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

ASSESSMENT OF VARIATION WORK ORDER ON BUILDING PROJECT PERFORMANCE AT JIMMA UNIVERSITY

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

By

Birhanu Alemayehu Asfaw

December, 2022
Jimma, Ethiopia

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Advisor: Dr. Lucy Feleke _____

Co-Advisor: Engr. Abebe Eshetu _____

December, 2021
Jimma, Ethiopi

DECLARATION

I declare that this research entitled **"**Assessment of variation work order on building project performance at Jimma University" is my original work and has not been submitted as a requirement for the award of any degree in Jimma University or elsewhere

.

Birhanu Alemayehu Asfaw _____ _____

NAME SIGNATURE DATE

As research Adviser, I hereby certify that I have read and evaluated this Proposal paper prepared under my guidance, by Dr. Lucy Feleke entitled "Assessment of variation work order on building project performance at jimma university " and recommend and would be accepted as a fulfilling requirement for the Degree Master of Science in Construction Engineering and Management.

Advisor: Dr. Lucy Feleke _____ _____

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ABSTRACT

Variation is inevitable in construction projects due to the complex nature of the construction industry. It is common in all types of construction projects and it determines the time limits and anticipated budget of the projects. Variation order is observed as one of the most frequently occurring issues in construction projects in Ethiopia.

This study investigated the variation orders on public building projects at Jimma University. The study is to identify the main causes of construction variation orders in public building construction projects in Jimma University; to assess the impact of construction variation orders on public building construction projects in Jimma University; and evaluate the positive and negative impacts of variation order on each sector and forward recommendations to effectively control and manage construction variation orders. This research relied mainly on analytical descriptive methodologies. Furthermore, the questionnaire was designed in the light of the literature review and tested by a pilot study, and then it is applied to a sample of 9 contracting in Jimma University. The collected data is manipulated by Excel and SPSS software using many statistical tools such as frequencies, mean score, Cronbach's alpha, relative importance index, and correlation coefficient tests.

The results indicated that change of plans or scope, inadequate shop drawing details, and ambiguous design details were the most causes of variation orders. The results also showed that increase in project cost, increase in overhead expenses, and delay in payment were the most impact of variation orders. The findings also suggested the most recommended strategies to minimize variation orders. These strategies were to produce a concluding design and contract document, to complete drawings at tender stage, and to supervise the works with experienced and dedicated supervisor to minimize variation orders on public building projects.

Key words: Variation order, cause, impact and recommendation

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ABBREVIATION

GCC	General Condition of contract
JiT	Jimma institute of technology
JU	Jimma University
RII	Relative importance index
SCC	Special condition of contract

CHAPTER ONE

INTRODUCTION

1.1. Background

The implementations of public projects are expected to provide further thrust to the construction sector. Therefore, it is important to ensure these projects are being implemented successfully without any major problems while minimizing the adverse impacts of variation orders on the project outcome. Variation orders are issued to correct or modify the original scope of work because changes during construction of projects are unavoidable. As the number of variation orders on a project increases, so does the possibility of misunderstanding among the contracting parties. Such a misunderstanding may occur because one or more of the parties lacks full knowledge of the variation order process itself, the costs involved in implementing changes, or the delays, conflicts, and interruption of the construction sequence and schedule which can adversely impact project coordination. Previous studies on variation orders are mainly focused on the causes of variation orders. Many times delays, cost overrun and quality defects of a construction can be attributed to variation at various stages of the project. Variation orders have an impact on overall project performance (Ruben, 2008). This is because variations can cause substantial adjustment to the contract duration, total direct and indirect cost, or both. Variation orders involved alteration, addition, omission, and substitution in terms of quality, quantity and schedule of work. 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, C. Williams, Lee,S., and Li, M., 1998). The work of (Ming, S., et. Al., 2004) 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. In most countries the occurrence of variation orders on building project seems usual. Variations and conflicts in construction projects, at work, and even in our daily lives are very common (Arain, F.M. & Pheng, L.S. , 2006). Due to general background of the problem in the construction industry and the specific problem within

the public buildings, there was a cause for the study. The objective of this study is to assess the impact of variation orders on public building projects. There are many projects which are being implemented in Ethiopia. In order to achieve the stated objective of the study, the scope would be too large to tackle. Therefore, the study was limited to Jimma University, which is one of university which is found in south western Oromia Region in Ethiopia where many public building projects are under construction.

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 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, (C. William, I., et. al., 2001). 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, and excess quantity during construction.

According to (Andualem, E. Y., 2004) 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, F. a., & Pheng, L., 2005). Therefore; one can conclude that variation order occurs everywhere in most construction projects and follows big problems.

However, studies showed the inevitability of variation 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.

1.3. Research Question

The research questions were

1. What are the major causes of construction variation that are prevalent in public building projects?
2. What are the significant impacts of variation order in public building projects performance in JU?

1.4. Objectives of the Study

1.4.1. General objective

- ✓ The general objective of this study to assess variation work order on project performance at building project.

1.4.2. Specific objective

1. To assess the major causes of construction variation on public building projects
2. To identify the main variation work order impact on project performance in Jimma university
3. To evaluate the impact on all sectors, they worked with variation order in Jimma university project

1.5. Significance of the Study

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

1.6. Scope and Limitation of the Study

This study is to identifying the impacts of variation order in public building projects. However, the title covers wide concepts and is very difficult to address in a single study. Therefore, this study identify the impacts of variation order on building construction sites in Jimma University.

The scope of the research is mainly focused on literature review and questionnaire survey. The questionnaire survey designed based on the impact of variation order on building construction. It is carried out through quantitative method through questionnaire and literature review and in the qualitative description. The respondents for this research involve consultants, clients, and contractors and the desk study is limited to building projects in Jimma University.

CHAPTER TWO

LITERATURE REVIEW

The aim of this chapter is to present a brief review for the available information concerning the variation work order nature and impact on building project. The review considers the following aspects:

2.1. Nature of variation orders

The nature of variation orders can be determined by referring to both the reasons for their occurrence and subsequent effects. (Arain, F.M. & Pheng, L.S., 2005b) Distinguished two types of variation orders, namely: beneficial and detrimental variation orders.

2.1.1 Beneficial variation orders

A beneficial variation order is one issued to improve the quality standard, reduce cost, schedule, or degree of difficulty in a project (Arain, F.M. & Pheng, L.S., 2005b). It is a variation order initiated for value analysis purposes to realize a balance between the cost, functionality and durability aspects of a project to the satisfaction of clients.

Value analysis is an organized approach to the identification and elimination of unnecessary costs which are defined as costs which provide neither use, nor life, nor quality, nor appearance, nor customer features (Kelly, J. & Male, S., 2002). Value analysis describes a value study of a project that is already built or designed and analyses the product to see if it can be improved (Zimmerman, W.L. & Hart, D.G., 1982). Therefore, a variation order is beneficial if it is initiated to enhance the client's value. Among others, the client's value system elements include time, capital cost, operating cost, environment, exchange or resale, aesthetic/esteem and fitness for the purpose (Kelly, J. & Duerk, D., 2002). A beneficial variation eliminates unnecessary costs from a project. According to (Zimmerman, W.L. & Hart, D.G., 1982) all designs have unnecessary cost regardless of how excellent the design team may be. A

beneficial variation order, therefore, seeks to optimize the client's benefits against the resource input by eliminating unnecessary costs. These benefits are understood to be the satisfaction of perceived needs for the development project that include social, economic and commercial aspects. Impliedly, a beneficial variation is initiated in the spirit of adding value to the project. However, it should be noted that regardless of how beneficial a variation order might be non-value-adding costs are likely to accrue as a result. For example a variation order to solve the discrepancies between contract documents involves the abortion of works that have already been executed. Cost for aborted works should not have been incurred if discrepancies were not found between contract documents.

2.1.2 Detrimental variation orders

A detrimental variation order is one that negatively impacts the client's value or project performance (Arain, F.M. & Pheng, L.S., 2005b). Arguably, a detrimental variation order compromises the client's value system. A client who is experiencing financial problems may require the substitution of quality standard expensive materials for substandard cheap materials. For example, on a construction project situated in a salty environment, steel window frames result in steel oxidation if selected in place of timber or aluminum frame.

2.2.3 Introduction on agents of variation orders

While variation orders are common in construction projects, an improved understanding would require their categorization into their root or origin agents and causes. The cognizance of the origin agent consists of the identification of the initiator of the variation orders. A study that focused on the point of view of developers of potential causes of variation orders suggested three main origin agents of variation orders (Arain&Pheng, 2006). These included "client", "consultant", and "contractors “. There is an interrelation between the origin agent and causes of variation orders.

2.1.4 Origin agents

- **Client**

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 utilization 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 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, minimizing the chance of them changing their minds 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.

- **Consultant**

Traditionally, clients have been relying on the expertise of the architect whose responsibility would be to carry out the design and supervise the works on site. 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 labor and plant while waiting for the consultant's decision. Acharyaet 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. Acharyaet al. (2006) accused consultants of protecting their interests at the expense of the interest of the client and the contractor. 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 is different from the perceived one. As a consequence, variation orders will be issued to ensure compliance with the requirements of 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, Acharyaet 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 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. Arainand 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 an 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 as omissions in the design but also provide an opportunity for professionals to review the contract documents thoroughly which would help in eliminating the variation orders arising because of conflicts in the contract documents.
- The control of the frequent changes in design by a consultant, and inadequate 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 various occurrences during the construction phases where the impact of variation order can be severe.

- **Contractor**

It is common for a contractor to be the origin agent of variation orders. Sweeney (1998) advised that in 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 review that problem, discuss the additional costs to correct the situation, agree on a price, and authorize 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 (Acharyaet al., 2006). The problem would have been avoided if the contractor had been experienced and aware of possible adverse situations. Variation 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.

2.3 Causes of Variation Orders

Change of schedule: A change of schedule during the project construction phase may result in a major reallocation of resources. A change in schedule means that the contractor will either be required to provide additional resources or keep some resources idle. In both cases, the additional cost is incurred (Fisk, 1997; O"Brien, 1998).

Change in scope: Change of plan or scope of the project is one of the most significant causes of variation in construction projects (CII, 1990b). It is usually the result of inadequate planning at the project definition stage or because of a lack of involvement of the owner in the design phase (Arainet al., 2004).

Owner's financial problems: The owner"s financial problems can affect project progress (Clough and Sears,1994; O"Brien, 1998). This problem often leads to changes in work schedules and specifications, affecting the quality of the construction.

Impediment to prompt decision-making process: Prompt decision-making is an important factor for project success (Sanvidoet al., 1992; Gray and Hughes,2001). Failure

to make the decision efficiently may result in a delay, causing the need for the change order due to cost increments.

Obstinate nature of the owner: A building project is the result of the combined efforts of the professionals involved, which have to work at the various interfaces of a project (Wang, 2000; Arainet al., 2004). If the owner is obstinate then this could cause major variations at the later stages of a project.

Change in specifications by the owner: Changes in the specification are a common phenomenon in construction projects with inadequate project objectives (O"Brien,1998). If these changes in the specification of the design or requirement are carried out, this leads to variations in the construction phase.

Change in design by the consultant: A change in design improvement by the consultant is a norm in contemporary professional practice (Arainet al., 2004). Changes in design were frequent in projects where construction starts before the design is finalized (Fisk,1997). Such changes affect the project in various ways depending on the timing of the change.

Conflicts among contract documents: Conflict between contract documents can result in misinterpretation of the actual requirement of a project (CII, 1986). The contract documents must be clear and precise. Insufficient details in the contract documents may result in delays to the project completion or cause variations in cost.

Design complexity: Complex designs require unique skills and construction methods (Arainet al., 2004). Complexity affects the flow of construction activities, whereas simpler and linear construction works are relatively easy to handle (Fisk, 1997).

Inadequate working drawing details: To convey a complete concept of the project design, the working drawings must be clear and concise (Geok, 2002). Inadequate working drawing details can result in misinterpretation of the actual requirements for the project (Arainet al., 2004), causing variations in the project.

Change in specification by the consultant: Changes in the specification are observed frequently in construction projects (O‟Brien, 1998). Changes in specification result in variations to the project, leading to delays and increased overall cost.

Unavailability of equipment: Unavailability of equipment is a procurement problem that can affect project completion (O‟Brien, 1998).

Shortage of skilled manpower: Skilled manpower is one of the major resources required for technological projects (Arainet al., 2004). Variations and delays may occur due to shortages of skilled labor.

Contractor's financial difficulties: Construction is a labor-intensive industry. Whether the contractor has been paid or not, the wages of the worker must still be paid (Thomas and Napolitan, 1995). If a contractor experiences financial difficulties during a project, it may result in lacking resource availability. Consequently, the progress of the project is affected which may require variation and extension of time. Poor workmanship: Defective workmanship may lead to demolition and rework in construction projects (Fisk, 1997; O‟Brien, 1998). This results in delays and increased costs. Poor procurement process: Procurement delays have various adverse effects on other processes in the construction cycle (Fisk, 1997). Other processes in the construction cycle are affected by poor procurement processes. Consequently, variations are required. Lack of strategic planning: Proper strategic planning is an important factor for the successful completion of a building project (Clough and Sears, 1994). The lack of strategic planning is a common cause of variations in projects where construction starts before the design is finalized (e.g., in concurrent design and construction contracts) (O‟Brien, 1998). Inadequate design: Inadequate design can be a frequent cause of variations in construction projects (CII, 1990a; Fisk, 1997). Various causes of variation orders reviewed from different literature are shown in 2.1 table.

Table 2.1 Causes of variation orders

No	Causes of variation orders
1	Change of plans or scope
2	Change of schedule
3	Change in specifications
4	Change in design
5	Errors and omissions in design
6	Incomplete design
7	Non-compliant design with government regulations
8	Unforeseen problems
9	Replacement of materials or procedures
10	Inadequate shop drawing details
11	Lack of judgment and experience
12	Financial problems
13	Inadequate scope of work for one or more parties to the contract
14	Design complexity
15	Lack of communication
16	Defective workmanship
17	Design discrepancies
18	Inadequate project objectives
19	Long lead procurement
20	Lack of coordination
21	Ambiguous design details
22	Unavailability of skills
23	Weather conditions
24	Lack of strategic planning
25	Lack of knowledge of available materials and equipment
26	Lack of involvement in the design of one or more parties in the contract
27	Non-compliant design with owner's requirement

28	Health and safety considerations
29	Lack of a specialized construction management
30	Obstinate nature of one or more of the parties to the contract
31	Differing site conditions
32	Poor procurement process
33	Conflicts between contract documents
34	Lack of required data
35	Unavailability of equipment
36	Unfamiliarity with or unawareness of local conditions
37	Socio-cultural factors
38	Change in government regulations
39	Technology change

2.4. Possible impacts of variation orders

Variation orders affect the cost, time, and quality of the construction project. In addition, variation orders may get to an extent of disputes among the parties to the construction projects. Moreover, variation orders are also proved to affect the health and safety conditions of a construction project.

2.4.1 Impact on cost

Variations add to the total cost of a project (Brahts, 1980). Variations in the scope of work may exceed the cost of the immediate change itself, (Fisk, E.R. and Reynolds, W.D., 2010). (Levy, 2012) (Enshassi, A, et. al., 2010), informs that there are direct and indirect costs to a construction project that result from variation orders. Direct costs constitute the additional costs incurred to perform the activities of the current variation orders and include: i) resources used including labor, material, plant, as well as transportation, to carry out the actual variation orders; ii) increase in overheads related charges and professional fees; iii) cost of resources that were used to carry out the terminated or substituted works; iv) cost of demolition of terminated or substituted works; and v) cost for resources lying idle before the ordered task restarts. The process

and implementation of variations in construction projects would increase the overhead expenses for all the participants concerned, (Arain, F.M. & Pheng, L.S., 2005). Overhead charges are normally provided from the contingency fund allocated for the construction project. Indirect costs are those incurred as a result of the occurrence of variation orders and include: i) change in cash flow; ii) loss of productivity; iii) cost for redesign and administration of variation order; iv) litigation-related costs in case disputes arise due to variation orders, v) cost of premiums for bonds and insurances, permits, fees, sales, and use tax, and vi) additional cost of supervision and field office personnel directly attributable to the variation. Variation orders also lead to delays in payment. If the main contractor was not paid due to variations, he or she in turn will not be able to pay his or her subcontractors.

2.4.2 Impact on time

Variation orders ultimately change the schedule of construction works and often result in time delays. In addition, (Twort, A.C. & Rees, J.G., 1995) state that extensive variations can make the contractor's task of constructing the works to his original program impossible, and therefore result in completion time changes. (Kwakye, AA, 1997) Argues that variation orders especially additional work disrupt production and construction programs. (Wambeke, B.W., Hsiang, S.M., & Liu, M., 2011) Studied two types of variations about time and the variations are; the starting times variation and the task duration variation. The starting time variation is the difference between the planned and actual starting times of a task on a weekly work plan. The task duration variation is the difference between the planned and actual task duration. Amongst many causes of variations identified by (Wambeke, B.W., et. al., 2011) that resulted in time delays were lack of crew skills/experience, the quality of documents, (errors in designs and/or drawings), weather impacts, etc. Often, the execution of a variation order involves slowdowns or delays in the contractor's operations, (Fisk, E.R. and Reynolds, W.D., 2010). The study of (Yogeswaran, K., et. al., 1997), informs that the effect of variations on the project time is observed to be considerable; 50% of the projects surveyed for this study had been granted an extension of time due to variations.

2.4.3 Impact on quality

Changes frequently have an impact on the performance of other work that is not in itself changed, (Fisk, E. R., & Reynolds, W. D., 2006). (Fisk, E. R., & Reynolds, W. D., 2006) Further explains that the impact of one phase of work that is being changed on another phase of work that is not being changed refers to the indirect delay or interference. Interferences may lead to quality defects. Hence, it may be assumed that variation orders lead to quality degradation of the construction project.

2.4.4 Impact on productivity

Variation orders have a direct relationship with individual and group productivity, especially in cases of lack of materials and information, as well as the work being out of sequence, (Alsuliman, J., et. al., 2012). In addition, (Arain, F.M. & Pheng, L.S., 2005), inform that interruption, delays, and redirection of work that are associated with variation orders hurt labor productivity. The impact of variation orders on productivity has been studied by many researchers; (Ibbs, W., K., Y. Ng, T., & Odabasi, M, 2003) "Construction Change: Likelihood, Severity, and Impact on Productivity". According to the study; Variation orders productivity Overtime: A Primer for the Construction Industry, outlined by (Levy, 2012) shows the impact of some types of variation orders on labor productivity include: stacking of trades: Multiple operations in physically limited space impact productivity from 10 to 30 % depending on weather it is minor or severe; morale and attitude: Multiple contract variations, disruption of labor rhythm, and competition for overtime can negatively impact productivity from 5 to 30 % for loss of morale; reassignment of manpower: Moving men off one task to another when variations occur can damage productivity as much as 15 %; crew size inefficiency: Adding new workers to an otherwise productive team affects labor rhythm; concurrent operations: Stacking of the contractor's own crew and adding new operations to an already planned sequence, unless a gradual and controlled process is implemented, will result in a loss productivity from 5 to 25 % whether minor or severe; dilution of supervision: If supervision must be shifted, or new foremen or journeymen must be instructed to supervise both basic and proposed changes, efficiency of operations will be affected by as

little as 10 % or as much as 25 %; learning curve: There will be a period when orientation to a new area and new work will require some time to acclimate to this new environment. Loss of productivity can range from 5 to 30 %; errors and omissions: When they are encountered, they are usually dealt with on a crash basis, and can create out-of-sequence work with diminished supervision. Minor situations result in minor losses (1 %), and major problems raise the level of inefficiency to 6%; beneficial occupancy: Crews having to work around a client's partial move-in activities can be disruptive. Loss of productivity to the contractor's crews can range from 15 to 40%; joint occupancy: Work being performed by other trades, possibly those employed by the client, results in a 5 to 20% loss; site access: Interference with planned work areas, poor man-lift management, and congested areas can affect productivity as much as 30%; logistics: When client-furnished material begins to flow uncontrolled into contractor work areas, contractor productivity can be reduced by as little as 10% and as much as 50%. When the ordered variations require new materials, tools, and equipment, they will result in delays, (Arain, F.M. & Pheng, L.S., 2005);

2.4.5 Impact on contractual relationships

Variation orders on construction projects can cause serious problems and (Kwakye, AA, 1997) discusses that when problems are not immediately solved as they arise, they can become major issues that will eventually end up in court or before an arbitrator for resolution. Additionally (Fisk, E.R. and Reynolds, W.D., 2010) argue that constructive changes are a major source of construction disputes. A constructive change arises when the contractor alleges that the client has acted, or failed to act, which resulted in a variation in the contract requirements. Disputes concerned with this change revolve around the interpretation of the plans and specifications. The client and his agents interpret the plans and specifications in such a way that they benefit the project, whilst the contractor read the plans and specifications in a manner that will minimize performance costs. Frequent communication and strong coordination can assist in eliminating disputes between professionals, (Arain, F.M. & Pheng, L.S., 2005).

2.4.6 Procurement delay

A revised procurement requests may be required when variations occur during the construction phase of the project (O"Brien, 1998). Arain and Low (2005), feel that variations that require new materials and specialized equipment are the cause of frequent procurement delays. Procurement delays were common effects of variations related to new resources for construction projects (Hester et al., 1991).

2.4.7 Rework and demolition

Rework and demolition are common and frequent due to variations in construction projects (Clough and Sears, 1994). The main effects when variations occur during the construction phase are rework and delays in project completion. Time and resources are wasted when rework and demolition occur. However, it does depends on the timing of the variations as if variations occur during the design phase, no rework or demolition is required on construction sites as things are not constructed yet (Arain and Low, 2005)

All the potential effects of variations are also correlated, resulting in the completion schedule delays in construction projects. The impacts of variation orders reviewed from different literature are shown in table 2.2

Table 2.2 Impacts of variation orders

No	Impacts of variation orders
1	Increase in project cost
2	Progress is affected but without any delay
3	Increase in overhead expenses
4	Quality degradation
5	Rework and demolition
6	Logistics delays
7	Additional specialist equipment/personnel
8	Poor safety conditions

9	Delay in payment
10	Poor professional relations
11	Disputes among professionals
12	Completion schedule delay
13	Complaints of one or more of the parties to the contact
14	The professional reputation of one or more parties adversely affected
15	Damage to the firm's reputation

2.5 Management of variation orders

As previously indicated variation orders are typically issued in the form of contract instructions. According to Segawaet al. (2002), contractual clauses state how variation orders should be initiated. In all cases, variation orders are issued by the consultant and must be given in writing or oral instruction should be subsequently confirmed in writing (Wainwright & Wood, 1983; FIDIC, 1999; Finsen, 2005; JBCC, 2005; Ssegawaet al., 2002). "Writing" includes drawings, faxes, e-mails, telegrams, magnetic tapes, and computer disks in which words and drawings may have been electronically recorded and are capable of being converted to text and drawings on paper or other similar media (Finsen, 2005). Since the contractor is not bound to comply with the oral instructions, all oral instructions have to be confirmed in writing by either the consultant or the contractor. Where variation orders are confirmed in writing by the contractor, the consultant has to confirm by signature. If the contractor is agreeable with the variation order, the works should proceed. The contractor and the consultant agree upon which method of valuation of variation orders should be used. The valuation of variation orders, while seen as an administrative step in the remuneration of changes effected to the contract, is, in reality, a rather complex matter involving a thorough understanding of contractual provisions, costing principles, and an exercise of fair judgment on the part of the values (Harbans, 2003).

The valuation of variation orders may be in the form of:

- Rates where contracted rates are adopted where the varied works are similar and extent and executed under similar conditions to items in the contract bills (Wainwright & Wood, 1983; JBCC, 2005);
- Day works consist of the payment of executed works on a basis calculating the prime cost of works including materials, labor, plant hire, and transport plus a percentage addition as agreed between parties to the contract(Harbans, 2003);
- Quotation where contractors submit a quotation to effect the work contained in a variation order; and
- Quantum merits a miscellaneous method where negotiated or agreed rates or payments are made on a reasonable sum (Harbans, 2003).

2.6 Chapter summery

This chapter reviewed the literature on variation orders and their impacts on project performance. Variation orders can potentially occur on all construction projects. They occur due to several reasons that include changes in design, construction, fabrication, transportation, or operability. Two types of variation orders were identified namely beneficial variation orders that lead to value improvement; and detrimental variation orders that lead to value degradation. Four origin agents for variation orders were identified. These included the client, the consultant, the Contractor, and unspecified "others". A comprehensive list of causes stemming from the four origin agents was developed. The literature suggested that the

- Change of schedule
- Change in scope
- Owner's financial problem
- Impediment prompt decision
- Obstinate nature of the owner
- Change in specification by the owner
- Change in design by the consultant
- Conflict among the contract document
- Design complexity

- Inadequate working drawing detail
- Change in specification by the consultant
- Unavailability of equipment
- Shortage of skilled manpower
- Contractor's financial difficulty
- Poor work man ship
- Lack of strategic planning and
- In adequate design, were factors influencing the occurrence of variation orders on construction projects

The occurrence of variation orders adversely impacts the performance of construction projects by, for example, contributing to cost and time overruns. The frequent occurrence of variation orders can affect the overall quality of work. If not carefully administered, a variation order may give rise to disputes between parties to the contract. From the pieces of literature, a list of effects (impacts) of variation orders was identified

- Progress is affected but without any delay
- Increase in project cost
- Hiring new professionals
- Increasing overhead expense
- Delay in payment
- Quality degradation
- Productivity degradation
- Procurement delay
- Rework and demolition
- Logistics delay
- Damage to the firm's reputation
- Poor safety condition
- Poor professional relations
- Despite among professionals
- Additional payment for contractors
- Completion schedule delay

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter presents and describes the approaches and techniques the researcher was used to collect data and investigate the research problem. These include the study area and period, study design, study variable, study population, sample size and sampling procedure, procedure of data collection, data analysis, ethical consideration, and data quality assurance.

3.1. Study Area and Period

The study conducted at Jimma University which is found in Jimma town have 3 campus in town, Southwestern Ethiopia located 346 km by road southwest of Addis Ababa. This research concerned with all building projects which are active now and done before in the

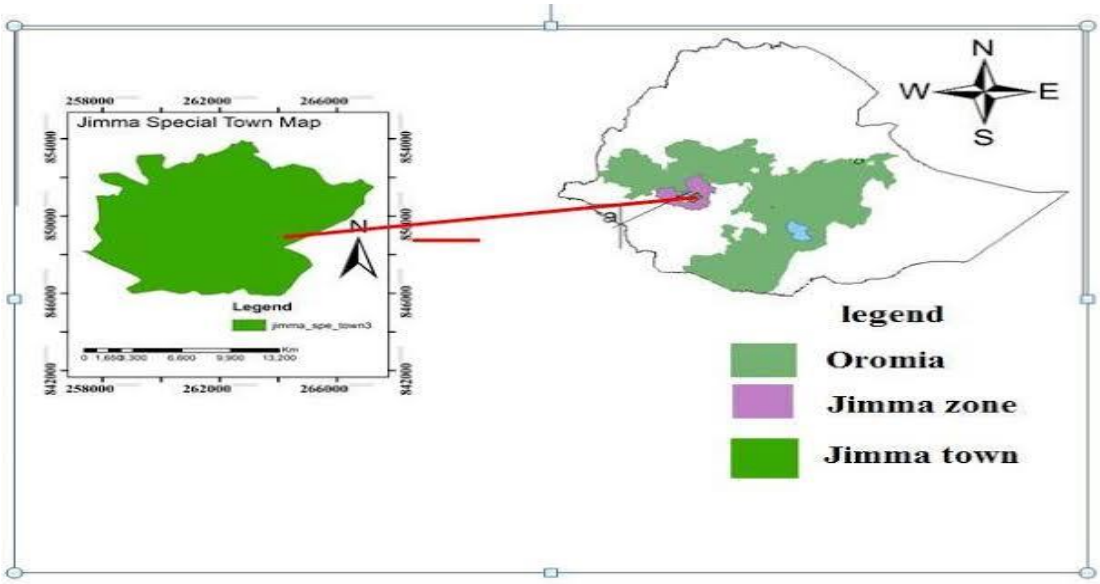

Fig 3.1. Map of Study Area

This research study carried out within the prescribed time frame as per the attached work schedule/plan from August to November 2022. Within the specified period the required research planning, preparation of data collection, sampling and analysis, writing up, and finally dissemination executed.

3.2. Study Design

The research is based on both qualitative and quantitative approaches. The research is analytical. Analysis of the bill of quantity, bill approved by the Client for payment, letters, drawings, specifications, General condition of contract (GCC), a special condition of contract (SCC), and similar documents are analyzed. The claim of the Contractor and time escalation reports are also analyze.

Similarly, a questionnaire survey carry out with structured and semi- structured questions regarding the research objectives. Users having a land plot or building inside the project area are included in the survey. Key informants will interview with semi-structured questions to verify the results of the questionnaire survey.

3.3. Study Variables

3.3.1. Dependent variables

In this research, the dependent variables include the impact of variation work order on building project performance.

3.3.2. Independent variables

In this research, the independent variables are design change, quality change, working area change, procedures of variation order Management, and implementation of variation order Management practice public building projects which are active and done before in the Jimma University compound.

3.4. Population

This research addressed a population of all building projects which were under execution and done before in Jimma University starting from 2008 E.C. and with financial progress greater than 80%.The population size is 5 contractors, 3 consultant and 1client.

3.5. Sample Size and Sampling Procedure

3.5.1. Sample Size

In this study, the questionnaire survey was to all construction professionals from clients, contractors, and consultants who participated during one of the phases of initiation, design, and construction of jimma university building projects.

3.5.2. Sampling procedures

Due to the nature of data to be collected from the relevant parties for the study, a purposive sampling method was adopted to select the population for the study. A combination of qualitative and quantitative approaches use in the study. Due to the nature of data to be collected from the desk study and the expected participants for the survey study, a purposive sampling method was adopted to select the population for the study. The interviewee and the respondents selected depending on their direct exposure to public building project activities. A desk study and questionnaire survey carry out to identify the impacts of variation orders on public building projects. These two units of analysis apply in the study to gather data directly from the concerned population.

3.6 Data collection Process

Data was collected from clients, contractors, and consultants who participated during one of the phases of initiation, design, and construction of university building projects using desk study, and questionnaire survey. The data collected with great care and attention.

3.7. Data Presentation and Analysis

The analysis was depending on the nature and form of the record data. Since the data will record using qualitative and quantitative approaches, the analysis was 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, Z. , 2004)

Descriptive statistical and SPSS software was use to analyze and present the data obtained from the questionnaires and observation.

The data that was obtain from the questionnaire through a Likert scale ranging from 1 (very low) to 5 (very high) analyses using SPSS software and MS EXCEL by Relative Importance Index (RII) formula which is used for ranking possible causes of variation and impact on building construction. Based on the result obtained from the RII calculation, ranking of the attributes in terms of their criticality as perceived by the respondents was done to establish the relative importance of various factors that contribute to variation order in building construction. RII method enables the determination of the relative importance of the various impact of a variation order in building construction projects.

Analysis of data consists of the following:

1) Calculating the Relative Importance Index (RII)
2) Ranking of factors in each category based on the Relative Importance Index(RII)

$$RII = \frac{\sum W}{A*N} \quad \ldots\ldots\ldots\ldots \textit{ equation no-1}$$

Where,

RII = is the Relative Importance Index,

W = weighting given to each factor by the respondents (ranging from 1 to 5),

A = highest weight (i.e. 5),

N = total number of respondents.

The values of RII range from 0 to 1 (0 not inclusive); the higher the RII, the more important the impact of variation on building construction. The RII value ranks and the results are present using tables and/or graphs

The variables are related using scaled items, mean and also validity and reliability of data will check using the Cronbach alpha. In SPSS Cronbach alpha is used for testing the reliability of series items. Cronbach alpha measures internal consistency between items in scale statics. Generally, reliability of more than 0.7 is good reliable.

3.8. Ethical considerations

A copy of the research proposal was submitted to the JU, JIT research coordinating office. Ethical clearance from Jimma University, JIT and permission from respective authorities and verbal consent of respondents‟ was be obtained before the data collection. Before continuing the study, acceptance should be given from local authorities. The purpose of the study was clearly described to the organization.

3.9. Data quality assurance

To improve the validity of the research findings, the triangulation approach will adopt for data gathering. This approach consists of combinations of qualitative and quantitative methods strengthened by the literature review.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 **Introduction**

This chapter analyses the data collected using questionnaires. The collected data from the questionnaires were tabulated and analyzed according to their ranking on Relative important Index (RII).

4.2 **Respondents' Background**

4.2.1 Response rate

The total number distributed to contractors, clients, and consultancies was 30 questionnaires and 24 questionnaires were returned.

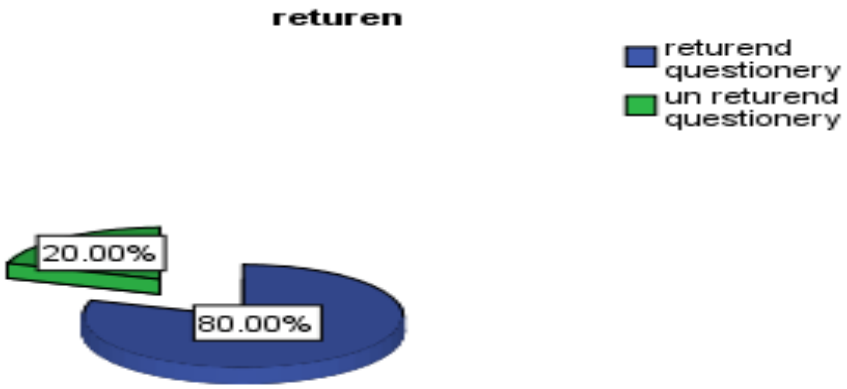

Fig 4.1 response rate

4.2.2 Organization Profile

The target respondents of the questionnaire survey were engineers from different positions in the construction industry at Jimma University. Among the (20.83%)

responses received from clients, (29.17%) were received from the consultant and (50.00%) from the contractor.

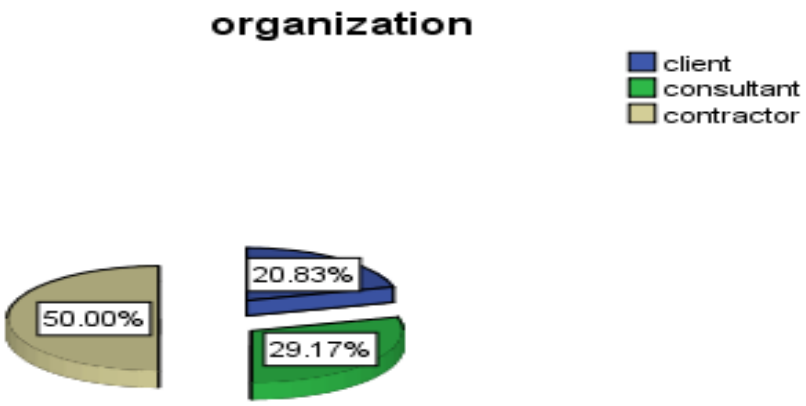

Fig 4.2 Type of organization

4.2.3 Respondents' Position

The target respondents of the questionnaire survey were engineers from different positions in the construction industry at Jimma University. Among the five responses received from clients, One (20%) of them were project office or while Four (80%) projected follow-up engineers. Among the Seven responses received from consultants, one (14.29 %) was assistance resident engineers, three (42.86 %) were resident engineers and three (42.86 %) were office engineers. And among the Twelve received from contractors, three (25%) of them were site engineers, five (41.67%) of them were office engineers, four (33.33%) were project engineer

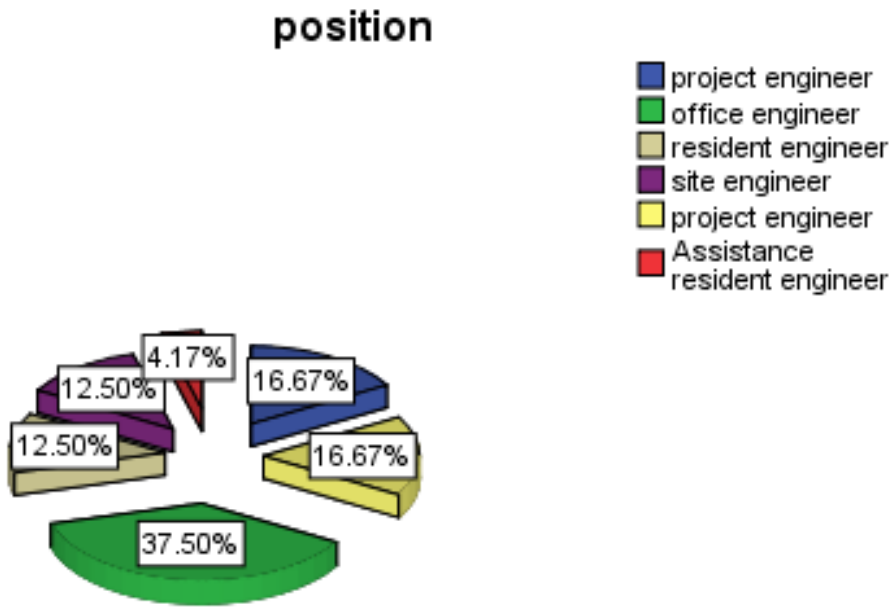

Fig 4.3 Respondent profile

4.2.4 **Respondents' Experience**

The respondents have different levels of work experience in building projects 16.67 % (4) of the respondents' firms have experience between 1 to 3 years in construction works and 29.17% (7) of the respondents experience between 4 to 6 years, 29.17% (7) of the respondents experience between 7 to 10 years 25 % (6) of respondents have experience 10 years and above.

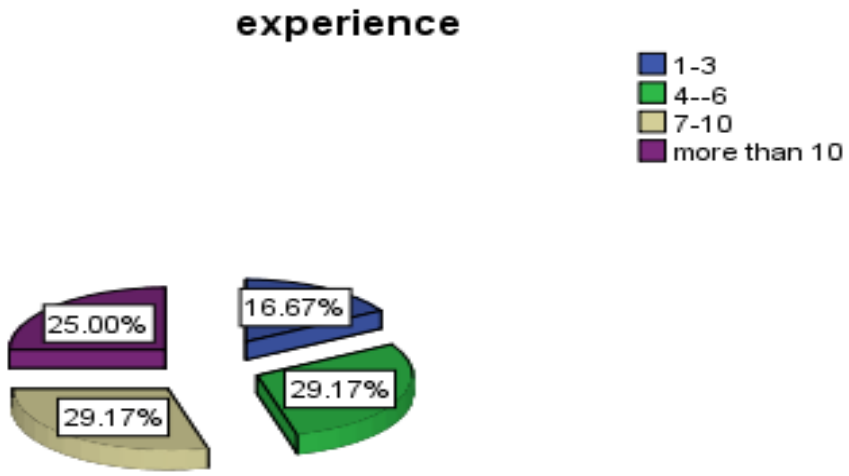

Fig 4.4 Respondent Experience

4.3 Causes of Variation Orders on Public Building Projects

4.3.1 Clients Group

Table 4.1 Frequency of causes of variation orders from the client's group

No	Causes of Variation Orders	RII of Client	Ranking
1	Replacement of materials or procedures	0.8800	1
2	Change in design	0.8800	1
3	Change of schedule	0.8800	1
4	Inadequate shop drawing details	0.8800	1
5	Defective workmanship	0.8800	1
6	Change of plans or scope	0.8400	2
7	Incomplete design	0.8400	2
8	Lack of judgment and experience	0.8400	2
9	Financial problems	0.8400	2

10	Unavailability of skills	0.8400	2
11	Obstinate nature of one or more of the parties to the contract	0.8400	2
12	Conflicts between contract documents	0.8400	2
13	Insufficient time for preparation of contract documents& design	0.8400	2
14	Lack of coordination	0.8000	3
15	Change in specifications	0.7600	4
16	Errors and omissions in design	0.7600	4
17	Unforeseen problems	0.7600	4
18	Design complexity	0.7600	4
19	Lack of communication	0.7600	4
20	Inadequate project objectives	0.7600	4
21	Lack of a specialized construction management	0.7600	4
22	Differing site conditions	0.7600	4
23	Poor procurement process	0.7600	4
24	Unfamiliarity with or unawareness of local conditions	0.7600	4
25	Technology change	0.7600	4
26	Inadequate design team experience	0.7600	4
27	Under estimation of initial quantity in the contract document	0.7600	4
28	Non-compliant design with government regulations	0.7200	5
29	Inadequate scope of work for one or more parties to the contract	0.7200	5
30	Design discrepancies	0.7200	5
31	Long lead procurement	0.7200	5
32	Weather conditions	0.7200	5
33	Lack of knowledge of available materials and equipment	0.7200	5
34	Health and safety considerations	0.7200	5
35	Unavailability of equipment	0.7200	5
36	Improper briefing by client	0.7200	5
37	The owner instructs modification to design	0.7200	5
38	Ambiguous design details	0.6800	6
39	Lack of strategic planning	0.6800	6
40	Lack of involvement in the design of one or more parties in the contract	0.6800	6
41	Non-compliant design with owner's requirement	0.6800	6

42	Lack of required data	0.6800	6
43	Change in government regulations	0.6400	7
44	Socio-cultural factors	0.6000	8

From Table 4.1 above, it was possible to rank the causes of variation orders by comparing their RII. According to the clients, replacement of material or procedures, change in design, change in schedule, inadequate working drawing details, and defective workman ship were the most ranking causes of variation which dominate with equal value (RII=0.8800) followed by Change of plans or scope, Incomplete design, and Lack of judgment and experience (RII=0.8400). And Socio-cultural factors were the least ranked cause of variation orders.

4.3.2 Consultants Group

Respondents of this group equally believed that Design discrepancies, Improper briefing by clients, and Weather conditions were the most ranking causes of variation orders.

Table 4.2: Frequency of causes of variation orders from the consultant group

No	Causes of Variation Orders	RII of	Ranking
1	Design discrepancies	0.7143	1
2	Improper briefing by client	0.7143	1
3	Weather conditions	0.7143	1
4	Lack of knowledge of available materials and equipment	0.6857	2
5	Differing site conditions	0.6857	2
6	Conflicts between contract documents	0.6857	2
7	Financial problems	0.6571	3
8	Unavailability of skills	0.6571	3
9	Lack of involvement in the design of one or more parties in the contract	0.6571	3

10	Insufficient time for preparation of contract documents &design	0.6571	3
11	Inadequate scope of work for one or more parties to the contract	0.6286	4
12	Design complexity	0.6286	4
13	Inadequate project objectives	0.6286	4
14	Long lead procurement	0.6286	4
15	Lack of strategic planning	0.6286	4
16	Non-compliant design with owner's requirement	0.6286	4
17	Obstinate nature of one or more of the parties to the contract	0.6286	4
18	Unfamiliarity with or unawareness of local conditions	0.6286	4
19	Inadequate design team experience	0.6286	4
20	Replacement of materials or procedures	0.6286	4
21	Change in specifications	0.6000	5
22	Incomplete design	0.6000	5
23	Non-compliant design with government regulations	0.6000	5
24	Ambiguous design details	0.6000	5
25	Lack of a specialized construction management	0.6000	5
26	Poor procurement process	0.6000	5
27	Unavailability of equipment	0.6000	5
28	Technology change	0.6000	5
29	Under estimation of initial quantity in the contract document	0.6000	5
30	Change of plans or scope	0.5714	6
31	Change in design	0.5714	6
32	Inadequate shop drawing details	0.5714	6
33	Lack of judgment and experience	0.5714	6
34	Defective workmanship	0.5714	6

35	Lack of coordination	0.5714	6
36	Owner instructs modification to design	0.5714	6
37	Errors and omissions in design	0.5429	7
38	Unforeseen problems	0.5429	7
39	Lack of communication	0.5429	7
40	Lack of required data	0.5429	7
41	Socio-cultural factors	0.5429	7
42	Change in government regulations	0.5429	7
43	Health and safety considerations	0.5143	8
44	Change of schedule	0.4857	9

As shown in Table 4.2, respondents of this group equally believed that Design discrepancies, Improper briefing by clients, and Weather conditions were the most ranking causes of variation orders (RII=0.7143). Lack of knowledge of available materials and equipment, Differing site conditions, and Conflicts between contract documents followed with equal value (RII=0.6857) and then Financial problems (RII=0.6571). According to the respondents of this category, the least ranked cause of variation orders was Change of schedule.

4.3.3 Contractors Group

Table 4.3: Frequency of causes of variation orders from the contractor group

No	Causes of Variation Orders	RI of	Ranking
1	Lack of judgment and experience	0.7667	1
2	Inadequate project objectives	0.7500	2
3	Differing site conditions	0.7500	2
4	Change of plans or scope	0.7333	3
5	Replacement of materials or procedures	0.7333	3
6	Inadequate shop drawing details	0.7333	3

7	Conflicts between contract documents	0.7333	3
8	Owner instructs modification to design	0.7333	3
9	Under estimation of initial quantity in the contract document	0.7333	3
10	Change in design	0.7167	4
11	Errors and omissions in design	0.7167	4
12	Change in specifications	0.7000	5
13	Incomplete design	0.7000	5
14	Financial problems	0.7000	5
15	Lack of involvement in the design of one or more parties in the contract	0.7000	5
16	Improper briefing by client	0.7000	5
17	Change of schedule	0.6833	6
18	Unforeseen problems	0.6833	6
19	Non-compliant design with owner's requirement	0.6833	6
20	Inadequate design team experience	0.6833	6
21	Design discrepancies	0.6667	7
22	Long lead procurement	0.6667	7
23	Lack of knowledge of available materials and equipment	0.6667	7
24	Poor procurement process	0.6667	7
25	Lack of required data	0.6667	7
26	Design complexity	0.6500	8
27	Lack of communication	0.6500	8
28	Obstinate nature of one or more of the parties to the contract	0.6500	8
29	Unfamiliarity with or unawareness of local conditions	0.6500	8
30	Insufficient time for preparation of contract documents& design	0.6500	8

31	Inadequate scope of work for one or more parties to the contract	0.6364	9
32	Unavailability of equipment	0.6333	10
33	Non-compliant design with government regulations	0.6167	11
34	Lack of coordination	0.6167	11
35	Unavailability of equipment	0.6000	12
36	Unavailability of skills	0.6000	12
37	Weather conditions	0.6000	12
38	Lack of strategic planning	0.6000	12
39	Technology change	0.6000	12
40	Ambiguous design details	0.5833	13
41	Health and safety considerations	0.5833	13
42	Lack of a specialized construction management	0.5833	13
43	Change in government regulations	0.5500	14
44	Socio-cultural factors	0.5167	15

From Table: 4.3 above, the most cause of variation according to these respondents is Lack of judgment and experience (RII=0.7667). The second and third-ranked cause was Inadequate project objectives, Differing site conditions (RII=0.7500), followed Change of plans or scope, Replacement of materials or procedures, Inadequate shop drawing details, Conflicts between contract documents, Owner instructs modification to design, and Under estimation of initial quantity in the contract document (RII=0.7333) and then change in design and Errors and omissions in design (RII=0.7167). Socio-cultural factors were the least ranked cause of variation orders.

4.3.4 Overall Responses for causes of variation work order

It was possible to rank the causes of variation orders by combining the responses of all respondents. The most raked causes of variation orders by all respondents were Change of plans or scope, and inadequate shop drawing details dominate with the same value.

Table 4.4: Frequency of causes of variation orders from the overall

No	Causes of Variation Orders	RI of	Ranking
1	Change of plans or scope	0.7167	1
2	Inadequate shop drawing details	0.7167	1
3	Ambiguous design details	0.7083	2
4	Improper briefing by client	0.7083	2
5	Lack of involvement in the design of one or more parties in the contract	0.7000	3
6	Differing site conditions	0.6917	6
7	Conflicts between contract documents	0.6917	6
8	Financial problems	0.6833	7
9	Lack of knowledge of available materials and equipment	0.6833	7
10	Under estimation of initial quantity in the contract document	0.6833	7
11	Change in specifications	0.6750	8
12	Long lead procurement	0.6750	8
13	Unfamiliarity with or unawareness of local conditions	0.6750	8
14	Inadequate design team experience	0.6667	9
15	Change in design	0.6583	10
16	Design complexity	0.6583	10
17	Design discrepancies	0.6583	10
18	Non-compliant design with owner's requirement	0.6583	10
19	Lack of coordination	0.6417	11
20	Obstinate nature of one or more of the parties to the contract	0.6333	12
21	Insufficient time for preparation of contract documents& design	0.6333	12
22	Owner instructs modification to design	0.6333	12
23	Weather conditions	0.6250	13
24	Defective workmanship	0.6250	13
25	Lack of strategic planning	0.6250	13
26	Poor procurement process	0.6250	13
27	Unavailability of equipment	0.6167	14
28	Technology change	0.6167	14
29	Inadequate project objectives	0.6167	14

30	Lack of judgment and experience	0.6083	15
31	Inadequate scope of work for one or more parties to the contract	0.6083	15
32	Lack of a specialized construction management	0.6083	15
33	Replacement of materials or procedures	0.5917	16
34	Lack of communication	0.5917	16
35	Errors and omissions in design	0.5833	17
36	Incomplete design	0.5833	17
37	Unforeseen problems	0.5833	17
38	Health and safety considerations	0.5833	17
39	Non-compliant design with government regulations	0.5667	18
40	Socio-cultural factors	0.5667	18
41	Change of schedule	0.5500	19
42	Change in government regulations	0.5500	19
43	Unavailability of skills	0.5417	20
44	Lack of required data	0.5333	21

As sown in Table: 4.4 above, it was possible to rank the causes of variation orders by combining the responses of all respondents. The most raked causes of variation orders by all respondents were Change of plans or scope, and Inadequate shop drawing details dominate with the same value (RII=0.7167). Ambiguous design details and Improper briefing by the client came next with equal value (RII=0.7083). Lack of involvement in the design of one or more parties in the contract followed by the value (RII=0.7000) and then Differing site conditions and Conflicts between contract documents (RII=0.6917). Unavailability of skills (RII=0.5417) and Lack of required data (RII=0.5333) were the least ranked causes of variation orders.

4.3.5 Cronbach's coefficient alpha for causes of variation work order

This procedure is used to measure the reliability of the questionnaire between each field and the mean of the whole fields of the questionnaire. Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. A "high “value of alpha is often used as evidence that the items measure an underlying (or latent) construct (UCLA, 2011).

Table 4.5: Cronbach's alpha and internal consistency (Prabhala, 2011)

No	Cronbach's alpha	Internal consistency
1.	$\alpha \supseteq 0.9$	Excellent
2.	$0.9 \supset \alpha \supseteq .8$	Good
3.	$.8 \supset \alpha \supseteq 0.7$	Acceptable
4.	$0.7 \supset \alpha$ 0.6	Questionable
5.	$0.6 \supset \alpha \supseteq 0.5$	Poor
6.	$0.5 \supset \alpha$	Un acceptable

Table 4. 6 Cronbach's coefficient alpha of causes of variation work order

No.	Groups	No. of respondent	Cronbach's coefficient alpha
1.	client	5	0.983
2	consultant	7	0.992
3.	contractor	12	0.994
4	Over all	24	0.985

As shown in Table 4.6, the Cronbach's coefficient alpha was calculated for all sectors (client, consultant, and contractor) in the building project individually for causes of the variation work order, and overall respondents were in the range from 0.983 and 0.994 which are more than $\alpha \supseteq 0.9$ with internal consistency grade Excellent from Table 4.5. This is to be considered high and closed to the full value, which is +1.0. These results make sure the reliability of the questionnaire.

4.3.6 Correlation and p-value

Correlation is a statistical technique that shows how strongly two variables are related to each other or the degree of association between the two. P-Value is labeled as “Sig”. In the SPSS output (“sig” stands for significance level).

Table 4.7 shows the top relative important index (RII) value from the overall answer for causes of variation orders. As we can see from the table almost all causes are correlated which are greater than 0.5 and significant values of less than 0.05.

Table 4. 7 Correlation and p-value for causes of variation orders

Ranking	Causes of Variation Orders	Significant or Not	correlation	P-value
1	Change of plans or scope	yes	0.516	0.033
2	Inadequate shop drawing details	yes	0.577	0.017
3	Ambiguous design details	yes	0.600	0.039
4	Improper briefing by the client	yes	0.577	0.046
5	Lack of involvement in the design of one or more parties in the contract	yes	0.601	0.021
6	Differing site conditions	no	0.467	0.008
7	Conflicts between contract documents	yes	0.530	0.012
8	Financial problems	yes	0.545	0.037
9	Lack of knowledge of available materials and equipment	yes	0.614	0.029
10	Under estimation of initial quantity in the contract document	yes	0.634	0.013

4.4 Impacts of Variation Orders on Public Building Projects

The impact of variation orders on building projects by all sectors group and overall response of the sector.

4.4.1 Clients Group

The respondents of this group responded that the most impact of variation orders was Progress affected but without any delay, Increase in overhead expenses ranked impacts by clients group.

Table 4.8: Frequency of impacts of variation orders from the client group

No	Impacts of Variation Orders	RI of	Ranking
1	Progress is affected but without any delay	0.8000	1
2	Increase in overhead expenses	0.8000	1
3	Additional specialist equipment/personnel	0.8000	1
4	Disputes among professionals	0.8000	1
5	Completion schedule delay	0.8000	1
6	Increase in project cost	0.7600	2
7	Poor professional relations	0.7600	2
8	Quality degradation	0.7200	3
9	Delay in payment	0.7200	3
10	Rework and demolition	0.6800	4
11	Complaints of one or more of the parties to the contract	0.6800	4
12	The professional reputation of one or more parties adversely affected	0.6800	4
13	Logistics delays	0.6400	5
14	Damage to the firm's reputation	0.6400	5
15	Poor safety conditions	0.6000	6

From Table: 4.8 Above, the respondents of this group responded that the most impact of variation orders was Progress affected but without any delay, Increase in overhead expenses, Additional specialist equipment/personnel, Disputes among professionals, and Completion schedule delay are 5 ranked impacts by clients group with equal value

(RII=0.8000) followed by Increase in project cost and Poor professional relations came next with equal value (RII=0.7600). Damage to the firm's reputation (RII=0.6400) and Poor safety conditions (RII=0.6000) was the least impact on variation orders on building projects.

4.4.2 Consultant Group

Table 4.9: Frequency of impacts of variation orders from the consultant group

No	Impacts of Variation Orders	RII of	Ranking
1	Increase in overhead expenses	0.7143	1
2	Rework and demolition	0.6571	2
3	Logistics delays	0.6286	3
4	The professional reputation of one or more parties adversely affected	0.6000	4
5	Progress is affected but without any delay	0.5714	5
6	Disputes among professionals	0.5714	5
7	Completion schedule delay	0.5714	5
8	Quality degradation	0.5250	6
9	Increase in project cost	0.5143	7
10	Additional specialist equipment/personnel	0.5143	7
11	Poor safety conditions	0.5143	7
12	Delay in payment	0.5143	7
13	Complaints of one or more of the parties to the contract	0.4857	8
14	Damage to firm's reputation	0.4857	8
15	Poor professional relations	0.4571	9

As it can be seen in Table: 4.9 above, it was possible to rank the impacts of variation orders. The most raked impact of variation orders by the consultants was an Increase in

overhead expenses, (RII=0.7143) followed by Rework and demolition (RII=0.6571). Logistics delays were the third-ranked (RII=0.6286) and the Professional reputation of one or more parties adversely affected was the fourth (RII=0.600). Poor professional relations were the least impact on variation orders on public building projects.

4.4.3 Contractor Group

It was possible to rank the impacts of variation orders by comparing their RI. According to the contractors group.

Table 4.10: Frequency of impacts of variation orders from the contractor group

No	Impacts of Variation Orders	RI of	Ranking
1	Increase in project cost	0.7167	1
2	Increase in overhead expenses	0.7000	2
3	Poor professional relations	0.6833	3
4	Delay in payment	0.6667	4
5	Complaints of one or more of the parties to the contract	0.6667	4
6	Logistics delays	0.6500	5
7	Additional specialist equipment/personnel	0.6400	6
8	Disputes among professionals	0.6333	8
9	Progress is affected but without any delay	0.6000	9
10	Quality degradation	0.6000	9
11	Damage to the firm’s reputation	0.6000	9
12	Rework and demolition	0.5833	10
13	Poor safety conditions	0.5833	10
14	The professional reputation of one or more parties adversely affected	0.5400	11
15	Completion schedule delay	0.5333	12

From the following Table 4.10, it was possible to rank the impacts of variation orders by comparing their RII. According to the contractors, an Increase in project cost (RII=0.7167) was the most ranked impact followed by an increase in overhead expenses (0.7000). Poor professional relations was the third (RII=0.6833) and Delay in payment and Complaints of one or more of the parties to the contact came next with equal value (RII=0.6667). According to the contractors, Completion schedule delay was the least ranked impact of variation orders (RII=0.5333).

4.4.4 Overall Responses for impacts of variation work order

It was possible to rank the impacts of variation orders by combining the responses of all respondents. The most raked impacts of variation orders by all respondents were increase in project cost, and increase in overhead expenses.

Table 4.11: Frequency of impacts of variation orders overall

No	Impacts of Variation Orders	RI of	Ranking
1	Increase in project cost	0.7250	1
2	Increase in overhead expenses	0.6667	2
3	Delay in payment	0.6500	3
4	Logistics delays	0.6417	4
5	Progress is affected but without any delay	0.6333	5
6	Additional specialist equipment/personnel	0.6333	5
7	Poor professional relations	0.6333	5
8	Disputes among professionals	0.6333	5
9	Rework and demolition	0.6167	6
10	Complaints of one or more of the parties to the contract	0.6167	6
11	Quality degradation	0.6083	7
12	Completion schedule delay	0.6000	8
13	The professional reputation of one or more	0.5917	9

	parties adversely affected		
14	Damage to firm's reputation	0.5750	10
15	Poor safety conditions	0.5667	11

As it can be seen in Table: 4.11 above, the most raked impacts of variation orders from the combined responses of all respondents were Increase in project cost (RII=0.7250) followed by an increase in overhead expenses (RII=0.6667). Delay in payment (RII=0.6500) and Logistics delays (RII=0.6417). Poor safety conditions (RII=0.5667) were the least ranked impact of variation orders as responded by all participants.

4.4.5 Cronbach's coefficient alpha for Impacts

This procedure is used to measure the reliability of the questionnaire in each field and the reliability of the questionnaire. Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. For impact cases, all sectors get a consistency of greater than 0.9. These results make sure the reliability of the questionnaire.

Table 4. 12 Cronbach's coefficient alpha of impacts of variation work order

No.	Groups	No. of respondent	Cronbach's coefficient alpha
1.	client	5	0.914
2	consultant	7	0.959
3.	contractor	12	0.932
4	Over all	24	0.942

4.4.6 Correlation and p-value

Correlation is a statistical technique that shows how strongly two variables are related to each other or the degree of association between the two. P-Value is labeled as "Sig". In the SPSS output ("sig" stands for significance level).

Table 4.13: correlation and p-value of impacts of variation

Ranking	Impacts of Variation Orders	Significant or Not	correlation	P-value
1	Increase in project cost	Yes	0.512	0.047
2	Increase in overhead expenses	No	0.489	0.027
3	Delay in payment	Yes	0.513	0.038
4	Logistics delays	Yes	0.559	0.026
5	Progress is affected but without any delay	Yes	0.548	0.027
6	Additional specialist equipment/personnel	No	0.467	0.064
7	Poor professional relations	Yes	0.587	0.014
8	Disputes among professionals	Yes	0.552	0.017
9	Rework and demolition	Yes	0.516	0.043

Table 4.13 shows the top relative important index (RII) value from the overall answer for impacts of variation orders. As we can see from the table almost all impacts are correlated which are greater than 0.5 and significant values of less than 0.05. The 2 and 6 impacts are not correlated with others.

4.5 Impacts of variation work all sector

4.5.1 Clients

All the respondents (24 people) give the value for the client each impacts of variation work order with the Linkert scale value, and by checking the mean value in SPSS software.

Table 4.14: mean impacts of variation orders from the client group

No	Impacts of Variation Orders	Mean	Ranking
1	Increase in project cost	4.00	1
2	Complaints of one or more of the parties to the contract	2.83	2
3	The professional reputation of one or more parties adversely affected	2.79	3
4	Damage to firm's reputation	2.75	4
5	Disputes among professionals	2.50	5
6	Completion schedule delay	2.46	6
7	Poor professional relations	2.33	7
8	Additional specialist equipment/personnel	2.25	8
9	Logistics delays	2.25	8
10	Progress is affected but without any delay	2.08	9
11	Quality degradation	2.04	10
12	Rework and demolition	2.04	10
13	Increase in overhead expenses	2.00	11
14	Delay in payment	1.83	12
15	Poor safety conditions	1.83	12

From Table: 4.13 below, all the respondents give the value for the client with the Linkert scale value, and by checking the mean value in SPSS software Increase in project cost get the mean value (4.00) ranked firstly Complaints of one or more of the parties to the contact mean value (2.83) ranked secondly and Professional reputation of one or more parties adversely affected mean value (2.79) are thirdly ranked. Poor safety conditions were ranked lastly with mean value (1.83).

4.5.2 Consultant Group

Respondents (24 people) give the value for the consultant on each impacts of variation work order with the Linkert scale value and by checking the mean value in SPSS software.

Table 4.15: mean of impacts of variation orders from the consultant group

No	Impacts of Variation Orders	Mean	Ranking
1	The professional reputation of one or more parties adversely affected	2.88	1
2	Complaints of one or more of the parties to the contract	2.75	2
3	Disputes among professionals	2.71	3
4	Delay in payment	2.67	4
5	Poor professional relations	2.63	5
6	Completion schedule delay	2.58	6
7	Damage to firm's reputation	2.42	7
8	Progress is affected but without any delay	2.29	8
9	Poor safety conditions	2.25	9
10	Quality degradation	2.21	10
11	Rework and demolition	2.04	11
12	Additional specialist equipment/personnel	2.00	12
13	Increase in project cost	2.00	12
14	Logistics delays	1.92	13
15	Increase in overhead expenses	1.83	14

From Table: 4.15 above, all the respondents (24 people) give the value for the consultant with the Linkert scale value and by checking the mean value in SPSS software Professional reputation of one or more parties adversely affected gets the mean value

(2.88) ranked firstly Complaints of one or more of the parties to the contact mean value (2.75) ranked secondly and Disputes among professionals mean value (2.71) are thirdly ranked. An increase in overhead expenses was ranked lastly with a mean value (of 1.83).

4.5.3 Contractor Group

All the respondents (24 people) give the value for the contractor on each impacts of variation work order with the Linkert scale value and by checking the mean value in SPSS software.

Table 4.16: mean impacts of variation orders from the contractor group

No	Impacts of Variation Orders	Mean	Ranking
1	Increase in overhead expenses	3.63	1
2	Rework and demolition	3.42	2
3	Progress is affected but without any delay	3.33	3
4	Logistics delays	3.25	4
5	The professional reputation of one or more parties adversely affected	3.04	5
6	Disputes among professionals	3.00	6
7	Poor safety conditions	2.92	7
8	Delay in payment	2.88	8
9	Additional specialist equipment/personnel	2.88	8
10	Completion schedule delay	2.83	9
11	Complaints of one or more of the parties to the contract	2.75	10
12	Damage to firm's reputation	2.67	11
13	Poor professional relations	2.63	12
14	Quality degradation	2.50	13
15	Increase in project cost	2.17	14

From Table: 4.16 above, all the respondents (24 people) give the value for the contractor with the Linkert scale value and by checking the mean value in SPSS software Increase in overhead expenses get the mean value (3.63) ranked firstly Rework and demolition mean value (3.42) ranked secondly and Progress is affected but without any delay mean value (3.33) are thirdly ranked. An increase in project cost was ranked lastly with a mean value of 2.17.

4.5.4 Cronbach's coefficient alpha for Impacts

This procedure is used to measure the reliability of the questionnaire between each field and the mean of the whole fields of the questionnaire. Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. A "high "value of alpha is often used as evidence that the items measure an underlying (or latent) construct (UCLA, 2011).

Table 4.18: Cronbach's coefficient alpha

No.	Groups	No. of respondent	Cronbach's coefficient alpha
1.	client	24	0.902
2	consultant	24	0.925
3.	contractor	24	0.895

4.6 Recommendation of Variation Orders on Public Building Projects

The frequency of recommended strategies to minimize variation orders on building projects by all sectors.

4.6.1 Clients Group

The recommended strategies to minimize variation by comparing their RII. According to the client, the most ranked recommended strategy was for the consultant should produce a concluding design and contract documents and complete the drawings before the tender stage.

Table 4.19: Frequency of recommendation of variation orders from the client group

No	Recommendation to minimize Variation Orders	RII of	Ranking
1	The consultant should produce a concluding design and contract documents	0.7600	1
2	Complete the drawings before tender stage	0.7600	1
3	Clients should provide a clear brief of the scope of works	0.7200	2
4	Get accurate information and research about procurement procedures, materials, and plant	0.7200	2
5	Carry out detailed site investigation including detailed soil investigations and consider it during the tendering stage	0.7200	2
6	Have the land application or land purchase completed before awarding contracts	0.7200	2
7	All involved parties should plan adequately before works start on site	0.6800	3
8	Spend adequate time on pre-tender planning phase	0.6800	3
9	The consultant should co-ordinate closely at design stage	0.6800	3
10	Once the tender is awarded, make no changes to the specifications	0.6800	3
11	Place experienced and knowledgeable executives in the engineering and design department	0.6800	3
12	Enhance communication between all parties	0.6400	4
13	Supervise the work with an experienced and dedicated supervisor	0.6000	5
14	Consultants should ensure that the design/specifications fall within the approved budget	0.6000	4

From Table 4.19, it was possible to rank the recommended strategies to minimize variation by comparing their RII. According to the client, the most ranked recommended strategy was for the consultant should produce a concluding design and contract documents and complete the drawings before the tender stage (RII=0.7600) followed by Clients should provide a clear brief of the scope of work, Get accurate information and research about procurement procedure, material and plant, Carry out detail site investigation including detail soil investigations and consider it during tendering stage and Have the land application or land purchase completed before awarding s(RII=0.7200). Adequate planning in advance is required by all involved parties before works start on site come next (RII=0.844). Supervise the works with an experienced and dedicated supervisor and Consultants should ensure that the design/specifications fall within the approved budget (RII=0.600) were the least ranked recommendation to minimize variation orders.

4.6.2 Consultant Group

Recommended strategy to minimize variation according to respondents of consultant group is Complete the drawings before the tender stage.

Table 4.20: Frequency of recommendation of variation orders from the consultant group

No	Recommendation to minimize Variation Orders	RII of	Ranking
1	Complete the drawings before tender stage	0.5714	1
2	The consultant should co-ordinate closely at design stage	0.5429	2
3	Supervise the work with an experienced and dedicated supervisor	0.5429	2
4	Once the tender is awarded, make no changes to the specifications	0.5429	2
5	Place experienced and knowledgeable executives in the engineering and design department	0.5429	2

6	The consultant should produce a concluding design and contract documents	0.5143	3
7	Enhance communication between all parties	0.5143	3
8	Consultants should ensure that the design/specifications fall within the approved budget	0.5143	3
9	All involved parties should plan adequately before works start on site	0.4857	4
10	Have the land application or land purchase completed before awarding contracts	0.4857	4
11	Clients should provide a clear brief of the scope of works	0.4571	5
12	Get accurate information and research about procurement procedures, materials, and plant	0.4571	5
13	Carry out detailed site investigation including detailed soil investigations and consider it during the tendering stage	0.4571	5
14	Spend adequate time on pre-tender planning phase	0.4286	6

From Table: 4.20 above, the most ranked recommended strategy to minimize variation according to respondents of this category is Complete the drawings before the tender stage (RII=.5714). The next recommendations were the consultant should co-ordinate closely at the design stage, Supervise the works with an experienced and dedicated supervisor, Once the tender is awarded, make no changes to the specifications and Place experienced and knowledgeable executives in the engineering and design department stage came with equal value (RII=0.5429). Spending adequate time in the pre-tender planning phase was the least ranked recommendation to minimize variation orders according to the consultants (0.4286).

4.6.3 Contractor Group

The recommendation to minimize variation according to the contractors was all involved parties should plan adequately before works start on site.

Table 4.21: Frequency of recommendation of variation orders from the contractor group

No	Recommendation to minimize Variation Orders	RII of	Ranking
1	All involved parties should plan adequately before works start on site	0.6500	1
2	The consultant should produce a concluding design and contract documents	0.6333	2
3	Place experienced and knowledgeable executives in the engineering and design department	0.6000	3
4	Complete the drawings before the tender stage	0.5833	4
5	Consultants should ensure that the design/specifications fall within the approved budget	0.5833	4
6	Carry out detailed site investigation including detailed soil investigations and consider it during the tendering stage	0.5833	4
7	Enhance communication between all parties	0.5667	5
8	Supervise the work with an experienced and dedicated supervisor	0.5667	5
9	Once the tender is awarded, make no changes to the specifications	0.5667	5
10	The consultant should co-ordinate closely at design stage	0.5500	6
11	Clients should provide a clear brief of the scope of works	0.5333	7
12	Have the land application or land purchase completed before awarding contracts	0.5333	7
13	Spend adequate time on pre-tender planning phase	0.5167	8

14	Get accurate information and research about procurement procedures, materials, and plant	0.5167	8

As shown in Table: 4.21 above, the most ranked recommendation to minimize variation according to the contractors was All involved parties should plan adequately before works start on site (RII=0.6500) followed by the consultant should produce a concluding design and contract documents (RII=0.6333) and then place experienced and knowledgeable executives in the engineering and design department (RII=0.6000). According to these respondents, getting accurate information and research about procurement procedure, material, and plant (RII=0.5167) was the least ranked recommendation to minimize variation orders.

4.6.4 Overall Responses

It was possible to rank the recommendation of variation orders by combining the responses of all respondents. The most raked recommendation of variation orders by all respondents were the consultant should produce a concluding design and contract documents.

Table 4.22: Frequency of recommendation of variation orders overall response

No	Recommendation to minimize Variation Orders	RII of	Ranking
1	The consultant should produce a concluding design and contract documents	0.6250	1
2	Complete the drawings before tender stage	0.6167	2
3	All involved parties should plan adequately before works start on site	0.6083	3
4	Place experienced and knowledgeable executives in the engineering and design department	0.6000	4
5	Once the tender is awarded, make no changes to the specifications	0.5833	5
6	Carry out detailed site investigation including detailed soil investigations and consider it during the tendering stage	0.5750	6
7	The consultant should co-ordinate closely at the design stage	0.5750	6
8	Enhance communication between all parties	0.5667	7
9	Supervise the work with an experienced and dedicated supervisor	0.5667	7
10	Consultants should ensure that the design/specifications fall within the approved budget	0.5667	7
11	Have the land application or land purchase completed before awarding contracts	0.5583	8
12	Clients should provide a clear brief of the scope of works	0.5500	9
13	Get accurate information and research about procurement procedures, materials, and plant	0.5417	10
14	Spend adequate time on pre-tender planning phase	0.5250	11

From Table: 4.22, it was possible to rank the recommended strategy to minimize variation orders. The most raked strategy by all respondents was the consultant should produce a concluding design and contract documents (RII=0.6250) followed to complete the drawings before the tender stage (RII=0.6167). All involved parties should plan adequately before works start on site (RII=0.6083) next. According to all the respondents, the least ranked strategy was once Spending adequate time in the pre-tender planning phase (RII=0.5250).

4.6.5 Cronbach's coefficient alpha for recommendation

This procedure is used to measure the reliability of the questionnaire between each question by SPSS software. The results show clearly all questions are reliable in each sector and overall responses> 0.9 get excellent.

Table 4. 23 Cronbach's coefficient alpha of recommendation of variation work order

No.	Groups	No. of respondent	Cronbach's coefficient alpha
1.	client	5	0.936
2	consultant	7	0.910
3.	contractor	12	0.938
4	Over all	24	0.940

4.6.6 Correlation and p-value

Correlation is a statistical technique that shows how strongly two variables are related to each other or the degree of association between the two. P-Value is labeled as “Sig”. In the SPSS output (“sig” stands for significance level).

Table 4.24 shows the top relative important index (RII) value from the overall answer for a recommendation of variation orders. As we can see from the table almost all recommendations are correlated which are greater than 0.5 and significant values of less than 0.05. The 4 and 5 recommendations are not correlated with others.

Table 4. 24 Correlation and p-value of recommendation of variation work order

Ranking	Recommendation for Variation Orders	Significant or Not	Correlation	P-value
1	The consultant should produce a concluding design and contract documents	yes	0.562	0.014
2	Complete the drawings before the tender stage	yes	0.535	0.028
3	All involved parties should plan adequately before works start on site	yes	0.578	0.012
4	Place experienced and knowledgeable executives in the engineering and design department	no	0.482	0.056
5	Once the tender is awarded, make no changes to the specifications	no	0.470	0.099
6	Carry out detailed site investigation including detailed soil investigations and consider it during the tendering stage	yes	0.506	0.04998
7	The consultant should co-ordinate closely at the design stage	yes	0.540	0.040

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the overall responses, it was concluded that change of plans or scope, inadequate shop drawing details, ambiguous design details, improper briefing by the client, and lack of involvement in the design of one or more parties in the contract were the most important causes of variation orders on public building projects in Jimma University.

From the overall responses, it was concluded that increase in project cost, increase in overhead expenses, Delay in payment, logistics delays, and Progress is affected but without any delay were the most important impacts of variation orders on public building projects at Jimma University.

Do the same thing as above correction Among 15 positive and negative impacts of variation orders, all the respondents given for clients and the level of an impact compared by the mean value given for the clients showed that an increase in project cost, complaints of one or more of the parties to the contact, professional reputation of one or more parties adversely affected, damage to firm's reputation, and completion disputes among professionals were the top five most higher mean value positive and negative impacts of variation orders on public building projects in Jimma university.

According to the consultants, the top five higher mean value positive and negative impacts of variation orders on public building projects were the professional reputation of one or more parties adversely affected, complaints of one or more of the parties to the contract, disputes among professionals, delay in payment, and poor professional relations.

Regarding the contractors, the top five higher mean value positive and negative impacts of variation orders on public building projects in Jimma university increased overhead expenses, rework and demolition, Progress affected but without any delay, Logistics delays, and Professional reputation of one or more parties adversely affected.

From the overall responses, it was concluded that an increase in project cost, rework and demolition, Progress is affected but without any delay, logistics delays, and the Professional reputation of one or more parties adversely affected delay were the higher mean value positive and negative impacts of variation orders on public building projects in Jimma University. The reliability of sectors all are greater than 0.9 which shows the reliability of the questionnaire responses.

The first impact was selected clients' mean value score of 4.00. The other listed impacts of variation order are selected from contractors'. As per the respondent highly affected in a variation work order in public building Jimma university are client and contractor.

From the overall responses, it was concluded that the consultant should produce a concluding design and contract documents, complete the drawings before the tender stage, all involved parties should plan adequately before works start on site, place experienced and knowledgeable executives in the engineering and design department, and once the tender is awarded, make no changes to the specifications were the most important recommendation of variation orders on public building projects in Jimma University.

5.2 Recommendation

Based on the findings of the research, the following recommendations are expected from key role players in construction projects.

- Work on plans or scope not to change the drawing that is the most causes of variation work order.
- An understanding of the causes of variation orders would be helpful for building professionals in assessing variation orders.
- Develop criteria for the selection of contractor according to the nature of the project and to have a good reputation and great experience.
- The client should allow sufficient time to prepare an elaborately detailed project brief. This will eliminate frequent variations to the original plan of the project due to client change of mind.
- The consultant must clear all ambiguous design details before starting constructing that leads to variation work order.

- Continuous coordination and direct communication, will eliminate design discrepancies and errors as well as omissions in design and also provide an opportunity for professionals to review the contract documents thoroughly. This would help in eliminating variations due to discrepancies in contract documents.
- Include everything they need in the contract from the beginning and avoid any requirements after implementation of works and develop a clear vision for projects.

REFERENCE

Kwakye, AA. (1997). *Construction Project Administration in Practice.* USA: Wokingham.

Alsuliman, J., Bowles, G., & Chen, Z. (2012). Current practice of variation orders in the Saudi Construction Industry. *Conference proceedings of the 28th annual ARCOM Smith* (pp. 3-5). Edinburgh : Association of Researchers in Construction Management.

Andualem, E. Y. (2004). *Assessing the impact of variation orders on public building projects in Addis Ababa.* Addis Ababa.

Arain, F. a., & Pheng, L. (2005). *Effective management of contract variations using a knowledge based decision support system.* United Kingdom: Cardiff university.

Arain, F.M. & Pheng, L.S. . (2006). Developers' views of potential causes of variation orders for institutional buildings in Singapore. *Architectural Science Review , 49*, 59-74.

Arain, F.M. & Pheng, L.S. (2005). *Effective Management of Contract Variations using a Knowledge Base Decision Support System.* Cardiff University: Centre for Education in the Built Environment CEBE.

Arain, F.M. & Pheng, L.S. (2005b). How Design Consultants Perceive Causes of Variation Orders for Institutional Buildings in Singapore. *Architectural Engineering and Design Management , 1*, 181-196.

Brahts, J. (1980). Construction Management and Engineering, John Wiley & Sons Inc., Canada Construction Quality in South Africa. In J. W. Inc., *Construction Management and Engineering* (pp. ISBN: 978-0-621-40169-1). Canada: A client/owner perspective.

C. William, I., Clarence, K. W., & Kwak, Y. H. (2001). Project Change Management System. *Journal of Management in Engineering* , 159-165.

Enshassi, A, Arain, F, and Al-Raee, S. (2010). Causes of variation orders in construction projects in the Gaza Strip. *Journal of Civil Engineering and Management , 16*, 540-551.

Fisk, E. R., & Reynolds, W. D. (2006). *Construction Project Administration.* Pearson Prentice Hall: New Jerse.

Fisk, E.R. and Reynolds, W.D. (2010). *Construction Project Administration.* Pearson Education, Inc,New Jersey.

Ibbs, C. Williams, Lee,S., and Li, M. (1998). *Fast-tracking's impact on project change* (Vol. 29). Project Managemen.

Ibbs, W., K., Y. Ng, T., & Odabasi, M. (2003). Project Delivery systems and project change: Quantitative analysis. *Journal of construction engineering and management* , 129.

Kelly, J. & Duerk, D. (2002). *'Construction Project Briefing/Architectural Programming' in Kelly, J, Morledge, R & Wilkinson, S, ed 'Best Value in Construction'.* RICS Foundation, OxfordOxford: Blackwell Publishing.

Kelly, J. & Male, S. (2002). *Value Management' in Kelly, J, Morledge, R & Wilkinson, S, ed. 'Best Value in Construction'.* Oxford: Blackwell Publishing.

Levy, S. (2012). *Project Management in construction.* USA : McGraw Hill Companies Inc.

Ming, S., Martin, S., & Chimay, A. . (2004). Managing Changes in Construction Projects. *Industrial Report, University of the West of England* , 7-10.

O'Leary, Z. . (2004). *The Essential Guide to Doing Research'.* London: Sage Publications .

Ruben, N. (2008). An analysis of the impact of variation orders on project performanc. *Theses & Dissertations* , 33.

Twort, A.C. & Rees, J.G. (1995). *Civil Engineering: Supervision and Management.* London: Arnold.

Wambeke, B.W., Hsiang, S.M., & Liu, M. (2011). Causes of variation in construction project task, starting times, and duratio. *Journal of Construction Engineering and Management , 137*, 663-667.

Yogeswaran, K., Kumaraswamy, M.M. & Miller, D.R.A. (1997). Claims for extensions of Time in Civil Engineering Projects. *Construction Management and Economics , 16*, 283-293.

Zimmerman, W.L. & Hart, D.G. (1982). *'Value Engineering - A practical approach for Owners, Designers and Contractors'*. New York: Van Nostrand Reinhold Company.

APPENDIXES

JIMMA UNIVERSITY JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

Dear participants, this questionnaire is developed to investigate variation work order impact on building project time: in the case of Jimma University, University of south western Ethiopia, which is going to be conducted as partial fulfillment of Master of Science in Construction Engineering and Management. The main objective of this research was to investigate the impact of variation work orders on public building projects at Jimma University. Your response, in this regard, is highly valuable and contributory to the outcome of the research. All feedback will be kept strictly confidential and will be utilized only for this academic research purpose. The questionnaire is divided into two parts. The first part of the questionnaire includes the background of the respondent. The second part includes the list of the identified impact of variation work on different aspects in view building projects in a public building. The respondents are asked to assess the degree of variation impact on the site. At the end of the second part of the questionnaire, an open-ended question is provided factors and effects of implementation and complexity of adoption standards are identified gives the direction of comments for improvement, suggestions or recommendations to the cause and impact variation work in a building project, if any.

Thank you indeed,

Birhanu Alemayehu Asfaw,

Post graduate student in Construction Engineering and management,

Jimma University, Jimma Institute of Technology, Faculty of civil and environmental engineering: Construction engineering and management chair.

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QUESTIONNAIRE

Dear respondent,

The purpose of this questionnaire and format is to obtain information and data for the specified research conducted as partial fulfillment of the requirements for a master's degree in civil engineering (Construction Engineering and Management) at Jimma University.

Research Topic

"Assessment of variation work order impact on building project performance in Jimma University"

Objective

The purpose of this research is to assess the variation work order impact on building project performance at Jimma University

Confidentiality

The data collected and the information to be answered in this questionnaire will be used for academic research purposes only. All specific companies and interviewee information will be kept confidential at all times. Only a generalized analysis of the information contained within this completed questionnaire will be utilized in the research process.

Instruction

Please answer, rate, and thick (✓) the questionnaire by choosing the appropriate choices. The questionnaire and data collection contain two parts. Part one contains the company and respondent's general information and part two deals with. …….I realize that there are numerous demands on your time. However, your involvement is a vital requisite for this.

Thank you,

Birhanu Alemayehu

Post graduate student, Construction technology and management

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Jimma

Section A: General respondent and Company information

Please Tick "√" one of the alternatives for questions

1. Type of organization you are working in?

Client Consultant Contractor

If others (Please specify) _____

2. What is your position in a company?

Construction/ Project Engineer Office engineer Resident engineer

Site Engineer Project manager If other (please specify) _____

3. Your General experience in the work related to the construction project

1-3 years 4-6 years 7-10 years' More than 10 yeas

SECTION B: CAUSES OF VARIATION ORDERS IN PUBLIC BUILDING CONSTRUCTION PROJECTS AT JIMMA UNIVERSITY

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

Indicator: 1 = Never 2 = Seldom 3 = Sometimes 4 = Often 5 = Always

From your point of view (and regardless of your experience) select the degree of influence and the degree of occurrence that lead to the presence of variation orders on a public building project

No	Cases of variation orders	1	2	3	4	5
1	Change of plans or scope					
2	Change of schedule					
3	Change in specifications					
4	Change in design					
5	Errors and omissions in design					
6	Incomplete design					
7	Non-compliant design with government regulations					
8	Unforeseen problems					
9	Replacement of materials or procedures					
10	Inadequate shop drawing details					
11	Lack of judgment and experience					
12	Financial problems					
13	Inadequate scope of work for one or more parties to the contract					
14	Design complexity					
15	Lack of communication					
16	Defective workmanship					
17	Design discrepancies					
18	Inadequate project objectives					
19	Long lead procurement					
20	Lack of coordination					
21	Ambiguous design details					
22	Unavailability of skills					
23	Weather conditions					
24	Lack of strategic planning					
25	Lack of knowledge of available materials and equipment					

26	Lack of involvement in the design of one or more parties in the contract					
27	Non-compliant design with owner's requirement					
28	Health and safety considerations					
29	Lack of a specialized construction management					
30	Obstinate nature of one or more of the parties to the contract					
31	Differing site conditions					
32	Poor procurement process					
33	Conflicts between contract documents					
34	Lack of required data					
35	Unavailability of equipment					
36	Unfamiliarity with or unawareness of local conditions					
37	Socio-cultural factors					
38	Change in government regulations					
39	Technology change					
40	Insufficient time for preparation of contract documents& design					
41	Improper briefing by the client					
42	Inadequate design team experience					
43	The owner instructs modification to design					
44	Underestimation of initial quantity in the contract document					

If any other causes of variation orders, please specify and specify the degree of influence

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_____

SECTION C: IMPACTS OF VARIATION ORDERS IN PUBLIC BUILDING CONSTRUCTION PROJECTS PERFORMANCE IN JIMMA UNIVERSITY

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

Indicator: 1 = No impact 2 = Low impact 3 = Medium impact 4 = High impact

5 = Very high impact

No	Impacts of variation orders	no impact				very high
		1	2	3	4	5
1	Increase in project cost					
2	Progress is affected but without any delay					
3	Increase in overhead expenses					
4	Quality degradation					
5	Rework and demolition					
6	Logistics delays					
7	Additional specialist equipment/personnel					
8	Poor safety conditions					
9	Delay in payment					
10	Poor professional relations					
11	Disputes among professionals					
12	Completion schedule delay					
13	Complaints of one or more of the parties to the contract					
14	The professional reputation of one or more parties adversely affected					
15	Damage to the firm's reputation					

If any other impact of variation orders, please specify and specify the degree of influence

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SECTION D: TO EVALUATE THE IMPACT ON ALL SECTORS (CLIENT, CONSULTANT AND CONTRACTOR) THEY WORKED WITH VARIATION ORDER IN JIMMA UNIVERSITY PROJECT

These are some of the positive and negative impacts gain for all sectors they worked with variation order Please indicate your level of agreement with which sectors is affected by these impact and if u think more than one sectors affected please thick on it and the level of impact in that sectors.

(A = client B = consultant C = contractor)

Indicator: 1 = No impact 2 = Low impact 3 = Medium impact 4 = High impact

5 = Very high impact

No	Impacts of variation orders	client					consultant					contractor				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	Increase in project cost															
2	Progress is affected but without any delay															
3	Increase in overhead expenses															
4	Quality degradation															
5	Rework and demolition															
6	Logistics delays															
7	Additional specialist equipment/personnel															
8	Poor safety conditions															
9	Delay in payment															
10	Poor professional relations															
11	Disputes among professionals															
12	Completion schedule delay															
13	Complaints of one or more of the parties to the contract															
14	The professional reputation of one or more parties adversely affected															
15	Damage to the firm's reputation															

If any other impacts on variation, please

specify_____

SECTION E: RECOMMENDATIONS TO MINIMIZE VARIATION ORDERS IN PUBLIC BUILDING CONSTRUCTION PROJECTS AT JIMMA UNIVERSITY.

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

Indicator: 1 = Unimportant 2 = Less important 3 = Important 4 = Very important5 = Very high important

No	recommendations to minimize	1	2	3	4	5
1	All involved parties should plan adequately before works start on site					
2	The consultant should produce a concluding design and contract documents					
3	Complete the drawings before the tender stage					
4	Spend adequate time in the pre-tender planning phase					
5	Clients should provide a clear brief of the scope of works					
6	The consultant should co-ordinate closely at the design stage					
7	Enhance communication between all parties					
8	Supervise the work with an experienced and dedicated supervisor					
9	Consultants should ensure that the design/specifications fall within the approved budget					
10	Get accurate information and research about procurement procedures, materials, and plant					

11	Carry out detailed site investigation including detailed soil investigations and consider it during the tendering stage					
12	Have the land application or land purchase completed before awarding contracts					
13	Once the tender is awarded, make no changes to the specifications					
14	Place experienced and knowledgeable executives in the engineering and design department					

If you have any other recommendations, please

specify_____

_____

Thank you