JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENTOF CAUSES AND IMPACTS OF VARIATION ORDER ON PUBLIC BUILDING CONSTRUCTION PROJECTS: IN JIMMA ZONE.

A Thesis submitted to Jimma University, Jimma Institute of Technology,School of Graduate Studies,Faculty of Civil and Environmental Engineering in Partial Fulfillment of the requirements for the Degree Master of Sciencein Construction Engineering and Management

By

Dejene Urge Ejersa

February. 2020
Jimma, Ethiopia

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Advisor: Engr. Bien Maunahan _____

Co - Advisor: Engr. SintayehuAssefa _____

February, 2020
Jimma, Ehtiopia

DECLARATION

I declare that this research entitled **"**Assessment of cause and impactof variation Order on Public Building Construction Projects: in Jimma zone" is my original work and has not been submitted as a requirement for the award of any degree in Jimma University or elsewhere.

Dejene Urge Ejersa _____ _____

As research Adviser, I hereby certify that I have read and evaluated this thesis paper prepared under my guidance, by Dejene Urge Ejersa entitled "ASSESSMENT OF CAUSE AND IMPACT OF VARIATION ORDER ON PUBLIC BUILDING CONSTRUCTION PROJECTS IN JIMMA ZONE" and recommend and would be accepted as a fulfilling requirement for the Degree Master of Science in Construction Engineering and Management.

Advisor:Engr. Bien Maunahan_____ _____

Co - Advisor:Engr. SintayehuAssefa_____

ABSTRACT

Thc construction industry is one of the most fundamental economic development of any country and job opportunity creatingfield for the most people in the surrounding and for those who are living in the country for both skilled and unskilled workforce. However nowadays, variation orders become a common problem for public building projects. This problem can be minimized by conducting the appropriate studies. The main objective of the study is to assess the causes and impacts of variation order on the public building constructions and to recommend the ways of minimizing mechanism.

The researcher followed a purposive sampling method to select the participants of the study by taking contractors who have licenses grade 1-5 that participated in public building constructions and their physical progression of construction completed 100%.Descriptive statistics for quantitative and explanation for qualitative data were used to achieve the objectives of the study. The questionnaires were distributed to project owners (clients), consultants, and contractors.In addition to questionnaires,interview was carried out to gather additional information. The collected data wasanalyzed using SPSS software version 22 to generate frequencies.Basesdthis,the researcher used RII to interprete the results.

Based on collected data,the results show that the main causes of variation order in selected construction projects were errors and omissions in design as well as in other documents(79.67%),change of client interest(77.33%),modification in design(74.00%), change of plans or scope(68.67%), shortage of time during preparation of design and BOQ or bid document(61.67%) that should be given attention from planning the project up to tendering stage.The results indicted that, variation orderoccurred more frequently in supper structure partof the selected public buildings(72.00%). As the result indicated, major impact of ariation order was on financial capacity of the client(72.00%).

The study concluded with recommendations that,the client must be capable in financial and provide a clear brief scope of works.Also client should invites different stake holders who have good experience to review the project design. The design and other bid of document must prepare by experienced and capable consultants or other persons.

KeyWords :*publicbuildings,variationorder,causes of variation order,impacts of variation order,contractor,consultant,client.*

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Table of Contents

LIST OF TABLES

LIST OF FIGURE

ACRONMYS

BOQ	Bill of Quantity
Engr	Engineer
Fre.	Frequency
FIDIC	International Federation of Consulting Engineers
GCC	General Condition of Contract
PPA	Public Procurement Property and Administration Agency
RII	Relative Important Index
SPSS	Statistical Package for Social Sciences
W/ro	Weizero

CHAPTER 1

INTRODUCTION

1.1. Background

The construction industry has the greatest input on economic development for any country. Studies show that, during construction there are different reasons the budget of the project can suggestively differ from the first valued price. Any addition, deletion, or any other revision to project goals and scope of work are considered to be variation, whether they increase or decrease the project cost or schedule (Ibbs*et al*., 2001). The work of (Sun &Meng, 2008) mentioned that a variation in construction projects refers to an alteration to design, building works, project programs or project aspects caused by modifications of preexisting conditions, assumptions, or requirements. Variation orders have an impact on overall project performance (Ruben, 2008). This is because variations can cause substantial adjustment to the contract duration, cost, or both.

Variations with their attached effects on construction projects continue to be a chronic problem worldwide and the situation is getting worse. However, the situation is greater in developing countries with the consequence of stagnated economic development (Ismail *et al.*, 2012). Detrimental variations may result into complexity with the consequence of negative impacts on the construction project performance in terms of time, cost,sand quality.

Under normal circumstances one would expect the project to be completed within the initially anticipated cost, time and quality, but most of the time reality takes the opposite this. As a result of adverse effects of variations, many cases of poor quality, late completion, and cost overruns are being reported in many construction projects and some of these projects have not been successfully implemented as expected (Mlinga, 2008).It may involve the alteration of the kind or standard of any materials to be used in the works (Nachatar*et al*., 2010). To date, several studies have been carried out on the causes and effects of variations in construction projects delivery (Priyantha*et al*., 2011). However, most of these researches were too general with little attention on public building projects. In addition, these researches have inadequately investigated the significant causes of detrimental variations in construction projects. Such studies include (Senaratne& Sexton,

2008) that contributed to theory and knowledge-based project change process; (Ndihokubwayo&Haupt, 2009) found that variation orders were not realistically priced resulting in an increased construction costs.

1.2. Statement of the Problems

Construction industry is the most role player ineconomic development as well to minimize the unemployment problem in the country. Nowadays, in our country construction is accelerated from time to time. But variation orders become a common problem in construction projects. This problem is observed as one of the most frequently occurring problems in construction projects in our country. In theJimma zone, this common problem also happens during the construction of buildings. Variation order has impact on these projects in terms of project cost, quality of projects, time is taken to construct. Generally, deviations from its objectives to be delayed, additional costs to the projects, and dispute between clients and contractors was happened. This problem can be minimized with an appropriate study on the causes and impacts of variation orders. Therefore, the study seeks to investigate the causes and impacts of variation order on public building constructions in Jimma zone.

1.3. Research Questions

The study wasattempt to find solutions to the following in the specified area.

1. What are the main causes of variation order on public building constructions?
2. Which causes of variation order are repeatedly occur?
3. What are the impacts of variation order on public building constructions?
4. How can the variation order be minimized on the construction of public building constructions?

1.4. Objectives

1.4.1. General Objectives

The main objective of the study wasto assess the causes and impacts of variation order on public buildings in Jimma zone.

1.4.2. Specific Objectives

1. To determine the main causes of variation order on public building constructions.
2. To identify the most frequently occurred variation orders on public building constructions.
3. To examine themajorimpacts of variation orders on public building constructions.
4. To determine the mechanism of minimizing the variation order on public building constructions.

1.5. Scope of the Study

Public buildings are constructed everywhere needed for public services. In the Jimma zone, these buildings are constructed by the Federal government, Regional government or local government. Therefore, the study was focused on public buildings which wererecentelyconstructed in Jimma zone.

1.6. Significance of the Study

The study can provide helpful information to all concerned bodies who areinterested to use the information provided to improve their ways of preparing contract documents as well asmanaging and controlling the project in proper waysduring construction period on public buildings to minimize variation order.

Other researchers can also use the findings as a reference for further research on cases.

This document can be the solution for problem variation order on public buildings.

CHAPTER 2

LITERATURE REVIEW

In order to develop a better understanding of the research objective, a comprehensive literature review has been conducted focusing on identifying the causes and their impacts of variations order. Since they involve human and non-human factors as well as many other variables, construction projects are complex which require close cooperation and coordination among stakeholders (Ahmed, 2005; Fetene, 2008). As a consequence of their complex nature and involving many players, Construction projects encounter variation which is costly and un-welcomed by all parties in construction (Arian & Low, 2007).

2.1. Causes of variations in construction projects

The causes of variations are the underlying reasons that precipitate variation orders in building projects. They are the incident for a variation order to be issued. Because these causes can affect construction projects adversely, (Arain&Pheng, 2006) suggested that it is important to investigate them.

A study conducted by (Alaryan*et al.*, 2014) identified five most common causes of change or variation orders to include: change in plans by owner; change in project scope by owner; problem on-site; error or omission in design (main element); poor design and poor working drawing details (secondary element). (Alaryan*et al.*, 2014) submission finds support in the assertion of (Ashworth,2013) that the most common reason for variations is to amend the designs in some way. The needs of the owner may change in the course of design or construction, market conditions may impose changes to the parameters of the project, and technological developments may alter the design and choice of the design consultants (Arain&Pheng, 2006). It is suggested that the consultants' review of the design may promote improvement changes and thus, the operations of the project. Most commonly, lack of timely and effective communication, lack of integration, uncertainty, a changing environment, and increasing project complexity are drivers of project variation (Arain*et al*., 2004). The causes of variations can be categorized according to the origin agent that initiates the variation (Jawad*et al*., 2009; Mohammad *et al.*, 2010). Thus, the causes of variations identified from literature review are as follows:

2.1.1. Client Related Variation Orders.

Nature of Client

The client or owner commonly initiated Variations during the design phase in construction projects (Oladapo, 2007). Built construction projects involveseveral participants with varying experience and knowledge in the field of engineering and construction (Keane, 2010). In most cases, the client has limited or no knowledge in the field of construction engineering. Inexperienced clients, unfamiliar with standard construction practices, may change budget, scope, design, schedule, or delay variation approvals with little appreciation of the effects of their actions (Engineers Australia, 2005; Sun &Meng, 2009). Clients who work in unison with practicing professionals can limit the number and effect of variations.

Scope or Brief

Change in scope or brief by the client is one of the most significant causes of variations in construction projects (Engineers Australia, 2005; Keane, 2010; Oladapo, 2007 ;Alnuaimi*et al*., 2010; Ismail*et al*., 2012). The project's brief sets the foundations of a construction project and needs to be executed correctly to minimize design variations in the latter stages of a project. The client's requirements and expectations can change during the life of a construction project. Variations to the project brief can be initiated by the client's finances, the desired schedule, omitted information, or simply a change of design requirements (Sun &Meng, 2009). A change in the scope or brief of a project has negative consequences on the detailed design and construction phases.

Project Schedule

Changes in the project schedule by the client can cause variations in construction projects (Sun &Meng, 2009). Any change to the project's schedule will determine resource allocations by consultants and contractors. Unforeseen resource changes imposed on third parties will incur additional costs.

Specifications

Changes to design specifications can cause variations in construction projects (Oladapo, 2007). Specification changes are often prevalent in construction projects with inadequate project objectives. Variations may include changes to the materials, finishes, or procedures used to produce the final product (Keane, 2010). As previously stated, the client's requirements and expectations can change at any time; thus changes in the specifications can impact negatively on a project.

Finances

The client's financial problems can cause variations in construction projects (Ismail *et al*., 2012; Sun &Meng, 2009). If the client encounters financial difficulty during the course of the project or has an insufficient budget to begin with ,the project may lack the required quality, encounter design variations or need the work schedule adjusted (Keane, 2010; Oladapo, 2007).

2.1.2. Consultant Related Variation Orders.

Nature of Consultant

Consultants have to work with esveral projects participants. The consultant's willingness to accommodate the ideas and desires of the client, other consultants and contractors are necessary for a project's success. A consultant awarded a project through competitive pricing may resort to unethical behavior, such as inadequate quality assurance processes to maximize their fee (Engineers Australia, 2005). It is the consultant's responsibility to act in the best interests of all parties involved (Engineers Australia, 2005). A consultant that acts unethically or is inflexible may cause variations during the life cycle of the project.

Design Changes and Errors/Omissions

Changes and errors in designs are one of the major causes of variations in construction projects (Keane, 2010; Alnuaimi*et al*., 2010; Duaij*et al*., 2007). Projects which begin construction before the design is finalized are prone to changes by design consultants. Consultants are often under strict schedules to design and document construction projects

(Engineers Australia, 2005). This method of business creates situations where the consultant may intentionally or accidentally omit design information. Neglecting a quality design process to satisfy a strict schedule can cause variations and disputes throughout the life of a project. The negative impact of these variations can vary depending on timing. A proper review of final design documentations can prevent design changes.

Design Documentation

According to a report conducted by Engineers Australia, 60 - 90% of all variations are caused by inadequate design and documentation (Engineers Australia, 2005). Poor quality design documents have created a non-competitive industry, cost over-runs, rework, increased stress, decreased morale, and diminished reputations of consultants (Engineers Australia, 2005). The report also outlined root causes of the diminishing quality of project design documents.

Ideally the consultant should provide design documentation detailing every aspect of the design and construction. Unfortunately, a clear and concise set of design documents are a rarity in today's marketplace due to the causes listed above. Inadequate documentation can also cause inaccurate design cost estimates of a project, leading to cost variations (Keane, 2010). The problem is industry-wide and needs to be addressed correctly to minimize the negative impacts of variations associated with poor design documentation.

Scope for Contractors

An inadequate scope of works for contractors can cause variations in construction projects (Ismail*et a*l., 2012). Construction sites contain a variety of contractors from different disciplines. A clear and thorough scope for each contractor is needed to limit variations.

Site Investigation

A thorough and detailed site investigation is needed to reduce the frequency and impact variations on construction projects (Wu *et al*., 2005). Site investigations include detailed topographical surveys and geotechnical investigations. These investigations are often seen as wasteful or unproductive by the client, yet they play a crucial role in the operation of a project. Design consultants often reduce the amount of investigation to reduce design

costs and be awarded the contract. Topographical surveys provide designers with current ground levels and locations of features relevant to the construction of the projects. They highlight problematic areas at theproject site and are the building blocks for which the design is developed. Dated or incomplete topographical surveys can affect design levels, quantities, schedules, standards applied and construction costs. Inadequate or limited geotechnical investigations can also impact a project's schedule and cost. Geotechnical information gathered by these investigations is often the basis for a structurally safe design that conforms to the necessary standards (e.g foundation design) (Wu *et al*., 2005). Remedial actions during the construction phase may be needed to correct the design. An accurate and detailed site investigation can dramatically reduce the number of variations on a construction project.

Contract Documentation

Misinterpretation and conflict between contract documents can cause variations in construction projects (Keane, 2010; Duai *et al*., 2007). Clear and concise contract documents provide all parties with a legal agreement on the scope of the work and expectations of all involved. Inadequate contract documents can impact a project's schedule and costs through variations.

Project Complexity

The technical complexity of a construction project can be the cause of variations. Construction projects which are unique or push the limits of engineering will be more likely to encounter variations (Keane, 2010; Sun &Meng, 2009).

Experience and Knowledge

The inexperience and lack of design knowledge of personal working at a consultancy can cause variations in construction projects (Chang *et al*., 2011; Chang, 2002). Consultants need personnel that is experienced and knowledgeable in all aspects of construction, design and documentation. Poor knowledge of available materials, equipment, and construction methods can increase cost and schedule changes in the construction phase (Keane, 2010). The rise of computer aided design programs has increased productivity of consultants (Engineers Australia, 2005). However, the ability to operate these complex

design programs is useless if the operator does not have competent design knowledge. The ability of consultants to effectively adapt and resolve design and construction issues will reduce the risk of variations occurring on the project.

2.1.3. Contractor Related Variation Orders.

Nature of Contractor

Contractors are employed to carry out work for the consultant. It is the contractor's responsibility to act in the best interests of the client. A contractor's desire for profitability can lead to unethical behavior, variations, and increased costs for the client. Variations can be seen as financial rewards for contractors (Keane, 2010).

Financial Problems

Financial difficulties of the contractor can cause variations in construction projects. Financial difficulties encountered by contractors can affect wages of workers and labor force. Unpaid wages or layoffs may decrease the quality of workmanship and increase the project schedule (Keane, 2010).

Differing Site Conditions

Differing site conditions can cause variations in construction projects (Alnuaimi*et al*., 2010; Keane, 2010). If site conditions are inconsistent with the description in the design, contractors may not be able to carry out specific construction techniques or construction requirements (Wu *et al*., 2005). Alternative methods or machinery may be needed to continue construction. Knowledge of the local conditions at the site is also necessary for contractors tocomplete their work (Keane, 2010).

Quality of Work

The quality of workmanship by the contractor can cause variations in construction projects. Poor workmanship has been recognized as a common cause for rework and delays in the project schedule (Sun &Meng, 2009). The use of subcontractors, over labor supplied by the immediate contractor, can make coordination of work challenging. In some cases,the complete demolition of the defected work is needed to satisfy quality

requirements (Keane,2010). Additional resources may be needed to keep the project on schedule. Remedial actions may cause variations in the project.

Design Complexity

As stated in previous sections, the technical complexity of a construction project can be the cause of variations (Keane, 2010). Construction projects which are unique or push the limits of engineering will need contractors with specialized skills and knowledge. Contractors unable to comprehend and construct a complex design efficiently may cause schedule delays and time variations.

Lack of Experience and Knowledge

Lack of experience and knowledge by the contractor can cause variations in construction projects (Sun &Meng, 2009). Contractors awarded the project are expected to be adept in the field of building and construction. Often the cost of an underperforming contractor is higher than the difference in less competitive tender bids (Chan &Yeong, 1995). Contractors may insist on alternative methods and materials specified in project documentation (Wu *et al.,* 2005). In some cases, they may be correct in doing so; however, changes incur the cost and schedule changes. The ability of contractors to construct and resolve construction issues will reduce the risk of variations occurring on the project.

2.1.4. Other Variations

Weather

Unforeseen weather events and conditions can cause variations in construction projects (Keane, 2010; Alnuaimi*et al*., 2010). During the life of a project, the construction site is exposed to a variety of normal and abnormal weather conditions. The geological location of the project also determines the weather conditions project participants should expect and plan for. Extreme weather conditions experienced in natural disasters can have severe impacts on site conditions and may delay or even terminate work (Wu *et al*., 2005). Remedial action is needed to continue construction. Weather conditions are difficult to predict and are often the main causes of schedule delays and cost variations (Sun &Meng, 2009).

Regulations

Change to government regulations can cause variations in construction projects (Chang *et al.,* 2011;Duaij*et al.,* 2007). Changes to government policy, law, code, and standards can negatively impact projects if they are implemented after design plans are finalized or construction has commenced (Wu *et al*., 2005). Regulations can impact health and safety, planning, employment, environmental and taxation elements of a project (Sun &Meng, 2009).

CHAPTER 3

RESEARCH METHODOLOGY

3.1. Study Area

The study was conducted in Jimma zone which is located in south west part of Ethiopia its capital town is Jimma town 356 km far from Addis Ababa city. Jimma Zone geographical coordinates are between 7° 13'- 8° 56N latitude and 35°49'-38°38'E longitude with an estimated no of population 3415011.The zone has a total surface area of 19,506.24 km^2 at which all area and lies in the climatic zone locally known as Dega, WoynaDega and Kola. Currently the zone is divided in to 17 Rural Woredas. Also it has 31 urban center with more than 2000 population (Profileof Jimmazone,2007&2008)

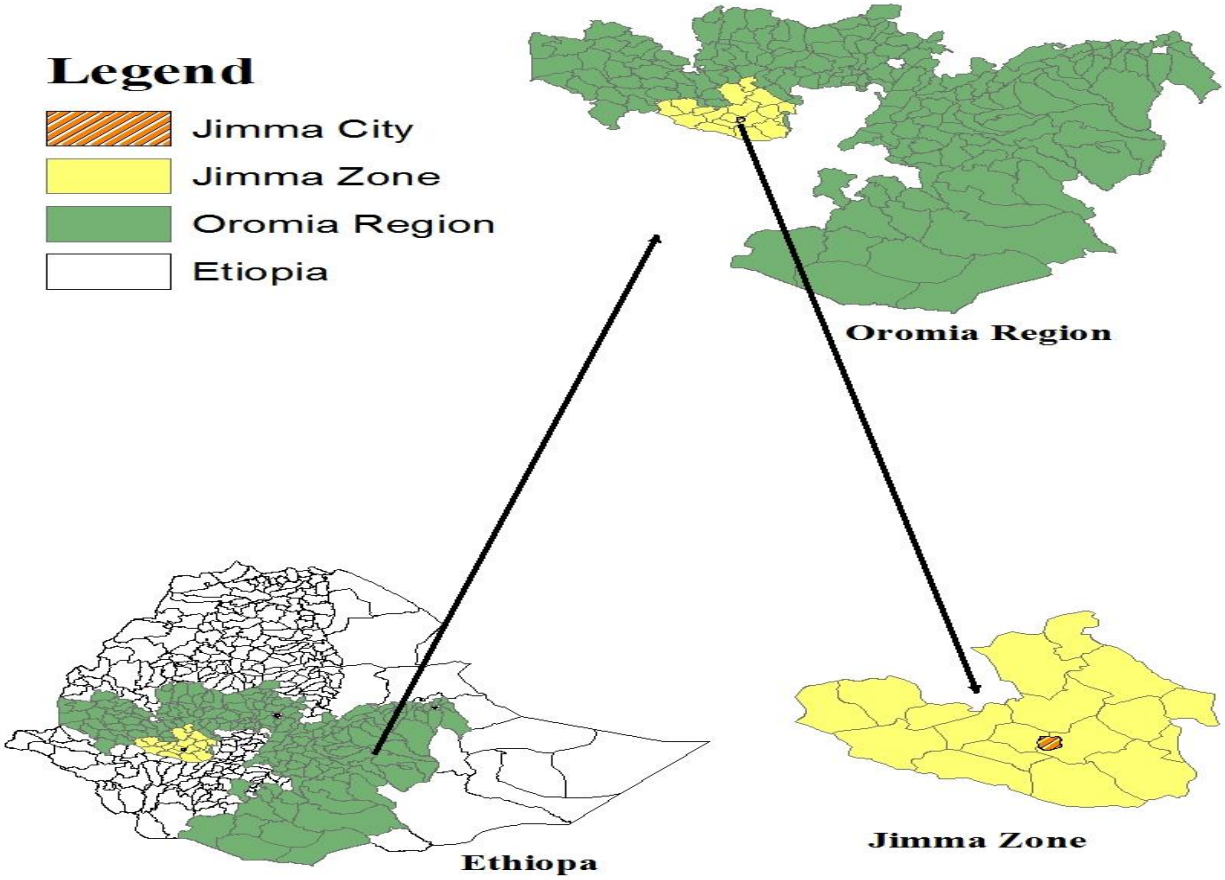

Figure 3.1 Map of the study area (Profile of Jimma Zone 2007 & 2008)

3.2. Research Design

The researcherfollowed the descriptive statistics research design. Both quantitative and qualitative research was conducted to achieve the objectives of the study. Based on purposive sampling techniques, the questionnaires and interviews were described and explained, and statistical analysis was used for final results.

3.3. Study Variables

3.3.1. Independent Variables

Causes and impacts of variationorders.

- Change of plans or scope
- Change of client interest
- Financial problems
- Quality of the projects

3.3.2. Dependent Variable

Variation order

3.4. Population and Sampling Method

The population was public buildingsbuilt by contractors whose their license grade 1-5 and finished recently2011(2018/19) in the study area. The data were taken from the client, contractor, and consultant.

A purposive sampling method was followed to selectrespondents of the study by taking contractors who have license grade 1-5those participated in public building constructions thattheir physical progression were 100% in Jimma Zone.

The projects were taken from two woredas(Dedo and Gatira) as well as jimmatown.Thequestionnaires were distributed for each project according to their staff member that regarding to the selected project.

The total distributed questionnaires were 71out of thespapers, 60 wereretumedand those respondents were from clients, contractors, and consultants (table 3.1). The questionnaires were distributed for Engineers (respondents) who were working in the selected project at different work levels. The researcher distributed the questionnaires based on their staff

members of each selected project. The interview carried out based on well experienced in the construction industry. The number of interview participants were4.That were taken fromdifferent type and interview conducted face-to-face with selected individuals.

Table 3 1 Type and number of projects taken as sample in the study area.

No	Type of Project	Number of Projects	Physical Progression	Distributed questionnaires	Returned
1	A –Office	7	100%	58	50
2	B-Health	1	100%	7	5
3	C. Hall	1	100%	6	5
	Total	9		71	60

3.5. Sources of Data

The researcher was used primary and secondary data. The primary data were questionnaires, interviews, and observation-based on selected projects. Secondary data were written or published documents regarding variation order on public buildings.

3.6. Data Collection Procedure

Based on quantitative and qualitative techniques, using questionnaires and interview were carried out. The questionnaires were closed questions (Likert scale questions), and these questionnaires were distributed and collected using helperdata collectors.Theinterview was conductedface-to-face with the interviewee asking questions by the researcher well experienced selected individuals in the construction industry.

3.7. Data Presentation and Analysis

The collected data obtained from questionnaire were analyzed using SPSS to generate frequencies.Basesdthis,the researcher used RII to interprete the results bycalculating using the following equation

$$RII_k^i(\%)=\frac{1\times(n1)+2\times(n2)+3\times(n3)+4\times(n4)+5\times(n5)}{5\times(n1+n2+n3+n4+n5)}\times 100$$

This equation has been used in a previous study (Shumank DEEP[1], Mohd ASIM[2],MohdKashifKHAN[3],2017).

where RII_k^i(%)is the Relative Importance Index of each factor, n1,n2,n3,n4, and n5 are indicateas below identified.

Under identification of the main causes of variation order on public buildings in the study area

- n1: Number of respondents answering (Never)
- n2: Number of respondents answering (Low Extent)
- n3 : Number of respondents answering(Medium Extent)
- n4 :Number of respondents answering(High Extent)
- n5: Number of respondents answering(Very high Extent)

Under identification of frequently occurrence of variation order on public buildings in the study area.

- ✓ n1: Number of respondents answering (No occurrence)
- ✓ n2: Number of respondents answering (Low occurrence)
- ✓ n3 : Number of respondents answering(Medium occurrence)
- ✓ n4 :Number of respondents answering (High occurrence)
- ✓ n5: Number of respondents answering (Very high occurrence)

Under identification of the majorimpactsof variation order on public buildings in the study area

- ❖ n1: Number of respondents answering (No impact,)
- ❖ n2: Number of respondents answering (Low impact)
- ❖ n3 : Number of respondents answering(Medium impact)
- ❖ n4 :Number of respondents answering(High impact)
- ❖ n5: Number of respondents answering(Very high impact)

Under identification ofminimizing mechanismsof variation order on public buildings in the study area

- n1: Number of respondents answering (unimportant)
- n2: Number of respondents answering (less important)
- n3 : Number of respondents answering(important)
- n4 :Number of respondents answering(very important)
- n5: Number of respondents answering(very high important)

Under Summary of Variation Order of variation order on public buildings in the study area

- n1: Number of respondents answering (Very low variation)
- n2: Number of respondents answering (Low variation)
- n3 : Number of respondents answering(Medium variation)
- n4 :Number of respondents answering(High variation)
- n5: Number of respondents answering(Very high variation)

Data were analyzed using the Relative Importance Index (RII) method. This method was used to identify the rank of causes, occurrence, major impact, and minimization mechanism of variation order depend on the selected projects.It provides a percentage that indicates the main cause, frequently occurred and major impact of a variation order in public building in Jimma zone.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1. Results

This chapter analyses the collecteddatausingquestionnairesandinterviews. Using the method discussed in Chapter 3,the questionnaireswere processed and statistically analyzed using SPSS and interviews from the selected individuals wereexplained.

4.1.1. Identification of Main Causes of Variation order

The interview results indicted that, the reasons that force to change the design, scope and schedule of the projects were the absence of discussion with the stake holders on preliminary design as well as rapid decision, not carefully done documents, technology can force to change design and scope and design and bid documents were prepared in governmental office by unexperienced engineers. Most the interviewee, responded that clauses of GCC in PPA or FIDIC no contribution on variation order but one respondent responded that it has contribution and it should be omitted because it encourages for variation order

The respondents result for each case was found that,(79.67%)errors and omissions in design as well as in other documents,(77.33%)change of client interest,(74.00) modification of design, (68.67 %)change of plans or scope, (61.67%)shortage of time during preparation of design and BOQ or document,(57.00%)bid document prepared by unexperienced Engineers, (54.00 %)inadequate working drawings details ,(53.00 %), Unforeseen problems, (51.33) conflicts between bid documents,(49.00 %) ambiguous and complexity in design,(43.33%)change in economic conditions, (41.00%) and change in government regulations were occurred..

This shows that variation can be happened in all cases but their weight quite difference. To answer the specific objective of the research, the main causes of variation order were rankedup to fifth stages as their results founded from respondents (figure 4.1)

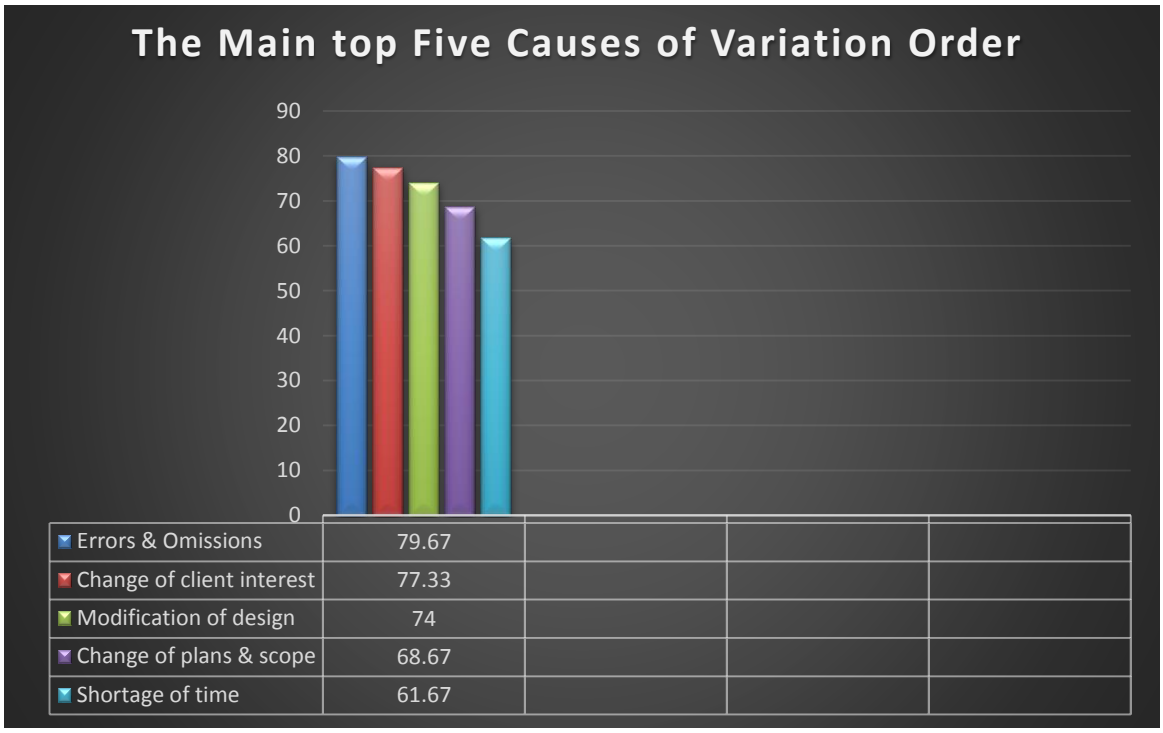

Figure 4.1 The main top five causes of variation order

In general all results of therspondents on the causes of variation order are indicated in the (table 4.1)

Table 4.1 Causes of Variation order

No	Descriptions	RII	Rank
1	Errors and omissions in design as well as in other documents	79.67	1
2	Change of client interest	77.33	2
3	Modificaton of design	74.00	3
4	Change of plans or scope	68.67	4
5	Shortage of time during preparation of design and BOQ or bid document	61.67	5
6	Bid document prepared by un experienced Engineers.	57.00	6
7	Inadequate working drawing details	54.00	7
8	Financial problems	53.00	8
9	Unforeseen problems	52.67	9
10	Conflicts between bid documents	51.33	10
11	Change of schedule	51.00	11
12	Ambiguous and complexity in design	49.00	12

13	Participating on tender without visiting	46.67	13
14	Unavailability of skilled workforce	46.33	14
15	Poor procurement	45.33	15
16	Change in economic conditions in the country	43.33	16
17	Conflicts between parties	42.67	17
18	Change in government regulations	41.00	18

4.1.2. Identification of the causes for Variation Order depending on the role of parties

To identify the role of parties that cause for variation order on project public buildings were ranked by using 5 pointsLikert scale.Therefore, each case in table 4.2were responded by the selected respondents to identify whose role causes the change order in the selected public buildings.The main results for each party were indicated according to the respondent's responded. It were found that project owners initiated variation orders due toChange of plans or scope(71.7%), financial problems (66.67 %)and Changed in design(43.3%). Consultant causes for variation order and initiate change due to errors and omissions in designs (90%),ambiguous and complexity in design and inadequate working drawing details (81.7%), Bid document prepared by unexperienced Engineers (63.3%), Conflicts between contract documents (60%) Change in design (52.7%). Moreover, respondents thought that the contractor initiated a variation order mainly due to a change of schedule (63.3%), participating in tender without visiting the condition of the site (60%). Other conditions were founded that change in economic conditions (31.7%), change in government regulations (33.3%), and unforeseen problems (40%). These can be indicated that directly or indirectly, the three parties were the source for causes for a variation order.

Table 4.2 Identification of the causes for variation order depending on the role of parties

No	Descriptions	Client		Consultant		Contractor	
		Fre.	%	Fre	%	Fre	%
1	Change of plans or scope	43.0	71.7	12.0	20.0	2.0	3.3
2	Change of schedule	11.0	18.3	8.0	13.3	38.0	63.3

3	Financial problems	40.0	66.7	9.0	15.0	10.0	16.7
4	change in design	26.0	43.3	32.0	52.3	2.0	3.3
5	Inadequate working drawing details	2.0	3.3	49.0	81.7	9.0	15.0
6	Errors in design	4.0	6.7	54.0	90.0	1.0	1.7
7	Poor procurement process	25.0	41.7	9.0	15.0	20.0	33.3
8	Change in government regulations	8.0	13.3	8.0	13.3	6.0	10.0
9	Change in economic conditions in country	7.0	11.6	6.0	10.0	8.0	13.3
10	Unforeseen problems	6.0	10.0	3.0	5.0	20.0	33.3
11	Conflicts between parties	18.0	30.0	20.0	33.3	19.0	31.7
12	Participating on tender without visiting condition of the site.	5.0	8.3	19.0	31.4	36.0	60.0
13	Bid document prepared by un experienced Engineers	11.0	18.3	38.0	63.3	8.0	13.3
14	Conflicts between contract documents	16.0	26.3	36.0	60.0	8.0	13.3
15	Shortage of time during preparation of design and BOQ or contract document	27.0	45.0	26.0	43.3	7.0	13.3

4.1.3. Identification of Frequently Occurrence of Variation Order onPublic Buildings

OnMain Part of Public Buildings

Based on the respondents' result,variation orderthe occurredonthe main parts of the selected public buildings in the study area in both sub-structure and supper structure.As respondents agreed,72% of variation order occurred in supper-structure parts, and 61 % occurred in sub-structure parts of the public buildings.Therefore, most variation orders frequently occurred in the supper structure parts (table 4.3).

Table 4 .3 Occurrence of Variation order on the main part of the buildings

No	Descriptions	RII	Rank
1	Supper-Structure	72	1
2	Sub-Structure	61	2

On Sub-Structure of Public Buildings

The respondents responded that variation orderon sub-structure part of the selected projectsoccurred (65%)in earthwork,(59.67%)in concrete work, (58.87%)in reinforcement,(56.69%) in formwork,and (56.67%) masonry work respectively occurred. Regarding to this part, change order occurred mostly in earth work (table 4.4).

Table 4 .4 Occurrence of Variation in Sub-Structure

No	Descriptions	RII	Rank
1	Earth work	65	1
2	Concrete work	59.67	2
3	Reinforcement	58.87	3
4	Form work	56.69	4
5	Masonry work	56.67	5

On Supper-Structure of Public Buildings

According to the respondents view, variation order occurred on supper structure of the selected public buildings were (69.67%) concrete work,(66.33%)reinforcement,(65.67%)finishing, (63.33%) metalwork,(60.03%)blockwork,(60 %) carpentry& Joinery work. These were the selected more occurred that taken their occurrence value when calculated according to the equation. Therefore, the most frequently occurred were ranked 1-5 works. The least was the sanitary work (table 4.5)

Table 4.5 Occurrence of Variation in Supper-Structure Frequency

No	Descriptions	RII	Rank
1	Concrete work	69.67	1
2	Reinforcement	66.33	2
3	Finishing	65.67	2
4	Metal work	63.33	4
5	Block work	60.03	5
6	Carpentry & Joinery work	60.00	5

7	Form work	51.33	7
8	Masonry work	50.67	8
9	Roof work	50.67	8
10	Electrical	50.33	10
11	Sanitary	50.00	11

Summary of Variation Order

As the respondents believed, the majority of variation order was the changing of quantity in constructed projects, and changing in quality was the least occurred (figure 4.2).

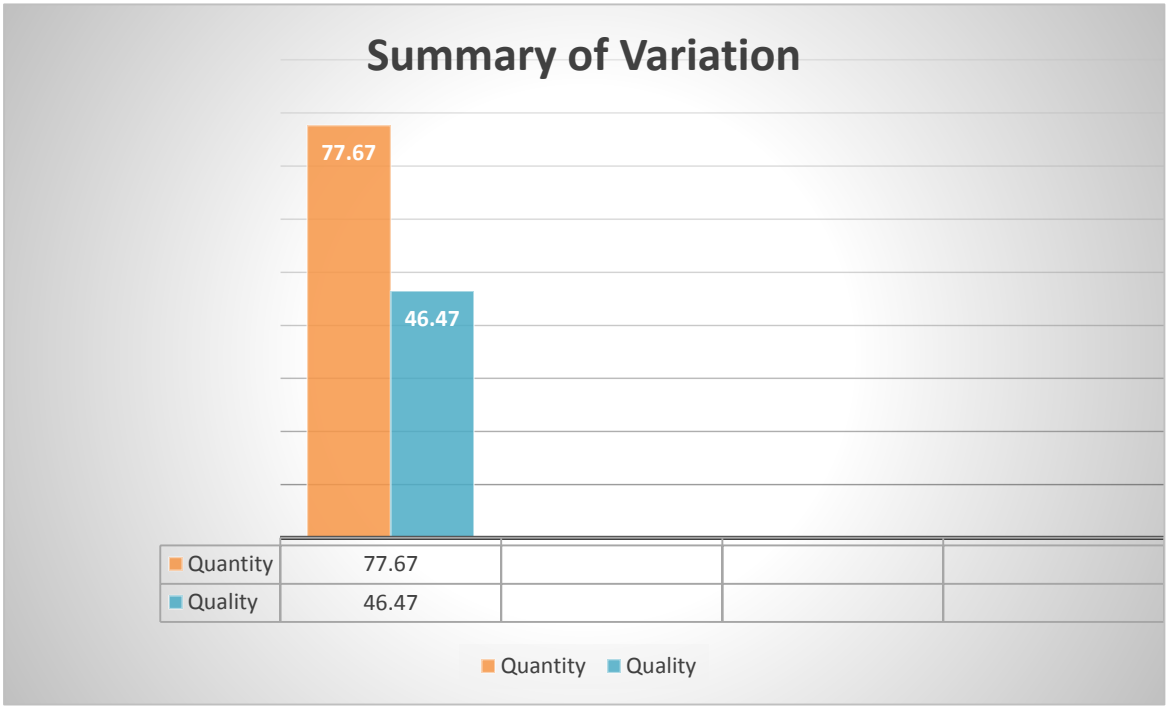

Figure 4.2 Summary of modification in changing order

In general, any modification (addition, omission or substitution) can bring variation order in any construction projects. According to the respondents of the selected projects in the study area, the result was ranked (78.33 %) addition, (52.33 %)substitution and omission (50.67 %) As the result of respondents indicated, the majority of variation order was seen occurred as an addition (figure 4.3).

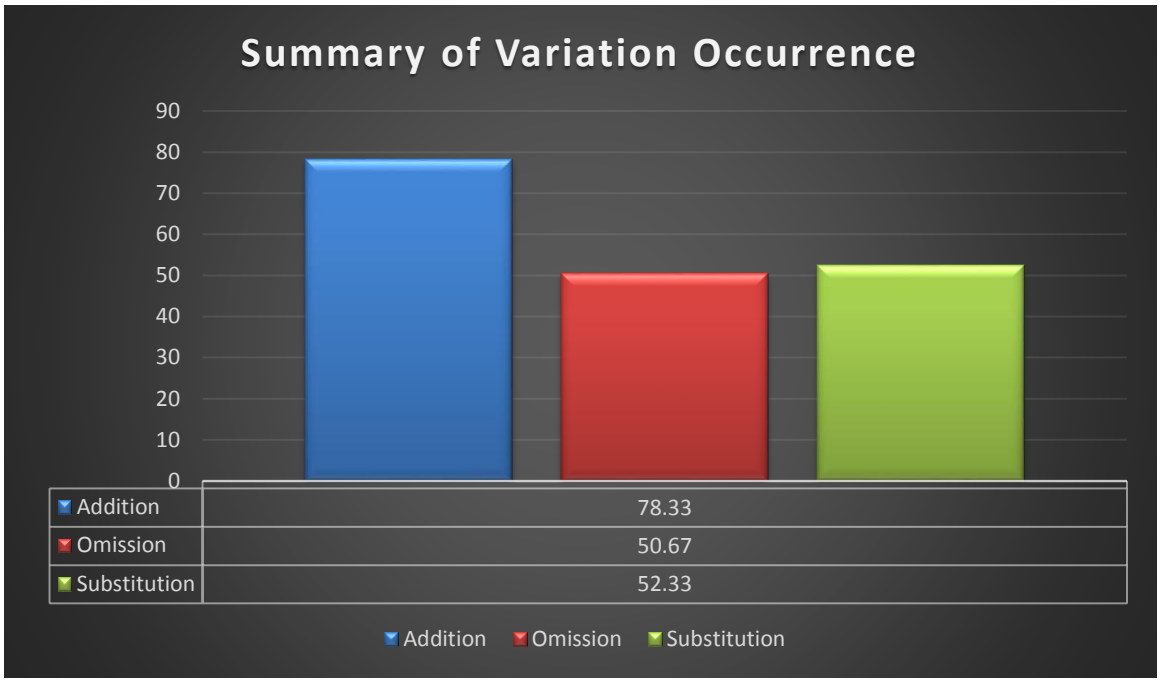

Figure 4.3 Summary of occurrence of variation order

4.1.4. Impact of Variation order

As noticed in the table 4.6,the respondents agreed that (72 %) has impact on financial capacity of the client,(70.33%)on schedule of the project, (67.67%) On payment time and Scope of the projects,(62.67%) coordination b/n parties,(59.33%)on design of the projects and (59.58%) quality of the projects.The impacts of variation order ranked according to the respondent agreed.As interviewee responded, the impacts of variation order were delaying on the completion time of the projects, incurring unexpected and additional cost on the client, sometimes wastage of resource and time.

This indicated that the significant (major) impacts of variation order influencedthe financial capacity of the client in the Jimma Zone of public buildings.

Table 4.6 Impact of Variation order

No	Descriptions	RII	Rank
1	On financial capacity of the client	72.00	1
2	On schedule of the project	70.33	2
3	On payment time	67.67	3
4	Scope of the projects	67.67	3
5	Coordination b/n parties	62.67	5

6	On design of the projects	59.33	6
7	Quality of the projects	46.33	7

4.1.5. Minimizing Mechanisms of Variation Order

Causes and impacts of variation order were interpretedbased on the results in the table4.3 and 4.4. As explained in chapter 3 variation order is a common problem. Thisproblem has to be minimized on public buildings. Therefore,respondents have given their response of minimization mechanism(table 4.7).

According to respondents view points,(80%) the design and bid documents of the project must be prepared by well-experienced consultants or concerned bodies,(80%) the client must be capable in financial capacity and provide a clear brief scope of works before tender awarded ,(79.67%)before tender awarded, bid document has to revise again & again for the correctness of document & design, (79.00%) the condition of the site including detail investigations of the soil, must be well observed to forecast and overview unforeseen situations,(78.67%)complete the drawings at tender stage,(70.33%)during preparation of design and BOQ as well as other bid documents enough time must begiven, (69.33%)avoiding delaying & complete on schedule(67.00%)the site of the project must be free from any obstruction,(66.33%)availability of construction materials,(65.67%)supervision works with an experienced and dedicated Engineers for the projects,(64.67%) well experienced and capable contractor and ,(52.00%) negotiation between parties during construction for the things which create dispute &Enhance communication between all parties,. In general, the above cases are arranged according to the respondent's view and ranked as their importance value. Therefore, all parties should have to focus on minimization mechanism ranking value to minimize the problems.

The interviewee suggested that public body and other stake holders should be involved in design review during preliminary period, design and bid documents must prepared by well experienced consultants or other bodies, to minimize variation orderson public building projects.

Table 4.7 Minimizing Mechanisms of Variation Order

No	Descriptions	RII	Rank
1	The client must be capable in Financial capacityand provide a clear brief scope of works before tender awarded.	80.00	1
2	The design and bid documents of the project must be prepared by well-experienced consultants	80.00	1
3	During the preparation of design and BOQ as well as other bid documents enough time must give	79.67	3
4	. Before tender awarded, the bid document has to revise again & again the correctness of document & design	79.67	3
5	The condition of the site including detail investigations of the soil, must be well observed to forecast and overview unforeseen situations	79.00	5
6	Complete the drawings at tender stage	78.67	6
7	Avoiding delaying & complete on schedule	69.33	7
8	The site of the project must be free from any obstruction	67.00	8
9	Availability of construction materials	66.33	9
10	Supervision works with an experienced and dedicated Engineers for the project	65.67	10
11	Well experienced and capable contractor	64.67	11
12	Negotiation between parties during construction for the things which create dispute &Enhance communication between all parties	52.00	12

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

The objectives of this research study was to determine the main causes,to identify the most frequently occurred, to examine the major impacts of variation orderand to determine the mechanism of minimizing the variation order on public buildingconstructions in Jimma zone.Based on purposivesampling methodregarding specific objectives the results in chapter 4 were arranged and concluded in this chapter.

The causes of variation orders were numerous according to the respondentsresponse,from these causes, the main top five were errors and omissions in design as well as in other documents, change of client interest,modification in design, change of plans or scope and shortage of time during preparation of design and BOQ or bid document werethe main causes that should be given attention from planning the project up to tendering stage. Therefore, the client must prepare himself in financial as well as scope of project.

According to the research respondents, variation order occurred in all sub-structure and supper structure of the selectedprojects.Butin supper structure partsvariation order occurred frequently. Under this part different works are there and in these works variation order frequently occurred in Concrete work,reinforcement, finishing, metal work, block work, carpentry & Joinery work. Especially during preparation of specification care for quantity is the mandatory because the respondents confirmed that the majority of variation wereoccurred in quantity(addition).

The study results show that, variation order has impacts and influence on financial capacity of the clients.This incur additional costs to the projects and shortage of budget was seen. It impacted on schedule of the projects that completion date of these projects was extended because of additional work.Scope of the projects can be decrease or increase as variation order seen in construction. Payment time was very late because of the adjustment of costs of these buildings. Variation order has impact on Coordination between parties during adjusting the cost.

Causes and impacts of variation order has to minimize to decrease the problems faced because of variation order happened. According to the respondents, minimization

mechanisms were indicated.In construction industry, clients, consultants, and contractors are involved on construction process during construction period of public buildings.The three parties must be participate in construction according to their role to run construction process in a proper ways.The clients must be capable in financial capacity and provide a clear brief scope of works before tender awarded.In the study of the causes of variation order,errors and omissions in design as well as in other documentshas high rate. If the clients provided clear scope and brief design with sufficient budget for the project, variation order will be minimized. The design and bid documentsof the projects must be prepared by well-experiencedand capable bodies. Before awarding tender, bid documents have to be revised again & again for the correctness of documents& design. The correct documents minimize variation order.The condition of the site including detail investigations of the soil, must be well observed toforecast and overview unforeseen situations. Sometimes the actual condition of the site taken highlighted for the proposed project not detailed, this leads to variation order.

Therefore, variation order has to be minimized baed on the identified causes to minimize its impacts according to the given recommendations.

5.2. RECOMMENDATIONS

- The client must be capable in financialand provide a clear brief scope of works before tender awarded to avoid the change of client interest on the fixedproject.
- Owner of the projects should invitedifferent stake holders who have good experience to review the project design.
- The design and other bid of document shall beprepare by experienced and capable regarded bodies.
- Time for the preparation of design and other document shall be enough also owner should ensure the design and specification fall within the allocated budget.

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APPENDIXES

Questionnaires

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MSc.in Construction engineering and Management

Questionnaires prepared for Clients, Contractors and Consultants (Services as consultants) the aim of this survey is to collect information on the title of **assessment cause and impact of variation order on public building constructions in Jimma zone**. The prepared questionnaire is only for the academic purpose and the information obtained from the respondents shall be treated with confidentiality. Your response is very important for the success of the study because all information that you provide determines the analysis, conclusion and recommendation of the research. You are kindly requested to give your response by ticking the mark (√) in the given tables to give your opinion. No need to write your name. I would like to thank you for your cooperation.

Part I:-Background information about the respondents

Instruction:- In order to answer the following questions, tick the appropriate answer (√) in the boxes located in front of your choice.

1. Educational level:- Diploma ☐, First degree☐, Second degree ☐, PHD ☐

2. For how long have you been engaged in construction activities?

1-5years☐, 6-10years☐, 11-15years☐, 16-20years☐, 20years and above☐

Part II

The Likert Scale questions

Type I

A. In your experience during public buildings construction, in which part of buildings variation order occurred more? The rank will be relative to each other.

1=No occurrence seen, 2=Low, 3=Medium, 4= High, 5=Very high

No	**Parts of construction**	**Ranking order**				
		1	2	3	4	5
1	Sub-structure					
2	Supper structure					

1. Sub-structure

2. 1=No occurrence seen, 2=Low, 3=Medium, 4= High, 5=Very high

No	**Parts of construction**	**Ranking order**				
		1	2	3	4	5
1	Earthwork					
2	Concrete work					
3	Reinforcement					
4	Formwork					
5	Masonry work					

3. Supper structure

4. 1=No occurrence seen, 2=Low, 3=Medium, 4= High, 5=Very high

No	**Parts of construction**	**Ranking order**				
		1	2	3	4	5
1	Masonry work					
2	Formwork					
3	Concrete work					
4	Reinforcement					
5	Block work					
6	Roof					
7	Carpentry and Joinery					
8	Metal work					
9	Finishing					
10	Sanitary work					
11	Electrical work					
	Specify if others					

1. To identify the **causes** of Variation Orders on Project Performance in public building projects tick by the sign (√) in the table provided below

1= Never, 2=Low extent, 3=Medium, 4=High extent, 5=Very high extent

No	**Descriptions**	**1**	**2**	**3**	**4**	**5**
1	Change of plans or scope					
2	Change of schedule					
3	Financial problems					
4	Modification of design					
5	Ambiguous and complexity in design					
6	Inadequate working drawing details					
7	Conflicts between parties					
8	Unavailability of skilled workforce					
9	Errors and omissions in designaswell as in other documents					
10	Participating on tender without visiting condition of the site.					
11	Shortage of time during preparation of design and BOQ or bid document					
12	Poor procurement process					
13	Bid document prepared by un experienced Engineers.					
14	Change in economic conditions in the country					
15	Unforeseen problems					
16	Conflicts between contract documents					
17	Change in government regulations					
18	Change of client interest					
	Specify if others					

2. To identify the **impacts** of Variation Orders on Project Performance in public building projects tick by the sign (√) according to the weight of impact in the table provided below 1=No impact, 2=Low impact, 3=Medium impact, 4= High impact, 5=Very high impact

No	**Descriptions**	**1**	**2**	**3**	**4**	**5**
1	On schedule of the project					
2	On financial capacity of the client					
3	Quality of the projects					
4	Coordination b/n parties					
5	Scope of the projects					
6	On payment					
7	On design of the projects					

2. To minimize Variation Orders on Project Performance in public building projects tick by the sign (√) according to the rank of the importance in the table provided below

1 = unimportant**,** 2 = less important, 3=important, 4 = very important, 5=very high important

No	**Descriptions**	**1**	**2**	**3**	**4**	**5**
1	Supervision works with an experienced and dedicated Engineers for the project.					
2	The client must be capable in Financial capacity and provide a clear brief scope of works before tender awarded					
3	The site of the project must be free from any obstruction					
4	The condition of the site including detail investigations of the soil, must be well observed to minimize unforeseen.					
5	Negotiation between parties during construction for the things which create dispute &Enhance communication between all parties					
6	Well experienced and capable contractor					

7	The design and contract documents of the project must be prepared by well-experienced consultants.					
8	Before procurement, contract document has to revise again & again the correctness of document & design					
9	Complete the drawings at tender stage					
10	Avoiding delaying & complete on schedule					
11	Availability of construction materials					
12	Forecast to overview unforeseen situations					
13	Once the tender is awarded, make no changes to the specifications					
14	During preparation of design and BOQ as well as other contract documents enough time must given					
	. If other, please specify					

5. Based on your experience, out of the following parties listed below, **whose role cause**for variation orders in public building constructions for the following descriptions. If you believe in it, you can tick more than one causes for one description.

1= Client, 2= Consultant, 3= Contractor

No	**Descriptions of causes**	1	2	3
1	Change of plans or scope			
2	Change of schedule			
3	Financial problems			
4	Modification of design			
5	Ambiguous and complexity in design			
6	Errors in design			
7	Poor procurement process			
8	Change in government regulations			
9	Change in economic conditions in country			
10	Unforeseen problems2			
11	Conflicts between parties			
12	Participating on tender without visiting condition of the site.			
13	Bid document prepared by un experienced Engineers			
14	Conflicts between bid documents			
15	Shortage of time during preparation of design and BOQ or bid document			
	If other, please specify			

When the variation order is summarized tick according to the level of their occurrence

1=Very low variation, 2=Low variation, 3=Medium variation, 4= High variation, 5=Very high variation

No	**Type of modifications done on variation**	1	2	3	4	5
1	Quantity					
2	Quality					
3						

1=Very low variation, 2=Low variation, 3=Medium variation, 4= High variation, 5=Very high variation

No	**Types of variations**	1	2	3	4	5
1	Addition variation (added variation)					
2	Omission variation (omitted variation)					
3	Substitution variation (substituted variation)					

Thank you for your cooperation

Interviews

To identify the causes and impacts of variation orders on public building constructions in Jimma zone, the researcher will use the interviews to collect data.

1. From your experience, what are the causes of variation orders on public building projects?
2. What are the reasons that force to change the design, scope and schedule of the project during construction?
3. What are the impacts of variation order in public building?
4. What do you suggest to minimize the variation orders on public building projects?
5. The bid document including design is papered by whom? Which one is preferable to minimize variation orders?
6. Do you believe that modification change order GCC has contribution to variation orders? If you believe, which article has a contribution to variation orders?

Thank you for your cooperation