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ASSESSMENT OF CAUSES AND COST IMPACT OF CHANGE ORDERS ON ROAD PROJECTS IN ETHIOPIA

BY

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ABBREVIATIONS

- FIDIC - Federation Internationale Des Ingenieurs-Conseils
- PCO - Potential Change Order
- RFI – Request for Information
- RFP - Request for Proposal
- CCD - Construction Change Directive
- CII – Construction Industry Institute
- MS – Mean Score

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ABSTRACT

This research makes assessment on the causes and cost impacts of change orders on road projects in Ethiopia. Emphasis is given to the identification of the root causes of change order categories from seventeen road project with a total of 123 reasons of causes of change order. As a result the most common reasons of causes of change order are categorized as: *design errors and omissions, scope change, unforeseen conditions, value engineering, force majeure* and *others.* Of the total reasons of causes of changes orders included in the study, 40.8% were caused by design errors and omissions, 29.3% by change of scope by owner, 15.8% resulted from other causes, 7.5% were caused by unforeseen conditions, 5.8% by value engineering and 0.8% due to force majeure.

In addition to identifying the major categories of change orders, the consequential cost impacts of these change orders were analyzed. As a result, those reasons of change order categorized under *value engineering* have a decrement cost impact which saves an amount of birr 23,861,361.94. The reasons of change orders in this category have positive cost impact on the total project cost as they are a saving to the project owner. However, the rest categories of causes of change order have increment or negative cost impacts with a total change order amount of birr 410,596,232.76. From this total cost increment 52.4% is caused by *change of scope;* 38.6% by *design errors and omissions*, and 7.6% contributed *other causes.* Though they are minor, 1.2% and 0.2%, the rest are contributed by *unforeseen conditions* and *force majeure* respectively in descending manner of their contribution.

Spearman rank order correlation analysis was used to evaluate whether consensus of opinions exists between groups of respondents. From the analysis of the results it can be concluded that the correlation between the attitudes of the respondents in all the three

groups is relatively weak. This is so, because two third of the groups assure the absence of significant consensus.

Key words: *change, change order, change order categories, cost impacts of change order.*

1. INTRODUCTION

Many times, change is necessary for the success of a project. "*change*, defined as any event that results in a modification of the original scope, execution time, or cost of work, happens on most projects due to the uniqueness of each project and the limited resources of time and money available for planning" (Hanna, 2002). While change orders are necessary to address unforeseen conditions and other unavoidable or unanticipated occurrences, they tend to negatively affect the progress of a construction project. In most public works, change orders are the main reason for construction delays and cost overruns (Wu, 2005). Change orders also lead to a decline in labor efficiency, loss of man hours, and costly disputes (Moselhi, 2005).

It is important to understand the impact change orders have on project performance, but it is also important to understand the causes of change orders. Since change orders affect the relationship between contracting parties, those parties participated in construction must be aware of the reason behind the change orders so that any change order that could arise during the life of a project can be handled properly. Due to the fact that construction contract is signed under the principle of *good faith*, which means that the parties trust each other to perform according to the contract and that the contract is fair with no intention of taking advantage of the parties during the life of the contract. However, as soon as the contract needs to be modified by generating a change order, the behavior of the parties could changes in relation to the initial good faith environment for this change orders are accompanied by consequential impacts on construction time and/or budget.

This research aims to study change orders on road construction projects in Ethiopia which occur most frequently and analyze their causes and the cost impact they impose on the projects.

1.1 Significance of the study

Over the last two decades, the construction industry of Ethiopia has boom more than any time in the history of the county's construction industry. As compared to other economic sectors, the construction sector has invested huge capital investment for the construction of different infrastructures such as dams, railroads, roads of different category, building complexes, water supply facilities, etc. However, of this capital investment, relatively considerable amount was allocated to the road sector for the development of road networks throughout the country. An assessment of fifteen years (July 1997 to June 2012) performance of road sector development program (RSDP) made by Ethiopian Roads Authority depicts that over the fifteen years of the RSDP physical works have been undertaken on a total of 81,363km of roads. The total budget invested during this period amounted to Birr 107.8 billion.

However, relatively several road projects in Ethiopia have encountered construction changes due to various causes during the course of their implementation. Some of the most common causes of changes in the construction sector are change of scope of work due to infinite needs of the owner, market conditions may impose changes to the parameters of the project, and technological developments may alter the design and the choice of the engineer. The engineer's review of the design may bring about changes to improve or optimize the design and hence the operation of the project. Further, errors and omissions in construction contract coupled with poor contract administration skills and inability to predict changes may force a change. All these factors and many others necessitate changes that are costly and generally un-welcomed by all parties.

Despite the fact that changes are inevitable phenomena in the construction projects, emphases must be given to accommodate changes in construction contracts. A change

clause has to be incorporated to define the way how owner, consultant and contractor handle changes. Therefore, change clauses and procedures must be set to process a change from the conceptual development until it is realized to its material equivalent in the field.

Hence, this research aims to assess causes of change orders and their cost impact on road construction projects in Ethiopia and lay the foundation for future research so that problems related to changes and change orders can be properly addressed.

1.2 Research Outline

This thesis comprises of three major chapters. Chapter one is *an introduction* explaining the importance of this research study, defines the problem of the statement, specifies the objectives, scope and limitations.

Chapter two is *the review of literature* on the subject of change in general and change orders in particular. The chapter is divided into five sections: construction change and change order, causes of change of change order, impacts of change order, legal aspects of change order and change order management. Construction change and change orders explains construction changes in general and change orders in particular. The legal aspect of change focuses on types of construction contracts and the way how change orders threated in those contract forms. As the name indicate, the cause and effect section deals with causes and effects of change order of change orders in construction. Change order management is about identifying contract requirements, identifying potential changes, determining entitlement, negotiation and recording the executed changes.

Chapter three, which is *the research design and methodology,* consists of four sections, the study approach and research type, data source and collection, the research population and finally method of analysis.

Chapter four, *the data analysis and discussion*, includes the questionnaire response rate, the existence and extent of change orders, assessment of major causes of change order

categories, assessment of cost impact of change orders and test for agreement. The fifth and the last chapter, *conclusion and recommendation*, explicitly put the conclusions of the research and make a recommendation on how to minimize changes and change orders in road construction projects in Ethiopia.

1.3 Statement of the Problem

Delivering the project to scope, budget and schedule is the number one challenge in dealing with change order **(***The Economist, 2012***)**. Most of the time, this is due to lack of adequate knowledge to predict and manage changes which may be encountered during the life of a project. Though changes in construction projects are very common and likely to occur from different sources at any stage of a project, they may have considerable impacts on the cost of the projects.

Owing to this fact, what are the causes for most contract changes in Ethiopian road construction projects? And what kind of cost impact do these causes impart on total project cost? This thesis is therefore, an attempt to make assessment on causes and cost impacts of change orders on selected road projects in Ethiopia.

1.4 Objective of the study

The following are the specific objectives of the research.

- To undertake thorough discussion on types of construction change and change orders their causes and impacts in general.
- To make assessment on the causes of change orders and their cost impact in road construction projects in Ethiopia.
- To formulate conclusions and recommendations.

1.5 The Study Scope and Limitation

Change order in road construction projects are caused by many factors. Each cause of changes has different rate of occurrence and cost impact. Therefore, this research work is designed to make assessment of the causes and cost impacts of change orders based on the categories of causes of change orders. To accomplish this, the research is limited to those change orders arise in selected road projects constructed between years 2003 to 2013 by Ethiopian Roads Authority. Hence, the epicenter of the research shall spin about the causes and cost impact of construction change orders.

2. LITERATURE REVIEW

2.1 Construction Changes and Change Orders

In a perfect world changes will be confined to the planning stages. However, late changes often occur during construction, and frequently cause serious disruption to the project (Oracle, 2009). In these circumstances, decisions are being made under pressure and cost and time invariably dominate the decision making process (O'Brien, 1998; Arain, 2005). Most forms of contract for construction projects allow a process for changes. Even though there may be a process in place to deal with these late changes, cost and time invariably dominate the decision making process. If the change affects the design, it will impact on the construction process and, quite possibly, operation and maintenance as well (Oracle, 2009).

To overcome the problems associated with changes to a project, the project team must be able to effectively analyze the change and its immediate and downstream effects (CII, 1990). An effective analysis of change and change orders requires a comprehensive understanding of the root causes of changes and their potential downstream effects. To manage a change means being able to anticipate its effects and to control, or at least monitor the associated cost and schedule impact (Hester, 1991).

2.1.1 Construction Changes

A change is defined in literature as any deviation from an agreed upon well-defined scope and schedule. Stated differently, a change is typically understood as the difference between the contract requirements as set forth in the original agreement between the parties and the requirements imposed subsequent to this agreement (Fisk, 1988). Construction contracts are assumed to be complete before they are implemented. However, changes can be initiated by all parties in the construction process. All

changes, however, must be approved by Owner before implementation. CII Publication 6-10 (1990) summarizes initiation of change orders as follows:

1. *Owner* may request/order a change, usually a scope change.
2. *Engineer* may originate a change because of differing site conditions or new governmental regulations etc.
3. *Project management firm/person* may originate a change, usually in schedule.
4. *Contractor* may initiate a change due to design errors, value engineering, or field requirement.

In addition, construction changes could occur at any of the three stages of construction. This is to mean that such changes may occur during *specification preparation*, ether by the owner's over ambition or the consultants' impracticable material and design specifications; at the *design stage* by the designer or consultant impractical design which may not consider the actual site condition; and finally during *the construction stage* by contractors' lack of special skills and frequent change demands of the owners.

Though the contract defines what constitutes a change, literatures categorize changes as *directed changes, constructive changes and cardinal changes* (CII Publication 6-10 (1990), Fisk 1988, Cox 1997). Hence, each of these changes will be discussed as follow:

2.1.1.1 Directed changes

Directed changes are changes that are directed by the owner and understood by the owner to be changes to the contract. Subject always to the specific requirements of the contract and examples of such changes include:

- Addition or deletion of work
- Revision to material specifications
- Revision to project phasing
- Change to site access or hours of operation
- Change to contract duration

2.1.1.2 Constructive Changes

Constructive changes typically resulted from a failure to do or not do on part of the owner or owner's representative. This type is not initially documented as a change and hence becomes a potential source of dispute. The failure of the owner or owner's representative may take the form of error in design or drawings, wrong Engineer's interpretation of contract documents, change in construction sequence imposed by a construction requirement etc. Depending on the specific requirements of the contract, constructive changes include the following:

- Failure to disclose material information
- Impossibility or impracticality of performing the work as designed
- Imposition of joint occupancy or use of the project before completion
- Slow turnaround of submittals and requests for information
- Untimely inspections

Constructive changes are usually more difficult to recognize than directed changes and, therefore, often become the basis for a dispute, or in the worst case, a formal claim.

2.1.1.3 Cardinal Changes

Cardinal change is a change outside the scope of the contract. This kind of change has the effect of making the work to be performed fundamentally different from the work the parties agreed to when the contract was bid and awarded. And it is executed only after complete redefinition of the scope and re-negotiation of the contract.

This type of change may not necessarily be a single change but can be the result of a number of changes that have the net effect of modifying the original scope. Cardinal changes are typically viewed as a breach of contract by the owner and a contractor is not obligated to proceed with a cardinal change if directed to do so by the owner. Such kinds of changes include the following:

- Unanticipated requirements imposed by third parties such as permitting agencies, utility companies etc.

- Unforeseen environmental issues.

2.1.2 Construction Change Orders

Change order is a written order to the contractor, signed by the owner, and issued after execution of the contract, authorizing a change in the work or an adjustment in the contract sum or the contract time (Hester, 1991). Whenever a change is encountered during the construction stage it must be notified either orally or in written form to the consultant. Then it will be subsided by a written change order from the consultant to the contractor if that change is a real deviation from what is agreed up on. These changes however occur after the award of the initial contract or after work might have commenced at the construction sites. Change orders can be classified in to formal change orders and informal change orders (O'Brien, 1998).

2.1.2.1 Formal Change order

Formal change order is issued in writing by an authorized representative of the owner or by the contractor to a sub-contractor. Formal change order rarely causes problems because they are generally identified before they are incorporated. They are based on a planned and deliberate choice of the contracting parties. Most often formal change orders include two types of change orders, *unilateral* and *bilateral change orders* as briefly discussed below:

i. Unilateral Change Order:

A unilateral change order is issued when an agreement is reached in negotiations or when a contractor fails to submit his proposals in time. It is based on the owner's estimate of cost and time for work. Most of the time such kind of change order is not considered desirable due to the fact that it requires owner's decision which may generate appeals. Hence, a unilateral change order should only be issued when reasonable efforts have been exhausted to reach an agreement.

ii. Bilateral Change Order:

It is a supplementary agreement whereby the owner's directives are issued to the contractor with a bilateral agreement as to price or time. The supplemental agreements are understood as being mutual agreements for the parties to increase or decrease the work agreed upon.

It is essentially a new negotiated contract which must be founded upon a bilateral agreement of the parties, and it is considered to be the proper medium for making changes that are outside the general scope of a contract.

2.1.2.2 Informal Change Order

Informal change order is the result of constructive changes, which arise from the informal acts and conduct of the owner or his representatives and it may increases the contractor's cost of performance. Informal change order has same effects like that of formal change order.

2.2 Causes of Change Order

Due to the fact that construction industry being a multi-party industry where the client played his role as a promoter of the project, the consultant act as a professional to assist the client in technical matters and assumed to be rational, and the contractor who constructs as per the drawing and specification. In such kind of working environment, change can be initiated by all parties in the construction process. An effective analysis of change and change orders requires a comprehensive understanding of the root causes of changes (Hester, 1991).

The causes of change orders have been identified in various literatures as *client initiated causes*, *consultant initiated causes*, and *contractor initiated causes*. Apart from these three, there are also *other causes* which can be considered as the fourth cause of change as discussed below.

2.2.1 Change Orders Caused by Project Owners

The most common change orders caused by project owners are initiated due to the following reasons:

- Change of scope or plan
- Change of schedule
- Financial difficulties
- Poor project objectives
- Change in specifications
- Change of material
- Late decision

One of the most significant causes of change in construction projects is *change of scope or plan* (CII, 1990b). And this is usually resulted due to insufficient planning at the project definition stage, or because of lack of involvement of the owner in the design phase (Arain, 2004). This cause of change affects the project severely during the later phases. Besides, during the construction phase of a project owners could *change the project's schedule* which may result in major resource reallocation (Fisk, 1997; O'Brien, 1998). Since time has an equivalent money value, a change in schedule means that the contractor will either provide additional resources, or keep some resources idle. In both cases additional cost is incurred. Whenever project owners *face financial difficulties* which obliges them to make changes in an attempt to reduce cost, the project progress and quality may be affected (Clough and Sears, 1994; O'Brien, 1998). Proper planning and review of project cash flow would be effective in eliminating this problem.

Poor project objectives are also the other important causes of changes in construction projects (Ibbs and Allen, 1995). As a result various change orders may arise during the project construction phase. One of the direct consequences of poor project objectives is *change in specification* (O'Brien, 1998). Change in specifications by the owner during the construction phase may require major changes and adjustments in project planning and procurement activities. *Change of materials* cause major change orders during the

construction phase. The replacement of materials affects the project contract amount (Chappell and Willis, 1996). Therefore, an adjustment to the original contract value is required if there is a change in materials. Prompt decision making is an important factor for project success (Sanvido , 1992; Gray and Hughes, 2001). A *delay in decision making* may hinder subsequent construction activities that may eventually delay the project progress.

2.2.2 Change Orders Caused By Consultant

This section discusses the causes of changes that were initiated by the consultant. In some cases, the consultant directly initiates changes or the changes are required because the consultant fails to fulfill certain requirements for carrying out the project. The following are some of the reasons of changes initiated by consultants.

- Change in design
- Errors and omissions in design
- Conflicts between contract documents
- Inadequate scope of work for contractor
- Technology change
- Value engineering
- Design complexity
- Inadequate working drawing details
- Lack of judgment and experience
- Lack of required data
- Ambiguous design details
- Inadequate design
- Noncompliance of design with government regulations
- Noncompliance of design with owner's requirements
- Change in specifications by consultant

In contemporary professional practice it became a norm to make *change in design* (Arain, 2004). The changes in design are frequent in projects where construction starts

before the design is finalized (Fisk, 1997). Most of the time this practice happens when the consultant believes improvement is vital for successful completion of the project. *Errors and omissions in design* cause of project delays (Arain ., 2004) and may lead to loss of productivity and delay in project schedule (Assaf, 1995).

Conflict between contract documents can result in misinterpretation of the actual requirement of a project (CII, 1986a). To convey complete project scope for participants, the contract documents must be clear and concise.

In a multi-party player environment, like construction, *the scope of work* for all the players must be clear and unambiguous for successful project completion (Fisk, 1997; Arain, 2004). *Technology change* is related to technological advancements which can accelerate the project's completion time. This could be a potential cause of changes in a project. Therefore, project planning should be flexible for accommodating new beneficial changes (CII, 1994b). This is because the new technology can be beneficial in the project life cycle, for instance, reducing maintenance cost of the project. *Value engineering* is related to those changes resulted due to economic condition and material changes. Such changes should ideally be carried out during the design phase (Dell'Isola, 1982). During the construction phase, value engineering can be a costly exercise, as change in any design element would initiate down-stream changes to other relevant design components (Mokhtar, 2000). *Complex designs* require unique skills and construction methods (Arain, 2004). Complexity affects the flow of construction activities, whereas simple and linear construction works are relatively easy to handle (Fisk, 1997).

To convey a complete concept of the project design, the working drawings must be clear and concise (Geok, 2002). *Insufficient working drawing details* can result in misinterpretation of the actual requirement of a project (Arain, 2004). Professional *experience and judgment* is an important factor for successful completion of a building project (Clough and Sears, 1994; O'Brien, 1998). The lack of professional experience increases the risk of errors in design as well as during construction. Eventually, this

may affect the project quality and delay the project completion. A *lack of required data* can result in misinterpretation of the actual requirements of a project (Assaf, 1995; Arain, 2002). Where there is insufficient data, consultants are compelled to develop designs based on their own perceptions, which may not be what the client wants. A clearer design tends to be comprehended more readily (O'Brien, 1998). Ambiguity in design is a potential cause of changes in a project. This is because ambiguity in design can be misinterpreted by project participants, leading to rework and delay in the project completion. *Inadequate design* can be a frequent cause of variations in construction projects (CII, 1990; Fisk, 1997). Design discrepancies affect the project functionality and quality. Eventually, this can affect a project adversely depending on the timing of the occurrence of the changes. *Noncompliance of design with government regulations* would render the project difficult to execute (Clough and Sears, 1994). This may affect the project safety and progress adversely, leading to serious accidents and delays in the project completion. A comprehensive design is one that accommodates the owner's requirements (Cox and Hamilton, 1995). A *noncompliance design with the owner's requirements* is considered an inadequate design (Fisk, 1997). Eventually, this may cause changes to accommodate the owner's requirements which may affect the project adversely during the construction phase. *Changes in specifications* are frequent in construction projects with inadequate project objectives (O'Brien, 1998). As mentioned earlier with respect to changes in specifications by the owner, this is also a potential cause of changes in a project, leading to reworks and delays in the project completion.

2.2.3 Change orders Caused by Contractors

As an active participant of the construction, contractors may suggest valuable changes to the project. Changes may also be required because the contractor fails to fulfill certain requirements for carrying out the project. Therefore, the most common reasons of changes caused by contractors will be discussed as follow:

- Lack of involvement in design

- Unavailability of equipment
- Financial difficulties
- Desired profitability
- Differing site conditions
- Defective workmanship
- Poor procurement process
- Lack of communication
- Lack of judgment and experience
- Complex design and technology
- Lack of strategic planning
- Lack of required data

Involvement of the contractor in the design may assist in developing better designs by accommodating his creative and practical ideas (Arain, 2004). *Lack of contractor's involvement in design* may eventually cause changes. Practical ideas which are not accommodated during the design phase will eventually affect the project adversely. *Unavailability of equipment* is a procurement problem that can affect the project completion (O'Brien, 1998). Occasionally, the lack of equipment may cause major design changes or adjustments to project scheduling to accommodate the replacement. Skilled manpower is one of the major resources required for complex technological projects (Arain, 2004).

Construction is a labor intensive industry. Whether the contractor has been paid or not, the wages of the worker must still be paid (Thomas and Napolitan, 1994). Contractor's *financial difficulties* may cause major changes during a project, affecting its quality and progress. *Contractor's desired profitability* can be a potential cause of change in construction projects. This is because changes are considered a common source of additional works for the contractor (O'Brien, 1998). The contractor may eventually strive to convince the project owner to allow certain changes, leading to additional financial benefits for him. *Differing site condition* can be an important cause of delays in

large building projects (Assaf, 1995). The contractor may face different soil conditions than those indicated in the tender documents. Eventually this may affect his cost estimates and schedule adversely.

Defective workmanship may lead to demolition and rework in construction projects (Fisk, 1997; O'Brien, 1998). Defective workmanship results in poor quality of work in construction projects (Arain, 2004). Eventually, this cause may affect the project adversely, leading to rework and delay in the project completion. The construction manager carries out the construction phase in an organized way to eliminate the risks of delays and other problems. *Procurement delays* have various adverse effects on other processes in the construction cycle (Fisk, 1997). Occasionally, the procurement delay may cause an entire change or replacement for originally specified materials or equipment for the project (Arain, 2004). This may therefore cause a need for project activities to be reworked. A *lack of communication* between parties may cause major changes that could eventually impact the project adversely (Arain, 2004). Detrimental changes, which affect the projects adversely, can usually be managed at an early stage with strong and continuous communication.

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

Proper strategic planning is an important factor for successful completion of a building project (Clough and Sears, 1994; CII, 1994a). *The lack of strategic planning* is a common cause of changes in projects where construction starts before the design is finalized, for instance, in concurrent design and construction contracts (O'Brien, 1998). *A lack of required data* may affect the contractor's strategic planning for successful project completion, leading to frequent disruptions during the construction process. This is because a lack of data can result in misinterpretation of the actual requirements of a project (Assaf, 1995; Arain, 2004).

2.2.4 Other Causes of Changes

The under listed causes of changes are those that are not directly related to the contracting parties. These causes affect progress of a construction project adversely by causing considerable changes.

- Weather conditions
- Safety considerations
- Change in government regulations
- Change in economic conditions
- Socio-cultural factors
- Unforeseen problems

Adverse weather conditions can affect outside activities in construction projects (Fisk, 1997; O'Brien, 1998). When weather conditions vary, the contractor needs to adjust the construction schedule accordingly. Occasionally, this may affect the project progress adversely, leading to delays in construction. *Safety* is an important factor for the successful completion of a project (Clough and Sears, 1994). Noncompliance with safety requirements may cause major changes in design. Lack of safety considerations may affect the project progress adversely, leading to serious accidents and delays in the project completion.

Local authorities may have specific codes and regulations that need to be accommodated in the design (Arain, 2004). Change in government regulations during the project construction phase may cause major changes in design and construction. This can affect a project adversely depending on the timing of the occurrence of the changes. *Economic condition* is one of the influential factors that may affect a construction project (Fisk, 1997). The economic situation of a country can affect the whole construction industry and its participants.

Professionals with different *socio-cultural backgrounds* may encounter problems due to different perceptions, and this may affect the working environment of the construction

project (Arain, 2004). Lack of coordination is common between professionals with different socio-cultural backgrounds (O'Brien, 1998). Eventually, project delays may occur that end up with vital changes in the entire project team. *Unforeseen conditions* are usually faced by professionals in the construction industry (Clough and Sears, 1994; O'Brien, 1998). If these conditions are not solved spontaneously, they may cause major changes in the construction projects. Eventually, this may affect the project adversely, leading to reworks and delays in the project completion.

2.3 Impacts of Change Orders

This type of literature studies changes in construction from a cost point of view. The literature published can be classified as either qualitative or quantitative. Qualitative studies discuss the various attributes of cost and schedule impacts without quantifying them. Quantitative studies on the other hand attempt to quantify the various attributes of cost and schedule impacts. Most of the quantitative studies were done on the productivity factor in change. CII has great contributions to this type of studies. Quantitative assessments of change impacts can be done for different purposes:

- ♦ To predict the impacts of change before construction (by owner or contractor)
- ♦ To calculate cost of change during construction (for accounting corrective actions)
- ♦ To calculate cost of change after project close out or for claim purposes

Attempts to quantify impacts of change usually confronted two major problems (*Zeitoun and Oberlender, 1993*):

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

The cost impact of a change is greatly affected by the timing of the change (*CII publications 5-1(1986) & 6-10 (1990)*). A change issued before construction has limited effects as compared to a change issued after construction has already started and materials have been procured. Also successive changes cost more than a single change. Changes after construction or completion of design must provide high cost saving to be justified.

The impacts of a change are classified in the literature as follows: (*CII publication 6-10,1990*)

1. Direct cost impact
2. Direct schedule impact
3. Indirect or Consequential impact

Let us examine each of these impacts and its attributes making reference to published literature on the subject.

2.3.1 Direct Cost Impact

The direct impacts are those limited to the work package in which a change is introduced. The cost impact could be positive (savings) to the owner or negative (more expenditure). The contractor's view of a change being positive or negative will be the opposite of the owner. A change may also have a positive cost impact to both owner and contractor. Further, a change may have zero cost impact to both parties. There are two components to the cost of a change: labor cost and material cost. Material cost is easy to estimate and predict to certain accuracy. However it is difficult to estimate labor cost due to:

- ♦ The effect of changes on the productivity rate itself.
- ♦ The uncertainty about the scope of a change (exact engineering, procurement, and construction activities that form a change work).

The discussion here about labor cost impact will use the situation where change is issued after construction as the setting. Labor cost of changes can be broken into three attributes (*CII publication 6-10, 1990*):

a) Productivity Degradation

b) Delays

c) Demolition and Rework

Of the direct cost impact attributes, productivity is the most difficult to estimate, measure and control.

a. Productivity Degradation

Interruption, delays and redirection of work, associated with change work have a negative impact on labor productivity which in turn translates into labor cost or dollar value. Many studies were conducted to evaluate this aspect of change (*CII publication 6-10 (1990), Thomas 1994 &1995, Hester 1991*). Two studies cited in CII publication 6-10 (1990) examined work by single craft crewmen and effects of changes on their productivity. "The setting of the first study was a major chemical facility and the craftsmen involved were union insulators". "Study 2 was undertaken on a revamp project at a refinery where changes were being generated at a rate that often exceeds 20 per week". Comparing the productivity index against the frequency of change, the studies concluded:

Productivity drops rapidly with increased frequency of interruptions.

- ♦ As the rate of disturbances to the normal flow of work increases, the extent of productivity degradation becomes compounded.
- ♦ More than 40% reduction in productivity was noticed with an extreme number of disturbances.

Productivity degradation is not the same for all tasks and settings. The following factors are noted:

1. Concentration required to accomplish the task
2. Machine intensive tasks vs. labor intensive tasks
3. Frequency of interruptions and duration of time between them
4. Worker expectation of the change and his opinion about it

We can also expect productivity of workers to be greatly affected in cases where workers were required to work overtime for prolonged periods to compensate for schedule delays. In a study by Thomas and Napolitan (1995) productivity values from three industrial projects constructed between 1989 and 1992 were used in the analysis. The study concluded that on average there was 30% loss of efficiency due to changes (25-50% was the actual range). It is worth noting that Thomas and Napolitan concluded that changes do not lead to productivity degradation or efficiency loss in them. Instead,

a construction change causes other disruptive influences to be activated. In fact, Thomas and Napolitan concluded that it is possible to perform changes without negatively impacting labor efficiency. However, it is difficult to qualify this statement. Changes are disruptive in nature and to think of eliminating some of these disruptions is impossible before the change is introduced.

Thomas and Napolitan show the same results in their Construction Industry Institute report (1994). The report indicated that earlier research done by the United Nations in 1965 identified two major factors affecting labor productivity, namely the nature of work being done (Organizational Continuity) and the management and the environment of the work (Executional Continuity). The United Nation's report has led to the development of a model called the Factor Model that tries to explain factors affecting labor productivity.

The CII report concluded again that changes normally lead to disruptions and these disruptions are responsible for labor productivity degradation: "The most significant types of disruptions are the lack of materials and information and having to perform the work out of sequence". Lack of material is reported as being the most serious disruption. The report emphasized that to manage changes one needs to manage these disruptions. However the disruptive effects "cannot be avoided in many instances".

b. Cost of Delay

To make 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 and materials may not be the same after the change is introduced. To procure or rent new material, tools and equipment will cause delay and cost of resources may be substantial. Furthermore, if delays are prolonged demobilization/remobilization may become quite costly. The cost of delay may apply to engineering and procurement activities if impacted by change (CII publication 6-10, 1990).

c. Demolition and Rework

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

i. Labor cost to demolish existing facility
ii. Equipment cost to demolish existing facility
iii. Materials wasted by removal of existing work
iv. Associated cost of engineering/shipping and handling of waste materials

2.3.2 Direct Schedule Impact

It is easy to document a schedule impact of a change after change work is done, because all data is 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. The cost of schedule slippage becomes very high if the contract includes a penalty clause.

Most projects are planned using a critical path method, CPM, (*CII publication 6-10, 1990*). This method of scheduling shows the activities included and their dependencies. CPM provides the basis against which impact of changes on schedule can be evaluated. Floats both total and free play an important role in schedule impact evaluation for they represent the flexibility available to handle the unforeseen conditions such as changes.

The magnitude of schedule slippage due to changes is reported by Zeitoun and Oberlender (1993) as 9% of the original schedule on average for 71 fixed price projects studied. In a study by Ibbs, Lee & Li (1998) on the effects of schedule acceleration on project changes, researchers concluded that "a high level of fast tracking generally does not result in any more changes than non-fast tracking projects". This study used data from an earlier study (Ibbs & Allen) sponsored by the Construction Industry Institute in which 108 projects were analyzed for change data. The study found that fast track projects, however, tend to generate more changes toward the end of the project,

resulting in increased labor intensity and a more hectic finishing and close out operation.

2.3.3 Consequential Impacts

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

The following are among the possible consequential effects (*CII publication 6-10, 1990*).

1. Effects on the methods or procedures used in other work packages due to a change in a previous task or package.
2. Degradation of productivity in subsequent packages or activity: Productivity studies cited earlier confirmed that a degradation of productivity in the change package is followed by productivity degradation in subsequent packages. A degradation of productivity was also noted in concurrent activities due to a change.
3. Increase in overhead cost – Obviously if the change has an impact on schedule, material or administration level, the project overhead increases proportionally.
4. Impacts on subcontractors: Normally subcontractors have their own plan and schedule assuming that the main contractor will maintain the original conditions that allow start and end of work as scheduled. When a change takes a place, the subcontractor may need to adjust his plans and schedule accordingly. The subcontractor in turn may seek price and or schedule adjustments.
5. Miscellaneous: The following are some potential cost items that may be overlooked:
    - Time value of capital tied due to a change
    - Shifting of work to a less favorable period.

- Additional bonding and insurance.
- Engineering work for correcting drawings and documents.
- Procurement activities effects

In summary, changes in construction generate effects that far exceed the working package or activity in which changes occur. This situation is called a "Ripple Effect". Thomas and Napolitan (1994) indicated that "While much has been said about the ripple effect, there have been no quantitative studies showing the magnitude of these effects".

An attempt to measure ripple effects quantitatively was done by Zeitoun and Oberlender (1993). The attempt was not successful, because of the relative respondent interpretation of the term 'ripple effect'. The researchers then proposed a method called 'ripple tree'. Again results obtained applying the ripple tree method came out to be inconsistent with the actual situation. Zeitoun and Oberlender (1993) attributed the unexpected results to erroneous historical data and suggested the use of the method during construction.

Nevertheless, managers of construction projects must develop the means to evaluate and estimate the consequential impacts of a change. An effective tool in consequential impact evaluation is the use of Work Breakdown Structure (WBS). A contractor should consider using the Work Breakdown Structure (WBS) as an evaluation tool especially on large projects. In this method, the whole project is broken into hierarchical fashion. Resources are allocated to each element in the WBS. "The WBS is a vital tool in change management. If a change involves work not previously included on the WBS, it can be logically added to the WBS and its relationship to the WBS element seen" (*CII publication 6-6, 1988*). Ripple effects can be traced by the use of WBS. The discussion of the details and applications of the WBS is beyond the scope of this paper and the reader is referred to the above CII publication. Other evaluation tools cited in literature include market factor (MF), forensic scheduling, and current control schedule. The details of these tools are covered in CII publication 6-6 and Hester et al (1991).

2.4 Legal Aspects of Change Orders

In this regard, literatures discussing legal aspects such as contract change, clause interpretation, substantiation and management of claims are referred. In this approach changes are looked as a major source of construction claims and disputes. The major legal aspects are (*CII publication 5-10 (1986), Cox 1997)***.**

- ♦ Selecting the best delivery system (contract format)
- ♦ Drafting and interpreting change clauses
- ♦ Documenting change orders to be ready in case of litigation

Most of these issues can be found in literature discussing claims and disputes and deal with after the fact approach. However, there are few points that affect how a project will cope with changes and problems foreseen. An owner's management of change orders and claims must also anticipate and provide for dispute prevention and dispute resolution processes from the outset.

2.4.1 Types of Construction Contracts

Whenever legal issues of change orders are raised, the contract format used could be the subject of concern. The actual form of agreement is often a very brief document which describes the contracting parties, authority, scope of the work, the consideration to be paid, penalties or bonuses, and the time for performance. This document is seldom the issue of concern whenever a dispute occurs between the contracting parties. Primarily, these documents for a construction project comprises of the *Agreement form, Bill of quantities, General conditions, Special conditions, Technical specification, Plans and Addenda* (*Alan T., Gordon R. 2004)*.

There are numerous contract types used in construction and depending on the project requirements contracts can be identified as either fixed price or cost reimbursable [*Ibbs, W., Neguyen, L., Lee, S. 2007*].

i) Fixed price contract

This category includes all contract types in which financial terms require the contractor to establish a stipulated sum for the completion or execution of a defined quantity of work. Under this category the following two most common types of contracts are referred:

a) *Lump Sum*: The contractor, in this type of contract, is required to construct the project in accordance with plans and specification for a fixed sum. Hence, the contractor is solely responsible for any cost exceeding the agreed amount.

The term lump sum is often used to indicate a lump sum contract including design procurement and construction. Sometimes it is referred to as simply turnkey contract.

b) *Unit Price*: This contract type contains a detailed list of estimated work quantities of different types of work units. Actual price paid (fixed) is determined by actual units done as constructed. In such kind of contract, the owner is required to take the risk of variation in quantity. However, unit price contract allows the owner the freedom to make changes in the volume of work and permit more control.

c) Guaranteed Maximum: In this type of contracts the owner is guaranteed a maximum price for executing the work as defined in the contract. Normally the contract contains incentive clauses for cost under-runs and penalty clauses for cost overruns. Ashly and Workman (1986) discussed the effects of incentives in the contract and concluded that they promote an attitude of motivation on the contractual relationship and take the form of inducements, encouragement and threats. The study also indicates that incentives are a tool used by owners to adjust the contractor's fee. The study includes full details of finding on contractual motivation which is beyond our scope of this review.

ii) Cost reimbursable contracts

This category includes all contract types, in which financial terms allows the contractor price adjustment relative to project costs. Ibbs et al (1986) summaries the type of contracts which fall under this category as:

a. Cost plus Fixed Fee

The contractor in this type of contract is paid whatever cost associated with the project plus a lump sum fee for corporate overhead and profit.

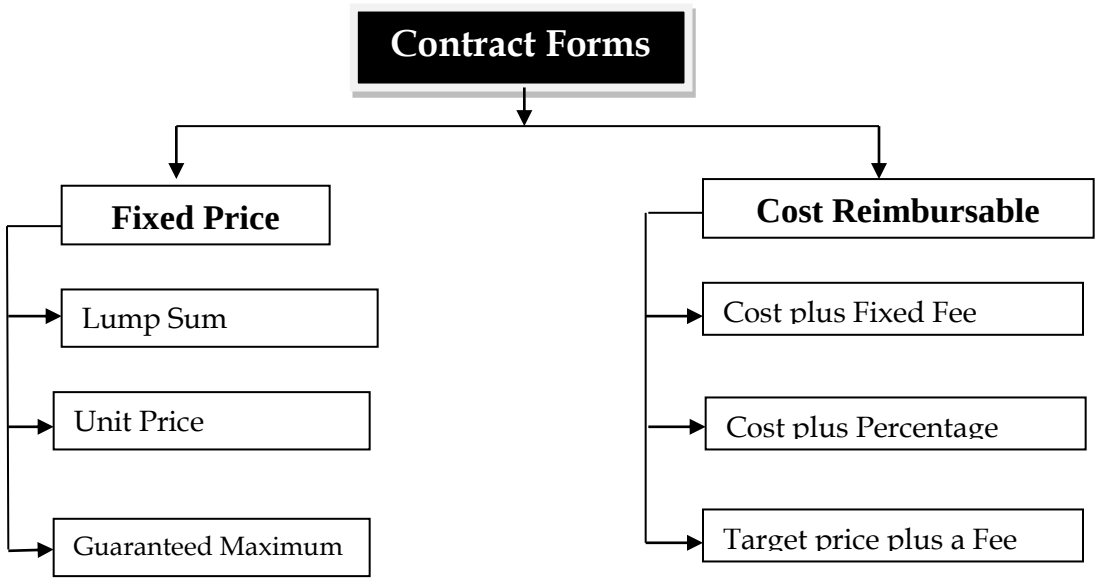
b. Cost plus Percentage

In this type of contract the contractor is paid all costs associated with the project plus a percentage of these costs rather than a fixed sum or fee.

c. Target Price plus a Fee

In this type of contract, a target price is first established for the cost of the project based on contract documents or unit prices. "The contractor's fee will be based on this sum. Typically financial arrangements make provision for the contractor to share any savings below the target price or participate in the liability of cost overruns".

The following block diagram depicts the contract format division:



Reimbursable contracts allow for contract adjustments relative to project scope as determined by the cost and do not, generally, address a final fixed price. Fixed price contracts allocate more risk to the contractor and thus require more effort, money, and time on design documentation before construction is initiated. Cost reimbursable

contracts require greater risk sharing between the owner and contractor and require more owners' personnel for contract administration during the construction phase to enforce cost and schedule. They are more easily used for fast tracking of design and construction. Reimbursable contracts are also very flexible for changing design or scope of work and establish the basis for a less adversarial relationship between the owner and contractor.

Ibbs et al (1986) indicated that "the choice of the type of contract (fixed cost versus cost reimbursable) should be heavily influenced by four circumstances:

1. The extent to which the work is defined
2. The desired allocation of risk between owner and contractor
3. The availability of owner expertise and effort on the project
4. The need to accommodate fast-tracking of design and construction

Often both forms of contracts exist on a project simultaneously. Prime contractors will often have cost reimbursable contracts with the owner and fixed price contracts with their subcontractors. In the Ethiopian construction industry fixed price contract is widely practiced.

2.4.2 Change orders and Contract Forms

Certainly not all types of contracts are equally sensitive to changes. If contracts are classified as either cost reimbursable or fixed cost, the latter will be the most sensitive to changes. Fixed price contracts are selected for projects in which the scope is well defined and the risk is low. Cost reimbursable contracts on the other hand are selected for vaguely defined projects for schedule acceleration. In cost reimbursable projects, there is a direct transfer of cost and schedule effects to the owner. Owners should consider changes when considering the type of contract for their project in terms of the ability of the contract to contain and minimize changes. In this regard, change clauses are an important element of the contract because they provide mechanism for contract modification (either to react to unexpected events or because the owner desires change)

and for appropriate compensation. The change clause establishes the right of the owner to make changes within certain limitations and through a defined mechanism. However, it was found that change clause is one of the most troublesome contract clauses. Problems most often encountered with construction change clauses involved definition and negotiation of costs, dispute resolution and time required for approval. Legal disputes over changes often focus on whether or not a compensatory change exists, the appropriate level of compensation, and the relative responsibility for a change.

2.5 Change Order Management

Construction contracts are unique in that they typically provide the owner the right to make changes to the contract documents without avoiding the contract. However, as the number of change orders on a project increase, so does the possibility of misunderstanding among the contracting parties. Such a misunderstanding may occur because one or more of the parties lack full knowledge of the change order process itself, the cost involved in implementing the change, or the delays, conflicts, and interruption of the construction sequence and schedule which can adversely impact the project coordination.

The discussion so far has concentrated on the legal and cost aspects of a change. Equally important is the need to have a well-developed program for the management of changes. This includes a change control program and change order administration during initiation, evaluation, approval and implementation. Most of what is written deals with the control part. The Changes Impact Task Force of the Construction Industry Institute (CII) prepared a checklist of the most common parameters to consider when considering a change. These parameters were classified under different categories. According to Thomas and Napolitan (1994), the major categories are:

- Size and scope
- Nature of the scope

- Timing
- Managing Impact
- Who does the change
- Site conditions (environment)

In its special publication (Oracle, 2009), change management best practices for the engineering and construction industry recognized five valuable steps for effective change management:

- Identifying contract requirements.
- Identifying potential changes.
- Determination of Entitlement and Effect of Change
- Negotiation and execution of change order.
- Recording the executed change.

2.5.1 Contract requirements Identification

The contract documents identify the requirements for the project in terms of its scope, schedule, and budget. The contract requirements must first be identified so that any deviation (that is, a change) can be recognized, because a change is essentially a requirement that deviates from the requirements set forth in the contract documents.

The contract documents typically include the following components:

- **Contract.** Addenda, agreement, special provisions, and all similar or related provisions and references.
- **Specifications.** General provisions, technical specifications, supplemental provisions or specifications, and other referenced standards.
- **Plans.** Project plans include standard plans, standard details, boring logs, or other information that depicts the work to be constructed or site conditions prior to the start of construction.

When reviewing the contract documents it is important to apply general rules of contract interpretation. This means reading the contract as a whole and following the order of precedence clause when interpreting the component contract documents.

The owner and contractor should also pay particular attention to the contract clauses related to notice and changes, because these clauses are the logical starting points for the identification and administration of changes.

2.5.1.1 Changes Clause

The *changes clause* could be the most important clause in a construction contract because it specifies that the owner can make changes in quantities or other alterations it deems necessary to complete the work (scope), which can affect the contract time (schedule) or cost (budget). The contractor, on the other hand, is obligated by the changes clause to execute changes to the work according to the owner's instructions, provided that a mechanism exists for the contractor to be compensated in terms of cost and time.

Changes include changing the quantities of work or the conditions under which it is to be performed, and suspending, adding, or eliminating work that is within the scope of the contract. Therefore,

- During the course of the contract, the owner through its agent has the right to make written changes in the quantities or other alterations as necessary to complete the work *[FIDIC 1987, Clause51 (a to f)].*
- Such changes in quantities or alterations neither invalidate the contract nor release the surety.
- Contract time will be adjusted [*FIDIC 1987, Clause 44.1 (a to e)*] for changes that require additional time to complete.

The changes clause, illustrated above, first addresses the potential scope, schedule, and budget effects of the change, then direct to the appropriate contract provisions governing payment and time extensions.

As to how this might work in practice, changes that affect the project's "critical path" might require the issuance of a time extension.

Likewise, the provisions that govern the payment requirements for the changed work are referenced by the changes clause. For contract changes that affect unit price work items, the preferred solution is typically to use the existing contract unit prices to price the changed work. If contract unit prices for the changed work do not exist, suitable rates or prices can be negotiated between the contracting parties. In the event of disagreement, the consultant, *as per clause 52.1 of the FIDIC condition of contract,* can fix such rates or prices which are, in his opinion, appropriate and notify the contractor accordingly, with a copy to the owner. However, the consultant can also determine provisional rates or prices to enable on-account payments to be included in certificates issued in accordance with *Clause 60*.

2.5.1.2 Contractor Notice Clause

The contractor typically has the responsibility of informing the owner of any condition that is potentially a change before proceeding with the affected work. Notice must typically be provided in written form, but some contracts might also allow oral notice. Contracts typically define notice as written notice that is provided within a certain time frame (typically, not longer than a week or so) of identifying a change. The notice clause is important because it prevents the contractor from prejudicing the owner's rights to investigate, mitigate, and document the change while the opportunity exists. In other words, the notice clause provides the owner with an opportunity to decide on the appropriate course of action before any work is performed or additional cost incurred and to document the changed work as it is performed. Notice clauses are often enforceable, and the contractor's failure to notify the owner within the specified time frame could result in the forfeiture of all rights for additional compensation or time. Notice provisions not only encourage or force the parties to communicate effectively, but they also instigate the collaborative process necessary for the project participants to resolve the change.

If the Owner responds unacceptably, or not at all, the contractor must provide a written notice within five working days of the first notice. The written notice has to include the following:

- A description of the situation;
- The time and date the situation was first identified;
- A clear explanation of why the situation represents a change to the contract, including accurate references to the pertinent portions of the contract;
- A statement of the amendments deemed necessary in the contract price(s), delivery schedule(s), phasing, time, and so on. Because of its preliminary nature, the Owner recognizes that this information may rely on estimates;
- An estimate of the time by which the Owner must respond to minimize cost, delay, or disruption; and
- Anything else that will help achieves a timely resolution.

As it was explained in the above paragraphs, the initial contract notice can be provided orally instead of in writing, which can save time - a benefit to both the owner and the contractor. The contractor is still required to provide written notice within five days if the owner responds differently than anticipated, or fails to respond to the oral notification. Conversely, if the owner agrees with the contractor that a change has occurred, then steps can be taken to document and administer the change. In summary, the notice clause should be part of a fair and workable change management process that serves the needs of the owner, the contractor, and the project in general.

2.5.2 Potential Changes Identification

When a potential change is identified, it is important to correctly classify it and follow the correct procedures. In this step of the process, a potential change is classified among the different types of change provisions that are defined by the contract.

Construction contracts are often thorough in identifying the different kinds of changes that might be encountered during construction and defining the procedures that must be followed upon their identification. The common types of change provisions defined in construction contracts are:

- Change in the character of work,
- Unforeseeable Site Conditions,
- Suspension of work,
- Extra work, or
- Elimination of work.

2.5.2.1 Change in the character of work

A change in the character of work is defined as a significant variation in quantity or change in the conditions under which the work is to be performed. Most of the time this happens due to the owner's contractual right to make change in quantities and alterations in the works that are necessary for the proper completion of the project. Such changes in quantities and alterations shall not invalidate the contract nor release the surety, and the contractor shall abide himself to the contractual obligations to perform the work as altered.

FIDIC 1987, condition contract Clause 51.1 grants the Engineer (Owner's representative) to make any variation of the form, quality or quantity of the works that may, in his opinion, be necessary. The type of variation this clause commands include "*increase or decrease the quantity of any work included in the contract*" and "*change the character or quality or kind of any such work.*

If the changes in quantities significantly change the character of the work under the contract, whether or not changed by any such different quantities or alterations, an adjustment, excluding loss of anticipated profits, will be made to the contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis

cannot be agreed upon, then an adjustment will be made either for or against the contractor in such amount as the Engineer may determine to be fair and equitable.
If the alterations or changes in quantities do not significantly change the character of the work to be performed under the contract, the altered work will be paid for as provided in *Sub Clause 52.1 of FIDIC 1987, condition contract* as follow:

All variations referred to in Clause 51 and any additions to the Contract Price which are required to be determined in accordance with Clause 52 (for the purposes of this Clause referred to as "varied work"), shall be valued at the rates and prices set out in the Contract if, in the opinion of the Engineer, the same shall be applicable. If the Contract does not contain any rates or prices applicable to the varied work, the rates and prices in the Contract shall be used as the basis for valuation so far as may be reasonable, failing which, after due consultation by the Engineer with the Employer and the Contractor, suitable rates or prices shall be agreed upon between the Engineer and the Contractor. In the event of disagreement the Engineer shall fix such rates or prices as are, in his opinion, appropriate and shall notify the Contractor accordingly, with a copy to the Employer.

2.5.2.2 Unforeseeable Site Conditions

Unforeseeable means not reasonably foreseeable by an experienced contractor [*FIDIC, MDB Harmonized 2010 edition*]. Such site conditions include natural and manmade physical conditions and other physical obstructions and pollutants, which the contractor encounters at the site when executing the works, including sub-surface and hydrological conditions but excluding climatic conditions.
Whenever such site conditions happen while executing, *Sub clause 4.12 of FIDIC, MDB Harmonized 2010 edition* treats the case as follow:
If the Contractor encounters adverse physical conditions which he considers to have been Unforeseeable, the Contractor shall give notice to the Engineer as soon as practicable. This notice shall describe the physical conditions, so that they can be inspected by the Engineer, and shall set out the reasons why the Contractor considers them to be Unforeseeable. The Contractor shall continue executing the Works, using such proper and reasonable measures as are appropriate for

the physical conditions, and shall comply with any instructions which the Engineer may give. If an instruction constitutes a Variation, Clause 13 [Variations and Adjustments] shall apply.

If and to the extent that the Contractor encounters physical conditions which are Unforeseeable, gives such a notice, and suffers delay and/or incurs Cost due to these conditions, the Contractor shall be entitled subject to notice under Sub-Clause 20.1 [Contractor's Claims] to:

(a) An extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and

(b) Payment of any such Cost, which shall be included in the Contract Price.

Upon receiving such notice and inspecting and/or investigating these physical conditions, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine (i) whether and (if so) to what extent these physical conditions were Unforeseeable, and (ii) the matters described in subparagraphs (a) and (b) above related to this extent.

However, before additional Cost is finally agreed or determined under sub-paragraph (ii), the Engineer may also review whether other physical conditions in similar parts of the Works (if any) were more favorable than could reasonably have been foreseen when the Contractor submitted the Tender. If and to the extent that these more favorable conditions were encountered, the Engineer may proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine the reductions in Cost which were due to these conditions, which may be included (as deductions) in the Contract Price and Payment Certificates. However, the net effect of all adjustments under sub-paragraph (b) and all these reductions, for all the physical conditions encountered in similar parts of the Works, shall not result in a net reduction in the Contract Price.

The Engineer shall take account of any evidence of the physical conditions foreseen by the Contractor when submitting the Tender, which shall be made available by the Contractor, but shall not be bound by the Contractor's interpretation of any such evidence.

2.5.2.3 Suspension of work

A suspension of work is defined as an order by the owner/or owner's representative to stop the work, or elements of the work, for a period of time. Work suspensions are changes of particular importance because they impede the contractor from performing

the work in the sequence or manner that the contractor intended. Suspension could be instigated by either of the contractual parties depending on their contractual right.

Suspension by the Employer/Engineer

Sub clause 40.1 of FIDIC Conditions of Contract recommends suspension of work where such suspension is necessary by reason of: *breach of contract by the contractor or climatic conditions on the site, or for the proper execution of the works or for the safety of the Works or any part thereof.*

Sub-Clause 40.1:

The Contractor shall, on the instructions of the Engineer, suspend the progress of the Works or any part thereof for such time and in such manner as the Engineer may consider necessary and shall, during such suspension, properly protect and secure the Works or such part thereof so far as is necessary in the opinion of the Engineer. Unless such suspension is:

(a) Otherwise provided for in the Contract,

(b) Necessary by reason of some default of or breach of contract by the Contractor or for which he is responsible,

(c) Necessary by reason of climatic conditions on the Site, or

(d) Necessary for the proper execution of the Works or for the safety of the Works or any part thereof,

If the performance of all or any portion of the work is suspended or delayed by the owner or owner's representative in writing for an unreasonable period of time (i.e. suspension lasting more than 84 days) and if permission to resume work is not given by the engineer, the contractor may submit in writing to the engineer requiring permission within 28 days to proceed with the suspended works pursuant to *Clause 40.3.*

Clause 40.3:

If the progress of the Works or any part thereof is suspended on the instructions of the Engineer and if permission to resume work is not given by the Engineer within a period of 84 days from the date of suspension then, unless such suspension is within paragraph (a), (b), (c) or (d) of Sub-Clause 40.1, the Contractor may give notice to the Engineer requiring permission, within 28 days from the receipt thereof, to proceed with the Works or that part thereof in regard to

which progress is suspended. If, within the said time, such permission is not granted, the Contractor may, but is not bound to, elect to treat the suspension, where it affects part only of the Works, as an omission of such part under Clause 51 by giving a further notice to the Engineer to that effect, or, where it affects the whole of the Works, treat the suspension as an event of default by the Employer and terminate his employment under the Contract in accordance with the provisions of Sub-Clause 69.1, whereupon the provisions of Sub-Clauses 69.2 and 69.3 shall apply.

Moreover, suspensions of work that delay critical path activities can extend the overall duration of the project, potentially resulting in both added costs and delaying the scheduled project completion date.

In the event of any delay, impediment or prevention by the Employer, or other special circumstances which may occur, other than through a default of or breach of contract by the Contractor or for which he is responsible, the contractor has to notify the Engineer within 28 days after such event has first arisen with a copy to the Employer pursuant to Sub-Clause 44.2 [*Contractor to Provide Notification and Detailed Particulars*]. No contract adjustment will be allowed unless the contractor has submitted the request for adjustment within the time prescribed.

Clause 40.2

Where, pursuant to Sub-Clause 40.1, this Sub-Clause applies the Engineer shall after due consultation with the Employer and the Contractor, determine

(a) Any extension of time to which the Contractor is entitled under Clause 44, and

(b) the amount, which shall be added to the Contract Price, in respect of the cost incurred by the Contractor by reason of such suspension, and shall notify the Contractor accordingly, with a copy to the Employer.

Upon receipt, the Owner will evaluate the contractor's request. If the Owner agrees that the cost and/or time required for the performance of the contract has increased as a result of such suspension and the suspension was caused by conditions beyond the

control of and not the fault of the contractor, its suppliers, or subcontractors at any approved stage, and not caused by weather, the Owner will make an adjustment.

No contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided for or excluded under any other term or condition of this contract.

Suspension by the Contractor

Contrary to sub-clause 40.1, sub clause 69.4 depicts that the contractor too has a contractual right of suspending the work or reduce the rate of work if employer fails to pay the contractor the amount certified under any payment certificate approved by the engineer within the time stated on the contract. However, this contractual privilege should be accompanied by a notice written to the employer and the engineer prior to suspending or reduce the rate of work.

Sub-clause 69.4 :

Without prejudice to the Contractor's entitlement to interest under Sub-Clause 60.10 and to terminate under Sub-Clause 69.1, the Contractor may, if the Employer fails to pay the Contractor the amount due under any certificate of the Engineer within 28 days after the expiry of the time stated in Sub-Clause 60.10 within which payment is to be made, subject to any deduction that the Employer is entitled to make under the Contract, after giving 28 days' prior notice to the Employer, with a copy to the Engineer, suspend work or reduce the rate of work….

If the Contractor suspends work or reduces the rate of work in accordance with the provisions of this Sub-Clause and thereby suffers delay or incurs costs the Engineer shall, after due consultation with the Employer and the Contractor, determine:

(a) any extension of time to which the Contractor is entitled under Clause 44, and

(b) the amount of such costs, which shall be added to the Contract Price, and shall notify the Contractor accordingly, with a copy to the Employer.

2.5.2.4 Extra Work

Extra work is defined as added work not provided in the original contract, but found to be essential for the satisfactory completion of the project within its intended scope. Extra work can be added to the project's scope due to a design consultant's error or omission, or through changes requested by the owner or demanded by a third party. The extra work clause is particularly important because it provides a mechanism for the owner to introduce additional elements of work. Whenever a need for extra work arise, *sub-clause 51.1(e) of FIDIC condition of contract* gives power to the Engineer to instruct the contractor to " *execute additional work of any kind necessary for the completion of the Works"* and the contractor shall do the work in accordance with the instruction.

2.5.2.5 Eliminated work

Eliminated work is defined as original contract items that are no longer desired or necessary to complete the work and are, thus, removed from the project's scope by the owner through a deductive change order. Eliminated work items can become the basis for disputes, however, if the contractor has already incurred cost for those items, for example, purchased materials. In such cases, it is customary for the contractor to request reimbursement for actual costs incurred. Whenever needs to omit works arise by the owner, sub-clause 51.1(b) of FIDIC condition of contract gives power to the Engineer to instruct the contractor to "*omit any such work (but not if the omitted work is to be carried out by the Employer or by another contractor)"*.

As indicated previously, after a contractor, owner, or third party has determined the type of change, appropriate change provision has to be identified as indicated previously, and it should then demonstrate that it has met all requirements set forth in that provision including notice requirements if the change was identified by the contractor. All contract documents, contemporary project records, and correspondence used to support the position that the potential change is a legitimate contract change should then be filed for further analysis. The following crucial steps are advised to be followed while keeping a record for a potential change.

2.5.3 Measuring the Effect of Change Order

As previously stated, the changes clause indicates that changes to the contract might be necessary for the satisfactory completion of the project or project conditions can differ from the conditions originally shown in the contract. The first step in determining the contractor's entitlement to additional costs or time related to an alleged change is establishing that a change, according to the contract, has in fact occurred, and then determining whether the contract provides the contractor with remedies for the change.

To establish that a change has occurred, the contractor should identify the specific change-related contract language associated with the alleged change. Then, referencing the specific change provision, the contractor should demonstrate that the alleged change is in fact a change by comparing it to the baseline requirements set forth in the contract. After establishing that a change has occurred according to the contract, the contractor must show that the relevant contract provision enables the recovery of additional time or costs that result from the allowable change.

Only after a contractor has established entitlement to a change can the effect of the change begin to be measured. Typically, a change will consist of either the addition or elimination of work. If a change requires the addition of work, the contractor should use the contract's time extension provision to determine how the delay associated with the change should be measured and the appropriate extension of time determined.

However, if the contract's time extension provision does not provide direction to the contractor on how to request additional contract time for the delay that might result from the additional contract work, then the contractor should use an appropriate schedule analysis technique to measure the delay to the project and the duration of the appropriate time extension.

2.5.4 Negotiation and Execution of Change Order

Many contracts dictate the process, including the duration of time that each party must follow to address any potential changes to the contract work. The contractor must

disseminate the information included with an owner's Request for Proposal (RFP) to all affected parties, including subcontractors, and then assemble the detailed responses to support the estimated cost or the delay resulting from the change within this specified period.

Upon receipt of a contractor's response to a RFP, the owner will review the information as described in the third activity of the change management process and respond to it within the period of time specified by the contract. At this time, the owner will either accept the contractor's proposal as submitted and generate a change order for signature or reject the proposal, noting the basis for the rejection. As a standard practice, both of these actions should be performed in writing for record-keeping purposes. If the contractor's proposal is rejected by the owner, the contractor could then respond in writing to the owner's decision or set up a meeting with the owner to negotiate the matter until an acceptable cost and time extension are agreed upon.

If it appears that the change order process is too lengthy and impact the progress of the work and cause further delays, the owner could choose to address the change through means other than a bilaterally executed change order. A construction change directive (CCD) could be issued to the contractor directing that the work be performed on a time-and-materials basis, invoking the force account provision in the contract, with or without a not-to-exceed amount. A unilateral change order issued by the owner to the contractor allows the work to be performed in accordance with the changes clause of the contract without the cost and a time extension being agreed upon by the two parties in advance.

It is advisable for the contractor and owner to work together as diligently as possible to agree upon the cost and time adjustment for the change. If the parties have been working together throughout the course of the project, then their collaboration might allow them to find a middle ground during the negotiation process based on effective communication and trust. However, it is always possible that the two parties will not come to an agreement. If the parties are unable to negotiate a mutually agreed upon

cost or time extension for the change, and if the contractor disagrees with performing the work included in a CCD after a final decision has been made by the owner, then the contractor's only remedy might be to continue its dispute through the channels identified by the contract.

2.5.5 Recording the executed changes

Documentation of changes is a key responsibility of all parties of the construction project, especially the contractor's and the employer representative's personnel. At the beginning of a project, the staff should create standardized forms, procedures, contract document log, an issues log, request for information (RFI) log, and potential change orders (PCO) log so that detail project information will be maintained.

Most of the time, the contract documents log begin with the bid documents and include the most recent drawings or sketches that might be issued as part of an RFI or supplemental specifications by the owner or the consultants.

The creation of the contract documents log aids in establishing the baseline requirements of the contract. As documents are revised and incorporated into the contract, they should be available to all project personnel so that the most recent information will be used in evaluating changes or aid in generating the as-built set of documents as the project progresses and work is being performed.

3. RESEARCH DESIGN AND METHODOLOGY

3.1 The Study Approach and Research Type

Research is described as a process of collecting, analyzing and interpreting information to provide solutions to questions. For the purpose of this thesis, research is defined as a practical investigation or exploration to find out new facts or assemble old facts by scientific ways for the purpose of developing existing theory or its application for real problems.

3.1.1 The Research Type

This research can be categorized as applied research, because the research was initiated from practical problems to make assessment on the causes of change order and their cost impact on road projects in Ethiopia. To get data necessary for the research, three methods are available: questionnaire surveys, review of project records, and case studies. Most researchers found through their research that questionnaire surveys are best when used to collect opinions from a large sample of people in a specific industry. The only drawback is that opinions can be biased based on their position within the industry. To counteract this perceived bias, in this research review of project record data of different road construction projects is used as a primary data source.

3.2 Data Source and Collection

The study has employed data sources to produce respondents' documents and archival documents. The respondents' documents were collected using questionnaires from professionals in the construction industry such as clients, consultants and contractors. Archival documents were mostly from reports of completed projects and those on progress, in which the project history was recorded and investigated thoroughly which were very important in identifying the recurrent problems related to change orders on road construction projects in Ethiopia. In addition, they helped to find out how change orders arise and being handled and managed.

During data collection, the most tiresome and challenging aspect was the unpunctuality and negligence of respondents. This so because, most of the time, the respondents' were not enthusiastic enough to give their response as per the schedule they agreed to return the questionnaire. Contrary to this, archival documents from Ethiopian Roads Authority were voluntarily provided by the project engineers, who were assigned to administer the contracts of each project under consideration, whenever they are asked their cooperation. The projects used as a data source were randomly selected by those

project engineers at the beginning of the data collection as per the command given by deputy director of Ethiopian Road Authority.

The questionnaire was carefully designed in light of getting high response rate from respondents. The responses for the structured part of the questionnaire are based on *Likert's-scale*, ordinal data commonly used to measure attitude, providing a range of responses to a given question or statement.

The variables of major causes of change order categories in road construction projects in Ethiopia were identified from the desk study by clustering each reason of change order in to major categories of change. Then, respondents are asked about their agreement on these variables whether they can be the causes of change order or not, so that the respondents are required to choose one of the above categories as per their attitude toward the causes.

Depending on the response given on the causes of change order, the respondents are once again inquired to give their response on the chance of occurrence of such variables based on the following choices:

Not at all = 0, Unlikely = 1, Likely = 2, Almost certain = 3, and Certain = 4.

The probability to happen of each of the variables based on their chance of occurrence is defined in percentile as follow: *Not at all= 0%, Unlikely= 0% - 25%, Likely =26% - 50%, Almost certain =51% - 99%, Certain = 100%*.

At last the respondents were inquired to give their response on the type of consequential cost impact the causes of change orders have based on their responses on the frequency of occurrence alleged causes of change order. The responses on the consequential cost impacts were expected to be given as: *Decrement (Positive) or Increment (Negative).*

The identification of the responsible party for the causes of change order and their cost impact was done after the required data regarding the causes and cost impacts of change order is gathered. The questionnaires are prepared in such a way that detailed information can be gathered in a systematically prepared matrix table.

3.3 The Research Population

The research samples are taken from stakeholders in road construction industry such as clients, contractors and consultants. Ethiopian Roads Authority, ERA, is the only and sole owner (employer) of the road projects used as a sample in the research. Whereas, there are considerable number of consultants and contractors in the road sector; of which few are used as a sample of the study, selected randomly based on their experience in the road construction projects.

Though the parties involved in the construction industry are not equally liable for the occurrence of changes, the samples were restricted to be fifteen from each party so that the questionnaires are fairly distributed among the respondents. This would avoid biasedness and miss conclusion due to uneven number of population size when the responses are analyzed.

3.4 Method of Analysis

In the analysis the *Mean Score method* is adopted to establish the relative importance of the causes of change order on the road construction projects in Ethiopia. In addition to this, Likert's scale of five ordinal measures of agreement towards each statement (*0, 1, 2, 3 and 4*) is used to calculate the mean score for each factor that is used to determine the relative ranking.

The mean score (MS) for each variables of cause of change order is computed by using the following formula:

$$MS = \frac{\sum(f \times S)}{N} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (3.10)$$

Where:-

MS – Mean Score

f – Frequency of responses for each score

S – Scores given to each factor (from 0 to 4)

N – Total number of responses concerning each factor

The difference in ranking of two groups of respondents for several factors (such as client Vs. consultant, client Vs. contractor, and consultant Vs. contractor) is measured using the ***Spearman rank correlation coefficient***, ρ (*Rho*).

The Spearman rank correlation coefficient, **ρ,** for any two groups of ranking is given by the following formula.

$$\rho = 1 - \frac{6 \times (\sum d_i^2)}{N \times (N^2 - 1)} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (3.20)$$

Where: **ρ** – Spearman rank correlation coefficient

d_i – The difference in ranking between each pair of factors

N – Number of factors (variables)

Procedure for hypothesis testing:

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

4. DATA ANALYSIS AND DISCUSSION

This part of the research deals with the analysis and discussion of the data gathered from the desk study and questionnaire survey. It includes the identification of the major causes of change order in road construction projects, rate of occurrences of variables of change orders, the relationship between: change orders and project contract amount, project type(new and upgrading) and change orders, the cost impact of the variables of change orders on road projects.

The procedure used in analyzing the results was aimed at establishing the relative importance of the various factors responsible for change orders and their cost impact. The questionnaire gives each respondent an opportunity to express their agreement or disagreement on whether that change order is the cause of dispute among the contracting parties or not. As a result respondents were expected to give their response as per the following alternatives: *strongly disagree*, *disagree*, *agree and strongly agree;* frequency of occurrence of the variables of causes of change order; and the cost impacts of each change order variables on the final cost of the project. For each variables of change order, the percentages of respondents' response were ranked for analysis purpose. On the basis of the ranking of the variables by the various groups, it was possible to identify the most important factors that influenced change order on road construction projects in Ethiopia.

In the desk study seventeen road construction projects constructed in almost the four corners of Ethiopia were surveyed and 123 total reasons of change orders and their corresponding costs were taken onto consideration. During the desk study, documents such as project completion status reports of each project were thoroughly investigated. This helps to understand the reasons behind each project's change orders, and the change order amounts accompanied by each cause of change order. Collecting these data helped to analyze and draw the relationship between rate of causes of change order and the corresponding associated cost and hence the gross cost impact of the change orders.

4.1 Questionnaire Response Rate

Detailed questionnaires were designed and distributed for the assessment of causes and cost impact of change order on road construction projects in Ethiopia. For this purpose, a total of 45 questionnaires were distributed equally among professional employees of contractors, consultants and employer (ERA). As a result, 38 of the questionnaires were returned back with completed answers for each question inquired.

Though 45 questionnaires were distributed, only 38 of them (84.44 percent) are returned.

Table – 1 below shows the number of questionnaires distributed to clients, consultants and contractors and the number of questionnaires returned from these stakeholders including their percentage response rate.

Table-1 Summary of Respondents' Response Rate

No.	Professional Respondents	Questionnaire Distributed		Questionnaire Returned		Response Rate
		No.	%	No.	%	%
1	Employer	15	33.33	14	36.84	93.33
2	Consultant	15	33.33	13	34.21	86.67
3	Contractor	15	33.33	11	28.95	73.33
	Total / Average	**45**	**100**	**38**	**100**	**84.44**

4.2 The Existence and Extent of Change Orders

In the desk study, the data were collected from seventeen road projects constructed across Ethiopia with a total project cost of 8,143,451,307.55 (*See Table – 2*). The projects range in value from birr 138,601,822.00 to birr 817,570,809.78 and were constructed between the years of 2005 and 2014. Sixteen different contractors completed these projects and participated in supplying the change order data used in this research. Moreover, a total of sixteen different local and international consulting firms participated in design and supervision of these projects. From the progress reports and

Other relevant documents of the projects, a total of 123 contract change orders were found and examined as shown in *table-3*.

Table – 2 projects included in the desk study and their Project Cost

Project Code	Name of Road Projects	Initial Project Cost	Net Amount of Change Order	Final Project Cost	Percentage Of Change order

					(%)
P1	Arerti - Gobesa	444,696,050.03	(46,307,004.54)	398,389,045.49	90
P2	Sembo - Sholagebeya	613,072,806.85	(64,266,499.62)	548,806,307.23	90
P3	Gindeber - Gobesa	755,411,059.74	(68,718,699.35)	686,692,360.39	91
P4	Mojo-Ejere-Arerti	407,320,609.16	5,161,076.68	412,481,685.84	101
P5	Wolkite - Hosaina	618,998,415.32	28,279,611.75	647,278,027.07	105
P6	Wukro - Zalambessa	530,187,942.00	170,216,010.63	700,403,952.63	132
P7	Gonder - Debark	690,779,965.13	83,306,143.32	774,086,108.45	112
P8	Gondar - Dansha	369,149,638.91	(14,214,407.57)	354,935,231.34	96
P9	Nazaret-Assela-Dodola	398,988,518.00	1,426,821.67	409,276,701.61	100
P10	Aposto - Irba Moda	660,938,029.10	109,663,504.10	770,601,533.20	117
P11	Irba Moda - Wadera	185,447,955.09	(4,342,346.28)	191,105,608.82	98
P12	Nekemte - Mekenajo	300,723,746.00	10,444,650.27	311,168,396.27	103
P13	Nekemte - Nejo	138,601,822.00	50,119,176.31	198,720,998.31	136
P14	Gore-Gambela	817,570,809.78	6,260,110.81	823,830,920.59	101
P15	Ginir - Beredimtu	541,718,515.05	30,420,788.38	572,139,303.43	106
P16	Irebti - Afdera	436,758,578.38	(2,483,53825)	434,275,040.13	99
P17	Yalo-Abala	233,086,874.01	91,769,472.51	324,856,346.52	139
TOTAL PROJECT COST		**8,143,451,307.55**	**386,734,870.82**	**8,530,186,178.37**	**105**

N.B: *Negative net change order amount means a decrement of cost and the positive one is increment of cost.*

During the desk study, the reasons for the change orders associated with each project name are tabulated as shown in *Table-3* with their corresponding change order amounts.

Table – 3 Summary of Reason of Change Orders and their change order amount

S/No	Reasons of Change Order	Change order	Project's

		Amount	Name
1	Change of two types of type A houses to type B houses.	(463,937.62)	**P1**
2	Re-alignment from km 83+008.922 to km 85+345.057 Back/88+003.497 Ahead.	(24,135,269.04)	"
3	Re-grading from km 79+060 to 79+600.	75,990.40	"
4	Realignment from km 88+541.107 to km 89+216.98 Back/89+280.899 Ahead.	(3,274,904.04)	"
5	Re-alignment from km 94+065.923 to km 96+409.492 Back/96+393.625 Ahead.	(3,612,475.03)	"
6	Re-grading of the vertical alignment from km 100+100 to 100+860 (end of the project).	(734,936.32)	"
7	Re-alignment from km 94+390 to km 95+209.4 Back/95+200 Ahead.	1,672,315.14	"
8	Re-alignment from km 96+000 to km 98+446.216 Back/98+500 Ahead.	(14,069,024.63)	"
9	Omission of the modified vertical alignment on V.O No.7 and to follow the original contract design.	734,936.32	"
10	Re-alignment from km 94+765 to km 95+043 Back/95+033 Ahead.	(1,738,203.17)	"
11	Re-alignment from km 91+499.641 to km 91+662 Back/91+679 Ahead.	(761,496.55)	"
	Net Amount of Change Order of Project - P1	**(46,307,004.54)**	
12	Overall design revision in relation to the requirements of geometric design and re-alignment from 0+000 to 59+833.05	(71,181,738.38)	**P2**
13	Re-alignment from km 36+900 to km 38+433.06 to provide better access to Sholagebeya town	1,239,542.26	"
14	Mitigation works for the landslide prone and back slope eroded road sections.	5,675,696.50	"

	Net Amount of Change Order of Project – P2	**(64,266,499.62)**	
15	Overall design revision in relation to the requirements of geometric design.	(69,953,131.09)	**P3**
16	Re-alignment as a result of the height of the retaining wall constructed around station 100+859 of contract-2, Arerti-Gobensa road project.	1,234,431.74	"
	Net Amount of Change Order of Project – P3	**(68,718,699.35)**	
17	Alignment change from station 33+960 to 34+415.66 of the bridge to get a better foundation and to minimize the scouring effect in the long run.	5,163,196.98	**P4**
18	Pavement design changes from station 58+000 to 59+000 and 59+500 to 64+500.	2,743,189.14	"
19	Design change of longitudinal drainage structure to accommodate expected surface water that may flow to the project road from station 0+000 to 1+300	4,258,520.87	"
20	Replacement of type "A" houses and some of type "B" houses to type "C" houses.	(6,731,876.47)	"
21	Longitudinal drainage structure design change.	(280,740.70)	"
	Net Amount of Change Order of Project – P4	**5,161,076.68**	
22	Design change of kilometer posts	8,786.86	"
23	Additional type B houses for the Engineers facility	3,536,250.00	**P5**
24	Extension of town section (Hosaina Town)	22,950,435.75	"
25	Design Modification of Woredas' town	(457,380.00)	"
26	Additional cross drainage structures	2,250,306.00	"
	Net Amount of Change Order of Project – P5	**28,279,611.75**	
27	Additional Engineer's house construction	3,247,952.29	**P6**

28	Change of 600mm pipe to 900mm	804,788.40	"
29	Fireweyni town section modification	15,444,484.92	"
30	Edagahamus town section modification	5,781,128.60	"
31	Change of Radio to Mobile	(606,468.61)	"
32	Adigrat town section modification	43,045,254.11	"
33	Pavement design change	3,103,281.43	"
34	Modification of drainage structures	4,850,908.74	"
35	Modification of drainage structures	(97,632.92)	"
36	Fatse town section modification	10,584,428.36	"
37	Provision of approach road at Zalambessa town	78,001,430.49	"
38	Additional two bridge works	4,211,241.60	"
39	Fireweyni town additional works	4,166,246.57	"
40	Fatse town concrete cover for ditch	1,769,792.11	"
41	HIV/AIDS and Alleviation works	2,393,105.57	"
42	Concreting shoulder in Fatse town	1,137,252.96	"
43	Slab culvert construction from 64+995	1,449,123.34	"
44	Roundabout construction in Adigrat town	1,137,252.96	"
45	Omission of the last 226 m in Zalambessa town	(2,126,216.44)	"
46	Omission of grassing and landscaping	(8,081,343.85)	"
	Net Amount of Change Order of Project – P6	**170,216,010.63**	
47	Design modification of town section at Amba-ghiorgis, Dabat and Debark towns.	50,658,919.37	**P7**
48	Re-alignment of km 25	3,173,128.95	"
49	Provision of median at Ambaghiogis & Dabat towns	1,358,250.00	"
50	Design modification of Gondar town section	28,115,845.00	"
	Net Amount of Change Order of Project – P7	**83,306,143.32**	
51	Deletion of stretch from km (-)2+000 to km 0+000 from scope of the contract	(1,176,158.00)	**P8**

52	Change in Specification for providing Asphalt concrete in lieu of DBST	1,234,431.74	"
53	Due to missing item of power door lock and electrical winch in type "A" vehicle	(263,925.00)	"
54	Re-construction of pipe culvert at km 64+610	92,250.00	"
55	Reduction in thickness of capping layer	(2,404,610.76)	"
56	Increase in BOQ quantities of bridge over Sanja river at km 66+927	887,971.81	"
57	Re-construction of pipe culvert at km 57+127	47,912.52	"
58	Reduction in quantity of Crushed stone base course	(12,632,279.88)	"
	Net Amount of Change Order of Project – P8	**(14,214,407.57)**	
59	Reduction in quantity of primer coat MC-30 cut back bitumen at 1.1 liter per square meter	(1,384,600.00)	**P9**
60	Additional pipe culvert at km 105+510	27,010.74	"
61	Reconstruction of existing pipe culvert at km 79+823	62,292.52	"
62	Deletion of pipe culvert at km 43+772	(7,543.79)	"
63	Deletion of new pipe culvert at km 75+200	(33,322.81)	"
64	Deletion of new pipe culvert at km 33+280	(45,872.65)	"
65	25% increase in BOQ quantity for Bill No. 2.04 (Pay item No. 42.03 (cut and borrow to fill)	7,194,457.50	"
66	Change in quantity for Elastomeric bearings for bridges item No. 5.13	61,456.37	"
67	Drainage system and side walk/foot path in urban sections of Tikil Dingay, Sanja and Saroka	(5,119,648.91)	"
68	Re-construction of pipe culvert at km 34+435	45,136.66	"
69	Re-construction of pipe culvert at km 34+714	85,762.42	"
70	Re-construction of pipe culvert at km 81+240	31,174.04	"

71	Providing and placing of Tack Coat RC-70 cut back bitumen complying with AASHTO M81 or M82 and application as per ERA STS division 6200 and 6700 complete.	47,930.47	"
72	Construction of new pipe culvert at km 4+389	35,672.10	"
	Net Amount of Change Order of Project – P9	**1,426,821.67**	
73	Widening of Bekoji town section	2,888,957.72	**P10**
74	Provision of walkways in urban sections	5,711,383.08	"
75	Change of wearing course from Double Bitumen Surface Treatment(DBST) to Asphalt Concrete (AC)	66,019,090.00	"
76	Provision of additional slab culverts	1,737,552.20	"
77	Design modification of Assasa town section	1,452,000.66	"
78	Construction of safe structures in flood prone areas of Kubsa and Assasa Town	5,426,806.64	"
79	Removing and relaying of existing pipes	742,153.50	"
80	Provision of Vehicular access	14,635,196.30	"
81	Change of Single Surface Treatment(SST) to AC at towns for parking lanes	11,050,364.00	"
	Net Amount of Change Order of Project – P10	**109,663,504.10**	
82	Change of drainage type from 900mm pipe culvert to slab culvert	37,216.00	**P11**
83	Change in design alignment of the road section from km 8+500 to km 10+578.709 and also construction of retaining walls along the project route; redesign of Kola River Bridge.	(16,005,353.40)	"
84	Change in design alignment of the road section from km 25+300 to km 27+150 and from km 31+100 to km 32+625.213	96,141.85	"
85	Provision of medians in Aletawondo town section	(84,975.92)	"

86	Change in alignment of the road section from km 69+680 to km 70+240	491,785.62	"
87	Replacement of natural gravel sub-base material by crushed stone material for sub-base layer construction in Bore town	1,855,500.00	"
88	Change in alignment of the road section from km 30+640 to km 32+520	(335,193.33)	"
89	Change in alignment of the road section from km 18+660 to km 19+512	(79,557.00)	"
90	Blending of capping material with crushed aggregate for sub-base layer construction from km 0+000 to km 17+000	2,722,569.90	"
91	Provision of center median curbstone	6,959,520.00	"
	Net Amount of Change Order of Project – P11	**(4,342,346.28)**	
92	Horizontal & vertical alignment to improve the sharp curve and steep gradient from km 155+820 to km 156+940	175,233.26	**P12**
93	Replacement of 15 existing corroded steel pipes and one new pipe culvert at 16 different locations.	1,890,391.68	"
94	Horizontal & vertical alignment to improve the sharp hairpin bends and steep gradient from km 134+400 to km 138+600	6,183,363.26	"
95	Demolition of existing slab culvert and re-construction of new slab culvert at station 138+587	239,996.59	"
96	Construction of lined ditch type II in undercut section having a highly expansive soil and < 5% gradient from 121+000 to 160+000	806,520.00	"
97	Construction of stairway at high cut back slope location for local villagers at 35 different locations	1,110,148.07	"
98	Replacement of existing damaged steel pipe culvert by a new concrete pipe culvert at km 112+346.15	38,997.41	"

	Net Amount of Change Order of Project – P12	**10,444,650.27**	
99	Provision of curbed median at Kibremengist town from km 144+160 to 151+160	595,971.74	**P13**
100	Change of Vehicles & House Type "A" by Type "B"	(2,702,989.12)	"
101	Additional Vehicles & House Type "B"	1,416,730.31	"
102	Provision of retaining wall from km 42+440 to 42+720	(1,789,927.70)	"
103	Provision of retaining wall from km 42+020 to 42+240	(6,499,430.54)	"
104	Review of design at Bridges km 25+345 & 26+784	(690,346.85)	"
105	Provision of retaining wall from km 41+156 to 41+440 to 42+240	(566,882.37)	"
106	Review of design at Logita Bridge km 36+470	5,379,507.05	"
107	Review of design at Gelana Bridge km 33+904	692,836.24	"
108	Review of design at Bonewa Bridge km 49+672	5,049,614.37	"
109	Provision of retaining wall from km 38+640 to 38+760 to 38+800 & 49+520 to 49+600	811,240.25	"
110	Provision of hand laid rock embankment unit rate	1,441,176.26	"
111	Provision of retaining wall for back holding at Gelana Bridge approach & other protection works	5,358,877.64	"
112	Change of Road standard from DBST to AC	41,622,799.03	"
	Net Amount of Change Order of Project – P13	**50,119,176.31**	
113	Additional covered U-ditch & Parking lane at Gimbi town	5,624,602.97	**P14**
114	Change in culvert type and sub-base thickness	635,507.84	"
	Net Amount of Change Order of Project – P14	**6,260,110.81**	
115	(1)Change of type D drain to trapezoid precast concrete, (2) change of type A drain (3) tack coat variation	5,420,788.38	**P15**
116	Design change of Aleltu and Agar Bridges	25,000,000.00	"

	Net Amount of Change Order of Project – P15	**30,420,788.38**	
117	Change of type A Vehicles and Engineers office type A to type B	(3,001,763.21)	**P16**
118	For foundation investigation	518,224.96	"
	Net Amount of Change Order of Project – P16	**(2,483,538.25)**	
119	Change of type A Vehicles and Engineers office type A to type B	(5,234,678.00)	**P17**
120	Additional 13 bridges	43,597,330.27	"
121	Additional 5 bridges, 32 slab/box culverts and 121 pipe culverts	49,265,792.24	"
122	Additional Engineer's Housing Accommodations	1,439,028.00	"
123	Additional Engineer's Housing Accommodations	2,702,000.00	"
	Net Amount of Change Order of Project – P7	**91,769,472.51**	
	TOTAL AMOUNT OF CHANGE ORDER	**410,596,232.76**	

From *table-3*, it can be easily seen that a substantial amount change order occurs in those road construction project under the study. As it is depicted in *table – 2*, the total project cost of those projects under consideration was **8,143,451,307.55**. However, as a result of the total amount of change order, the total project cost increased by an amount of 410,596,232.76 birr. This amount is around five percent (5%) of the total sum of project cost of the projects under consideration.

Hence, the desk study has proved the existence of change order in the road construction project in Ethiopia to the extent that the causes and cost impact of change

orders on road construction projects in Ethiopia must be studied so that the stake holders in the construction industry be aware of the causes of change orders and their cost impact while managing the construction contracts.

4.3 Assessment of Major Causes of Change Order Categories

Though causes of change order are identified by the different researchers, as shown in the literature review, all of the stated causes might not represent the causes of change order in the case of road construction in Ethiopia. In this research, after careful review of the available literature, six major categories of causes of change order are selected to reduce redundancy of similar causes and to look for one which would reduce overlap when sorting data. One of the objectives of this research is to identify the causes which were resulting in change orders. Therefore, the following is a list of the major categories of causes of change order used in this research:

1. Design Errors and Omissions
2. Scope Change
3. Unforeseen Conditions
4. Value Engineering
5. Force Majeure
6. Others

Design Errors and Omissions - This cause relates to items that were omitted, improperly drawn or improperly coordinated by the design team. *Scope Change* - An owner directed scope change can occur due to unexpected needs, change of business, purpose of project, acquisition of more capital, or the depletion of expected available funds. *Unforeseen Conditions* - Unforeseen conditions are defined as conditions in the field that do not match the expected conditions. *Value Engineering* - substitution as a result of improved function or a reduced cost. *Force Majeure* -Time delays due to forces beyond the control of the contractor. *Others* – Other causes of change order includes those causes with indirect effect on the project.

Table – 4, Major categories of Change Order and Reasons of change

No	Major Categories of Change Order	Reasons of causes of change order
1	Design errors & Omission	• Replacement of materials or procedures • Change in specifications • Change in design • Design discrepancies • Conflicts between contract documents • Design complexity • Ambiguous design details • Inadequate working drawing detail
2	Change of scope	• Noncompliance of design with owner's requirements • Inadequate project objectives • Inadequate scope of work
3	Unforeseen conditions	• Unforeseen problems • Differing site condition • Increase /decrease in quantities • Right of way problems
4	Value Engineering	• Replacement of material and equipment • Change in economic conditions • Inflation
5	Force majeure	• Harsh weather Conditions • Natural disaster , etc.
6	Others	• Health and safety condition • Change in government regulations • Defective workmanship • Lack of skilled man power • Technology changes, etc.

Those reasons of change order depicted in *table – 3*, are grouped in to major categories of causes of change order along with their corresponding change order amount as shown in the *tables 5 (a) – (f).*

Table – 5 (a) Change orders due to Design Errors and Omissions

S/No	Reasons of Change Order	Change order Amount	Project

1	Re-alignment from km 83+008.922 to km 85+345.057 Back/88+003.497 Ahead.	(24,135,269.04)	P1
2	Re-grading from km 79+060 to 79+600.	75,990.40	"
3	Realignment from km 88+541.107 to km 89+216.98 Back/89+280.899 Ahead.	(3,274,904.04)	"
4	Re-alignment from km 94+065.923 to km 96+409.492 Back/96+393.625 Ahead.	(3,612,475.03)	"
5	Re-grading of the vertical alignment from km 100+100 to 100+860 (end of the project).	(734,936.32)	"
6	Re-alignment from km 94+390 to km 95+209.4 Back/95+200 Ahead.	1,672,315.14	"
7	Re-alignment from km 96+000 to km 98+446.216 Back/98+500 Ahead.	(14,069,024.63)	"
8	Omission of the modified vertical alignment on V.O No.7 and to follow the original contract design.	734,936.32	"
9	Re-alignment from km 94+765 to km 95+043 Back/95+033 Ahead.	(1,738,203.17)	"
10	Re-alignment from km 91+499.641 to km 91+662 Back/91+679 Ahead.	(761,496.55)	"
11	Overall design revision in relation to the requirements of geometric design and re-alignment from 0+000 to 59+833.05	(71,181,738.38)	P2
12	Re-alignment from km 36+900 to km 38+433.06 to provide better access to Shola-gebeya town	1,239,542.26	"
13	Overall design revision in relation to the requirements of geometric design.	(69,953,131.09)	P3
14	Re-alignment as a result of the height of the retaining wall constructed around station 100+859 of contract-2, Arerti - Gobensa road project.	1,234,431.74	"

15	Alignment change from station 33+960 to 34+415.66 of the bridge to get a better foundation and to minimize the scouring effect in the long run.	163,196.98	P4
16	Pavement design changes from station 58+000 to 59+000 and 59+500 to 64+500.	2,743,189.14	"
17	Design change of longitudinal drainage structure to accommodate expected surface water that may flow to the project road from station 0+000 to 1+300	4,258,520.87	"
18	Longitudinal drainage structure design change.	(280,740.70)	"
19	Design change of kilometer posts	8,786.86	"
20	Design Modification of Woredas' town	(457,380.00)	P5
21	Change of 600mm pipe to 900mm	804,788.40	P6
22	Fireweyni town section modification	15,444,484.92	"
23	Edagahamus town section modification	15,781,128.60	"
24	Adigrat town section modification	43,045,254.11	"
25	Pavement design change	3,103,281.43	"
26	Modification of drainage structures	4,850,908.74	"
27	Modification of drainage structures	(97,632.92)	"
28	Fatse town section modification	10,584,428.36	"
29	Provision of approach road at Zalambessa town	78,001,430.49	"
30	Omission of the last 226 m in Zalambessa town	(2,126,216.44)	"
31	Omission of grassing and landscaping	(8,081,343.85)	"
32	Design modification of town section at Amba-ghiorgis, Dabat and Debark towns.	50,658,919.37	P7
33	Re-alignment of km 25	3,173,128.95	"
34	Design modification of Gondar town section	28,115,845.00	"
35	Deletion of stretch from km (-)2+000 to km 0+000 from scope of the contract	(1,176,158.00)	P8
36	Reduction in thickness of capping layer	(2,404,610.76)	"
37	Widening of Bekoji town section	2,888,957.72	P9

38	Change of wearing course from Double Bitumen Surface Treatment(DBST) to Asphalt Concrete (AC)	66,019,090.00	"
39	Design modification of Assasa town section	1,452,000.66	"
40	Change of Single Surface Treatment(SST) to AC at towns for parking lanes	11,050,364.00	"
41	Change of drainage type from 900mm pipe culvert to slab culvert	37,216.00	P10
42	Change in design alignment of the road section from km 8+500 to km 10+578.709 and also construction of retaining walls along the project route; redesign of Kola River Bridge.	(16,005,353.40)	"
43	Change in design alignment of the road section from km 25+300 to km 27+150 and from km 31+100 to km 32+625.213	96,141.85	"
44	Change in alignment of the road section from km 69+680 to km 70+240	491,785.62	"
45	Change in alignment of the road section from km 30+640 to km 32+520	(335,193.33)	"
46	Change in alignment of the road section from km 18+660 to km 19+512	(79,557.00)	"
47	Horizontal & vertical alignment to improve the sharp curve and steep gradient from km 155+820 to km 156+940	175,233.26	P11
48	Horizontal & vertical alignment to improve the sharp hairpin bends and steep gradient from km 134+400 to km 138+600	6,183,363.26	"
49	Design change of Aleltu and Agar Bridges	25,000,000.00	14
NET AMOUNT DUE TO DESIGN ERRORS AND OMISSION		**158,583,295.80**	

Table – 5 (b) Change orders due Change of Scope

S/No	Reasons of Change Order	Change order Amount	Project
1	Additional type B houses for the Engineers facility	3,536,250.00	P5
2	Extension of town section (Hosaina Town)	22,950,435.75	"
3	Additional cross drainage structures	2,250,306.00	
4	Additional cross drainage structures	2,250,306.00	"
5	Additional two bridge works	4,211,241.60	P6
6	Fireweyni town additional works	4,166,246.57	"
7	Fatse town concrete cover for ditch	1,769,792.11	"
8	Concreting shoulder in Fatse town	1,137,252.96	"
9	Slab culvert construction from 64+995	1,449,123.34	"
10	Roundabout construction in Adigrat town	1,137,252.96	"
11	Provision of median at Ambaghiogis & Dabat towns	1,358,250.00	P7
12	Change in Specification for providing Asphalt concrete in lieu of DBST	1,234,431.74	"
13	Additional pipe culvert at km 105+510	27,010.74	P8
14	Construction of new pipe culvert at km 4+389	35,672.10	"
15	Provision of walkways in urban sections	5,711,383.08	"
16	Provision of additional slab culverts	1,737,552.20	"
17	Construction of safe structures in flood prone areas of Kubsa and Assasa Town	5,426,806.64	P9
18	Removing and relaying of existing pipes	742,153.50	"
19	Provision of medians in Aletawondo town section	(84,975.92)	P10
20	Replacement of natural gravel sub-base material by crushed stone material for sub-base layer construction in Bore town	1,855,500.00	"
21	Provision of center median curbstone	6,959,520.00	"
22	Construction of stairway at high cut back slope location		

	for local villagers at 35 different locations	1,110,148.07	P11
23	Provision of curbed median at Kibremengist town from km 144+160 to 151+160	595,971.74	"
24	Provision of retaining wall from km 42+440 to 42+720	(1,789,927.70)	P12
25	Provision of retaining wall from km 42+020 to 42+240	(6,499,430.54)	"
26	Provision of retaining wall from km 41+156 to 41+440 to 42+240	(566,882.37)	"
27	Provision of retaining wall from km 38+640 to 38+760 to 38+800 & 49+520 to 49+600	811,240.25	"
28	Provision of hand laid rock embankment unit rate	1,441,176.26	"
29	Provision of retaining wall for back holding at Gelana Bridge approach & other protection works	5,358,877.64	"
30	Change of Road standard from DBST to AC	41,622,799.03	"
31	Additional covered U-ditch & Parking lane at Gimbi town	5,624,602.97	P13
32	Change in culvert type and sub-base thickness	635,507.84	"
33	(1)Change of type D drain to trapezoid precast concrete, (2) change of type A drain (3) tack coat variation	5,420,788.38	P14
34	Additional 13 bridges	43,597,330.27	P17
35	Additional 5 bridges, 32 slab/box culverts and 121 pipe culverts	49,265,792.24	"
NET AMOUNT DUE TO CHANGE OF SCOPE		**215,255,073.71**	

Table – 5 (c) Change Orders due to Unforeseen Condition

S/No	Reasons of Change Order	Change order Amount	Project
1	Increase in BOQ quantities of bridge over Sanja river at km 66+927	887,971.81	P8
2	Reduction in quantity of Crushed stone base course	(12,632,279.88)	"
3	Reduction in quantity of primer coat MC-30 cut back bitumen at 1.1 liter per square meter	(1,384,600.00)	"

4	25% increase in BOQ quantity for Bill No. 2.04 (Pay item No. 42.03 (cut and borrow to fill)	7,194,457.50	"
5	Change in quantity for Elastomeric bearings for bridges item No. 5.13	61,456.37	"
6	Review of design at Bridges km 25+345 & 26+784	(690,346.85)	P12
7	Review of design at Logita Bridge km 36+470	5,379,507.05	"
8	Review of design at Gelana Bridge km 33+904	692,836.24	"
9	Review of design at Bonewa Bridge km 49+672	5,049,614.37	"
NET AMOUNT DUE TO UNFORESEEN CONDITIONS		**4,558,616.61**	

Table – 5(d) Change orders due to Value Engineering

S/No	Reasons of Change Order	Change order Amount	Project
1	Change of two type A houses to type B houses.	(463,937.62)	P1
2	Replacement of type "A" houses and some of type "B" houses to type "C" houses.	(6,731,876.47)	P4
3	Change of Radio to Mobile	(606,468.61)	"
4	Drainage system and side walk/foot path in urban sections of Tikil Dingay, Sanja and Saroka	(5,119,648.91)	P8
5	Change of Vehicles & House Type "A" by Type "B"	(2,702,989.12)	P12
6	Change of type A Vehicles and Engineers office type A to type B	(3,001,763.21)	P16
7	Change of type A Vehicles and Engineers office type A to type B	(5,234,678.00)	P17
NET AMOUNT DUE TO VALUE ENGINEERING		**(23,861,361.94)**	

Table – 5 (e) Change Orders due to Force majeure

S/No	Reasons of Change Order	Change order Amount	Project
1	Construction of lined ditch type II in undercut section having a highly expansive soil and < 5% gradient from 121+000 to 160+000	806,520.00	P11

NET AOUNT DUE TO FORCE MAJEUR	**806,520.00**	

Table – 5 (f) Change orders due to other causes

S/No	Reasons of Change Order	Change order Amount	Project
1	Additional Engineer's house construction	3,247,952.29	P6
2	HIV/AIDS and Alleviation works	2,393,105.57	"
3	Due to missing item of power door lock and electrical winch in type "A" vehicle	(263,925.00)	P8
4	Re-construction of pipe culvert at km 64+610	92,250.00	"
5	Re-construction of pipe culvert at km 57+127	47,912.52	"
6	Reconstruction of existing pipe culvert at km 79+823	62,292.52	"
7	Re-construction of pipe culvert at km 34+435	45,136.66	"
8	Re-construction of pipe culvert at km 34+714	85,762.42	"
9	Re-construction of pipe culvert at km 81+240	31,174.04	"
10	Providing and placing of Tack Coat RC-70 cut back bitumen complying with AASHTO M81 or M82 and application as per ERA STS division 6200 and 6700 complete.	47,930.47	"
11	Provision of Vehicular access	14,635,196.30	P9
12	Blending of capping material with crushed aggregate for sub-base layer construction from km 0+000 to km 17+000	2,722,569.90	"
13	Replacement of 15 existing corroded steel pipes and one new pipe culvert at 16 different locations.	1,890,391.68	P11
14	Demolition of existing slab culvert and re-construction of new slab culvert at station 138+587	239,996.59	"
15	Replacement of existing damaged steel pipe culvert by a new concrete pipe culvert at km 112+346.15	38,997.41	"
16	Additional Vehicles & House Type "B"	1,416,730.31	P12
17	For foundation investigation	518,224.96	P16
18	Additional Engineer's Housing Accommodations	1,439,028.00	P18

19	Additional Engineer's Housing Accommodations	2,702,000.00	P19
NET AMOUNT DUE TO OTHER CAUSES		31,392,726.64	

One of the key questions presented at the beginning of this research was, "***What are the causes of most contract changes in Ethiopian road construction projects?***" And as it was mentioned above, form seventeen projects about 123 change order records were analyzed to answer this question. Of the changes included in the study a review of the project record data showed that 40.8% were caused by design errors and omissions, 29% were change of scope by owner, 15.8% resulted from other causes, 7.5% were caused by unforeseen conditions. The rest were caused by value engineering and force majeure (*see table-6 below*).

Table – 6, Summary of Major Causes of Change order category by percent

No	Major Categories of Causes of Change order	Number of Change order	Total Change order (In %)
1	Design errors and omissions	49	40.8
2	Change of scope	35	29.3
3	Unforeseen conditions	9	7.5
4	Value Engineering	7	5.8
5	Force majeure	1	0.8
6	Others	19	15.8
	TOTAL	**123**	**100**

The causes of change order from the questionnaire survey are identified based on respondents' response on each change order category by the frequency of their occurrence during the construction period. The factors which are chosen by the respondents as causes of change order on road construction projects in Ethiopia are identified from the returned questionnaires based on the mean scores (MS) of the three groups of respondents, clients, consultants and contractors for each variables of change

order. In this research variables of change order which have a mean score of greater than 2 are taken as causes of change order; since a mean score of less than 2 means the respondents do not agree that the variable could be considered as a cause of change order.

Table - 7, Frequency of occurrence of Change order categories based on the responses of clients, consultants and contractors;

No.	Major Categories of Causes of Change Order	Mean Score (MS)			Weighted Average
		Employer	Consultant	Contractor	
1	Design errors and omissions	3.00	4.00	2.00	3.00
2	Change of scope	1.80	3.23	3.64	2.91
3	Unforeseen conditions	2.00	2.00	4.00	2.67
4	Value Engineering	2.00	2.00	2.73	2.24
5	Force majeure	1.50	1.00	2.00	1.50
6	Others	2.29	2.00	2.36	2.22

As we can observe from the weighted average column of *table – 7*, the major categories of causes of change order, in their descending order, are design errors and omissions, change of scope, unforeseen conditions, value engineering, others (*like administrative issues and the interests of third parties*) and force majeure. Due to the fact that, the reasons behind the occurrence of each change order are the results of some unfulfilled interests or needs of either of the contracting parties, during the implementation of the project ideas in to the ground, identifying the responsible party for each category of change order will give meaning to the research. Hence, the respondents once again asked to identify the contracting party which could be responsible in relation to each cause of change order category. The identification of responsible party is useful to understand who causes change order so that the liable party shall be accountable contractually.

The data gathered during the desk study regarding the reasons of change order proves that most of the change orders were the results of poor design and contract administration, which can be minimized before the implementation of project. As a

result, employers believe that if designs, specifications and contract documents were prepared correctly from the start, the rate of occurrence of change orders would have been minimal.

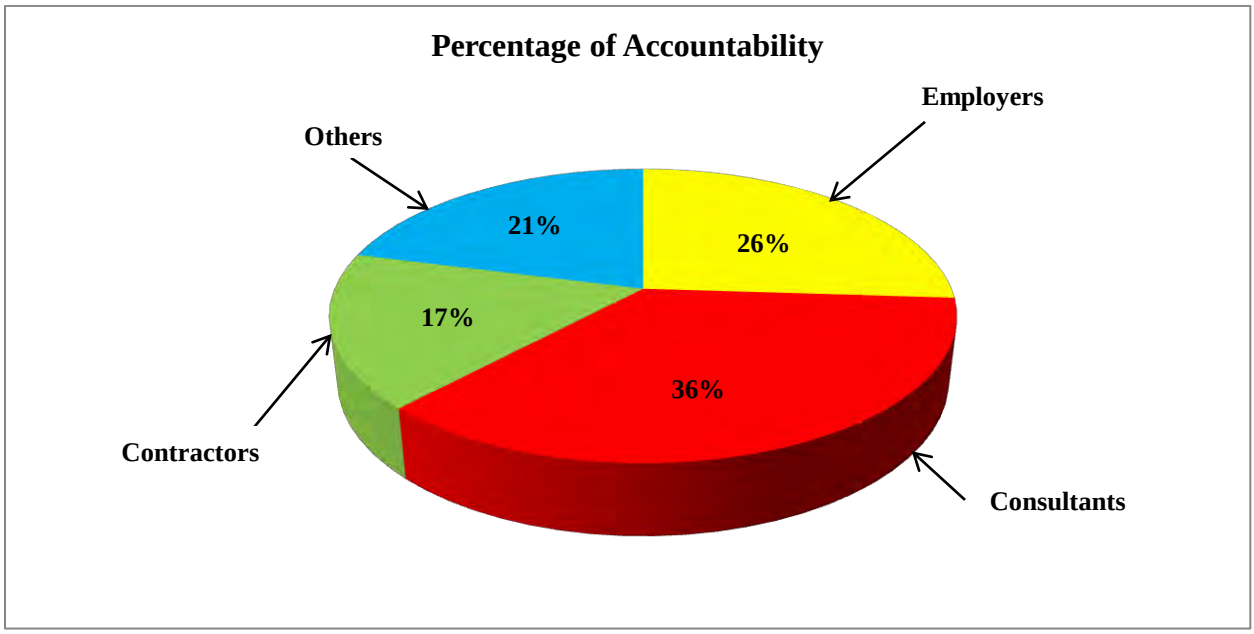
However, consultants on the other extreme blame that it is the employer that initiate changes orders due to their rarely satisfying demands. To make the research free of any biases, responsibility of each contracting party in causing the change orders was rated during the questionnaire survey and the accountable party was selected based on the maximum percentile on each change order category. The identification of the accountable party for causes of change orders is depicted in *Table – 8* below.

Table – 8, Percentage of Accountability for the cause of change order

No.	Categories of Change Order Causes	Percentage of Accountability (%)			
		Employer	Consultant	Contractor	Others
1	Design errors and omissions	18.42	76.38	5.26	-
2	Change of scope	65.79	18.42	10.53	5.26
3	Unforeseen conditions	5.26	57.89	13.16	23.68
4	Value Engineering	28.95	10.53	52.63	7.89
5	Force majeure	10.53	15.79	5.26	68.42
	AVERAGE RESPONSIBILITY (%)	**26**	**36**	**17**	**21**

For the question that inquired to identify which contracting party is accountable for the occurrence of each category of change order causes, the respondents give their responses to ascertain the liability of the contracting party relative to each category of change order cause. As a result, 76.38 percent of the respondents make consultants to be liable for the occurrence of most *design errors and omissions*. Regarding *change of scope*, the second category of causes of change order, 65.79 percent of the respondents agree that employers are accountable for the occurrence of most scope changes. The other three change order categories, *unforeseen conditions, value engineering and force majeure* are

also caused by consultants, contractors and other causes with accountability percentage of 57.89, 52.63 and 68.48 respectively. In a nut shell, when change order categories analyzed together, respondents assure that 36 percent of the changes are caused by consultants, 26 percent caused by employers, 21 percent by other causes and 17 percent by contractors.



The respondents were also asked to explain their reasons why they make each specific contracting party being accountable for the cause of each category of change order. And from the feedback given by the respondents, it is due to consultants' lack of required data, ambiguous design details, design discrepancies, conflict between contract documents; inadequate working drawing details etc. make consultants liable for the occurrence of change orders.

Employers are also blamed for having inadequate scope of work, inadequate project objective, frequent change of ideas, being delayed in resolving right-of-way issues. Regarding to the contribution of contractors to change orders is expressed in relation to financial shortages, lack of skilled man power, lack of knowledge of contract management, etc.

Apart from those parties mentioned above, other causes such as third parties, like utility agencies and governmental bodies are blamed for not cooperating with contracting parties when their cooperation is needed. In addition to these, inflation or increase in the cost of construction materials, change in foreign exchange rate are found to be caused by government related actions.

4.4 Assessment of Cost Impact of Change Orders

The second key question to be answered in this research was '***what kind of cost impact do the causes of change orders imply?***' To answer this question, the cost implication of each reasons of change order collected during the desk study are analyzed along with the questionnaire response given by respondents for questions designed to assess the cost impact of causes of change order.

From the desk study, the net amount of each category of causes of change order is analyzed as shown in *table-9* below.

Table – 9 Cost impacts of change orders and their total change order amount percentile

No	Categories of Causes of Change order	Cost impacts of Change orders		Total Change order Amount (In %)
		Positive *(Decrement)*	**Negative** *(Increment)*	
1	Design errors and omissions		158,583,295.80	38.6
2	Change of scope		215,255,073.71	52.4
3	Unforeseen conditions		4,558,616.61	1.2
4	Value Engineering	(23,861,361.94)		-
5	Force majeure		806,520.00	0.2
6	Others		31,392,726.64	7.6
TOTAL AMOUNT OF CHANGE ORDER		**(23,861,361.94)**	**410,596,232.76**	**100**
NET AMOUNT OF CHANGE ORDER		**386, 734,870.82**		

As shown in the above *table-9,* those causes of change included in value engineering have total change order amount of birr 23,861,361.94. This amount is a decrement of change order amount, the impact of those reasons of causes of change order categorized under value engineering would be considered as positive impact since they are savings to the employer. Whereas, except value engineering all other major categories of change orders have a total change order amount of birr 410,596,232.76; which is an incremental

cost impacts which are considered as expenses to the project owners. However, the combined impacts of all categories of change order shows an incremented (negative) impact of birr 386,734,870.82.

Therefore, when we look at the cost impact of value engineering from the desk study, we can conclude that, in this specific study, value engineering has a reduction cost impact in those road construction projects under consideration. However, the rest categories of causes of change order have incremental cost impacts.

This implies that the total project cost of those projects under consideration, which was birr 8,143,451,307.55, now increased by 5 percent to 8,530,186,178.37 birr. 52.4 percent of this increment is caused by *change of scope; design errors and omissions* share 38.6 percent, and *other causes* have 7.6 percent contribution. Though they are minor, 1.2 and 0.2 percent, the rest are contributed by *unforeseen conditions* and *force majeure* respectively in descending manner of their contribution.

Consequently, from the analysis of those categories of change order with respect to their accompanied change order amount we can observe that change of scope contribute huge share to the cost increment. The next greater cost increment was resulted due to design errors and omissions and the rest by other causes, unforeseen conditions and force measure in their descending order of contribution on the total cost increment.

In addition to the data gathered during the desk study about the consequential cost impacts due to change orders, questionnaire survey was also conducted to assess the cost impact of change orders from the respondents' perspective. During cost impact analysis, respondents were asked if change orders are one of the causes of dispute among the contracting parties. If so, they were also requested whether it is due to consequential cost impact. As a result, 82 percent of the respondents agreed that change orders, most of the time, are causes of dispute among contracting parties due to their accompanied cost impact.

From the respondents' response the mean score (MS) of the frequency of occurrence of cost impact due to each major category of causes of change order is analyzed as shown in the table – 10 below.

Table – 10, Mean Score (MS) of Cost Impact of Major Categories of Change Order causes

No.	Major Categories of Causes Change Order	Mean Score (MS)			Weighted Average
		Employer	Consultant	Contractor	
1	Design errors and omissions	2.70	2.23	3.45	**2.80**
2	Change of scope	2.07	2.15	2.91	**2.38**
3	Unforeseen conditions	2.36	2.00	2.36	**2.24**
4	Value Engineering	2.36	2.54	3.09	**2.66**
5	Force majeure	2.86	2.46	3.45	**2.92**
6	Others	-	-	-	-

As depicted on *Table – 10* above, the weighted average of the mean scores of the respondents show that *force majeure* was ranked first for its consequential incremental cost impact. This is so, because, respondents may understand the question from point of view of the catastrophic effects of force majeure. *Design errors and omissions* became the next category of causes of change order which can be accompanied by considerable cost impact. Value engineering is the third category of cause of change order for its cost impact when exists during the construction. The rest categories of causes of change order having undeniable cost impact are *change of scope* and *unforeseen conditions* in their descending order. *Other causes* did not be ranked by the respondents as a potential cost incurring causes of change order.

This questionnaire response regarding the cost impact contradicts the results obtained during the desk study, because during the desk study it was found that *the change of scope* contributes much to the total cost increment (*52.4 percent*) and other causes had considerable shares (*7.6 percent*) of the cost increment during the desk study. However, in the questionnaire survey, *the design errors and omission* being ranked higher for its

consequential cost impacts and *other causes* were not considered as potential cost incurring categories of change order.

However, both the desk study and the responses analyzed from the questionnaire survey show that design errors and omissions are major causes of change order categories having considerable amount of incremental cost impact.

In response to the question forwarded to respondents to identify the type of consequential cost impact occurred due to each cause of change order category, around *74 percent* of the respondents confirmed that these causes of change order bring an incremental or negative cost impacts.

At the end, a question that inquires "*which contracting party is most of the time being victim of the cost impacts and why?"* was asked and *87 percent* of the respondents gave their response as employers were victims of the cost impact. Whereas *13 percent* them consider that contractors are being victim of the cost impacts. Those respondents who assure that employers are victims of the cost impact justify their reason that employers incur considerable amount of money due to change orders which can at least be minimized if proper feasibility studies were prepared and actual site data are collected and analyzed before the implementation of the project. However, those respondents who chose contractors as being victim of the cost impact argue that when change orders occur, they are accompanied by rework, which deteriorates the workers efficiency, inflation, delayed procurement process and delayed payments etc.

Despite the above mentioned facts, cost impacts of change orders will be a source of conflict between the employers and the consultants. This is mainly due to the fact that employers are assumed as if they are non-professional and whose main responsibility is to initiate the project ideas so that the consultants, who are the professional staff, are expected to realize the employer's project ideas in to their material equivalent based on scientific analysis of data collected from the sites where the project is going to be implemented and manage the contract efficiently. However, the reality is not as expected that consultants, despite the employer's frequent change of ideas, became

sources of change orders due to their improper designs and inefficient contract management. This leads employers to unexpected additional project costs and project delays.

In a nut shell, cost impacts due to change order in Ethiopian road construction projects incurs extra budget, which is expected to be financed from the country's limited economy, which lead to budget deficits for construction projects. As a result, new projects that the government planned to promote and implement could either be extended other fiscal years' plan or canceled totally.

4.5 Test for Agreement

In this section, the degree of agreement or disagreement between the stake holders (*i.e. consultants vs contractors, consultants vs employers, and contractors vs employers*) on the variables of causes of change orders and their cost impact on road construction projects in Ethiopia is tested using Spearman rank correlation coefficient, ***ρ, rho***. The analysis here was done on the mean values for causes of change orders and the cost impacts. The purpose of a hypothesis test is to avoid being deceived by chance of occurrences.

The tests also helped to evaluate whether consensus of opinions exist among respondents.

The Null Hypothesis (H_o):

There is no agreement in the ranking of causes/cost impacts of change order between two groups of respondents.

The Alternative Hypothesis (H_A):

There is agreement in the ranking of causes/cost impacts of change order between two groups of respondents.

The Spearman correlation coefficient (ρ) is calculated using equation 3.2 and tabulated as shown in *table 11*.

In order to decide whether to accept or reject the null hypothesis the level of significance, 95% (P=0.05) is used. This allows to state whether or not there is *agreement* between respondents' opinion.

If the calculated value of ρ is greater than the critical value, **Ho** is rejected; i.e there is evidence of a statistically significant agreement between the groups. If the calculated value of ρ is less than the critical value, **Ho** is accepted; i.e there is no evidence of a statistically significant agreement between the groups.

Table – 11, Summary of correlation test on the ranking of variables of causes of change order based on chance of occurrence.

Groups	Respondents	ρ	Critical value	Significance for P<0.05	Accept/Reject The Null Hypothesis
1	Consultant Vs. Contractor	0.819	0.886	Non-Significant	Accept
2	Consultant Vs. Employer	0.903	0.886	Significant	Reject
3	Contractor Vs. Employer	0.812	0.886	Non-Significant	Accept
Average		**0.845**	**0.886**	**Non-Significant**	**Accepted**

In this case, with a significant level of 95% (P=0.05) the calculated values of the Spearman's correlation coefficient, ρ, for group-1 (*i.e. Consultant Vs. Contractor*) and group-3 (*i.e. Contractor Vs. Employer*) are less than the critical value**.** As a result, for these two groups the null hypothesis becomes accepted. This is due to the fact that there is no significant agreement between the two groups. However, the calculated values of ρ for group-2 (*i.e. Consultant Vs. Employer*) is greater than the critical value**.** Therefore, the null hypothesis is rejected; and hence we can conclude that there is agreement between the respondents.

From *table-11* it is observed that the average calculated values of Spearman's correlation coefficient, rho (ρ) is 0.845 which is less than the critical value of 0.886. This shows the absence of significant agreement between the attitudes of the respondents in all the three groups. In other words the correlation between the respondents attitude is relatively weak. This implies that most of the respondents have different perception on the frequency of occurrence of causes of change order.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The research set out to analyze the leading *causes and cost impact of change orders on Road construction Projects in Ethiopia*, with the objectives *to undertake thorough discussion on types of construction change orders, their causes and effects in general, to identify the specific*

causes of change orders and their consequential cost impact. A desk study and questionnaire surveys were used to identify the existence and extent of causes and cost impacts of change order on road construction projects in Ethiopia.

Based on this finding of the desk study and questionnaire surveys, the following conclusions are drawn:

1. The most common reasons of change order encountered during the construction of road projects in Ethiopia are categorized into the following major causes of change orders: *Design Errors and Omissions, Change of Scope, Unforeseen Conditions, Value Engineering, Force Majeure and Others.*
2. From the total change orders encountered 40.8 percent of the change orders were caused by *design errors and omissions*, 29 percent occurred due to *change of scope by owner*, 15.8 percent resulted from *other causes*, 7.5 percent were caused by *unforeseen conditions*. The rest were caused *by value engineering* and *force majeure*.
3. The frequency of occurrence of changes in Ethiopian road construction projects shows that *design errors and omissions* are the most frequent cause of change order followed by *change of scope*, *unforeseen conditions*, *value engineering*, *others* and *force majeure* respectively in their descending order of occurrence.
4. Of the three parties involved in the construction, 36 percent of the changes orders are caused by *consultants*, 26 percent caused by *employers*, 21 percent by *other causes* (third parties such as regulatory bodies) and 17 percent by contractors.

5. Regarding consequential cost impacts occurred due to the change orders, the desk study revealed that except *value engineering,* all other causes of change order categories have *incremental (negative)* associated cost impacts. Of the total incremental costs, 52.4 percent are caused by *change of scope;* 38.6 percent caused by *design errors and omissions*, and 7.6 percent by *other causes*. Though they are minor, 1.2 and 0.2 percent respectively, the rest are contributed by *unforeseen conditions* and *force majeure*.

However, the weighted averages of the mean scores of the questionnaire respondents show that *force majeure* was ranked first for its consequential incremental cost impact. *Design errors and omissions* became the next category of causes of change order which can be accompanied by considerable incremental cost impact. *Value engineering* is in the third level of category of cause of change order for its cost impact. The rest categories of causes of change order having undeniable cost impact are *change of scope* and *unforeseen conditions* in their descending order. *Other causes* did not ranked by the respondents as a potential cost incurring causes of change order.

This questionnaire response regarding the cost impact, except for *design errors and omission* contradicts the results obtained during the desk study. This contradiction could happen due the fact that the respondents may consider force majeure from its catastrophic effect.

However, both the desk study and the responses analyzed from the questionnaire survey show that *design errors and omissions* and *change of scope* are major causes of change order categories having considerable amount of incremental cost impact. From this fact, we can conclude that both project owners and consultants were accountable for the occurrence of most of the change orders on road construction projects in Ethiopia.

5.2 Recommendations

Forwarding recommendations was one of the objectives of the research. Therefore, based on the findings of the research, the following recommendations are made:

1. As a promoter of the projects, the employer (*such as the Ethiopian Roads Authority in the context of this research*), should undertake thorough and comprehensive project feasibility study before the implementation of the projects to their material equivalent. This would avoid the time and again change of project ideas by the employer. To help minimize such change of ideas, it is better if the

opinions of other stake holders are properly addressed. And once the project is started, the employer should stick to the very first of its project ideas as much as possible to avoid the scope changes that can be encountered at some point of the project's life.

2. Consultants should play their role, as per the expected disciplinary requirements, from the project inception to its implementation on the ground. This is so, because it is the consultant's responsibility to coordinate all sorts of information that can satisfy the employers' and other stake holders' interest. Hence, the consultant should do the following before the commencement of the project:
    - Collect actual and genuine field data during site investigation.
    - Make proper and holistic feasibility study that can accommodate different stake holders' interest.
    - Make a peer review on the feasibility study and collect professional opinion as an input during design. This would minimize change orders due to unforeseen conditions.
    - Make feasible design that can at least minimize future changes due to design errors and omissions.
    - Prepare clear, concise and comprehensive contract document which can accommodate changes and resolve disputes that can occur as a result of change orders.
3. As a key practical player of the construction industry, contractors are accustomed to different types of change orders. Therefore, contractors are recommended to:
    - Foresee changes that can be encountered during project implementation and make aware other parties on how they are going to be handled.
    - Avoid interests of extra profits that could be generated as a result of changes.

- Avoid adversarial relations, due to change orders, with contracting parties and try to solve issues related to changes amicably based on change order clauses on the contract document.

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Appendix B

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

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

	Level of significance for one tailed test			
	0.05	0.025	0.01	0.005
	Level of significance for two tailed test			
N (number of subjects)	0.10	0.05	0.02	0.01
5	0.900	1.000	1.000	-
6	0.829	0.886	0.943	1.000
7	0.714	0.786	0.893	0.920
8	0.643	0.738	0.833	0.881
9	0.600	0.683	0.783	0.833
10	0.564	0.648	0.746	0.794
12	0.506 0.456	0.591 0.544	0.712 0.645	0.777 0.715

14				
16	0.425	0.506	0.601	0.665
18	0.399	0.475	0.564	0.625
20	0.377	0.450	0.534	0.591
22	0.359	0.428	0.508	0.562
24	0.343	0.409	0.485	0.533
26	0.329	0.392	0.465	0.515
28	0.317	0.377	0.448	0.496
30	0.306	0.364	0.432	0.478

Note: when there is no exact number use the next lowest number.