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SCHOOL OF GRADUATE STUDIES  
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**THESIS TITLE  
THE EFFECT OF VARIATION DUE TO DESIGN CHANGE ON  
BUILDING PROJECT PERFORMANCE IN ADDIS ABABA DELTA  
ENGINEERING CONSTRUCTION PLC  
BY  
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**JANUARY, 2023**

**ADDIS ABABA, ETHIOPIA**

## **DECLARATION**

I declare that this thesis entitled “The effect of variation due to design change on building project performance in Addis Ababa delta construction plc is my original work. This thesis has not been presented for any other university and is not concurrently submitted in candidature of any other degree. To the best of my knowledge and belief this thesis contains no materials previously published or written by another person except where due reference is made.

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**signature**

**January, 2023**

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## **LIST OF ACRONYMS AND ABBREVIATIONS**

SD	Standard Deviation
BATCODA	Building and Transport Construction Design Authority
CII	construction industry institute
PLS	Partial Least Square
PMBOK	Project Management Body of Knowledge
SPSS	Statistical Package for the Social Sciences
VIF	variable insignificant factor

## **ABSTRACT**

*The construction industry contributes significantly to any nation's economy by creating jobs and wealth. In terms of cost and time, many projects performed very poorly. Variation due to design change is one reason for this low performance. This is due to the fact that project costs, schedules, and time can be affected by design change. Due to internal and external factors, one or more parties initiate the design change, which delays and increases costs in construction projects. Therefore, this research is to identify the effect of variation due to design change on construction project performance in Addis Ababa Delta Engineering Construction Plc. Explanatory quantitative research designs were used to achieve the research objective. Data gathered through a questionnaire the research methodology engaged a questionnaire survey about the effect of variation due to design changes during the building construction, which are distributed to the project managers, client and the Engineers. The purpose of this research is to determine how a design change affects the performance of a construction project in Addis Ababa. A sample of 111 respondents from the client, design consultant, supervision consultant, and contractor sides were also used to test the hypotheses. Statistical Package for the Social Sciences (SPSS) Version 26 was used to conduct descriptive and inferential statistics on the data. Frequency, mean, and standard deviation were used for descriptive statistics. In order to answer the research objectives, correlation and multiple regression were used for the inferential statistics. The relationships that exist between the variables were examined using correlation analysis; The correlation matrix showed that every independent variable's coefficient of correlation was positive and strongly correlated with the dependent variable. The four independent variables (client-related, design consultant-related, supervision-consultant-related, and contractor-related design change factors) affect construction project performance, as revealed by additional regression analysis in addition to correlation analysis. It was determined that consultant-related factors the major factors affecting project performance. Consultants should give a brief explanation of the design document with the respective professional appointed by the client. And giving awareness about the consequence of design change in the construction phase, and also Consultant's supervisors should have collective experience about construction project.*

*Key words: - design, design change, variation, project performance; building construction project*

## **CHAPTER ONE**

### **1. Introduction**

#### **1.1 Back Ground of the Study**

The nature of construction industry is complex and uncertain because of different firms are involved from inception stage to commissioning stage. Design is a process of creating the description of a new facility, usually represented by detailed plans and specifications; construction planning is a process of identifying activities and resources required to make the design a physical reality Ed., (2003).in an integrated system, the planning for both design and construction can proceed almost simultaneously, examining various alternatives which are desirable from both viewpoints and thus eliminating the necessity of extensive revisions under the guise of value engineering.

A construction project is particularly prone to a high degree of change for a variety of reasons, including the disruption of monetary and fiscal disorder, a lack of time and effective communication, environmental changes, and the project's increasing complexity of project. Its performance is affected by the changes, particularly in terms of cost, time, and quality of work. The construction industry has a significant impact on the economies of all nations (Fisk, 2000). Construction industry has a great impact in the economy of all countries. This huge industry which is the backbone of the social, economic & political development of a country, so needs proper management to meet its targeted goal.

This industry is full of uncertainties this make it unique from other industries. Therefore, it requires unique management. Generally, construction projects are unique (different from one another). Construction management is different from general management of corporations by the mission- oriented of the projects. (Nega, 2008) Design is the process of making a new facility's description, which is shown by detailed plans and specifications; construction planning is a process of identifying all the required steps, activities and resources required to make the design a physical reality In an integrated system, the planning for both design and construction can proceed almost Concurrently, examining various alternatives which are desirable from both point of view and thus avoiding the necessity of extensive revisions under the guise of value engineering.

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Construction planning is the process of identifying all the necessary steps, activities, and resources to make the design a physical reality. As the project moves from planning to design, it is also possible to conduct a constructability review of the designs. Consultant firms account for the majority of the design preparation portion, according to Ethiopia's construction industry. The issue of design change is common and has an effect on the performance of the construction project as a whole. The design change initiated by one of the parties, including the owner, consultant, consultant, construction management, politics and economics, the natural environment, contractors, and technological advancements. Owner-requested design changes can include additions, deletions, or changes to the original work scope.

The Consultant is required to prepare as-built final drawings and records of the works in accordance with the first Ethiopian condition of the contract (BATCODA) in order to provide the Investor with information regarding the visible work and enable the Investor to carry out future changes to the design of the works without conducting an investigation. These records ought to contain every information and date that has changed since the beginning of the Maintenance Period.

The construction industry has a significant impact on the economies of all nations. In order to achieve its central objective, this vast industry—the foundation of a nation's social, economic, and political development—needs effective management. This industry is full of uncertainties this make it different from other industries. Therefore, it requires different management. Generally, construction projects are unique from one another. Construction management is distinguished from general management of corporations by the mission- oriented of the projects. Design changes/variation which are the cause of delays and cost overrun may occur due to internal and external factors and these delays and cost overrun which rises during construction leads the parties in the construction to conflict.

## **1.2 Statement of the Problem**

There are huge and complex construction projects in Ethiopia right now, especially in Addis Ababa. However, these projects have struggled to achieve their objectives. The performance of a construction project can be affected by a number of things, one of which is the design change Burati (1992). Changes in construction projects are very common, can come from a variety of sources, can happen at any point in the project, and can have a significant negative impact including costs and delays, among other things. The project schedule, work report re-estimation, and additional equipment, material, labor, and time requirements can all be delayed indefinitely as a result of a significant change. overtime. If changes are not dealt with through a formal change management process, they can become a major cause of contract disputes, which is a serious risk that could cause the organization failure. project. Chile, 2008. Yana, R. H. A., and M. A. conducted research that found that change to the Wibowoc's design result in lower productivity, longer completion times, disputes between owners and contractors, lower quality, higher project costs, additional payments to contractors, material and tool delays, backlogs, cost increases, payment delays, demolition and rework, and so on. It is becoming increasingly common knowledge that design change have an effect on construction project costs, and that these variation/change unavoidably result in cost overruns. According to Ikediashi's research, the most significant causes of project cost overruns and eventual project failure are design deviations and frequent design change.

The construction industry performance measured through three essential parameters cost, time and quality. However, a change in design can have an effect on the entire project process, with the following effects mostly occurring in the Ethiopian construction industry. time Overruns and cost Overruns, issues with quality, an increase in overhead costs, wasted materials from rework, productivity losses from equipment and materials, claims, and client-contractor disagreements. When a design change occurs during the construction phase, the most common outcomes for projects are delays, increased costs, waste of materials, and disagreements between parties. Currently, Ethiopia is home to a number of very large and intricate construction projects, particularly in Addis Ababa. However, it has been observed that those projects have struggled to

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achieve their objectives. A construction project's performance could be affected by a number of things, but one of those things is a change in design. Burati (1992) The effect of design changes on building project costs has been researched and assessed. It is now common knowledge that cost overruns are frequently brought on by design change. Ikediashi et al. (2014), research on construction projects found that (2014), they discovered that the most important variables that lead to cost overruns and ultimately project failure are frequent design changes and variations. In a different study, Cheng (2014) stated that the project's imprecise and poorly specified scope, multiple scope changes, and unclear drawings, guidelines, and regulations were the most significant causes of cost overruns. These factors influence not only the project's cost but also the workforce's morale and cause design change at any stage of the project, resulting in some reworks. In addition, Ibbs (2005) emphasized the significant loss of labor productivity brought about by design revisions, which eventually results in cost overruns and delays.

In a similar vein, Hanna (2004) discovered that in the United States, worker productivity decreased as a result of frequent design change to electrical and mechanical building components. Changes to the design increase indirect costs due to claims and disputes that occur later in the project, in addition to issues with productivity. In a study by Ayininuola and Olalusi (2005), frequent design changes were linked to a change in the scope of work by the owners. As a result, key causes of the high number of building failures emerged.

The negative effects of design changes have been identified by various researchers around the world. Mohamad et al. state that (2012) Due to their impact on cost and time performance, design change can result in competition among clients, contractors, and consultants. Olawale and Sun (2010) say that design changes are frequently linked to construction project time and cost overruns.

The identified effects of building project design change can be used as a benchmark to reduce the occurrence of design changes and for construction stakeholders to develop management strategies for change of design.

The researchers believe that this paper advances the field by demonstrating the relationship between dependent and independent variables, determining the connection between contractors'

related design change factor and building project performance in Addis Ababa Delta Engineering construction plc, and determining the impact of design changes on project performance. Given the preceding information, researchers believe that it is essential to evaluate the effect of design changes during the construction phase in order to minimize the negative effects of design changes, such as project delays, increased costs, waste of materials, and disagreements among parties during construction projects. Additionally, it is very important to know which factors are more responsible for the performance of the project.

In the building construction industry, particularly in architecture, there are frequently distinctions between the design phase and the construction phase. Materials, structure, and build quality are just a few examples. Projects run the risk of incurring cost and time overruns, which can be noticed by construction firms. It is necessary to come up with the right design, pique the interest of the employees/client, and demonstrate an understanding of how to overcome differences in order to meet the needs of customers and successfully complete building construction projects. in construction and design.

### **1.3 Research Objectives**

#### **1.3.1 General Objective**

The general objective of this Study is to identify the effects of variation due to design change on building project performance found in Addis Ababa Delta Engineering construction plc.

#### **1.3.2 Specific Objectives**

The specific objective of this thesis is to determine the following

- ✓ To identify the presence and extent of variation due to Design changes.
- ✓ To identify the relationship between clients related design change factor and building project performance in Addis Ababa Delta Engineering construction plc.
- ✓ To identify the relationship between design consultants related design change factor and building project performance in Addis Ababa Delta Engineering construction plc.
- ✓ To identify the relationship between supervision consultants related design change factor and building project performance in Addis Ababa Delta Engineering construction plc.

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- ✓ To identify the relationship between contractors related design change factor and building project performance in Addis Ababa Delta Engineering construction plc.

## **1.5 Research hypothesis**

**Ho:** The clients determine the Project performance in Delta engineering construction PLC.

**H1:** The client does not determine the Project performance in Delta engineering construction PLC.

**Ho:** Contractors affects Project performance in Delta engineering construction PLC.

**H1:** Contractors does not affect Project performance in Delta engineering construction PLC.

**Ho:** Design consultants determine the Project performance in Delta engineering construction PLC.

**H1:** A Design consultant does not determine the Project performance in Delta engineering construction PLC.

**Ho:** Supervision consultants determine the Project performance in Delta engineering construction PLC

**H1:** A Supervision consultant does not determine the Project performance in Delta engineering construction PLC

## **1.6 Scope of the Study**

Conceptually, the study mainly focuses on building projects the identification of the Effect of variation due to design change and their relative effects located in Addis Ababa Delta Engineering Construction Plc. Geographically, the study was conducted in Addis Ababa specifically in Delta Engineering construction Plc. Because of this, the population and its size were limited specifically in the Delta Engineering construction Plc. The research focused on contractors, consultants and clients which are registered by Addis Ababa city construction bureau in delta engineering construction plc. The tools used in the study also scoped based on the population and sample size. Methodologically, the research approach that will be used in this research is a quantitative approach. Quantitative research used to examine the relationship among variables. This research contains a dependent and independent variable which was measured numerically by using correlation and regression. The questionnaire survey was adapted



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to get feedback on opinions of respondents “on the effect of variation due design to change on building project performance in Addis Ababa Delta Engineering Construction Plc”.

### **1.7 Significance of the Study**

This study focuses mainly on the effects variation due to design change. The finding in this study will helps us to differentiate the effect variation due to design change on building project performance in Addis Ababa Delta Engineering Construction Plc and corrective action to be taken in order to minimize design change in terms of cost and time. This study will enable clients, design consultants, supervision consultant and contractors to understand the effects of design change and help them in developing plans which can help them to minimize the effect of design changes and practice good project performance. And it can also help to reduce the effect variation due to design change in different phase of construction especially in execution phase and getting the knowledge how to avoid design changes before starting the project.

### **1.8 Limitation of the Study**

This study was limited to show the design change effect in construction phase in the perspective of professionals on contractor’s, client and design consultant, supervision consultant side. In this research internal design change factors were only included because it is difficult to control and manage external design change factors such as political economic, the natural environment, advances of technology, and the third-party.

### **1.9 Organization of the Study**

This thesis has five chapters. The study's background, problem statement, objective, significance, scope, and limitations are all discussed in the first chapter. The second chapter provides a detailed literature review that provides the theoretical basis of the study by comprehensively evaluating what other scholars had already done on the effect of design change/variation on project performance. The method used to arrive at the study's findings was explained in detail in Chapter three. In particular, the chapter provided an explanation of the research design and approach, as well as the population, sampling, and data collection techniques used to gather the required data. After analyzing the data that was collected, the results were explained in Chapter

four. The key findings were summarized in Chapter five, and the study was concluded with recommendations based on the findings.

## **CHAPTER TWO**

### **2. Literature review**

#### **2.1 Introduction**

##### **2.1.1 Conceptual and Theoretical Literature**

This chapter provides a detailed review of different works of literature that are related to the objectives of the study. In order to develop a better understanding of the research objective, focusing on identifying the reason of design change or variation, and control and administrate it, their effects and how to manage.

Construction projects are complex because they involve human and nonhuman factors as well as numerous other variables., which require close cooperation and coordination among stakeholders (Ahmad Safun Bin Ahmad Radzi, 2015) and (Fetene, 2018) As a consequence of their complex nature and involving many players, Construction projects experience variation which is costly and unwelcomed by all parties in construction (Arian, The Potential Effects Variation Order on Institutional Buildings, 2015) (Arian, Modeling for Management of Variation Order in Institutional, 2017). According (O'Brien, 1998) even the most carefully-planned projects may necessitate changes due to many factors.

Similarly, (al, January 1, 2017) 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 reality of life in construction projects. These changes, well managed, small and have little effect on construction projects. On the other hand, changes may be large, poorly managed, and have huge negative impacts on construction project performances with regard to time and cost (Hanna, 2012).

(Arian,2015) also indicated that these changes lead to many problems such as change in contract price, or contract schedule, decreasing labor productivity and disputes among project participants.

In agreement with (Arian, The Potential Effects Variation Order on Institutional Buildings, 2015) and (al, January 1, 2017) pointed out that variation in construction projects can cause adjustments to the contract duration, total direct and indirect cost, or both. In addition to this, variations can also cause disturbance in the planned work, schedule, increased cost through rework and decreased efficiency of the base contract work (Hanna, 2012).

In agreement with (al, January 1, 2017) and (Hanna, 2012), (Ibrahim, 2016) also show that, variation orders as one of the most major sources of cost growth and disruptions. (O'Brien, 1998)

However, described that variation may increase contractual disputes among project participants. To reduce their negative effects, changes in construction projects should be managed and as well as administrated once they occur.

## **2.2 Basics of Variations**

### **2.2.1 Definition of Variation and Variation Order**

“Change” in construction is also repeatedly used to identify an addition or omission 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 change, substitutions, addition, omission and alterations etc.

Change or variation in construction as any alteration to the basis upon which the contract was let in its generic sense (Galloway P.E, 2017). That means any difference from an agreed upon defined scope and schedule. Change as any modification to the guidance prepared to the contractor by the owner or owner representative (Fisk, 2000).

The above definition includes modification to plans, specification or any other documents. Because the contractor at the beginning receives, the contract package in the form of plans, drawings and other documents. For example, indicates that the term alteration on the contact embraces not only changes to the work with the provisions of the contract but also changes to contract conditions themselves (Ibrahim, 2016).

Change order is a formal means 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. Because variation or changes can be

initiated by all parties in the construction process; but all changes must be approved by Owner or his representative before implementation (Fisk, 2000), (O'Brien, 1998), (Cariappa, 2012), (A.H., 2015) and (Popescu, 2017).

**1. Classified changes based on major phases in construction projects as;**

1. Design,
2. Construction,
3. Fabrication and
4. Transportation or operability

Design change among others consists of 52.5% of total changes which mainly falls in to three categories. (Yunus, 2017)

✓ **Design modification/change caused by improvement through design process.** These include design changes resulting from design reviews, technological advancement or constructability reviews.

✓ **Design changes originated by owner.** this modification includes scope changes.

✓ **Design changes initiated by engineer or consultant familiar with the process.** Design modifications initiated by an experienced engineer or consultant |in addition, the study identifies design errors and omissions as one of the primary causes of changes in construction projects. This includes the addition or omission of certain items that have an impact on the construction projects.

Besides this, the study indicates also design errors and omissions as one of the major causes of changes in construction projects. In addition, the study identifies design error and omission as one of the primary contributors to project modifications.

Similarly, changes as construction and design changes refer to changes due to unforeseen site conditions which may not necessarily require redesign (Cariappa, 2012). An example of this includes error and omissions. Unlike to construction change, Design changes refers to variation that are made due to the update of requirements in the original scope, changes of requirements outside the original scope and modification in design necessary by unforeseen conditions

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The third basis of classification is the net effect of changes or variation on scope (Fisk, 2000). This classification consists of;

- 1. Additive:** - is change as addition of work to the original scope
- 2. Deductive:** - change just to the opposite of this that is changes which involves deletion or shrinkage scope of the work.
- 3. Rework:** - The majority of rework changes are brought by a lack of quality. Even though this kind of change doesn't necessarily mean changing the scope, it has a significant impact on costs.
- 4. 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 those, (Stokes, 2015) and (Fisk, 2000) based on this they are classified as;

- 1. Formal or direct change:** Formal or direct change is a change introduced by the owner or his representative under the mechanism of change clauses.
- 2. Constructive changes:** changes that resulted from a failure to do or not to do on part of the client or its representative. This could be caused by a design or drawing error, an engineer's incorrect interpretation of the contract document, or a change in the construction methods required 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.
- 3. Cardinal changes:** 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.

Classified changes as based on time (Bruce Hallock, December 2016.)

- 1. Anticipated:** any change that is planned ahead of time and occurs generally as intended.
- 2. Emergent:** change on the other hand spontaneous and arises out of conditions that were not anticipated or intended.

## **2.3 Causes, Effects and Management of Variation**

### **2.3.1 Causes of Variation**

Construction projects are typically undertaken in ever-fluctuating natural and business environments. Due to this, they are influenced by changing variables and unpredictable factors that result from different sources and the sources include performances of construction parties, environmental conditions, involvement of other parties and contractual relations (al, January 1, 2017).

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 worst case (Arian, The Potential Effects Variation Order on Institutional Buildings, 2015), (al, January 1, 2017).

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. This however requires a comprehensive understanding of the root causes (al, January 1, 2017).

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.

#### **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 (Revy, 2013). In most cases scope change is made by owner's choice due to various reasons (A.H., 2015) (O'Brien, 1998). 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. Change of plan or scope of project is the most significant causes of change in construction (A.H., 2015).

Any change to the project scope almost always requires an adjustment of the project cost or schedule (Douglas Edward E., 2013) . 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**

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 (O'Brien, 1998) (Fisk, 2000)

### **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 (A.H., 2015). This problem affects project progress and quality so that proper planning and review of project cash flow would be effective to minimize this problem (O'Brien, 1998) O'Brien suggests.

### **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.

### **2.3.1.4 Obstinate nature**

The success of construction project is the result of professionals combined efforts. 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 (Arian, Modeling for Management of Variation Order in Institutional, 2017)

### **2.3.1.5 Change in design by consultant**

Design related changes or variations for improvement are very common in construction projects (Mokbel, 2013) and (Arian, The Potential Effects Variation Order on Institutional Buildings, 2015). Most of the changes in design especially happen in projects where construction starts before design is finalized because of urgency. Quoting pointed out that More than 75% of the problem encountered on site was generated at the design stage.

### **2.3.1.6 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.

#### **I. Non-compliance of design and specification requirements**

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

#### **II. Non-compliance with owner requirements**

Design is said to be comprehensive if it accommodates owner's requirements (Arian, The Potential Effects Variation Order on Institutional Buildings, 2015). Noncompliance with owner's requirements is considered to be inadequate design Noncompliance of any of the contract documents results in variation to accommodate owner's requirements later during construction (Fisk, 2000).

#### **III. 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 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 (A.H., 2015). In this case the proposed method of construction and materials to be used might be outdated.

### **2.3.1.8 Design complexity**

Complex design may require the involvement of skilled professional and construction methods (Arian, The Potential Effects Variation Order on Institutional Buildings, 2015) 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.

### **2.3.1.9 Lack of professional experiences**

Professional experience is an important factor for successful completion of construction projects (Arian, Modeling for Management of Variation Order in Institutional, 2017). 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.

### **2.3.1.10 Defective workmanship**

Defective workmanship of completed work may bring demolition and re-work or it may bring changes in some instances (O'Brien, 1998) 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 (Arain et al. (2004)).

### **2.3.1.11 Differing site conditions**

The real condition cannot be shown on drawings and specification or it cannot be determined during site investigation (Yunus, 2017) If different site conditions face during construction phase it may causes variation. In most case the contractors 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.

### **2.3.2 Effects of Variation**

“Change or variation affects every aspect of human endeavor, and construction is no exception” (Bruce Hallock, December 2016.) And the reported of recent survey of professional engineers identified change as the major cause of project failure. Similarly, 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 (A.H., 2015) Legal and cost aspect/impact of variation and the magnitude of this impact will be briefly described below.

#### **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 (A.H., 2015) In this case changes are considered as major sources of claims and disputes.

The major legal aspects according to (Thomas, 2015) mentioned include,

- ✓ Selecting the best delivery system (contract formats)
- ✓ Drafting and interpreting change clauses
- ✓ 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 (Hanna, 2012). An extensive study by CII (Construction Industry Institute) cited by many authors has great contributions on this issue. (A.H., 2015) Citing CII describes that quantitative assessment of change impacts are done for three different purposes. These are:

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

#### **A. 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 (Arian, The Potential Effects Variation Order on Institutional Buildings, 2015). Sometimes a change may also have a positive or no cost impact at all for to both contractors and owners.

Labor cost impact focus on the situation where change is issued after construction are categorize labor cost of changes into three (Thomas, 2015) Productivity degradation

- a) Delays
- b) 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. Productivity drops with increased

frequency of interruptions. 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.

**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.

**c) Demolition of works**

Changes, which are introduced when the construction is underway or even complete, involve several direct cost items 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

**B. 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. 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.

**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 %. (Arian, The Potential Effects Variation Order on Institutional Buildings, 2015).

#### **2.3.2.4 Potential Effects of Variations**

The effects of variations have been studied by many researchers (Thomas, 2015), (Ibrahim, 2016), (Arian, The Potential Effects Variation Order on Institutional Buildings, 2015) etc. Under this heading the findings of some of these authors and all the potential effects identified from literature will be discussed.

##### **1. Progress is affected but without any delay**

Variation during progress may affect the project performance and quality (Assaf SA, 2005). 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. Increase in project cost**

Increasing project cost is the most common effect of variation in construction projects during construction phase (Arian, Modeling for Management of Variation Order in Institutional, 2017). 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 (Ibrahim, 2016) . Specialized manpower is one of the integral resources required for complex projects (Fisk, 2000).

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).

##### **3. Decrease in quality**

Variation, if it is frequent, it may affect the quality of works adversely (Fisk, 2000). Also, quality of work was usually poor because of frequent variations. (Ibrahim, 2016).

#### **4. Delay in payment (cash flow problem)**

Delay in payment occurred frequently due to variation in construction (Arian, Modeling for Management of Variation Order in Institutional, 2017) and (Arain & Pheng, 2005 and (A.H., 2015). 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.

#### **5. Decrease in productivity**

Interruptions, delays and rework which are associated with variation order have a negative impact on labor productivity. (Thomas, 2015) 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.

#### **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 (Arian, The Potential Effects Variation Order on Institutional Buildings, 2015).

Therefore, rework and demolition are potential effect variation in construction projects. The degree of this effect depends on the timing of their occurrences (al, January 1, 2017), their effects are severe during construction stage since variations or changes at design stage may not require rework and demolition.

#### **7. Disputes between contracting parties**

Variation is major causes of claims in construction projects (Kumaraswamy, 2008) and (Fisk, 2000). If these claims are not amicably solved, they result in dispute that may affect the relation among contracting parties and between professionals of the contracting parties.

### **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 (Cally, 2005). Effective management of variation orders in turn requires a comprehensive understanding of the root causes and their potential consequential effects, 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.

The management aspect of variation will be briefly discussed below:

Both owner and contractor should play significant roles in establishing and maintaining well managed processes (al, January 1, 2017) in change management because successful implementation of effective change management processes benefits both project owner and contractors (Douglas Edward E., 2013). 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.

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, change is a major cause of project failure (Bruce Hallock, December 2016.).

There are two basic concepts during change management. These are;

**A. Managing the processes of change**

**B. Administrating the change order processes**

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.

#### **2.3.3.2 Controlling Variation**

If project content is allowed to change freely, the rate of change will exceed the rate of progresses controls that should be provided for all phases of a major project change order as one of the major issues that should be controlled (Tiong, 2006). Studied various In the meantime in agreement with (al, January 1, 2017) in previous section, he suggested that change order control system should be established for the ultimate benefit of both owner and contractors.

#### **2.4.2 Relationship between triple constraints**

George E. P. Box stated “All models are wrong. Some are useful.” (*Box, 1979*) The Triple Constraint model is both wrong and not useful. It says that cost is a function of time and scope, that these three factors are related in a defined and predictable way. The Triple Constraint says that if we want to shorten the (time) we must increase cost. It says that if we want to increase scope, we must increase cost or schedule.

However, the data says otherwise. Why is it that the majority of projects that are over budget are also late? This runs contrary to the constraint.



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Why is it that projects that is both late and over budget also have a tendency to under deliver (scope)? Again, this is not consistent with the Triple Constraint.

Yes, they can all be explained away. But that is exactly the problem. The Triple Constraint model has been with us for too long precisely because we are able to explain away the facts, rather than confront the model.

A new Triple Constraint is proposed which is supported by the facts and which will focus project managers and management in a new direction.

A poor mental model prevents progress and the Triple Constraint has done just that. It influences how we measure projects. We have used the measures of delivered functionality, actual cost and schedule versus planned for as long as can be remembered. Yet, despite the best efforts of many we continue to achieve relatively poor project results.

The Triple Constraint model is at the core of the problem. Our belief in the Triple Constraint has forced us to focus on the only other factor available, people, as the primary factor for change. People are important; however, they are only one component.

This presentation explores a new model, the Value Triple Constraint model that focuses project managers in a new direction and leads to the integration of Project Management, Process Management and Business Analysis.



*Figure 1. Relationship between triple constraints*

#### **2.4.2.1 Effects of Cost Overrun**

Cost overruns have obvious effects for the key stakeholders in particular, and on the construction industry in general. To the client, cost overrun implies added costs over and above those initially agreed upon at the onset, resulting in less returns on investment. To the end user, the added costs are passed on as higher rental/lease costs or prices. To the professionals, cost overrun implies inability to deliver value for money and could well tarnish their reputations and result in loss of confidence reposed in them by clients. To the contractor, it implies loss of profit for no completion, and defamation that could jeopardize his/her chances of winning further jobs, if at fault. To the industry as a whole, cost overruns could bring about project abandonment and a drop in construction activities, bad reputation, and inability to secure project finance or securing it at higher costs due to added risks. (*Stumpf, (2000)*) All these consequences undermine the viability and sustainability of the construction industry.

The effects of cost overrun are not confined to the construction industry but are reflected in the state of the overall economy of a country. They state that delays and cost overruns in construction projects prevent the planned increase in property and service production from taking place, and this phenomenon in turn affects, in a negative way, the rate of national growth (*Arditi D., 1997*).

## **2.5 Empirical Literature Review**

The construction industry performance measured by three major parameters cost, time and quality. However, the design change affects the whole process of project and the effects listed below are mostly occurred in Ethiopia Construction industry. Cost overrun, time overrun, quality problem, increases overhead expenses, wastage of materials due to rework, Productivity degradation due to equipment and material, claim and disputes occur between client and contractor. The most common effects for those projects that change of design took place during construction stage were delay of the projects, increasing of cost of the project (cost overrun), abandoning of the project, wastage of materials and conflicts between the parties. (IJERT)

The study conducted in Nigeria found that design change due to poor working drawing (omission on structural drawing) leads to variation. design changes frequently impact project cost and time and have the potential to increase the possibility of conflicts between owners and contractors. Project time and cost change impact can become severe if owners do not consider the fact that a change in one part of the project may cause a series of changes in other parts of the project, which is known as the “change ripple effect.” Therefore, for the well-organized delivery of construction projects, it is essential to have an efficient design change management system. The critical appraisal of literature relating to causes of design changes and the resultant rework that cause delay and disruption which result in time delays and cost overruns in building construction projects has been presented. The effects of design change from different scholars can be summarized as additional payment for contractors, rework, demolition, completion schedule delay, increased overhead expenses and increase the possibility of conflicts between owners and contractors.

Design change is one of the causes for the arising of cost overrun and time over run in the construction industry according to different studies. Many studies have been conducted in different countries to identify the factors affecting time overrun in construction projects.

According to (*Mahamid, 2011*) Indicated that the most several factors affecting time delay in construction projects in the West Bank in Palestine from the owner perspective are poor communication between construction parties, poor resource management, delays in

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commencement, insufficient inspectors, and rework. (*BattainehHussien., 2002*) Found that contractors and consultants agreed that owner interference, inadequate contractor experience, financing and payments, labor productivity, slow decision making, improper planning, and subcontractors are among the top ten most important factors of construction delay in Jordan.

(*AL-Hejj.si, 2006*) Discussed the delay in large construction project in Saudi Arabia. Seventy-three factors affecting time overrun were identified during the research. They concluded that the most common factor of delay identified by the contractors, the consultants and the owners is “change order”.

Another study conducted in Kuwait to study the causes of time and cost overrun in construction projects. They concluded that the main causes of delays are change orders, owners’ financial constraints, and owners’ lack of experience. They stated the following recommendation to the owners in order to minimize time delays: (*Koushki P.A, 2005*)

In this research to establish a conceptual and contextual framework for the research objectives. An in-depth literature review was conducted to identify the causes, effects, and management aspects of variations and design changes

The first section of this literature review introduces some broad concepts about variations and changes, including definitions and variations. The review focused on identifying factors that contribute to variation/change and its consequences (effects) after having a clear understanding of variation and its classifications.

The researcher discovers variation as a phenomenon that can be invested in construction projects through the in-depth literature review processes. In light of this, the third subchapter of the literature review is devoted to the management and control of construction project change/variations. The various controlling mechanisms of variations and how to administer them have been thoroughly discussed in these subheadings.

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## 2.6 Conceptual framework

**Dependent variable:** The dependent variable in this research is construction performance effect on construction performance.

**Independent variable:** The independent variables in this study include internal factors such as client/employee related factors (Gov't), contractor related factors, design consultant related factors, Supervision consultant related factor causing design change.

### Independent variable

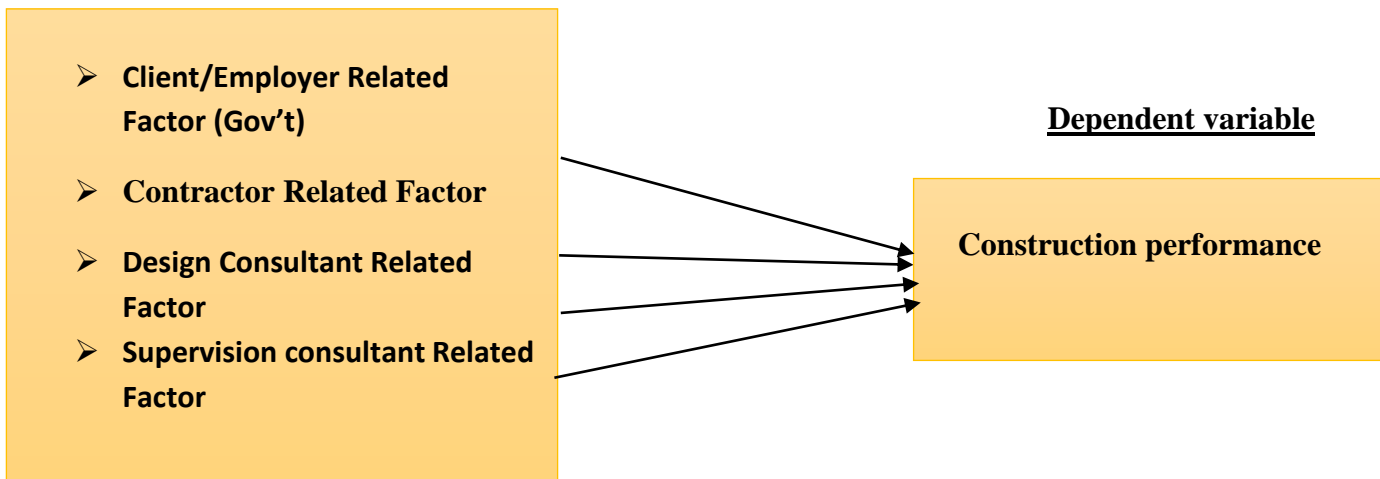


Figure 2. Source (Conceptual frame work J. Y. B. Hui, H. Abdul-Rahman and W. Chen)

Indicators for the project performance effect

- Time over run
- Cost overrun
- Demolition and Rework
- Decrease in quality
- Project delay
- Decrease in productivity
- Dispute between parties
- Material wastage

## **CHAPTER THREE**

### **3. METHODOLOGY**

#### **3.1 Introduction**

The purpose of this chapter is to elaborate on the project's based on objective of the study. Methodological approach. The detail section that describes the research approach, the population, sample size, sampling method, data source, and data analysis was discussed.

#### **3.2 Research Approach**

There are three basic approaches to research quantitative approach, the qualitative approach and mixed approach. The research approach that is used in this research is a quantitative approach. Quantitative research used to examine the relationship among variables. This research have a dependent and independent variable which was measured numerically by using correlation and regression. The questionnaire survey was adapted to get feedback on opinions of respondents “on the effect of variation due to design change on building project performance in Addis Ababa Delta Engineering Construction Plc”.

#### **3.3 Research Design**

The purpose of this study was to identify the effect of variation design change on building project performance in Addis Ababa delta engineering construction plc. the study establishes causal relationships between the dependent variable (effect on project performance) and the independent variable (design change factors), explanatory research was conducted. According to Kumar (2011), the goal of explanatory research is to determine why and how two situation or phenomena are related to one another.

### **3.4 Population, Sample Size and Sampling Technique**

#### **3.4.1 Population**

The populations for this research were the construction building projects that have variation due to design change in delta engineering construction plc. According to Mark (2009) the entire collection of cases from which a sample is taken is called the population. clients, contracting, design, supervision, and consulting firms were significant data sources. The professional construction employees, such as site engineers, project managers, quantity surveyors, and supervisors, were in a better position to provide the information required by this study because the primary objective of the research is to identify the effect of variation caused by design change. The population consist of 41 contractors, 23 clients who give contracts to contractors, 34 design consultants, and 22 supervision consultants registered with the Addis Ababa construction bureau. (Delta engineering construction plc)

#### **3.4.2 Sampling**

Studies are typically conducted on samples because it is usually impossible to study the entire population. A sampling method is one in which every person in the population has the same chance of being included in the sample. According to Mark (2009), taking in the entire population for this study is challenging due to the difficulty of conducting a comprehensive survey when there is a limitation of budget and time constraint. As a result, the probability sampling method was used. probability samples the chance of selecting each case from the population is known and equal for all cases Mark (2009). Probability sampling is often associated with survey and explanatory research method. When conducting research survey, it is relevant that the researcher samples random participant. This permit for more accurate findings possible to get results from a larger number of respondents. This shows random sampling goes with the research design of this research. Among the probability sampling methods, a simple random sampling was used since a simple random sampling technique will give each member of the study population an equal chance of being selected.

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### **3.4.3 Sample Size**

The samples for this study are contracting companies' contractors and design consultants, supervision consultant and clients from the delta engineering construction plc. The total number of contracting companies as client's 23, contractors 41, Design consultants 34, and supervision consultants 22 so the total population was 120. From this, selecting a portion of the population from the total population this was decided by calculating the sample size using Yamane (1967) method. This method is relevant to a known population size.

$$n = \frac{N}{1+N(e)^2}$$

Where, n= sample size

N= known population size

e= error level

e= error level (in this case it is 5% with a confidential interval of 95%)

#### **For clients who hired the above contractors**

Total Number = 23

$n = N$

$$\begin{aligned} & \frac{1}{1 + N(e)^2} \\ & = \frac{23}{(1+23*0.0025)} \\ & = 22 \end{aligned}$$

#### **For Contractor**

Total Number of= 41

$n = N$

$$\begin{aligned} & \frac{1}{1 + N(e)^2} \\ & = \frac{41}{(1+41*0.0025)} \\ & u= 37 \end{aligned}$$

#### **For Design Consultant**

Total Number = 34



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$$\begin{aligned}
 n &= N \\
 1 + N (e)^2 \\
 &= 34 / (1 + 34 * 0.0025) \\
 &= 31
 \end{aligned}$$

**For Supervision Consultant**

Total Number = 22

$$\begin{aligned}
 n &= N \\
 1 + N (e)^2 \\
 &= 22 / (22 * 0.0025) \\
 &= 21
 \end{aligned}$$

*Table 1. Sample size*

Category	Number of categories (population)	Number of Sample
Client	23	22
Contractor	41	37
Design Consultant	34	31
Supervision consultant	22	21
Total	120	111

Source own survey (2022)

The respondents of the questionnaire are construction professionals. This includes project managers, resident engineers, site engineers, office engineers, designers, supervisors, quantity surveyors who are directly related to design change in construction sites. An employee of the company whose job is not directly related to construction and non-professional employee of the company like daily labors are not included.

### **3.5 Data Collection Method**

#### **3.5.1 Source of Data**

The study depended on both primary and secondary data. The Primary data come from first-hand data collected by the candidate by using questionnaires each item in the questionnaire developed to address the research objectives. The secondary sources of data are obtained using relevant books, journals, magazines and articles.

#### **3.5.2 Data Collection Tools**

In this study, methods of data collection include questionnaire. It is convenient while conducting survey research. A questionnaire is a research tool that contains questions for the purpose of collecting information from respondents through survey or statistical study and to gather the data needed from a sample population. Each item in the questionnaire developed to address the research objectives.

#### **3.5.3 Data collection**

There are several instruments of collecting primary data, particularly in surveys. Important ones are: observation method, interview method, through questionnaires among which a researcher is supposed to select to achieve the objectives of the research. Selection of data collection method depends on different factors such as nature and scope of enquiry, availability of fund, time needed and precision required. The type of research and data needed dictate what type of data collection methods to be used.

The methods to be used to collect the data for this research were questionnaire Survey document analysis. The questionnaires were preparing in accordance with the objectives of the research.

Documents are written and printed materials that official researches that focused on variation in construction projects and accordance with the research objective. The information was gathered from construction project site cooperative workers including, site engineers, office engineers and Project manager at the project during this project progress.

### **3.5.4 Questionnaire**

As stated by Mark et al., (2009) a questionnaire is the most widely used method in survey strategy. Survey provides an effective way to collect responses from a large sample before making analysis. To obtain the needed data, a structured questionnaire was used as a data collection tool, due to the sample size and the quantitative approach of the study. The questionnaire was divided into four main parts. Section I solicited general (factual) information about respondents. second section focused about general information about variation due to design change is a problem in the Ethiopian construction industry in general and that of delta engineering construction projects in particular, the third section consisted a total of 25 design change cause factors. These design change factors were categorized into four major groups. Seven factors were associated to the client, six factors were categorized under design consultant, six factors were categorized under supervision consultant, and six factors were categorized under contractor. the Last section consisted a total of seven project performance factors. The questionnaire is open 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 factor (from 1-5) to identify potential causes the ratings used were: strongly disagree = 1; disagree = 2; Neutral = 3; Agree = 4; and strongly agree = 5. For the effect part respondent are requested to put the possible effects corresponding for each contributing factor by rating the most recurrent effects based on their experience.

### **3.6 Method of Analysis**

#### **3.6.1 Method of data analysis for Questionnaire**

In order to answer research questions and objectives, descriptive and inferential statistics were used. Descriptive statistics such as frequencies and percentages were used to present the demographic and educational characteristics of respondents. Pearson Correlation analysis was conducted to test the existence of a significant relationship between the design change factors and project performance. Then, the multiple regression analyses were also conducted to determine by how much percent the independent variable i.e. design change factors explain the dependent variable which is project performance. In this context, data was collected, summarized and, analyzed using statically Package for Social Scientist (SPSS) version 26.

#### **3.6.2 Reliability**

The Reliability of the collected data was assessed using a statistical package for social sciences (SPSS). A reliability test is conducted to check whether each item in the scale is free from error of measurement (Kumar, 2011). If a questionnaire is examined at different times and across different populations, and it produces the same results, the questionnaire is "reliable" (Field, 2009) In this test, Cronbach's alpha values range from 0 (un-reliable) to (reliable) with 0.7 being considered a relatively strong value of reliability. Widely used methods when using SPSS for assessing reliability are Cohen's Kappa Coefficient for categorical data and Cronbach's alpha for continuous data (Likert-type scales). Since the data collection was based on a Likert-scale, Cronbach's alpha method was used to check reliability.

*Table 2. Reliability Statistics Cronbach 'Alpha result*

<b>Variables</b>	<b>Cronbach' Alpha</b>
<b>Client Factors</b>	
<b>Design Consultant Factors</b>	0.702
<b>Supervision consultant</b>	0.730
<b>Contractors Factors</b>	0.760
<b>Effect On Project Performance</b>	0.710
<b>Over all Reliability</b>	<b>0.827</b>

Source own survey (2022)

Therefore, the internal consistency of, 25 design change factors, 7 project performance effects, which constitute a total of 32 variables of Likert Scale questions were verified by calculating “Cronbach’s alpha” from the valid responses. The higher the alpha coefficient score, the more reliable the generated scale is. A value of 0.7 is an acceptable coefficient. The result showed an alpha coefficient value of 0.827 is greater than 0.7 that confirmed the questionnaire reliability by all respondents which measure the same construct.

### **3.6.3 Validity**

The validity, in essence, refers to the appropriateness of the measures used, the accuracy of the analysis of the results and generalizability of the findings” (Mark et al., 2009: p.202). To provide supporting evidence that the researcher measure what it intends to measure, a test for content validity was conducted by a pilot study. To check the content validity 20 questionnaires were distributed to experienced professionals in construction projects. After that, the questionnaires were modified based on the received comments and distributed to the targeted populations.

## CHAPTER FOUR

### 4. PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA RESULT AND DISCUSSION

#### 4.1 INTRODUCTION

This chapter presents finding of survey data analyzed and interpreted in line with the study objectives. The finding of the data gathered are presented based on the research methodology designed. For this purpose, statistical instruments called descriptive statistics such as: mean, mode, median, and frequency, standard deviation, rank by using tables, figures and additional explanations are used to perform data analysis. The data was collected from client, contractor, design consultant and supervision consultant. This part of the study deal with presenting, analyzing and interpreting the data gathered from questionnaires' data analysis consist of descriptive and inferential analysis.

#### 4.2 Questionnaire Response Rate

For the purpose of gathering primary data, questionnaires were distributed to client, contractor, design consultant, Supervision consultant. Accordingly, from 111 of the respondents 111 questionnaires were collected that is 100% appropriately filled and responded to the questions. A response rate of 50% is adequate, 60% is good, and 70% and above is perfect to appropriately represent the entire population. Therefore the response rate of this research was above 70% and it is perfect to appropriately represent the entire population.

#### Questionnaires survey response rate

Table 3. Respondents Response Rate

Target respondent	Number of samples	Number of respondents	Percentage (%)
Client	22	22	19.8%
Contractor	37	37	33.3%
Design consultant	31	31	27.9%
Supervision consultant	21	21	18.9%
Total	111	111	100%

Source own survey (2022)

## The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc

### 4.3 Descriptive Analysis Result

#### 4.3.1 Demographic Characteristics of Respondents

In this section the general profile of the respondents are analyzed using frequency and percentage. The demographic information used in this research were educational background, profession, type of organization the respondents represent.

Table 4. Respondents Response Rate

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
<b>Project performance</b>	111	3.71	5.00	4.3990	.32240
<b>Clients</b>	111	3.86	5.00	4.4595	.33553
<b>Contractor</b>	111	3.17	5.00	4.4189	.36781
<b>Design Consultant</b>	111	3.17	5.00	4.3724	.34957
<b>Supervision Consultant</b>	111	3.17	5.00	4.4054	.36902
<b>Valid N (listwise)</b>	111				

Source own survey (2022)

Table 5. Respondents' organization type

Type of your organization					
		Frequency	Percent	Valid Percent	Cumulative Percent
<b>Valid</b>	Client	22	19.8	19.8	19.8
	Contractor	37	33.3	33.3	53.2
	Design Consultant	31	27.9	27.9	81.1
	Supervision Consultant	21	18.9	18.9	100.0
	Total	111	100.0	100.0	

Source own survey (2022)

The second question asked in the demographic section was the type of organization the respondents represent. Of all 107 questionnaire collected 19.8 % were professionals from the

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client side, 27.9 % from design consultant side, , 18.9 % from supervision consultant side, and 33.3 % from the contractor side. This implies that all the contracting parties were well represented by the respondents.

*Table 6.Respondents Company experience*

Company experience construction industry					
		Frequency	Percent	Valid Percent	Cumulative Percent
<b>Valid</b>	0-5 year	14	12.6	12.6	12.6
	6-10 year	50	45.0	45.0	57.7
	11-15 year	40	36.0	36.0	93.7
	> 20	7	6.3	6.3	100.0
	Total	111	100.0	100.0	

Source own survey (2022)

The above table indicates the experience of the respondent, 12.6% were zero up to five years, 45% were six up to ten years, 36% of the respondent employees are in the range of eleven up to fifteen years, four 6.3% of the respondent was above twenty years' experience in the industry. Consequently, it was believed that respondents had some knowledge and understanding of the topic related to design change in general and awareness of the effect of design change on building construction projects in particular. This makes them dependable and credible sources of information which is vital to realize the research objective.



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Table 7. Respondents professional position.

Position in the organization or on site					
		Frequency	Percent	Valid Percent	Cumulative Percent
<b>Valid</b>	Project Manager	3	2.7	2.7	2.7
	Office engineer	33	29.7	29.7	32.4
	Site engineer	28	25.2	25.2	57.7
	Consultant supervisor	23	20.7	20.7	78.4
	Client supervisor	13	11.7	11.7	90.1
	Contractor	11	9.9	9.9	100.0
	Total	111	100.0	100.0	

Source own survey (2022)

Of all 107 questionnaires collected the professional position of respondents indicates that 2.7 % of the respondents were project managers, 20.7% consultant supervision, 30% site engineers, 25.2% Site engineer, 29.7% office engineers, clint supervision, 11.7%, contractor 9.9%. This implies that all the questioners were filled and responded by professionals who are directly related to the thesis topic or design change

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*Table 8. Respondents Year of Experience*

Professional experience in construction industry					
		Frequency	Percent	Valid Percent	Cumulative Percent
<b>Valid</b>	0-5 year	20	18.0	18.0	18.0
	6-10 year	44	39.6	39.6	57.7
	11-15 year	38	34.2	34.2	91.9
	> 20 years	9	8.1	8.1	100.0
	Total	111	100.0	100.0	

Source own survey (2022)

The above diagram indicates the Respondents professional experience in construction industry ,18.0 % were zero up to five years, 39.6 % were six up to ten years, 34.2% of the respondent employees are in the range of eleven up to fifteen years, four 8.1% of the respondent was above twenty years’ experience in the industry.

*Table 9. Respondents Level of education*

Level of education					
		Frequency	Percent	Valid Percent	Cumulative Percent
<b>Valid</b>	MSc	54	48.6	48.6	48.6
	Bachelor	50	45.0	45.0	93.7
	Diploma	7	6.3	6.3	100.0
	Total	111	100.0	100.0	

Source own survey (2022)

Level of education of respondent are 48.6% of the respondents has MSc, 45.0% of the respondents were holding Bachelor, 6.3s% were diploma. That means most of the respondents have higher educational status.

#### **4.4 Analysis of Inferential Statistics Result**

The major objective of the study is to assess the effect of variation due to design change on construction project performance and to assess the existed relationship. For this purpose, inferential statistics of correlation & regression analysis have been used and the result is presented in the below sections.

##### **4.4.1 Test of Normal Distribution (linear assumption)**

In order for the linearity assumption to be fulfilled, the dependent variable should be a linear function of the independent variable. And this has been checked using Normal probability plot of independent variables with the dependent variable. And this can be checked by looking comparing the results with the linear line and the result is as shown in the figure below. The P-P Plot of Normality Test is cumulative probability plots of residuals.it is used to judge whether the distribution of variables is consistent with a specified distribution. If the Standardized residuals are normally distributed, the scatters should fall on or tightly close to the normal distribution line. This shows that the scatters of the residuals basically fall straightly on the normal distribution line, indicating a normal distribution of residual. Having this in mind the below diagram shows that the data is normally distributed.

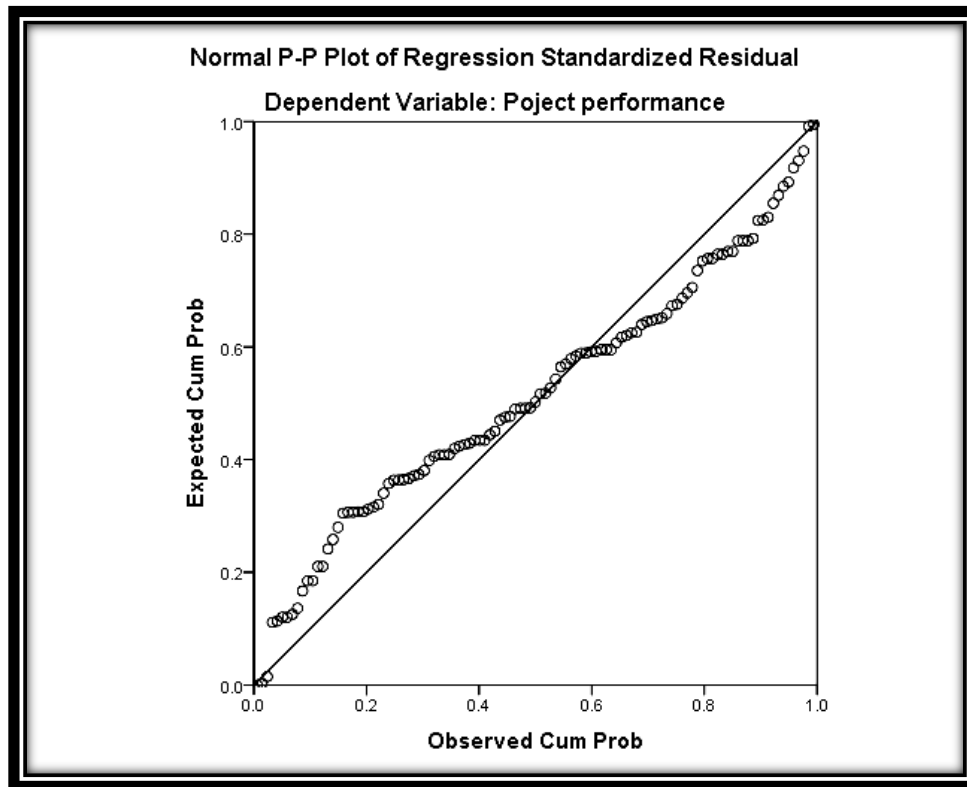


Figure 3. Test of normal distribution

Source own survey (2022)

#### 4.4.2 Homoscedasticity Test

Homoscedasticity refers to level of dispersion of errors consistently throughout all the independent variables. This can be checked by visually examining the plot of standardized residuals. If the latter is not even, fan and butterfly shapes are common patterns for violation. The following is a scatter plot of standardized residuals versus the standardized predicted value obtained using SPSS software.

$$\text{COV}(U_i, U_j) = 0$$

Where: COV means the covariance between two variables

$U_i$ : Error term one

$U_j$ : Error terms two

Scatter plot  
Dependent variable: project performance

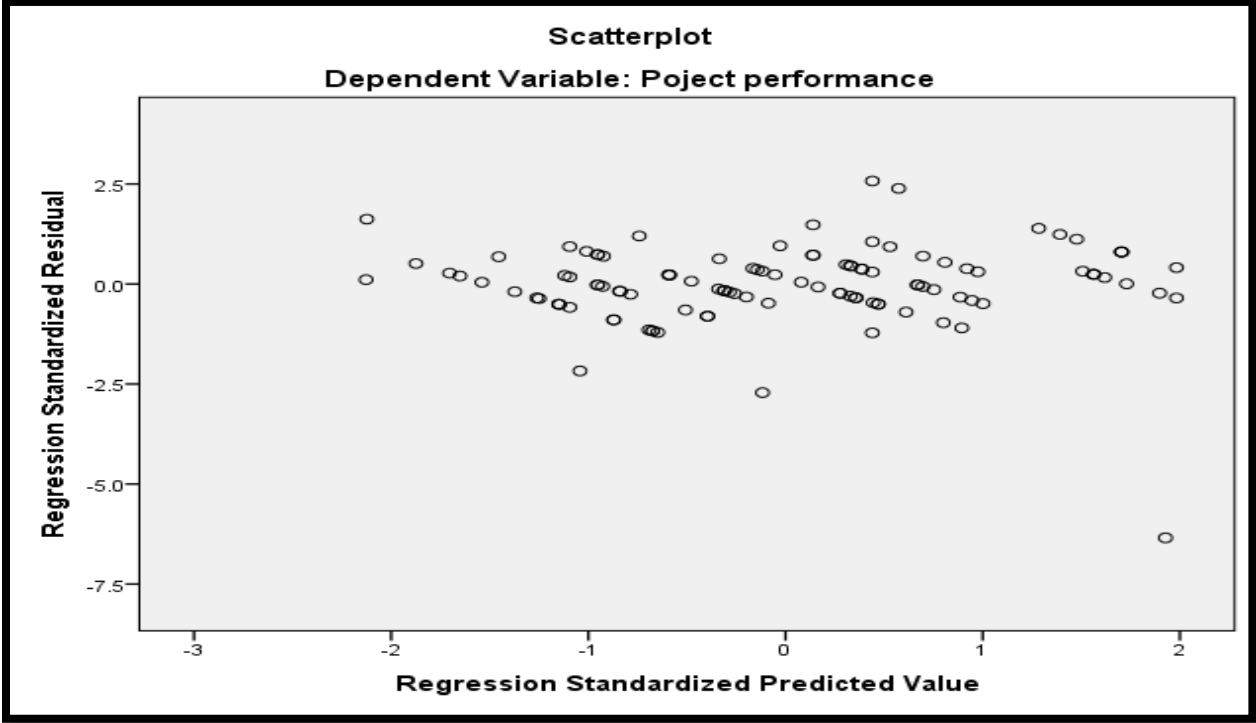


Figure 4.Homoscedasticity Test

Source own survey (2022)

**4.4.3 Autocorrelation Test**

If the possible ranges of Durbin-Waston >2.5 the autocorrelation between the two variables are negative. If the value of Durbin-Watson <1.5 the autocorrelation between two variables is positive and the value nearest to 2.0 the autocorrelation between two variables is zero or nothing. Based on this fact the value of Durbin-Watson in this research was 1.937 which is ~2. That means there was no autocorrelation between them. Therefore, assumptions three and three weren't violated.

(Assumption 3 test):  $COV (X_t, U_t) = 0$

Where: COV means the covariance between two variables

$X_t$ : Predictor variables

$U_t$ : Error terms

*Table 10. Model Summary Durbin-Watson*

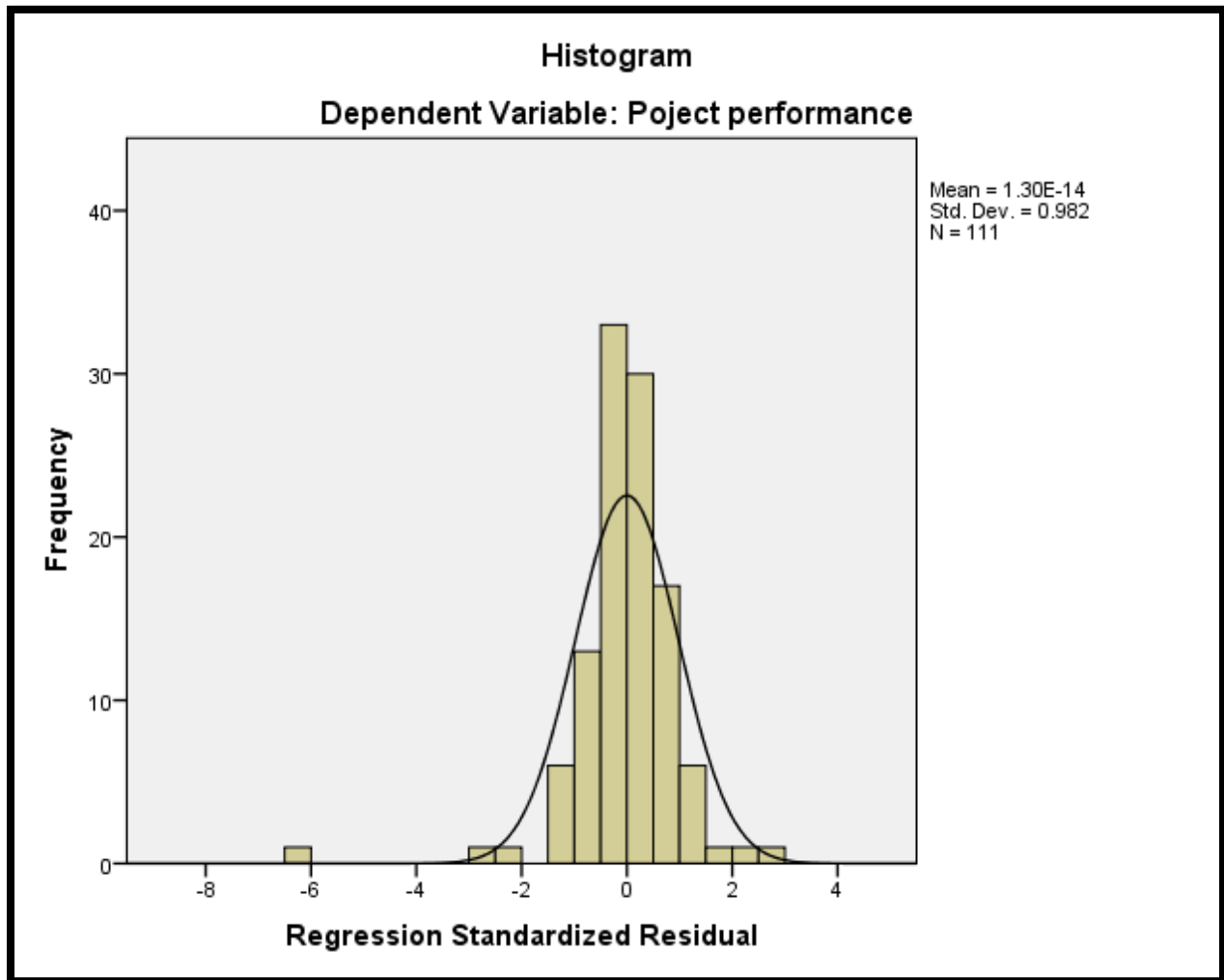
Model Summary			
Model	Change Statistics		Durbin-Watson
	df2	Sig. F Change	
1	106 <sup>a</sup>	.000	1.937

- a. Predictors: (Constant), Supervision Consultant, Contractor, Design Consultant, Clients
- b. Dependent Variable: Project performance

Source own survey (2022)

#### **4.4.4 Normality Test**

In order to check whether the normality test was adequately met, the histogram was used in this study. If the residuals are normally distributed, the histogram should be bell-shaped (Brooks, 2008). A normality test is used to determine whether sample data has been drawn from a normally distributed population (within some tolerance).



*Figure 5. Normality Test*

Source own survey (2022)

#### **4.4.5 Correlation Analysis**

is used to test relationships between quantitative variables or categorical variables. In other words, it's a measure of how things are related. A correlation coefficient is a way to put a value to the relationship. (Field, 2009) Correlation coefficients have a value of between -1 and 1. A "0" means there is no relationship between the variables at all, while -1 or 1 means that there is a perfect negative or positive correlation (negative or positive correlation here refers to the type of graph the relationship will produce). Sig (2-tailed) if the value is less than or equal to 0.05 we can conclude that there is a statistically significant correlation between the variables. (Field, 2009)

*Table 11. Measures of Association and Descriptive Adjectives Table Measures of Association and Descriptive Adjectives*

<b>Measure of Association</b>	<b>Descriptive Adjective</b>
> 0.01 to 0.30	Low
> 0.30 to 0.70	Moderate
> 0.70 to 0.90	High
> 0.09 to 1.00	Very high

Source: (Field, 2009)

Hence the correlation output of dependent and independent variable is interpreted based on table



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		Project performance	Clients	Contractor	Design Consultant	Supervision Consultant
Project performance	Pearson Correlation	1	.696**	.502**	.699	.699
	Sig. (2-tailed)		.000	.000	.000	.000
	N	111	111	111	111	111
Clients	Pearson Correlation	.696**	1	.348**	.683**	.683**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	111	111	111	111	111
Contractor	Pearson Correlation	.502**	.348**	1	.382**	.382**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	111	111	111	111	111
Design Consultant	Pearson Correlation	.554**	.399**	.296**	.405**	.405**
	Sig. (2-tailed)	.000	.000	.002	.000	.000
	N	111	111	111	111	111
Supervision Consultant	Pearson Correlation	.699**	.683**	.382**	1**	1**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	111	111	111	111	111

*Table 12. Correlations Matrix between the Dependent and Independent Variable*

Source own survey (2022)

Based on the survey result, the correlation between Client factor & its effect on project performance is positive and they are significantly correlated at ( $R = .696^{**}$ ), ( $P < 0.01$ ). This shows that an increase in client related design change/variation would lead to an increase in the effect of project performance or it would affect project performance. Similarly, the correlation between contractor factor and its effect on project performance with ( $R = .502^{**}$ ), ( $P < 0.01$ ) accordingly, the relationship between the two variables is moderately positive and statistically significant. This shows that an increase in contractor related design change would lead to an increase in the effect of project performance or it would affect project performance. From the survey result, the correlation between design consultant factor and its effect on project performance is positive and they are significantly correlated at  $R = .554^{**}$ , ( $P < 0.01$ ) which reveals a high relationship of the two variables. This shows that an increase in consultant related design change would lead to an increase in the effect of project performance or it would affect project performance. the correlation between supervision consultant & its effect on project performance is positive and they are significantly correlated at ( $R = .699^{**}$ ), ( $P < 0.01$ ). This shows that an increase in client related design change/variation would lead to an increase in the effect of project performance or it would affect project performance. According to Field, (2009) a correlation between two variables does not imply that one event causes the second to occur. In order to understand how the dimensions of design change/variation affect project performance and thus to test hypotheses, multiple regression was carried out. But before running the regression the basic assumptions for regression have been analyzed.

#### 4.4.6 Test of Multicollinearity

Multicollinearity is a situation when a high correlation is detected between two or more predictor variables. Collinearity, in statistics, is the correlation between independent variables, such that they express a linear relationship in a regression model. Multicollinearity describes a situation in which more than two independent variables are associated so that, when all are included in the model, a decrease in statistical significance is observed. If the coefficient of tolerance is greater than 0.2 and the coefficient variable insignificant factor (VIF) is less than 10, it would not have collinearity between the variables. As shown in the table above the coefficient of tolerance is  $> 0.2$  and  $VIF < 10$ . Therefore, assumption four was not violated.

As shown in the table below. The tolerance and VIF of the variables show there is no multicollinearity. VIF value for Client factor is 1.960, consultant factor 2.544 and Contractor is 1.673 so it fits the requirement and multicollinearity is not a problem.

#### Collinearity test

*Table 13. Multicollinearity Table*

Model		Coefficients	
		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Clients	.510	1.960
	Contractor	.822	1.217
	Design Consultant	.790	1.265
	Supervision Consultant	.496	2.016

Source own survey (2022)

#### **4.4.7 Multiple Regression Analysis**

Since descriptive analysis does not determine any significant results in predicting the effect of various design change factors on project performance, further analysis using advanced statistical methods such as multiple linear regression is required. Multiple regression analysis is widely used method in research to explore the correlation between one dependent (target) variable and more than two independent (predictors) variables. In this study, the overall effect on project performance as a dependent variable is correlated with owner related design change, contractor related design change, design consultant related design change, and supervision consultant related design change, as independent variables by using the technique of standard multiple regressions in SPSS. The result of multiple regression is the development of a regression equation (line of best fit) between the dependent and independent variables. The following tables show the regression analysis for the variables, results are discussed and interpreted based on the table below.

*Table 14. Model Summary Effect on Project Performance*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.820 <sup>a</sup>	.672	.659	.18817

a. Predictors: (Constant), Contractor, Client, Design Consultant, supervision consultant

b. Dependent Variable: Effect on construction Project Performance

Source own survey (2022)

As the above table depicted, the adjusted R<sup>2</sup> value of the model is 0.659, indicating that 65. % of the variation in project performance is explained by client related factors, design consultant related factors, supervision consultant related factor and contractor related factors. In other words, 35. % of the variation in project performance in the Addis Ababa delta engineering construction building project cannot be explained by the study variables and there are other factors that can influence the construction project performance.

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The value of F must be greater than 5. In this study, the value of F is 54.226 at a 0.000 significant level which is greater than 5, this implies that all independent variables are jointly relevant to the regression.

*Table 15. ANOVA of effect on Project Performance*

ANOVA <sup>a</sup>						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	7.680	4	1.920	54.226	.000 <sup>b</sup>
	Residual	3.753	106	.035		
	Total	11.433	110			

Source own survey (2022)

a. Dependent Variable effect on Project performance

b. Predictors: (Constant), Supervision Consultant, Contractor, Design Consultant, Clients

The F-ratio in the ANOVA table 15 above tests whether the overall regression model is a good fit for the data. The table shows that the independent variables statistically significantly predict the dependent variable,  $F(4, 106) = 54.226, p < .005$  (i.e., the regression model is a good fit of the data).

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**Coefficients**

*Table 15. Regression coefficient*

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error			
1	(Constant)	.092	.302		.303	.763
	Clients	.309	.075	.322	4.131	.000
	Contractor	.177	.054	.202	3.285	.001
	Design Consultant	.224	.058	.243	3.880	.000
	Supervision Consultant	.265	.069	.303	3.840	.000

Source own survey (2022)

The values of the unstandardized Beta Coefficients ( $\beta$ ) indicate the effects of each independent variable on the dependent variable. Furthermore, the values of the unstandardized Beta Coefficients in the Beta column of the Table above, indicate which independent variable (determinants of design change) makes the strongest contribution to explain the dependent variable (effect on project performance) when the variance explained by all other independent variables in the models controlled. The t value and the sig (p) value indicate whether the independent variable is significantly contributing to the prediction of the dependent variable. The findings of the regression analysis showed that client related factors, design consultant related factors, supervision consultant related factor and contractor have major effect on project performance with  $\beta$  coefficient as (0.322), (0.202), (0.243) and 0.303 respectively After

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processing of multiple regressions, the following regression model has been resulted based on the above information the final linear equation formulates as follows. Overall effect on Project Performance The project performance =0.92+ (0.309\*Client) + (0.177\*Contractor) + (0.224\*Design consultant) + (0.265\*Supervision consultant).

$$Y = 0.092 + 0.039 X1 + 0.177 X2 + 0.224 X3 + 0.265 X4 + e$$

Where Y =Effect on Project Performance

X1 = client related factor

X2 = consultant related factor

X3 = contractor related factor

e = sampling error

### **4.5 Hypothesis Testing**

Hypothesis testing is a formal procedure for investigating our ideas about the world using statistics. It is most often used by scientists to test specific predictions, called hypotheses that arise from theories. Hypothesis testing is based on standardized coefficients beta and P-value to test whether the hypotheses are rejected or not. Upon on the above testing result, the researcher tests each proposed hypothesis were tasted as follows.

#### **Hypothesis 1: Client related design change has effect on project performance.**

Ho: The client does determine the Project performance in Delta engineering construction PLC.

H1: The client does not determine the Project performance in Delta engineering construction PLC

The results of regressions as obtainable above, revealed client has a strong significant on affecting the project performance with a beta value (beta = 0.309), at 95% confidence interval (p = 0.00). Consequently, the null hypothesis is do not rejected and client has a positive influence on project performance in delta engineering construction.

**Hypothesis 2: contractor related design change has effect on project performance.**

Ho: The client does determine the Project performance in Delta engineering construction PLC.

H1: The client does not determine the Project performance in Delta engineering construction PLC

The results of regressions as obtainable above, revealed client has a strong significant on affecting the project performance with a beta value ( $\beta = 0.177$ ), at 95% confidence interval ( $p = 0.00$ ). Consequently, the null hypothesis is do not rejected and contractor has a positive influence on project performance in delta engineering construction.

**Hypothesis 3: Design consultant related design change has effect on project performance.**

Ho: The client does determine the Project performance in Delta engineering construction PLC.

H1: The client does not determine the Project performance in Delta engineering construction PLC

The results of regressions as obtainable above, revealed client has a strong significant on affecting the project performance with a beta value ( $\beta = 0.224$ ), at 95% confidence interval ( $p = 0.00$ ). Consequently, the null hypothesis is do not rejected and design consultant has a positive influence on project performance in delta engineering construction.

**Hypothesis 4: supervision consultant related design change has effect on project performance**

Ho: The client does determine the Project performance in Delta engineering construction PLC.

H1: The client does not determine the Project performance in Delta engineering construction PLC

The results of regressions as obtainable above, revealed client has a strong significant on affecting the project performance with a beta value ( $\beta = 0.265$ ), at 95% confidence interval ( $p = 0.00$ ). Consequently, the null hypothesis is do not rejected and supervision consultant has a positive influence on project performance in delta engineering construction.



## **CHAPTER FIVE**

### **5. Conclusions and recommendations**

#### **5.1 Summary of Major Findings**

The main objectives of this research were to identify the effects of variation due to design change on building project performance found in Addis Ababa Delta Engineering construction plc.. This study used a quantitative research approach and due to the purpose, an explanatory research design was used. The target population for this study was contractors, supervision consultants, design consultant and clients. Based on the research objective, questionnaires were prepared and distributed to 111 professionals. From this, the researcher collects 111 from the sample through. The collected data were analyzed using a statistical package for social science software (SPSS). Multiple Regression analyses were employed for testing the hypotheses. Prior to applying regression analysis, reliability, and correlation analysis tests required to perform regression were performed. With regard to reliability, the results showed that all measures used in this study had an acceptable level of reliability.

The specific objective of this thesis guided this research

- To identify effect of variation due to Design changes on building project performance in Addis Ababa Delta Engineering construction plc.
- To identify the relationship between clint, design consultants, supervision consultants and contractor related design change factor and building project performance in Addis Ababa Delta Engineering construction plc.
- To identify the presence and extent of variation due to Design changes.
- To recommended or show directions to minimize causes of Design changes and what are corrective action/measures to be taken in order to minimize/eliminate design change.

The major finding from the study in delta construction and literatures reveals that the causes of design change in the study area includes lack of design review during design process, addition and omission in design, variation or change of plan by clients, incomplete contract document. In addition to this, the finding from the study indicated the major effect of variation due design change has an impact on construction performance as Completion schedule delay, Increase in project cost, Wastage of materials during rework, Productivity degradation and working extra hours (overtime) to meet deadlines of the project

### **5.2 Conclusions**

As it is clearly stated in the first chapter the main objectives of this research were to identify the effects of variation due to design change on building project performance found in Addis Ababa Delta Engineering construction plc. as well as in the industry which is followed by identification of 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 uses questionnaire survey descriptive and inferential methods of analysis to find out the result through the analysis. The result obtained in this process 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 due to design change is a problem or not in delta engineering construction projects as well as in Ethiopian construction industry. Based on the data obtained from the questionnaire survey, the study concluded that variation is one aspect of project management problem in delta engineering construction projects.

According to the result obtained from the questionnaire survey, respondent strongly agreed on design change/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 construction project.

## **The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc**

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The second objective of this study were to identify if there was any relationship between client, design consultant, supervision consultant and contractor factor with its project performance effect.

In this study, it was found that all design change factors client related, design consultant related, supervision consultant related and contractor related factors have a significant relationship with effect on project performance. Which means that there exists a positive and significant relationship between design change and effect on project performance. This implies that when design change increase effect on project performance will increase. The study result show that project performance was affected by design change factors client, consultant, and contractor by 65% which is very significant. We can conclude that if serious attention is not given to this design change factor which significantly affect the project performance it will be very difficult to achieve project objectives.

The third specific objective of this research was aimed to identify the presence and extent of variation due to Design changes. The result revealed that, Decrease in Productivity, increase in project cost, Delay of project are the top 3 most significant effects of variations due to design change in delta engineering construction project. Based on the data from questionnaire survey the research concluded that variation as one of the major problems in Delta engineering construction project.

**The major effects identified in this research are Decrease in Productivity, increase in project cost, Delay of project.**

And most affected parties that affect the construction project performance of respondent were indicate Client/Employer (Gov't)and design consultants are the most affected parties, respondent were indicate Employer/clients are the most affected parties.

**Based on the survey result Employer/clients and design consultants are more responsible in initiating majority of the specified causes and Employer/clients (government) also the most affected party as a result of the consequential effects**

### **5.3 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/change order on construction design so as to minimize their effects on construction performance. Based on this the recommendation will focus in addressing the major effect identified through the research processes.

#### **5.3.1. Recommendation on how to minimize the effect of variation due to design change**

To minimizing the effect of variation due to design change the following points proposed as solution forwarded by the respondent is presented as follows;

##### **Recommendation for client**

- It is very important for clients/government body to involve in feasibility studies, planning and design stages to know the right timing for starting the project.
- Active involvement owner at **design** and planning stages
- Provide adequate judgement for planning and design of the construction projects on vital time only are recommended.

##### **Recommendation for Design supervision**

- Clear and well requirements and controlling mechanisms that evaluates whether the requirement is achieved or not is very important in feasibility studies, planning and design stages is crucial.
- Provide adequate time for planning and design.
- 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 enable good designers to be motivated and the poor once to take care and learn out of their mistakes.

**Recommendation for contractor**

- By having constant and fixed meeting schedules where the parties could discuss the current design and actual work on site. The contractor has to improve communication and coordination between stakeholders. This will avoid variation design change.
- Critical review and thorough detailing of design and contract documents can be considered to minimize change or variations of design.

**Recommendation for supervision consultant**

- Consultants should give a brief explanation of the design document with the respective professional appointed by the client. And giving awareness about the consequence of design change in the construction phase, and also Consultant's supervisors should have collective experience about construction project.
- The design consultants are recommended to make detailed investigations during the design which will eliminate design change, design errors, and unrealistic contract requirements. This would help in reducing cost overrun and time overrun which affect the project performance.

## The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc

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### REFERENCE

- Arian, F. &. (2005). [http://www.cebe.heacademy.ac.uk/publication /work papers/pdf/working paper\\_10.pdf](http://www.cebe.heacademy.ac.uk/publication/work_papers/pdf/working_paper_10.pdf). Retrieved march 19, 2020
- Arian, F. &. (2015). The Potential Effects Variation Order on Institutional Buildings. *Emerald Journal (FAC)*, Vo. 23.No 11/12, pp 495-510.
- Arian, F. &. (2017). Modeling for Management of Variation Order in Institutional. *Engineering, Construction and Architectural Management*, Vol. 14 .No 5, pp.
- A.H., A.-D. (2000). Change orders in construction projects in Saudi Arabia. Thesis, King Fahd University of petroleum & minerals, Dhahran, Saudi Arabia.
- A.H., A.-D. (2015). Change orders in construction projects in Saudi Arabia. *Msc. Thesis*,. Saudi Arabia.: King Fahd University of petroleum & minerals, Dhahran.
- Assaf SA, A. K.-H. (2005). Causes of delay in large building construction projects. *Journal of project management in Engineering, ASCE*, pp 45-50.
- Ahmad Safun Bin Ahmad Radzi. (2015). the study of causes and effects of change order to. *Msc. Thesis, Universiti Teknologi Malaysia*. Malaysia. al, I. e.
- AL.-Hejj.si, A. S. (2006). Causes of delay in large construction projects *Project Management*, Vol. 24, No. 4,. *International Journal of*, pp. 349-357.
- A.H., A.-D. (2015). Change orders in construction projects in Saudi Arabia. *Msc. Thesis*,. Saudi Arabia.: King Fahd University of petroleum & minerals, Dhahran
- Assaf SA, A. K.-H. (March/April, 1995,). Causes of delay in large building construction projects:. *Journal of project management in Engineering, ASCE*, 45-50.
- Bruce Hallock, P. ( December 2016.). Managing change vs. administrating the change order processes. *the Nielson-Wurster group, Inc, newsletter*, pp. Vol.1.6,.
- Bruce Hallock, P. (December 2006.). *Managing change vs. administrating the change order processes*. Inc, newsletter, Vol.1.6: The Nielson-Wurster group.
- Box, G. E. (1979). Robustness is the Strategy of Scientific Model Building. In R.L. Launer & G.N. Wilkinson (Eds). In M. A. Robustness in Statistics. Burlington.
- Brooks, F. (1995). *The mythical man-month (Anniversary ed.)*. . Boston, MA, USA: AddisonWesley Longman Publishing Co., Inc. ISBN 0-201-83595-9.
- BattainehHussien., O. a. (2002). Causes of construction delay: traditional contracts. *International Journal of Project Management*,, Vol. 20, No.1, pp. 67-73.
- Bethke, E. ((2003)). *Game Development and Production*. p.65.

## **The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc**

---

Brem. (2011). *T214 Understanding Complex Systems – TMA02. Q4.*

Burati, J.L., Farrington, J.J. & Ledbetter, W.B., (1992). ‘Causes of Quality Deviations in Design and Construction’, *Journal of Construction Engineering and Management*, 118(1), pp.34–49

Chris Hendrickson, *Project Management for Construction*, S. Edition, Ed., 2003

Cheng, Ying-Mei. “An Exploration into Cost-Influencing Factors on Construction Projects.” *International Journal of Project Management* 32, no. 5 (July 2014): 850–860. doi:10.1016/j.ijproman.2013.10.003.

Cally, B. M. (2005). *Change order management*. AACE International Transaction.

Cariappa, A. (2012). The effects of changes on performance of construction projects. *Msc.thesis*.

Canada: University of New Brunswick.

Carl S. Chatfield, T. D. (2003). *Microsoft Office Project 2003 Step by*.

Delone, W. H., & McLean, E. R. ( (1 April 2003). ). "The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. *Journal of Management Information Systems*. , 19 (4).

Douglas Edward E. (2013). *Effective management of project change orders*,. AACE Internationa.

Fisk, E. (2000). *Construction Project Administration*. Prentice-Hall, Upper Saddle: 6th ed.

Galloway P.E. (2017). cumulative impact. *The Nielson-Wurster groupInc ,newsletter*, vol.26.

Galloway P.E. (2007). *cumulative impact*. The Nielson-Wurster group ,Inc ,newsletter,: Vol.26, June 2007.

Gde Agung Yana, A.A., Rusdhi, H.A., & Agung Wibowo, M. (2015). Analysis of factors affecting design changes in construction project with Partial Least Square (PLS). *Procedia Engineering*, 125, 40-45.

Hanna, A. L. (2012). Statistical Fuzzy approach to quantify cumulative impact of change orders. *Journal of computing in civil Engineering*, Vol 16,No 4, pp 252-258.

## The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc

---

Hanna, A. L. (January 1, 2007.). Statistical Fuzzy approach to quantify. *Journal of Professional Issues in*, Vol 133.No 1.

<https://support.microsoft.com>.(n.d.).

<https://www.academia.edu>.(n.d.).

Iliyas J. Suleiman and Valentine G. M. Luvara, "Factors Influencing Change of Design of Building Projects during Construction Stage in Dar-es-Salaam Tanzania," *International Journal of Construction Engineering and Management*, vol. 4, pp. 93-101 , 2016.

Ibrahim, N. H. (2016). Variation orders in Universiti Teknologi Malaysia (UTM) construction projects. *Msc. Thesis*. Malaysia: Universiti Teknologi Malaysia.

Mendelssohn. (2017). *design related changes* .

International Journal of Engineering Research & Technology (IJERT)

ISSN: 2278-0181 <http://www.ijert.org>

Ibbs, W., (2012). 'Construction change: Likelihood, severity, and impact on productivity', *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, (August), pp.67-73.

Ikediashi, D. I, S. O. Ogunlana and A. Alotaibi, "Analysis of project failure factors for infrastructure projects in Saudi Arabia," *Journal of Construction in Developing Countries* 19, p. 35, 2014(January 1, 2017). Quantified Impact of Project Change. *Journal of Professional Issues in Engineering Educations & Practices*,, Vol 133.No 1,.

J. B. H. Yap, H. Abdul-Rahman and C. Wang, "A Conceptual Framework for Managing Design Changes in Building Construction," *MATEC Web of Conferences* , vol. 66, no. 0021, 2016

Koushki P.A, A.-R. K. (2005). Delays and cost increases in theon of private residential projects in Kuwait constructi,. *Journal of Construction Management and Economics*, Vol. 23, No.3, pp. 285-294.

Kumaraswamy, M. M. (2008). "Claim for extension of time in civil engineering projects.

*Construction Management and Economics*, Vol. 16 No.3, pp. 283-294.



fanal paper pdf.pdf

Mokbel, H. (2013). Assessing the parametric building model capabilities. *Msc. Thesis*. Worcester polytechnic institutes.



## **The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc**

---

Mahamid. (2011). Causes, Magnitude and Cost Estimating. *Cost and Time Overrun in Road Construction*:

Mohammad, N., Che Ani, A.I., Rakmat, R.A.O.K., & Yusof, M.A. (2010). Investigation on the causes of variation orders in the construction of building project – a study in the state of Selangor, Malaysia. *Journal of Building Performance*, 1(1), 73-82.

Nega, F. (2008). Cause and effects of cost over run in public building construction projects in Ethiopia, Unpublished Master's Thesis, Addis Ababa University, Ethiopia.

Oluwas eun Sunday, Dos umu and Clinton O, Aigbavboa, "Impact of design errors on variation cost of selected building project in Nigeria," Primosten, Croatia, 2017

O'Brien, J. (1998). *Construction Change Order*. McGraw Hill, New York, NY.

O'Brien, J. (1998). *Construction Change Order*. Hill, New York, NY Oxford.

Pamela McGhee, P. M. (2007). *Painless Project Management*. p.74.

PMBOK. (Third Edition 2004 ).

Rana, A. (2017, July 6). *ResearchGate*. Retrieved from ResearchGate:

<https://www.researchgate.net>

Roger, A. (December 1999). Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria. *International Journal of Project Management*, 17(6): 337–342.

Revay, S. (2013). *Coping with changes, AACE International Transaction*. CDR.25, .

Stumpf, G. ((2000)). . Schedule delay analysis. *Construction Engineering Journal*. , 42(7):32–43.

Sun, M., & Meng, X. (2009). Taxonomy for change causes and effects in construction projects. *International Journal of Project Management*,

Tiong, R. (2006). Effective controls for large scale construction projects. *Project Management journal* , pp. 32-42.

## **The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc**

---

Thomas, H. a. (2015). The Effects of Changes on Labor Productivity. The Pennsylvania State University, USA: CII Document 99 .

Valeh Moayeri , Design Change Management in Construction Projects Using Building Information Modeling (BIM), Canada:Concordia University, 2017.

Yunus, N. U. (2017). Variation control affecting construction works for Lembaga Kemajuan Tanah Persekutuan (FELDA). *Msc. Thesis*. Malaysia: Universiti Teknologi Malaysia.

Zaneldin and Essam, "Construction Claims in United Arab Emirates: Types, Causes, and Frequency," *International Journal of Project Management* 24, p. 453–459, 2006.

**APPENDIX A**

**Questionnaire**

**St. Mary's University**

**Project Management Department**

Dear Respondent,

I am kindly requesting your willingness to participate in this research “**the effect of variation due to design change on projects performance in Addis Ababa delta engineering construction plc**”. The questioner is designed for partial fulfillment of MA in project management. The general objective of this thesis is to assess causes and effects of variation due to Design change on building projects in Addis Ababa. The research result could be used as an input for clients, contractor and consultants, academician or other interested groups.

It is believed that your participation in this research will contribute in achieving objective of the research. Thus the quality of your response towards the question item determines the quality of the research result. Therefore please answer the question as objectively and honestly as possible and according to the instruction contained in body of the questionnaire. Finally, I want to assure you that all information provided in this survey will be treated with strict confidentiality and allowed to serve for the purpose of the research under consideration. If you have any question please feel free to contact me through the provided addresses.

Thank you in advance for your cooperation!!

**Contact Address**

Jerusalem Johnson

E-mail: Jerryyesi@gmail.com

Phone No: 0919869662

# The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc

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## Section A: Company and respondent profile

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

A. Name of your organization (optional) .....

B. project participated in (project name) .....

### 1.1. Type of your organization

Client    design Consultant    supervision consultant    Contractor     
other\_\_\_\_\_

### 1.2 Your firm/Company experience *construction industry*: -

0–5-year    6- 10-year    10–15-year    \_\_\_\_\_ >20 year

### 1.3 Your position in the organization or on site

Project manager    Office engineer    Site engineer  
 Consultant supervisor    Client supervisor    contractor    other \_\_\_\_\_

### 1.4 Your professional experience in *construction industry*:

0–5-year    6- 10-year    10–15-year    \_\_\_\_\_ >20 year

### 1.5 Level of education

PHD    MSc    Bachelor    Diploma    Other \_\_\_\_\_

**Section B: Basic information about variation**

2. Variation due to design change is a problem in Ethiopian construction industry in general and that of delta engineering construction projects in particular?

Agree       strongly agree       Disagree       strongly disagree

**The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc**

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**Section C: Factors which contributes for the effects of variation and their consequential and Factors influencing design change /variation (Measure of independent variable)**

3.The table Below are list of factors influencing design change. From your experience, please express your opinion on which factors influence design change (which factor causes design change/variation) in Addis Ababa Delta Engineering Construction Plc building projects?

	<b>A. Factors related to Client/Employer (Gov't)</b>	<b>Strongly Disagree (1)</b>	<b>Disagree (2)</b>	<b>Neutral (3)</b>	<b>Agree (4)</b>	<b>Strongly Agree (5)</b>
1	Changes requested by the owner					
2	Addition or omission of scope					
3	Owner's change of schedule due to financial problem					
4	Change of funding or budget from the owner					
5	Owners failure to review document at the right time					
6	Owner instructs additional work/scope change					
7	Owner's needs during the design stage are unclear or not well-defined					

<b>B. Factors Related to Contractor</b>	<b>Strongly</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly</b>
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**The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc**

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		<b>Disagree (1)</b>	<b>(2)</b>	<b>(3)</b>	<b>(4)</b>	<b>Agree (5)</b>
<b>1.</b>	Request to use available materials					
<b>2.</b>	Unrealistic construction's schedule					
<b>3.</b>	Changes initiated by contractors to improve quality and constructability					
<b>4.</b>	Poor communication between contractor and other parties					
<b>5</b>	The construction budget is too low.					
<b>6</b>	Shortage of material					

**The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc**

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	<b>C. Factors related to Design Consultant</b>	<b>Strongly Disagree (1)</b>	<b>Disagree (2)</b>	<b>Neutral (3)</b>	<b>Agree (4)</b>	<b>Strongly Agree (5)</b>
1	Modification to design (improvement)					
2	Failure by the consultant to perform design					
3	Unrealistic period to design;					
4	Errors and omission in design					
5	poor coordination of design team member					
6	Unclear and inadequate details in drawings					

	<b>D. Factors Related to Supervision consultant</b>	<b>Strongly Disagree (1)</b>	<b>Disagree (2)</b>	<b>Neutral (3)</b>	<b>Agree (4)</b>	<b>Strongly Agree (5)</b>
<b>1.</b>	Failure by the supervision effectively					
<b>2.</b>	The low consultant fee					
<b>3.</b>	Changes/variation made as a request of a consultant					
<b>4.</b>	underestimation of the cost of the project					
<b>5</b>	consultants who are not familiar with the regulations and construction permits					
<b>6</b>	Inadequate investigation of site before the design period					



**The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc**

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**Section D: EFFECT OF DESIGN CHANGE ON CONSTRUCTION PERFORMANCE (MEASURE OF DEPENDENT VARIABLE)**

4. The following table identified effect of design change on project performance. Please indicate the level of their influence on affecting the project performance

<b>E. Effect of Design change on project performance</b>						
		<b>Strongly Disagree (1)</b>	<b>Disagree (2)</b>	<b>Neutral (3)</b>	<b>Agree (4)</b>	<b>Strongly Agree (5)</b>
<b>1.</b>	Increase in project cost					
<b>2.</b>	Demolition and rework					
<b>3.</b>	Results dispute among parties					
<b>4.</b>	Decrease in Productivity					
<b>5</b>	Delay of project					
<b>6</b>	Wastage of material					
<b>7</b>	Decrease in quality of work					

**APPENDIX B**

**OVER ALL RELIABILIRTY**

**Case Processing Summary**

		N	%
Cases	Valid	111	100.0
	Excluded <sup>a</sup>	0	.0
	Total	111	100.0

a. Listwise deletion based on all variables in the procedure.

**Reliability Statistics**

Cronbach's Alpha	N of Items
.827	5

**CLIENT RELATED FACTOR**

**Reliability Statistics**

Cronbach's Alpha	N of Items
.733	7

**DESIGN CONSULTANT RELATED FACTOR**

**Reliability Statistics**

Cronbach's Alpha	N of Items
.702	6

# The Effect of Variation Due to Design Change on Building Project Performance in Addis Ababa Delta Engineering Construction Plc

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## SUPERVISION CONSULTANT RELATED FACTOR

### Reliability Statistics

Cronbach's Alpha	N of Items
.730	6

## CONTRACTOR RELATED FACTOR

Cronbach's Alpha	N of Items
.760	6

## PROJECT PERFORMANCE RELATED FACTOR

### Reliability Statistics

Cronbach's Alpha	N of Items
.710	7