



ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF CIVIL ENGINEERING

SCHOOL OF GRADUATE STUDIES

**IMPACTS OF CHANGE ORDERS
ON PUBLIC BUILDING PROJECTS IN DEBRE BIRHAN**

BY

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ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY
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Impacts of Change Order on public Buildings in Debre Birhan City

Declaration

I, the undersigned, declare that this thesis, entitled '*Impacts of Change Orders on Public Buildings in Debre Birhan City*', is my original work and it hasn't been presented for a masters or any other degree in this or any other university, and all sources of materials used for the thesis are duly acknowledged.

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March, 2017

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This thesis was conducted under my supervision and submitted to the graduate school for examination with my approval.

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Dedication

To my wife Lubaba Oumer, thank you for your restless effort in raising our smart kids lonely to enable me accomplish this thesis.

To my youngest babies Ahmed and Aba Bakr Ali, ‘welcome to this world and may you be better men than your dad and useful to your community’.

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List of abbreviations

1. **MoWUD**: Ministry of Works and Urban Development
2. **CO**: change order
3. **RII**: Relative Important Index
4. CII Construction Industry Institute
5. GCC: General Condition of Contract
6. CMS: Construction Management system
7. FIDIC Federation Internationale des Ingenieurs-Conseils: a French acronym interpreted in English as International Federation of Consulting Engineers
8. IPD Integrated Project Delivery
9. JBCC The Joint Building Contracts Committee
10. PPA Public Procurement Agency
11. PMBoK: Project Management Body of Knowledge

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Abstract

Change orders are almost inevitable in construction projects which are a result of the nature of the industry and uniqueness of the projects. Changes play significant role in determining the final cost and time of projects. In Ethiopian construction projects changes are used to occur frequently and in excessive magnitude. Construction projects in Debre Birhan are suffering from change orders in similar fashion with the other regions of Ethiopia. This research assessed the impacts of change orders on public building projects in Debre Birhan, Ethiopia. The objectives of the study were to identify the major causes of changes and their impacts on public building construction projects; and finally to recommend the controlling strategies to reduce changes. To accomplish those objectives literature review, desk study and questionnaire survey were conducted. By using literature review 40 suggested causes and 21 suggested impacts were identified. The questionnaire achieved 80.77% rate of return. The data was analysed by a Microsoft excel software package using Relative Importance Index (RII), and Spearman correlation coefficient as methods. The results were presented in tables. The results suggested that change/modification in design, change in specification, error & omission in design and differing site conditions were chosen as the most common causes of change order. Using RII of the cumulative frequency, the four most significant impacts of change orders were cost overrun, time overrun(delay of completion time), affection of project progress and increase in overhead cost.

Key words: change, change order, change management, project, cause, impact, control

1. Introduction

1.1. Background of the study

Webster's dictionary defines “change” in the construction industry as transformation or modification, a variation or deviation, the substitution of one thing for another and a replacement or substitution (Galloway, 2007).

In construction, change order is defined as "an action that specifies and justifies a change to the scope of a construction contract that alters the original time of completion or the project total cost, or both" (Mokbel, 2003).

The nature of the Construction Industry and the uniqueness of projects as well as disintegration of design and construction process, increase the probability of changes. Change refers to a deviation to the particular aspect of a project, including design and specification, schedule, cost, scope and so forth. Causes of changes are considerably different as projects are unique in nature and follows different impacts on projects and consequently the project management.

Changes in drawings and contract documents usually lead to change in the contract price and/or schedule. Changes also increase the possibility of contractual disputes. In general, changes present problems to all parties involved in the construction process. Changes are the major cause of project failure (Hallock, 2006).

In most construction project changes are generally inevitable (lbbs et al, 2001). Owner needs may change during design or construction phases due to market desire and business conditions or technological developments. These changes may alter the project variables like design and specifications. Design revisions may lead to design improvements or optimizations and accordingly effect project executions.

According to Hanna *et al* (2002), change “is any event that results in a modification of the original scope, execution time, or cost of work, happens on most projects due to uniqueness of each project and the limited resources of time and money available for planning.”

Change management means trying to handle a change effectively and efficiently. Effectively, meaning that the change and consequences are resolved. Efficiently, meaning that it is done at

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minimum costs and time delay. Change management seeks to forecast possible changes; identify changes that have already occurred; plan preventive measures; and coordinate changes across the entire project.

The causes of the change orders and their effects on the project cost and schedule are complex and influenced by numerous interrelated factors. Change management is a critical problem faced by the construction industry. It has been revealed that improving the administrative process of change orders is useful in reducing the cost and risk for all the project participants and encourages a more trustful relationship” (Mohamed et al, 2013)

As per Burati & Ledbetter (1992) and Love & Li (2000) errors and omissions in design documents or construction defects may impose a change. All of these factors and more others necessitate changes which are cost and time consuming and normally un-welcomed by all parties. Therefore in most cases changes can be considered as the main causes of time extensions, cost overruns and quality defects at various phases of a construction project.

According to Abdissa (2003) claims arise out of variation is the significant cause of construction claims in Ethiopia next to claims due to delay and disruption.

A change is an alteration to design, building work, project program or other project aspects caused by modifications to pre-existing conditions, assumptions or requirements(scope), budget or schedule (Ming & Xianhai, 2009).

Tewedros (2015) determined that inadequate design, error and omission in design and ambiguous design were the main causes of consultant originated variations while Right of way (access to site) problem, change of plans or scope and inadequate objectives were the main causes of client originated variations. According to him, in most situations variations have resulted in cost overrun, time overrun and disputes.

1.2. Statement of the problem

The construction industry in Ethiopia is rapidly growing sector. A number of construction projects are undergoing in various fields of civil engineering. Large and complex infrastructure

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projects including roads, buildings, railways, dams and stadiums have been building attracting contractors and construction companies from all over the country.

In most construction projects changes are generally inevitable, (William et al, 1995). Owner needs may change during design or construction phases due to market desire and business conditions or technological developments.

The most important causes of cost overrun in Ethiopian public building construction projects were found to be inflation or increase in the cost of construction materials, poor planning and coordination, change orders due to enhancement required by clients, excess quantity during construction (Fetene, 2008)

According to Abdissa (2003) claims arise out of variation are the significant causes of construction claims in Ethiopia next to claims due to delay and disruption. Changes are almost impossible to avoid, because even the most thoughtfully planned projects may necessitate changes due to various factors (Arain & Pheng, 2005). Therefore; one can conclude that change order occurs everywhere in most construction projects and follows big problems.

However studies showed the inevitability of changes in most construction projects, there are no available researches done on the place selected to this study. The majority of the researches are local and project based but projects are unique by nature. That is why the researcher of this study wants to do on this title and has his own contribution in the area.

1.3. Questions of the Research

This research is aimed to answer:

- What are the major causes of construction changes that are prevalent in public building projects?
- What are the significant impacts of changes in public building projects in Debre Birhan?

1.4. Purpose of the study

Studies conducted by the Construction Industry Institute, Thomas & Napolitan (1994), have shown that changes have considerable and serious impacts on projects that range from

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productivity to schedules. Therefore; to manage such impacts a deep knowledge of causes and impacts of changes is essential.

The purpose of this study is to identify causes of change orders and their impacts on project performances. Having the awareness of change causes and impacts will benefit to stakeholders in construction work in predicting and preparing a good plan of their projects.

1.5. General and specific objectives

2.1.1. General objective

- To assess the extent of change orders and identify the causes and impacts of change orders on public building projects.

2.1.2. Specific objectives

- To assess the extent of construction change orders in public building projects.
- To identify the major causes of change orders those are prevalent in public building projects.
- To investigate the main impacts of changes in building projects in Debre Birhan City Administration.
- To recommend ways to minimize causes of changes and their impacts based on the findings.

1.5. Significance of the study

The findings of this study will provide valuable and relevant information for all contracting parties regarding on change orders in the building construction projects in Debre Birhan City Administration. It will assist for project owners in Debre Birhan city administration and contractors contributing to understand changes identify the potential causes and effects of changes at design and construction stages to minimize and control variation orders and its consequential impacts. The study will also lay the foundation for further research on the subject matter.

1.6. Scope of the study

The research focuses on identifying causes and impacts of changes in public building projects found in Debre Birhan City. Data collection is limited to literature review based on research

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papers, books, websites, and reports; questionnaire survey, and also desk study. The desk study is limited to building projects in Debre Birhan City Administration.

1.7. Methodology and Procedure of the study

In this research both qualitative and quantitative data were used.

- Project contract documents including drawings, programme of works, bills of quantities, site meeting minutes and correspondence; and open ended questions were used as a qualitative method in the desk study.
- Both preliminary and full literature review was also conducted for collecting data.
A preliminary literature provided an understanding of the background and key concepts of the research study and the basis upon which the problem statement was formulated. The literature examined was compiled mainly from textbooks, journals, conference proceedings, theses and dissertations.
- Quantitative methods focus attention on measurements and amounts (more and less, larger and smaller, often and seldom, similar and different) of the characteristics displayed by the people and events that the researcher studies (Thomas, 2003). In this research closed-ended questions were used as a quantitative data.

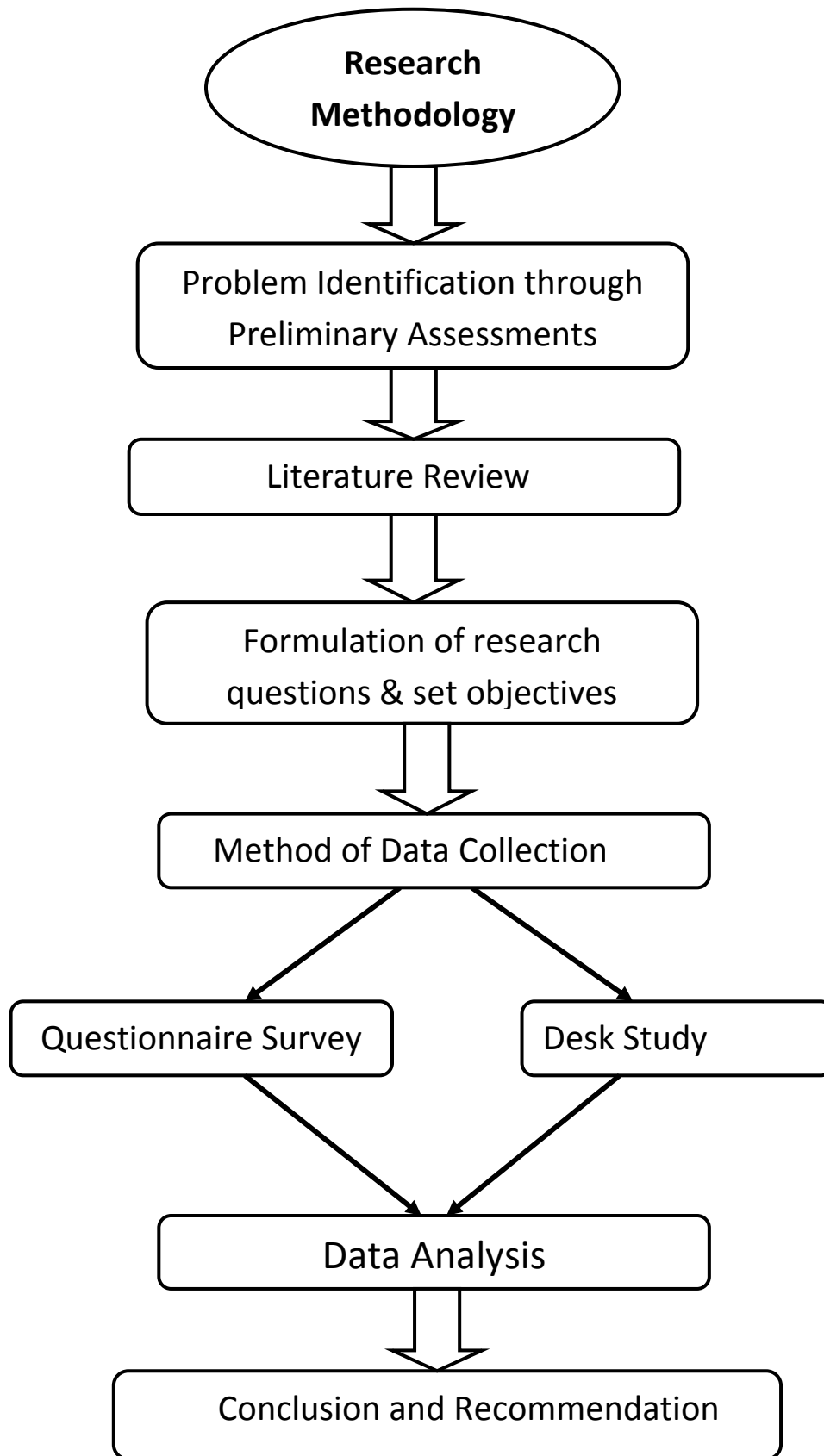


Figure 1: Flow chart diagram of research Methodology

Chapter Two

2. Literature Review

2.1. Introduction

An extensive literature review was performed to study the major factors causing change orders, impacts of change orders in public building construction projects and their controlling strategies.

2.1.3. Change Order Definition

A change is any kind of revision to or deviation from an agreed and well-defined scope and schedule of the project. Namely, change is any modification to the contractual documents and project characteristics provided to the contractor by the owner or owner's representative. This includes changes applied to designs, specifications, project location and organization.

Webster's dictionary defines "change" in the construction industry as transformation or modification, a variation or deviation, the substitution of one thing for another and a replacement or substitution (Galloway, 2007).

Ibbs *et al* (1995) declared that *"Change is normally defined as any event that results in a modification of the original scope, execution time, cost, and/or quality of work"*.

Another definition by Ibbs, (2005) explains that *"change defines as any variation to the original project scope. It can be physical (more units of work) or less tangible (change the reporting requirements or resequence the project schedule to accommodate an earlier opening)"*.

Sun & Ming (2009) declared that *"in construction projects, a change refers to an alteration to design, building work, project program or other project aspects caused by modifications to preexisting conditions, assumptions or requirements"*. As per Antill & Woodhead (1990), changes are alterations, variations, deductions, extras, or omissions of work.

Hanna *et al* (2002) stated that *"Change is defined as any event that results in a modification of the original scope, execution time, or cost of work"*.

In construction, change order is defined as "an action that specifies and justifies a change to the scope of a construction contract that alters the original time of completion or the project total cost, or both" (Mokbel, 2003).

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A change is any modification to the contractual guidance provided to the contractor by the owner, owner's agent, or design engineer (CII, 2000).

As per Lee (2001) change is any event, which results in a modification of the original scope, execution time or cost of work.

A Change Order is a written instrument prepared by the Architect and signed by the Owner, Contractor and Architect (Libor et al, 2003).

Any additions, deletions, or other revision to project goals and scope are considered to be changes, whether they increase or decrease the project cost, schedule or quality. Change can be the responsibility of any project involved party including the owner, contractor and consultant or a third party. Frequently, uncertainties, changing environment, insufficient and untimely communication, poor integration, and growing complexity of the project provoke the risk of change (Naoum, 1994). Variations are mostly inevitable in any construction project (Ibbs *et al*, 2001).

Therefore, in every construction project, a contingency value is usually assigned to consider the possible variations during the project lifecycle, by keeping the overall project cost fixed. Consequently, any regular form of construction contract provides a clear definition of change or variation with regards to specific actions and activities.

The process of change implementation in project is usually complying with the procedures stipulated in the contract; by means of change (variation) orders. A change order is a written order issued by the owner to the contractor after execution of the contract, approving a change in the work or a modification in the project cost or schedule (Clough & Sears, 1994).

2.2. Prevalence of change orders on construction projects

2.2.1. Introduction

A construction contract is a business agreement that is subjected to variability. Contractual clauses relating to changes allow parties involved in the contract to freely initiate variation orders within the ambit of the scope of the works without alteration of the original contract. Change orders involve additions, omissions, alterations and substitutions in terms of quality, quantity and schedule of works. Any minor change that the client or his/her architect wished to make later

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would mean that the contract had to be cancelled and a new one drawn up (Wainwright & Wood, 1983).

Under contractual provisions, the client has the right to vary the extent and the nature of the performance to be rendered by the contractor (Wainwright & Wood, 1983).

2.2.2. Pervasiveness of change orders on construction projects

Unfortunately, because construction projects involve complex operations which cannot be accurately determined in advance, variation orders occur. Arguably, variation orders cannot be avoided completely (Mohamed, 2001). Ssegawa *et al* (2002) asserted that the presence of variation clauses in contracts amounts to admitting that no project can be completed without changes. Even if carefully planned, it is likely that there will be changes to the scope of the contract as the work progresses (Harbans, 2003).

Hanna *et al* (2002) indicated that variations occur given the uniqueness of each project and the limited resources of time and money available for planning. Various authors intimate that variation orders are common to all types of projects (Thomas *et al*, 2002; Arain & Pheng, 2005a; Oladapo, 2007).

Ssegawa *et al* (2002) added that it is hardly possible to complete a construction project without changes to the plans or the construction process itself due to the complexity of construction activities. Variation orders occur due to a number of reasons ranging from finance, design, aesthetic, geological, weather conditions to feasibility of construction, statutory changes, product improvement, and discrepancies between contract documents. Further, the human behaviour of parties to the contract cannot be predicted. Variation orders may arise from changes in the minds of parties involved in the contract. Variation orders may be initiated either by clients or by contractors (Harbans, 2003). Most contracts these days must make provisions for possible variations given the nature of building construction (Finsen, 2005; Wainwright & Wood, 1983). A degree of change should be expected as it is difficult for clients to visualise the end product they procure (Love, 2002).

Unforeseen conditions may arise which require measures that have not been provided for in the contract (Finsen, 2005). However, the disadvantage of the variation clause is that architects tend not to crystallize their intentions on paper before the contract is signed. This is because they

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know the variation clause will permit them to finalize their intentions during the term of the contract (Wainwright & Wood, 1983).

Ashworth (2001) added that the advantage of the variation clause is that it allows the architect or other designers to delay making some decisions almost until the last possible moment.

An unfortunate aspect of the variation clause is that it tends to encourage clients to change their minds and embark on building projects without having properly thought through their project requirements (Finsen, 2005).

The construction industry does not grasp that the reduction of the occurrence of variability may optimally lower construction delivery costs. Ibbs (1997) concluded that the greater the amount of change the greater the negative impact on both productivity and cost. .

2.2.3. Classification of Changes

According to the basis and the purpose of classifications changes can be categorized in several ways. Changes in construction can be categorized based on the cause that forced them including design, construction technology, operability, external factors and so on. Ibbs et al, (1997) categorized the changes in five types; namely, “*change in scope*”, “*differing site conditions*”, “*delays*”, “*suspensions*”, and “*acceleration*”. As per Motawa et al. (2007) changes can be classified based on effect, need and time of occurrence and summarized as follows.

Table 2.1: Types of Changes

Bases of variation	Types of changes
Effect	Beneficial, neutral and detrimental(disruptive)
Need	Elective or required, discretionary or nondiscretionary, and preferential or regulatory
Time	Anticipated or emergent, proactive or reactive, and pre-fixity or post-fixity

In this paper the most common classifications of change orders are presented.

i. Beneficial Changes

“*Beneficial*” changes are those that really enhance project quality, reduce schedule, cost, or level of complexity in the project design or execution. A “*beneficial*” change reduces or eliminates inessential expenses from a project therefore; it optimizes the owner’s benefits against the project resource input. The “*beneficial*” changes not only provide a direct, immediate and

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positive effect, but they also can prepare the base and conditions for oncoming activities to be managed efficiently.

The project managers should encourage and support the “*beneficial*” changes. For instance, changes which derive from value engineering process can reduce project cost, schedule, or complexity, should be welcomed by the project team, since these changes benefit the project.

ii. Detrimental (Deleterious)

“*Detrimental*” changes are those that impose unfavorable or damaging impact to the project or decrease owner benefits (Arain & Pheng, 2005). Generally it depends on individuals prospective whether change can be considered as a conflict or a precious action. A change which is considered as “*beneficial*” change by a party might be considered as “*detrimental*” for the other one. But actually the changes should be assessed by their effects on the project not on parties to consider them as “*beneficial*” or “*detrimental*”.

However, “*detrimental*” changes should be minimized since they reduce owner benefit and impact the project negatively. Project managers must perceive that “*detrimental*” changes are not always considered as “*detrimental*” until problems occur. They may arise whenever there are not sufficient or adequate solution options to the problem they present. Obviously, the timing of a change usually defines if the change is “*detrimental*” or “*beneficial*”. A change caused in the early stages of a project may be beneficial, but the same change later in the project may raise the project schedule and cost overrun.

iii. Neutral Changes

These are changes which have no both negative and positive impacts on the performance of a project.

iv. Required and Elective Changes

Changes can also be categorized as “*required*” or “*elective*” changes. A “*required*” change is compulsory due to the limitations or acuteness of the problem and should be analyzed and processed in different way than an “*elective*” change. For instance variation on design to accord with a building code is a required change that should be executed urgently than other elective changes.

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On the other hand an “*elective*” change is in which there are several alternatives to modify the initial project objectives, resources, or schedule. An “*elective*” change must be authorized only if the advantages of that change significantly outbalance its expenses. In order to assess the elective changes a benefit-to-cost (B/C) ratio scale is utilized as a criteria for approving them.

v. Compensable, Excusable and Non-excusable Changes

Another type of change classification which is more frequent in construction contracts is based on the change compensation type named: “*compensable*”, “*excusable*” and “*non-excusable*” changes.

“*Compensable*” changes are those which usually are proposed by the owner or client in reply to their needs or required changes in project. For example changes of design by client due to market demand or variations of project safety consideration due to new codes and standards are all compensable.

“*Excusable*” changes are the changes which are not the client suggestions but they are proposed by the consultant in reply to technical problems or possible document errors which were the responsibility of the consultant to predict or foresee them. For instance the execution of structure for controlling the landslides is excusable change which would be paid to the contractor but there would not be any payment for consultant.

“*Non-excusable*” changes but are the changes completely in the responsibility of the contractor which would not be any payment for them. Construction errors or quality faults that lead to rework or demolition are examples of this kind of change. Since they are completely in the responsibility of contractor they would not be compensated.

vi. Controllable and Uncontrollable Changes

Changes can be grouped based on their controllability namely “*controllable*” and “*uncontrollable*”. “*Controllable*” changes are those which their cause sources are under the control of the contractor, like workmanship, labor productivity, clerical errors, material procurement, etc. These changes are extremely important because the contractors are usually the only responsible for them and cannot ask for extra funds for them. “*Uncontrollable*” changes include “*Change Causes*” over which the contractor has less or no effective control. Weather conditions, inflation, unforeseen ground conditions are of this type of changes.

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According to (Antill & Woodhead, 1990), delays as changes can be divided into four categories:

1. The changes over which neither party has any control
2. The changes over which the client or owner has control
3. The changes over which the consultant or designer has control
4. The changes over which the contractor or subcontractor has control

It is obvious that changes of type 1 are part of the contractor's legal financial risk, therefore, depending on contract clauses, might not be recompensed for any cost, but the project completion date should be extended to protect contractors from liquidated problems. On the other hand it is also acceptable that for changes of type 2 and 3 the contractor should receive reasonable recompense for cost or schedule overruns, whereas for type 4 changes the contractor must endure entire responsibility of cost and time overruns.

2.3. Change Orders and contractual provisions

Standard forms of contracts usually include a clause under which the employer or his representative is able to issue an instruction to the contractor to vary the works which are described in the contract. A change in scope, the introduction of different materials, revised timing and sequence are all usually provided for by the variations clause. It will also usually include a mechanism for evaluating the financial effect of the variation and there is normally provision for adjusting the completion date. In the absence of such a clause the employer will face a problem of varying to required works. The contractor could either refuse to carry out the work or undertake the work or insist up on payment on a quantum merit or fair valuation basis. Calculation of the price for the extra work applying this method could involve payment in excess of the contract rates.

There are different conditions of contract which are being used in the construction industry. The following are the widely used types of conditions of contract in Ethiopian construction industry.

- Ministry of Urban Development and Construction (MUDC),
- Public Procurement proclamation (PPA), and
- Federation Internationale Des Ingenieurs Conseils (FIDIC)

These contract conditions clearly define the duties and responsibilities of the parties involved in the contract and it describes the guidelines for contract administration, they consequentially alter

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variation of construction works unless and otherwise they are deleted or replaced by other words or sentences in the specific conditions of contract for a project.

2.3.1. General Conditions of Contract for Civil Works Project (MoWUD, 1994)

The following change order related clauses are given in the condition of contract for construction of civil works, prepared by Ministry of Urban Development and Construction (MoWUD, 1994):

Clause 51: Variations

According to this clause the engineer shall have the power to order the contractor to do and the contractor shall do any of the following:

- a. Increase or decrease the quantity of any work included in the contract,
- b. Omit any such work,
- c. Change the character or quality or kind of any such work,
- d. Change the levels, lines, position and dimensions of any part of the works, and
- e. Execute additional work of any kind necessary for the completion of the works and no such variation shall in any way vitiate or invalidate the contract, but the value, if any, of all such variations shall be taken into account in ascertaining the amount of the counteract price.

Clause 52: Valuation of variations

All extra or additional work done or work omitted by order of the engineer 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 extra or additional work then 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 shall, in his opinion, are reasonable and proper.

2.3.2. General Conditions of Contract for Civil Works (UNDP, 2000)

It is a condition of construction contract which was developed for United Nations Development Program (UNDP, 2000) projects. It described variation in the following clauses:

Clause 15a: The engineer may instruct the contractor, with the approval of the employer and by means of change orders, all variations in quantity or quality of the works, in whole or in part, that are deemed necessary by the engineer.

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Clause 48.1: The engineer may have the power to introduce any variations to the form, type or quality of the works or any part thereof which he considers necessary and he shall have power to order the contractor to do and the contractor shall do any of the following:

- a. increase or decrease the quantity of any work under the contract;
- b. omit any such work;
- c. change the character or quality or kind of any such work;
- d. change the levels, lines, positions and dimensions of any part of the works;
- e. execute additional work of any kind necessary for the completion of the works, and no such variation shall in any way vitiate or invalidate the contract.

For an increase cost of contract or altering the works due to variations according to this condition is stipulated under clause 48.2 as follows.

•**Clause 48.2:** The engineer shall, however, obtain the written approval of the employer before giving any order for any variations which may result in an increase of the contract price or in an essential alteration of the quantity, quality or character of the works.

•**Clause 48.3:** No variations shall be made by the contractor without an order in writing from the engineer. Variations requiring the written approval of the employer under clause 48.2 shall be made by the contractor only upon written order from the engineer accompanied by a copy of the employer's approval. It is provided that, subject to the provisions of the contract, no order in writing shall be required for any increase or decrease in the quantity of any work where such increase or decrease is not the result of an order given under this clause but is the result of the quantities exceeding or being less than those stated in the bill of quantities.

2.3.3. General Conditions of Contract for Procurement of Works (PPA, 2011)

As described in Public Procurement Agency (PPA, 2011) under clause 15 entitled with “Modifications by change orders” the following sub clauses describe about change order and related activities.

Sub Clause 15.1. The Engineer shall have power to order any modification to any part of the works necessary for the proper completion and /or functioning of the works. Such modifications may include additions, omissions and substitutions, changes in quality, quantity, form, character,

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kind, position, dimension, level or line and changes in the specified sequence, method or timing of execution of the works.

Sub Clause 15.2. All change orders shall be issued in writing, it being understood that:

- (a) If for any reason, the Engineer shall find it necessary to give an order orally, he shall as soon as possible thereafter confirm the order by any change order;
- (b) If the Contractor shall confirm in writing an oral order given for the purpose of GCC Clause 15.2 (a) and the confirmation shall not be contradicted in writing forthwith by the Engineer, any change order shall be deemed to have been issued for the modification.

Sub Clause 15.3. Except as provided by GCC Clause 15.2 prior to any change order for modification, the Engineer shall notify the Contractor of the nature and form of such modification. As soon as possible, after receiving such notice, the Contractor shall submit to the Engineer a proposal containing

- (a) Description of the tasks, if any, to be implemented or the measures to be taken and a program for execution; and*
- (b) Any necessary modifications to the program of implementation of tasks or to any of the Contractor's obligations under the contract; and any adjustment to the contract price in accordance with the rules as set out in this Clause.*

Sub Clauses 15.4. Following the receipt of the Contractor's submission referred to in GCC Clause 15.3, the Engineer shall, after due consultation with the Public Body and, where appropriate, the Contractor, decide as soon as possible whether or not the modification shall be carried out. If the Engineer decides that the modification shall be carried out he shall issue the change order stating that the modification shall be carried out at the prices and under the conditions given in the Contractor's submission referred to in GCC Clause 15.3 or as modified by the Engineer in accordance with GCC Clause 15.5.

Sub Clause 15.5. The prices for all modifications ordered by the Engineer in accordance with GCC Clause 15.2 and 15.4 shall be ascertained by the Engineer in accordance with the following principles:

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- (a) where work is of similar character and executed under similar conditions to work priced in the bill of quantities or price schedule it shall be valued at such rates and prices contained therein;*
- (b) where work is not of a similar character or is not executed under similar conditions, the rates and prices in the contract to be agreed through negotiation between the Engineer and the Contractor shall conform to the prevailing market price;*
- (c) if the nature or amount of any modification relative to the nature or amount of the whole of the contract or to any part thereof shall be such that in the opinion of the Engineer any rate or price contained in the contract for any item of work is by reason of such modification rendered unreasonable, then the Engineer shall fix such rate or price as in the circumstances he shall think reasonable and proper;*
- (d) where a modification is necessitated by default or breach of contract by the Contractor, any additional cost attributable to such modification shall be borne by the Contractor.*

Sub Clause 15.6. On receipt of the change order requesting the modification, the Contractor shall proceed to carry out the modification and be bound by these GCC in so doing as if such modification were stated in the contract. The works shall not be delayed pending the granting of any extension of time for completion or adjustment to the contract price. Where the order for a modification precedes the adjustment to the contract price, the Contractor shall keep

2.3.4. Conditions of Contract for Construction (FIDIC, 1999)

The FIDIC (1999) under clause 3.3, it stipulates that the engineer may issue to the contractor instructions and additional or modified drawings which may be necessary for the execution of the works and the remedying of any defects, all in accordance with the contract. But, not all instructions vary the contractual arrangements or the way the works are being undertaken. As stated under clause 13.1 of FIDIC (1999), variations may be initiated by the engineer at any time prior to issuing the taking-over certificate for the works, either by an instruction or by a request for the contractor to submit a proposal.

The contractor shall execute and be bound by each variation, unless the contractor promptly gives notice to the engineer stating (with supporting particulars) that the contractor cannot

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readily obtain the goods required for the variation. Upon receiving this notice, the Engineer shall cancel, confirm or vary the instruction.

According to FIDIC (1999) each change may include:

- a) Changes to the quantities of any item of work included in the contract (however, such changes do not necessarily constitute a variation).
- b) Changes to the quality and other characteristics of any item of works.
- c) Changes to the levels, positions and/or dimensions of any part of the works.
- d) Omission of any work unless it is to be carried out by others.
- e) Any additional work, plant, materials or services necessary for the permanent works, including any associated tests on completion, boreholes and other testing and exploratory work. or
- f) Changes to the sequence or timing of the execution of the works.

The FIDIC (1999), under clause 13.2 states that the contractor may, at any time, submit to the engineer a written proposal which (in the contractor's opinion) will, if adopted, (i) accelerate completion, (ii) reduce the cost to the employer of executing, maintaining or operating the works, (iii) improve the efficiency or value to the employer of the completed works, or (iv) otherwise be of benefit to the employer.

Under clause 13.3 of FIDIC (1999), it stipulates that if the engineer requests a proposal, prior to instructing a variation, the contractor shall respond in writing as soon as practicable, either by giving reasons why he cannot comply (if this is the case) or by submitting:

- a) description of the proposed work to be performed and a program for its execution
- b) contractor's proposal for any necessary modifications to the program according to the program stated and to the time for completion, and
- c) Contractor's proposal for evaluation of the variation.

The engineer shall, as soon as practicable after receiving such proposal, respond with approval, disapproval or comments. The contractor shall not delay any work whilst awaiting a response. Each instruction to execute a variation, with any requirements for the recording of costs, shall be issued by the engineer to the contractor, who shall acknowledge receipt.

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Each instruction to execute a variation, with any requirements for the recording of costs, shall be issued by the engineer to the contractor, who shall acknowledge receipt. Each variation shall be evaluated in accordance with clause 12 [Measurement and Evaluation: It states that the works shall be measured, and valued for payment], unless the engineer instructs or approves otherwise in accordance with this clause.

Even though the above contract conditions include the usual variations clause, there may be circumstances which could lead to additions or changes introduced by the employer which falls outside the variations clause. Contractors who find themselves with unattractive contract prices would find it to their advantage to be able to argue that a change introduced by the employer fell outside the variations clause thus leaving the way open to argue that payment for the change should be on a quantum merit or fair valuation basis. In the above different contractual provisions, all the contracts have stipulated the various methods by which the contractor will be reimbursed. The contracts have a specific procedure covering the process of handling variations to the work.

2.4. Change Orders and Project Delivery Systems

A project delivery system is a system designed to achieve the satisfactory completion of a construction project from conception to occupancy. A project delivery method may employ any one or more contracting formats to achieve the delivery.

Every owner responsible for the implementation of a construction project must make an early and important decision regarding the method by which the project will be designed and constructed (Odabasi *et al.*, 2003). Because of financial, organizational and time constraints, various project delivery methods have evolved to fit particular project and owner needs.

Methods that have gained in popularity include Design-Bid-Build (DBB), Design-Build (DB), and the latest, Integrated Project Delivery (IPD). Proponents of particular alternative methods advocate or promise improvements over the traditional system in terms of project schedule and cost control, and the number of disputes (Levy, 2006). The Integrated Project delivery method, although to date only used on a negligible number of projects, is included here due to interest in understanding the concept.

2.5. Causes of change orders

Any factor which leads to any kind of adjustment or variation in project initial specification, objectives, documents and scope as well as project characteristics is called change cause.

(Sun&Mengs, 2009) declares that “Causes of change are conditions or events that either directly trigger or contribute to a change in construction projects.”

Changes may arise in a project due to several reasons, including scope changes, design variations, or unpredictable conditions. Some causes of changes in construction projects are general and common causes like design errors or scope changes; however, some causes can be country-specific or project-specific causes for instance, material shortage, prices escalation and project complexity and technology.

Some changes can be originated by project participants, like contractor experience of similar work or poor financial resources of owner and etc. however, some causes of changes can be originated from parties from out of the project; like getting permission from municipality.

There are numerous reasons behind the changes in projects and they can be classified based on several factors. They may occur because of unknown ground, weather or site conditions as well as contractual discrepancies, administrative problems, varied market conditions and general demand and etc. All of these issues and many more cause to inevitable changes which are generally costly and undesirable by all project involved parties.

Change can occur from different sources (Motawa *et al.* 2007) and by various causes related to external, organisational and project environments (Sun and Meng, 2009). Change orders are usually issued to cover changes in the scope of work, material quantities, design errors, and unit rate changes. (Ismail *et al*, 2012) reported that 26 factors are responsible for change orders.

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Table 2. 1: Summary of causes of change orders (Ismail et al, 2012)

No	Group	Factors	References
1	Design errors	Errors Omissions Ambiguities Inconsistencies. Impossibilities. Change in design request. Design criteria changes. In adequate design. Change in design by consultant. Design complexity. Inadequate working drawing details. Inadequate shop drawing details. Consultants' lack of required data. Non compliance of design with owner's requirements. Change in specifications by consultant. Lack of contractor's involvement in design.	(County,2005;Liboret al, 2003;WSDOT,2007; Hallock,2006;Cor,1998). (Liboret al,2003;WSDOT, 2007;ArainandPheng,2005; Hallock,2006;Cor,1998). (Hunt,2005). (Hunt,2005). (Hunt,2005). (County,2005). (WSDOT,2007). (Arain,2005). (Arain, 2005; Arain and Pheng,2005). (ArainandPheng,2005). (ArainandPheng,2005). (Arainand Pheng, 2005). (Arain and Pheng, 2005). (ArainandPheng,2005).(Ara inandPheng,2005).

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2	Changes in market conditions	Specified item became unavailable. New products became available, cheaper, and more efficient. Substitution of materials or procedures.	(Hunt, 2005). (Hunt, 2005). (Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).
3	Scope and quantities of work	Significant changes in the quantities of work. Significant alteration of the work. Method of construction: Final measurements/calculations. Quantity changes to meet field conditions. Plan errors. Materials plan errors. Change of plans or scope by owner. Change in specifications by owner. Change in the owner's requirements (changes in scope). Owner, architect or contractor, contractor desire to improve his financial conditions.	(Ohio Department of Transportation, 1998). (Ohio Department of Transportation, 1998). (Ohio Department of Transportation, 1998). (Ohio Department of Transportation, 1998). (Ohio Department of Transportation, 1998). (Ohio Department of Transportation, 1998). (Ohio Department of Transportation, 1998). (Ohio Department of Transportation, 1998; WSDOT, 2007). (Arain, 2005; Arain and Pheng, 2005). (Arain, 2005; Arain and Pheng, 2005). (Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008). (Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).
3	Scope and quantities	Contractor financial difficulties. Additional or modified scope of work.	(Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

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	of work	Change of schedule by owner. Inadequate project objectives. Impediment in prompt decision making process. Obstinate nature of owner. Change in work sequence.	(Libor et al,2003). (Arain and Pheng, 2005). (Arain and Pheng, 2005). (Arain and Pheng, 2005). (Arain and Pheng, 2005). (Cor, 1998).
4	External conditions	Uncovering disclosed existing conditions. Uncovering unknown existing conditions. Strikes. Extreme weather condition. Material non- availability. Unforeseen site condition. Presence of field conditions not described in the bid.	(Hunt, 2005). (Hunt, 2005). (George, 1982). (George, 1982). (George, 1982). (George, 1982). (County, 2005).
5	Differing Site Conditions	Differing site conditions. Safety considerations. Differing subsurface conditions. Differ from conditions represented in the bid documents.	(Arain and Pheng, 2005). (Arain and Pheng, 2005). (Ohio Department of Transportation, 1998). (Libor et al, 2003).
6	Suggestion to initiate better	Suggestions to initiate faster. Suggestions to initiate more economical construction.	(Hunt, 2005). (Hunt, 2005).
6	Suggestion to initiate better	Value engineering.	(Al-Dubaisi, 2000), (Al-Jishi and Al-Marzoug, 2008; Mokbel, 2003).
7	Changes in	Non performance of a team member.	(Boot, 2005).

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	design preference	Delays in the project. Defective workmanship. Unavailability of skills. Unavailability of equipment. Poor procurement process. Long lead procurement.	(Boot, 2005). (Arain and Pheng, 2005). (Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008; Arain and Pheng, 2005). (Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008; Arain and Pheng, 2005). (Arain and Pheng, 2005). (Arain and Pheng, 2005).
8	Contract conditions	Contract conditions. Size of project. Magnitude of facility. Type of construction (new-renovation). Previous similar projects between owners and contractor. Type of contract. Owner project's budget. Consultant's lack of judgment and experience. Lack of consultant's knowledge of available materials. Honest wrong beliefs of consultant.	(Boot, 2005). (George, 1982). (George, 1982). (George, 1982). (George, 1982). (George, 1982). (George, 1982). (Arain and Pheng, 2005). (Arain and Pheng, 2005). (Arain and Pheng, 2005).
8	Contract conditions	Honest wrong beliefs of contractor. Equipment obstinate nature of consultant. Materially unbalanced Bid. Mathematically unbalanced Bid. Contractor's desired profitability.	(Arain and Pheng, 2005). (Arain and Pheng, 2005). (Manzo, 1998). (Manzo, 1998). (Arain and Pheng, 2005).

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		Contractor's obstinate nature. Lack of a specialized construction manager. Fast track construction. Contractor's lack of judgment and experience. Lack of strategic. Contractor's lack of required data.	(Arain and Pheng, 2005). (Arain and Pheng, 2005). (Arain and Pheng, 2005). (Arain and Pheng, 2005). (Arain and Pheng, 2005). (Arain and Pheng, 2005).
9	Actions by others	Utility companies. Regulatory agencies. Local governments. Allowed mark-up. A prevalent practice on this project and/or district. Emergency. Building codes/inspector.	(Ohio Department of Transportation, 1998; Libor et al, 2001). (Ohio Department of Transportation, 1998; Libor and Lewis, 2003). (Ohio Department of Transportation, 1998; Libor and Lewis, 2003). (QAR, 1998). (QAR, 1998). (QAR, 1998). (Hunt, 2005).

Source: Mohammad F. Al-Hams, Simulation Model of Change Orders and their Impact on Building Projects Performance in Gaza Strip, 2010, PP10-15

2.6. Responsible parties for the causes of change orders

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

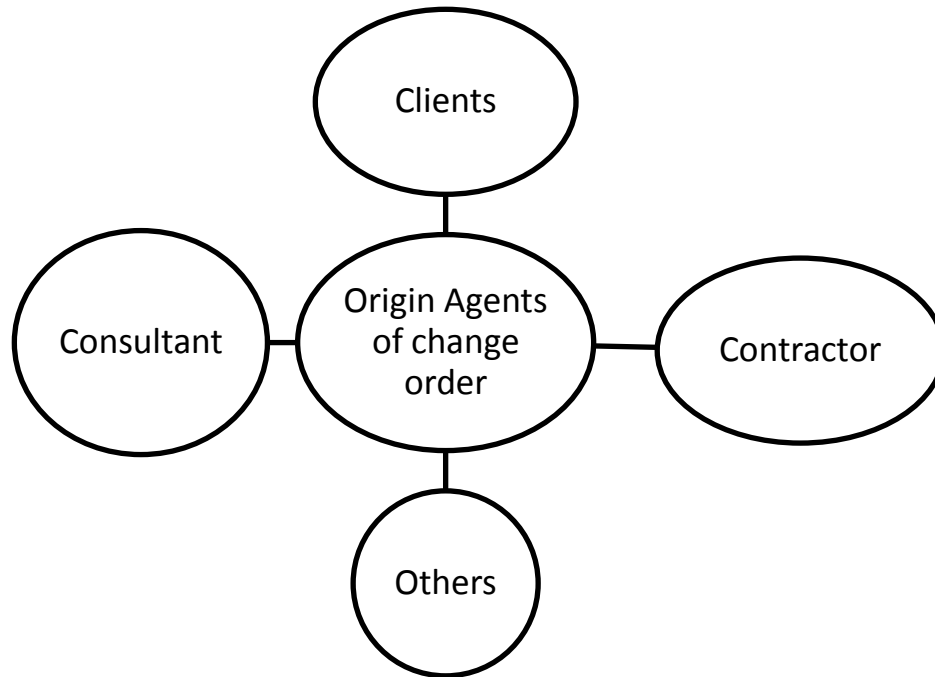


Fig 2.2: Responsible parties of change order

Source: Arain & Pheng (2006b)

2.6.1. Clients

The client as the project initiator plays a major role in the construction project from the inception to the completion phases. As a result, clients influence the likelihood of the occurrence of variation orders. Clients anticipate the needs and objectives of projects, establish the scope of works and the required quality standards. During the construction stage, clients initiate variation orders due to various reasons.

Uyun (2007) remarked that the principal reason for the client to initiate variation orders is a change in requirements, for example, rethinking of the needs or change of the use of the anticipated future utilisation of finished works. Clients are mainly classified under two categories: Clients who have the knowledge and experience of the construction industry and those without or with little experience. Clients with experience in construction are involved during the design stage by providing professional guidance to the design team. This participation

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may contribute to the avoidance of continuous changes during the construction stage. For example, public entity clients and private development companies have their own professional team responsible either for design or supervision of a commissioned designer. The technical input into the design by clients prevents them from fully relying on the designer, minimising the chance of them changing their mind during the construction stage. Clients without or with little knowledge in construction tend to follow the guidance of the designer without any clear idea that their requirements have been met.

Uyun (2007) remarked that it is sometimes very difficult to determine the exact requirements of the client. If the objectives of the project are inadequately defined, it is common that clients will tend to change their minds along the way. Clients struck with unexpected financial difficulties during the construction stage initiate changes in order to suite their conditions. Changes may include replacement of materials, change of design, scope and schedule of works. As a result, such changes lead to quality standard degradation and high maintenance cost.

2.6.2. Consultant

Nowadays, the complexity of modern projects, the emergence of new technologies and financial accountability demand a wide range of expertise from consultant team rather than a single body representing the client. The consultant team includes architects, designers, specialist engineers, project managers and cost consultants. Members of the consultant team have power to effect variation orders upon delegation by the client or on their behalf.

In case errors, omissions or discrepancies are found in the design or a conflict is discovered between the contract documents, it is the duty of the consultant to provide a remedial solution. A contractor who finds a problem to interpret ambiguous design details and inadequate working drawings notifies the concerned consultant as soon as possible. A contractor cannot proceed with work where ambiguous situations arise. A delay by a consultant in issuing a variation order may result in losses in terms of idle labour and plant while waiting for the consultant's decision. Acharya *et al* (2006) suggested that consultants should aim at getting an understanding of the overall scope and goals of the project, make sure they understand deliverables and offer specific suggestions when it makes sense. All has to be done relatively quickly without having any negative effect on productivity. Unfortunately, the feeling of superiority of the consultant over the contractor may hinder the consultant from giving attention to requests by the contractor.

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Acharya *et al* (2006) accused consultants of protecting their own interest at the expense of the interest of the client and the contractor.

Basically, the role of the consultant is to advise the client on technical, legal and financial matters. Where deemed necessary, it is common for the consultant to issue a variation order for improvement purposes. During the briefing stage, clients state their requirements and these constitute the basis for formulating contract documents.

Unfortunately, a failure by the consultant to interpret the requirements results in the design being different from the perceived one. As a consequence, variation orders will be issued to ensure compliance with the requirements for the client.

Technology change may influence a consultant to initiate variation orders. Zimmerman and Hart (1982) indicated that it is impossible to be knowledgeable of all new materials and products that are constantly entering the market. The designer may be unaware of affordable alternative materials for finishes. This can lead to variation orders when full information about the materials is available. However; Acharya *et al* (2006) insisted that when a new technology is applied, at the same time, it must be seen whether skilled people are available to convert the technology into the real work. Otherwise, improper application of the technology may lead to quality degradation or monetary losses.

Focusing more effort during the design phase would contribute greatly to the reduction of the occurrence of variation orders during the construction phase. Arain and Pheng (2005b) suggested the following:

- The involvement of the consultants in the design phase would assist in clarifying the project objectives and in identifying the non-compliance with their requirements at early stage. Eventually, this may help in eliminating the occurrence of variation orders arising from errors and design discrepancies during the construction stage where the impact of variation orders can be severe.
- The continuous coordination and direct communication would not only eliminate design discrepancies and errors as well omissions in the design, but also provide an opportunity for professionals to review the contract documents thoroughly that would help in eliminating the variation orders arising because of conflicts in contract documents.

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- The control of the frequent changes in design by consultant, and in adequate working drawing details would be through thorough detailing of the design.

This process will provide an opportunity for the consultant to review and finalize the design during the design phase. This would assist in reducing the variation occurrences during the construction phases where the impact of variation order can be severe.

2.6.3. Contractor

It is common for a contractor to be the origin agent of variation orders. Sweeney (1998) advised that on every project, participants should keep an eye on problems. All parties to the contract have to be aware that the information provided by the consultant is not always accurate. It is the contractor's responsibility to advise the consultant to issue a variation order when a technical problem is discovered. Levy (2002) indicated that general contractors or their subcontractors may discover an obvious discrepancy, omission, error, or conflict in the contract document and request that the architect reviews that problem, discuss the additional costs to correct the situation, agree on a price, and authorise the variation order. A contractor may propose alternative construction methods where his experience shows that the proposed technology will not fulfill the desired fitness and function of a design. A wrong assumption by the designer for a technical school building in Nepal resulted in roof leakage (Acharya *et al.*, 2006). The problem would have been avoided if the contractor had been experienced and was aware of possible adverse situations.

Change orders initiated following the default of the contractor are frowned upon by the client. Situations that give rise to default include defective workmanship, unfamiliarity with local conditions, poor management and lack of efficient communication. As a consequence, the contractor may not only suffer monetary loss but also damage to the reputation of the firm.

2.6.4. Others/Situations beyond control of parties to the contract

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

2.7. Impacts of change order

Changes in projects can cause substantial adjustment to the contract duration time, total direct and indirect cost, or both (Tiong 1990; Ibbs 1997; Ibbs et al. 1998). Delay in schedule, increase in project cost and disputes between owner and contractor are The most important effects of variation orders from the perspective of the employer, consultants and contractors (Research Journal of Applied Sciences, 2012).

The occurrence of variation orders has an adverse impact on project performance. Thomas *et al* (2002) suggested that variability generally impedes project performance. Ibbs (1997) concluded that variation orders affect project performance as they adversely affect productivity and project costs. Hanna et al (2002) also found that projects with many variation orders cause the contractor to achieve lower productivity levels than planned. Variation orders adversely impact project performance in terms of cost increment, time overruns, quality degradation, disputes and professional relations.

2.7.1. Project Cost increment

Cost overruns are unexpected increases to the project budgeted amount. According to Lee (2008) cost increment/cost overrun is defined as *the difference between the actual and estimated costs as a percentage of the estimated cost, with all costs calculated in constant prices; and actual and estimated costs can be defined as follows:*

1. *“Actual costs are defined as the accounted costs actually spent, as determined at the time of project completion.”*
2. *“Estimated costs are defined as the budgeted or forecasted costs at the time of project approval.”*

Most of the construction projects are exposed to the risk of cost overrun especially during construction phase due to the high range of financial turnover, numerous risk factors and uncertainties associated. Unfortunately, many construction projects incur cost overruns. However, all variation orders do not increase the costs of construction. Omissions in most cases reduce costs while additions increase costs (Ssegawa *et al*, 2002). Various studies have revealed that change orders contribute to these cost overruns. Arguably, the more the number of variation orders, the more they are likely to affect the overall construction delivery cost.

2.7.2. Time overruns

As per Arain & Pheng (2005) and Andualem (2014) completion schedule delay is a frequent result of variations in construction projects. It can be defined as the difference between the time used to complete the whole project and the estimated time to complete the project (Ibbs *et al*, 2003).

Several authors agree that variation orders present as one of the reasons for project time overruns (Chan & Yeong, 1995, Mohamed, 2001). It was found that change orders issued during various phases of construction projects negatively affected both the completion time and costs of projects (Koushki *et al*, 2005). Hanna *et al* (2002) found that as the number of variation orders increases the more significant productivity losses become. Productivity is the amount of output over a unit of time. Therefore, loss in productivity implies loss of time and subsequent delays. Yogeswaran *et al* (1997) classified delays into 'excusable' and 'non-excusable', where the former category relieves the contractor of liability for liquidated damages and the latter is due to the contractor's culpable delay.

2.7.3. Quality degradation

The quality of work was usually poor because of frequent changes which contractors tended to compensate for the losses (CII, 1995; Ndiokubwayo and Haupt, 2007). Quality may be compromised as contractors try to compensate for losses they are not optimistic about recovering.

2.7.4. Disputes among professionals

Like poor professional relations, disputes among professionals are also potential effects of frequent changes in construction projects. Disputes over change orders and claims are inevitable and the change clauses are often the source of project disputes (Arain and Pheng, 2005; Al Dubaisi, 2000).

(Harbans & Sri, 2003)warned that unless a mutually acceptable solution is agreed by the parties, valuation of variations in the form of variation orders will continue to remain at the forefront of disputes and claims making their way ultimately to arbitral tribunals or the corridors of justice. (Ssegawa *et al*, 2002) reported that more than one third of disputes pertained to how to determine losses that stem from variation orders.

2.7.5. Poor Professional relations

A construction project creates professional relationships between parties to the contract. Each project successfully completed constitutes an added experience to participants and their reputation builds up. The excessive occurrence of variation orders due to design errors or omission may undermine the professionalism of the designer. Change orders may affect professional relations, leading to disputes which must be resolved firstly through negotiation; then they may be resolved by litigation (Arain & Pheng, 2005).

2.7.6. Rework

Changes which are imposed when construction is underway or even completed usually lead to reworks (CII, 1990). Rework and demolition are potential effects of changes in construction, depending on the timing of the occurrence of the changes.

These effects are to be expected due to changes during the construction phase (Arain and Pheng, 2005; Al-Dubaisi, 2000; Al-Jishi and Al-Marzoug, 2008).

2.7.7. Delay in payment

Delay in payment occurred frequently due to changes in construction projects (CII, 1990). Changes may hinder the project progress, leading to delays in achieving the targeted milestones during construction (CII, 1995), which leads to delay in the payment to the contractors (Arain and Pheng, 2005).

2.7.8. Tarnish firm's reputation

Changes are referred to as a major source of construction claims and disputes. The claims and disputes may affect the firm's reputation adversely, leading to insolvency in severe cases. Changes also increase the possibility of professional disputes. Conventionally, changes present problems to all the parties involved in the construction process (Arain and Pheng, 2005).

2.7.9. Procurement delay

Variations which are imposed when construction is underway may require revised procurement requests (O'Brien, 1998). Procurement delays can be frequent due to variations that require new materials and specialized equipment. Hester *et al.* (1991) observed that procurement delays were common effects of variations related to new resources for construction projects.

2.8. Controls of Change Order and Change Management

All the risk factors must be managed efficiently in order to achieve a successful project in construction activities. Change as a risk factor in construction is not an exception in this case, since the great number of construction defects, cost overruns and schedule delays arise from the changes in projects. Changes are considered as one of the most critical factors in project success. Therefore managing the change in an effective way is significantly important. By managing the changes in project life cycle the existing change cases will be controlled efficiently and future changes will be minimized.

2.8.1. The Necessity of Change Control and Management

Changes orders can cause significant adjustments to the contract duration time, total cost, or both (Ibbs, 1997; Tiong, 1990 and Ibbs *et al.*, 1998). Therefore, project management teams need to have sufficient capabilities to handle the changes effectively in order to reduce the negative impacts on the project.

Since changes are frequent and normal in projects, it is advisable to understand that project managers encounter, embrace, adapt, and apply them to affect positively the events they face and to conceive changes as growth (C.Huntoon, 1998). Kartam (1996) has recommended that conflicts would be lessened when a problem has been studied and managed in early stages of the project, since the problems can be recognized and beneficial changes can be made.

Common project planning and management tools such as risk analysis can be applied to minimize the detrimental effects of change, since they give perceptions and predictions to identify potential and possible conflicts (Mallak *et al.*, 1996). Pinto & Kharbanda (1995) recommended that effective communication can bring about changes which can positively affect the project, since management team members can learn precious lessons from the conflict event.

Another approach which can be considered before the project commence is to contemplate through the project, utilize the tools previously explained and apply their results to prevent conflict. Development and execution of a project “*Change Management System*” prior to project initiation is an effective and positive action toward effectual management of changes. By implementing project “*Change Management System*”, project involved parties would be able to reduce deleterious changes and encourage beneficial changes. Project management teams should

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have the proper ability to identify potential impacts of changes; so that they can minimize their undesirable impacts on the project. Consequently, possible cost and schedule overruns in a project can be minimized when there is either a systematic approach to change efficiently or a systematic method to evaluate and compare the conflicts in corresponding projects.

Furthermore, decision making is an important issue that occurs during the project life cycle and is necessary in almost each phase of the project. Since, these decisions can usually affect the current or future tasks and events; they are significantly effective on project. In order to make the process of “decision-making” effective, project participants must have a general perception of other similar or related projects. This underlines the importance of having an effective communication and documentation system.

2.8.2. Change Control and Management Systems

Today the Harold Kerzner’s proposed proverb is accepted as a general law in construction industry that: *“If project content is allowed to change freely, the rate of change will exceed the rate of progress”*. This content is clear enough to the importance of the change control in projects. Because of the increasing competence in market, high range of construction cost and complexity of project risks, the utilization of change control and change management techniques to ensure the project success is inevitable.

Tiong (1990) carried out a research on a variety of required controls applied during all phases of a project including: *“design control”*, *“schedule and cost control”*, *“quality control”*, *“change order control”* and *“document control”*. He deduced that, in order to increase the project success and profitability, a comprehensive system for change order control should be established.

According to CII (1990) the following procedures will facilitate the process of change control:

1. The project objectives and owner needs should be specified early in the project and design scoping paper or the conceptual development should be clear enough. Related divisions in the owner’s organization should be consulted during the process of defining project objectives.
2. The owner must undertake to implement change control process in project. The owner may establish a change review committee including the owner’s representatives like Business Manager, Project Engineer, and Process Engineer to perform the owner’s

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commitment of reducing change effects. These individuals should be assigned early in the project, and the responsibilities and procedures made clear to all parties.

3. In order to encourage change recognition, reporting, and resolution, teamwork by the owner, engineer and contractor is required during the entire project lifecycle.
4. Freezing the design is an effective control method. Numerous owners freeze the design and terminate changes after drawings completion phase.
5. Each change must be justified from a cost viewpoint. Both direct and indirect cost effects of changes must be analyzed before approval for execution.
6. In order to prevent any delay in evaluation, approval, and execution of change, the expedient and efficient change procedures must be followed.
7. Owners should severely strive in the early stages of design development to lessen the possible changes during detailed design and construction phase.

“Project Management Body of Knowledge (PMBOK) Guide” defines the function of scope change as concerned with:

1. Influencing the factors which create scope changes to insure that changes are beneficial.
2. Determining that a change has occurred.
3. Managing the actual changes when and if they occur.

“PMBOK Guide” also suggests that *“scope change control must be thoroughly integrated with the other control processes (time control, cost control, quality control, and others)”*.

According to a systematic change control method, it is requisite to reflect all the approved changes in the project plan; as changes to the *“project scope”, “project cost and schedule”* and the *“project resource plan”*.

The main concept of any *“Change Management System”* is to predict, identify, assess, resolve, record, and learn from changes and conflicts in a way that support the overall project priorities. Learning from the faults and problems are important, since the project team members will be able to improve and implement their experience in future. By applying a systematic approach to deal with changes, the performance of project work and the chance of project success should increase.

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In spite of numerous academic research literatures and practical reports, there is a great lack of knowledge about systematic approaches for project change management. Hallock (2006) recommended three logics behind the lack of comprehensive and efficient effort for systematic change management:

- Most standard forms of contract in the construction and engineering industries do not include a provision for change management. If you asked many in the industry would point to the "Changes" provision of the contract and ask what more is required.
- The division of authority on projects has contributed to the problem. Who is going to take the lead; the Owner, the A/E or the Contractor? When one focuses on change as a risk, the assignment of responsibility may become clearer.
- The sheer volume of information on large projects, the duration, and multiple stakeholders has made it difficult to produce a comprehensive plan which fully defines the project requirements and manages the needs of all the stakeholders.

According to the standard of “*Project Management Body of Knowledge*” (PMBOK), the “*Integrated Change Control Process*” should be implemented from project commencement through completion. It is emphasized that change control is essential since projects rarely performed precisely according to the project plan and schedule.

The project management program and other project characteristics must be preserved by effective change managing which includes either rejecting or approving changes. Therefore if a change would be approved it should be incorporated into a revised baseline.

The “*Integrated Change Control Process*” includes the following change management procedures specifying the level of details through the project life cycle:

1. Identifying that a change must be occur or has occurred.
2. Influencing the factors that circumvent integrated change control to ensure that only authorized changes are executed.
3. Reviewing and approving the requested changes.
4. Managing the approved changes when they occur, by regulating the flow of requested changes.

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5. Maintaining the integrity of baselines by releasing only approved changes for incorporation into project products or services, and maintaining their related configuration and planning documentation.
6. Reviewing and approving all recommended corrective and preventive actions.

In 1994 the “*Construction Industry Institute*” (CII) established a “*Project Change Management Research Team*” to investigate a method to prevent or minimize the negative impacts of project change such as inflated costs, delays, claims, and litigations. They postulated that significant savings in project schedule and total execution cost are achievable in any construction project by improving the management of changes (C.P.C.M.R.Team, 1994).

Ibbs et al as a member of team William Ibbs (2001) recommended a comprehensive two-level process model for change management, with principles as the base, and management processes to apply these principles.

1. Level of starting principles
2. Level of management processes

The first level includes five principles:

1. Promote a balanced change culture
2. Recognize change
3. Evaluate change
4. Implement change and
5. Continuously improve from lessons learned.

Promote a Balanced Change Culture

“*Promote a balanced change culture*” is the first principle of “*Change Management System*” (CMS), in which the probable conflicts between team members will be minimized by promoting the group communication and documentation of the project objectives. Also the concept of “*beneficial*” and “*detrimental*” changes must be introduced to the project management team in order to establish a common perception about changes. Therefore, the project management team will be able to anticipate changes and prepare to handle them efficiently prior to change happens.

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➤ Recognize Change

The team members, through an efficient communication, are encouraged to develop discussions and to discover the potential changes. Early identification of changes will facilitate managing change more effectively and earlier in project life. After identification of possible changes, they should be assigned as “*required*” or “*elective*” changes. The project team should also determine the potential positive or negative effects of changes on project, and take action to reduce negative change.

➤ Evaluate Change

In this stage management team should evaluate the “*acceptability*” and “*implementation*” of proposed changes. In order to prevent the cost escalation due to delayed approval of change, the changes with high priority should be identified and prepare the financial resources for interim approval promptly. On the other hand, if the change is not decisive at that time, it should be considered more consciously to see whether it is necessary or not. The main reason for this reconsideration is to maximize the profitability of the project due to change and to minimize the negative impacts of change. Therefore, the unnecessary and inefficient changes should be screened in order to increase the profit.

The elective changes, which are not critical and mandatory, should be accepted only if the advantages of those changes significantly exceed their costs. The benefit-to-cost (B/C) ratio can be used as a guideline for authorizing of such elective changes.

The later changes in the project should have a higher level of (B/C) ratio than an earlier change; since there would be unexpected impact costs in association with late changes.

➤ Implement Change

The main purpose to have the “*Change Management System*” is to implement changes more efficiently. Therefore this stage is very important in the change management process. The most important issue during a change management process is that the approval of the changes should be authorized by the upper management. Before the change is authorized, all project parties which are affected by the change must be informed about it and then it should be granted. If the management has failed to foresee and communicate with other parties about pending changes, they will bring about other troubles and further changes. Change implementation should also be monitored. Monitoring implementation of changes is not only limited to monitoring the process

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of the implementation, but also solving the probable difficulties. The process of monitoring requires comprehensive documentation of a change to resolve disputed impacts later or to learn lessons from the change.

➤ **Continuously Improve from Lessons Learned**

The final stage of the “*Change Management System*” is to learn continuously from the faults which caused to changes. The key concept of this part is to define the main causes of change and to assess the errors which made them so the errors can be corrected in systematic way. These causes and errors should be discussed between team members to ensure that every person will have the opportunity to argue about and recognize the main causes of changes.

Giving the knowledge about the causes of change to project team members is very important and effective; because the experience of change management allows them to avoid similar faults and mistakes in the future.

2.8.3. Recommendations for Better Change Control and Management:

1. Most construction projects have changes during their lifecycle, therefore, managers should be prepared enough to handle and deal with them. In fact, the process of change management must be started before the project construction phase; since the impacts of defects during pre-construction phase affects the project execution negatively. Therefore the implementation of effective (CMS) during all project phases and even throughout the administrative processes is significantly important.
2. Since the responsibility of implementation of (CMS) is not limited to a specific project participant, so each project participant must exert it on his own territory.
3. A great number of changes are evitable and controllable which can be prevented formerly. For instance, if the project would be awarded to a capable contractor then the risk of “poor financial resource of contractor” would be minimized. Therefore some remedies should be applied by project involved parties in order to minimize the possibility of change occurrence or even the negative effects of changes. Thus the process of change management and control will be facilitated by preventative actions.
4. An effective communication and coordination between project participants and with external parties would help the management team to eliminate the changes arising due to conflicts during project lifecycle.

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Assaf & Al-Hejji (2006) recommended the following points to project participants in order to minimize negative impacts of changes in construction projects:

Owners should consider the following factors:

- Timely payments to the contractor
- Reducing the number of change orders during construction
- Reviewing and approving of design documents on time
- Scrutinizing and paying specific attention during project delivery phase
- Contractors should give special attention to following factors:
- Balancing the labor quantity in compatible with task amount
- Attempting to increase the productivity of labor
- Reducing the financial and cash flow problems
- Giving priority for planning and scheduling
- Efficient site management and supervision

Consultants should look to the following points:

- Reviewing and approving design documents on time
- Having a positive flexibility in responsibilities
- Considering the correspondence between the cost and quality

Finally; Architect/design engineer should focus on the following issues:

- Producing design documents on time
- Trying to lessen mistakes and discrepancies in design documents

Faisal *et al* (2005) also suggested recommendations based on the research and literature review as follows:

- The project professionals should be involved during the project design phase in order to reduce the probable changes due to errors, discrepancies and omissions during the construction phase.
- The effective coordination and communication between project team members should be established in order to help to reduce and eliminate the changes arising from project design as well as variations caused by contractual conflicts and discrepancies.
- The controlling of design and detailing of the drawings should be executed by the consultants carefully; in order to reduce the changes of design during the construction

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phase and also to provide the opportunity for reviewing and finalizing the design documents during the design stage.

- A brief project scope and objectives should be provided for the contractors and project team members in order to eliminate and reduce the changes arising from the unclear project scopes.

Chapter Three

3. Research Methodology

3.1. Introduction

This chapter outlines the research methodology and identifies the tools and techniques employed in a systematic data collection exercise. According to Walliman (2005) a plan of action must be developed that shows how the problems will be investigated, what information will be collected using which methods, and how this information will be analysed in order to arrive at conclusions and develop recommendations. Methodology describes the practical way in which the whole research project has been organised (Oliver, 2004). Research projects synthesize and analyse existing theory, ideas, and findings of other research, in seeking to answer a particular question or to provide new insights (Fellows & Liu, 1997).

Once the problem statement has been formulated, it should become evident what kind of data will be required to study the problem, and also what kind of analysis would be most appropriate to analyse the data (Walliman, 2005). The problems investigated in this study were causes and impacts of change orders on construction projects. It is anticipated that the identification of the causes of change orders may lead to their reduction, possible elimination and improvement in overall project performance.

3.2. Methodological approaches

The methods of collecting data affect the analyses which may be executed and subsequently, the results, conclusions, values and validity (Fellows & Liu, 1997). To improve the validity of the research findings, the triangulation approach was adopted for data gathering. This approach consists of combinations of qualitative and quantitative methods strengthened with the literature review.

3.2.1. Qualitative method

The qualitative approach seeks to gain insights and understanding people's perceptions of 'the world.' The beliefs, understandings, opinions, views of people are investigated (Fellows & Liu, 1997). Qualitative methods in this study seek to obtain the perception of construction industry

stakeholders i.e., clients, consultants and contractors, about the causes and impacts of change orders on public building projects.

i. Qualitative research as descriptive data

Qualitative research is descriptive and data include open-ended questions, interviews, field notes, memos, personal documents, internet materials, charts, maps, tables, diagrams and other official records (Neutens & Robinson, 2002; Blaxter *et al.*, 2001). In this research project contract documents including drawings, programme of works, bills of quantities, site meeting minutes and correspondence were used as a source of information.

ii. Qualitative research as descriptive data

Qualitative research is descriptive and data include interviews, field notes, memos, personal documents, questionnaires, internet materials, charts, maps, tables, diagrams and other official records (Neutens & Robinson, 2002; Blaxter *et al.*, 2001). In this research project, contract documents included drawings, programme of works, bills of quantities, site meeting minutes and correspondence were as a source of information.

3.2.2. Quantitative methods

Quantitative methods focus attention on measurements and amounts (more and less, larger and smaller, often and seldom, similar and different) of the characteristics displayed by the people and events that the researcher studies (Thomas, 2003). In this research closed-ended questions were used as a quantitative data.

3.3. Primary and Secondary data

3.3.1. Primary data

i. Pilot Study

Walliman (2005) advised that it is best to test a pilot study on peoples of a type similar to the intended sample, so as to anticipate any problem of comprehension or other source of confusion (Walliman, 2005). Prior to sending out the final questionnaire, a pre-test questionnaire or pilot study was conducted using a sample of MSc. students in Construction Technology and Management students at Adama Science and Technology University. 0949904289

ii. Questionnaire

A questionnaire enables a researcher to organize the questions and receive replies without actually having to talk to every respondent (Walliman, 2005). The questions are fixed and are the same for each respondent. All of the questionnaires were hand-delivered and responded in the presence of the researcher. This option might be time consuming but yielded a high response rate. Other questionnaires were sent by post where deemed necessary.

➤ Closed-ended questions

Respondents were restricted in the way they answered the questions as they were required to select one answer from among the given ones. Closed-ended questions, as they provide 'readymade' categories within which respondents reply to the questions asked by the researcher, help to ensure that the information needed by the researcher is obtained (Kumar, 2005).

➤ Open-ended questions

These are questions that seek to get the opinion of respondents. An open-ended question is a qualitative enquiry aiming at minimising the imposition of predetermined responses when gathering data whereby people can respond in their own words (Patton, 2002). (Kumar, 2005) indicated that open-ended questions provide a wealth of information provided respondents feel comfortable about expressing their opinions; provide the respondents an opportunity to express themselves freely resulting in a greater variety of information; virtually eliminate the possibility of the investigator's bias.

3.3.2. Secondary data

In this study a preliminary and full literature study were conducted. A preliminary literature provided an understanding of the background and key concepts of the research study and the basis upon which the problem statement was formulated.

A full literature review is part of the research process itself rather than part of the preparation for research. Such a literature review demonstrates that a researcher is knowledgeable of the area under investigation, shows how previous research studies support the current one and generate new research ideas through discovering what was left behind by others. The literature examined was compiled mainly from journals, conference proceedings, theses, text books and dissertations. According to Melville & Goddard (1996) these are the most reliable sources of information and are the most referenced in scientific reporting.

3.4. Population and Sampling

The population of the questionnaire is the group where the researcher is interested in. In this study the questionnaire survey were sent to all construction professionals from clients, contractors and consultants who participated during one of the phases of initiation, design and construction of public building projects. This research also addressed a population of all public buildings projects which were under execution in Debre Birhan city Administration starting from June 2002E.C. and with a financial progress greater than 20%.

3.5. Data analysis

Data analysis encompasses the compilation and interpretation of the data collected. Analysis will depend on the nature and form of the recorded data. Since the data has been recorded using qualitative and quantitative approaches, the analysis will be done accordingly. Whether it is qualitative or quantitative data, the main rule of any form of analysis is to move from raw data to meaningful understanding data (O'Leary, 2004).

3.5.1. Qualitative analysis

The analysis of qualitative data consists of abstracting all points that a researcher considers to be relevant to the topic from the raw data under investigation. Qualitative data is analysed thematically which include analysis of words, concepts, literary devices, and/or non-verbal cues (O'Leary, 2004). During the interview, especially a semi-structured one, interviewees are not always straight forward to the point. The researcher may have some few basic questions but often the conversation takes direction upon the response of the interviewee. In this research there were qualitative data gathered especially from the desk study.

3.5.2. Quantitative analysis

Descriptive analysis was done using the data gathered by close ended questions.

3.5.1.1. Descriptive

Descriptive statistics are used to describe and summarise the basic features of the data in a study, and are used to provide quantitative descriptions in a manageable and intelligible form (O'Leary, 2004). Descriptive statistics measure the central tendency (mode, median, mean); the dispersion (standard variation) will be adopted. In this case the following analyses were done:

A. The Relative Importance Index (RII)

The analysis included ranking the factors in terms of degree of important. In the computation of the relative importance index the following formula was used.

$$RII = \frac{N_1 + 2N_2 + 3N_3 + 4N_4 + 5N_5}{5(N_1 + N_2 + N_3 + N_4 + N_5)} \dots \dots \dots \text{Equation 3.1}$$

Where:

RII = Relative importance index

N1, N2, N3 = number of responding indices

B. The spearman's rank correlation coefficient

The correlation coefficient (*Rho*) evaluates the weakness or strength of a linear relationship between two variables. The value of (*Rho*) varies between +1 and -1. The closer the (*Rho*) value to 1, the stronger is the relationship between the two variables.

$$Rho(\rho_{cal}) = 1 - \frac{6 * (\sum d_i^2)}{N(N^2 - 1)} \dots \dots \dots \text{Equation 3.2}$$

Where:

Rho (ρ_{cal}) = Spearman's rank correlation coefficient

d_i = the difference in ranking between each pair of factors

N = number of factors (variables)

Spearman's correlation coefficient method was used herein to measure the relationship strength between the change order origin agents (i.e, client Vs contractor, client Vs consultant and contractor Vs consultant).

The responses was analysed using the Microsoft Excel software package. The analysis includes ranking the factors in terms of degree of effecting.

Chapter Four

4. Data Analysis and Discussion

4.1. Introduction

This Chapter examines and analyses the results of data gathered from desk study, interview and questionnaire survey which was distributed among professionals working in the public building construction projects found in Debre Birhan, Ethiopia.

This chapter consists of two major parts. The first part is related to the respondents' general profile and rate of response. The second part focuses on ranking and discussing the major causes of change orders, identifying the major origin agents, consequential impacts and proposed controls of change orders based on the opinions of the professional respondents from the Contracting parties i.e. the Consultant, Contractor and Client. Each ranking is made using relative importance index data analysis method based on the importance of frequencies of occurrence for the causes, origin agents, impacts and proposed controls of change orders to identify the most important factors in the public building construction projects of Debre Birhan town. Agreements of the respondents on the rankings of the causes, effects and controls of change orders, i.e. between contractor and consultant, between client and contractor, and between consultant and client were also tested using Spearman's correlation coefficient.

A desk study was also conducted for randomly selected completed and undergoing public building projects in Debre Birhan City. Documents surveyed include project progress reports, Contract documents, supplementary agreements, change orders, correspondence letters and other complementary documents. Based on the data collected, the total amount of change was compared to their corresponding original contract amount and time, also the number of change orders was identified with their corresponding reasons for the changes.

4.2. General information about the respondents and the questionnaire

The questionnaire involved both closed and open-ended questions and distributed to the respondents. Closed-ended questions were formulated such that respondents choose one option from a limited list of possible answers. Data was captured and analyzed using RII method of ranking. The open-ended questions allowed respondents to answer the same questions without

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restricting the manner in which they answered them. In this study no respondent answer any of the open-ended questions.

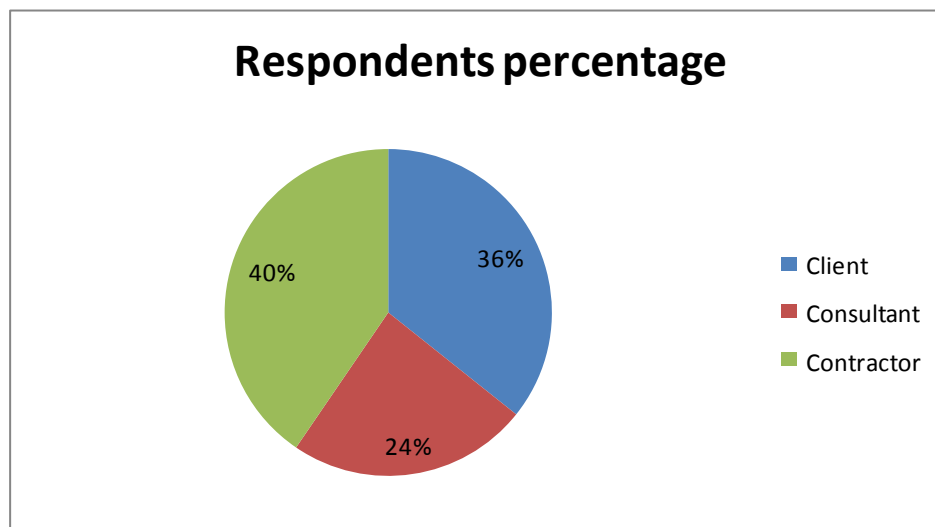
4.3. Questionnaire return rate

The respondents were grouped into three major groups namely client, consultant and contractor. The returns from the three groups are tabulated in **Table 4.1** below which shows an average response rate. Out of 52 respondents, only 42 (80.77%) of them completed and returned the questionnaire. Forty two questionnaires from 15 clients, 10 consulting engineers and 17 contractors were received. Table 4.1 below also shows the experience of respondents in building construction.

Table 4.1: Questionnaire return rate

Group	Number of distributed questionnaires	Number of returned questionnaires (Valid)	Response rate (%)
Client	17	15	82.24
Consultant	13	10	76.92
Contractor	20	17	85.00
Others	-	-	-
Total	51	42	82.35

Fig 4.1: involvement of participants



4.4. Respondents' experience

Proportions of the respondents in terms of number of years of involvement in building projects are tabulated in **Table 4.2**. As it can be observed the majority of the respondents from the clients, consultants and contractors are between five to ten years of experience.

Table 4.2 Respondents' Experience (Returned)

No	Experience in building project	No of respondents			
		Consultant	Contractor	Client	Others
1	Less than 5 years	2	4	5	-
2	From 5-10 years	6	8	8	-
3	From 10-15 years	2	5	2	-
4	16 and above years	-	-	-	-
5	Total	10	17	15	-

4.5. Findings from the questionnaires

In the questionnaires, the respondents were asked to rate the degree of contribution of the variables drawn from the literature review. Furthermore, the respondents were also asked to add other variables or factors that contributed to the causes, impacts and controls that they perceived as being necessary. The responses were analyzed using the Microsoft Excel software package.

The questionnaires distributed to the respondents consisted of forty two (40) causes, twenty two (22) impacts and twenty three (21) controls of change orders identified from the literatures.

The analysis was divided in to three points of views: the clients' point of view, the consultants' point of view and the contractors' point of view and a correlation test was done between each group. A ranking system using the Relative Importance Index (RII) method was calculated to find the most significant factor for each section. The value of RII ranges from 0.2 to 1 in which 0.2 represents least frequent whereas 1 represents highly frequent.

4.5.1. Causes of change orders on public buildings

4.5.1.1. Causes of change orders

The frequency of the causes of change orders were identified by using a 5 point Likhert scale, namely:

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- Never = 1;
- Seldom = 2;
- Sometimes = 3,
- Often = 4; and
- Always = 5

The causes of change orders were ranked by comparing their relative importance index values.

i. From Consultants' point of view

From Table 4.3 below, it was possible to rank the causes of change orders by comparing their RII values. According to the consultant's, change in specification was the most frequent cause of change order with RII of 0.780 followed by change/modification in design, errors and omissions in design and differing site conditions with RII value of 0.760, 0.740 and respectively. As per the consultants unavailability of equipment was ranked as the least frequent cause of change order with RI = 0.328 followed by health and safety conditions and fast track construction with RII value of 0.38 and 0.380 respectively.

Table 4.3 frequency of occurrence of causes of change order from consultants' point of view

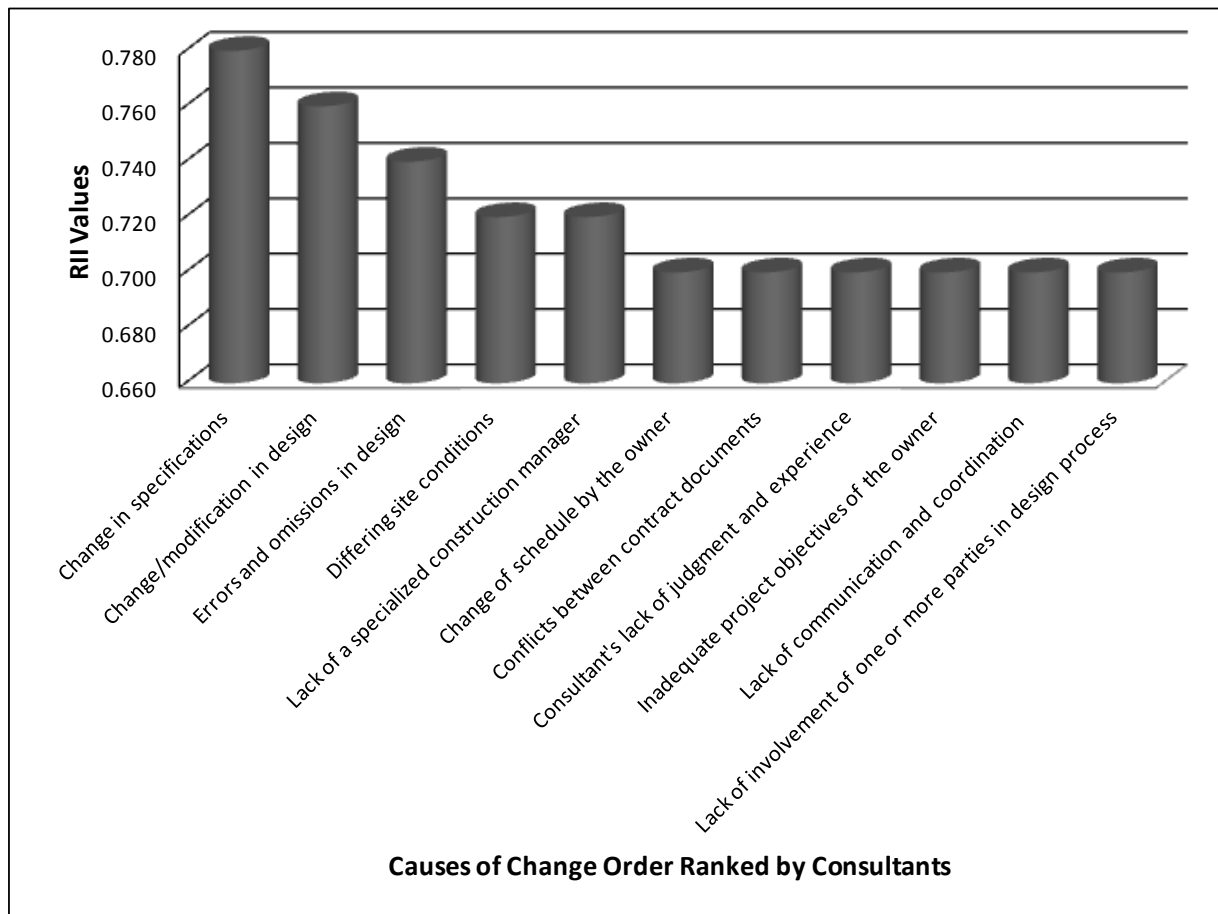
S.N	Causes of Change Order	RII	Rank
1	Change in specifications	0.780	1
2	Change/modification in design	0.760	2
3	Errors and omissions in design	0.740	3
4	Differing site conditions	0.720	4
5	Lack of a specialized construction manager	0.720	4
6	Change of schedule by the owner	0.700	6
7	Conflicts between contract documents	0.700	6
8	Consultant's lack of judgment and experience	0.700	6
9	Inadequate project objectives of the owner	0.700	6
10	Lack of communication and coordination	0.700	6
11	Lack of involvement of one or more parties in design process	0.700	6
12	Design complexity	0.680	12
13	Ill-defined scope of work to the contractor	0.680	12
14	Poor procurement process	0.680	12
15	Unavailability of skills (shortage of skilled labor)	0.680	12
16	Unclear design details	0.680	12
17	Contractor's desired profitability	0.660	17
18	Design discrepancies	0.660	17
19	Impediment in prompt decision making process	0.660	17
20	Unforeseen problems	0.660	17

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21	Defective workmanship	0.640	21
22	Value engineering /Improvement of design by the contractor in more economical way/	0.640	21
23	Change in government regulations	0.620	23
24	Owner's Financial problems	0.620	23
25	Speculation on desired profitability	0.620	23
26	Consultant's lack of required data	0.600	26
27	Contractor's lack of required data	0.600	26
28	Substitution of materials or procedures	0.600	26
29	Lack of knowledge of available materials and equipment	0.580	29
30	Logistics delay	0.580	29
31	Change in economic conditions	0.540	31
32	Land acquisition	0.540	31
33	Obstinate nature of one or more of the parties to the contract	0.540	31
34	Socio-cultural factors	0.520	34
35	Unfamiliarity with or unawareness of local conditions	0.520	34
36	Technological development/change	0.500	36
37	Contractor's financial problem	0.380	37
38	Fast track construction	0.380	37
39	Health and safety considerations	0.380	37
40	Unavailability of equipment	0.320	40

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Figure 4.2: Top eleven causes of change order ranked by consultants



ii. From clients point of view

As it can be observed from table 4.4 below change/modification in design, Errors and omissions in design, differing site conditions and lack change in specification were the most significant causes of change order with RII value of 0.787, 0.773, 0.733 and 0.720 respectively. However; healthy and safety conditions, unavailability of equipments and fast track construction were the list significant causes of change order as per the client's perception with RII value of 0.32, 0.40 and 0.400 respectively.

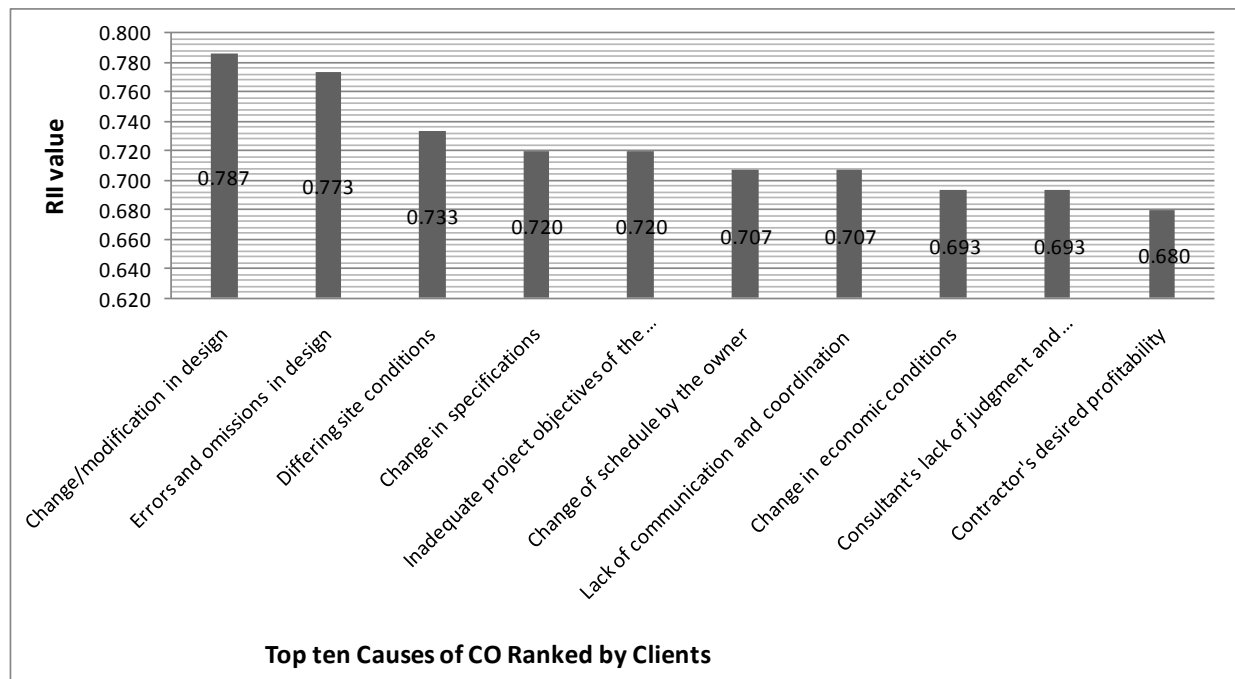
Table 4.4 frequency of occurrence of causes of change order from clients' point of view

S.N	Causes of Change Orders	RII	Rank
1	Change/modification in design	0.787	1
2	Errors and omissions in design	0.773	2
3	Differing site conditions	0.733	3
4	Change in specifications	0.720	4

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5	Inadequate project objectives of the owner	0.720	5
6	Change of schedule by the owner	0.707	6
7	Lack of communication and coordination	0.707	6
8	Change in economic conditions	0.693	8
9	Consultant's lack of judgment and experience	0.693	8
10	Contractor's desired profitability	0.680	10
11	Lack of a specialized construction manager	0.680	10
12	Unclear design details	0.680	10
13	Conflicts between contract documents	0.667	13
14	Unforeseen problems	0.667	13
15	Impediment in prompt decision making process	0.653	15
16	Owner's Financial problems	0.653	15
17	Poor procurement process	0.653	15
18	Unavailability of skills (shortage of skilled labor)	0.653	15
19	Ill defined scope of work to the contractor	0.640	19
20	Lack of involvement of one or more parties in design process	0.640	19
21	Speculation on desired profitability	0.640	19
22	Value engineering /Improvement of design by the contractor in more economical way/	0.640	19
23	Defective workmanship	0.627	23
24	Design discrepancies	0.627	23
25	Land acquisition	0.613	25
26	Unfamiliarity with or unawareness of local conditions	0.613	25
27	Consultant's lack of required data	0.600	27
28	Design complexity	0.600	27
29	Substitution of materials or procedures	0.600	27
30	Contractor's lack of required data	0.587	30
31	Obstinate nature of one or more of the parties to the contract	0.560	31
32	Logistics delay	0.533	32
33	Socio-cultural factors	0.533	32
34	Technological development/change	0.533	32
35	Contractor's financial problem	0.467	35
36	Lack of knowledge of available materials and equipment	0.427	35
37	Change in government regulations	0.400	37
38	Fast track construction	0.400	37
39	Unavailability of equipment	0.400	39
40	Health and safety considerations	0.320	40

Fig 4.3: Top ten causes of Change order ranked by clients



iii. From Contractors' Point of View

Change /modification in design, change specification and lack of specialized construction manager were the most frequent causes of change order on public building projects in Debre Birhan city as per contractors' point of view with RII value of 0.753, 0.741, and 0.729 respectively. As shown from table 4.5, health and safety considerations, unavailability of equipment and change in government regulation were the least frequent causes of change order with RII value of 0.341, 0.376 and 0.400 respectively.

Table 4.5 frequency of occurrence of causes of change order from contractors' point of view

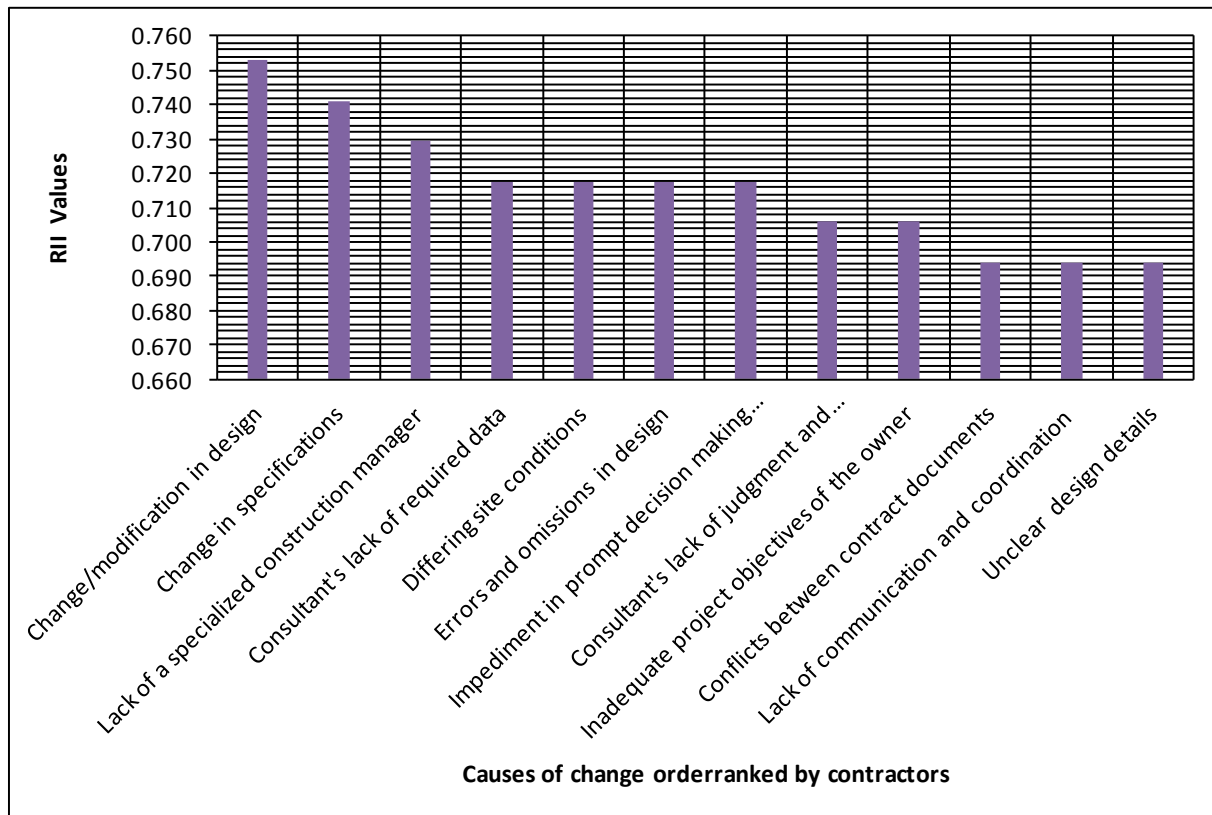
S.N	Causes of Change Orders	RII	Rank
1	Change/modification in design	0.753	1
2	Change in specifications	0.741	2
3	Lack of a specialized construction manager	0.729	3
4	Consultant's lack of required data	0.718	4
5	Differing site conditions	0.718	4
6	Errors and omissions in design	0.718	4
7	Impediment in prompt decision making process	0.718	4
8	Consultant's lack of judgment and experience	0.706	8
9	Inadequate project objectives of the owner	0.706	8
10	Conflicts between contract documents	0.694	10
11	Lack of communication and coordination	0.694	10
12	Unclear design details	0.694	10

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13	Design discrepancies	0.682	13
14	Lack of involvement of one or more parties in design process	0.659	14
15	Change of schedule by the owner	0.647	15
16	Defective workmanship	0.635	16
17	Poor procurement process	0.624	17
18	Unavailability of skills (shortage of skilled labor)	0.612	18
19	Unforeseen problems	0.612	18
20	Change in economic conditions	0.600	20
21	Design complexity	0.600	20
22	Ill-defined scope of work to the contractor	0.600	20
23	Owner's Financial problems	0.600	20
24	Speculation on desired profitability	0.576	24
25	Unfamiliarity with or unawareness of local conditions	0.565	25
26	Contractor's desired profitability	0.553	26
27	Land acquisition	0.541	27
28	Obstinate nature of one or more of the parties to the contract	0.541	27
29	Substitution of materials or procedures	0.541	27
30	Contractor's lack of required data	0.529	30
31	Contractor's financial problem	0.518	31
32	Value engineering /Improvement of design by the contractor in more economical way/	0.518	31
33	Logistics delay	0.506	33
34	Technological development/change	0.506	34
35	Socio-cultural factors	0.482	35
36	Fast track construction	0.424	36
37	Lack of knowledge of available materials and equipment	0.412	37
38	Change in government regulations	0.400	38
39	Unavailability of equipment	0.376	39
40	Health and safety considerations	0.341	40

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Figure 4.4: Causes of change order ranked by contractors



iv. Cumulative frequency of occurrence of causes of change order

From table 4.7 below one can conclude that respondents ranked change/modification in design, change in specification and errors and omissions in design as the most frequent cause of change order.

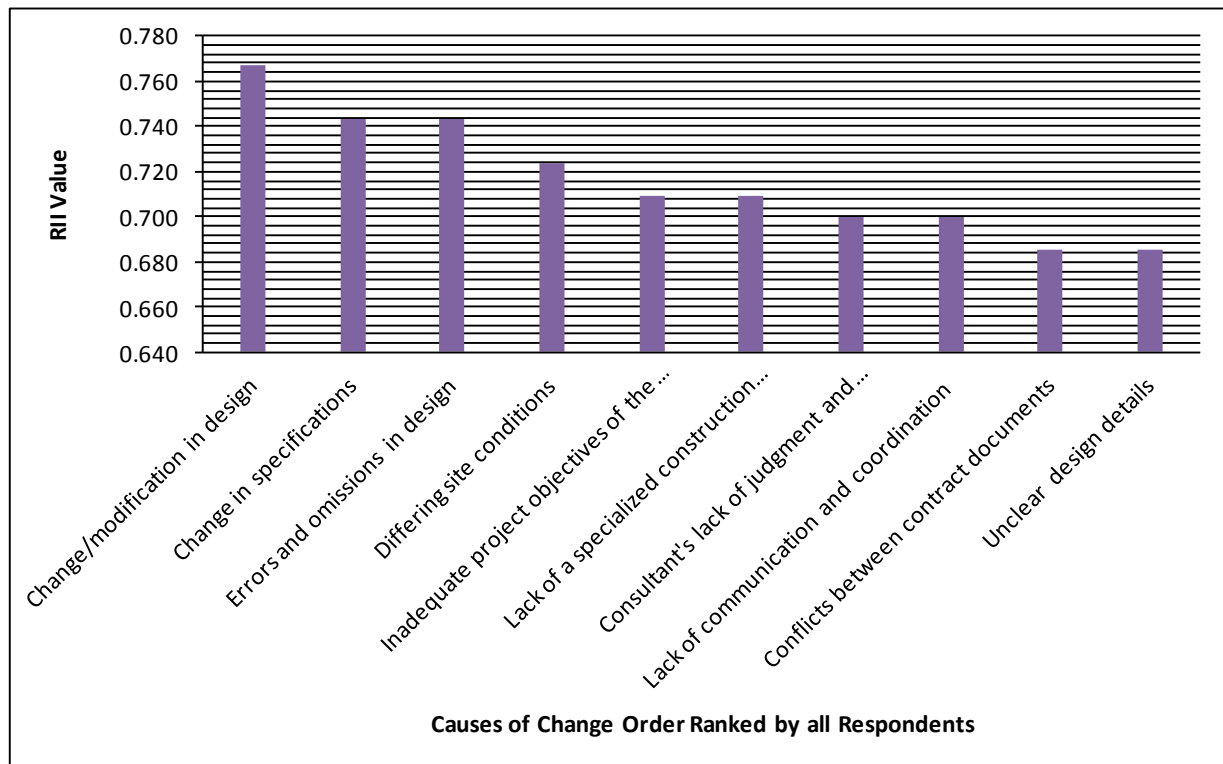
Table 4.6: Cumulative frequency of occurrence of causes of change orders, N = 40

S.N	Causes of Change Orders	RII	Rank
1	Change/modification in design	0.767	1
2	Change in specifications	0.743	2
3	Errors and omissions in design	0.743	2
4	Differing site conditions	0.724	4
5	Inadequate project objectives of the owner	0.710	5
6	Lack of a specialized construction manager	0.710	5
7	Consultant's lack of judgment and experience	0.700	7
8	Lack of communication and coordination	0.700	7
9	Conflicts between contract documents	0.686	9
10	Unclear design details	0.686	9
11	Change of schedule by the owner	0.681	11
12	Impediment in prompt decision making process	0.681	11

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13	Lack of involvement of one or more parties in design process	0.662	13
14	Design discrepancies	0.657	14
15	Consultant's lack of required data	0.648	15
16	Poor procurement process	0.648	15
17	Unavailability of skills (shortage of skilled labor)	0.643	17
18	Unforeseen problems	0.643	17
19	Defective workmanship	0.633	19
20	Ill-defined scope of work to the contractor	0.633	19
21	Contractor's desired profitability	0.624	21
22	Owner's Financial problems	0.624	21
23	Change in economic conditions	0.619	23
24	Design complexity	0.619	23
25	Speculation on desired profitability	0.610	25
26	Value engineering /Improvement of design by the contractor in more economical way/	0.590	26
27	Substitution of materials or procedures	0.576	27
28	Unfamiliarity with or unawareness of local conditions	0.571	28
29	Contractor's lack of required data	0.567	29
30	Land acquisition	0.567	30
21	Obstinate nature of one or more of the parties to the contract	0.548	31
32	Logistics delay	0.533	32
33	Technological development/change	0.514	33
34	Socio-cultural factors	0.510	34
35	Contractor's financial problem	0.467	35
36	Lack of knowledge of available materials and equipment	0.457	36
37	Change in government regulations	0.452	37
38	Fast track construction	0.405	38
39	Unavailability of equipment	0.371	39
40	Health and safety considerations	0.343	40

Fig 4.5: Top 8 causes of change Order Ranked by all groups of respondents



4.5.1.2. Correlation Test

Correlation test was done using equation 3.2 of the Spearman correlation coefficient test and tabulated as shown below in table 4.6. The summarized spearman correlation coefficient shows that there is a strong correlation between each of the three groups. This implies that most of the respondents have the similar perception about the causes of change orders.

Table 4.7: Summary of correlation test on the ranking of causes of change order

Respondents	$Rho(\rho_{cal}) = 1 - \frac{6 * (\sum di^2)}{N(N^2 - 1)}$	Relationship
Client Vs contractor	0.837	Strong
Client Vs Consultant	0.841	Strong
Contractor Vs Consultant	0.824	Strong

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3.5.3. Impacts of change orders

There were twenty two (22) impacts of change order identified from literatures and presented to respondents of client, consultant and contractor groups. The impact of change orders on public building projects was determined using a 5 point Likert scale, namely:

- No impact = 1;
- Low impact = 2;
- Medium impact = 3;
- High impact = 4; and
- Very high impact = 5.

The impacts of change orders were ranked by comparing their relative importance index.

3.5.4. Contractors group

The most frequent impacts for contractors group were time overrun; affect progress of a project and project cost overrun **RII** value of 0.882, 0.800 and 0.788 respectively. Time Reduction (completion before contract time), Degradation of health & safety conditions and Additional health & safety equipments & other needs with 0.541, 0.541 and 0.565 respectively were the least frequent impacts of CO.

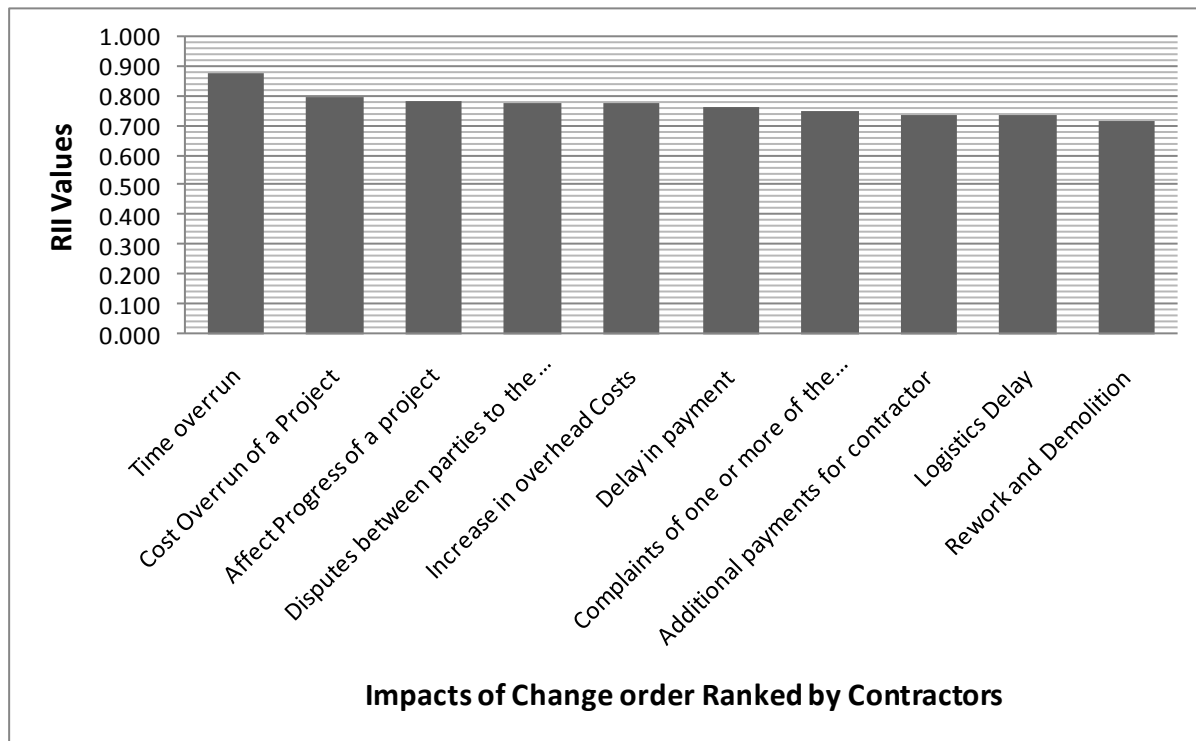
Table 4.8: frequency of impacts of change order from contractors group

S.N	Impacts of change orders	RII	Ranking
1	Time overrun	0.882	1
2	Affect Progress of a project	0.800	2
3	Cost Overrun of a Project	0.788	2
4	Disputes between parties to the contract	0.776	4
5	Increase in overhead Costs	0.776	4
6	Delay in payment	0.765	6
7	Complaints of one or more of the parties to the contact	0.753	7
8	Additional payments for contractor	0.741	8
9	Logistics Delay	0.741	8
10	Rework and Demolition	0.718	10
11	Additional specialist equipment/personnel	0.694	11
12	Productivity degradation	0.682	12
13	Poor professional relations	0.671	13
14	Procurement delay	0.671	13
15	Professional reputation of one or more parties adversely affected	0.624	15
16	Quality enhancement	0.612	16
17	Quality degradation	0.600	17

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18	Decrease firm's reputation	0.588	18
19	Cost Reduction	0.576	19
20	Additional health & safety equipments & other needs	0.565	20
21	Degradation of health & safety conditions	0.541	21
22	Time Reduction /completion before contract time/	0.541	21

Fig 4.6: Top ten Impacts of change order Ranked by Contractors Group



3.5.5. Consultants group

As shown in the table 4.11 below cost overrun, increase in overhead costs and time overrun were the most frequent impact of change order as per the perception of the consultants group with RII value of 0.800, 0.780 and 0.780 respectively. But time Reduction /completion before contract time, decrease firm's reputation and enhance quality were the least frequent impacts in the ranking with RII value of 0.400, 0.400, and 0.418 respectively.

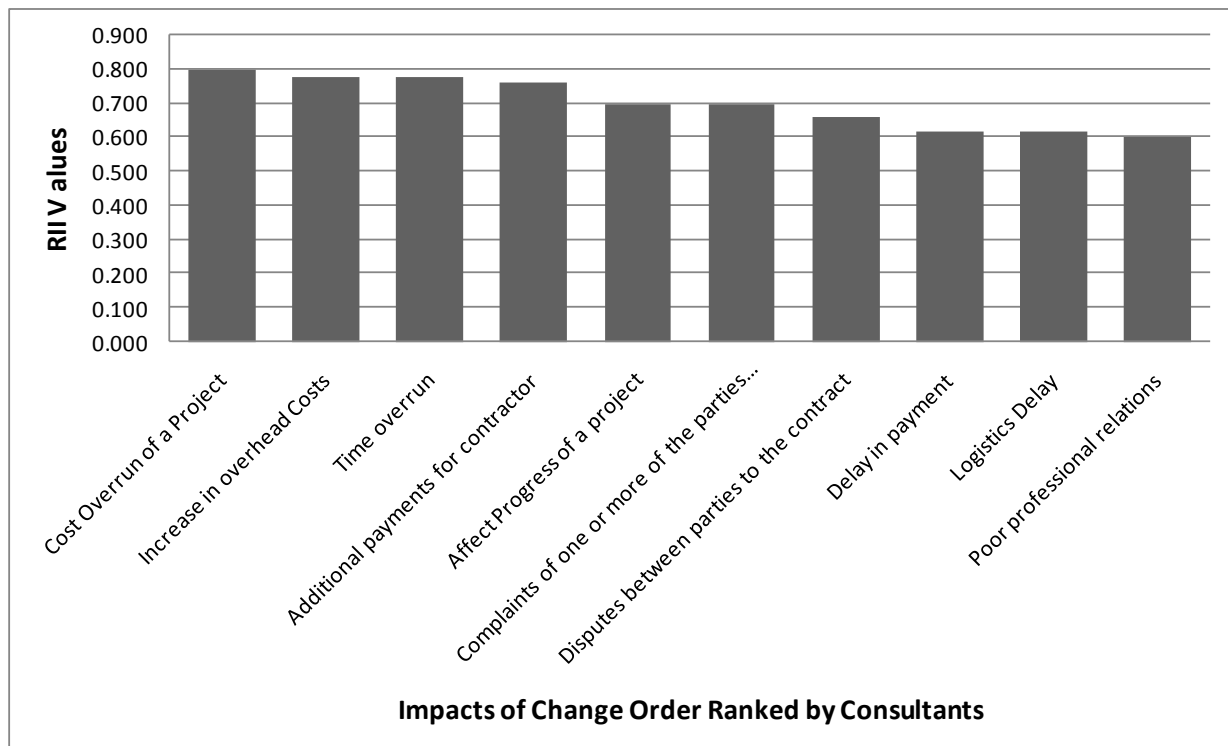
Table 4.9: Frequency of impact of change orders from consultant group

S.N	Impacts of change order	RII	Ranking
1	Cost Overrun of a Project	0.800	1
2	Increase in overhead Costs	0.780	2
3	Time overrun	0.780	2
4	Additional payments for contractor	0.760	4

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5	Affect Progress of a project	0.700	5
6	Complaints of one or more of the parties to the contract	0.700	5
7	Disputes between parties to the contract	0.660	7
8	Delay in payment	0.620	8
9	Logistics Delay	0.620	9
10	Poor professional relations	0.600	10
11	Procurement delay	0.580	11
12	Quality degradation	0.580	11
13	Productivity degradation	0.560	13
14	Rework and Demolition	0.540	14
15	Additional specialist equipment/personnel	0.520	15
16	Professional reputation of one or more parties adversely Affected	0.500	16
17	Cost Reduction	0.480	17
18	Degradation of health & safety conditions	0.440	18
19	Additional health & safety equipments & other needs	0.420	19
20	Quality enhancement	0.418	20
21	Decrease firm's reputation	0.400	21
22	Time Reduction /completion before contract time/	0.400	21

Fig 4.7: Top ten Impacts of Change Order Ranked by Consultants



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3.5.6. Clients group

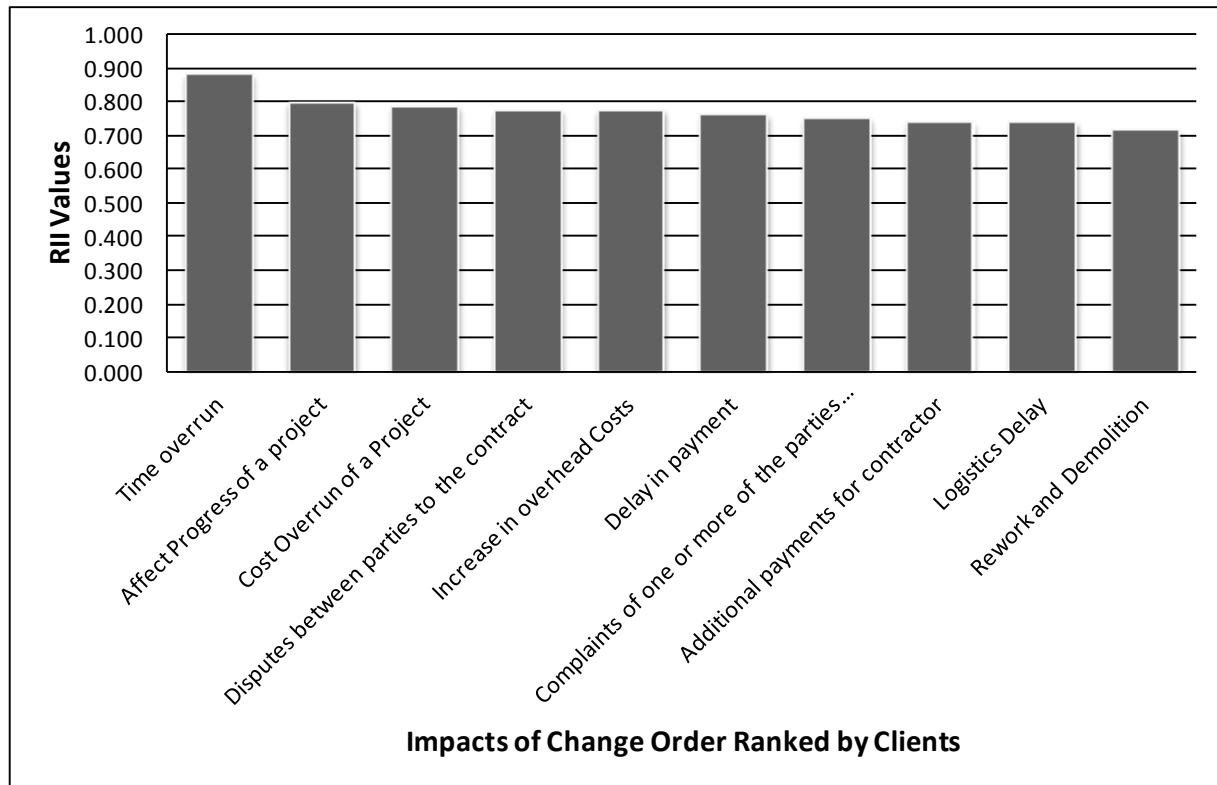
According to client's point of views project cost overrun, increase in overhead cost, additional payments for contractors and affect project progress were the most frequent impacts of change order with RII value of 0.827, 0.827, 0.813 and 0.813 respectively.

Table 4.10: Frequency of impact of change order from clients group

S.N	Impacts of change orders	RII	Ranking
1	Cost Overrun of a Project	0.827	1
2	Increase in overhead Costs	0.827	1
3	Additional payments for contractor	0.813	3
4	Affect Progress of a project	0.813	4
5	Time overrun	0.800	5
6	Delay in payment	0.760	6
7	Logistics Delay	0.747	7
8	Additional specialist equipment/personnel	0.733	8
9	Disputes between parties to the contract	0.733	8
10	Procurement delay	0.720	10
11	Complaints of one or more of the parties to the contact	0.707	11
12	Productivity degradation	0.707	11
13	Quality degradation	0.667	13
14	Poor professional relations	0.653	14
15	Rework and Demolition	0.653	15
16	Quality enhancement	0.640	16
17	Cost Reduction	0.613	17
18	Professional reputation of one or more parties adversely affected	0.587	18
19	Time Reduction /completion before contract time/	0.573	19
20	Degradation of health & safety conditions	0.560	20
21	Decrease firm's reputation	0.547	21
22	Additional health & safety equipments & other needs	0.387	22

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Fig 4.8: Top ten Impacts of Change Order Ranked by Clients



i. Correlation Test

The correlation among the respondents was so strong as shown in the table below. This implies that the respondent's perception about the impacts of change order is somewhat similar.

Table 4.11: Summary of correlation test on the ranking of impacts of CO involvement frequency

Respondents	$Rho(\rho_{cal}) = 1 - \frac{6 * (\sum di^2)}{N(N^2 - 1)}$	Relationship
Client Vs contractor	0.751	Strong
Client Vs Consultant	0.743	Strong
Contractor Vs Consultant	0.779	Strong

ii. Cumulative frequency of impacts of change order by all respondents

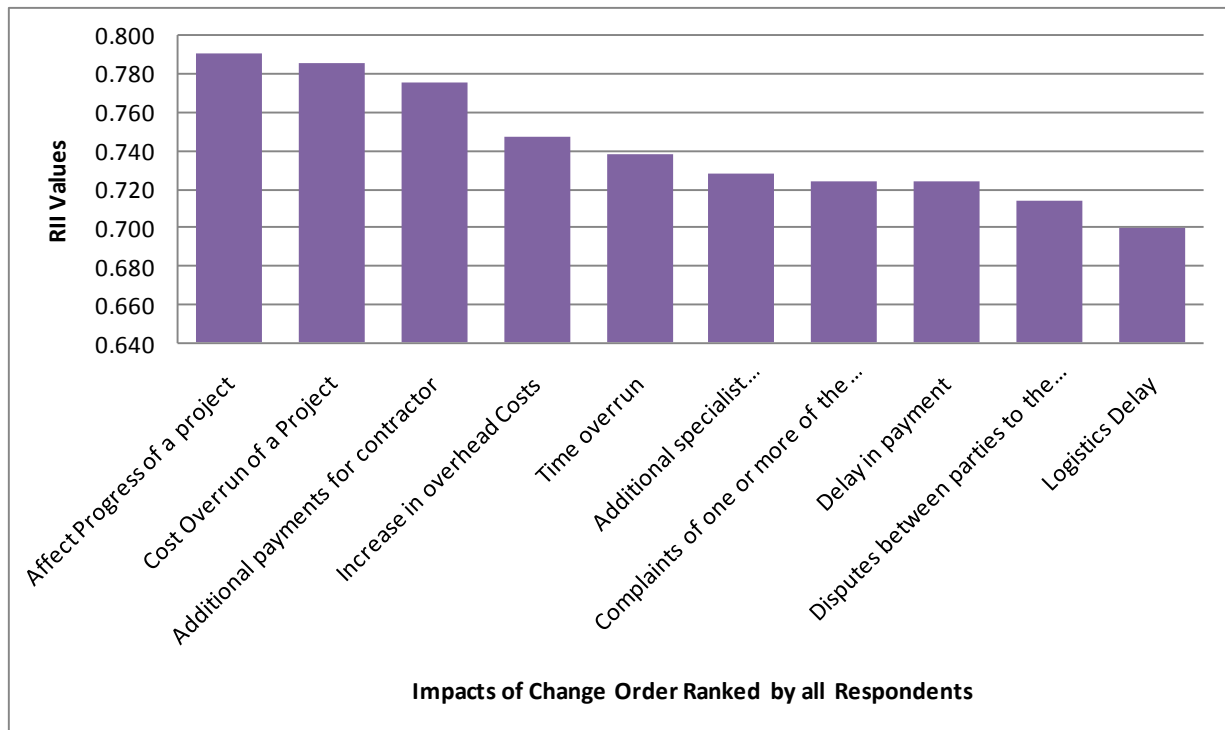
As shown in table 4.14 Cost Overrun of a Project, time overrun and increase in overhead cost are the most frequent impact of changes.

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Table 4.12: cumulative frequency ranking of change order impacts

S.N	Impacts of change orders	RII	Ranking
1	Additional health & safety equipment& other needs	0.467	22
2	Additional payments for contractor	0.771	5
3	Additional specialist equipment/personnel	0.667	10
4	Affect Progress of a project	0.776	4
5	Complaints of one or more of the parties to the contact	0.724	8
6	Cost Overrun of a Project	0.810	2
7	Cost Reduction	0.567	17
8	Decrease firm's reputation	0.529	19
9	Degradation of health & safety conditions	0.524	20
10	Delay in payment	0.729	7
11	Disputes between parties to the contract	0.733	6
12	Increase in overhead Costs	0.795	3
13	Logistics Delay	0.714	9
14	Poor professional relations	0.648	14
15	Procurement delay	0.667	10
16	Productivity degradation	0.662	12
17	Professional reputation of one or more parties adversely affected	0.581	16
18	Quality degradation	0.619	15
19	Quality enhancement	0.572	18
20	Rework and Demolition	0.652	13
21	Time overrun	0.829	1
22	Time Reduction /completion before contract time/	0.519	21

Fig 4.9: Top ten impacts of change order ranked by all Respondents



4.6. Discussions and findings of data from the desk study

3.5.7. Discussion of data from the desk study

The desk study was carried out to know the existent and extent of change orders in public building projects and accomplished by using nine (9) public buildings projects with a financial progress of more than 20%. The selected projects were started since 09/10/2002E.C. Documents surveyed during the desk study include contract documents, project progress reports, supplementary agreements, approved change orders, corresponding letters and other complementary documents. The studied documents were signed, stamped and legal documents at law. The following projects were studied under the desk study.

Table 4.13: projects studied as a desk study

S.N	Project Name	Contract Amount	Contract Time
A	North Shewa Zone Court Office Building	16,533,397.41	3years & 175 days
B	DBU Auditorium and Main Gate	61,499,950.49	
C	North Shewa Zone Administration All-Round Hall	26,146,144.00	365 days
D	Debre Birhan Medium and Higher Industrial	64,165,90.37	590 days

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	Shade		
E	DBU Post Graduate Complex Building	100,535,798.76	2 years
F	Debre Birhan Health Science College Skill Lab	3,573,006.77	500 days
G	Debre Birhan Kebele 04 Health Center OPD Block	956,048.73	150 days
H	04 Kebele Youth Center	9,370,218.04	365 days
I	Debre Birhan 07 Kebele Youth Center	2,609,954.66	365 days

Table 4.14: Summary of cost overruns due to change order in studied building projects

Project	Contract Amount	Cost overrun due to CO	Percentage (%)
A	19,013,407.02	2,540,942.77	13.36%
B	61,499,950.49	9,573,964.05	15.57%
C	22,794,047.00	3,352,096.83	14.71%
D	64,165,960.73	8,609,761.78	13.42%
E	100,753,798.97	7,580,872.97	7.52%
F	3,796,753.21	194,562.64	5.12%
H	962,902.06	25,225.04	2.62%
I	2,609,954.66	1,069,644.03	40.98%

➤ **Project A: North Shewa Zone Higher Court Office Building**

This is a G+3 building project which was signed on 09/10/2002 E.C. with a contract value of 19,013,407.02 Birr for 3 years and 175 days of contract time. It was faced with design related changes, omission and discrepancy among contract documents. The following changes were occurred:

- Telephone line Installation and gutter additional work – missed item
- Design improvement due to insufficient available land
- Discrepancy of contract documents on steel structure work of the roof
- Design improvement for column and top tie beam
- Supplementary contract

Due to those changes the project faced additional cost of 2,540,942.77 Birr; i.e., 13.36% of the total cost, but didn't require additional time due the initial contract time was so excess.

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➤ **Project B: DBU Auditorium and Main Gate**

The tender price of this project was 61,499,950.49Birr. This project was 100% completed during the time of collecting this data. In this project there was a change in design and omission of items. These includes: gutter and copping, change metal doors and windows schedules specifications, missing of steel structure item, change of floor pots and water proofing structure. These changes resulted in cost overrun of 9,573,964.50Birr and completion schedule delay. The client interest was the origin of all changes.

➤ **Project C: North Shewa Zone Administration All-Round Hall**

This project was awarded with a contract price of 22,794,047.00Birr. The approved change orders in this project were change/improvement in design and change in gypsum and electromechanical works. These include the following:

- Additional work of mezzanine floor to increase seating capacity of a hall
- Change order request in gypsum and electro-mechanical work items

The changes in this project was originated from the client and resulted in additional cost of 3,352,096.83Birr and 270 days of additional time.

➤ **Project D: Debre Birhan Medium and Higher Industrial Shade**

It was signed on 04/10/2007 with a contract price of 64,165,960.37Birr for a contract period of 180days and its financial progress was 54% while collecting this data. This project faced a change order due to lack of site adaptation as an input for designing, volume change and rainfall. These include:

- Excavation of additional volume of soft and hard rock and
- change of assumed soil excavation in to soft and hard rock due to lack of design adaptation
- Volume change in sanitary works
- Volume change in site work and fence work
- Rainfall

Those changes resulted in additional cost of 8,609,761.78Birr; i.e., 13.42% of the original contract amount, and 140 days of time extension.

➤ **Project E: DBU Post Graduate Complex Building**

DBU Post Graduate Complex Building was with a contract sum of 100,753,798.76. Its progress was 21% during the time of collecting this data. As the other projects volume change in excavation of earth work item was happened which results in additional cost of 7,580,872.97Birr and 55 days of additional time. The origin of the change order was the consultant.

➤ **Project F: Debre Birhan Health Science College Skill Lab**

This project was signed on 12/08/2007E.C. with a contract amount of 3,796,753.21Birr and contract period for 500 days. The financial progress of this project was 89% while collecting this data. The changes occurred in this project was addition of storm drainage system change in volume of excavation. These changes resulted in additional cost of 194,562.64Birr and extension of time by 182 days.

➤ **Project G: Debre Birhan Kebele 04 OPD Block**

The contract amount of this project was 956,048.73Birr with a contract time of 150 days starting from 13/08/2007E.C and its progress was 88% while collecting this data. The changes occurred during construction was omission in design and design error. There was omission of water tower and design error of incinerator part. These changes resulted in additional time of 90 days.

➤ **Project H: Debre Birhan Kebele 04 Youth Center**

This project was 100% completed even if it was faced with a challenge of 6(six) approved change orders which was caused by change in specification and incomplete land acquisition issue. It was signed with a contract amount of 962,902.06Birr and incurred additional cost of 25,228.04Birr and additional time of 365days due to those changes. The casual parties for those changes were the consultant and the client. These changes were:

- Change of external walls' paint from plastic paint to quartz
- Change of internal wall's paint from plastic paint to gypsum finish
- Design improvement of window door schedule and window sill finishing.
- Change of EGA roofing to euro tile
- Late payment
- Incomplete land acquisition issue

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➤ Project I: Debre Birhan Kebele 07 Youth Center

This project is a completed project. Its contract amount was 2,609,954.66 Birr. Change in specification was the main causes of change order in this project. It was faced with 3(three) approved change requests in which their origin was the client. These were:

- Change of floor finish to ceramic floor
- Change of external wall paint to quartz paint
- Change of stair case riser and going finish from ceramic tile to marble tile

Cost overrun of 1,069,644.03Birr (40.98%) and additional time of 180 days was granted to the contractor due to the above change orders.

Table 4.15: Summary of major causes, impacts and origin agents of change order data from the desk study

Project	Causes of change order	Impacts of change order	Origin Agents
A	○ Change in design ○ Omission of items ○ Discrepancy of contract documents ○ Design improvement	○ Cost overrun ○ Delay in payment	○ Clients
B	○ Change in design ○ Omission of items ○ Change in specifications	○ Cost overrun ○ Time overrun	○ Clients
C	○ Change in design ○ Omission of items ○ Design improvement	○ Cost overrun ○ Time overrun	○ Clients
D	○ Design problem ○ Excess Rainfall	○ Cost overrun ○ Time overrun ○ Disputes	○ Clients ○ Consultants ○ Others
E	○ Design problem	○ Cost overrun ○ Time overrun	○ Consultants
F	○ Omission in Design	○ Cost overrun ○ Time overrun	○ Clients ○ Consultant
G	○ Omission in Design ○ Error in design	○ Cost overrun ○ Time overrun	○ Clients ○ Consultant
H	○ Change in design ○ Incomplete land acquisition ○ Change in specifications	○ Cost overrun ○ Time overrun ○ Disputes	○ Clients ○ Consultant
I	○ Change in design ○ Change in specifications	○ Cost overrun ○ Time overrun	○ Client

3.5.8. Findings of data from the desk study

As shown in table 4.20 there were seven major causes of change orders, four impacts and three major origin agents identified in the detail study. These are summarized as follows:

- Major causes of change order
 - Change/modification in design
 - Design error and omission
 - Change in specification
 - Discrepancy of contract documents
 - Others
 - Incomplete land acquisition
- Major impacts of change order
 - Cost overrun
 - Time overrun
 - Disputes
 - Delay in payment
- Major origin agents of change order
 - Clients
 - Consultants
 - Others

Chapter Five

5. Conclusion and Recommendation

5.1. Conclusion

This study revealed the existent and extent of change order on public building projects in Debre Birhan by carrying out the preliminary investigation and the desk study in addition to the questionnaire survey to answer the first and second objectives. The desk study of the nine projects confirmed that the most frequent causes of change orders on public building projects were change/modification in design, change in specification and design error and omission.

According to the responses received from the clients change in specification, change/modification in design, error and omission in design and differing site conditions were the most frequent causes of change order whereas project cost overrun, increase in overhead cost and additional payment to contractors ranked as the most frequent impacts of change order. Among the twenty one (21) change order controlling strategies clients showed that previous knowledge of similar projects, comprehensive site investigation and preparation of sufficient design details were chosen as the most recommended strategies to minimize change orders in public building construction projects in Debre Birhan City Administration.

The questionnaire survey indicated that among 40 causes of change orders, the responses received from the consultants' showed that change in specifications, change/modification in design, errors and omissions in design, differing site conditions were the top four most frequent causes of change orders on public building projects. Consultants' also ranked project cost overrun, increase in overhead cost and time overrun as the most common impacts of change order. They also recommended that comprehensive site investigation, preparation of project brief clearly and thoroughly and previous knowledge of similar projects as best strategies to minimize changes.

According to the contractors', the top five most frequent causes of change orders on public building projects were change/modification in design, change in specification, lack of specialized

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construction manager, differing site conditions and error and omission in design. They also revealed that time overrun, affection of project progress, cost overrun, increase in overhead cost and disputes between parties to the contract as the top five impacts of changes; and comprehensive site investigation, preparation of clear project brief and sufficient design details, continuous coordination and direct communication and owners' involvement at planning, design and construction phases as the top five as the top five change order minimizing strategies.

From the overall responses, it was concluded that change/modification in design, change in specification, error and omission in design and differing site conditions were the most important causes of change orders on public building projects in Debre Birhan while clients were the most common causal parties; and time & cost overrun were the most significant impacts. There was a strong correlation between ranking given by clients and consultants, client and contractor as well as consultant and contractors groups.

5.2. Recommendations

5.2.1. Recommendation for the clients

In order to reduce change orders owners are recommended to take the following actions:

1. Owners should think of their projects and have clear project objectives and prepare project brief clearly and thoroughly.
2. Participate in the pre-design and design phases to make sure it meets all their requirements so that to minimize changes/modification in design and specification changes.
3. Owners should stop to use a standard plan which is prepared for one area and used to circulate to other places for similar projects because projects are unique in nature and it is useful to do site adaptation to avoid differing site conditions.
4. Hire experienced consultants, contractors, and construction managers to avoid work repetition.
5. When thinking a new a project owners should search for similar projects which were done previously so that to avoid similar problems.
6. Communicate with the consultant and the contractor regularly to avoid any deviations from the agreed upon work scope.

5.2.2. Recommendations for contractors

1. Follow the owner's instructions and scope of work as much as possible
2. Hire experienced workers, engineers, and construction managers to avoid work repetition.
3. Find the way they can participate in the design process so that the design well and can avoid differences.

5.2.3. Recommendations for consultants

1. Firstly, they should equip themselves with knowledge and experience and understand the owner's scope of work thoroughly to avoid design changes/modifications, error and omissions in design
2. Update themselves with new and recommended materials, technologies and work procedures so that to aware owners at early stages and minimize change of plan and specifications.

5.3. Future works

This study focused on indentifying causes, impacts and controlling strategies to minimize change orders as well as the main origin agents of the causes. Therefore my fellow researchers are recommended to focus on change order impacts interms of loss of productivity, quality degradation, time and cost overrun.

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Appendixes

Appendix A: Questionnaire Data Analysis

Respondents Category	Client	Consultant	Contractor	Others	total
Quantity	15	10	17	0	42

Section B: Causes of Change Order and Major Origin Agents

1. Causes of Change Order

Likert Scale values

Never = 1

Seldom = 2

Sometimes = 3

Often = 4

Always = 5

a. Respondents: Clients, N= 15

S.N	Causes of Change Orders	Frequency of occurrence					RI
		1	2	3	4	5	
1	Change in economic conditions	0	2	5	7	1	0.693
2	Change in government regulations	8	1	5	0	1	0.400
3	Change in specifications	0	1	6	6	2	0.720
4	Change of schedule by the owner	0	1	6	7	1	0.707
5	Change/modification in design	0	0	3	10	2	0.787
6	Conflicts between contract documents	1	0	8	5	1	0.667
7	Consultant's lack of judgment and experience	0	3	4	6	2	0.693
8	Consultant's lack of required data	1	4	7	0	3	0.600
9	Contractor's financial problem	7	0	4	4	0	0.467
10	Contractor's desired profitability	0	3	4	7	1	0.680
11	Contractor's lack of required data	4	0	6	3	2	0.587
12	Defective workmanship	0	4	6	4	1	0.627
13	Design complexity	2	2	6	4	1	0.600
14	Design discrepancies	1	5	2	5	2	0.627
15	Differing site conditions	0	0	7	6	2	0.733
16	Errors and omissions in design	0	0	5	7	3	0.773
17	Fast track construction	8	0	6	1	0	0.400
18	Health and safety considerations	11	0	3	1	0	0.320
19	Ill defined scope of work to the contractor	0	3	9	0	3	0.640
20	Impediment in prompt decision making process	1	1	7	5	1	0.653
21	Inadequate project objectives of the owner	0	4	2	5	4	0.720
22	Lack of a specialized construction manager	1	0	8	4	2	0.680
23	Lack of communication and coordination	0	2	8	0	5	0.707

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24	Lack of involvement of one or more parties in design process	0	7	2	2	4	0.640
25	Lack of knowledge of available materials and equipment	6	3	4	2	0	0.427
26	Land acquisition	0	5	6	2	2	0.613
27	Logistics delay	3	3	6	2	1	0.533
28	Obstinate nature of one or more of the parties to the contract	0	10	0	3	2	0.560
29	Owner's Financial problems	0	3	6	5	1	0.653
30	Poor procurement process	0	3	6	5	1	0.653
31	Socio-cultural factors	0	7	6	2		0.533
32	Speculation on desired profitability	0	3	8	2	2	0.640
33	Substitution of materials or procedures	0	4	7	4	0	0.600
34	Technological development/change	1	5	7	2	0	0.533
35	Unavailability of equipment	9	0	3	3	0	0.400
36	Unavailability of skills (shortage of skilled labor)	0	4	4	6	1	0.653
37	Unclear design details	0	2	7	4	2	0.680
38	Unfamiliarity with or unawareness of local conditions	0	7	2	4	2	0.613
39	Unforeseen problems	1	2	6	3	3	0.667
40	Value engineering /Improvement of design by the contractor in more economical way/	0	6	3	3	3	0.640

b. Respondents: Consultants , N = 10

S.N	Causes of Change Orders	Frequency of occurrence					RII
		1	2	3	4	5	
1	Change in economic conditions	2	5	0	0	3	0.540
2	Change in government regulations	0	2	5	3	0	0.620
3	Change in specifications	0	0	3	5	2	0.780
4	Change of schedule by the owner	0	0	7	1	2	0.700
5	Change/modification in design	0	0	4	4	2	0.760
6	Conflicts between contract documents	0	0	6	3	1	0.700
7	Consultant's lack of judgment and experience	0	2	4	1	3	0.700
8	Consultant's lack of required data	0	4	3	2	1	0.600
9	Contractor's financial problem	4	4	1	1	0	0.380
10	Contractor's desired profitability	0	2	3	5	0	0.660
11	Contractor's lack of required data	2	1	4	1	2	0.600
12	Defective workmanship	0	3	3	3	1	0.640
13	Design complexity	1	0	5	2	2	0.680
14	Design discrepancies	0	2	4	3	1	0.660
15	Differing site conditions	0	2	2	4	2	0.720
16	Errors and omissions in design	0	0	5	3	2	0.740
17	Fast track construction	5	2	2	1	0	0.380
18	Health and safety considerations	6	0	3	1	0	0.380
19	Ill defined scope of work to the contractor	0	1	5	3	1	0.680
20	Impediment in prompt decision making process	0	1	6	2	1	0.660
21	Inadequate project objectives of the owner	2	0	1	5	2	0.700
22	Lack of a specialized construction manager	0	0	6	2	2	0.720
23	Lack of communication and coordination	0	1	4	4	1	0.700
24	Lack of involvement of one or more parties in design process	1	1	1	6	1	0.700

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25	Lack of knowledge of available materials and equipment	3	1	2	2	2	0.580
26	Land acquisition	3	2	2	1	2	0.540
27	Logistics delay	2	3	0	4	1	0.580
28	Obstinate nature of one or more of the parties to the contract	1	4	3	1	1	0.540
29	Owner's Financial problems	1	2	3	3	1	0.620
30	Poor procurement process	0	2	3	4	1	0.680
31	Socio-cultural factors	0	5	4	1	0	0.520
32	Speculation on desired profitability	0	2	5	3	0	0.620
33	Substitution of materials or procedures	0	3	5	1	1	0.600
34	Technological development/change	1	4	4	1	0	0.500
35	Unavailability of equipment	7	0	3	0	0	0.320
36	Unavailability of skills (shortage of skilled labor)	0	2	3	4	1	0.680
37	Unclear design details	1	3	1	1	4	0.680
38	Unfamiliarity with or unawareness of local conditions	3	0	5	2	0	0.520
39	Unforeseen problems	0	3	2	4	1	0.660
40	Value engineering /Improvement of design by the contractor in more economical way/	2	0	4	2	2	0.640

c. Respondents : Contractors, N= 17

S.N	Causes of Change Orders	Frequency of occurrence					RII
		1	2	3	4	5	
1	Change in economic conditions	3	2	6	4	2	0.600
2	Change in government regulations	8	3	4	2	0	0.400
3	Change in specifications	0	2	6	4	5	0.741
4	Change of schedule by the owner	0	5	5	5	2	0.647
5	Change/modification in design	1	2	0	11	3	0.753
6	Conflicts between contract documents	2	0	7	4	4	0.694
7	Consultant's lack of judgment and experience	3	0	5	3	6	0.706
8	Consultant's lack of required data	0	2	8	2	5	0.718
9	Contractor's financial problem	6	3	2	4	2	0.518
10	Contractor's desired profitability	4	5	2	3	3	0.553
11	Contractor's lack of required data	2	4	9	2	0	0.529
12	Defective workmanship	3	3	0	10	1	0.635
13	Design complexity	1	5	6	3	2	0.600
14	Design discrepancies	3	0	4	7	3	0.682
15	Differing site conditions	0	1	8	5	3	0.718
16	Errors and omissions in design	1	0	8	4	4	0.718
17	Fast track construction	7	3	5	2	0	0.424
18	Health and safety considerations	10	3	3	1	0	0.341
19	Ill defined scope of work to the contractor	1	4	7	4	1	0.600
20	Impediment in prompt decision making process	0	4	4	4	5	0.718
21	Inadequate project objectives of the owner	1	2	5	5	4	0.706
22	Lack of a specialized construction manager	0	1	8	4	4	0.729
23	Lack of communication and coordination	0	4	6	2	5	0.694

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24	Lack of involvement of one or more parties in design process	0	6	4	3	4	0.659
25	Lack of knowledge of available materials and equipment	7	4	4	2	0	0.412
26	Land acquisition	1	7	6	2	1	0.541
27	Logistics delay	4	4	6	2	1	0.506
28	Obstinate nature of one or more of the parties to the contract	0	10	3	3	1	0.541
29	Owner's Financial problems	2	3	6	5	1	0.600
30	Poor procurement process	0	3	9	5	0	0.624
31	Socio-cultural factors	7	0	7	2	1	0.482
32	Speculation on desired profitability	2	3	8	3	1	0.576
33	Substitution of materials or procedures	5	0	7	5	0	0.541
34	Technological development/change	2	6	7	2	0	0.506
35	Unavailability of equipment	10	1	4	2	0	0.376
36	Unavailability of skills (shortage of skilled labor)	1	5	4	6	1	0.612
37	Unclear design details	0	2	5	10	0	0.694
38	Unfamiliarity with or unawareness of local conditions	1	8	3	3	2	0.565
39	Unforeseen problems	2	3	5	6	1	0.612
40	Value engineering /Improvement of design by the contractor in more economical way/	1	8	5	3	0	0.518

d. Cumulative Frequency

S.N	Causes of Change Orders	Frequency of occurrence					RII
		1	2	3	4	5	
1	Change in economic conditions	5	9	11	11	6	0.619
2	Change in government regulations	16	6	14	5	1	0.452
3	Change in specifications	0	3	15	15	9	0.743
4	Change of schedule by the owner	0	6	18	13	5	0.681
5	Change/modification in design	1	2	7	25	7	0.767
6	Conflicts between contract documents	3	0	21	12	6	0.686
7	Consultant's lack of judgment and experience	3	5	13	10	11	0.700
8	Consultant's lack of required data	1	10	18	4	9	0.648
9	Contractor's financial problem	17	7	7	9	2	0.467
10	Contractor's desired profitability	4	10	9	15	4	0.624
11	Contractor's lack of required data	8	5	19	6	4	0.567
12	Defective workmanship	3	10	9	17	3	0.633
13	Design complexity	4	7	17	9	5	0.619
14	Design discrepancies	4	7	10	15	6	0.657
15	Differing site conditions	0	3	17	15	7	0.724
16	Errors and omissions in design	1	0	18	14	9	0.743
17	Fast track construction	20	5	13	4	0	0.405
18	Health and safety considerations	27	3	9	3	0	0.343
19	Ill defined scope of work to the contractor	1	8	21	7	5	0.633
20	Impediment in prompt decision making process	1	6	17	11	7	0.681
21	Inadequate project objectives of the owner	3	6	8	15	10	0.710
22	Lack of a specialized construction manager	1	1	22	10	8	0.710

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23	Lack of communication and coordination	0	7	18	6	11	0.700
24	Lack of involvement of one or more parties in design process	1	14	7	11	9	0.662
25	Lack of knowledge of available materials and equipment	16	8	10	6	2	0.457
26	Land acquisition	4	14	14	5	5	0.567
27	Logistics delay	9	10	12	8	3	0.533
28	Obstinate nature of one or more of the parties to the contract	1	24	6	7	4	0.548
29	Owner's Financial problems	3	8	15	13	3	0.624
30	Poor procurement process	0	8	18	14	2	0.648
31	Socio-cultural factors	7	12	17	5	1	0.510
32	Speculation on desired profitability	2	8	21	8	3	0.610
33	Substitution of materials or procedures	5	7	19	10	1	0.576
34	Technological development/change	4	15	18	5	0	0.514
35	Unavailability of equipment	26	1	10	5	0	0.371
36	Unavailability of skills (shortage of skilled labor)	1	11	11	16	3	0.643
37	Unclear design details	1	7	13	15	6	0.686
38	Unfamiliarity with or unawareness of local conditions	4	15	10	9	4	0.571
39	Unforeseen problems	3	8	13	13	5	0.643
40	Value engineering /Improvement of design by the contractor in more economical way/	3	14	12	8	5	0.590

Section C: Impacts of Change Order

Please indicate your level of agreement with the following questions on a scale 1 to 5

Indicator: 1 = No impact

2 = Low impact

3 = Medium impact

4 = High impact

5 = Very high impact

1. Following are list of impacts of change orders. From your experience, what is the impact of change orders on building projects?

a. Respondents: Contractors

S.N	Impacts of Change Order	Frequency of					RII	Ranking
		1	2	3	4	5		
1	Additional health & safety equipments & other needs	1	6	5	5	0	0.565	20
2	Additional payments for contractor	0	2	5	6	4	0.741	8
3	Additional specialist equipment/personnel	1	1	5	9	1	0.694	11
4	Affect Progress of a project	0	1	4	7	5	0.788	2
5	Complaints of one or more of the parties to the contact	0	0	6	9	2	0.753	7
6	Cost Overrun of a Project	0	0	5	7	5	0.800	2
7	Cost Reduction	1	6	4	6	0	0.576	19
8	Decrease firm's reputation	1	3	10	2	1	0.588	18

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9	Degradation of health & safety conditions	1	9	2	4	1	0.541	21
10	Delay in payment	1	1	3	7	5	0.765	6
11	Disputes between parties to the contract	0	0	4	11	2	0.776	4
12	Increase in overhead Costs	0	1	4	8	4	0.776	4
13	Logistics Delay	0	2	4	8	3	0.741	8
14	Poor professional relations	0	1	10	5	1	0.671	13
15	Procurement delay	0	4	5	6	2	0.671	13
16	Productivity degradation	0	2	8	5	2	0.682	12
17	Professional reputation of one or more parties adversely affected	1	4	7	2	3	0.624	15
18	Quality degradation	1	5	5	5	1	0.600	17
19	Quality enhancement	0	4	8	5	0	0.612	16
20	Rework and Demolition	0	4	3	6	4	0.718	10
21	Time overrun	0	0	0	10	7	0.882	1
22	Time Reduction /completion before contract time/	2	7	4	2	2	0.541	21

b. Respondents: Consultant

S.N	Impacts of Change Order	Frequency					RII	Ranking
		1	2	3	4	5		
1	Additional health & safety equipments & other needs	2	5	3	0	0	0.420	19
2	Additional payments for contractor	0	1	3	3	3	0.760	4
3	Additional specialist equipment/personnel	1	3	5	1	0	0.520	15
4	Affect Progress of a project	1	1	3	2	3	0.700	5
5	Complaints of one or more of the parties to the contact	0	0	5	5	0	0.700	5
6	Cost Overrun of a Project	0	1	2	3	4	0.800	1
7	Cost Reduction	1	7	0	1	1	0.480	17
8	Decrease firm's reputation	3	5	1	1	0	0.400	21
9	Degradation of health & safety conditions	3	2	5	0	0	0.440	18
10	Delay in payment	1	2	3	3	1	0.620	8
11	Disputes between parties to the contract	0	4	2	1	3	0.660	7
12	Increase in overhead Costs	0	0	4	3	3	0.780	2
13	Logistics Delay	0	3	4	2	1	0.620	9
14	Poor professional relations	0	2	7	0	1	0.600	10
15	Procurement delay	0	3	5	2	0	0.580	11
16	Productivity degradation	1	3	3	3	0	0.560	13
17	Professional reputation of one or more parties adversely affected	0	5	5	0	0	0.500	16
18	Quality degradation	1	3	2	4	0	0.580	11
19	Quality enhancement	3	4	4	0	0	0.418	20
20	Rework and Demolition	2	3	2	2	1	0.540	14
21	Time overrun	0	1	2	4	3	0.780	2
22	Time Reduction /completion before contract time/	5	2	1	2	0	0.400	21

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c. RESPONDENTS = CLIENT GROUP

S.N	Impacts Change order	Frequency of occurrence					RII
		1	2	3	4	5	
1	Additional health & safety equipments & other needs	9	0	5	0	1	0.387
2	Additional payments for contractor	0	0	6	2	7	0.813
3	Additional specialist equipment/personnel	3		1	6	5	0.733
4	Affect Progress of a project	0	1	2	7	5	0.813
5	Complaints of one or more of the parties to the contact	0	2	4	8	1	0.707
6	Cost Overrun of a Project	0	0	2	9	4	0.827
7	Cost Reduction	4	1	2	6	2	0.613
8	Decrease firm's reputation	4	0	8	2	1	0.547
9	Degradation of health & safety conditions	4	1	6	2	2	0.560
10	Delay in payment	0	0	7	4	4	0.760
11	Disputes between parties to the contract	1	2	2	6	4	0.733
12	Increase in overhead Costs	0	1	2	6	6	0.827
13	Logistics Delay	2	1	2	4	6	0.747
14	Poor professional relations	0	2	8	4	1	0.653
15	Procurement delay	0	1	7	4	3	0.720
16	Productivity degradation	0	2	6	4	3	0.707
17	Professional reputation of one or more parties adversely affected	4	2	2	5	2	0.587
18	Quality degradation	2	1	4	6	2	0.667
19	Quality enhancement	0	1	10	4	0	0.640
20	Rework and Demolition	2	0	6	6	1	0.653
21	Time overrun	0	0	4	7	4	0.800
22	Time Reduction /completion before contract time/	5	2	1	4	3	0.573

d. Respondents: All Respondents

S.N	Impacts Change order	Frequency of occurrence					RII
		1	2	3	4	5	
1	Additional health & safety equipments & other needs	12	11	13	5	1	0.467
2	Additional payments for contractor	0	3	14	11	14	0.771
3	Additional specialist equipment/personnel	5	4	11	16	6	0.667
4	Affect Progress of a project	1	3	9	16	13	0.776
5	Complaints of one or more of the parties to the contact	0	2	15	22	3	0.724
6	Cost Overrun of a Project	0	1	9	19	13	0.810
7	Cost Reduction	6	14	6	13	3	0.567
8	Decrease firm's reputation	8	8	19	5	2	0.529
9	Degradation of health & safety conditions	8	12	13	6	3	0.524
10	Delay in payment	2	3	13	14	10	0.729
11	Disputes between parties to the contract	1	6	8	18	9	0.733
12	Increase in overhead Costs	0	2	10	17	13	0.795
13	Logistics Delay	2	6	10	14	10	0.714
14	Poor professional relations	0	5	25	9	3	0.648

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15	Procurement delay	0	8	17	12	5	0.667
16	Productivity degradation	1	7	17	12	5	0.662
17	Professional reputation of one or more parties adversely affected	5	11	14	7	5	0.581
18	Quality degradation	4	9	11	15	3	0.619
19	Quality enhancement	3	9	22	9	0	0.572
20	Rework and Demolition	4	7	11	14	6	0.652
21	Time overrun	0	1	6	21	14	0.829
22	Time Reduction /completion before contract time/	12	11	6	8	5	0.519