4 and 47.22 % of the budget for economic development is allocated for road construction in the years 2005/06, 2006/07 and 2007/08 respectively. When it is compared with the total capital budget of the country in these fiscal years, it takes 26.13, 28.45 and 28, 74%. Although considerable amount of government expenditures is allocated to the road sector program, the implementation of the road sector program faces extremely low performance in terms of time and cost.

Ismael (1996) on his study of managing construction projects in Ethiopia indicated that there has been delay up to 460% by considering 13 projects executed between 1985 and 1995. A study by

Abebe and Girmay (2003), on claims in international projects in Ethiopia also indicated that the financial claim in these projects ranges between 200-300% of the project cost in our road construction projects. The study showed that there was considerable amount of delay in these projects. In agreement with Ismael (1996) they also investigated variation as one of the major causes of delay in these projects. Fetene N. (2008), in his study of causes and effects of cost overrun in public building projects also indicated variation as one of the contribution factor for cost overrun. Similarly Abdo A. (2006), in the study of delays in public building construction projects and their consequences investigated variation as one factor that contributes for delay in the specified projects. The data on Fig 1.3 below also which are collected from some completed and undergoing road construction projects also strengthen this fact.

Table 1.3; Amount and percentage of variations in some completed road construction projects

S.No	Project	Original Contract Amount [ETB]	Amount of Variation Order (VO) [ETB]	Percentage of VO [%]
1	A	405,973,872.12	446,359,748.90	109.95
2	B	289,838,439.05	192,278,636.15	66.34
3	C	310,979,872.92	75,217,827.39	24.19
4	D	172,533,963.00	70,639,441.00	40.94
5	E	56,425,487.00	10,138,171.00	17.97
6	F	327,070,830.00	85,309,861.18	26.08

(Sources progress and completion reports of each project)

From the above discussion one can observe that construction variation is one aspect of project management problems in the Ethiopian construction industry which requires considerable attention. However no previous study properly addresses the issue so far. This is the main reason why the researcher got interested to conduct the research on variation.

The ultimate goals of many researches on variation are to minimize their effect, which requires effective analysis of variation and variation order by the project team. According to Arain and Pheng (2005b) and Ibbe *et al.* (2001), effective analysis of variations in turn requires a comprehensive understanding of the root causes and their potential downstream effects. That is the main reason why the research as beginning on variation related issues in Ethiopia aim to identify the root causes of variations and their consequential effects. Thus, the reasons why this research focuses on road upgrading projects are:

1. Road construction projects consumes considerable amount of scarce financial resources as compared with other public construction projects.
2. Ethiopia is listed among those countries which have very low density of road network in Africa. This indicates that road construction projects in Ethiopia will keep on consuming more financial resources since they are the major development constraints.

1.3 Statement of the Problem

As one of infrastructure or civil engineering projects, road construction projects are greatly affected by ground conditions, weather accessibilities and other uncertainties which eventually requires variation to be made to the original contract which may affect the project cost and its duration as well as the quality.

Arian and Pheng (2005a) indicated that the most frequent effect of variation is project cost and time over run due to additional work or change in design which is not incorporated prior to signing of contract. Similarly, Kaming *et.al* (1997) and Elinwa and Joshua (2001) indicated variations as one of the major causes of delay in construction projects.

However, in the implementation of any projects be it public or private, the clients need its project to fulfill the three common elements, i.e. meets the cost, time and quality requirements. Any deviations from these objectives in most cases cause projects to be delayed and additional costs to the project implementing agent. What causes these variations or deviation and how to minimize it is the question to be answered in this research.

1.4 Significance of the Study

As a result of the smaller density of road network in ratio, road construction projects in Ethiopia are at an infant stage, indicating that similar road construction projects will continue for the coming many years. The finding of this research, therefore, may have its own contribution on contract administration of the implementing agent in the future in general and in minimizing variation in particular.

1.5 Objectives of the Study

Based on the background of the study, the main objective of this research is to mitigate and reduce the issuance of variation orders during the implementation of road sector projects in Ethiopia so as to minimize the impact of variation on the performance of these projects in the future. To achieve this goal the research will have the following specific objectives;

- i. To assesses the existence of variation and its extent
- ii. To identify the major causes of variations and their consequential effects
- iii. To identify initiators of these causes and most affected parties
- iv. To forward possible recommendation in order to minimize variation in road construction projects based on the finding of the study

To addresses the above objectives the research will have the following specific questions

1. Is variation a problem in Ethiopian Federal road construction projects; what is the extent of the problem?
2. What are the major causes of variation and their consequential effects?
3. Which contracting party/parties are more responsible in initiating majority of these causes and which are most affected?
4. What are the possible measures to be taken in order to minimize variation in Ethiopian Federal Road construction projects?

1.6 Scope and limitation of the Study

Ethiopian government through its agencies (representative) Ethiopian Roads Authority (ERA), Addis Ababa City Road Authorities (AACRA) and Regional Rural Road Authorities have started a major road sector program to increase the road network in the country which includes new, upgrading and rehabilitation projects. This study will focus on Federal road upgrading and rehabilitation projects implemented by ERA during the RSDP I and II programs since 1997.

Punch (2000) cited by Abraham (2008) describes limitation as limiting conditions which are unavoidable present in particular research. With this understanding, the limitation of this

research that limits its application mainly is reliability of the response of respondent in the questionnaire survey.

1.7 Methodology

This research started with problem identification which was done through unstructured literature review and informal discussion with colleagues and professionals in the sector.

Up on obtaining the identified problems, conceptual and contextual literature reviews were conducted to have in depth understanding on the issue of variation and variation order, focusing on causes and effects and methods on how to minimize variations. The literature reviewed includes books, dissertations, magazines, journals, news paper etc. In additions to this document search such as progress and completion reports and other relevant documents has been done within Ethiopian Roads Authority, the implementing agency of the road sector development program in Ethiopia to have some contextual base. The document search was mainly intended to collect values of variations orders and their cause from some randomly selected upgrading and retaliation projects undergoing and already completed. Besides this, a questionnaire survey has been conducted to strengthen the study. The questionnaire was distributed to contractor, consultant and the employer (ERA). Then, checking and sorting of data were done and analyzed using different statistical tools.

Finally, from the analysis of result and brief discussion; conclusions and recommendations were forwarded

1.8 Organization of the Thesis

The study is divided into five chapters, the first chapter discusses on general introduction, background of the study, statement of the problem, objectives, scope, methodology adopted to achieve the objectives of the study and organization of the thesis. In the second chapter the basics of variation, its causes, effects and methods or strategies on how to minimize variations and the management aspect were discussed. Chapter three will described the research methodology to be followed in order to achieve the objectives of the study. The results of the data obtained from the desk study on selected road construction projects and questionnaire

survey were presented and discussed accordingly in Chapter four. Finally, in Chapter five, conclusions and recommendations were forwarded based on the major findings of the study.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Introduction

In order to develop a better understanding of the research objective, a comprehensive literature review has been conducted focusing on identifying the causes of variations, their effects and on the way how to manage, control and administrate it.

Since they involve human and non human factors as well as many other variables, construction projects are complex which require close cooperation and coordination among stakeholders (Ahmed, 2005 & Fetene, 2008). As a consequence of their complex nature and involving many players, Construction projects encounter variation which is costly and un-welcomed by all parties in construction (Robert, 1996, Arian & Low, 2007). According O'Brien (1998) even the most well planned projects may necessitate changes due to various factors.

Similarly, Ibbs et al (2001) and Pinto & Kharbanda (1995) also described that change and conflicts are very common not only at work place but also in our daily lives and they conclude change as a fact of life in construction projects. In agreement with the above authors Arain & Pheng (2005b) and Edward E. (2003) also indicated variation as an inevitable phenomenon in construction projects.

These changes may be small, well managed, and have little effect on construction projects. On the other hand changes may be large, poorly managed, and have tremendous negative impacts on construction project performances in terms of time and cost (Hanna et al. , 2002). Arain and Pheng (2005b) also indicated that these changes leads to several problems such as change in contract price, or contract schedule, decreasing labor productivity and disputes among project participants.

In agreement with Arian and Pheng (2005b), Ibbs et al (2001) pointed out that variation in construction projects can cause substantial adjustments to the contract duration, total direct and indirect cost, or both. Besides this, variations can also cause disruption in the planned work

schedule, increased cost through rework and decreased efficiency of the base contract work (Hanna et al, 2002). In agreement with Ibbs and Hanna, Nor Hayati (2006) also indicated that, variation orders as one of the most significant sources of cost growth and disruptions. O'Brien (1998) on the other hand described that variation may increase contractual disputes among project participants. To minimize their negative consequences, changes in construction projects should be properly managed and as well as administrated once they occur. To achieve this, the project team should not only effectively analyze variations and its downstream effects but should also identify and use for forecasting and mitigating variations sources (CII, 1994b quoted in Arain & Pheng (2005b). According to Ibbe *et al.* (2001), effective analysis of variations and variation order however requires a compressive understanding of the root causes and their downstream effects.

Hence as a first research in variation related issues in Ethiopian construction industry with main focus of road construction projects, the objective of this thesis is to identify the major causes and their consequences on Ethiopian federal roads construction projects. With this background the subsequent subchapter will discuss the causes, effects and strategies to control changes or variation in order to build the conceptual basis of the research.

2.2 Basics of Variations

Under this headings definitions of variations and their classifications based on various will be briefly described

2.2.1 Definition of Variation and Variation Order

Although there is a slight difference between the word variation and change, different authors use the word interchangeably. In agreement with these authors the words variation and change are also interchangeably used throughout this research.

Since there is no single definition for variation that is accepted worldwide different standards and researchers define variation in different ways. According to Galloway (2007), the Webster's dictionary gives 32 definitions for the word "change". Out of these definitions Galloway (2000) summarizes the definitions of changes which are close to changes in construction industry as follows,

- o To become altered or modified...
- o A transformation or modification...
- o A variation or deviation
- o The substitution of one thing for another
- o A replacement or substitution

Galloway (2007) indicated that, all these definitions do not give a complete meaning for changes in the construction industry. “Change” in construction are also routinely used to identify an addition or deletion to the contracted scope of work. As a common usage in the industry it means any alteration to the contract provisions or scope of work, including modifications, substitutions, addition, deletions and alterations etc.

In agreement with Galloway, many other authors define change or variation in construction as any alteration to the basis upon which the contract was let in its generic sense. That means any deviation from an agreed upon defined scope and schedule. Similarly, Fisk (2000), Yu (1996) and Arain & Pheng (2005a) stated change as any modification to the guidance provided to the contractor by the owner or owner representative.

The above definition includes changes to plans, specification or any other documents. Because the contractor initially receives, the contract package in the form of plans, drawings and list of other documents. For example, Nor H.(2006) indicates that the term alteration on the contract embraces not only changes to the work with the provisions of the contract but also changes to contract conditions themselves.

According to Fisk (2000), O’Brien (1998), Cariappa A. (2000), Al-Dubaisi A.H. (2000) and Calin M (1997), change order is a formal vehicle for making a change or modification in the work of previously approved contract. The change order to modify the original contractual agreement becomes part of project documents after it is approved by the client or its representative. Because variation or changes can be initiated by all parties in the construction process; however, all changes must be approved by Owner or his representative before implementation

For the purpose of this research variation 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 the definition of variation order is taken as it is in agreement with the above authors.

2.2.2 Types of Changes or Variations

Depending on the basis and purposes of classification, change can be classified in many ways. According to Nurul (2000), variations can be grouped into three general categories based on the following criteria;

- a) The identity of the initiators
- b) The nature of the variation
- c) The consequence or effects of variation, which in turn consists of other details under each category. With this general idea classification of changes by different authors' and their classification bases is summarized in the following table. .

Table 2.1; Classification of variation

No	Author	Classification basis	Types
1	J.Burati (1992) and Cariappa A. (2000)	Phase/causers/ originator	- o Design - o Construction - o Fabrication - o Transportation or operability
2	Various authors (E.g. Arian and Pheng (2205), Al-Dubaisi A.H (2000)) etc	Account/responsible or initiator	- o Client/owner - o Contractor - o Consultant - o Miscellaneous
3	Fisk (2000) and Stokes & Judith (1986)	Procedures Introducing them	- o Formal or direct change - o Constructive change - o Cardinal change
4	Bruce (2006)	Time	- o Anticipated - o Emergent

With this basis J.Burati (1992) classified changes based on major phases in construction projects as;

- o Design,
- o Construction,
- o Fabrication and
- o Transportation or operability

J.Burati further studied on design changes and he concluded that design change among others consists of 52.5% of total changes which mainly falls in to three categories.

1. Design changes caused by improvement through design process. These include design changes resulting from design reviews, technological advancement or constructability reviews.
2. Design changes originated by owner. An example of this change includes scope changes.
3. Design changes initiated by engineer or consultant familiar with the process, which includes, additions or deletion of some items that affect the operation of the facility,

Besides this, the study indicates also design errors and omissions as one of the major causes of changes in construction projects.

Similarly, Cariappa.A. (2000) classified changes as construction and design changes. According to this author, construction changes refer to changes due to unforeseen site conditions which may not necessarily require redesign. An example of this includes error and omissions. Unlike to construction change, Design changes refers to changes that are made due to the update of requirements within the original scope, changes of requirements outside the original scope and changes in design necessary by unforeseen conditions

The third basis of classification is the net effect of changes or variation on scope proposed by Fisk (2000). According to Fisk this classification consists of;

- o Additive,
- o Deductive,
- o Rework and,
- o Force majeure:

Fisk (2000) describes additive change as addition of work to the original scope and deductive change just to the opposite of this that is changes which involves deletion or shrinkage of the

scope of the work. According to Fisk (2000), contractors called this changes negative change, since it involves decreasing of the contract sum. Rework change is in most cases due to quality deficiency. This type of change may not involve scope change however it brings a considerable amount of cost impact. Force majeure change on the other hand includes changes which results with factors that are beyond the control of the contracting parties.

Changes can also be classified based on the procedures used to introduce them (Stokes & Judith (1986) and Fisk (2000)), based on this they are classified as;

- o Formal or direct change,
- o Constructive changes and,
- o Cardinal changes;

Formal or direct change is a change introduced by the owner or his representative under the mechanism of change clauses. Constructive change on the other hand refers: changes that resulted from a failure to do or not to do on part of the client or its representative. This may take the form of error in design or drawing, wrong engineer's interpretation of contract document, change in construction methods imposed by the construction requirements. This type of change may not be initially documented as a change, because of this they become potential sources of dispute. Cardinal change is change which is out of the scope of the contract and they are executed after complete redefinition of the scope and re-negotiation of the contract. Because of this, this type of change is called "scope" change. This may not necessarily be a single change it can be the result of a number of changes that have a net effect of modifying the original scope. According to Nor H. (2006)), they can be owner generated: i.e. variation requested by owner for various reason or field generated: which come up when problems or conflicts are detected in the field. In both cases variation order can have numerous negative effects to project cost and schedule.

Bruce (2006) classified changes as;

- o Anticipated and
- o Emergent

According to Bruce, anticipated change is any change that is planned ahead of time and occurs generally as intended. Emergent change on the other hand spontaneous and arises out of conditions that were not anticipated or intended.

Apart from this, many researchers also classified changes on the bases of their initiator or originators, Based on this changes can be classified as owner related, consultant related, contractor relate and others or miscellaneous, which consists of cause that cannot be categorized under client, contractor and consultant.

In addition to the above major classifications, a study on the effect of labor productivity by Thomas and Napolitan (1994) under CII cited in Al-Dubaisi A.H (2000) has listed some other classification basis such as, subject, a matrix which shows type and originator and based on account group which are responsible for changes such as client, contractor and consultant etc.

2.2 Causes, Effects and Management of Variation

2.3.1 Causes of Variation

Construction projects are typically undertaken in ever-fluctuating natural and business environments Ibbs *et al.* (2007). Due to this, they are influenced by changing variables and unpredictable factors that result from different sources (Ibbs *et al.* (2007) and Arian & Pheng (2007). According to theses authors the sources include performances of construction parties, environmental conditions, involvement of other parties and contractual relations. As a consequence of these changes, construction projects may face problems which could cause delay in project completion time; cost overrun and inefficiency or lost in productivity even dispute among the contracting parties in the worse case (Arain *et al.*2004, Ibbs *et al.* (2007). In order to reduce the negative impacts of variation which are described above, project management teams should respond to variation effectively in a proactive way. According Ibbe *eta al* (2001) this however requires a comprehensive understanding of the root causes.

Recognizing this fact many researchers has conducted their study on causes of variation. In the subsequent parts the findings of various researchers and the identified factors from different literatures will be presented.

Nurul (2007) studied variation control affecting construction works in Malaysia. His finding revealed that 32% of variations comes from errors in bill of quantities, re-measurement of the work contributes 25%, change due to local authority requirements has a contribution of 19% to variation since requirements are not properly followed, clients request takes 10% of the

variations, change in design shares 9%, changes to the site conditions and superintendents instructions has a contribution of 5% and 1% respectively.

Similarly, Al-Dubaisi A.H (2000) in his study on change order in construction industry of Saudi Arabia investigated that, change of plans by owner, substitution of materials and procedures, error and omission in design, owner's financial problems and change in design by consultant are the five top most causes which contributes for variations.

Baharuddin (2005) conduct a study on variation order in transmission projects, his finding indicated, change in underground cable roots are the first important factor which brings much of the changes from the point of views of project owners'. Incomplete scoping and inadequate bill of quantities is the second factor which contributes for variations. The third factor is change in transmission route, which is followed by design changes and new requirements respectively.

Arain and Pheng (2005b) in their study on effective management of contract variation using a knowledge based decision support system concluded that error and omission in design, change in specification by owner, unforeseen problems, change of plan or scope by the owner and design discrepancies (inadequate design) are the five top important factors that contributes for variation in Singapore.

As a result of an in-depth literature search in addition to the above major findings on causes of variation, the following factors which contribute for change or variation were also identified and will be discussed in detail. In the mean time these factors will also be used as a basis for questionnaire development for the study

2.3.1.1 Change in defined scope

On many construction projects there will be a change in scope, time, cost and/or quality of work (Revay, 2003). In most cases scope change is made by owner's choice due to various reasons (O'Brien 1998, Al-Dubaisi A.H (2000) such as insufficient planning at the project definition stage, lack of owner involvement at the design stage, technological changes which requires owner to upgrade the project, availability of unexpected fund or change in project requirements as a result of change in projection or demography etc. According to Al-Dubaisi A.H (2000), Change of plan or scope of project is the most significant causes of change in construction. Any

change to the project scope almost always requires an adjustment of the project cost or schedule (Edward E. 2003). This type of change is costly especially if it is made latter in construction processes. To minimize the change in scope, the project should be well defined at planning stages.

2.3.1.2 Change of schedule by owner

According to O'Brien (1998 and Fisk 2000), change of schedule during construction phase may results reallocation of major resources. Due to time value of money this change is costly when it is compared with other changes such as material and scope changes. Because change in schedule may cause the contractor to provide additional resources in a short time to perform certain activity which is out of his schedule or idle some of his resources committed for a certain activity. In both case additional cost will be incurred.

2.3.1.3 Owner's financial problems

In the course of construction contract the owner of the facility may run into difficult financial situation that force him to make changes in order to reduce cost (Al-Dubaisi A.H, 2000) This problem affects project progress and quality (O'Brien 1998). O'Brien suggests that proper planning and review of project cash flow would be effective to minimize this problem.

2.3.1.4 Replacement of standard, materials and procedures

Replacement of materials, work procedure or a certain standard during construction which is specified in a contract originally is also one of the potential causes for variation because it requires a change order to substitute the specified materials or work procedures originally (Al-Dubaisi A.H, 2000, Arain & Pheng 2005 and O'Brien, 1998).

2.3.1.5 Obstinate nature

The success of construction project is the result of professionals combined efforts (Arain and Pheng, 2005b). If the owner or any contracting party in the project has an obstinate nature, it may be difficult to accommodate creative and beneficial ideas. This may later on cause major variations and affects the project adversely.

2.3.1.6 Change in design by consultant

Design related changes or variations for improvement are very common in construction projects (Mokbel, 2003 and Arain, 2005b). Most of the changes in design especially happen in projects where construction starts before design is finalized because of urgency. Arain & Assaf (2003) quoting Mendelssohn (1997) pointed out that; more than 75% of the problem encountered on site was generated at the design stage.

2.3.1.7 Inadequate contract documents

Inadequate contract document which includes non compliances of design and specification with owner, local authorities and standard requirements, lack of knowledge of available resources, error and omissions in design and specification ambiguous contract documents etc are also major causes of variation or in construction projects..

2.3.1.7.1 Non compliance of design and specification requirements

Inadequate design and specification can be frequent causes of variation in construction projects (Fisk, 2000). According to Fisk, although it depends on time of occurrence, design discrepancies affect project functionality and quality which ultimately affect projects adversely

2.3.1.7.1.1 Non compliance with owner requirements

Design is said to be comprehensive if it accommodate owner's requirements (Arain & Pheng, 2005a). Noncompliance with owner's requirements is considered to be inadequate design (Fisk, 2000). Non compliance of any of the contract documents results in variation to accommodate owner's requirements later during construction.

2.3.1.7.1.2 Non compliance with government requirements

Non compliances of design with government/local authorities' regulation is also one aspect of inadequate contract document because it may affect the safety and progress adversely and leads to serious accident and delay in project completion to reconsider these requirements.

2.3.1.7.1.3 Non compliance with standard requirements

Although it is not common since most of the designers are familiar with available standards, sometimes there is case that non compliances of design with available standard requirements might also contribute for variations in construction projects.

2.3.1.7.2 Lack of knowledge of available resources

Knowledge of available resources such as material and equipment is very important for developing a comprehensive design (Arian and Pheng, 2005a). Otherwise it will have a great contribution for variation to happen during construction.

2.3.1.7.3 Error and omission in design

It is impossible to create 100% error free design (Al-Dubaisi A.H, 2000). Mokebel (2003) also indicated that, error and omission are common in construction contract documents. Among the many project documents, one may find a not deleted item by mistake; it may consist of incomplete specification or unreferenced details or others. In order to correct these errors and omissions change order will be issued which will ultimately causes cost and schedule adjustment during construction.

2.3.1.7.4 Ambiguous and conflicting contract documents

In construction contract it is a common practice that different documents are prepared by different professionals during design stages (Arain & Assaf, 2003). In spite of close coordination between design professionals, sometimes conflicting and ambiguous documents might be found. In most cases, various contracts include guidelines as to which document governs in case of conflict. However, the contracting parties may not agree on the governing document (Al-Dubaisi A.H, 2000). The reason for this is, ambiguous design may be misinterpreted by project participant, leading to demolition and re-works which results in delay and additional project cost (O'Brien 1998).

2.3.1.8 Lack of proper communication and coordination

In multi-player environment like construction projects it is very important to have strong and proper communication and coordination continuously among all parties involved in the processes

(Al-Dubaisi A.H, 2000 and Arain & Pheng, 2005b). The owner should convey his new idea in timely basis to the consultant and the consultant should also update the contractor for any change as early as possible since it may result variation later. Nurul U. (2007) on the other hand indicated that producing quality design depends on effective coordination among diverse disciplines involved in the process.

2.3.1.9 Technology changes

Technology change is a potential cause of variations in construction projects. Many construction projects may face changes because of this reason especially when the period between design and construction is considerably longer (Al-Dubaisi A.H, 2000). In this case the proposed method of construction and materials to be used might be outdated.

2.3.1.10 Design complexity

Complex design may require the involvement of skilled professional and construction methods (Arain & Pheng, 2005 and Fisk, 2000). In the meantime it affects the flow of construction activities, whereas simple and linear construction works are relatively easy to handle (Fisk, 2000). Hence complexity may also be major causes of variations in construction projects especially when the required professionals and equipment to implement the construction method are not easily available in the surrounding.

2.3.1.11 Lack of professional experiences

Professional experience is an important factor for successful completion of construction projects (O'Brien, 1998 and Arain & Pheng, 2005). Because lack of professional experience will increase the risk of errors in design and construction which ultimately results in variations to rectify the error during construction.

2.3.1.12 Value Engineering (mechanism of saving cost for mutual benefit)

Arain and Pheng (2005b) recommend adapting the principles of value engineering during the design phase. They however have a reservation in exercising value engineering during construction phase. Their argument here is, it might be costly, as variation in any design element would initiate downstream variations to other relevant design components.

2.3.1.13 Lack of prompt decision making

Prompt decision making is an important factor for project success (Gray and Hughes, 2001). According to Fisk (2000), one of the most aggravating conditions is the length of time that elapses between the time at which change proposed and finally rejected or approved as a change order. Sometimes a delay in decision making may also be a cause for another variation since it hinders subsequent construction activities which sometimes cause variations latter.

2.3.1.14 Lack of required data

Considering all the relevant data and information in design can help participants to understand the actual situation. On the contrary lack of required data may results in misinterpretation and wrong assumption of actual requirements of projects both at design and construction stages (Arain and Assaf (2003) quoting Al-Hazmi, 1987). This may not satisfy the client need and ultimately results in variation or changes.

2.3.1.15 Lack of contractors proper evaluation of contract document at tendering phase

In order to avoid problems and pitfalls during the construction stage Edward E. (2003) recommends that the contractor to properly review the entire contract documents such as design and technical specification clearly prior to signing the contract agreement. Arain and Pheng (2007) similarly suggested that getting the contractor involved in design can minimize the interface problem between him and the designer and benefits the client out of his practical experience. In reality, it is difficult to practice this concept in traditional (design bid build) types of project delivery methods.

2.3.1.16 Unavailability of skills (shortage of skilled manpower)

Sometimes certain particular activity may require an expertise which may not be available in the local market. Because of this reason the owner or consultant may be forced to modify the method or procedures of construction (Arain & Assaf, 2003). This problem is more obvious and likely to occur in more complex projects.

2.3.1.17 Unavailability of equipment

Like unavailability of skilled manpower lack of pieces of equipment may force change to the plan. One of the reasons for these causes is the fact that some designs are prepared away from the location of construction by companies which are not familiar with the resources available locally.

2.3.1.18 Contractor's financial difficulties

There are many players involved in construction activities, these includes skilled and unskilled laborers, sub contractors, suppliers etc, whether she/he is paid or not the contractor should pay the wages of the workers, subcontractors and suppliers (Arain and Pheng, 2007). Contractor's financial problem may cause major variation in construction projects which affects the progresses of the work.

2.3.1.19 Contractor's strategy to get additional work with better unit price

Although no contractor admit this, some contractors welcomed variation as a source of additional work and an advantage to recoup the financial losses that may face in the main contract or to maximize their profit. In this case contractors placed themselves on a favorable position while negotiating the price for variation item (Al-Dubaisi A.H, 2000 and Marsh, 1998). Because of this contractors may eventually strive to convince the project owner to allow certain variations, leading to additional financial benefits for them.

2.3.1.20 Defective workmanship

Defective workmanship of completed work may bring demolition and re-work or it may bring changes in some instances (Fisk, 2000 and O'Brien, 1998). Arain et al. (2004) indicated that defective workmanship results in low quality in construction projects. Eventually, this may affect the project adversely and leads to rework as well as delay in the project completion.

2.3.1.21 Unfamiliarity with local conditions

Being familiar with local condition is one of the important factors for successful construction projects (Clough and Sears, 1994 quoted in Arain & Pheng, 2005). If the contractor is not aware

of the local conditions, it would be extremely difficult for him to carry out the work. As a result of this project may delay and it may also end up with vital variation.

2.3.1.22 Lack of specialized construction manager

The construction manager is responsible to carry out the project activities in an organized manner to eliminate delay and other problems on the project. However, lack of specialized project manager may lead to several problems, such as defective workmanship and delay in the overall schedule of the project which may result in variation.

2.3.1.23 Poor procurement processes of contractors

Poor procurement has numerous adverse effects on the processes in the construction cycle (Fisk, 2000). Occasionally, a delay in the contractor procurement processes may cause an entire design to be changed or replacement of originally specified materials as well as equipment for project (Arain *et al.*, 2004). This may result in project activities to be demolished and reworked.

2.3.1.24 Complex design and technology

Complex design and technology require detailed interpretation by contractor's since it may face him for the first time (Arain & Pheng, 2007). This may affect the flow of construction activities, leading to delays in the project completion because of rework and disruption of sequence of work schedule.

2.3.1.25 Lack of proper planning

Strategic planning is an important factor for successful completion of any project. O'Brien (1998) showed lack of strategic planning in construction project as a common cause of variations.

2.3.1.26 Differing site conditions

The real condition cannot be shown on drawings and specification or it cannot be determined during site investigation (Nurul U., 2007). If differing site conditions face during construction phase it may cause variation. In most cases the contractor is entitled to claim for the costs incurred and to sustain losses when such a case happens. Beyond variation, this may cause

dispute among parties if the claim by the contractor due to this variation is not considered by the owner.

2.3.1.27 Unexpected weather conditions

Weather condition can affect outside activities in construction projects (O'Brien, 1998 and Fisk 2000). This cause is considered as an example of force majeure discussed in various literatures. The cause may result in adjustment of contract schedule to compensate the lost time due to weather conditions which alter his work. In addition to this the contractor is also entitled to compensation of cost if the work done is damaged by this action (Al-Dubaisi A.H, 2000).

2.3.1.28 Change in government regulation

Normally the designer insures that his design is in compliance with the requirements of the local authority. However, there are situations in which new regulation may be issued between design and construction period which may force some changes to the original plan (Al-Dubaisi A.H, 2000).

2.3.1.29 Right of way (or access to site) problem

The issue of right of way in road construction is complex and time consuming as well as expensive (Mark T. and Murray F., 2004). According to (Mark T. and Murray F., 2004), in many cases, the right of way costs for new or expanded roadways exceed the cost for construction. These authors recommend designers to carefully consider every access point in every project in order to minimize design change after construction is started.

A report by the international law and labor organization about Infrastructure reconstruction after tsunami disaster in 2004 states that, although reconstruction of infrastructure benefits people majority of the people are reluctant to handover their land for public use. According to this report in many cases problems arise during processes of providing compensation to the community their land is handed over for infrastructure purpose. The report also indicated dispute between these communities and the government as a result of land accusation for infrastructure development was the most predominant issue on the ongoing rehabilitation and reconstruction processes. The report suggested law enforcement as one important solution to minimize dispute between land owners and the government. It further describes the community should be willing

to provide land for infrastructure development and the government in turn should be committed in providing replacement land and appropriate compensation.

Right of way problem is not limited to only land acquisition issues with the community. A report by Indiana road system utility reallocation task force indicated that utility reallocation becomes a major conflicting issue between transportation and utility industries, which are responsible for highway improvements and utility facilities. 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 cost 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 those arising from the relocation 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 forward 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.

2.3.2 Effects of Variation

Bruce (2006) said that “Change or variation affects every aspect of human endeavor, and construction is no exception”. Bruce also reported that a recent survey of professional engineers identified change as the major cause of project failure. Similarly, Al-Dubaisi A.H (2000) and Arain & Pheng (2005) indicated that, variation will affect not only the effectiveness of the project but it will affect the performance of the project team which is mainly indicated in terms of completion time and additional direct and indirect project costs as well as healthy professional and contracting parties relationships. Under this sub heading, the legal and cost aspect/impact of variation and the magnitude of this impact will be briefly described.

2.3.2.1 Legal Aspects

To understand legal aspects of variations it is required to refer literatures discussing on issues such as contract changes, clauses interpretation, substantiation and management of claims (Al-

Dubaisi A.H., 2000). In this case changes are considered as major sources of claims and disputes. The major legal aspects according to (CII publications 5-10 (1986), Cox 1997) cited in (Al-Dubaisi A.H. (2000) include,

- o Selecting the best delivery system (contract formats)
- o Drafting and interpreting change clauses
- o Documenting change orders to be readily available in case of dispute as well as litigation

2.3.2.2 Cost Aspects

There are many studies on changes in construction from cost point of view. These literatures are classified as either qualitative or quantitative. The qualitative studies discuss the various attributes of cost and schedule impact without quantifying them. Quantitative studies on the other hand attempt various attributes of cost and schedule impacts. Most of the quantitative studies on cost aspect of change were done in relation to productivity issues (Ibbs *et al.*, 1997, Hanna *et al.*, 1998). An extensive study by CII cited by many authors has great contributions on this issue.

Al-Dubaisi A.H, (2000) citing CII describes that quantitative assessment of change impacts are done for three different purposes. These are:

- o To predict change impacts before construction (by owner or contractor)
- o To calculate change cost during construction (for accounting corrective action)
- o To calculate change cost after project close out or for claim purpose

However attempts to quantify change impacts usually face two major problems (Ibbs *et al.*, 2007 and Hanna *et al.*, 1998):

- o Difficulty in collection and accuracy of data
- o Difficulty in assessing indirect impacts of changes

The cost impact of change is greatly affected by the timing of changes (Ibbs, 2003). According Ibbs, changes issued before construction has little effect as compared with change issued after construction has already started and materials have procured (Al-Dubaisi A.H, (2000) citing CII publication 6-10, 1990). Based on this research, the impact of changes are classified as follows,

- o Direct cost impact
- o Direct schedule impact
- o Indirect or consequential impact, the details of these will be briefly described in the following paragraphs

2.3.2.2.1 Direct Cost

The direct impacts are those limited to the work package in which a change is introduced. These cost impact could be positive (savings) to the owner or negative (more expenditure). From contractor's view of a change being positive or negative will be the opposite (Arain & Pheng, 2005). Sometimes a change may also have a positive or no cost impact at all for to both contractors and owners'. Direct cost has two components: labor cost and material cost. During quantifying the impact of change determining material cost is easy to estimate and predict to certain accuracy. However it is quite difficult to estimate labor cost due to the following reasons:

- o The effect of changes on the productivity rate which is difficult to quantify and,
- o The uncertainty about the scope of a change

Most of the literature about labor cost impact focus on the situation where change is issued after construction is already started. These literatures categorize labor cost of changes into three attributes (CII publication 6-10, 1990, cited in Al-Dubaisi A.H, 2000):

- a) Productivity degradation
- b) Delays
- c) Demolition and Rework

a) Productivity degradation

Interruption, delays and redirection of work, associated with change work have negative impact on labor productivity which in turn translates into labor cost. Many studies were conducted to evaluate this aspect of change (CII publication 6-10 (1990), Thomas et al 1994 & 1995, Hester et al 1991) cited in Al-Dubaisi A.H, (2000) : Most of these studies agreed that productivity drops with increased frequency of interruptions. They also noticed that as the rate of disturbances to the normal flow of work increases, the extent of productivity degradation becomes compounded by comparing the productivity index against the frequency of change. Their finding also indicates that more than 40% reduction in productivity was noticed with an extreme number of disturbances. In addition to this the researchers indicate that productivity of workers can be greatly affected in case where workers were required to work overtime for prolonged periods to compensate for schedule delays to accommodate changes. Tomas and Napolitan (1995) cited in Al-Dubaisi A.H, (2000) revealed that on average there was 30% loss of efficiency due to changes. These two authors and CII as cited by Al-Dubaisi A.H, (2000) also indicated that changes do not lead to productivity degradation or efficiency loss by themselves instead they

activate other disruptive influences which ultimately results in productivity degradations. According to these authors the most significant types of disruptions are lack of materials and information and performing the work out of sequences.

b) Cost of delay

Making a change and process takes time. This usually results in placing a hold on the work and waiting for new instructions to come. In addition, equipment, tools, materials and even some times professional may not be the same after the change is introduced. As a result of this procuring or renting new material, tools and equipment and hiring new professionals will cause delay and cost of resources may be substantially increase. Furthermore, if delays are prolonged demobilization/remobilization may become quite costly. The cost of delay may also be applied to engineering and procurement activities if impacted by change (CII publication 6-10, 1990) cited in Al-Dubaisi A.H (2000).

c) Demolition of works

Changes, which are introduced when the construction is underway or even complete, involve several direct cost items (CII publication 6-10, 1990) which can be summarized as follows;

1. Labor cost to demolish existing facility
2. Equipment cost to demolish existing facility
3. Materials wasted due to removal of existing work
4. Associated cost of engineering/such as transporting and handling of waste materials

2.3.2.2.2 Direct schedule impacts

It is easy to document a schedule impact of a change after change work is done, because all data can be easily available regardless of its accuracy. However, it is difficult to predict impact of change on schedule before making a change because of the many uncertainties related to labor productivity, material availability or job interference etc. Most construction projects are planned using a critical path method, CPM, (CII publication 6-10, 1990). This method of scheduling shows the activities included and their dependencies. CPM provides the basis against which impact of changes on schedule can be evaluated. Floats both total and free play an important role in schedule impact evaluation for they represent the flexibility available to handle the unforeseen conditions such as changes. The magnitude of schedule slippage due to changes is reported by

Zeitoun and Oberlender (1993) as 18% of the original schedule on average for 71 studied fixed price projects (Arain and Pheng 2005a).

2.3.2.2.3 Indirect or consequential impacts

There are always indirect impacts to changes that are overlooked or underestimated (CII publication 6-10, 1990). Consequential effects can occur later in other work packages and thus on the total project. Therefore it is essential to acknowledge this possibility and establish the mechanism to evaluate its consequences. The contract change clause should fully consider both direct and indirect (consequential) effects.

According to (CII publication 6-10, 1990), the following are some of the possible consequential effects resulted from changes or variations

1. Effects on the methods or procedures used in other work packages due to a change in a previous task or package
2. Degradation of productivity in subsequent packages or activity: According to Al-Dubaisi A.H (2000) earlier studies on productivity confirmed that degradation of productivity in the change package results in productivity degradation of subsequent packages.
3. Increase in overhead cost: it is obvious that if change has an impact on schedule, material or administration level and the project overhead increase proportionally due to prolonged contract period,
4. Impacts on subcontractors: in construction projects most subcontractors will prepare their own plan and schedule assuming that the main contractor will maintain the original conditions that allow start and end of work as scheduled. This may require the subcontractors to adjust their plans and schedule accordingly which in turn causes subcontractor to seek price and or schedule adjustments accordingly,
5. Miscellaneous: The following are some potential cost items overlooked which are resulted as a Consequence of changes or variation:
 - o Time value of capital tied due to a change
 - o shifting of work to a less favorable period
 - o Additional bonding and insurance
 - o effect on procurement activities

This indicates that changes in construction generate effects that far exceed the working package or activity in which changes occur. According to Thomas and Napolitan (1994) cited in Al-Dubaisi A.H (2000), this situation is called a “Ripple Effect”. They pointed out that, although much has been said about the ripple effect, there have been no quantitative studies showing the magnitude of these effects”. A study by Zeitoum and Oberlender (1993) cited Thomas and Napolitan (1994) reported that the study on ripple effects were not successful because of the respondents interpretation of the term ‘ripple effect’ as an example.

2.3.2.3 Magnitude of the Impact of Variation

The cost and schedule impacts of changes vary widely from one project to another. Although there have been cases where change cost accounted for as high as 100% of the budgeted funds, the industry norm of this percentage is about 10 %.(Arain & Pheng 2005a and 2005b).

Burati et al, (1992) cited in Al-Dubaisi A.H (2000), studied changes and their associated cost on new, retrofit and upgrading projects under the guidance of CII considering fixed price and cost plus contracts. The results showed that deviation (change) cost amounted to an average of 12.4% of the total project cost. Similar figures were cited by Zietoun and Oberlender (1993) for the cost growth because of changes. In this study 5.3% was the median accumulative cost growth and 9% the schedule growth. These results are for fixed price contract projects. Different results were given for cost re-reimbursable contract projects. In this study, the construction management delivery system experienced the highest cost growth (12.1%) and the lowest schedule growth. The open bid solicitation system showed a very high schedule growth which is about 18%.

2.3.2.4 Potential Effects of Variations

The effects of variations have been studied by many researchers (Thomas and Napolitan 1994, Arain & Pheng, 2005, Nor H’, 2006, Al-Dubaisi A.H., 2000, Nurul. H, 2000) etc. Under this heading the findings of some of these authors and all the potential effects identified from literature will be discussed.

Arain and Pheng (2005a) studied effects of variations in institutional buildings in Singapore. Their finding revealed that increase in project cost is the first most important effect of variation. Arian and Pheng further described that every major additions or alteration eventually increases

the project cost. In order to cater these variations most construction projects allocate contingency amount however in most cases the amount of variation exceeds this sum and results in cost overrun. The second frequent effect in this study was additional payment for contractor. The reason cited for this effect was contractors consider variations as common sources of additional work and an opportunity to achieve their desired profit margin. Next to additional payment to contractors, the third frequent effect of variation identified by Arain and Pheng (2005a) is disruption of progress which does not lead to delay in project completion schedule. Under many circumstances most standard conditions compel contractors to accommodate the variation work by utilizing free float in the construction schedule. Because of this some variation may not affect the completion schedule except only the progress of some activities within the project. They identified completion schedule as a fourth recurrent effect. According to Arain and Pheng, this is contributed by major variation and frequent minor ones. Increased in overhead expense for all parties which is because of processes and implementation of variation was the fifth frequent effect in the study of Arain & Pheng (2005a).

Similarly Al-Dubasi (2000), on his study of changes in Saudi Arabia construction projects pointed out, increase in project cost, delay in completion schedule, additional revenue to contractors, demolition and rework and increase in contractors overhead are the five top most important effects for construction projects in Saudi Arabia.

Nor H. (2006) on the other hand identifies increase in project cost, delay in payment, procurement delay, logistics delay and delay in completion schedule as the top most significant effect in Malaysia.

Ahmed Z. (2008) also investigated increases in project cost, delay in project completion lost of productivity, and rework at some part of the project and loss of opportunity as the top five most important effects of variations or changes.

Apart from these, many researchers carried out on the effects of variations orders in construction projects (CII 1986, CII 1990, Clough and Sears, 1994 Thomas and Napolitan, 1994, Fisk, 2000 and Ibbs *et al.* 1998). The effects identified from these literatures will be described below;

2.3.2.4.1 Progress is affected but without any delay

Variation during progress may affect the project progress and quality (Assaf *et al.* 1995). If the activity of variation issue is not on critical path, the contractor will utilize the free float to accommodate variation. In this case variation affects the progress but without causing any delay in the overall project completion.

2.3.2.4.2 Increase in project cost

Increasing project cost is the most common effect of variation in construction projects during construction phase (Arain and Pheng, 2005a). According to Nur H (2006), any major additions or alterations in the design eventually increase project costs due to various reasons such as hiring new professional and increased overhead expense to implement the change. Fisk (2000) described, specialized manpower is one of the integral resources required for complex projects. Therefore depending on the nature and its occasion, some variations may require hiring new professionals or changing in the entire project team. In addition to increasing project cost the situation may also affect the project progress greatly especially when there is no readily available professional in the market. The processes to implement variations in construction projects would also increase the overhead expenses (O'Brien, 1998).

2.3.2.4.3 Delay in payment (cash flow problem)

Delay in payment occurred frequently due to variation in construction (Arain & Pheng, 2005 and AL-Dubaisi, 2000). Because, variation may hinder the project progress and leads to delay in achieving the targeted milestones during construction work. This eventually affects payment to the contractor which in turn affects his overall cash flow and the payment to be made to suppliers and subcontractors since the contractor may not pay them unless he gets payment from the client.

2.3.2.4.4 Decrease in quality

Variation, if it is frequent it may affect the quality of works adversely (Fisk, 2000). Nor H. (2006) citing CII (1995) also indicated that quality of work was usually poor because of frequent variations.

2.3.2.4.5 Decrease in productivity

Interruptions, delays and rework which are associated with variation order have a negative impact on labor productivity. Thomas and Napolitan (1994) conclude that variation normally led to disruptions and these disruptions were responsible for labor productivity degradation. They also pointed out the most significant types of disruptions were lack of materials and information as well as the work out of sequence.

2.3.2.4.6 Demolition and rework

Rework and demolition are frequent occurrences due to variation in construction projects. Variation issued during the progress of the construction work or even after completion usually leads to rework and delay in project completion (CII, 1994 quoted in Arain & Pheng, 2007). Therefore rework and demolition are potential effect variation in construction projects. The degree of this effect depends on the timing of their occurrences (Ibbs, 2003), their effects are severe during construction stage since variations or changes at design stage may not require rework and demolition.

2.3.2.4.7 Delay in logistics supply (procurement processes)

Variations which are imposed while construction is underway may require suspension as well as revision of procurement request (O'Brien, 1998). Procurement delays may occur due to variation which requires new materials and equipment (Fisk, 2000). Arain & Pheng (2005a) observed that procurement delays were significant effects of variation in construction projects where variation in the construction phase required new materials, tools, equipments and other logistic supplies.

2.3.2.4.8 Disputes between contracting parties

Kumaraswamy *et al.* (1998) and Fisk (2000) identified that, variation as major causes of claims in construction projects. If this claims are not amicably solved they results in dispute that may affect the relation among contracting parties and between professionals of the contracting parties.

2.3.2.4.9 Damages to firm's reputations

If dispute among contracting parties occurs frequently, it may adversely affect firm reputations and it may leads to insolvency in some cases.

2.3.2.4.10 Delay in completion schedule

Delay in completion schedule is a frequent result of variations in construction projects (Ibbs, 1997). Nur H., 2006 quoting Zeitoum and Oberlender (1993), indicated that the magnitude of schedule delay as 9% of the original schedule by assessing 71 fixed price construction projects. Kumaraswamy *et al.* (1998) in his study on claims for extension of time due to excusable delay in Hong Kong's civil engineering projects also indicated that 50% of the projects surveyed were delayed as a result of variations.

2.3.2.4.11 Disruption of work (hold on)

Change in a certain work package can put the work on other activities on hold (Al-Dubaisi A.H, 2000). This happens when activities are interdependent. This action may freeze a certain craft crew or shift in schedule. Speedy and quick change order procedures are very vital in order to minimize this effect.

2.3.3 Management and Administration of Variation

2.3.3.1 Introduction

Since changes to the work are inevitable in construction projects, effective management of variations order processes should be given higher priority by all project participants (Bob M., 1997, Ibbs et al, 1997). According to Ibbs et al. (2001), effective management of variation orders in turn requires a comprehensive understanding of the root causes and their potential consequential effects. In agreement with Ibbs *et al*, Bruce (2006) also pointed out that, the ability to identify factors which causes variation or change is the first step in managing variation since it enables to manage them accordingly. Because of this the previous sections were dedicated on identification of the root causes and their consequences. Under this sub heading the management aspect of variation will be briefly discussed.

Both owner and contractor should play significant roles in establishing and maintaining well managed processes (Ibbs *et al.* ,2001) in change management because successful implementation of effective change management processes benefits both project owner and contractors (Edward E., 2003 and Bob M., 1997) indicates that in order to minimize variation and variation order

problems should be studied collectively at the earliest stage; this enables problems to be identified as early as possible and beneficial variation to be made at the right time which otherwise will have deleterious effect in any projects. Edward E. (2003) also suggested that the earlier that project resolves change processes, the more likely the project will be able to effectively manage changes. Because projects have a declining ability to recover the lost schedule and costs in their latter stages, that means implementation of changes during the construction phase takes time and diverts resources from the work effort. Besides giving more emphasis to project change management at the earlier stages Edward E. (2003) recommends that the overall change processes must be managed efficiently during all stages.

According to Bruce (2006), the term "Change Management" suggests that change can be controlled and we can tailor our response to change to minimize the risks of failure and maximize opportunities because according to Bruce, change is a major cause of project failure. Bruce (2006) forwarded two basic concepts during change management. These are;

- o Managing the processes of change
- o Administrating the change order processes

In order to facilitate the way to manage changes Bruce (2006) classified changes as anticipated and emergent change. Bruce indicated that the processes of managing anticipated changes is not difficult since it is a matter of processing planned events on the contrary managing and administrating the emergent change requires more thought.

According to Bruce (2006) process of managing variation is a similar task of fire fighting, his argument is like that of the fire department knows that fire will happen, the contracting parties also know that change will happen at some instance and provide a means on how to handle it, however like that of the fire protection department, the contracting parties in a construction may also know some times that when, what kind and how big the change or variation will happen. Similarly, in order to fight the fire, the fire department has all the necessary equipments, the resources, and the training in place to deal with any eventuality. Likewise contractors and owners need to develop similar tools in order to manage project changes. The discussion in the following paragraphs therefore will focus on such tools which enables the parties to prevent if not minimize changes.

Bruce (2006) classified the responses to change into two; reactive response and the anticipatory or proactive response. The project stakeholders need to act in a proactive manner to cope with changes in an efficient manner and not in a reactive way because dealing with changes in a reactive way may results unplanned consequences of delayed completion dates and claims for extra costs.

With this background, managing change means therefore implementing changes in a planned and systematic way with a main goal of achieving more effectively implementation of new or revised work on an ongoing project, as well as organization. Because changes not only impact the changed work, but when not properly controlled seriously impact the "unchanged" works too.

Many researches on management of variation or changes (Arain and Pheng, 2007, Al-Dubaisi A.H., 2000, *Gray and Hughes (2001)*, Bruce (2006) and Thomas and Napolitan, 1994) agree on a certain basic principle of managing changes or variations with slight differences. An extensive study on the subject of changes/variation by construction industry institute (CII),(1994) cited in Al-Dubaisi A.H.(2000) and Ibbs *et al.* (2001) proposed a project change management system (CMS) similar to the above authors.

The central idea of these variation management system proposed by many of the above researchers includes, identification of variations at the beginning stage followed by recognizing it, then evaluation of the variation to see its effect is important, after this it becomes easy to implement variation. As a final step, the researchers agreed that learning from past experience as an imperative step, because professional can improve and apply their experiences in future projects by taking proactive measures in order to reduce potential variation. The summary of these principle proposed by many of the above researchers result in the following variation management model.

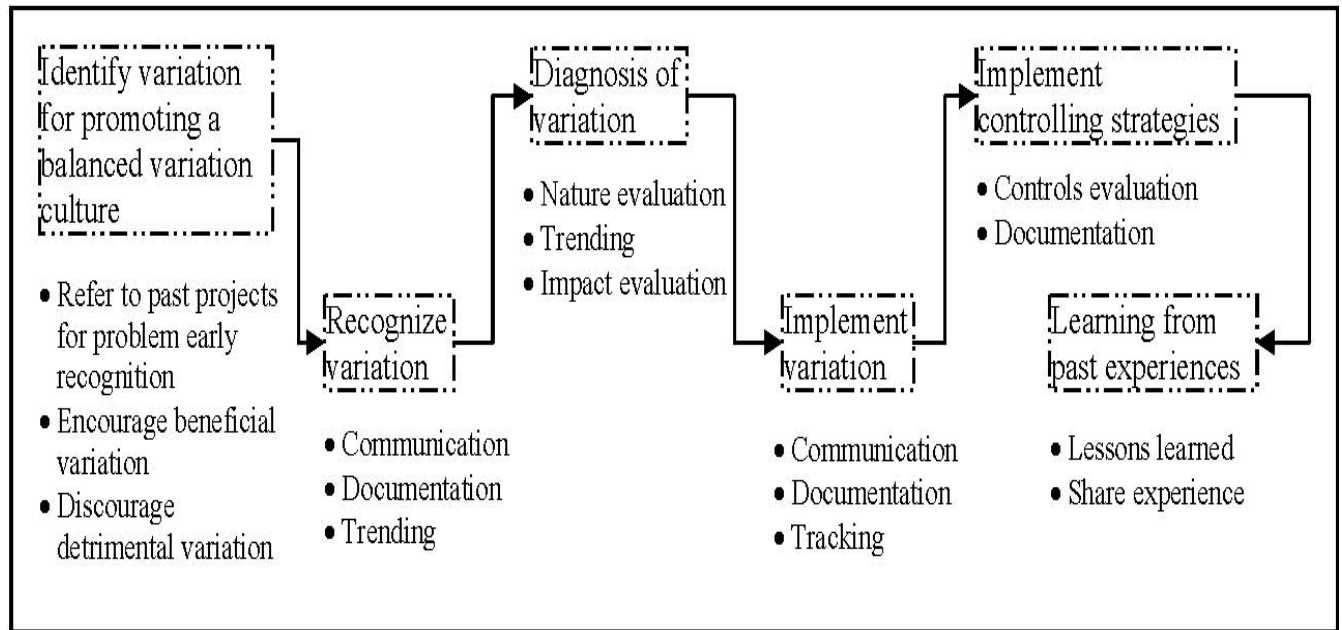


Fig 2.1; Fundamental principles of variation management model adapted from Arain & Pheng (2005b)

The study by the construction industry institute further described these fundamental principles in detail as follows;

a) Promoting a balanced change culture; According to construction industry institute (CII) this means allowing beneficial changes to proceed and discouraging or preventing detrimental. Detrimental changes are defined as “those that reduce owner value or have a negative impact on a project” and beneficial changes means the just the opposite. The recommends value engineering, understanding the basis of evaluation, financial justification for elective changes and maintaining accountability as a means to prevent detrimental changes from occurring.

b) Recognize change; construction industry institute (CII) described that; there is strong disagreement between various parties in construction project on what a change constitutes. Because of this CII recommends, establishing an environment that allows team members which openly communicate on changes or variation is very important.

c) Evaluate Change; this principle requires a change to be classified as required or elective. CII describes required changes as required to meet original objectives of the project while elective changes as additional features that enhance the project.

d) Implement Change; According to CII, in the implementation of changes flexibility of team members in the project at any point on the schedule is crucial. In order to effectively implement

changes Established procedures must be set for authorization and documentation. Authorization assures all parties to be communicated regarding the change and that the change can be implemented. The research team stressed that the implementation process should contain a documentation system to follow up on the cumulative impact of changes.

e) Continuously improve from the lessons learned; Many other studies and the study by CII emphasized the need to learn from the lessons of past projects executed by an organization. Be it in change management or any other project strategies and philosophies should take advantage of lessons learned from past similar projects from the outset. CII research team concluded that if this processes is properly implemented significant amount of construction cost can be saved.

2.3.3.2 Controlling Variation

Al-Dubaisi .H. (2000) citing W. Bruce Pruitt (1992) presents one of the proverbs proposed by Harold Kerzner ‘If project content is allowed to change freely, the rate of change will exceed the rate of progresses. Tiong (1990) studied various controls that should be provided for all phases of a major project: Tiong stated change order as one of the major issues that should be controlled. In the mean time in agreement with Ibbs *et al* (2001) in previous section, he suggested that change order control system should be established for the ultimate benefit of both owner and contractors.

Spurting this concept, Dellon (1986) also described that “As construction costs continue to rise, the use of project management techniques is needed to ensure credibility and productivity”. This means as the project cost increases it requires more attention since it becomes complicated and difficult to manage. As an extension to this, Dellon and many other researchers such as (Kaming *et al*, 1997 and Kumaraswamy *et al.*, 1998b) indicated that change orders have a significant contribution for growth of both project cost and time schedule. This indicates that change control is essential to minimize the consequences of changes.

With this understanding, various controlling mechanisms have been suggested by many researches (CII publication 6-12, 1990, Ibbs *et al.* 2001 and Arain and Pheng 2005b). Fig 2.2 below summarizes some of the controlling mechanism at design, at the interface of design and construction and construction stage suggested by various researchers.

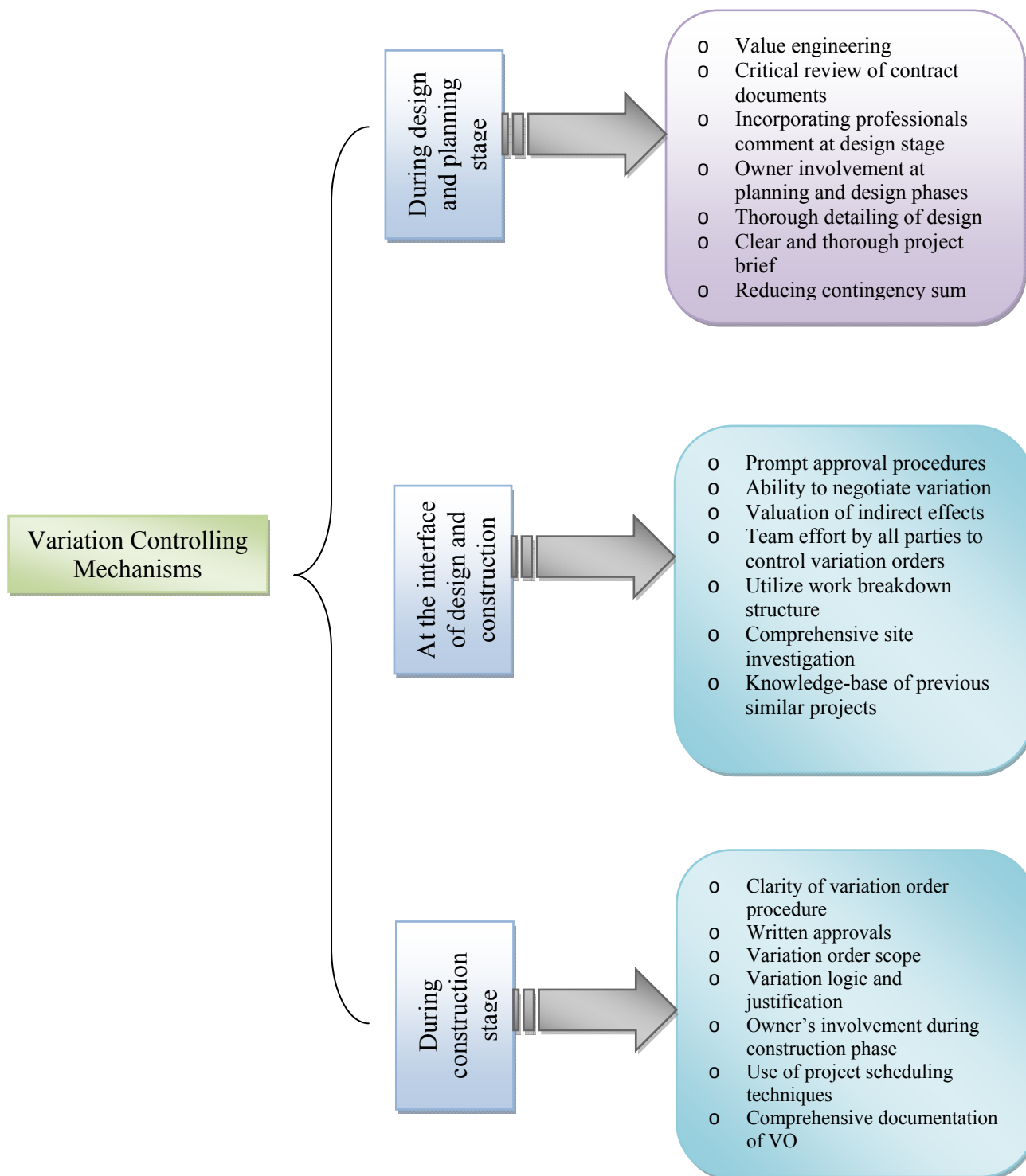


Fig 2.2; controlling mechanisms for variations order adapted from Arain and Pheng (2005)

Table 2.2; Summary of literature review on controlling mechanism Adapted from Arain and Pheng (2005b)

Stage	Controlling mechanisms	Description
A) Design	1. Value engineering at conceptual phase	Value engineering at design stage can be exercised as cost saving mechanism, since this can assist in clarifying project objectives and reducing design discrepancies at the early stage (Arain and Pheng, 2005).
	2. Critical review of contract documents	Contract documents are the main source of information for any project. Critical review of this document at design stage will minimize ambiguity and conflicts between contract documents which ultimately results in misinterpretation of the actual requirement of a project
	3. Incorporating professionals comment at design stage	According to O'Brien, 1998, involvement of professionals at this stage would assist in developing a comprehensive design with minimum discrepancies by accommodating their practical ideas. On the other hand, not accommodating this practical ideas during the design phase may affect the project adversely.
	4. Owner involvement at planning and design phases	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, 2000). Hence, this may help in eliminating variations during the construction stage where the impact of the variations can be severe
	5. Thorough detailing of design	A clearer design tends to be comprehended more readily (O'Brien, 1998). Because this would also assist in identifying the errors and omissions in design at an early stage before construction going on. This eventually minimizes variations arising from ambiguities and errors in design.
	6. Clear and thorough project brief	A clear and thorough project brief is an important control for variations in construction projects (O'Brien, 1998) since it helps in clarifying the project objectives to all the participants
	7. Reducing contingency sum	The provision of a large contingency sum may affect the participants' working approaches (Arain and Pheng, 2005). This may causes the designer not develop a comprehensive design and encourage him to relay on rectifications in design as variation orders during the later stages of the construction project.

B) At Design- construction interface	1. Prompt approval procedures	As it is previously described, According to Fisk 2000, 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. 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.
	2. Ability to negotiate variation	Ability to negotiate variation is an important factor for the effective control of variation orders Arian and Pheng (2005) quoting (Clough and Sears, 1994). The authors suggested that, Effective negotiation can assist the professional team in minimizing the negative impacts of the variation. They also recommend that, parties in the processes should have the following skills and information to effectively i.e., the knowledge of contract terms, project details, technology, labor rates, equipment, methods and negotiation skills.
	3. 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 a mechanism to evaluate these consequences (Ibbs <i>et al.</i> , 2001). According to (Fisk, 2000), Indirect effects of variations will have substantial ultimate effects for complex project (Fisk, 2000). Professionals should thus evaluate the total overall effects a change may have in the long run, to manage variation order effectively
	4. Team effort by all parties to control variation orders	Coordination is important in a multi-participant environment as in most construction projects (Assaf <i>et al.</i> , 1995). Detrimental variations, which affect the projects adversely, can usually be managed at an early stage with due diligence in coordination.
	5. Utilize work breakdown structure	A work breakdown structure (WBS) is a management tool for identifying and defining work (Arian and Pheng, 2005). 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 activities can be easily checked. According to Arian and Pheng, 2005, Ripple effects of variations can also be traced by the use of WBS.

		Currently time space diagram is also used widely than that of WBS
	6. Comprehensive site investigation	Comprehensive site investigations essential to develop proper planning for construction activities (Fisk, 2000). As mentioned earlier, Assaf <i>et al.</i> , 1995 concluded differing site conditions as one of the important cause of delays in large building projects. Therefore, a comprehensive site investigation would help in reducing potential variations in a project
	7. Knowledge-base of previous similar projects	A knowledge-base would facilitate an effective management process (Arian and Pheng, 2005 and Ibbs <i>et al.</i> , 2001). From the outset, project strategies and philosophies should take advantage of lessons learned from past similar projects (Arian and Pheng, 2005). If professionals have a knowledge-base established on past similar projects, it would assist them to plan effectively before starting a project, both during the design phase as well as the construction phase, minimize and control variations and their effects.
C) Construction	1. Clarity of variation order procedures	Clarity of variation order procedures is an integral part of effective management of variation orders (Arian and Pheng, 2005). Because clarifying variation order procedure to all parties at early stage in the project life, would help in reducing the processing time and other mishandling issues (Ibbs <i>et al.</i> , 2001).
	2. Written approvals	Any variation in the work that involves a change in the original contract must be approved in writing by the owner or his representative (Arian and Pheng, 2005 quoting (CII, 1990a; Hester <i>et al.</i> , 1991; Cox, 1997)). Because verbal agreements can be forgotten, leaving the contractor without any legal proof to get compensation for the variations
	3. Variation order scope	A well defined scope helps the professional team in recognizing and planning appropriately to minimize the negative impact of the variation (Ibbs <i>et al.</i> 2001). CII (1994b) cited in Arian and Pheng (2005), pointed out that defining the variation scope is a common disagreement between parties in a project. Thus, the effective definition of the scope of work is of paramount importance to identify and manage variations.
	4. Variation logic and justification	Knowing the logic behind any variation and justification for implementation is one of the principles of effective change management proposed by Ibbs <i>et al.</i> (2001). The principle required a change to be classified as required or elective. According to these authors required

		changes are changes which are necessary to meet original objectives of the project while elective changes are additional features that enhanced the project. This enables the professionals in promoting beneficial variations and eliminating detrimental variations.
	5. Owner's involvement during construction phase	Like that of the design stage involvement of the owner during the construction phase would also assist in identifying noncompliance with the requirements and in approving the variations promptly (Ibbs <i>et al.</i> , 2001). In addition to this enables him to be aware of ongoing activities and assist in prompt decision making.
	6. Use of project scheduling techniques	Managing variation means being able to anticipate its effects and to control, or at least monitor, the associated cost and schedule impact (Arian and Pheng, 2005). Using one of the most known scheduling techniques in the construction industry is helpful in identifying the downstream effects of any variations on subsequent construction activities. Arian and Pheng, 2005 suggested that this may assist in eliminating detrimental effects.
	7. Comprehensive documentation of VO	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 (O'Brien, 1998). According to Fisk, 2000, 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. Arian and Pheng (2005) suggested that the documentation of variation orders and claims assist to track the effects of variation and claim events on time and cost. Besides this, a documented source of knowledge about previous variation orders is also helpful in learning from past experience from similar projects on how to handle variations

2.3.3.3 Administration of variation

2.3.3.3.1 Introduction

The purpose of this sub chapter is to provide an overview on variation or change order process starting from initiating until the change is ready to be implemented. In order to successfully

implement change order administration there must be a number of important forms and guidelines that must be followed and adhered. According to Al-Dubasi (2000), failure to follow these steps might jeopardize the right of a contractor to collect fair compensation for a change and unable to properly control the cost and schedule impact to the client/owner.

Because of this, most standard forms of contract include a clause under which the employer or his representative is able to issue an instruction to the contractor to vary the works which are described in the contract. It will also usually include a mechanism for evaluating the financial effect of the variation and there is normally provision for adjusting the completion date. In the absence of such a clause the employer will not have a means to vary the work in a given contract which might be essential for proper execution of the project.

Due to this fact, every major company as an owner has its own forms and procedures to properly manage the processes of change. In the following paragraphs change order processes recommended by Bureau of Engineering Project Delivery Manual (BoEPDM) (2009), the provision of FIDIC (1987) and MoWUD (1994) will be briefly discussed.

According to BoEPDM (2009) the purpose of this Procedure is to provide an overview of the change order process which is used to implement and document changes to the construction contract. BoEPDM defines change order as a document issued to the Contractor to identify required changes to the original plans, specifications, or other contract documents. Upon successful negotiation of the associated changes in project scope, cost and schedule, the final change order with the proper signatures becomes a legal amendment to the construction contract.

2.3.3.3.2 Responsibility

In order to effectively administrating change orders, the guideline by BoEPDM assigns specific tasks for key professionals participating in the project. According to BoEPDM (2009), the project manager is authorized to make any variation whatever he think is essential for the project. In addition to this BoEPDM assign specific tasks for construction manager and project engineer in the administration of variations.

According to BoEPDM(2009), the Project Manager: is responsible for monitoring both the frequency and scope of change orders and their impact on the project's budget and schedule and for obtaining authorization when the change exceeds the contingency fund reserved for the project. In addition, the PM is responsible for monitoring errors and omissions through the review of change orders to possibly assign liability to the design consultant at the project's end in this guideline. Although it is not explicitly stated in FIDIC (1987) and MoWUD (1994) the Engineer has also the same authority like that of the project manger stated under BoEPDM (2009)

2.3.3.3 Procedure

Change orders may be required for a variety of reasons in construction projects, but according to BoEPDM (2009) most often changes are resulted from unforeseen conditions, errors and omissions, or changes in scope. These are the three change order categories used by the Bureau. BoEPDM and other Authors (such as Al-Dubasi H., 2000) agree that changes may be initiated /requested by the Designer, Owner, Contractor, or may be initiated directly by the Engineer. The procedure for initiating and processing change orders adapted from Canada research council, 2008 is presented in following Flowchart (Fig 2.3).

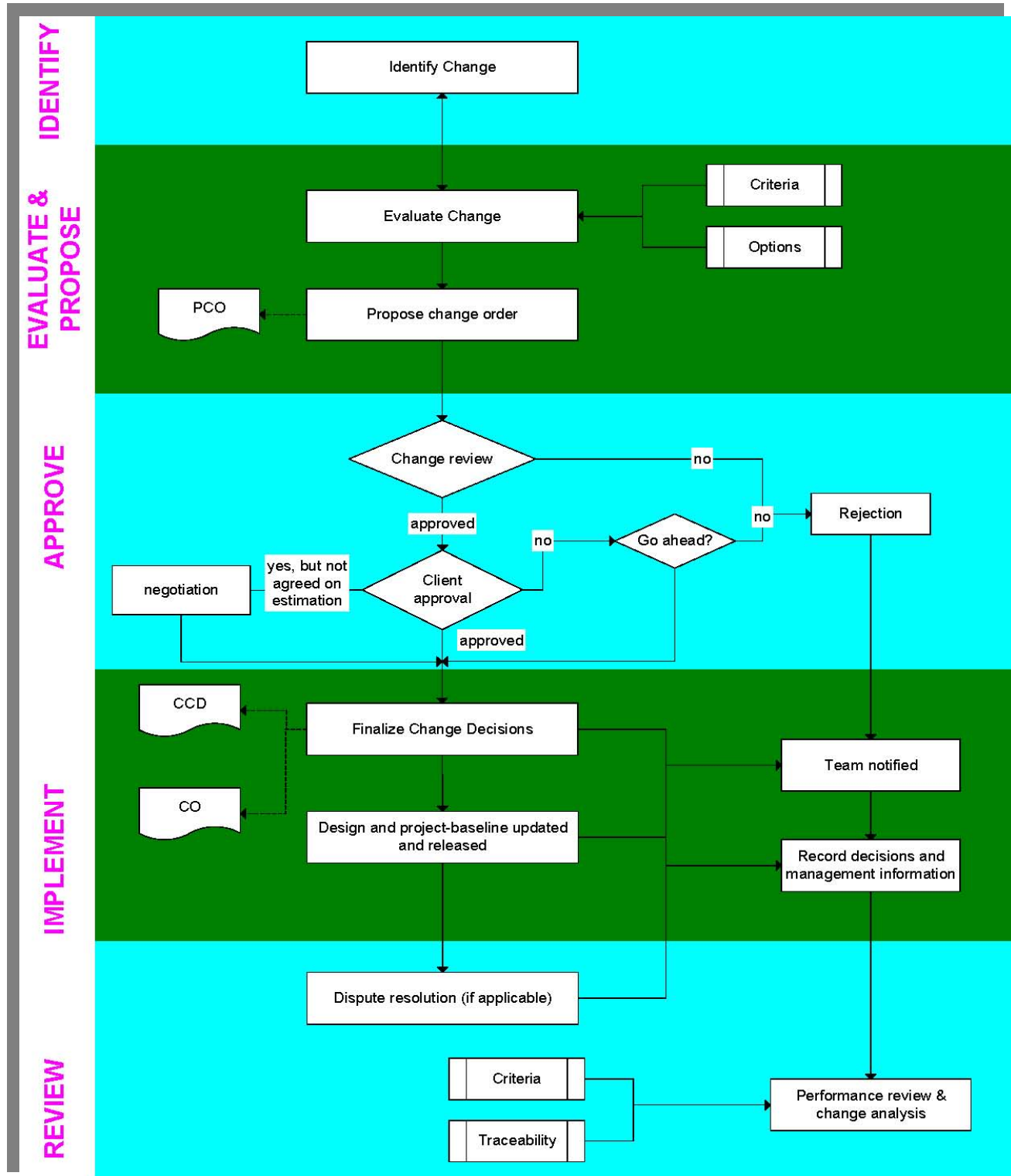


Fig 2.3; Flow chart showing the processes of change order (source. Canada research council, 2008)

The following are the key elements of the change order process depicted in the flowchart (Fig 2.3).

1. Identify and define the required change.
2. If it is required, prepare a Change Order Initiation Form that includes a preliminary cost estimate and an estimate of the impact to the project schedule.
3. When required, obtain authorization for the change from the concerned body (in most cases the client).
4. Issue any one of the following types of change orders:

a. Preliminary Change Order: to request a cost quotation and time impact Analysis from the Contractor for the proposed change prior to starting the work. The common practice according to FIDIC (1987 and MoWUD (1994) regarding this issue is almost same with the BoEPDM manual.

b. Emergency Change Order: to direct the Contractor to start work prior to negotiating the cost when the change is urgent. In this case BoEPDM recommends specifying a not-to-exceed Price limit or amount. However, FIDIC (1987 and MoWUD (1994) does not specify any thing in this regard. Both FIDIC and MOWUD however described that, the variation shall be issued to the contractor in writing and the value shall be valued based on the provisions under valuation of variation in each documents which are almost the same.

c. Time and Materials change order: According to BoEPDM (2009) it is issued to the contractor to proceed with the work within a specific not-to-exceed dollar amount, while documenting daily labor, material and equipment costs. This concept is addressed in a similar way in both FIDIC (1987) and MoWUD (1994) as day work. In both cases, the Engineer can issue an instruction to the contractor if in his opinion it is necessary or desirable to execute any varied work on a day work basis. The Contractor shall then be paid for such varied work under the terms set out in the day work schedule included in the Contract and at the rates and prices affixed thereto by him in the Tender. In this case the contractor is expected to consult the Engineer for expenses.

5. Negotiate all cost and time changes with the Contractor. All three that is MoEPDM (2009), FIDIC (1987) and MoWUD describes in order to fix the rate of new items which is not specified in the contract and some related time and cost impact of the change the contractor and the Engineer as well as the Employer/ client should negotiate properly.
6. If the negotiations fail and the Contractor do not agreed on a suitable rate or day work basis to perform extra work and the change is necessary, a Unilateral Change Order is issued to the Contractor to immediately proceed with the requested change the amount determined reasonable by the Engineer. According to BoEPDM this shall be used only when absolutely necessary since the Contractor will likely dispute the amount.
7. Finally the issue the final Change Order to finalize the processes.

A) Initiating Change Order

Changes may be initiated directly by the Engineer, Design consultant, Owner, or Contractor (FIDIC, 1987, MoWUD, 1994 and BoEPDM, 2009), however Each change request must be carefully reviewed against the project plans and specifications to verify the necessity of a change to the construction contract and should be approved by the Employer/client or Employers representative.

Prior to initiating a change order the Engineer must identify and clearly define the required change to the construction contract by carefully reviewing all change requests to verify that the proposed change is required and will necessitate a change to the construction contract. According to BoEPDM (2009), this requires a thorough review of the entire project document which includes the project plans and specifications, all information, submittals, schedule updates and correspondence, as well as good judgment and careful interpretation of the contract documents.

Once a thorough review of the required documents is done, the first step in the change order initiation process is to identify the party requesting the change (i.e., the Contractor, Designer, or Owner) and the reason for the change order. After identifying the specific reason for the proposed change, the Engineer must clearly define the extent of the proposed change, including required changes to the work and the contract documents

Then, the Engineer must review the cost of the proposed change. Typically, this cost analysis is presented as a rough order of magnitude cost estimate

After identifying and clearly defining the scope of the change and its associated cost and schedule impact, the Engineer should complete the Change Order Initiation Form if it is required for the project. In order to have clear understanding of the change, all documents including sketches, reviewed plan or specification etc should be attached to the form. Then the change order should be approved by all responsible/concerned bodies if applicable.

B) Processing change orders

Regardless of the type of change order, preliminary, emergency or day work type, the following three key elements for processing a change order remain the same:

1. Issue the change order.
2. Review the Contractor's cost quotation and time impact analysis.
3. Negotiate/reconcile all cost and time changes with the Contractor.

C) Finalizing change order

After negotiating its cost and time impact, a change order may be "finalized" by issuing any one of the following three types of change orders;

Change Order: When the cost and time impacts of a change order are jointly agreed upon, the Engineer shall issue a change order, which documents the agreed, upon scope, cost and schedule adjustments to the construction contract. The change order processed through this procedure becomes a legal and binding amendment to the construction contract.

Unilateral Change Order: If the cost and time impact of a change order *cannot* be successfully negotiated and one of the following conditions applies, the Engineer may issue a unilateral change order which documents the scope, cost, and schedule an adjustment that deems reasonable: When it signed by the authorized bodies, the unilateral change order constitutes an amendment to the construction contract; however, the Contractor has a legal right to dispute the cost and time adjustments set under this change order.

Cancelled Change Order: If the cost and time impact of the proposed change cannot be successfully negotiated and it is elective, the owner can totally cancel the change order, in this case, the Engineer must notify the Contractor and other concerned parties in writing that the change order is already canceled

2.4 Summary of Literature Review

In order to have conceptual and contextual basis on the research objectives in depth literature review have been conducted on identification of causes, effects and the management aspect of variations.

Based on this the first part of this literature review introduces some general ideas about variations or changes which includes definitions and types of variations. After having a clear vision about variation and its classifications the review concentrated on identification factors which contribute variation to happen and its consequences (effects). Through this review 35 potential causes that contribute for variations and 12 possible effects were identified and establishes the base for questionnaire development. Under sub heading of 2.3.1 and 2.3.2 the identified potential causes and effects have been briefly described.

Through the in depth literature review processes the researcher realizes variation as an investable phenomena in construction projects. Recognizing this fact the third sub chapters of the literature review dedicated on how to control and administrate variations in construction projects. In this sub headings the various controlling mechanisms of variations and the way how to administrate it has been thoroughly discussed.

CHAPTER THREE

3. RESEARCH DESIGN & METHODOLOGY

3.1 Introduction

According to Kumar (1999), research is defined as processes of collecting, analyzing and interpreting information to provide solution for question or problem. With this background research design and methodology is therefore a means which ties up all the research processes jointly and guides the researcher to achieve the aim and objectives of the study. That means it is a plan of constructing the research structure to show all the most important parts of the research together.

With this understanding, the purpose of this chapter is therefore to present research methodology/procedure which will be followed to achieve the ultimate goal of the research which is specified at the beginning.

3.2 Research Approach

The overall study approach is summarized in Figure 3.1 below. It explains how the entire study is planned and implemented to achieve the research objectives in the research processes.

The research started with problem identification which has been done through unstructured literature review and informal discussion with colleagues and professional in the sector. As an output of this step cause of variation and their effects in Ethiopian Federal road construction projects were identified as a proposed problem to be studied.

Once the research area is identified conceptual and contextual literature review have been done to have an in depth understanding on the research topic and its objectives focusing on causes and effects and methods on how to control/minimize variations and its consequences. The review includes books, journal and articles, internet sources and archival document search such as progress and completion reports with Ethiopian Roads Authority, the implementing agency of the road sector development program in Ethiopia. The document search was mainly intended to

collect values of variations orders and their causes from some upgrading and rehabilitation projects which are undergoing and already completed through random selection.

After an in-depth review of literature, a questionnaire was designed and distributed to contractors, consultants and the employers (ERA) staffs to get their professional opinion out of their experience.

Upon obtaining the desired data, checking and sorting of data has been done. This was followed by analysis to obtain the result and thoroughly discussions in order to draw a conclusion and to forward recommendations based on the finding of the study.

3.3 Sources of Data and Data Collection Approach

Nurul (2000) quoting Brukley et al (1976) grouped the methodology of data collections under four headings, namely opinion research, empirical research, archival research and analytical research. According to Brukley each method has its own strength and limitation none of the above methods is superior that of the other. The choice which one to use is decided based on the research/survey objective, the nature of the information and resources available (Jobber, 1991 quoted in Nurul, 2001).

To identify the major causes and consequential effects of variation order in Federal Road construction projects in Ethiopia, a desk study approach and questionnaire survey were carried out. The purpose of the desk study was to obtain actual data from the source documents which included the contract documents, variation orders and progress as well as completion report to have contextual bases on variations in Ethiopian road sector development program. Besides this a literature review to develop conceptual basis for the study was also conducted side by side. Through the above literature review, potential causes, effects and methods of controlling and administration of variation orders were identified. The review provided the basis to design the questionnaire which was distributed to professionals involved in the road sector program.

For the questionnaire survey the respondent was randomly selected from the employer's organization (ERA), contractors and consultants both domestic and international who have been

involved in the road sector development program. The questionnaire which consists of both open and close ended question was distributed among these professionals.

The answer for the structured questionnaire was rated based on Likert's-scale of five ordinal measures of agreement on each contributing factors (from 1-5) to identify potential causes. For the effect part respondent are requested to put the possible effects corresponding for each contributing factors by rating the most recurrent effects based on their experience.

First the possible factors that causes variation or changes are identified, in this case respondents are asked about their agreement on whether variation in Ethiopian construction industry are a problem or not based on the following scale of measurements.

- ☐ Agree
- ☐ strongly agree
- ☐ Disagree
- ☐ strongly disagree

After this they are asked to compare variations with other problems in construction industry, reasons for claims by contractors and activities that are more subjected for changes in order of priority, the contribution of variation towards cost and time overrun and in percentage and the reason why variation clauses are included in a contract to enrich the information related the objectives the research and to check the consistency of the response by respondent.

Once these basic questions are answered by the respondents then they are asked to about the potential of each factor in causing variation or changes according to the frequency of occurrence and their impact on cost and time over run based on the following scale of measurements.

For frequencies of occurrence

- 1- No occurrence
- 2- Low occurrence
- 3-Medium occurrence
- 4- High occurrence
- 5-Very occurrence

For impact on cost and time over run

- 1- No impact
- 2- Low impact

3-Medium impact

4- High impact

5-Very impact

After identification of the most important factors that contributes in causing variations or changes, respondents are asked to indicate the responsible parties for the causes and most affected party/parties out of the effects or consequences of variation or changes from various stakeholders involved.

3.4 Sample Size

The required sample size for the research for each parties involved in the survey was determined statistically using the following expression (Kish, 1995 cited in Arian and Pheng 2005b).

$$n_0 = (p \cdot q) / V^2 \dots\dots\dots [3.1]$$

$$n = n_0 / [1 + (n_0 / N)] \dots\dots\dots [3.2]$$

Where:

n_0 : First estimate of sample size

p: The proportion of the characteristic being measured in the target population

q: Complement of p or 1-p

V: The maximum standard error allowed

N: The population size

n: The sample size

To maximize n, p was set at 0.5. The target populations, N were no specific value, 34, 37, 16, and 15 for the employer, Domestic contractors, domestic consultants, International contractors and international consultant respectively. The list of contractors and consultants currently involved in road construction projects were obtained from Ethiopian Roads Authority (ERA). To account for possible error in the respondent answers from the questionnaire, the maximum standard error V was set at 10% or 0.1. Substituting in Equations 1 and 2 above, the minimum required samples were calculated to be 25, 14.4, 14.9, 10.46, and 9.33 for the employer, Domestic contractors, domestic consultants, International contractors and international consultant respectively. This means that the minimum sample size of 25, 15, 15, 11, and 10 for the employer, Domestic contractors, domestic consultants, International contractors and international consultant respectively is statically acceptable for analysis of the responses.

A survey of 69 professionals that has been involved in the Federal road upgrading construction projects in Ethiopia was carried out. The professional included directors, Department heads, section heads and project engineers from employer's side, Resident and contract engineers from the consultant's side, project managers and site engineers from the contractor's side. A 5-point likert scale was used in the questionnaire to gauge the most important causes based on their rate of occurrence, their impact on time and cost overrun. For the effects part respondent was asked to indicate the corresponding effects for each cause in rank 1-5 on the sides of each cause. However majority of the respondent rank the first three effects for each cause. Because of this only the first three ranking was considered for the analysis. The scale of measurement to calculate the mean score which is converted in to percentage later is;

3- for the first rank

2- for the second rank and,

1-for the third rank,

Finally respondents were requested to propose possible measures which minimize variation in order to minimize the effects and their response was analyzed qualitatively.

3.5 Method of Analysis

In this research both descriptive and inferential statistics were used for analysis of data collected from various sources. The mean score method of analysis was implemented to rank the causes of variations or changes in Ethiopian Federal Road construction projects based for on frequencies of occurrence and their impacts on time and cost overrun. Then average of the mean score of these three (i.e. frequency of occurrence, impact on cost overrun and impact on time overrun) was calculated to determine the overall ranking based on the three criterion. The consequential effects of the corresponding identified causes were be described as a percentage of respondent responses. The mean score (MS) for each potential factor of variations is computed using the following expressions.

$$MS = \frac{\sum (fxS)}{N} \dots\dots\dots [3.3]$$

Where:

MS = Mean score

f = frequency of response for each score

S = score given to each factor (0 to 4)

N = Total number of responses for each factor

In order to test the agreement, strength and direction of relation between different parties or factors, the Spearman's rank of correlation was implemented because of its advantages of not requiring the assumption of normality and or homogeneity of variances. In this research it is used to show the degree of agreement between the different parties involved in the survey. The correlation coefficient varies between +1 and -1, while -1 results from a perfect negative relationship (disagreement). On the other hand a sample estimate correlation close to unity in magnitude implies good or strong correlations, while value near to zero indicates little or no correlation. This correlation coefficient is used to measure and compare the association between the rankings of two parties for a single cause, while ignoring the ranking of the third one. And it was calculated using the following formula.

$$r_s = 1 - \left[\frac{6 \sum d^2}{(n^3 - n)} \right] \dots \dots \dots [3.4]$$

Where:

r_s = the Spearman's correlation coefficient between two parties

d = the difference between rank assigned variables for each causes

n = the number of parties of rank

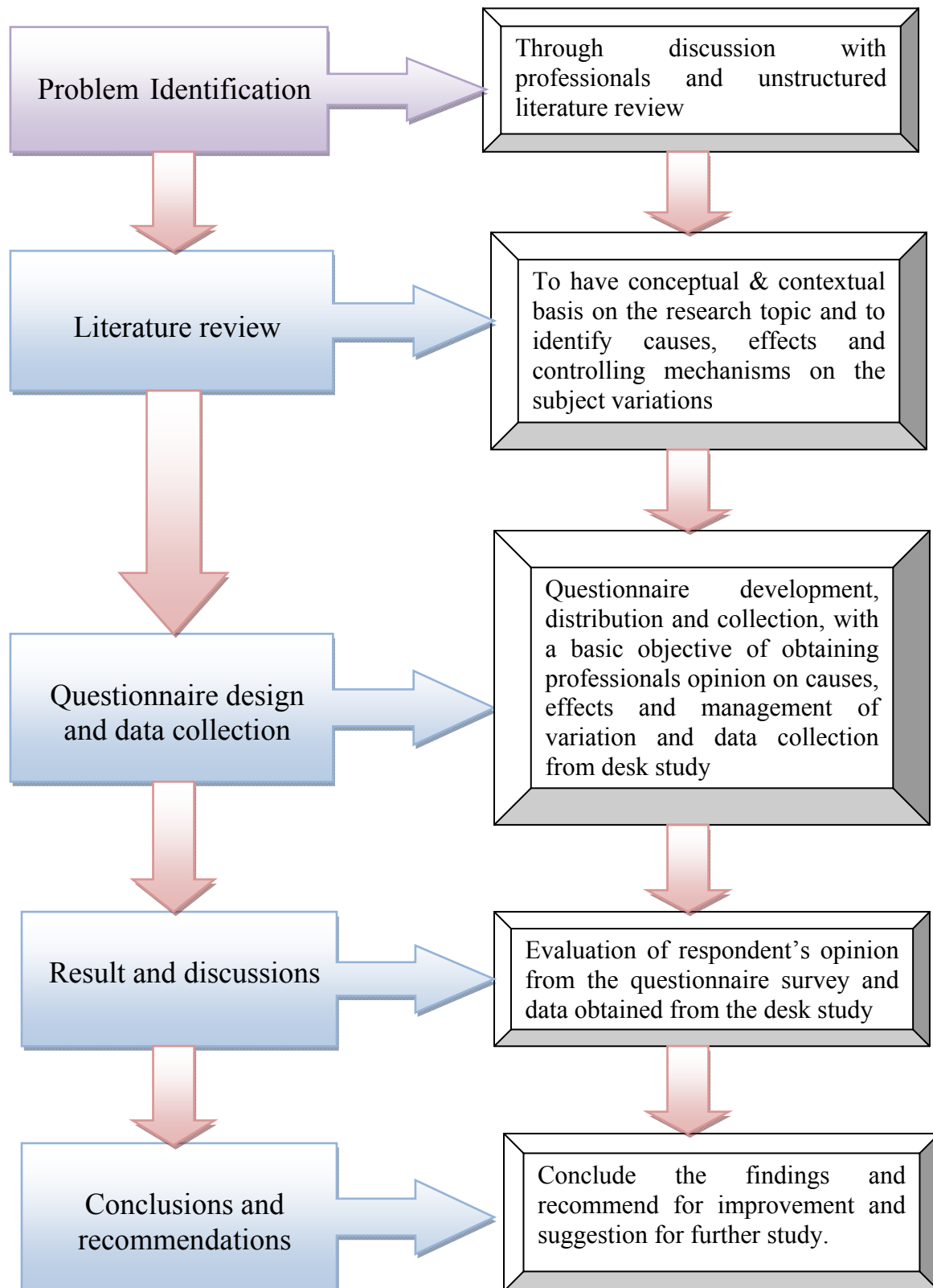


Fig 3.1; Flow chart of brief research methodology

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1 Introduction

In this part of the research the result of the data analysis gathered from both desk study and questionnaire survey will be presented, interpreted and analyzed and discussed in detail to justify the existence of the problem, identification of causes and their consequences together with initiators of each causes and most affected parties as a result of these causes.

In the questionnaire survey first respondent were asked to expresses their opinion on the existence of variation as a problem in Ethiopian construction industry by choosing any one of the four alternatives, “agree”, “strongly agree”, “disagree” and “strongly disagree”. Once they indicated this, respondents were then asked to forward their opinion on both increases in project cost and schedule, to prioritize which problems are more critical in contract administration and which activity brings most of the variations in construction projects, finally they were asked to respond on identification of causes, effects and the initiators of the causes and most affected parties with each causes side by side.

The reason for the development of the questionnaire in this manner was to obtain a continuous flow on what causes variations in Ethiopian road construction projects, who initiates/causes most of these variations, what is their consequences and who is more affected with each variation issue. As the ultimate goal of this research is to minimize variations order in Ethiopian Federal road construction projects so as to minimize its effects this will have a great contribution to forward possible mitigation actions. From this point of view the questionnaire was comprehensive to extract more information and to identify, the initiators/ responsible parties, the consequences of each cause and the most affected parties corresponding to each causes.

However, it was somehow cumbersome, time taking and requires respondent’s interpretation to realize one in terms of the other since the variables (i.e. causes, initiators, effects and most affected parties) were interconnected each other. In this sense I have to be honest to say that the

questionnaire was a demanding. To the contrary questionnaire should be easy to respond and consumes less time as much as possible. Therefore I relay appreciate my respondents who completed this demanding questionnaire by taking their precious time.

In addition to the questionnaire survey, a desk study was also conducted within the road sector implementing agent head office (ERA). The documents referred during the desk study include progress and completion report, contract and claim submittal, variation orders, dispute review experts report, correspondent's letters and other important documents. The purpose of the desk study was to investigate the amount of variation as compared to the original contract amount and to identify the reason why the change or variation was made. The data gathered in this processes will be presented in sub heading 4.2 and it will be briefly discussed under 4.3.

4.2 Background of respondent and questionnaire survey response rate

Out of the 69 questionnaires 23 were distributed for Employers staff, 22 for consultants and 25 for contractors which are involved in Federal Road Construction projects. The survey was conducted between December 2008 and February 2009. Out of the distributed 69 questionnaire, 48 professionals responded to the survey which is 15(65 %), 11(79 %), 8 (62%), 5 (63 %), 9(82 %) from Employer, Domestic Consultants and, Domestic Contractors, International Contractor and International Consultants respectively.

Before starting the analysis, the returned questionnaire was checked for their reliability and out of the 48 questionnaires 46 were found to be suitable for data analysis. This yields a response rate of 66.67%. The details of respondent responses and its rate is summarized in Table 4.1.

Table 4.1; Questionnaire survey response rates

Respondents Category	Questionnaires		Percentage	Valid responses	Percentage
	Distributed	Returned			
Employer	23	15	65%	15	65%
Domestic Consultants	14	11	79%	11	79%
Domestic Contractors	13	8	62%	7	54%
International Contractors	8	5	63%	5	63%
International Consultants	11	9	82%	8	73%
Total	69	48	69.57%	46	66.67%

4.3 Existence and extent of the problem

The first step in this research was to check whether variation exists and it is a problem in Ethiopian Federal road construction projects as well in Ethiopian construction industry which is one of the specific objectives of the research.

To answer this question, data was gathered from some completed and undergoing Federal road construction projects. In the mean time professional involved in the road sector program was also asked to express their opinion on whether variation is a problem or not in Ethiopian Federal road construction projects as well as in Ethiopian construction industry. The result (data) obtained from both sources revealed variation as one of the major problems in Ethiopian Federal road construction projects and this is also an indication it is a problem in Ethiopian construction industry too.

As it is indicated in Fig. 4.1 below 86.96 % of the respondent for this research acknowledged variation as one problem in Ethiopian construction industry, the remaining 13.04% however do not agree on the subject of variation as a problem. Out of the 86.96%, 32.61% (37.5%) of the respondent strongly agreed and 54.35% (62.5%) simply agree on variation as one of the major problem in Federal road construction projects.

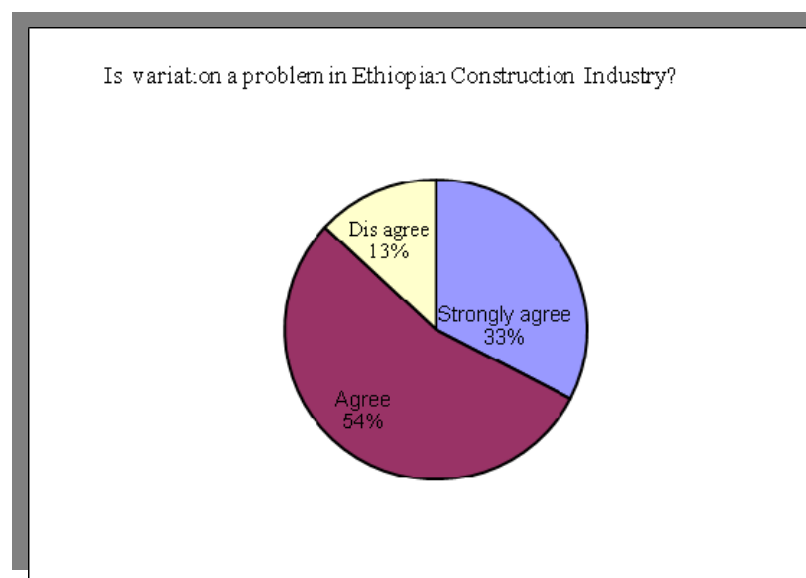


Fig. 4.1; Respondent responses on whether variation is a problem or not in Ethiopia

Similarly the following data from Federal road construction projects depicted that variation is one of the major problems in Ethiopian Federal road construction projects. As it is indicated in Table 4.2 below the percentage of variations in some randomly selected Federal road construction projects exceeds to the extent 100% of the original contract amount. And the average value of variation order was determined to be 30.41% which is much more than identified in literatures.

Table 4.2, Number, Amount and percentage of variation in some randomly selected road projects

No	Project	Original contract value [Birr]	No of VO	Amount of VO [Birr]	Variation [%]
1	A	346262115.21	5	37104544.98	10.72
2	B	405973872.1	38	446359748.9	109.95
3	C	177338107.7	4	8090984	4.56
4	D	289838439.1	18	192278636.2	66.34
5	E	162178583	12	4340410.9	2.68
6	F	310979872.9	30	75217827.39	24.19
7	G	341179223.9	1	99012622.34	29.02
8	H	283224198.6	3	32324419.81	11.41
9	I	172533963.00	5	70639441	40.94
10	J	256542439.1	12	8251296.66	3.22
11	K	56425487	10	10138171	17.97
12	L	395575959.6	5	2829119.17	0.72
13	M	327070830		85309861.18	26.08
	Total	3525123091.12		1071897083.48	30.41

To reinforce this concept further, professionals involved in the road sector program were also asked to forward their opinion on increase in project cost and schedule due to variation. The result for this is summarized in Fig. 4.2. The figure shows that the percentage increase in project cost due to variations. According to this Figure majority of the respondent which is more than 60% of the respondent indicated that increase in project cost due to variation ranges between 6-20%. This is much more less than the average value obtained in the desk study (30.41%). Both of the sources indicated that the amount of variation is considerable and requires some attention.

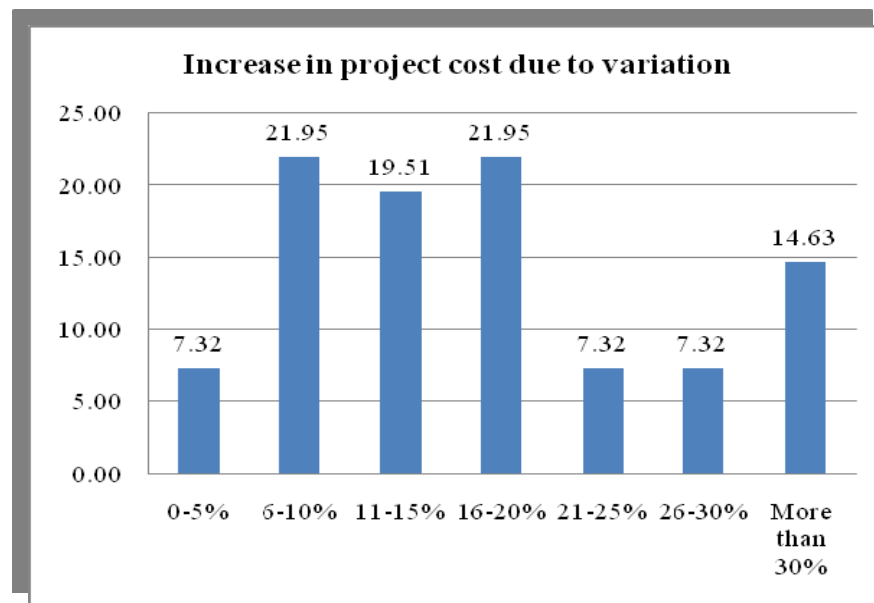


Fig. 4.2, Respondent responses on increase in project cost due to variation

The same has been done for increase in project schedule; the result for this question is presented in Fig 4.3. According to this Fig, majority of the respondent (more than 60%) indicates that the contribution of variation for schedule slippage is more than 20%. Interpreting this fig more, 62.5% of the respondent (out of the 60%) indicated that the contribution ranges between 21-30%, and the remaining 37.5% on the other hand said even it is more than 30%.

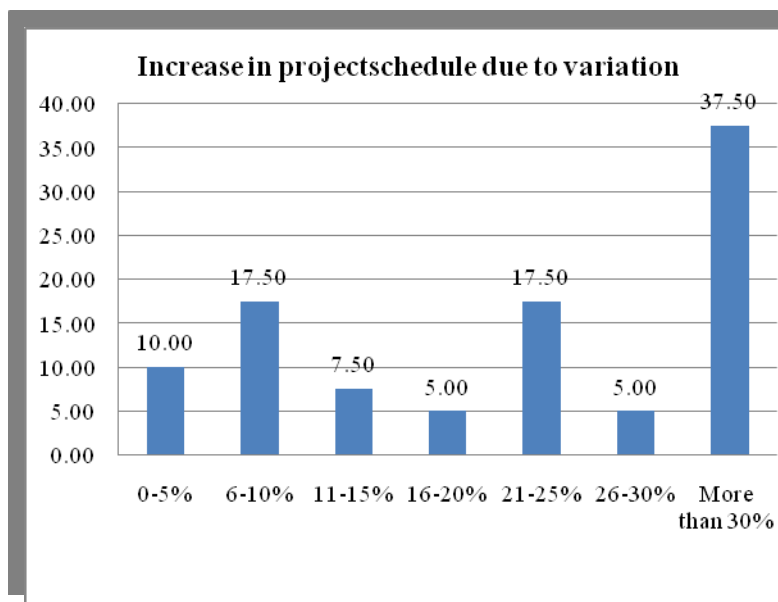


Fig. 4.3, Respondent responses on increase in project schedule due to variation

Once variation is identified as a problem in the road sector program based on both the desk study and the questionnaire survey, it will be useful to have an overview on, how significant is the problem as compared with other major problems such as delay, cost overrun and quality issues etc., which activity is more subjected for change or variation and the degree of its impact on both time and cost. Of course it is difficult to judge variation independently as a problem in comparison with the above problems since one is the cause for the other. However it is also important to know the extent of the problem and its contribution as a problem in Ethiopian construction industry.

To achieve this, respondents in the questionnaire survey were asked to forward their opinion on, how significant is variation as an independent problem in comparison with others and which activities are more subjected to variation/changes more frequently.

Based on this Fig. 4.4 and Fig.4.5 demonstrates the response of respondents on how significant is variation as a problem in Ethiopian Federal Road construction projects and the activity which is more subjected for frequent changes/variations. Although variation and claims/dispute are the causes for delay and cost overrun an attempt was made to compare these issues as an independent problem to see the extent of these issues as a problem by themselves. With this understanding, the result in Fig. 4.4 below indicated that variation as one of the most significant problem in contract administration next to delay in Ethiopian Federal Road Projects.

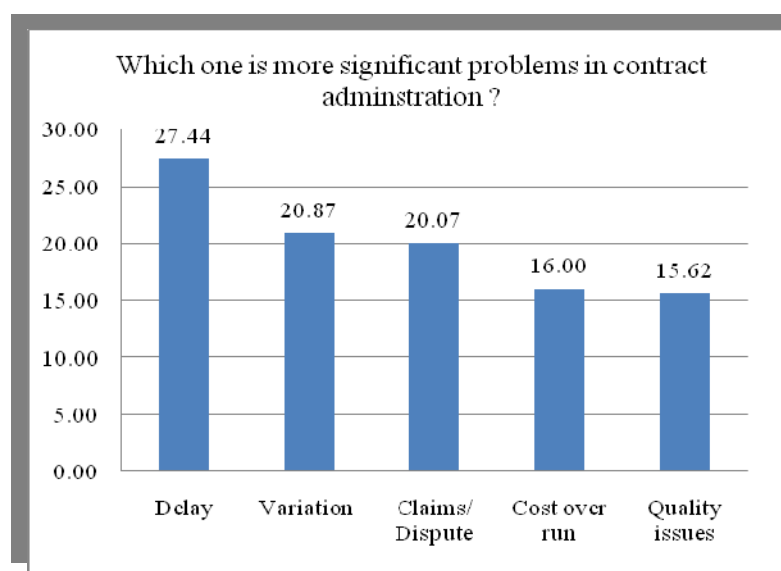


Fig. 4.4, Respondent responses on more significant problem in contract administrations

Similarly, the result in Fig. 4.5 indicated that Earth work as an activity which causes variation in Ethiopian Federal road projects next to drainage structures.

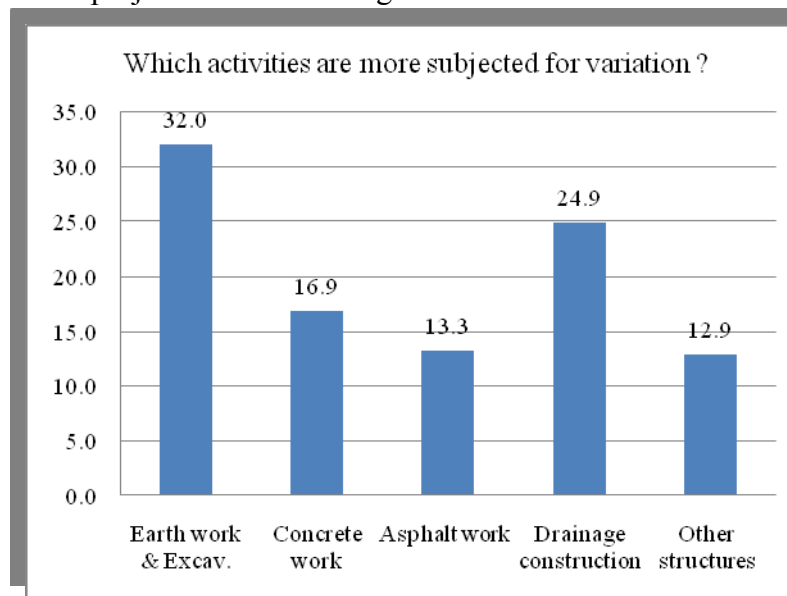


Fig. 4.4, Respondent responses on which activity more subjected for variation

The result obtained from the desk study and questionnaire survey which is discussed above indicated that, variation as one of the most significant problem in managing road projects within Ethiopian Federal Road Sector development program.

4.4 Analysis of Results

After identifying variation as one of the major problems in Ethiopian Federal Road projects and indicating its extent (the magnitude of its impact on cost and time), It will be so crucial to identify what causes this variation, which party initiates which causes, what is the consequential effects of each cause and which party is most affected as a result of these causes.

Taking this into consideration, this sub chapter will present the result of the analysis from both desk study and the questionnaire survey on major causes, initiators, effects and parties which are more affected as a result of the identified causes and effects.

The questionnaire listed 35 potential causes and 12 effects of variations for Federal road Construction projects. Each respondent was asked to rate the 35 potential causes and to rank the top 5 recurring consequential effects out of the 12 effects listed for each causes based on his/her

professional judgment from their experiences. In addition to this, respondents was also asked to indicate the initiators/ responsible and the most affected parties as a result of each of these causes as well as consequential effects. The analysis result of the respondent response on causes, initiators, consequential effects and that of most affected parties as a consequence of each cause is summarized in Table 4.3.

For each causes their consequential effects are indicated in (column 12, 13 and 14), who initiates them are also indicated in (column 8,9,10 and 11) and the most affected parties by each cause are summarized under (column 15, 16 and 17). Moreover the mean score for each of the three criterions that is frequency of occurrence (column 3), impact on cost (column 4) and impact on time (column 5) and the average of all three together (column 6) is also summarized and the ranking based on the average of the three criterion indicated in (column 7) of Table 4.3.

Besides this, the rank of each potential causes by all parties involved in the survey were also analyzed and summarized in Table 4.4 below in order to have an overview on which cause is most important for which parties.

Table 4.3, Summary of questionnaire survey results on causes, initiators, consequential effects and most affected parties by each causes

Rank	Potential causes of variations (factors contributing for variations)	Rating of causes based			Average MS	Rank	Responsible/Initiator(s)				Major consequential effects for each causes			Most affected party		
		Occurrence	Impact on cost	Impact on time			CL	DCS	SCS	CT	1	2	3	Client	Contractors	End users
		MS	MS	MS												
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
29	Right of way problems (access to site)	4.19	3.95	4.37	4.17	1	49.1	10.9	16.4	23.6	D	A	L	40.00	41.54	15.38
1	Change in defined scope (Additions or omissions)	3.51	3.89	4.11	3.84	2	46.6	8.2	31.5	13.7	A	D	B	53.13	32.81	12.50
25	Lack of proper planning	3.69	3.60	3.88	3.72	3	24.0	4.0	24.0	48.0	D	A	G	34.43	55.74	6.56
14	Lack of contractors proper evaluation contract document at tendering phase	3.64	3.64	3.77	3.68	4	9.6	7.7	7.7	75.0	D	A	L	32.76	53.45	13.79
18	Contractors financial problems	3.63	3.30	4.00	3.64	5	9.3	2.3	7.0	81.4	D	E	G	22.41	56.90	18.97
7.3	Error and omission in design and specification	3.41	3.74	3.63	3.59	6	12.7	47.3	20.0	20.0	A	D	L	41.94	45.16	12.90
13	Lack prompt decision making (quick response)	3.59	3.55	3.64	3.59	7	41.3	6.7	32.0	20.0	D	A	B	33.33	46.03	20.63
7.4	Ambiguous and conflicting contract documents (design, spec. \$ others)	3.23	3.80	3.70	3.58	8	22.4	41.4	15.5	20.7	A	D,L	K	44.12	44.12	11.76
17	Equipment shortage	3.47	3.21	3.93	3.53	9	7.0	0.0	4.7	88.4	D	G	A	21.31	55.74	19.67
16	Shortage of skilled manpower	3.49	3.35	3.64	3.49	10	16.0	16.0	25.9	42.0	F	C	A	30.30	53.03	15.15
6	Design changes by consultant	3.33	3.51	3.62	3.49	11	21.8	20.0	52.7	5.5	A	D	B	48.33	45.00	6.67
22	Lack of specialized construction manager	3.35	3.42	3.63	3.47	12	8.9	2.2	15.6	73.3	D	A	G	24.53	67.92	5.66
7	In adequate contract documents	3.32	3.50	3.49	3.43	13	33.9	32.2	11.9	22.0	A	D	L	47.54	42.62	9.84
11	Lack of professional experiences	3.19	3.49	3.56	3.41	14	12.3	21.9	27.4	38.4	A	D	F	36.11	47.22	13.89
15	Lack of required data	3.23	3.43	3.57	3.41	15	22.8	31.6	17.5	28.1	D	A	B	32.26	53.23	11.29
26	Differing site conditions	3.30	3.36	3.52	3.39	16	18.8	25.0	16.7	39.6	D	A	G	34.48	56.90	5.17
2	Change of schedule	3.31	3.07	3.51	3.30	17	24.6	3.5	14.0	57.9	D	A	J	28.57	51.79	17.86
23	Contractors poor procurement processes	2.98	3.31	3.50	3.26	18	23.9	4.3	6.5	65.2	D	A	E	32.76	50.00	13.79
27	Unexpected weather conditions	3.11	3.05	3.59	3.25	19	7.7	11.5	11.5	69.2	D	A	G	35.29	48.53	14.71
7.2	Lack of knowledge of available resources	2.84	3.34	3.18	3.12	20	14.0	28.1	15.8	42.1	A	D	G	26.00	62.00	12.00
19	Contractors interest to improve their financial difficulties	2.98	2.94	3.39	3.10	21	7.9	2.6	7.9	81.6	D	G	E	26.53	57.14	14.29
20	Defective workmanship	2.95	2.98	3.37	3.10	22	9.1	3.6	27.3	60.0	H	D	F	31.67	51.67	15.00
4	Replacement of standard of the road and construction procedure	2.09	3.41	3.46	2.99	23	51.8	8.9	25.0	14.3	A	D	L	38.46	38.46	23.08

8	Lack of proper communication and coordination	2.84	2.84	3.09	2.92	24	21.6	8.1	33.8	36.5	D	G	A	40.54	41.89	17.57
3	Owner's financial problems	2.43	2.95	3.38	2.92	25	79.5	0.0	2.6	17.9	C	D	B	20.63	57.14	22.22
21	Unfamiliarity with local conditions	2.77	2.79	3.05	2.87	26	3.8	19.2	11.5	65.4	D	A	E	22.00	66.00	10.00
12	Value engineering (a mechanism of saving cost)	2.68	3.03	2.78	2.83	27	28.8	16.9	23.7	30.5	A	D	F	32.50	62.50	2.50
7.1.b	Non compliance of design & specification with Government requirements (Local or Federal)	2.41	2.87	3.00	2.76	28	52.5	27.5	12.5	7.5	A	D	B	43.14	31.37	25.49
10	Design complexity	2.50	2.67	2.88	2.69	29	14.8	48.1	18.5	18.5	D	A	G	29.55	63.64	4.55
5	Obstinate nature (Don't considering others constructive idea)	2.49	2.64	2.84	2.66	30	23.3	16.3	25.6	34.9	D	A	G,K	28.26	54.35	15.22
7.1.a	Non compliance of design & specification with Owner requirements	2.29	2.71	2.89	2.63	31	41.0	33.3	12.8	12.8	A	D	B	51.11	28.89	20.00
7.1.c	Non compliance of design & specification with Standard requirements	2.23	2.82	2.76	2.60	32	26.2	33.3	26.2	14.3	A	D	B	43.40	37.74	16.98
28	Change in government regulation	2.35	2.84	2.61	2.60	33	68.3	2.4	4.9	24.4	A	D	E,L	39.58	45.83	12.50
24	Complex design and technology	2.26	2.57	2.93	2.59	34	18.2	41.8	16.4	23.6	A	D	G	29.27	58.54	9.76
9	Technology changes	2.09	2.48	2.62	2.40	35	22.2	17.5	23.8	36.5	A	D	J	37.21	60.47	2.33

For the effect part the letters under column 12, 13 and 14 refers the following:

A Increase in project costs
 B Suspension of work
 C Delay in payment
 D Delay in completion time
 C Delay in Logistic supply
 F Decrease in quality

G Decrease in productivity
 H Demolition and Rework
 I Damage firm reputation
 J Affects progress without delay
 K Damage professional relations
 L Results dispute among parties

The abbreviation under responsible parties/initiators represents;

MS= Mean Score
 CL=Client/Employer
 DSC=Design Consultants
 SCS=Supervision Consultants
 CT=Contractors

Table 4.4; Summary of questionnaire survey results on causes of variation (rating of each factor by all parties involved in the survey)

Potential causes of variations (factors contributing for variations)		Employers		Domestic Contractors		Domestic Consultants		International Contractors		International Consultants	
		MS	Rank	MS	Rank	MS	Rank	MS	Rank	MS	Rank
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	Change in defined scope (Additions or omissions)	4.04	2	3.86	11	4.00	2	3.53	18	3.33	3
2	Change of schedule	3.09	22	3.48	17	2.85	24	4.27	2	3.57	2
3	Owner's financial problems	2.59	32	4.05	8	2.94	23	2.75	29	2.50	29
4	Replacement of standard of the road and construction procedure	3.27	17	3.00	24	3.26	16	2.70	31	2.26	34
5	Obstinate nature (Don't considering others constructive idea)	2.45	34	2.96	25	2.56	34	2.87	26	2.81	18
6	Design changes by consultant	3.38	14	3.98	9	3.47	14	3.80	8	3.14	7
7	In adequate contract documents	3.52	9	3.33	20	3.64		3.67	10	3.00	13
7.1.a	Non compliance of design & specification with Owner requirements	2.87	28	2.61	29	2.76	27	2.20	34	2.29	33
7.1.b	Non compliance of design & specification with Government requirements (Local or Federal)	3.31	15	2.11	35	2.74	29	2.58	32	2.29	32
7.1.c	Non compliance of design & specification with Standard requirements	2.71	29	2.44	31	2.58	32	2.58	33	2.56	26
7.2	Lack of knowledge of available resources	3.02	24	3.43	19	3.17	19	3.47	20	2.71	20
7.3	Error and omission in design and specification	3.62	7	4.07	7	3.63	9	3.67	11	3.00	14
7.4	Ambiguous and conflicting contract documents (design, specification and other contract doc.)	3.69	6	3.62	14	3.67	6	3.67	12	3.10	9
8	Lack of proper communication and coordination	2.89	27	2.81	26	3.13	20	3.13	25	2.64	21
9	Technology changes	2.20	35	2.29	32	2.66	30	2.73	30	2.33	31
10	Design complexity	2.71	30	2.21	33	2.80	25	3.33	23	2.44	30
11	Lack of professional experiences	3.52	10	3.32	21	3.80	3	3.63	14	2.62	22
12	Value engineering (a mechanism of saving cost)	3.00	25	2.61	30	2.45	35	3.53	17	2.62	23

13	Lack prompt decision making (quick response)	3.47	12	4.14	6	3.53	11	4.13	3	3.00	15
14	Lack of contractors proper evaluation (review) of design and specification at tendering phase	3.93	4	3.71	13	3.80	4	3.87	7	2.81	19
15	Lack of required data	3.20	19	4.29	4	3.07	21	3.93	5	3.02	12
16	Shortage of skilled manpower	3.30	16	4.43	2	3.43	15	3.60	15	2.95	16
17	Equipment shortage	3.52	11	3.76	12	3.50	13	3.60	16	3.33	4
18	Contractors financial problems	3.77	5	4.33	3	3.67	7	3.53	19	2.90	17
19	Contractors interest to improve their financial difficulties	3.22	18	3.55	16	2.58	33	3.93	6	2.53	27
20	Defective workmanship	3.18	20	3.18	23	3.00		2.87	27	3.19	6
21	Unfamiliarity with local conditions	2.93	26	2.71	28	2.80	26	3.40	22	2.62	24
22	Lack of specialized construction manager	3.40	13	4.19	5	3.23	17	3.67	13	3.05	10
23	Contractors poor procurement processes	3.15	21	3.43	18	3.20	18	3.73	9	3.05	11
24	Complex design and technology	2.56	33	2.19	34	2.74	28	3.47	21	2.17	35
25	Lack of proper planning	3.98	3	3.90	10	3.53	12	4.00	4	3.14	8
26	Differing site conditions	3.60	8	3.29	22	3.77	5	3.33	24	2.57	25
27	Unexpected weather conditions	3.04	23	3.57	15	3.57	10	2.77	28	3.24	5
28	Change in government regulation	2.67	31	2.76	27	2.63	31	2.20	35	2.52	28
29	Right of way problems (access to site)	4.09	1	4.52	1	4.22	1	4.47	1	3.71	1

As shown in Table 4.3 and 4.4, 35 causes of variation orders were tabulated according to their mean score values. To ascertain whether the rankings of the 35 causes by different parties which are employers, domestic contractors, domestic consultants, international contractors and international consultants were correlated using spearman's correlation coefficient. The result in Table 4.5 indicated that the ranking by the employer and domestic consultants were strongly correlated, there was also a good correlation between the employer and domestic contractors. The strong correlation between the employer and domestic consultants are an employee of the client it is obvious that consultants need to keep the interest of the client in most cases. The less correlation between employer and domestic contractors indicated that the two parties may pointed the causes towards one another. Furthermore Table 4.5 indicated that there is relatively less correlations between domestic consultant and domestic contractors, this is also as expected and the possible reason for this could be both parties may blame one another. From the correlation result in Table 4.5 it can be seen that there was a very weak correlation between domestic consultants and international contractor's response. One of the possible reasons for this might be difference in understanding the basic concepts of the contract provisions and experience.

Table 4.5; Summary of spearman's correlations for causes of variations

Respondents category	Employer/ Client	Domestic contractors	Domestic consultants	International contractors	International consultants
Employer/Client	1.000	0.637	0.776	0.599	0.561
Domestic contractors	0.637	1.000	0.523	0.654	0.665
Domestic consultants	0.776	0.523	1.000	0.350	0.560
International contractors	0.599	0.654	0.350	1.000	0.560
International consultants	0.561	0.665	0.560	0.619	1.000
Number of variables	N=35				

Based on the result of the analysis from respondent's response the most important causes of variation in Ethiopian Federal road construction projects were identified. Table 4.6 below shows the major causes of variation in Ethiopian Federal road projects.

Table 4.6; Major causes of variation in Ethiopian Federal road construction projects

S.No	Causes	Mean	Rank
29	Right of way or access to site problem	4.17	1
1	Change in defined scope	3.84	2
25	Lack of proper planning	3.72	3
14	Lack of contractors proper evaluation (review) of tender documents at tendering phase	3.68	4
18	Contractors financial problems	3.64	5

The result showed that right of way problem, change in defined scope, lack of proper planning, lack of contractors proper evaluation of tender documents at tendering stage and contractors financial problems as the most important causes of variation in Federal road construction projects in Ethiopia. Besides identifying the major causes respondents were also asked to indicate the initiators of the causes, their consequential effects and most affected parties corresponding to each cause and the result is summarized as follows (Fig 4.7).

Table 4.7; Major causes of variations their initiators, consequential effects and most affected parties

Rank	Identified major cause	Score [MS]	Initiators/Responsible parties		Consequential effects for each major identified causes		Most affected parties	
			Parties	Score [%]	Effects	Score [%]	Parties	Score [%]
1	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	Right of way problems (access to site)	4.17	Client	49.09	Delay in completion time	37.37	Client	40.00
			Contractor	23.64	Increase in project cost	26.77	Contractor	41.54
			Sup. Cons.	16.36	Dispute among parties	12.63	End users	15.38
			Des. Cons.	10.91				
2	Change in defined scope (Additions or omissions)	3.84	Client	46.58	Increase in project cost	48.64	Client	53.13
			Sup. Cons.	31.51	Delay in completion time	32.27	Contractor	32.81
			Contractor	13.70	Suspension of works	6.36	End users	12.50
			Des. Cons.	8.22				
2	Lack of proper planning	3.72	Contractor	48.40	Delay in completion time	35.03	Contractor	56.90
			Client	24.00	Increase in project cost	24.87	Client	22.41
			Sup. Cons.	24.00	Decrease in productivity	13.20	End users	18.97
			Des. Cons.	4.00				
4	Lack of contractors proper evaluation (review) of tender documents at tendering phase	3.68	Contractor	75.00	Delay in completion time	33.01	Contractor	34.43
			Client	9.62	Increase in project cost	23.92	Client	55.74
			Sup. Cons.	7.69	Dispute among parties	11.00	End users	6.59
			Des. Cons.	7.69				
5	Contractors financial problems	3.64	Contractor	81.40	Delay in completion time	34.68	Contractor	56.90
			Client	9.30	Delay in logistic supplies	21.39	Client	22.41
			Sup. Cons.	6.98	Decrease in productivity	11.56	End users	18.97
			Des. Cons.	2.33				

According to Fig 4.7, right of way problem and change in defined scope are initiated by the employer. The major effects of this problem are delay in completion time, increase in project cost and dispute among parties. Fig 4.7 indicated that contractors are the most affected parties next to the employer.

Unlike right of way problem the most recurring effects of change in defined scope are increase in project cost, delay in completion time and suspension or disruption of work. Moreover the result indicated client is more responsible in initiating these types of changes. The initiator of this cause is client in most of the cases followed by supervision consultant. The result also showed that client is most affected party as a result of this cause.

Lack of proper planning, lack of contractors proper evaluation of tender document at tendering stage and contractors financial problem are the third, fourth and fifth important causes of variation in Ethiopian Federal road projects. All these causes are initiated by contractors and they are also the most affected parties. The result showed that the most frequent consequential effects for these three causes are delay in completion time followed by increase in project cost for the third and fourth causes and delay in logistics supply for the fifth one.

To supplement the result from questionnaire survey and to have an overview on the extent of the problem a desk study was conducted. The result obtained from the desk study which shows the amount of variations and the reason what causes this variations or changes is summarized in Table 4.5 below. The result indicated that the amount of variations as compared with original contract amount for 12 randomly selected road construction projects and the major reasons which bring these variations into existence.

According to these data, widening of road section at some towns change in alignment, changing the pavement from double surface treatment into asphalt concrete, provision of parking lanes in some towns, considerable changes in quantity, construction of additional drainage facilities and omissions as well as additions were some of the major reasons that causes variations in Ethiopian Federal road project considered in the desk study.

Table 4.8; Summary of the result from desk study

S>No	Project	Original contract value [Birr]	Status [%]	No. of VO	Amount of variations [Birr]	Variation [%]	Major reason for the variation
1	A	346262115.21	50% completed	5	37104544.98	10.72	Extension of culvert, Construction parking lane Widening of town section, Alignment change
2	B	156883974.2		6	12811463.92	8.17	Construction of additional culvert, Widening of town section, Replacement of asphalt grade, Alteration of bitumen application rate
3	C	405973872.1	Completed	38	446359748.9	109.95	Alignment change due to archeological site, Time related cost due to extended period of performance Omission of bridge, Construction of retaining wall Provision of additional drainage system, Application of stabilization measures
4	D	177338107.7	Completed	4	8090984	4.56	Construction of vehicular accesses, Construction of concrete curve, Considerable change in back fill quantity Application DST at parking lane
5	E	289838439.1	Completed	18	192278636.2	66.34	Sampling and testing, Provisions of gabion for river training, Omission of pavement for some length due to right of way, Design update and additional quantity, Time related cost due to extended period of performance, Qty. increase due to unforeseen conditions.
6	E	162178583	Completed	12	4340410.9	2.68	Sub surface exploration, Change in thickness of paved ditch to fit in to the finished level f main rod, Change in design of bridge and its railing
7	F	341179223.9	50% comp.	1	99012622.34	29.02	Changing the pavement from double surface treatment in to asphalt concrete
8	G	283224198.6	60% comp.	3	32324419.81	11.41	Widening of road section at major towns and reconstruction of bridges
9	H	172533963.00	Completed	5	70639441	40.94	Provision of pavement for drainage, Increasing parking lane, Design and reconstruction of old bridge
10	I	256542439.1	Completed	12	8251296.66	3.22	Construction of additional road length
11	J	56425487	Completed	10	10138171	17.97	Repairing land slide area, Omission of masonry retaining wall, Provisions of Km post and road marking
12	K	395575959.6	Completed	5	2829119.17	0.72	Construction of bridge and alignment change Construction of paved side drain and omission of 12.452km length of road which results 17898485.35 reduction (the net effect is only 2829119.17

From each of the respondent responses in Fig 4.5 the summary of the most responsible parties in initiating majority of the causes were done. The result, unlike the other literatures indicated that contractor is the most responsible party in initiating most of these causes. The result also showed that client or the employer is the next party which is responsible in causing most of the causes.

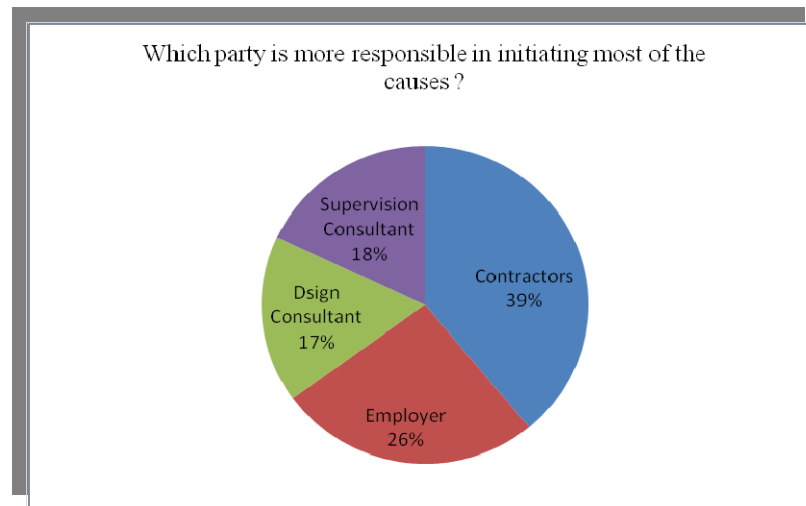


Fig. 4.5; Respondent responses on the more responsible parties in initiating the causes

In addition to identification of causes, a section of the questionnaire contained 12 potential effects of variations order for Federal road construction projects in Ethiopia. Respondent were asked to rank 1-5 each of the recurrent consequential effects corresponding to all the 35 causes from the listed 12 potential effects in order to identify the consequences of each cause in Ethiopian Federal road construction projects. From each of these responses to identify the consequential effects for each cause the effects were also analyzed in order to identify the major ones among the 12 potential effects. The result of this analysis is tabulated in Table 4.6 based on percentage of respondent's response, which is calculated from the mean score value.

Table 4.9, Percentage of effects of variation results from questionnaire survey

No	Potential effects of variations	Percentage [%]
A	Increase in project costs	25.56
B	Suspension of work	8.29
C	Delay in payment	2.73
D	Delay in completion time	28.21
E	Delay in Logistic supply	4.80
F	Decrease in quality	6.11

G	Decrease in productivity	7.51
H	Demolition and Rework	3.51
I	Damage firm reputation	1.45
J	Affects progress without delay	3.10
K	Damage professional relations	1.99
L	Results dispute among parties	6.75
Total		100%

Similar to that of cause, the ranking by all parties for effects were tested to check the agreement between respondents using spearman's rank correlations for the 12 effects listed above. The result of the spearman's correlation coefficient is summarized in Table 4.10.

The overall result of spearman's rank correlations revealed that the professional from all categories (parties) agreed on the potential effects of variations in Ethiopian Federal road construction projects. The result in general indicates that there is a better agreement as compared with causes. In this result it is indicated that there is a strong correlation between employer and consultants both domestic and international and less correlation is observed on responses between the employer and domestic contractors. The reason for this is the same with the cause because they may not agree on the resulting effects which is directly related with who is affected.

Table 4.10 Summary of spearman's correlations for effects of variations

Respondents category	Employer/ Client	Domestic contractors	Domestic consultants	International contractors	International consultants
Employer/Client	1.000	0.699	0.909	0.762	0.902
Domestic contractors	0.699	1.000	0.741	0.916	0.797
Domestic consultants	0.909	0.741	1.000	0.720	0.776
International contractors	0.762	0.916	0.720	1.000	0.881
International consultants	0.902	0.797	0.776	0.881	1.000
Number of variables	N=12				

From the result of the analysis in table 4.9, delay in completion time, increase in project cost, suspension or disruption of work, decrease in productivity and dispute among contracting parties are identified as major effects of variation among the 12 potential effects of variations which has been identified from literatures. The result is summarized in Table 4.11 below.

Table 4.11, Major effects of variation in Ethiopian Federal road construction projects

S.No	Effects	% of respondent responses	Rank
29	Delay in completion time	28.21	1
1	Increase in project cost	25.56	2
25	Suspension of work	8.29	3
14	Decrease in productivity	7.51	4
18	Dispute among parties	6.75	5

In addition to Table 4.11, Fig 4.6 below indicated the relative importance of these major effects identified through this research processes. From this Fig, it can be realized that more than 50% the respondent agreed that delay in completion time and increase in project cost are the most recurrent effects in Ethiopian Federal road projects.

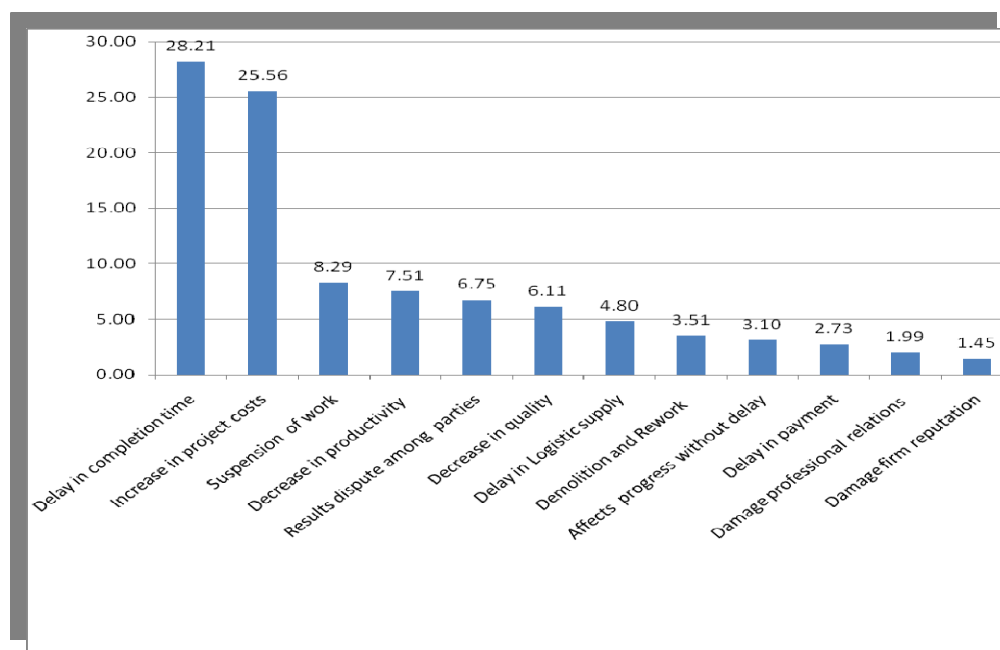


Fig. 4.6, Percentage of effects of variation

After they identified causes, more responsible parties in initiating these causes and effects of variations, respondents were also asked to indicate the most affected parties as a result of the resulting effects. Based on this, Fig 4.7 below shows respondents' response on which contracting party is more affected as a result of variation.

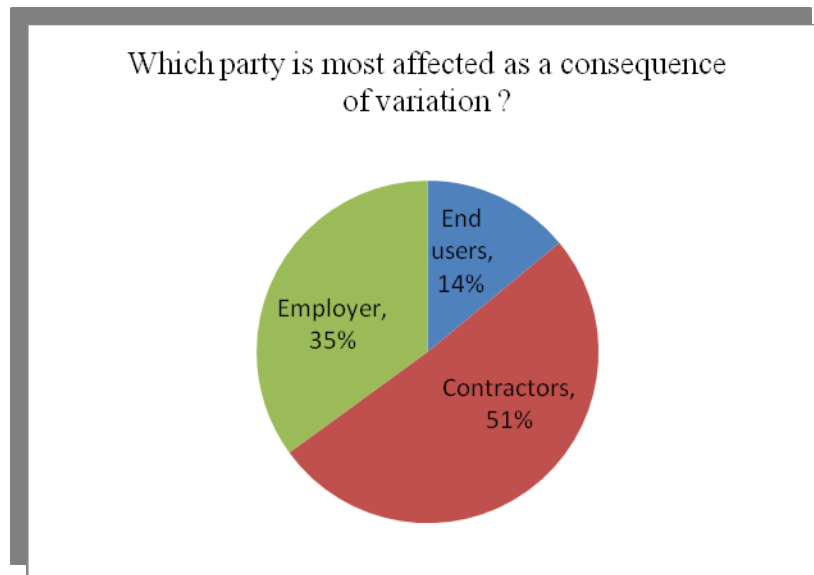


Fig. 4.7; Respondent responses on the most affected parties as a consequence of variations

Besides addressing the major objectives of identifying the major causes, initiators of the causes, most affected parties and their consequences respondent were also requested to forward their opinions on how to minimize variations so as to minimize their effects. Summary of the proposed solution forwarded by the respondent is presented as follows;

- ❖ Looking for alternative project delivery type such as design build
- ❖ Providing adequate time and staff at design stage and assign specialized project manager
- ❖ Improving contractors and consultants selection criteria to select capable consultants
- ❖ Establish a system that ensures accountability on design consultants for their poor designs
- ❖ Proper public /stakeholder's consultation to accommodate the variation issue at earliest stage (i.e. during planning and design).
- ❖ Defining the project scope clearly through detail site investigations at planning and design stages and proper planning in all aspect
- ❖ Improve quality of design, quality of tender document and develop trust among contracting parties
- ❖ Improving the time taking decision processes of variation order by ERA and promptly responding for variations order
- ❖ Detail review of design
- ❖ Better understanding of owner requirement and forecasting possible technology changes
- ❖ Knowledge of available resources

4.5 Discussion

Through the questionnaire survey in Ethiopian Roads Authority, the implementing agency of the road sector program, contractors and consultants both international and domestic the most important causes and their frequent effects of variation orders for Federal road projects were analyzed and tabulated. From the result obtained, the five most significant causes, their initiators, effects and most affected parties with each of these significant causes and effects of variation were identified and will be discussed below.

4.5.1 Most significant causes of variation order

In this section, the five most important causes of variations identified based on all the three criteria will be presented and only the top five causes based on the overall criteria will be discussed.

Based on this right of way problems, lack of proper planning, lack of contractors proper evaluation of tender documents at tendering phase, contractors financial problems and lack of prompt decision making (quick responses) are the top five causes in terms of rate of occurrence.

Similarly right of way problem, change in defined scope, ambiguous and conflicting contract documents, error and omission in design and specification and lack of proper planning are the five top causes based on the impact of causes on cost and the top five causes based on their impact on time are right of way problems, change in defined scope, contractors financial problems and equipment shortage and lack of proper planning. And the most significant causes based on the overall criteria that are rate of occurrences, and both impact on time and cost are right of way or accesses to site, change in defined scope, lack of proper planning, lack of proper evaluation of tender documents at tendering phase by contractors and contractor's financial problems. In the following paragraphs the details of identified causes based on the overall criteria will be presented.

The result indicated that right of way problem is the most significant cause in all the three criteria, this implies that these cause is frequently occurring and it has got high impact on cost and time. Change in defined scope has less rate of occurrence but it has high impact on time and cost. Lack of proper planning on the other hand occurs frequently but its impact on time and cost

is less. The result also revealed that contractor's financial problem has less frequency of occurrences, low impact on cost and high impact on time. Similarly error and omissions in design and specification and ambiguous contract documents occurs less frequently and has less impact on time, however they have high impact on cost. In the following paragraphs only the five most significant causes of variations or changes identified based on the overall criterion will be discussed.

1. Right of way or access to site problem

The first most significant causes identified as major causes of variation in Ethiopian Federal road construction projects is right of way or accesses to site problem. According to (Mark T. and Murray F., 2004), A report by the international law and labor organization (2009), and a report by Indiana road system utility reallocation task force (2009) right of way problem in relation to land accusation from a community to infrastructure development and relocating utility facilities are one of the predominant problem in road construction projects. According to these authorities the issue is complex and time consuming as well as expensive. Mark T. and Murray F.(2004) pointed out that in many cases, the right of way costs for new or expanded roadways exceed the cost for construction since it contributes many time related costs as a result of delay, cost of compensation and utility relocation. Mark T. and Murray F. (2004) recommend designers to carefully consider every accesses point in every project in order to minimize design change after construction is started.

In the context of Ethiopian Federal road construction projects the right of way problem is related to land acquisition issue from the community in rural and urban areas for the purpose of infrastructure development and relocating of utility facilities. The land required for these projects includes the land to be used for the construction of the road which includes appropriate right of way according to the requirements of ERA's standards for both rural and town sections and other part of the land which will be used as local material sources such as quarry site etc.

As it is clearly indicated in Table 4.4, the cause is ranked first by all respondents' consultants, contractors and the employer. This implies that right of way is one of the serious problems which results variations in Ethiopian Roads Authority. According to my informal interview with Ethiopian Roads Authorities higher officials after the analysis, the common problems with right

of way emanates from both perspectives. These are land acquisition from land owners for infrastructure development in rural and urban areas and relocating of utility facilities such as telephone, water supply and telephone lines, which has the same nature in what is discussed in the above paragraphs from literatures.

The common problems which are associated with land acquisition issues include; lack of awareness by the community, the fast growth of population which results in critical shortage of land resources and aggravate the land issue to be sensitive, estimation for compensation, the processes in ERA to finalize the compensation submitted by the surrounding committee member, which varies from region to region and unfair in the eyes of the implementing agent (ERA) and lack of law enforcement etc.

Currently the applicable law regarding this issue is the law that was drafted in 1936 (E.C), which is not as such strong in terms of the financial punishment as well as other consequences on those who violet the specified law. Recognizing this now ERA is drafting a new law that will improve the existing ones.

The best example of variation as a result of right of way in Ethiopian Federal road construction projects, part of the road in one road upgrading project in town which was totally omitted from the contract since the surrounding community which could be affected by the project was not willing to be resettled or shifted.

On the other hand problems related relocation of utility facilities such as water supply, electricity and telephone lines are resulted from lack of proper coordination between utility companies and the road sector implementing agent (ERA) and lack of information on underground utility lines even by the utility companies itself since there is no proper map which indicates the exact location of these lines.

In agreement with literature the consequential effects of this problem is delay in completion time, increase in project cost and dispute between parties. It is obvious since the estimation and compensation issue takes much time. In addition to increasing the project cost and time schedule thorough the specified processes the situation will push the work/activity to unfavorable seasons. Besides this it may also exposes contracting parties' to escalated cost of materials and labor.

2. Change in defined scope

The second most important causes of variation for Ethiopian road construction projects identified in this research is change in defined scope, which include addition, omissions or modifications of the original scope. According O'Brien (1998) and Al-Dubasi (2000), this type of changes in most cases is made by owner's choice due to many reasons such as insufficient planning at the project definition stage, lack of proper consultation with owner at the design stage, technological changes which requires owner to upgrade the project, availability of unexpected fund or change in project requirements as a result of change in projection or demography etc. Furthermore Al-Dubasi pointed out that change of plan and scope of project as the most significant causes of change in construction. In agreement with what O'Brien (1998) and Al-Dubasi (2000) suggested the respondent response on who is responsible for the change in this research revealed (Table 4.7) that most of the changes due to defined scope were initiated by the employer. 46.58 % of the respondents agreed that client is responsible in initiating scope change. From result of the desk study it can be realized that many of the reasons for the changes or variation such as widening of town section, construction of additional road, reconstruction of bridge and other structures, omissions of part of a road in some projects can be categorized as scope change (see Table 4.8).

Since change in defined scope can be caused by many reasons, this finding agreed with the finding of many other researchers on variations. For example Arain (2005) on his study on causes of variations in Singapore identified that change in specification by owner and change in plan or scope by owner as third and fourth factor of the five top causes of variations. Similarly a study on changes in Saudi Arabia found out that change of plan by owner is the first cause of variation among the five causes in his finding. Baharuddin (2005) also concluded in complete scoping as the second top most important causes of variation in Transmission projects.

3. Lack of proper planning

The third most significance cause identified in this research is lack of proper planning. According O'Brien (1998), strategic planning is an important factor for successful completion of any project. O'Brien on the other hand argues that lack of strategic planning in construction project as one of the common causes of variations. The survey result in this research indicated that contractors and client are more responsible in initiating this causes. It is true that both lack of

planning by contractors and client has major influences to cause variations. From contractors perspective lack of proper planning can cause delay in logistics supply and procurement of required resources which ultimately causes change in sequences of work with available resources such as materials, equipments or manpower, or even pending some activities until the resources become ready at the construction site. If the activity that was pending is on critical path, the situation may results in delay and additional time related and extended period of performance costs. In some cases, shifting the sequence of operation may also results mobilization and remobilization of construction resources, which also will have a contribution for delay and additional costs.

Lack of proper planning by client will also causes variation in many ways, because proper planning will help the employer to clearly define the scope of the project and to accommodate other project requirements too. To the contrary, lack of proper planning will contribute to variations in the sense that it will not enables to incorporate all the project requirements which ultimately requires later to be accommodated as variations.

4. Lack of proper evaluation of tender documents at tendering phase by contractors

The fourth most important cause of variation indentified in this research is lack of proper evaluation of tender documents at tendering phase by contractors. According to Edward E. (2003), in order to avoid problems and pitfalls during the construction stage contractors has to properly review all the tender documents, such as design and technical specification clearly prior to signing the contract agreement. Arain and Pheng (2005b) and Edward E. (2003) suggested that getting the contractor involved in design can minimize the interface problem between the contractors and the designer. Both authors also agreed that involvement of contractor may also benefits owners out of their practical experiences about the current market conditions and construction techniques. In reality, this situation is very difficult to be practice in Ethiopian Federal Road construction projects since most of the road contracts are based on traditional (design bid build) project delivery system. In this system there is no room for the contractor to be involved at design stage; however the contractors can critically evaluate the tender documents at tendering phase in order to minimize variations during construction which otherwise results

variation. The result in Table 4.7 also revealed that contractors are responsible in initiating such causes.

According to the respondent response in Table 4.7 column 5, 75% of the respondent indicated contractors are most responsible in initiating such changes or variation. Moreover, respondent indicated that delay in completion time, Increase in project cost and dispute among contracting parties are the consequences of these causes. Furthermore the result indicated that contractors are the most affected parties as a result of this cause, 56.9% of respondent in Table 4.7 agreed on this issue. Although lack of proper evaluation of tender document at tendering stage is identified as one of the major cause in this research no other researchers on variation that I referred identified it as a major cause. One of the reason for this might be contractors in these countries have their own design offices that will properly evaluate the documents at tendering phase and the project delivery system used in these countries may allow contractors to be involved at design stage.

5. Contractors financial problems

The fifth important cause in Federal road construction project which is identified as one of the major cause of variation in this research is contractor's financial problems. Although this factor seems to be remote to cause variations in construction projects in a sense that the employer may not accommodate any variation as a result of financial problem with contracting parties. In reality contractors financial problem will have contribution to variation which results in delay or schedule change (Al-Dubaisi. H, 2000). Due to the fact that, most of our domestic contractors started road construction projects in recent years, this situation affects their ability to properly execute and deliver these large projects according to their schedule.

The financial difficulties of local contractors are well addressed in a mid-term review of RSDP II (DCI, 2005). The report stated that since they are beginner, all local contractors have faced major constraints including shortage of capital, equipment and lack of experience in project management. Recognizing this fact Ethiopian government has put a lot of favorable conditions in order to build their capacity such as providing projects with 20% advanced payment without producing the required collateral (DCI, 2005). According to the report even with this assistance

many of the domestic contractors could not survive. Contractors like, Baro Construction (Gog-Akobo road), Ajeco Construction (Wenbera-Guba), African engineers (Alme Ketema-sekota) were among the various contractors who were affected by this situation and they are not functioning now and some more are still striving for their existence.

A study with the assistance of the World Bank cited on domestic construction industry (ERA, 2005) also identify the same problem and forwards a strategy that aims to improve the capacity and participation of domestic private contractors. Based on the recommendation in this study the government took some measures to facilitate local contractors & consultants' participation by introducing contracting out works, improving regulations launching studies to identify the problems of the industry, reforming the contract documents of government financed projects as required, etc. From the above discussion one can realize that identifying contractors financial problems as one of the most significant causes of variation is not as such surprising.

Besides identifying causes of variations, the research also aimed to identify initiators of these causes and most affected parties with each causes. The initiators of the identified causes will be discussed here and the most affected parties with each effect will be discussed latter after discussing the identified effects. From the summary of the result by respondents in the questionnaire survey on initiators for each causes (Fig 4.5) majority (39%) of the respondent indicated contractors are more responsible in initiating most of the causes, 26% said client or the employer, 18% said Supervision consultant, the last 17% said Design consultant.

4.5.2 Most significant effects of variation order

Similar to that of the causes the five most important identified effects includes delay in completion time, increase in project cost suspension or disruption of work, decrease in productivity and dispute among contracting parties. These effects will be briefly discussed in the following paragraphs.

1. Delay in project completion time

In agreement with Al Dubasi H (2000), Nur H. (2006) and Ahmed (2008) one of the most significant effects which ranked first is Delay in project completion time. According to Ibbs,

1997, delay in completion schedule is a frequent result of variations in construction projects. Nur H.,(2006) quoting Zeitoum and Oberlender (1993), indicated that the magnitude of schedule delay about 18% of the original schedule by assessing 71 fixed prices construction projects. Although he did not indicated the magnitude, Kumaraswamy *et al.* (1998) in his study on claims for extension of time due to excusable delay in Hong Kong's civil engineering projects also found out that 50% of the projects surveyed were delayed as a result of variations. However, the magnitude of schedule slippage in our country far exceeds this figure. The result from both the questionnaire survey and desk study reveals the delay in completion time is more than 30%.

2. Increase in project cost

The second most frequent effect of variation orders identified in this research is increase in project cost. The finding agrees with the findings of many other researchers such as Arian and Pheng (2005), Ahmed Z. (2008), Aldubaisi H. (2000) and Nor H. (2006). All these authors concluded increase in project cost as the first most important effects of variation in their studies. Like delay in completion time this was not also unexpected since the ultimate impact of any changes or variation is time and cost. Arian and Pheng (2005a) and Nur H. (2006) both indicated increase in project cost results due to frequent variations in the project, as variation orders may affect the project's total direct and indirect costs.

According to Arian and Pheng (2005b) a contingency sum is allocated in every construction project to cater for possible variations in the project, in order to keep the overall project cost with in estimated budget. However, frequent major variations may lead to cost overrun in the contingency sum in most construction projects. The same is true in Ethiopian Federal Road construction projects; the amount of variation far exceeds the contingency sum allocated to cater variation.

3. Suspension or hold on works

The third significant effect identified in this research is suspension or hold on work. Change in a certain work package may cause other activities to be held on (Al-Dubaisi A.H, 2000). This will happen when one activity depends on the other one. This situation was observed in project B, when the Asphalt Grade and application rate was changed from what has been described in the

original contract. During this time part of some activities in this project were interrupted for some times until the changed Asphalt transported to the country from abroad. This situation may freeze a certain craft crew and equipments for some time and shift the schedule of the work to some unfavorable seasons. More over if the activity suspended lies in a critical path it may also results in delay in completion time.

4. Decrease in productivity

The fourth major effect identified in this research is decrease in productivity. Arain and Pheng (2005b) indicated that changes leads to several problems such as change in contract price, or contract schedule, decreasing labor productivity and disputes among project participants. According to Arian and Pheng decrease in productivity is one of the major effects of changes in construction projects. Recognizing this many studies were conducted to evaluate this aspect of change (CII publication 6-10 (1990), Thomas et al 1994 &1995, Hester et al 1991) cited in Al-Dubaisi A.H, (2000). Most of these studies argued that interruptions, delays and rework which are associated with variation order have a negative impact on labor productivity. In agreement with the above researchers Thomas and Napolitan (1994) indicated that variation normally leads to disruptions and these disruptions were responsible for labor productivity degradation. The finding of CII as it is reported by Al-Dubaisi A.H, (2000) indicated that more than 40% reduction in productivity was noticed with an extreme number of disturbances. Similarly, the finding of Thomas and Napolitan (1994) showed that on average there was 30% loss of efficiency due to changes. During the desk study it was observed that, some of the claims for extension of time as a result of variation were related to disruption.

5. Dispute among parties

The fifth significant effect of variation in Ethiopian Federal road construction projects is dispute among contracting parties. O'Brien (1998) indicated that variation increases contractual disputes among project participants. In agreement with O'Brien, Kumaraswamy *et al.* (1998), Fisk (2000) and many other authors indicated, variation as one of the major causes of claims. The result of the questionnaire survey in this research also revealed the same. In the survey respondent were asked to identify the most significant reason for claims from the lists that

consists variations order, error in documents, delay caused by design teams, unforeseen events and tendering processes. 26.95% of the respondent response indicated variation as a primary reason/sources of claim; the next is error in documents with 22.27%, which is followed by delay caused by design teams with 20.36%. If the negotiation on time and cost effects of this variation between the employer and the contractors in construction projects is not successful this may results in dispute.

During the desk study this was observed in project C and project E. Majority of the claims issues in these projects were variation related. Beyond being a claim issue they were also results dispute among the contractor and employer. This has been observed in one of the projects considered in the desk study, in this project there has been about 11 claim issues among others most of the disputed claim headings which amounts 374,941,689.42. Out of this more than 220 million birr was due to variations which include additional quantities, extension of period of performance and additional associated cost, disruption operation as a result of varied work to structures, land slide measures and additional cost due to late removal of obstructions/right of way.

Similarly, the survey result on most affected parties was summarized in the same manner and the respondents indicate in majority of the cases (51.19%) contractors are more affected, next to client (35.18%) as a consequences of variations in these projects, the remaining 13.62% of respondent indicated end users are also affected to some extent due to the specified effects of variation.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

As it is clearly stated in the first chapter one of the main objectives of this research were to identify whether variation is a problem or not in Ethiopian Federal road construction projects as well as in the industry which is followed by identification of what causes these variations, which contracting party is more responsible in initiating most of these variation or changes, what is their consequences and which party is more affected by each of these causes. To achieve these objectives, the study use questionnaire survey and desk study as a research instrument and mean score methods of analysis to find out the result through the analysis. The result obtained in this processes has been presented and discussed in the previous chapter. In this chapter the major finding of the research which has been discussed before will be briefly summarized in accordance with the objectives of the research.

The first objective of the research was to investigate whether variation is a problem or not in Ethiopian federal road construction projects as well as in Ethiopian construction industry. Based on the data obtained from both the questionnaire survey and the desk study, the study concluded that variation is one aspect of project management problem in Ethiopian Federal road sector development program.

According to the result obtained from the questionnaire survey, 86.96% of the respondent agreed on variations as one of the major problems which contributes for delay and cost overrun and dispute between contractors and the employer during the implementation of the road sector development program in the last ten years (RSDP I and RSD II period). Out of the 86.96%, 32.67% (which is 37.5 %) of respondent strongly agreed and the remaining 54.35% (62.5%) simply agreed on variation as one major problem in these projects. The result of the desk study also strengthen this finding, it indicates that magnitude of variations in these projects ranges between 0.72% and 109% with 38 variation orders.

Based on the data from both the desk study and questionnaire survey the research concluded that variation as one of the major problems in Ethiopian Federal Road Construction Projects

The second objective of this research was identification of causes of variations. To achieve this, 35 variables (potential causes) were identified from literature and respondents were then requested to rate these factors based on their experience in terms of their frequency of occurrences and impact on time and cost. The result showed that, right of way or accesses to site 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 are the five top most significant causes of variations in Ethiopian Federal road construction projects.

Right of way or accesses to site 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 are identified as major causes of variations in Ethiopian Federal road projects

The third specific objective of this research was aimed to identify initiators of these causes and most affected parties as a result of variation. To achieve this, the research tries to summarize the results on identification of parties who is more responsible in initiating/causing most of the changes or variation issues. In this regard, 25.59% of the respondent said client/the employer is responsible in initiating most of variations, 17.18% said Design consultant, 18.48% said supervision consultant and majority of the respondent which is more one third (38.65%) said contractors are more responsible in initiating most of the variation issues. Similarly, the survey result on most affected parties was summarized in the same manner and the result indicated that, 35.18% of the respondent indicated that client is most affected, 13.62% said end users and the remaining half which is 51.19% said that contractors are most affected.

Based on the survey result contractors are more responsible in initiating majority of the specified causes and it is also the most affected party as a result of the consequential effects

The fourth specific objective of this research was aimed to identify the major effects of variations in Ethiopian Federal road construction projects. The result revealed that, delay in completion time, increase in project cost, suspension or disruption of work, decrease in productivity, and dispute between parties respectively are the most significant effects of variations in Ethiopian Federal road construction projects.

The major effects identified in this research are delay in completion time, increase in project cost, suspension (hold on) of work, decrease in productivity, and dispute between parties

5.2 Recommendations

In addition to, identifying the major causes, effects, initiator of these causes and parties which are most affected through the identified effects one of the specific objectives of this research was to forward recommendations based on the finding of the study in order to minimize variation order so as to minimize their effects. Based on this the recommendation will focus in addressing the major causes identified through the research processes.

5.2.1 General recommendations

As it is indicated in the introductory part of chapter four the questionnaire was somehow difficult to understand and time consuming. At the end of this research I realized that the questionnaire was not comprehensive to address the objective of the research. It missed some important questions to be included and contained some unnecessary questions which don't fit with any of my objectives. One of the reasons for this was developing the questionnaire before complete literature review. Because of this I strongly recommend my junior colleagues to realize their objectives and complete majority of the literature review concepts before they developed their questionnaire. This is one of the major lesson I learned through this research processes in addition to addressing the major objectives of the research.

5.2.2 Recommendation on how to minimize variation as a result of right of way or accesses to site problem

The first significant cause identified in this research is right of way or accesses to site problems. As it is clearly described in the previous section (i.e. review of literature and discussion part), the major sources of this problems are utility relocation and land acquisition from the public in towns and rural areas. With this understanding the following measures can be considered during pre-feasibility, feasibility, planning and design stages;

a) Regarding utility issues;

- ❖ Most of the problems with utility lines are due to lack of information about their exact location even by the utility companies themselves. In order to minimize this problem utility company should develop a map that clearly indicates the location of utility lines especially the underground ones so that planners and designers can easily refer the map to

consider the issues as early as possible. Besides this, utility companies should also look for some advanced technologies such as ground penetrating radar and acoustic pipe tracers and other techniques which enable to detect underground utility location easily since most of the utility lines are buried long time ago.

- ❖ In the meantime establish proper communication, coordination and cooperation among the road sector implementing agent (ERA), design consultants, utility companies and highway contractors for a better future in this regard is paramount.

b) Regarding land acquisition problem;

- ❖ Improving the awareness of local peoples on how important is the project to the community and the capital resources spend to these projects
- ❖ Proper consultation with the public/stakeholder's to accommodate the variation issue at earliest stage (i.e. during feasibility study, planning and design). According to the respondent's suggestion in addition to addressing the issue of right of way or accesses to site or land issues consultation with stakeholders will have a great contribution to consider the needs of local authorities which results variations later. The data from the desk study indicated widening of road section based local authorities request are frequent causes of variations in these projects.
- ❖ According to my information during the interview the estimation for compensation by the surrounding committee varies from region to regions. In order to minimize the gap, ERA should develop a compressive guideline on this issue and establish effective way of administrating the issue.

5.2.3 Change in defined scope and lack of proper planning

Literatures indicate that change in defined scope are common in construction projects and it is made by owner's choice due to many reasons (O'Brien, 1998 and Al-Dubaisi A.H, 2000) such as insufficient planning at the project definition stage, lack of involvement owner at the design stage, technological changes which requires owner to upgrade the project etc. In agreement with literatures, the finding of this study also revealed that client is responsible in initiating or causing this type of changes. With this background the following measures/controlling mechanisms can be considered in order to minimize change in defined scopes;

- ❖ Clear and well requirements and controlling mechanisms that evaluates whether the requirement is achieved or not is very important for contracting parties especially who are involved in feasibility studies, planning and design stages is crucial.
- ❖ Exercising the concept of value engineering at design stage and establishing a system that makes designers to be accountable for their poor design, this might enables good designers to be motivated and the poor once to take care and learn out of their mistakes.
- ❖ Provide adequate time for planning and design
- ❖ Active involvement owner at design and planning stages
- ❖ Critical review and thorough detailing of design and contract documents can be considered to minimize this type of change or variations.

5.2.4 Lack of proper evaluations of tender documents at tendering stage

- ❖ Although I don't agree the respondent in this particular issue, the overall result on most affected parties indicated that contractors are more affected as consequences of variations in Ethiopian Federal Road Construction projects. This can be an indication that there is considerable problem that contractors are facing as a result of variation or changes. In order to minimize the impact on them during construction, contractors should properly evaluate the tender documents at tendering stages rather than looking for a way to vary the work and come up with claims. Because this might damage their firm reputation.
- ❖ Literatures suggested that contractor's involvement at design stage would minimize pitfalls during construction stages and it also benefits owner to have a practical idea from contractors. From this or other point of view ERA should try to practice alternative project delivery system such as design build (or Turnkey) etc.

5.2.5 Contractor's financial problems

- ❖ Domestic contractor's financial problems or capacity issues are addressed in many studies and possible solutions are forwarded in these studies. Moreover some measures are taken on the basis of the proposed solutions in these studies. This should continue strategically to build capacity of domestic contractors sustainably.

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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 and that all sources of materials used for the thesis have been duly acknowledged.

Name: Tadesse Ayalew

Place: Addis Ababa, Ethiopia

Date of submission: July 15, 2009

Signature: _____

Title of the thesis:

“Causes and effects of variations in Ethiopian Federal Road Projects”

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

Name: Professor Dr.-Ing Abebe Dinku

Signature: _____

Date: _____

ANNEX

Questionnaire

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
FACULTY OF TECHNOLOGY
CIVIL ENGINEERING DEPARTMENT



QUESTIONNAIRE SURVEY
ON
CAUSES AND EFFECTS OF VARIATION/CHANGES IN ETHIOPIAN FEDERAL ROAD CONSTRUCTION PROJECTS
BY
TADESSE AYALEW
ADVISOR: PROFESSOR. ABEBE DINKU (DR.-ING.)
FOR THE PARTIALFULFIMLMENT OF MSc. DEGREE IN CIVIL ENGINEERING
(MAJOR CONSTRUCTION TECHNOLOGYAND MANAGEMENT)
DECEMBER, 2008

General Information

A. Objective

The objective of this research is to identify major causes of variations and their consequential effects on Federal Road Construction projects in Ethiopia and to recommend possible remedial measures that minimize changes/variations.

B. Purpose of the survey and other important information

1. The purpose of this survey is to obtain data for the specified research conducted as a partial fulfillment of Msc. Degree in Construction Technology and Management at Addis Ababa University and the data obtained from the survey will be held confidential and it is used for only academic purpose.
2. For the purpose of this research variation is defined as any event that results in modification of the original scope, execution time, cost and/or quality or quantity.
3. Your open and prompt response is highly essential to fulfill the objective of this research and to address the problem
4. For any further information the researcher can be reached through 0912 015584(Tadesse Ayalew)

Thank you very much

Section A: Company and respondent profile

1. Please provide the following information about your professional and organizational profile by marking (X) in the space provided.

Name of your organization (optional).....Some of the projects participated in

Type or origin of your organization	Your firm experience in		Your position in the organization	Your professional experience in	
	The construction industry	Road projects		The construction industry	Road projects
Client/Employer	0-5 years	0-5 years		0-5 years	0-5 years
Domestic Consultant	6-10 years	6-10 years		6-10 years	6-10 years
Foreign Contractor	10-15 years	10-15 years		10-15 years	10-15 years
Domestic Contractor	15-20 years	15-20 years		15-20 years	15-20 years
Others (specify).....	More than 20	More than 20		More than 20	More than 20

Section B: Basic information about variation

2. Variation/change is a problem in Ethiopian construction industry in general and that of road construction projects in particular?

☐ Agree ☐ Strongly agree ☐ Disagree ☐ Strongly disagree

3. Please complete the following table based on your experiences

a) Put in order of priority	b) Mark (X) under your choice		c) Put in order of priority	d) Put in order of priority
Which one is more significant problem in contract management	% Increase in project Cost due to variation	% Increase in project schedule due to variation	Reason for claims by contractors	Which activities are more subjected for changes
Variation	0-5%	0-5%	Variation order	Earth work & Excav.
Claims/ Dispute	6-10%	6-10%	Errors in documents	Concrete work
delay	11-15%	11-15%	Unforeseen event	Asphalt work
Cost over run	16-20%	16-20%	Tendering processes	Drainage construction
Quality issues	21-25%	21-25%		Other structures
Others	21-25%	21-25%	Delay caused by design team	Others.....
Others	More than 30%	More than 30%	Others.....	Others.....

Comment (if any).....

Section C: Factors which contributes for the causes of variation and their consequential effects

4. Tables on page 3, 4 and 5 consist of list of possible causes of variations in construction projects identified from literatures. Based on your experience what is the likely contribution of these factors to variations/changes in federal road construction projects that you have involved? Please rate your answer based on rate of occurrence & their impacts on cost and time by marking (X) under each preferences. In addition please indicate the initiators and the possible consequential effects for each potential factor which causes variation. Please also forward possible measures to be taken in order to minimize variations/changes.

Causes & Effects of Changes/variations in Ethiopian Federal Road Construction Projects

[illegible]

Causes & Effects of Changes/variations in Ethiopian Federal Road Construction Projects

[illegible]

Causes & Effects of Changes/variations in Ethiopian Federal Road Construction Projects

List of possible factors that causes changes/variations in construction projects (Please rate these factors based on their frequency of occurrence and impact on cost & time in the next three columns and indicate the responsible party/parties in the fourth column)	Rate of occurrence					Impact on cost over run					Impact on time over run					Initiator					Among the following lists (A-L) of potential effects of changes/variations please indicate the most recurrent effects for each possible cause as ranked 1-5										Please enumerate possible measures to be taken to minimize changes/variations
	No occurrence (0)	Low occurrence(1)	Medium occurrence(2)	High occurrence(3)	Very high occurrence(4)	No Impact(0)	Low Impact(1)	Medium Impact(2)	High Impact(3)	Very high Impact(4)	No Impact(0)	Low Impact(1)	Medium Impact(2)	High Impact(3)	Very high Impact(4)	Client/Employer	Contractor	Design consultant	Supervision Consultant	A= Increase in project costs B= Suspension of work C= Delay in payment D= Delay in completion time E= Delay in Logistic supply F= Decrease in quality					G= Decrease in productivity H= Demolition and Rework I= Damage firm reputation J= Affects progress without delay K= Damage professional relations L= Results dispute among parties						
																				1	2	3	4	5	Most affected party/parties						
																				Client	Contractor	End Users	Others								
28 Change in government regulation																															
29 Right of way problems (access to site)																															
Others (please specify if any)																															
30																															
31																															

Section D: You're over all comments on the subject variation /changes

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Thank you very much for successfully completing the questionnaire

If you visit ERA and that is convenient for you, you can return the completed questionnaire to Ato Ayalew or to his secretary at procurement department of ERA (First floor, Room No 108)