AN ANALYSIS OF THE IMPACT OF VARIATION ORDERS ON PROJECT PERFORMANCE

By

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A DISSERTATION PRESENTED TO THE HIGHER DEGREES COMMITTEE OF THE CAPE PENINSULA UNIVERSITY OF TECHNOLOGY IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF TECHNOLOGY: CONSTRUCTION MANAGEMENT

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I dedicate this work to my parents who nurtured my potentials.

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LIST OF ABBREVIATIONS

CPM	Critical Path Method
FIDIC	French acronym interpreted in English as International Federation of Consulting Engineers
JBCC	The Joint Building Contracts Committee
JIT	Just in Time
PERT	Programme Evaluation Review Technique
SPSS	Statistical Package for Social Scientist
TQC	Total Quality Costs

ABSTRACT

Abstract of Dissertation Presented to the Higher Degrees Committee of the Cape Peninsula University of Technology in Fulfilment of the Requirements for the Degree of Master Technology in Construction Management

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This study investigated the impact of variation orders on project performance in order to take proactive measure to reduce them. The study had the following objectives, namely (1) to investigate the prevalence of variation orders on construction projects; (2) to determine the cost impact of variation orders; (3) to examine to what extent variation orders added value to construction projects; (4) to determine whether the activities associated with variation orders may be regarded as waste; (5) to identify the predominant origin agent as well as the causes of variation orders; and (6) to establish the nature and extent of the impact of variation orders on overall project performance.

Literature relative to the research area was extensively reviewed. The data gathering approaches included an exploratory study on costs of variation orders on two construction projects, interviews with three top management personnel in construction contracting companies, the audit of site instructions with regard to waste and their

value-addedness and self-administered questionnaires. A purposive sampling method was followed to identify participants into the study.

The audit of site instructions revealed that most variation orders were beneficial. However, 14% of site instructions had waste associated with them. It was possible to quantify apparent waste associated with variation orders by means of an ‘origin-cause matrix’ designed for that purpose. Problematic situations arising from the occurrence of variation orders included discrepancies between the claimed and certified amounts. Variation orders impacted project performance with regard to cost and time overruns and disputes between parties to the contract. Most variation orders involved additional works. The complexity of works was the most predominant factor influencing the occurrence of variation orders. The reduction of the occurrence of variation orders was traced back to the pre-contract stage given that the most predominant origin agent of variation orders was the client and then due to an unclear brief of works to be executed. Suggestions regarding the reduction of variation orders include (1) adequate planning in advance is required by all involved parties before works start on site, (2) consultants should do a thorough concluding design and working drawings and contract documents should be complete at tender stage, (3) clients should provide clear brief, (4) enhance communication and all parties should be proactive at all times, (5) works should be supervised with an experienced and dedicated supervisor and (6) consultant should ensure that the design/specifications fall within the approved budget and the budget team should be appointed and participate during the design phase. The study suggests further investigation regarding the development of a more equitable basis of valuation of cost recovery which was beyond the scope of this research.

CHAPTER 1
INTRODUCTION

1.1 Background

The desire to reduce non value-adding activities on construction projects emanated from the recognition of the need to reduce waste and the resultant optimisation of the use of resources. Waste has been part of estimating conventions for a very long time. However, the scientific study of waste started in the United Kingdom in 1963 during investigations into a new form of tender documentation (Skoyles & Skoyles, 1987). This study revealed a considerable disparity between the norm used by contractors and the actual waste that occurs on site. Subsequently, many research studies have been carried out to analyse waste, its origin, causes and negative impact in a bid to take proactive action to minimise it. Saukkoriipi (2005) argued that several studies that have been carried out regarding poor quality, costs and non value-adding activities on building projects included only some of the activities and cost items. Saukkoriipi (2005) believed construction stakeholders failed to have a comprehensive appreciation for how extensive non value-adding activities could be. An understanding of waste would require the definition of what value-adding and non value-adding activities are. An activity is value-added if it is judged to contribute to customer value or satisfy an organisational need (Tsai, 1998). From the perspective of the client, Saukkoriipi (2005) defined non-value adding activities as those which

absorb resources without adding value to the customer. These are waste of resources typically transferred to the client; hence as a consequence, they contribute to higher construction delivery costs.

Several studies pertaining to reduction of waste have focused entirely on waste of materials on construction sites. Skoyles and Skoyles (1987) viewed waste as a loss of profit. Wyatt (1978) and the Chartered Institute of Building (1980) focused on the reduction of waste in material handling. Alwi, Hampson and Mohamed (2002) described non value-adding activities as physical waste found on site and other waste that occurs during the construction process. Other studies examined costs of rework due to the poor quality of the end-product. These included costs of quality deviation defined as changes to the requirements that result in rework, as well as products or results that do not conform to all specification requirements, but do not require rework (Burati, Farrington & Ledbetter, 1992). Abdul-Rahman, Thompson and White (1996) captured the costs of non-conformance during the construction project and suggested that their reduction would improve profit margin, competitiveness and client satisfaction. Love and Li (2000) and Love and Sohal (2003) stipulated that costs of rework included variations and defects.

The Swedish government investigated major problems in the construction sector such as high costs *"Byggkostnadsdelegationen"*, general quality-related problems *"Byggkvalitetsutredningen"*, general problems *"Byggkommissionen"* and reduction of costs for producing new buildings *"Byggkostnadsforum"*. However, these investigations did not consider the need to identify non value-adding activities and their associated costs (Saukkoriipi & Josephson, 2003). Consequently, a ground-breaking investigation was initiated into the existence of non value-adding activities in all phases of the construction process. According to Saukkoriipi (2005) the analysis

of the reduction of construction costs should consider the whole value chain including material producers, suppliers, subcontractors, contractors, client and end users, and finance activities that are not part of the traditional value chain. In fact, the concept of non value-adding activities compels construction industry stakeholders to explore waste associated with activities traditionally not perceived as non value-adding. This knowledge allows for the implementation of improvement measures.

Studies have been done on aspects such as caused by the piece-rate[1] (Saukkoriipi, 2004), non value-adding activities arising from defects and inspections, non-productive use of resources, injuries and other ill-health problems and municipality systems and structures (Saukkoriipi, 2005), non value-adding costs arising from traditional competitive tendering (Hassel, Josephson, Langstrom & Saukkoriipi, 2005) and non value-adding costs hidden in taxes (Saukkoriipi & Josephson, 2005). However, to date, few studies have been carried out to investigate the non value-adding activities associated with the changes or variations during the construction stage.

Previous studies relating to variation orders have mainly focused on management aspects and their overall costs (Mohamed, 2001; Charoenngam, Coquinco & Hadikusumo, 2003; Arain, 2005). Koskela and Vrijhoel (2000) revealed two principles underlying the theory of waste reduction. These included reduction of variability and time compression that lead to waste reduction. Clearly, in construction terms, variability is referred to as variation orders. Arguably, variation orders may be seen as counter to the principle of waste reduction. The more variation orders on a project, the greater the likelihood that they become time consuming and costly elements in construction projects (Mohamed, 2001). While academicians and

[1] "piece-rate" refers to a kind of incentive pay consisting of a fixed wage and a bonus negotiated between the employer and employees on specific tasks before commencement of works on site

practitioners concur that variation orders are common in the construction industry their potential effect on project performance has been overlooked.

A variation order is any modification to the contractual guidance provided to the contractor by the client or the client's representative (Arain & Pheng, 2005b). Success in managing variation orders results in uninterrupted construction operations and agreed project costs as well as duration (Charoenngam *et al.*, 2003). But, this is not always practically achievable. A variation order has to be managed carefully. Otherwise disputes between a client and a contractor related to cost and time of work might occur (Charoenngam *et al.,* 2003). Variation orders often involve additional cost and disruption to work already under way, leading to cost and time overruns (Chan & Yeong, 1995). A study of delays and cost increases in the construction of private residential projects in Kuwait revealed that a number of variation orders issued during the construction phase led to both delays and cost increases (Koushki, Al-Rashid & Kartam, 2003). The projects that experienced variation orders incurred more than 58% time delay and cost increases when compared to those with no variation orders (Koushki *et al,* 2003). The magnitude of variation orders varies from one project to another. Though there have been cases where variation costs accounted for as much as 100 percent of the budgeted funds, the industry norm has been determined to be about 10 percent (Arain & Pheng, 2005b). The study by Charoenngam *et al* (2003) of variation orders on construction projects found that the average cost escalation was 7% of the original project cost with an average time extension of 30% more than the original project duration. Studies have revealed the significant reduction in both cost increase and time delay as a result of a complete design before commencement of works on site resulting in the prevention of variation orders (Koushki *et al,* 2005). Arguably, the more the occurrence of variation orders,

the greater the likelihood that unnecessary costs could accrue impacting on the overall project cost. Whenever a variation order is issued, whether leading to additions, alterations, omissions or substitutions, unnecessary costs are likely to be incurred. Al-Hakim (2005a) identified three types of operations, namely non value-adding, necessary but non value-adding and value-adding operations. Unfortunately, the construction industry lacks sufficient knowledge to identify and quantify non value-adding costs associated with variation orders. The realistic quantification of such costs is problematic due to lack of appropriate techniques for their measurement. In practice, non value-adding costs arising from variation orders that are transferred to the client are underestimated. For example, one may be able to calculate the costs of aborted works, but non value-adding costs arising from non-productive time, redesign and overheads are not attributed to such an activity.

Koskela (2000) indicated that every time a task is divided into two subtasks executed by different specialists, non value-adding activities increase, such as, for example, inspecting, moving and waiting. By uncovering non value-adding activities arising from variation orders it is possible to take proactive measures to reduce them. A clearer understanding of variation orders and subsequent waste is possible if they are categorised by their origin and identification of possible waste zones. Koskela (2000) suggested a framework of formation of waste and value loss that takes into account the following:

- Waste and value loss;
- Factors causing loss; and
- Root causes.

Similarly, when a variation order is issued, numerous non value-adding activities/costs are likely to arise. These include unplanned site meetings, travelling and communication expenses, idle plant and labour during the waiting time,

demolitions, time taken by the designer to understand the required change and redesign, cost and time for litigation in case misunderstanding arises between the contractor and the client or his/her consultant. These represent a waste of resources and are typically paid for by the client. Variation orders do not only affect project performance in terms of time and cost, they also adversely affect the quality, health and safety and professional relations [2](Arain & Pheng, 2005b). However, factors influencing the occurrence of variation orders and their adverse impact on project performance vary from one project to another. Factors include the nature of works, the complexity of the project and the procurement method.

In a developing country like South Africa where existing infrastructure and buildings are being upgraded or replaced with newly built ones, the occurrence of variation orders on construction projects seems inevitable. Love (2002) noted that a degree of change should always be expected as it is difficult for clients to visualise the end product they procure. Though it is likely that variation orders cannot be avoided completely, they can be minimised or prevented if their origin and causes were clearly known (Mohamed, 2001). The greater the knowledge and awareness of non value-adding activities associated with variation orders, the greater the prospects of their avoidance and consequent reduction of overall construction delivery costs.

1.2 Problem statement

The research problem may be stated as follows:

Variation orders on construction projects have the potential to unnecessarily increase the cost of construction without adding value to the project in which case they may be regarded as waste, and the identification of their causes might lead to their reduction, possible elimination and subsequent improvement in overall project performance.

[2] Sixteen potential effects of variation orders were compiled from studies of various authors

1.3 Hypotheses

The hypotheses to be tested in this study are:

- H1. Variation orders are prevalent on all construction projects
- H2. Variation orders always increase the cost of construction
- H3. All variation orders add value to construction projects
- H4. Variation orders may be regarded as waste
- H5. Variation orders may be eliminated if their causes are identified
- H6. Variation orders negatively affect overall project performance
- H7. The predominant origin agent of variation orders is the client.

1.4 Aim

The aim of this research is to investigate the impact of variation orders on project performance in order to take proactive measures to reduce them.

1.5 Objectives

The primary objectives of the study are:

- To investigate the prevalence of variation orders on construction projects;
- To determine the cost impact of variation orders;
- To examine to what extent variation orders add value to construction projects;
- To determine whether the activities associated with variation orders may be regarded as waste;
- To identify the predominant origin agent as well as the direct causes of variation orders; and
- To establish the nature and extent of the impact of variation orders on overall project performance.

1.6 Methodology

As depicted in Figure 1.1, the objectives of this research will be achieved as follows:

- Literature and previous studies related to the area of research will be extensively reviewed.

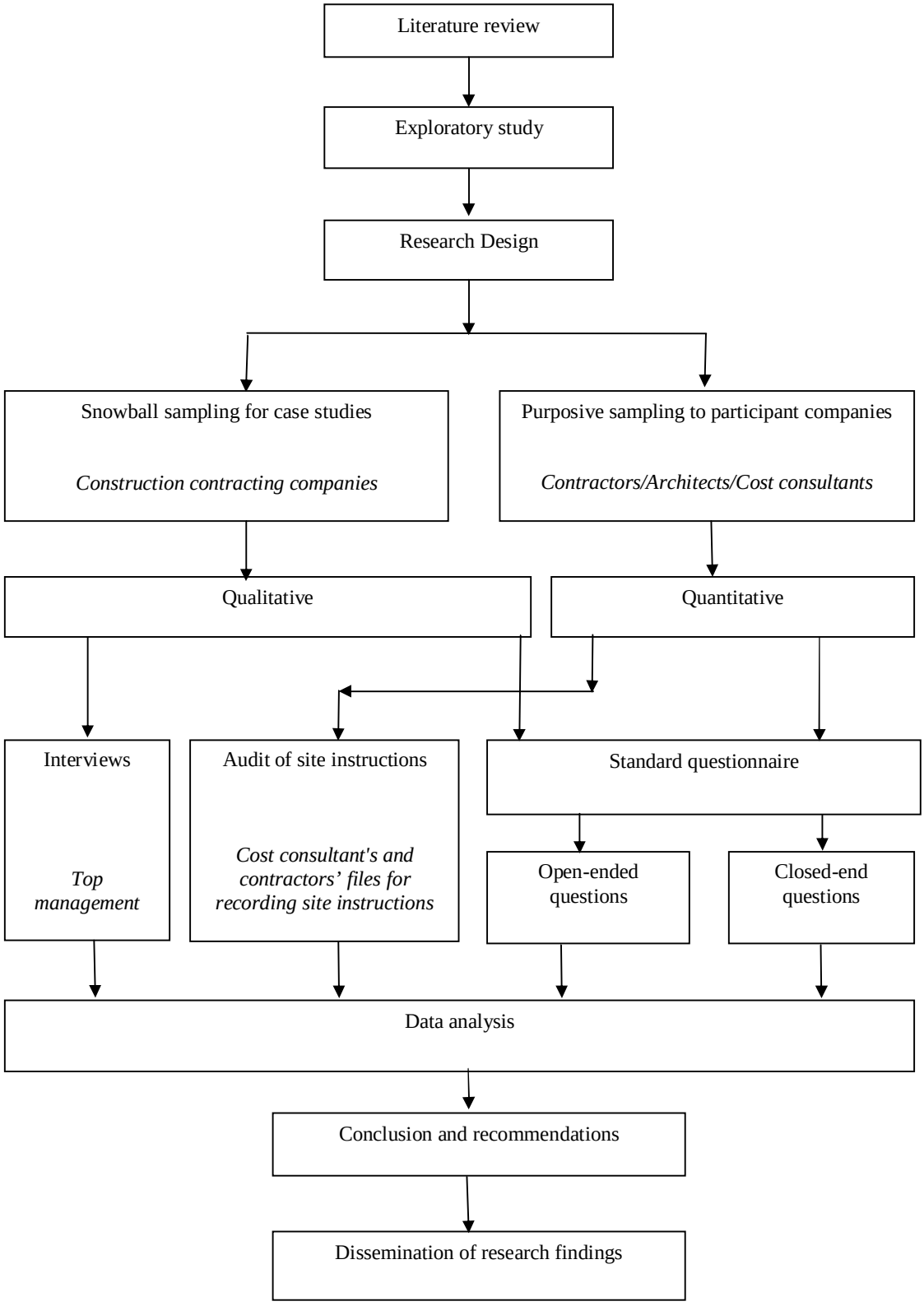

Figure 1.1 Framework of the research study

- An initial exploratory study will be done on two apartment developments to identify and examine the origin and causes of construction cost variations and a

development of a tool for identification of waste zone of variation orders. The findings of this study will provide the basis for the research design of the main study.

- The research design is based on a purposive sampling selection process in terms of which a representative sample of stakeholders/participants in the construction process will be surveyed and a selection of similar construction projects from which to derive further data on variation orders. In particular, case studies, interviews with relevant parties such as site and head office management, self-administered surveys and examination of project documentation and records will form the basis of the research methodology.

- Gathered data will be analysed using appropriate statistical analysis tools. Both quantitative and qualitative methods will be used.

Conclusions will be drawn from the analysed data and recommendations for improvement and future study will be formulated. Hypotheses will be tested and the findings summarised.

1.7 Limitations

The study will be confined to the Cape Peninsula geographical area in the Western Cape Province of South Africa where a number of construction projects and industry stakeholders will be accessed. This physical limitation is informed by both budgetary limitations and time frame. Documents, records and variation orders to be analysed will include those issued from the commencement of work on the various projects until the end of April 2008. Case studies will be conducted on projects where information regarding various aspects of variation orders will be investigated.

1.8 Assumptions

- It is assumed that proposed participant companies for case studies will cooperate and allow access to their sites and documentation records as required by the study.

- It is assumed that variation orders will occur on the construction projects under investigation before and during the field data gathering period.

- It is assumed that records from projects documentation regarding to variation orders will be accurate and participants will be honest in providing correct information.

1.9 Key concepts

Non value-adding activity: is an activity that absorbs resources without adding value to the customer, namely both internal and external customers (Saukkoriipi, 2005).

Value-adding: is to change the form, fit, or function of a product in order to satisfy the customer (Allen, 2000).

Variation order: is any modification to the contractual guidance provided to the contractor by the client or client's representative (Arain & Pheng, 2005b).

Waste is used synonymously as non value-added activity (Saukkoriipi, 2005).

1.10 Ethical considerations

In order to comply with internationally accepted standards, the name of participant organisations and individuals will not be recorded on research instruments. No compensation will be paid to any respondent or participant in the study. Quality assurance will be done with respect to the following aspects:

- Quality of data capturing;
- Accuracy in calculations; and
- Correctness and completeness of questionnaires if used, especially where open-ended questions are concerned.

1.11 Chapter outline

Chapter One: Introduction - Chapter one will comprise the background, problem statement, hypothesis, aim, objectives, methodology, limitations, assumptions, key concepts, ethical statement, chapter outline and chapter summary.

Chapter Two: Literature Review - This chapter will explore previous studies related to non value-adding activities and will uncover waste associated with variation orders. The origin, causes and impact of variation orders on projects performance will be discussed.

Chapter Three: Methodology - This chapter will discuss the tools and methods to be used for data gathering.

Chapter Four: Analysis of the exploratory study and interviews - This chapter will constitute the presentation and analysis of data gathered at the early stage of the research. It will cover the exploratory study and interviews.

Chapter Five: Data analysis - This chapter will constitute the presentation and analysis of data gathered at the late stage of the research. It will analyse research instruments and the audit of site instructions.

Chapter Six: Summary and Conclusions - Conclusions and recommendations will be drawn based upon data analysis, linking them to the problem statement, hypothesis and objectives of the subject under investigation.

1.12 Chapter summary

This chapter outlined the framework of the entire research study. The preliminary literature review focused on the historical background of the recognition of waste in construction and subsequent studies pertaining to waste reduction. Subsequently, a problem statement relating to the potential contribution to unnecessary increase of project costs owing the occurrence of variation orders was formulated. The aim of the study was to investigate the adverse impact of variation orders on project performance and their reduction. Key concepts included non value-adding activities, value-adding activities, variation orders and waste. The research data gathering complied with internationally accepted ethical standards. The research outline provided an overview set up of each chapter of the study.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature on variation orders with emphasis on the existence of non value-adding activities associated with variation orders. It covers, *inter alia,* the following areas:

- Prevalence and nature of variation orders on construction projects;
- Contractual provisions authorising variation orders;
    - Categorisation of contract instructions;
    - Administration of variation orders;
- Origin and causes of variation orders;
- Factors influencing the occurrence of variation orders such as
    - the nature of works;
    - the complexity of the project;
    - the procurement method;
- Waste associated with variation orders;
- Impact of variation orders on overall project performance
    - Cost overruns;
    - Time overruns;
    - Quality degradation;
    - Health and safety; and
    - Relationships between the project team.

2.2 Prevalence of variation orders on construction projects

2.2.1 Introduction

A construction contract is a business agreement that is subject to variability. Contractual clauses relating to changes allow parties involved in the contract to freely initiate variation orders within the ambit of the scope of the works without alteration of the original contract. Variation orders involve additions, omissions, alterations and substitutions in terms of quality, quantity and schedule of works. Without contractual

clauses, the building contractor would have to agree to erect the building shown on the drawings and represented in the bills for a contract sum. Any minor change that the client[3] or his/her architect wished to make later would mean that the contract had to be cancelled and a new one drawn up (Wainwright & Wood, 1983). Once a contract has been concluded, its terms cannot be changed unless the contract itself contains provisions for variation and then the only permitted variations are those that fall clearly within the contractual terms (Willis & Willis, 1980). Uff (2005) indicated that a clause permitting variation of works is an essential feature of any construction contract because without it the contractor is not bound to execute additional work or to make omissions or changes. Under contractual provisions, the client has the right to vary the extent and the nature of the performance to be rendered by the contractor (Wainwright & Wood, 1983). Furthermore, the contractor could not refuse to carry out the varied obligation with the only remedy being an adjustment of price to be paid for the performance, and in appropriate circumstances, an extension of time in which to execute such performance (Finsen, 2005). Ssegawa, Mfolwe, Makuke and Kutua (2002) argued that the spirit in which variation orders are permitted allows the contract to proceed without compiling another contract to cater for the changes.

2.2.2 Pervasiveness of variation orders on construction projects

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

[3] Literature refers to employer, owner or customer.

progresses (Harbans, 2003). Hanna *et al* (2002) indicated that variations occur given the uniqueness of each project and the limited resources of time and money available for planning. Various authors intimate that variation orders are common to all types of projects (Thomas *et al*, 2002; Arain & Pheng, 2005a; Oladapo, 2007). Ssegawa *et al.* (2002) added that it is hardly possible to complete a construction project without changes to the plans or the construction process itself due to the complexity of construction activities. Variation orders occur due to a number of reasons ranging from finance, design, aesthetic, geological, weather conditions to feasibility of construction, statutory changes, product improvement, discrepancies between contract documents (Hanna *et al,* 2002; Ssegawa *et al,* 2002; Harbans, 2003; Uyun, 2007). Further, the human behaviour of parties to the contract cannot be predicted. Variation orders may arise from changes in the minds of parties involved in the contract. Variation orders may be initiated either by clients or by contractors (Harbans, 2003).

Most contracts these days must make provisions for possible variations given the nature of building construction (Finsen, 2005; Wainwright & Wood, 1983). A degree of change should be expected as it is difficult for clients to visualise the end product they procure (Love, 2002). Unforeseen conditions[4] may arise which require measures that have not been provided for in the contract (Finsen, 2005). However, the disadvantage of the variation clause is that architects tend not to crystallise their intentions on paper before the contract is signed because they know the variation clause will permit them to finalise their intentions during the term of the contract (Wainwright & Wood, 1983). Ashworth (2001) added that the advantage of the variation clause is that it allows the architect or other designers to delay making some decisions almost until the last possible moment. An unfortunate aspect of the variation

[4] Such as adverse ground conditions affecting foundations, which become apparent only during excavation.

clause is that it tends to encourage clients to change their minds and embark on building projects without having properly thought through their project requirements (Finsen, 2005). Traditionally, the client's *prima* perceived requirements include functionality, durability and optimality. In order to achieve these requirements, clients appoint a consultant team to advise them on design and optimum use of resources. On the other hand, contractors concern themselves predominantly with construction costs and their reduction. Little recognition is given to the fact that the clients or their agents may be sources of higher construction costs. Clients and consultants typically forget that issuing numerous variation orders result in higher construction costs. For example, a client who targets a completion date may want works to start on site while the design is still at a sketchy plan stage. In some cases, the construction works may overlap the design where the contractor will have to wait for the detailed design. As a result, some works are put on hold and others are subject to abortion or demolition. Arguably, the costs for aborted works are wastage of resources and are typically transferred to the client. They contribute to higher construction delivery costs. According to Skoyles and Skoyles (1987) one of the reasons for higher than necessary costs lies in the lack of awareness. The construction industry does not grasp that the reduction of the occurrence of variability may optimally lower construction delivery costs. Ibbs (1997) concluded that the greater the amount of change the greater the negative impact on both productivity and cost.

2.2.3 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 & Pheng, 2005b) distinguished two types of variation orders, namely: beneficial and detrimental variation orders.

2.2.3.1 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 & Pheng, 2005b). It is a variation order initiated for value analysis purposes to realise a balance between the cost, functionality and durability aspects of a project to the satisfaction of clients. Value analysis is an organised 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 & Male, 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 & Hart, 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 & Duerk, 2002).

A beneficial variation eliminates unnecessary costs from a project. According to Zimmerman & Hart (1982) all designs have unnecessary cost regardless of how excellent the design team may be. A beneficial variation order, therefore, seeks to optimise 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.

2.2.3.2 Detrimental variation orders

A detrimental variation order is one that negatively impacts the client's value or project performance (Arain & Pheng, 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 to sub-standard cheap materials. For example, on a construction project situated in a salty environment, steel window frames result in steel oxidation if selected in lieu of timber or aluminium frames.

2.3 Contractual provisions relative to variation orders

2.3.1 Classification of contract instructions

As has been previously stated, a variation order is any modification to the contractual terms of a project by the client or the client's representative (Arain & Pheng, 2005b). It is a formal decision to alter a previous decision which affects the work or objectives of the other teams (Bennett, 1985). In practice, variation orders are issued in the form of site[5] instructions typically issued by architects. Uff (2005) argued that disputes often arise as to whether an instruction constitutes a variation order because the contract does not contain a definition of what may constitute a variation. Ssegawa *et al.* (2002) contend that there is no single definition of what a variation is. Not all architect's instructions constitute variation orders such as for example, an instruction to remove defective work (Wainwright & Wood, 1983; FIDIC, 1999). The JBCC[6] (2005) defined a contract instruction as a written

[5] Literature refers to site/contract/Architect's instruction

[6] The Joint Building Contracts Committee

instruction signed and issued by or under the authority of the principal agent to the contractor. The FIDIC[7] (1999) general conditions clause 3.3 stipulates that the engineer may issue to the contractor instructions and additional or modified drawings which may be necessary for the execution of the works and the remedying of any defects, all in accordance with the contract. But, not all instructions vary the contractual arrangements or the way the works are being undertaken. Consequently, some contract instructions may be considered as variation orders while others are not. Clause 17 of the Principal Building Agreement discusses the contract instructions (JBCC, 2005). With reference to this clause, Finsen (2005) identified five categories of contract instructions that will be further discussed.

2.3.1.1 Instructions to vary the works

Clause 17.1.1[8] empowers the consultant to initiate variations regarding to alteration to design, quality or quantity of the works provided that such contract instructions do not substantially change the scope of the works. According to Finsen (2005) it is unclear how substantial a change must be to 'substantially change the scope of the works'. The consultant may issue the instruction to add or omit a considerable portion of a building, but the instruction may not have the effect of changing the building from one type to another such as, for example, from a hotel to an office building (Finsen, 2005).

2.3.1.2 Instructions to resolve discrepancies

Clause 17.1.2 allows the consultant to issue instructions in terms of rectification of discrepancies, errors in description or omissions in contract documents. Clause 17.1.19 relates instructions issued with regard to compliance with Acts of Parliament.

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[7] FIDIC is a French acronym that stands for Fédération International des Ingénieurs-Conseils interpreted as International Federation of Consulting Engineers.

[8] JBCC Series 2000 refers to principal agent who is appointed by the employer and other agents whose power to issue contract instructions are vested.

2.3.1.3 Instructions to reiterate or enforce contractual provisions

These instructions do not vary the contractual conditions. Rather they enforce or reiterate the contractual conditions where works that have been executed or materials or goods brought to site do not conform to what has been described in the original contract documents. However, these instructions may be considered as variation orders where they were not part of the original contract or if they were incidental from instructions that relate to any of the following, namely:

- Removal of any materials and goods from the site and the substitution of any other materials;
- Removal or re-execution of any work;
- Opening up work for inspection;
- Testing of work and materials and goods;
- Protection of the works;
- The list for practical completion, works completion, final completion and defects; and
- Access for previous contractors and subcontractors to remedy defective works.

2.3.1.4 Instructions to deal with monetary allowance

Instructions dealing with monetary allowance do not alter the contractual arrangements. They give power to the consultant to indicate how to spend money budgeted under prime cost amounts for nominated subcontractors and suppliers. However such instructions become variation orders if, for example, an adjustment made to the prime cost sum for materials supplied by a nominated supplier where the original quality is changed such as the supply of clay bricks in-lieu of cement bricks. These instructions include:

- Nominated and selected subcontractor amounts and the work to be executed as well as the appointment of nominated and selected subcontractors;
- Proof of payment to nominated and selected subcontractors;
- Notice to subcontractors;
- Prime cost amounts and the purchase of materials and goods covered; and
- Contingency and other monetary provisions included in the contract sum.

2.3.1.5 Instructions to protect the client's interest

These instructions do not change the original contract agreement, but they are intended for employees residing in a site camp who are considered to be a nuisance. They prevent employees from becoming involved with illegal activities or members of their families to squat on camp. These include:

- Removal from site of any person employed on site; and
- Removal from site of any person not engaged on or not connected with the works.

From Table 2.1, it is clear that all contract instructions are not variation orders. The instruction to vary the design, quality and quantity of the works and to resolve discrepancies in contract documents are variation orders. To a certain extent, the instructions to reiterate the contractual provisions are not variation orders. However, they become variation orders when they are incidental to the two previous ones or they were omitted in the original contract. The instruction dealing with monetary allowance is considered as a variation order in extreme cases when the monetary adjustments result from the two first kinds of contract instructions. The instructions to protect the client's interest are not variation orders since they do not change the original contractual agreement.

Table 2.1 Classification of contract instructions

No	Instruction category	Qualification
1	To vary the design, quality or quantity of the works	Variation order
2	To resolve discrepancies	Variation order
3	To reiterate or enforce contractual provisions	In some cases it may be a variation order if incidental to instruction 1 or 2
4	To deal with monetary allowance	It may be a variation order if monetary adjustments are the result of instruction number 1 and 2
5	To protect the client's interest	Not a variation order

2.3.2 Administration of variation orders

As previously indicated variation orders are typically issued in the form of contract instructions. The process of administering variation orders is shown on Figure 2.1 below. According to Ssegawa *et 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; Ssegawa *et al.*, 2002). "Writing" includes drawings, faxes, e-mails, telegrams and 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 valuers (Harbans, 2003).

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

- Rates where contracted rates are adopted where the varied works are of similar character and extent and executed under similar conditions to items in the contract bills (Wainwright & Wood, 1983; JBCC, 2005);
- Day works which consist of the payment of executed works on a basis calculating the prime cost of works including materials, labour, 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 meruit* is a miscellaneous method where negotiated or agreed rates or payment are made on a reasonable sum (Harbans, 2003).

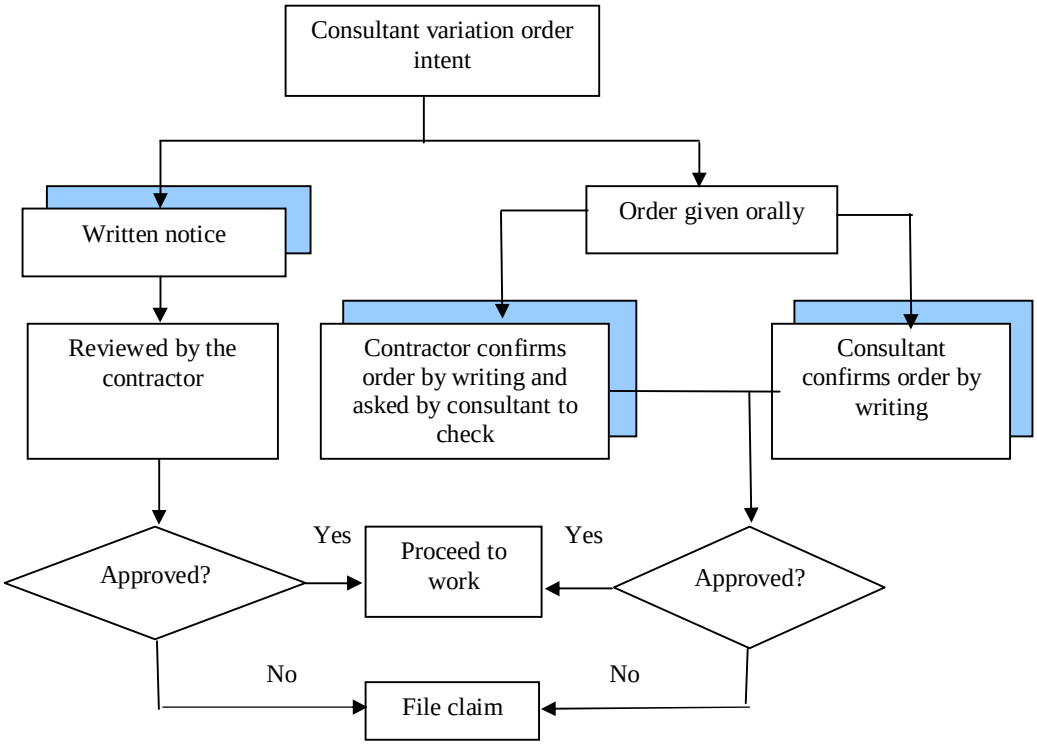


Figure 2.1 Variation order process

Source: Adapted from Charoenngam *et al* (2003:200).

2.4 Origin and causes of variation orders

2.4.1 Introduction

While variation orders are common in construction projects, an improved understanding would require their categorisation into their root or origin agents and causes. The cognisance of 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 four main origin agents of variation orders (Arain & Pheng, 2006). These included "client", "consultant", "contractors" and "others". There is an interrelation between the origin agent and causes of variation orders.

2.4.2 Origin agents

2.4.2.1 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 utilisation of finished works. Clients are mainly classified under two categories: Clients who have the knowledge and experience of the construction industry and those without or with little experience. Clients with experience in construction are involved during the design stage by providing professional guidance to the design team. This participation may contribute to the avoidance of continuous changes during the construction stage. For example, public entity clients and private development companies have their own professional team responsible either for design or supervision of a commissioned designer. The technical input into the design by clients prevents them from fully relying on the designer, minimising the chance of them changing their mind during the construction stage. Clients without or with little knowledge in construction tend to follow the guidance of the designer without any clear idea that their requirements have been met. Uyun (2007) remarked that it is sometimes very difficult to determine the exact requirements of the client. If the objectives of the project are inadequately defined, it is common that clients will tend to change their minds along the way. Clients struck with unexpected financial difficulties during the construction stage initiate changes in

order to suite their conditions. Changes may include replacement of materials, change of design, scope and schedule of works. As a result, such changes lead to quality standard degradation and high maintenance cost.

2.4.2.2 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 labour and plant while waiting for the consultant's decision. Acharya *et al.* (2006) suggested that consultants should aim at getting an understanding of the overall scope and goals of the project, make sure they understand deliverables and offer specific suggestions when it makes sense. All has to be done relatively quickly without having any negative effect on productivity. Unfortunately, the feeling of superiority of the consultant over the contractor may hinder the consultant from giving attention to requests by the contractor. Acharya *et al.* (2006) accused consultants of protecting

their own interest at the expense of the interest of the client and the contractor. Basically, the role of the consultant is to advise the client on technical, legal and financial matters. Where deemed necessary, it is common for the consultant to issue a variation order for improvement purposes. During the briefing stage, clients state their requirements and these constitute the basis for formulating contract documents. Unfortunately, a failure by the consultant to interpret the requirements results in the design being different from the perceived one. As a consequence, variation orders will be issued to ensure compliance with the requirements for the client.

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

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

- The involvement of the consultants in the design phase would assist in clarifying the project objectives and in identifying the non-compliance with their requirements at early stage. Eventually, this may help in eliminating the occurrence of variation orders arising from errors and design discrepancies during the construction stage where the impact of variation orders can be severe.

- The continuous coordination and direct communication would not only eliminate design discrepancies and errors as well omissions in the design, but also provide an opportunity for professionals to review the contract documents

thoroughly that would help in eliminating the variation orders arising because of conflicts in contract documents.

- The control of the frequent changes in design by 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 finalise the design during the design phase. This would assist in reducing the variation occurrences during the construction phases where the impact of variation order can be severe.

2.4.2.3 Contractor

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

2.4.2.4 Situations beyond control of parties to the contract

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

2.4.3 Causes

There are many causes of variation orders. Table 2.2 shows causes of variation orders stemming from the above discussed origin agents (Arain & Pheng, 2006).

Table 2.2 Origin and Causes of variation orders

No	Causes of variation orders	Client	Consultant	Contractor	Others
1	Change of plans or scope	○			
2	Change of schedule	○			
3	Client's financial problems	○		○	
4	Inadequate project objectives	○			
5	Replacement of materials or procedures	○			
6	Impediment in prompt decision making process	○			
7	Obstinate nature of the client	○	○	○	
8	Change in specifications	○	○		
9	Change in design by the consultant		○		
10	Errors and omissions in design		○		
11	Conflicts between contract documents		○		
12	Inadequate scope of work for contractor		○		
13	Technology change		○		
14	Value engineering		○		
15	Lack of coordination		○		
16	Design complexity		○	○	
17	Inadequate working drawing details		○		
18	Inadequate shop drawing details		○		
19	Consultant's lack of judgment and experience		○	○	
20	Lack of consultant's knowledge of available materials and equipment		○		
21	Honest wrong beliefs of consultant		○		
22	Consultant's lack of required data		○		
23	Ambiguous design details		○		
24	Design discrepancies		○		
25	Non-compliant design with government regulations		○		
26	Non-compliant design with owner's requirement		○		
27	Lack of contractor's involvement in design			○	
28	Unavailability of equipment			○	
29	Unavailability of skills			○	
30	Contractor's desired profitability			○	
31	Differing site conditions			○	
32	Defective workmanship			○	
33	Unfamiliarity with local conditions			○	

Table 2.2 Continued

No	Causes of variation orders	Client	Consultant	Contractor	Others
34	Lack of a specialised construction manager			○	
35	Fast track construction			○	
36	Poor procurement process			○	
37	Lack of communication			○	
38	Long lead procurement			○	
39	Honest wrong beliefs of contractor			○	
40	Lack of strategic planning			○	
41	Contractor's lack of required data			○	
42	Weather conditions				○
43	Health and safety considerations				○
44	Change in government regulations				○
45	Change in economic conditions				○
46	Socio-cultural factors				○
47	Unforeseen problems				○

Source: Adapted from Arain and Pheng (2006)

2.5 Factors influencing the occurrence of variation orders

Unfortunately, variation orders are typically expected to occur in all construction projects. However, the frequency of their occurrence varies from one project to another depending on various factors (Arain & Pheng, 2005b). Factors influencing the occurrence of variation orders include the nature of the works, the complexity of the project and the procurement method.

2.5.1 Nature of the works

Construction works involve building, civil and/or specialist works. Building works include, for example, the construction of residential houses, commercial premises and offices. Civil works include, for example, the construction of roads and infrastructural installations. Construction projects that involve extensive unforeseen conditions are likely to generate variation orders. For example, civil works involving bulk earth excavation and building works that include specialist works beyond the expertise of the designer cannot accurately be determined before works commence on

site. According to Uyun (2007), the drawings and specifications do not always show the real site conditions nor do preliminary investigations. Despite this situation, it is common that works commence on site while some trades and building elements still need to be completely designed or detailed. Consequently, contracts contain provisional quantities and sums that will be subject to future adjustment. The presence of provisional quantities or sums in a contract is a clear indication of the likely occurrence of variation orders in a project. Gidado (1996) suggested four possible causes of project uncertainty, namely:

- Lack of complete specification for the activities to be executed;
- Unfamiliarity with the inputs and/environment by management;
- Lack of uniformity, such as when material to be worked with varies with place and time or teams working together vary with place and time or the role of the teams keeps varying with place and time.
- Unpredictability of the environment, such as the effect of weather and refurbishment of very old buildings having no record drawings.

2.5.2 Complexity of the project

Project complexity is a result of continuous demands for speed in construction, cost and quality control, health and safety in the work place and avoidance of disputes, together with technological advances, economic liberalisation and globalisation, environmental issues and fragmentation of the construction industry (Gidado, 1996). Project complexity consists of many varied interrelated parts (Baccarini, 1996). Ireland (2007) indicated that complexity involves an item having two or more components or two or more variables. Two types of project complexity are distinguished, namely organisational or management complexity and technological or technical complexity (Baccarini, 1996; Ireland, 2007).

A construction project involves a management structure for a certain period of diverse organisations including contractors and consultants. Management complexity

refers to business aspects of the project, parties involved in a contract and their relationships in terms of communication, allocation of responsibility and authority of decision making and allocation of tasks.

Technological complexity refers to difficulties and intricacies during the transformation process involving materials, tools, techniques and skills needed to complete a construction project. Experts interviewed by Gidado (1996) understood project complexity:

- As having a large number of different systems that have to be put together with a large number of interfaces between elements;
- As a situation whereby construction works on a confined site with difficult access require many trades to work in close proximity and executed at the same time;
- As a project which is difficult to specify clearly how to achieve a desired goal or how long it would take;
- As a project which requires a lot of details about how it should be executed;
- As a project which requires efficient coordinating, control and monitoring from the start to finish; and
- As a project which requires a logical link because owing a series of revisions during construction and without interrelationships between activities, of which it becomes difficult to successfully update the programme in most effective manner.

The degree of project complexity is classified as low, medium and high complexity (Ireland, 2007). The greater the project complexity, the greater the likelihood of variation order occurrence. A variation order issued due to the complexity of the design may take time for the design team to understand the required change and redesign while works on site are put on hold. Ireland (2007) discussed a complex project involving an electronic engineer working for one contractor and a computer scientist working for another that resulted in an error that cost $600,000 to redesign and rebuild connectors. The error resulted from 256 connectors being

misaligned by one position such that the electronic engineer started with sequence 1 through 256 while the computer scientist started with the sequence 0 through 255. The variation order issued in this case was to solve the problem resulting from the project complexity.

2.5.3 Procurement method

The participants in a construction project constitute a multi-organisational body generally including a client, designers, specialist consultants, project managers and constructors. The path followed to deliver the project differs from one project to another. Typically, this is a procurement method that stipulates the form of contractual arrangement between participants or parties to the contract. One type of procurement method may result in more variation orders than another. For example, Love (2002) indicated that non-traditional procurement methods are subject to greater occurrence of errors, omissions and changes than the traditional methods.

2.5.3.1 Traditional method

Traditionally, an employer who wished a project to be constructed would invariably commission a designer or design team to prepare drawings of the proposed scheme and, if the scheme was sufficiently large, employ a quantity surveyor to prepare documentation, such as bills of quantities, from which the contractor could prepare a bid price (Ashworth, 1998). Since the works commence on site when the design is complete, the occurrence of variation orders in this arrangement is minimised. Koushki *et al*. (2005) revealed that clients who spent more time and money on the design phase issued less variation orders than those who allocated insufficient money and time to this phase. The more time spent on completing the contract documents before commencement of works, the more likely the avoidance of discrepancies between the contract documents, errors and omissions into the design.

Consequently, there is less variation orders. Turner (1990) indicated that since clients and their consultants control the origin of variations, variations should not occur if pre-construction design has been good.

2.5.3.1 Non-traditional methods

Over the years other forms of procurement[9] have emerged, namely, non-traditional methods. Ashworth (1998) indicated that changes in procurement methods are the result of a move away from the craft base to the introduction of off-site manufacture, the use of industrialised components, the wider application of mechanical plant and equipment, the improved knowledge of production techniques, the recognition that involvement of the contractor into both the design and the way works are carried out on site will result into quality of finished works. For example, design and construct procurement methods where the contractor is responsible for the design and construction are deemed to overcome the problem of variation order occurrence. The involvement of contractors into the design is an opportunity for them to use specialised knowledge and methods of construction evolving from their own design[10] and as a result, there is less scope for variations than with the design and construct approach (Ashworth, 1998).

The package deal procurement method requires the client to view completed projects of a specific design and choose a suitable project or design from the catalogue. Owing to the completeness of the design, this procurement method is less prone to variation orders.

The fast track procurement method is appropriate for situations where the client targets the shortening of the overall design and construction process. When the design

[9] Discussion is confined to some examples of procurement methods relevant to the subject matter.

[10] Some argued that the design will be more influenced by the contractor's construction capabilities than the design requirements of the employer (Ashworth, 1998)

for the whole section of the works, such as foundations, is completed the work is then let to the contractor, who will start this part of the construction work on site while the remainder of the project is still being designed (Ashworth, 1998). Turner (1990) indicated that variations should be expected on construction projects that lack pre-design. Variation orders resulting from design errors and omissions can be problematic where construction overlaps the design.

2.6 Waste associated with variation orders

2.6.1 Introduction of the concept of waste vis-à-vis variability

The paradigm of waste as used in construction has various meanings depending on one's point of view. Very often, waste has been referred to as physical losses of material occurring during the construction process. Formoso *et al.* (1999) argued that most studies on waste are based on the conversion model in which material losses are considered to be synonymous to waste. According to Formoso *et al.* (1999), waste is defined as any inefficiency that results in the use of equipment, materials, labour, or capital in larger quantities than those considered as necessary in the production of the building. However, it should be understood that the contractor recognises allowable waste as the percentage for losses of material allocated to bill rate components by the estimator at tender stage and it varies from one material to another. For example, stockpile material such as sand and gravel may be allocated a higher percentage while countable material such doorframe, may be allocated null waste. Allowable waste is unavoidable waste and its acceptable level corresponds to the assumptions made relating to conditions including nature and consistency of material in relation to the protection necessary, the shape to be cut or the receptacle to be emptied (Skoyles & Skoyles, 1987). Waytt (1978) indicated that unavoidable waste arises from factors outside the contractor's control and usually occurs when the manufacturer or supplier's

material or components fail to match the requirements of designers. For example, the bills of quantities provide the net floor area. Consequently, the contractor has to allow extra quantities for cutting waste when ordering floor tiles. Skoyles and Skoyles (1987) designated this kind of waste as natural in a sense that it constitutes the usual waste like cutting to bond, or the residue left in a can. The contractor usually measures the actual waste of material on site against the allowable at tender. The quantity exceeding the allowable is non-recoverable because it constitutes a loss that was not budgeted for. Unfortunately the existing estimating and contact valuation techniques do not provide a clear breakdown of losses of materials resulting from variation orders. For example, cement that hardens in the stores following an instruction to suspend works is not allocated to the variation order account. Waste of materials resulting from variation orders may occur in the following circumstances:

- Compensating waste arising when material ordered for one specific purpose is used for another. For example, facing bricks ordered for external wall erection may be used for internal plastered walls when there is a shortage of common bricks.
- Waste due to the uneconomic use of plant arising when the plant lies idle on site as a result of a variation order. Saukkoriipi and Josephson (2006) estimated the waste for non-productive use of resources at more than 10% of a project's production cost.
- Waste of materials due incorrect decision, indecision or inconsistence inspection of works by the project consultant.
- Waste of materials after demolition of a portion of work caused by the variation order to change a trade. For example, waste for breaking a wall to accommodate a new door.
- Waste due to wrong use of material or waste stemming from materials wrongly specified.

Some authors defined waste beyond physical losses of materials. Al-Hakim (2005a) defined waste as anything that adds no value to producing the required services. The value consists of two components: production performance and freedom

from defects (Koskela, 1992). The production of services requires resources and flow of activities over a certain portion of time. According to Koskela (1992), the new philosophy[11] of production consists of both conversion and flows: since only conversions add value, the improvement of flow activities should primarily be focused on reducing or eliminating them, whereas conversion activities have to be made more efficient. Therefore, waste reduction is enhanced by avoiding flow variability.

2.6.2 Principle of the theory of waste reduction

Koskela and Vrijhoel (2000) revealed two principles underlying the theory of waste reduction, namely reduction of variability and time compression. Thomas *et al* (2002) indicated that variability can induce fluctuating and unexpected conditions, making objectives unstable and obscuring the means to achieve them. In fact, the construction operations are considered as a conversion process with various interlinked activities. Alwi *et al.* (2002) noted that uncertain flow into the conversion process contributes to the expansion of non value-adding activities or waste. Arguably, variation orders may be seen as counter to the above stipulated principle of waste reduction. The more variation orders on a project, the greater the likelihood that they become time consuming and costly elements in construction projects (Mohamed, 2001). Whenever a variation order is issued, whether leading to additions, alterations, omissions or substitutions, unnecessary costs are likely to be incurred. According to Koskela (1992), the inherent waste in construction is created by both rework due to design or construction error and non value-adding activities in material and work flows, such as waiting, moving, inspecting, duplicated activities and accidents. Chan

[11] New philosophy of production refers to an evolving set of methodologies, techniques and tools, the genesis of which was in the Japanese JIT (Just In Time) and TQC (Total Quality Costs) effort in car manufacturing (Koskela, 1992)

and Yeong (1995) identified the reduction of variation orders as one of the pre-requisites of keeping the cost within budget and completing the project on time.

The construction industry has developed concepts and tools for cushioning the interruption of workflow. These included the lean construction concept and work scheduling techniques. Lean construction is a waste reduction concept based on lean production philosophy. Lean production or lean manufacturing is a system approach for an uninterrupted work flow where each phase builds upon the previous one. Since activities consume resources over a certain portion of time, waste is eliminated by eliminating activities that are judged to be time consuming without adding value to the product. According to Al-Hakim (2005b), lean production is lean because it uses less of everything via considerable reduction of wastes. Al-Hakim (2005b) remarked that lean production is originally designed for firms employing or moving towards achieving a just-in-time (JIT) system. However, the application of JIT to construction differs substantially from its application to manufacturing because construction and manufacturing are different types of production, and because of the greater complexity and uncertainty of construction. It has been argued that the construction industry still lags behind owing to characteristics that distinguish it from other industries. According to Ashworth (1998), characteristics include:

- The physical nature of the product;
- The product is normally manufactured on the employer's premises, that is to say the construction site;
- Projects that are one-off designs and therefore no prototype model is available;
- The industry has been arranged in such a way that design has normally been separated from construction;
- The organisation of the construction process; and
- The methods used for price determination.

Managerial tools have been designed to optimally reduce time spent on a construction project. These include the critical path method (CPM), Programme Evaluation Review Technique (PERT) and Gantt chart methods. Unfortunately, an inherent uncertainty in a construction project is a clear indication that it is hardly possible to keep a continuous work flow without interruption.

2.6.3 Non value-adding activities associated with a variation order

Koskela (2000) indicated that every time a task is divided into two subtasks executed by different specialists, non value-adding activities increase, such as, for example, inspecting, moving and waiting. Similarly, when a variation order is issued, numerous non value-adding activities/costs are likely to arise. These include an increase in improvised travelling and communication expenses; idle plant and labour during the waiting time; demolitions; time taken by the designer to understand the required change and redesign; cost and time for litigation in case the misunderstanding arises between the contractor and the client or his/her consultant. These costs represent a waste of resources and are typically paid for by the client. Thomas *et al.* (2002) believed that a focus on reducing work variability may lead to improved work performance by increasing throughput. They also suggested that flexibility in responding to variability can lead to improved performance by permitting rapid changes as needed. Bennett (1985) concluded that controlling and seeking to eliminate variation orders is an important part of construction project management.

2.7 Impact of variation orders on project performance

Given a well-structured schedule of works, maximum project performance would be achieved if the work invariably flows smoothly within time limits and anticipated budget constraints. However, it is rare that projects perform precisely in

line with their original schedule due to reasons such as, for example, business condition changes, delivery slips, and corrections to design (Al-Hakim, 2005b). The occurrence of variation orders has an adverse impact on project performance. Thomas *et al.* (2002) suggest that variability generally impedes project performance. Ibbs (1997) concluded that variation orders affect project performance as they adversely affect productivity and project costs. According to Arain and Pheng (2005b) variation orders are an unwanted but inevitable reality of any construction project. Further, Hanna *et al.* (2002) found that projects with many variation orders cause the contractor to achieve lower productivity levels than planned. Variation orders adversely impact project performance in terms of cost overruns, time overruns, quality degradation, health and safety issues and professional relations.

2.7.1 Cost overruns

Construction projects involve recognised phases of which two are particularly important, namely the pre-construction and construction phases. Given that the construction phase typically consumes more resources than the pre-construction phase, attention to cost planning is focused on the construction phase. Clients desire to know in advance the total cost of their finished construction projects. Clients prefer final construction costs to equate to the originally forecast tender figure. Unfortunately, many construction projects incur cost overruns. However, all variation orders do not increase the costs of construction. Omissions in most cases reduce costs while additions increase costs (Ssegawa *et al.*, 2002). Various studies have revealed that variation orders contribute to these cost overruns. A study of the effects of variation orders on institutional building projects revealed that variation orders contributed substantially to increases in construction project costs (Arain & Pheng, 2005b). The analysis of variation orders on 12 combined sewer overflow projects

found that costs escalated by 7% of the original project costs (Mohamed, 2001). Arguably, the more the number of variation orders, the more they are likely to affect the overall construction delivery cost. In fact, variation orders have both a direct and indirect effect on cost. Direct costs constitute the additional costs incurred to perform the activities of the current variation orders. Bower (2000) identified the following direct costs associated with variation orders:

- Time and material charges related to immediately affected tasks;
- Recalculation of network, increased time-related charges and overheads;
- Reworks and standing time;
- Timing effects for example winter time;
- Inflation, change to cash flow and loss of earnings; and
- Management time, head office and site charges.

While the direct costs associated with a variation order can be easily calculated, Bower (2000) argued that indirect costs are more difficult to quantify. Indirect costs are costs incurred as a result of variation orders, whether they are apparently linked to them or not. These include:

- Rework and making good on affected trades other than the actual variation order. It was revealed that the cost of rework caused by variation orders accounted for more than four-fifth of the total costs of rework (Love & Li, 2000).
- Change in cash flow due to effect on inflation and financial charges;
- Loss of productivity due to interruption where the gang has to familiarise with new working condition, tools and material;
- Cost for redesign and administration of the variation order; and
- Litigation-related costs in case disputes arise due to the variation order.

2.7.2 Time overruns

Clients require their construction projects to be completed within minimum time limits. It is anticipated that projects finished within the shortest possible time achieve some monetary savings. Contractors are heavily penalised when they exceed the original project delivery date. The penalty imposed is meant to compensate

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

2.7.3 Quality degradation

Patrick and Toler (n.d.[12]) indicated that contracts with a significant degree of risk for unknown variables such for example, lump sum, contractors may cut corners on quality and quantity to maximise profits. If variation orders are frequent, they may potentially affect the quality of works. Quality may be compromised as contractors try to compensate for losses they are not optimistic about recovering.

2.7.4 Health and Safety

Variation order occurrence can lead to revision of health and safety considerations. The OHS (2003)[13] clause 5.3 (e) stipulates that where changes are brought about, sufficient health and safety information and appropriate resources are to be made available to the contractor to execute the work safely. This is because

[12] No date retrieved July 17, 2008, from http://www.tolerlaw.com/files/Contract%20Negotiations%20(FINAL).pdf

[13] South African Minister of Labour under section 43 of the Occupational Health and Safety Act No 85 of 1993, Construction Regulation formulated after consultation with the Advisory Council for Occupational Health and Safety.

change in construction methods, materials and equipment may require additional health and safety measures (Arain & Pheng, 2005). Furthermore, the OHS (2003) clause 5.14 requires the contractor[14] to provide the principal contractor[15] with any information which might lead to health and safety of any person at work carrying out construction work or any person who might be affected by the work of such a person at work or which might justify a review of the health and safety plan.

2.7.5 Professional relations

A construction project is not merely brick and mortar brought together. Rather, it creates professional relationships between parties to the contract. Each project successfully completed constitutes an added experience to participants and their reputation builds up. But disputes may arise between parties to the contract due to variation orders. Misunderstandings may arise when contractors are not satisfied with the determination of the valuation of variation orders by the client's consultant. Parties to a contract are left to argue over the cost, time effects and due compensation of a variation order (Bower, 2000). Possibly because contractors are not confident about the outcome of such negotiations, they usually request higher values for variation orders than the actual cost incurred. Bower (2000) opined that consequently there is tension between parties as the contractor continually pushes the client to settle claims for additional costs while invariably feeling that the reimbursement has been insufficient. This can be very damaging to the relationship between the representatives of all parties (Bower, 2000). Charoenngam *et al.* (2003) remarked that disputes between the client and the contractor can occur if variation orders are not

[14] Contractor means an employer, as defined in section 1 of the Act, who performs construction work and includes principal contractor

[15] Principal contractor means an employer, as defined in Section 1 of the Act, who performs construction works and is appointed by the client to be in overall control and management of a part of the whole of construction site

managed carefully. Harbans (2003) warned that unless a mutually acceptable solution is agreed by the parties, valuation of variations in the form of variation orders will continue to remain at the forefront of disputes and claims making their way ultimately to arbitral tribunals or the corridors of justice. Finsen (2005) found that a large proportion of current arbitrations were on claims for additional time and additional expenses. Ssegawa *et al.* (2002) reported that more than one-third of disputes pertained to how to determine losses that stem from variation orders. The excessive occurrence of variation orders due to design errors or omission may undermine the professionalism of the designer. Workers are demoralised when they have to demolish a portion work that they had already completed.

2.8 Chapter summary

This chapter reviewed literature on variation orders and their implications for project performance. Variation orders can potentially occur on all construction projects. They occur due to a number of reasons that include finance, changes in the minds of parties involved into the contract, weather conditions and feasibility of construction, statutory changes, product improvement, and discrepancies between contract documents. 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.

Variation orders are issued in the form of site or contract instructions. However, not all site instructions constitute a variation order. From five categories of site instructions that were identified, only two categories constituted variation orders. These included the instruction to vary the design, quality of works and the instruction to resolve discrepancies between contract documents. The instructions to reiterate or enforce contractual provisions, to deal with monetary allowance, and to protect the

client's interest became variation orders only if they were incidental to the first or second types of instructions. Under contractual conditions, a variation order is only valid if it is confirmed in writing. The valuation of a variation order demands a thorough understanding of contractual provisions, costing principles and fair judgment on the part of the valuer.

Four origin agents for variation orders were identified. These included the client, the consultant and unspecified “others”. A comprehensive list of causes stemming from the four origin agents was developed. The literature suggested that the nature of works, complexity of the project and selected procurement methods were factors influencing the occurrence of variation orders on construction projects.

There are direct and indirect non value-adding costs or waste associated with variation orders. Non value-adding costs contribute to higher construction delivery costs due to wasted materials and inefficient use of resources. The occurrence of variation orders lead to fluctuation of unexpected conditions and uncertain work flow hence the likely expansion of non value-adding costs.

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 works. If not carefully administered, a variation order may give rise to disputes between parties to the contract.

CHAPTER 3
METHODOLOGY

3.1 Introduction

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

Once the problem statement has been formulated, it should become evident what kind of data will be required to study the problem, and also what kind of analysis would be most appropriate to analyse the data (Walliman, 2005). The problem investigated in this study is the potential of variation orders on construction projects to impact the overall performance of these projects through, *inter alia*, increasing the cost of construction without adding value to the project. It is anticipated that the identification of the causes of variation orders may lead to their reduction, possible elimination and improvement in overall project performance.

A number of hypotheses will be tested. According to Neutens and Rubinson (2002), the hypothesis is the tentative attempt by a researcher to predict the significant

results of the research study process. When a research problem has been identified, it is necessary to indicate how the problem will be investigated or overcome to formulate research objectives (Walliman, 2005). These are linked to hypotheses as anticipated answers to the research problem.

3.2 Methodological approaches

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

3.2.1 Qualitative method

The qualitative approach seeks to gain insights and understanding people's perceptions of 'the world.' The beliefs, understanding, opinions, views of people are investigated (Fellows & Liu, 1997). Qualitative methods in this study seek to obtain the perception of construction industry stakeholders relative to the impact of variation orders on project performance. Observations were done on specific construction projects. According to Bodgan and Biklin (1998), qualitative research has the following characteristics:

3.2.1.1 Natural setting of qualitative research

Qualitative data has the natural setting as the direct source of data, and the research is the key instrument. Data were collected from construction project sites. The reason that a qualitative researcher goes to the location under study is determine the context and experience the situations that can best be understood when they are directly observed (Neutens & Rubinson, 2002). The selected sites

involved the observation and interpretation of the opinions of participants and physical exploration of executed works.

3.2.1.2 Qualitative research as descriptive data

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

3. 2.1.3 Qualitative data as a process rather than outcome

Qualitative research is concerned with process rather than with outcomes or products. The research sought to know what is exactly happening on a particular case under investigation by an interaction with the site personnel involved into day-to-day site works and administration.

3.2.1.4 Qualitative data analysed inductively

Qualitative research data is analysed inductively: Qualitative data is not collected to prove or disapprove a prior hypothesis, but rather it is first collect and then grouped together (Neutens & Rubinson, 2002). Open-ended questions were formulated to seek the opinions from relevant stakeholders in the construction industry including contractors, architect and cost consultants.

3.2.1.5 Meaning is essential for qualitative research

Meaning is of essential concern to the qualitative approach. The investigation seeks to know personal experience of participants or the opinions from the experts into the field. Experts included top management personnel from construction contracting companies knowledgeable of issues related to the variation orders.

3.2.2 Quantitative methods

Quantitative methods focus attention on measurements and amounts (more and less, larger and smaller, often and seldom, similar and different) of the characteristics displayed by the people and events that the researcher studies (Thomas, 2003). Quantitative data included the following:

- Quantifying apparent waste and categorisation of variation orders; and
- Closed-ended questions.

3.3 Secondary data

The secondary data is in the form of literary sources covering relevant topics of the subject matter. Two distinct literature studies were adopted as proposed by Melville and Goddard (1996), namely a preliminary and a full literature study.

3.3.1 Preliminary literature study

A preliminary literature study allowed a feel for the topic to be acquired and the issues involved, and an understanding of how the proposed research would fit into it. A preliminary literature provided an understanding of the background and key concepts of the research study and the basis upon which the problem statement was formulated.

3.3.2 Full literature study

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

Cape Peninsula University of Technology (CPUT) libraries and electronically from websites.

3.4 Primary data

3.4.1 Exploratory study

The design of this research study was informed by the findings of an exploratory study. Given that a broad aim of the research was to uncover non value-adding activities within various stages of construction projects, the exploratory study was to determine whether the topic of variation orders was worthy for research. The preliminary findings suggested that non value-adding activities accrued as a result of variation orders and the need for a further study of the phenomenon.

3.4.2 Sampling

The objective of sampling is to provide a practical means of enabling the data collection and processing components of research to be carried out while ensuring that the sample provides a good representation of the population (Fellows & Liu, 1997). Walliman (2005) indicated that sample should be free from bias. Otherwise, the type of selected sample will greatly affect the reliability of subsequent generalisation. Sampling strategies are categorised into two main groups, namely probability and non-probability sampling (Blaxter, Hughes & Tight, 2001)

3.4.2.1 Probability sampling

Probability sampling is also known as random sampling. In random sampling, each member of the population has an equal chance of being selected (Fellows & Liu, 1997). The advantage of this method is that it is free from bias. The disadvantage is that the selected sample may not have provided the relevant expected information or may not be willing to provide the required information. A list of construction industry registered professional firms located in the Western Cape province was compiled from which a representative sample was derived. These included 112 registered

quantity surveying practices, 547 architectural firms (Professions and Projects Register, 2006) and 103 MBA [16] members listed in the "general contractors" category (http://www.mbawc.org.za/search.asp, retrieved August 21, 2007). This method was later abandoned upon advice that it would most likely yield a low response rate. A non-probability sampling technique was then adopted. The compiled list of companies was used to select participant companies for the survey.

3.4.2.2 Non-probability sampling

Non-probability sampling is also known as non-random sampling. Although non-random sampling is viewed as providing a weak basis of generalisation, it is a useful method for certain studies (Walliman, 2005). Given the nature of required data to be gathered from the field and the anticipated cooperation of selected participants, a non-random sampling method was judged to be the most suitable. The purposive and snowball sampling methods were adopted.

- Purposive sampling

Purposive sampling consists of handpicking supposedly typical or interesting cases (Blaxter *et al,* 2001). According to Walliman (2005) and O'Leary (2004), purposive sampling is labelled as "theoretical sampling". It is a useful sampling method consisting of getting information from a sample of the population that one thinks knows most about the subject matter (Walliman, 2005). O'Leary (2004) indicated that there is a growing recognition that non-random samples can credibly represent the populations, given that the selection is done with the goal of representativeness in mind. Furthermore, "purposive" highlights the importance of conscious decision-making in non-random sample selection (O'Leary, 2004). This

[16] The Master Builders and Allied Trades' Association known to most people as MBA is an association for employers in the building industry founded in 1891. Its members are either builders, building contractors, building merchants or manufacturers of building products (Retrieved August 21, 2007, from http://www.mbawc.org.za/main.html)

method was used to select the companies to which questionnaires were sent. Companies were selected based on whether contact details were available and, in particular, phone numbers. An initial telephonic inquiry was done to invite the participation of selected companies.

- Snowball sampling

The snowball sampling technique used in this research study consisted of building up a sample through informants (Blaxter *et al.*, 2001). Neutens and Rubinson (2002:147) described how snowball sampling is conducted: "In the first stage, a person possessing the requisite characteristics is identified and interviewed. This person then identifies others who may be included in the sample. The next stage is to interview these persons, who in turn identify still more respondents who can be contacted and interviewed in the following stages". This method was used to identify the construction projects to be used as case studies.

3.4.3 Interviews

Any person-to-person interaction between two or more individuals with a specific purpose in mind is called an interview (Kumar, 2005). The interview may be conducted face-to-face or by telephone. The interview involves questioning or discussing issues with people and it is viewed to be a very useful technique for collecting data which would probably not be accessible using techniques such observations and questionnaires (Blaxter *et al.*, 2001). Because of its flexibility, an interview is a useful method of obtaining information and opinions from experts during the early stages of the research project (Walliman, 2005). Three kinds of interviews are distinguished: unstructured, semi-structured and structured. Semi-structured interview were conducted with top management personnel from contracting construction companies on issues pertaining to variation orders occurrence in their

companies. Interviewees were first informed of the focus of the interview prior to meeting. This helped the interviewees to prepare for interview in advance. Interviews were conducted either in meeting rooms or in offices of the interviewees.

3.4.4 Audit of site instructions

Variation orders are issued in the form of site or contract instructions. The audit was done by means of a set of questions provided in Appendix B. The analysis consisted of assessing whether site instructions had work implication, value-addedness and apparent waste associated to them. Apparent waste was the demolitions and alterations of works already erected.

3.4.5 Field data capturing

3.4.5.1 Pilot Study

Prior to sending out the final questionnaire, a pre-test questionnaire or pilot study was conducted using a sample of Bachelor of Technology final year Construction Management, Health and Safety and Quantity Surveying students at Cape Peninsula University of Technology. Walliman (2005) advised that it is best to test a pilot study on peoples of a type similar to the intended sample, so as to anticipate any problem of comprehension or other source of confusion (Walliman, 2005).

3.4.5.2 Standard Questionnaire

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

- Closed-ended questions

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

- Open-ended questions

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

3.4.6 Feedback from peers

The quality of this study was improved by discussions with peers in the form of conversations, and presentations at meetings and seminars. Comments from reviewers of the conference and journal papers produced during this research study were taken into consideration to improve the quality of this research study.

3.5 Data analysis

Data analysis encompasses the compilation and interpretation of the data collected. Analysis will depend on the nature and form the data has been recorded. Since the data has been recorded using qualitative and quantitative approaches, the analysis will be done accordingly. Whether it is qualitative or quantitative data, the

main rule of any form of analysis is to move from raw data to meaningful understanding (O'Leary, 2004).

3.5.1 Qualitative analysis

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

3.5.2 Quantitative analysis

Quantitative analysis uses the syntax of mathematical operations to investigate the properties of data (Walliman, 2005). Quantitative data is analysed statistically. Statistical analysis can be:

3.5.2.1 Descriptive

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

3.5.2.2 Inferential

Inferential statistics draw conclusions that extend beyond the immediate data (O'Leary, 2004). Raw data from the closed-ended questions will be captured using Statistical Package for Social Sciences (SPSS) and subsequent calculations will be generated then interpreted.

3.5.3 Testing the hypothesis

A hypothesis is a hunch, assumption, suspicion assertion or idea about a phenomenon, relationship or situation, which one intends to investigate in order to find out how right she/he is (Kumar, 2005). A hypothesis may either be rejected or not rejected. As a hypothesis is usually constructed on the basis of what is commonly believed to be right, disproving it might lead to something new that has been ignored by previous researchers (Kumar, 2005).

3.6 Validity and reliability of the research instrument

3.6.1 Validity

Validity is referred to as the correctness or credibility of a description, conclusion, explanation, interpretation, or other sort of account (Maxwell, 1996). In terms of measurement procedures, validity is the ability of an instrument to measure what it is designed to measure (Kumar, 2005). In fact, the research is concerned with investigating a hypothesised casual relationship between an independent variable and dependent variable. If such a relationship is found, inferences are drawn about the population and, perhaps, a variety of circumstances in which the relationship may apply beyond those of the particular study carried out (Fellows & Liu, 1997). Therefore, validity is premised on the assumption that what is being studied can be measured or captured, and seeks to confirm the truth and accuracy of this measured and captured data, as well as the truth and accuracy of findings or conclusions drawn from the data (O'Leary, 2004).

3.6.2 Reliability

Reliability is premised on the notion that there is some sense of uniformity or standardisation in what is being measured, and that methods need to consistently capture what is being explored (O'Leary, 2004). An instrument is proven reliable if it provides the same results on repeated trials. A research instrument is reliable if it is

consistent and stable, and, hence, predictable and accurate. Reliability will be analysed using SPSS by calculating the correlation of values of items for questions of which responses are predicted.

An appropriate reliability test for a single occasion data collection is Cronbach's coefficient alpha which is an estimate of internal consistency of responses to different scale items (Tredoux & Durrheim, 2002). Cronbach's alpha coefficient varies from 0 to 1; the more the coefficient is closer to 1, the more reliable.

The Cronbach's alpha coefficient is calculated as follows:

$$r_{\alpha} = \frac{n}{n-1}(1 - \frac{\sum \sigma_j^2}{\sigma^2})$$

Where: r_{α} = sum of the item variance

σ^2 = variance of the total score of the scale

n = number of items

3.7 Efficiency of tools used for communication

Tools used for communication and data collection included:

- Telephone conversations: telephone calls were important means of communication as they enabled the researcher to make appointments to meet the targeted interviewees.
- Short Message Service: the advantage of using the SMS was that a researcher could send messages to the respondents' mobile phones in case their calls were unanswered or unreachable.
- Postage: where deemed necessary, questionnaires was sent to respondents with stamped return envelops. A follow-up was done until the researcher received the completed questionnaires back.
- E-mails: this type of communication proved to be efficient as the researcher was able to make appointment prior to meet interviewees.

3.8 Chapter summary

In this chapter, methodological approaches including qualitative and quantitative methods investigating the outcomes of variation orders were explained.

The source of primary and secondary data was outlined. These included the literature review, exploratory study, interviews, sampling and field data gathering. Methods for data analysis and appropriate tests were discussed.

CHAPTER 4
ANALYSIS OF THE EXPLORATORY STUDY AND INTERVIEWS

4.1 Introduction

This chapter analyses the data gathered at the early stage of the research. It comprises the exploratory study and interviews. The exploratory study investigated the prevalence of occurrence of variation orders on construction projects. Since variation orders are issued in form of site or contract instructions, an appropriate methodology was designed to examine cost variation of site instructions on construction projects. Apparent waste associated with variation orders was identified. Consecutive interviews were conducted with top management personnel from contracting companies knowledgeable of issues related to variation orders.

4.2 Exploratory study

4.2.1 Aim and methodology

The research study on the impact of variation orders on project performance started with an exploratory study conducted in March 2007. A comparative analysis of variation orders was done on two completed apartment complexes. Empirical data in the form of records of variation orders was obtained from a reputable cost consultant company in South Africa. The company kept comprehensive records including short descriptions, monetary values, reasons and details of the person who requested a variation. The study identified the origin agents and causes of variation orders. Subsequently their values, number and associated waste were quantified.

Variation orders were first grouped according to the four origin agents namely the "client", the "consultant", the "contractor" and "others". In this context, "client" included the development initiator and owners and/or tenants who financed the projects. "Consultant" included the whole professional team that represented the client. "Contractor" included the main contractor and the subcontractors. "Others" included weather conditions, national and local regulations or any other conditions beyond control of either party to the contract. The analysis of records for reasons of variations confirmed many of the causes that were identified in the preliminary literature review of the research and these included:

- Design changes which arise from the client/consultant, contractor, occupier and supplier/manufacturer or change initiated for improvement purpose.
- Design errors which are mistakes made in the design.
- Design omissions which arise when an item or component is omitted from the design.
- Construction changes which are initiated to improve constructability or due to site conditions. Change may be made by the client, the consultant or the occupier after some work has been performed on site. Change may be made if the process or product needs` to be altered/rectified or if there is a need to improve quality.
- Construction errors which are the result of erroneous construction method procedures.
- Construction omissions which are those activities that occur due to omission of some activities during the construction.
- Damage caused by accident or inclement weather.
- Additional preliminaries (Love & Li, 2000).

Table 4.1 Illustration of waste zones of variation orders

(Origin - cause)		Causes						Total
		1	2	3	4	5	…	
Origin agents	A		Xx	xx	Xx			XX
	B	Xx		xx				XX
	C	xx	Xx			xx		XX
	…	xx			Xx			XX
Total		XX	XX	XX	XX	XX		XX

In order to identify waste formation zones, the framework of Koskela (2000) was considered. Each variation order was analysed in terms of three parameters, namely value, originating root and cause. This was made possible by designing an origin-causes matrix as illustrated in Table 4.1. Row A, B, C, etc. contain variation orders as per origin agent and column 1, 2, 3, etc. contain variation orders as per causes. The shaded areas represent the origin-cause that is prone to waste. For example, by assuming that column 2 represents construction error and column 5 represents damage, the magnitude of waste is then calculated as follows:

$$\sum(A2;C2;C5).$$

4.2.2 Projects particulars

4.2.2.1 Project A

The tender sum for the residential apartment (Project A) was R28,315,000 and the original planned works duration was 9 months. There were numerous additional works associated with the continuously revised electrical works. The reinforcement for concrete slabs changed from post-tensioned to conventional rebar. As the contractor could not finish on agreed time, the extension of time of 25 days was granted. Unfortunately, due to a further failure to complete works during the revised completion period, the contractor was charged a penalty of R13,000 per day totaling R923,000 in 71 days above the extended period. The total penalty levied was 3% of the contract sum and the actual completion period was 12 months which was an increase of 33% of the original contract period. Arguably, the numerous changes of electrical works contributed to delay.

4.2.2.2 Project B

The tender sum for the shopping apartment (Project B) was R61,617,996 and the original planned works duration was 11 months. The contractor was granted an

extension of time of 26 days which was a time overrun of 9% over the planned works duration. The consultant's records were silent relative to the reason for such an extension. No penalties were levied against the contractor.

4.2.3 Occurrence of variation orders

Tables 4.2 and 4.3 show the occurrence of variation orders grouped by origin agent and cause on projects A and B respectively. The breakdown of variation orders into the origin agent and causes was done following the listing earlier mentioned. For each subcategory, the total amount, the percentage, the corresponding number of occurrence, the lowest, the average, the median and the highest amounts were quantified.

4.2.3.1 Project A

In total, 75 variation orders occurred on project A of which 59 variation orders totalling R2, 216,260 resulted in cost increases and 16 variation orders totalling R139, 660 resulted in cost reductions. However, the overall cost increases outweighed the cost reductions. The net value of variation orders was 8% (R2,076,600) of the contract sum.

4.2.3.2 Project B

In total, 118 variation orders occurred on project B of which 94 variation orders resulted in cost increases totalling R2,625,380 and 24 variation orders resulted in cost reductions totalling R592,461. However, the overall cost increases outweighed the cost reductions. The net value of variation orders was 4% (R2,032,919) of the contract sum.

4.2.4 Origin agents of variation orders

4.2.4.1 Project A

On project A, the consultant initiated 80% (R1,779,312) of the total cost increases. The client contributed 12% (R270,152). Arguably, the consultant as the

origin agent might be overestimated. It is possible that the consultant could have issued instructions on behalf of the client either directly or indirectly based on the requests of tenants. By combining the consultant and the client contributions, the value of variation orders would be of the order of 92%. The highest value of variation orders was 86% (R120,723) of the total value of reductions initiated by the consultant. The average value of R90,051 on this project was a result of additional external works. Considering all originating agents the average value increase of variation orders was R37,564 and the average cost reduction was R8,729. While the value of variation orders might suggest a marginal variation between the cost of each variation, this in reality is not the case. For example, the highest cost increase originated from the consultant and was an increase of R374,626 while the lowest was R450. In some cases extreme values might misrepresent the significance or the impact of the overall monetary value of variation orders. The total number of variation orders was 49 for the total amount of R1,796,649 with a median value of R15,521.

4.2.4.2 Project B

On project B, the consultant initiated 58% (R1,504,300) of the total cost increases and the client contributed 36% (R954,025). By combining the consultant and the client contributions, the value of variation orders would be of the order of 94%. The highest value of variation orders was 83% (R492,661) initiated by the client. The value of the client originated variation orders was highest on average. Considering all originating agents the average value increase of variation orders was R27,930 and the average cost reduction was R24,686. The total number of variation orders originating from the client was 25 for the total amount of R954,025 with a median value of R4,426.

4.2.5 Causes of variation orders

4.2.5.1 Project A

The main cause of variation orders was design changes amounting to 81% (R1,796,312). The corresponding lowest value was R450, the highest value was R374,626 and the median value was R17,175. There would appear to be some correlation between the cost increase originated by the consultant and caused by the design changes. The consultant initiated changes amounted to 80% while the design changes amounted to 81%.

4.2.5.2 Project B

The main cause of variation orders on this project was design changes amounting to 55% (R1,444,094). The corresponding lowest value was R2,078, the highest value was R185,020 and the median value was R8,590. There would appear to be some correlation between the cost increase originated by the consultant and caused by the design changes. The consultant initiated changes amounted to 58% while the design changes amounted to 55%.

4.2.6 Identification of waste zones of variation orders

Tables 4.4 and 4.5 record variation orders that occurred on projects A and B. The origin-cause matrix clearly shows the number and value corresponding with each origin-cause. It was possible to identify variation orders that were likely to generate waste.

4.2.6.1 Project A

On project A, the cost of the design errors resulting from the consultant (B2) was 4% (R83,360) of the net total sum. These were costs for remedial works to imported joinery as a result of inefficiency in design co-ordination and repair that was done on electrical cables and damaged conduits. It is argued that costs for demolition of erected works due to design error constitute waste of resources. The cost for

construction errors resulting from the contractor (C5) was R3,738. An instruction was issued to repair damage done by the contractor (C7) to neighbouring buildings during demolition works; but the works were not yet executed and records did not show how much this was going to cost.

4.2.6.2 Project B

On project B, the cost of design errors resulting from the consultant (B2) was 4% (R82,135) of the net total sum of variation orders and the cost resulting from the construction error of the contractor (C5) was 1% (R12,395). The combination of the cost of errors originating from the consultant and the contractor amounted to 5% (R94,530) of the net total sum of variation orders. It is evident that the consultant and the contractor had generated situations that yielded waste and unnecessary costs. In most cases, costs for waste are transferred to the account of the client and as a consequence, construction delivery cost escalates.

Table 4.2 Variation orders grouped according to their origin agents and causes - Project A

	Cost increase							Cost decrease								
Origin	Amount	%	V no	Lowest	Average	Median	Highest	Amount	%	V no	Lowest	Average	Median	Highest	Tot v	Tot Net
A	270,152	12	3	23,423	90,051	74,904	171,825					-			3	270,152
B	1,779,312	80	49	450	36,312	15,521	374,626	120,723	86	15	3,606	8,048	4,410	42,015	64	1,658,589
C	3,738	0	2	?	1,869	1,869	?								2	3,738
D	163,058	8	5	10,365	32,612	31,837	55,174	18,937	14	1	18,937	18,937	18,937	18,937	6	144,121
TOT	2,216,260	100	59		37,564			139,660	100	16		8,729			75	2,076,600
	Cost increase							Cost decrease								
Cause	Amount	%	V no	Lowest	Average	Median	Highest	Amount	%	V no	Lowest	Average	Median	Highest	Tot v	Tot Net
1	1,796,649	81	48	450	37,430	17,175	374,626	12,015	9	1	12,015	12,015	12,015	12,015	49	1,784,634
2	83,360	4	3	6,697	27,787	10,121	66,542								3	83,360
3								101,208	72	13	3,606	7,785	3,606	42,015	13	-101,208
4	160,688	8	5	13,355	32,138	31,837	47,862	26,437	19	2	7,500	13,219	13,219	18,937	7	134,251
5	3,738	0	1	3,738	3,738	3,738	3,738								1	3,738
6																
7	?		1		?		?								1	-
8	171,825	8	1	171,825	171,825	171,825	171,825								1	171,825
TOT	2,216,260	100	59		37,564			139,660	100	16		8,729			75	2,076,600

Keys: A. Client, B. Consultant, C. Contractor, D. Others
1. Design change, 2. Design error, 3. Design omission, 4. Construction change, 5. Construction error, 6. Construction omission, 7. Damage, 8. Additional Preliminaries

Table 4.3 Variation orders grouped according to their origin agents and causes - Project B

Origin	Cost increase							Cost decrease							Tot v	Tot Net
	Amount	%	V no	Lowest	Average	Median	Highest	Amount	%	V no	Lowest	Average	Median	Highest		
A	954,025	36	25	1,640	38,161	4,426	**300,000**	492,661	83	16	1,865	30,791	6,783	**249,200**	41	461,364
B	1,504,300	58	63	2,500	23,878	9,383	185,020	99,800	17	8	2,724	12,475	7,917	50,000	71	1,404,500
C	12,395	0	1	12,395	12,395	12,395	12,395								1	12,395
D	154,660	6	5	120,000	30,932		34,660								5	154,660
TOT	2,625,380	100	94		27,930			592,461	100	24		24,686			118	2,032,919
Cause	Cost increase							Cost decrease							Tot v	Tot Net
	Amount	%	V no	Lowest	Average	Median	Highest	Amount	%	V no	Lowest	Average	Median	Highest		
1	1,444,094	55	71	2,078	20,339	8,590	185,020	80,700	14	10	1,865	8,070	6,783	16,308	81	1,363,394
2	82,135	3	4	11,500	20,534	17,318	36,000								4	82,135
3								461,761	78	13	4061	35,520	4,061	249,200	13	-461,761
4	495,116	20	14	2,790	35,365	6,900	171,181	50,000	8	1	50,000	50,000	50,000	50,000	15	445,116
5	12,395	0	1	12,395	12,395	12,395	12,395								1	12,395
6	1,640	0	2	?	820	820	?								2	1,640
7																
8	590,000	22	2	290,000	295,000	295,000	300,000								2	590,000
TOT	2,625,380	100	94		27,930			592,461	100	24		24,686			118	2,032,919

Keys: A. Client, B. Consultant, C. Contractor, D. Others
1. Design change, 2. Design error, 3. Design omission, 4. Construction change, 5. Construction error, 6. Construction omission, 7. Damage, 8. Additional Preliminaries

Table 4.4 Origin-Cause matrix of variation orders - Project A

Origin Agent	Variation order occurrence by number								Tot (no)	Percentage
	Causes									
	1	2	3	4	5	6	7	8		
A. Client	2							1	3	4%
B. Consultant	44	3	13	4					64	85%
C. Contractor					1		1		2	3%
D. Others	3			3					6	8%
Net tot	49	3	13	7	1	0	1	1	75	100%
Origin Agent	Variation order occurrence by value								Tot net amount	Percentage
	Causes									
	1	2	3	4	5	6	7	8		
A. Client	R98,327							R171,825	R270,152	13%
B. Consultant	R1,596,768	R83,360	R101,208	R79,669					R1,658,589	80%
C. Contractor					R3,738		?		R3,738	0%
D. Others	R89,593			R54,582					R144,121	7%
Net tot	R1,784,634	R83,360	-R101,208	R134,251	R3,738	R0	R0	R171,825	R2,076,600	100%

Keys: 1. Design change, 2. Design error, 3. Design omission, 4. Construction change, 5. Construction error, 6. Construction omission, 7. Damage, 8. Additional Preliminaries

Table 4.5 Origin-Cause matrix of variation orders - Project B

Origin Agent	Variation order occurrence by number								Tot (no)	Percentage
	Causes									
	1	2	3	4	5	6	7	8		
A. Client	28		10			1		2	**41**	**35%**
B. Consultant	53	4	3	11					**71**	**60%**
C. Contractor					1				**1**	**1%**
D. Others				4		1			**5**	**4%**
Net tot	81	4	13	15	1	2	0	2	**118**	**100%**
Origin Agent	**Variation order occurrence by value**								**Tot net amount**	**Percentage**
	Causes									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**		
A. Client	R314,385		-R444,661			R1,640		590,000	**R461,364**	**23%**
B. Consultant	R1,049,009	R82,135	-R17,100	R290,456					**R1,404,500**	**69%**
C. Contractor					R12,395				**R12,395**	**1%**
D. Others				R154,660					**R154,660**	**7%**
Net tot	**R1,363,394**	**R82,135**	**-R461,761**	**R445,116**	**R12,395**	**R1,640**	**R0**	**R590,000**	**R2,032,919**	**100%**

Keys: 1. Design change, 2. Design error, 3. Design omission, 4. Construction change, 5. Construction error, 6. Construction omission, 7. Damage, 8. Additional Preliminaries

4.2.7 Summary of findings

A comparative study was done on two apartment complexes, namely Projects A and B. A total number of 75 and 118 variation orders averaging 8% (R2,076,600) and 4% (R2,032,919) of the contract sum (R28,315,000 and R61,617,996) occurred on projects A and B respectively. It is argued that numerous variation orders on both projects contributed to time overruns and had potentially contributed to waste. Both projects A and B incurred delays and time for completion escalated at 33% and 9% over the original completion time respectively. On project A, a contractor was levied penalties amounting to 3% (R923,000) of the original contract sum. Arguably, the numerous variation orders contributed to delays where the contractor might have failed to properly justify to which extent his productivity and progress was affected. The findings of the exploratory study revealed that the consultant and the client combined were the predominant origin agents of variation orders. The design changes were the highest cause of occurrence of variation orders.

By analysing each variation order in terms of the value, origin agent and the cause, it was possible to identify that variation orders were likely to generate waste. On project A, the cost of the error originating from the consultant and the client was 4% (R87,098) of the total net sum (R2,076,600). On project B, the combination of the cost of error originating from the consultant and the contractor was 5% (R94,530) of the net total sum of variation orders (R2,032,919). The origin-cause matrix proved to be an efficient tool that provided a breakdown of uncovering the probable magnitude of waste associated with variation orders.

4.3 Interviews

4.3.1 Introduction

These interviews focused on the perceptions of construction industry practitioners on variations orders on their construction projects. In total three interviews were conducted, namely with a senior contracts surveyor (A), a managing director (B) and a construction manager (C).

4.3.2 Preparation of interviews

Prior to conducting the interviews, the human resources departments of the construction contracting firms were first phoned indicating the purpose of the interview. A request was made to meet quantity surveyors and construction managers who were well acquainted with the administration of variation orders. The telephone conversation was thereafter confirmed in writing with an e-mail highlighting the main points that would be covered during the interview. The investigation was an exploratory one aimed at discovering whether there were construction projects which experienced variation orders and the perceptions of respondents towards the occurrence of variation orders with regard to non value-adding activities.

4.3.3 Senior Contracts Surveyor Interview

A letter to the general contractor requesting permission to conduct an interview was sent on the 12th July 2007. Subsequently, the human resources manager confirmed the site and the names of two quantity surveyors to be contacted. The interview with the senior contract surveyor hereafter known as A was conducted on Tuesday the 17th July 2007. A was involved in a project consisting of the refurbishment and additional works of a six-storey shopping complex. Most of the trades were subcontracted and employees on site were estimated at around 100. The main contractor was only involved in concrete

work, setting out and management of the construction work. A discussed some of the situations that led to non value-adding costs as a result of variation orders such as, for example, idle labour. A attributed the variation orders on the project mainly to the type of contract. Since it was a fast-track contract, omissions in design and errors led to many variation orders. Late instructions, discrepancies in design, many instructions that disrupted the programme, substitution from standard to purpose-made doors that were not readily available contributed to additional non value-adding costs. A acknowledged that variation orders on that project had the impact on additional costs. Variation orders could be expected on projects involving refurbishment works where the design was normally not final or complete.

4.3.4 Managing Director Interview

A one hour interview was held on the 26th July 2007 with the managing director of a construction contractor hereafter known as B. B indicated that his company adhered to the culture of waste reduction by the way they conducted business. The company was mainly involved with design-build contracts and as a result, this company enjoyed a strong relationship with its clients since they worked together as a team. Teamwork was preferred because everyone involved in the project understood every aspect from the start to completion. Whenever a problem arose between parties, it was amicably resolved without wasting time. The company was also committed to waste reduction by avoiding wastage of materials, idle plant and labour and progressive improvement in productivity. The design-build type of contract had great potential to reduce the occurrence of variation orders because of the involvement of the contractor in the design. B discussed a non-design-build contract consisting of refurbishment works of a shopping centre project where they were experiencing many variation orders. He attributed the occurrence of

variation orders to the lack of involvement of the contractor and the tenants to indicate their requirements at an early stage of the design. Concerning the issues affecting the contractor when dealing with variation orders, B claimed that the contractor did not always receive the full amount claimed for. Variation orders had psychological effects on workers when they were asked to demolish what they had already built. According to B, there was nothing wrong with variation orders as long as they were initiated for improvement purposes. But, variation orders were seen as a problem when parties to the contract started blaming each other. He suggested that the most important thing was to build good relationships between the parties. Care should be taken to avoid damaging the relationship between parties to the contract. Variation orders could be avoided especially those caused by design changes. These design errors resulted from overtrading of architectural firms. As the construction industry was booming in South Africa, architectural firms opened new offices in various provinces without having enough skilled and experienced staff to efficiently manage those offices. As a result, architects became overloaded by work such that they could not commit enough time to produce detailed designs.

4.3.5 Contracts Manager Interview

The interview was held on the 16th August 2007 on site with a contract manager hereafter known as C. The project consisted of refurbishment of the shopping centre with erection additional parking decks. C discussed the project in terms of the occurrence of variation orders. The project experienced numerous variation orders mainly due to design changes initiated either by the client or the consultant. Several variation orders affected the activities that were on the critical path resulting in rescheduling of programme of works. Some trades were put on hold while the contractor was waiting for the instruction

or the plans of amended design to be completed. With respect to why the consultant could not finish the design before commencement of the works, C suggested that the client could be the origin agent for that. In fact, the client wanted the work to start earlier on site without recognising that incomplete designs would result in problems. More time should be invested in design to avoid excessive variation orders. C cited cases where the construction overlapped the design when work started on site before the design was complete. When asked about how contractors priced variation orders, C confirmed that contractors typically overcharged on variation orders since they were not optimistic that the claimed amount would always be certified.

4.3.6 Summary of findings of interviews

The findings revealed that variation orders were likely to happen on construction projects with many contributing to increasingly non value-adding activities. Typically, contractors overcharged on variation orders. Incomplete design was found to be a possible major cause of variation orders. However, most of these could be avoided.

4.4 Chapter summary

A comparative analysis of two projects revealed that variation orders contributed to cost and time overruns. Most predominantly, the client and the consultant were the origin agents. Design changes were the most predominant origin agents of variation orders. Interview with experts including a contracts surveyor, managing director and a construction manager confirmed the potential for adverse impact of variation orders on the project performance.

CHAPTER 5
DATA ANALYSIS

5.1 Introduction

This chapter analyses the data gathered using a questionnaire and an analysis of site instructions. It discusses the pilot study, profile of participants in the study, reliability testing, analysis of questionnaire responses and site instructions and formulates conclusions.

5.2 Pilot study

A pilot study was conducted to determine the appropriateness of the first draft of the final questionnaire. The questionnaire itself was subdivided into five sections and had a total number of 25 questions comprising both closed-ended and open-ended questions. Since it was anticipated that respondents could complete the questionnaire without guidance of the researcher, it was necessary for all questions to be self-explanatory. The pilot questionnaire was tested among a group of respondents having the same skills as the targeted respondents for the final questionnaire. Twenty five questionnaires were distributed and completed by Bachelor of Technology: Quantity Surveying, Construction Management and Health and Safety students at the Cape Peninsula University of Technology. Subsequently, a few amendments were necessary as a result of either non-responses or improperly answered questions. A final version of the questionnaire was produced (Appendix A).

5.3 Profile of participants

Out of 30 targeted companies, 23 (77%) duly completed and returned the questionnaire. As depicted in Figure 5.1, participant companies included contractors (44%), architects (4%), cost consultants (31%), project management (4%), clients (4%), and developers (13%).

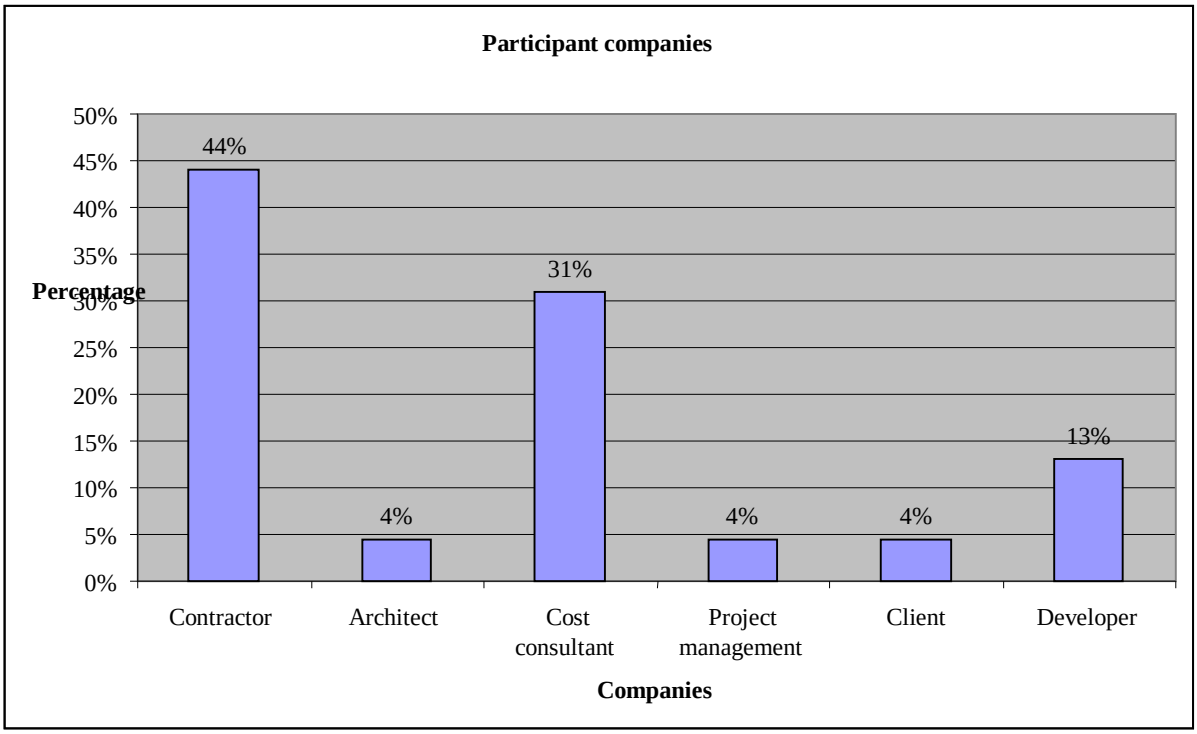


Figure 5.1 Primary construction involvements

From Figure 5.2 the positions held by respondents in their organisations is evident. These positions included quantity surveyors, lecturers, directors, site managers, clerks of works, and architects.

From Table 5.1 it is evident that the experience of respondents in the construction industry ranged from two years and one month to 40 years. The median length of experience in construction was 10 years. While respondents had been in their present companies for a period ranging from 1 month to 26 years, the median length of time that

they had worked there was 4 years. Their experience in their present positions ranged from one month to 25 years with the median experience being 3 years. All respondents had been involved with the administration of variation orders. This finding has implications for the expected reliability of responses.

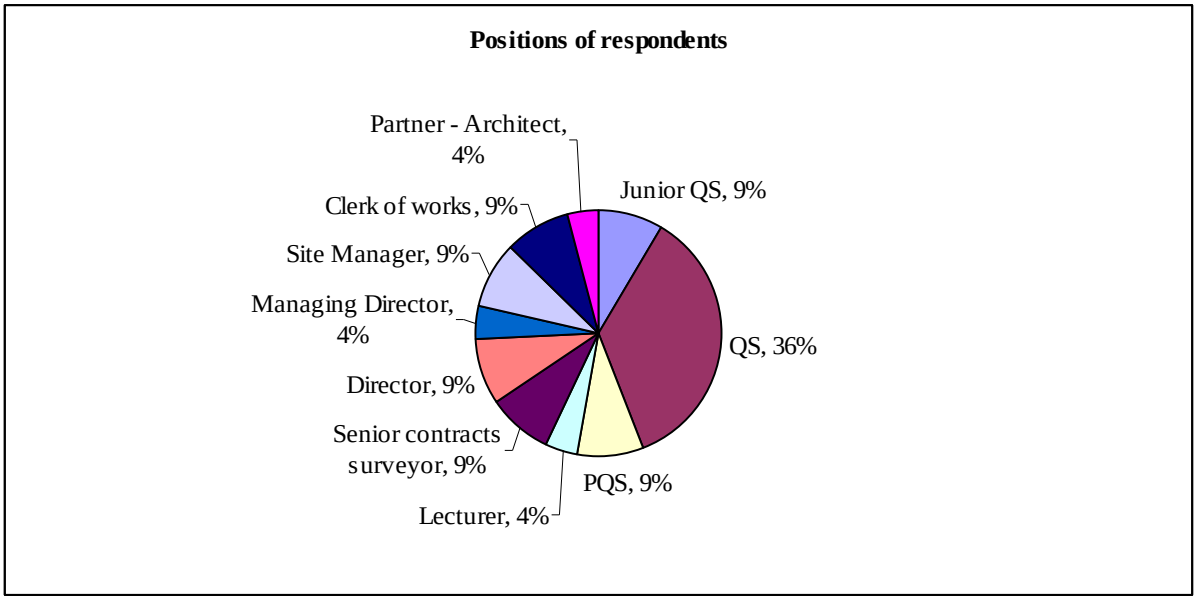


Figure 5.2 Position of respondents

Table 5.1 Experience of respondents

	N	Median	Std. Dev.	Min	Max
Length of employment in the construction industry (years)	23	10.0	10.3	2.1	40.0
Length of current of employment at company (years)	23	4.0	7.4	0.1	26.0
Length of time in present position (years)	23	3.0	6.5	0.1	25.0

5.4 Reliability testing

Reliability is concerned with how far one can rely on the consistency of a measure (Rose & Sullivan, 1996). Reliability testing for independent variables calculates the coefficient of reliability based on the average correlation of items within a scaled test considering the items were standardised. Cronbach's alpha coefficient used to test the reliability varies from 0 to 1; the closer the coefficient is to 1, the more reliable the scale.

The Cronbach's alpha coefficient of scale should be above 0.7; however, it is common to find low Cronbach's alpha coefficients, for example, 0.5 for scales with fewer than ten items (Pallant, 2005). The reliability of a scale varies depending on the sample that is used (Pallant, 2005). The lower the number of items, the more likely the reliability coefficient will be lower. For this study, it was established that the value of 0.6 would be reliable for questions having between 5 and 12 items. The overall Cronbach's alpha coefficient for all scaled questions was 0.9 which satisfies the reliability test requirements. Table 5.2 shows the reliability test summary for questions 10, 14, 19, 23 and 24. Steps followed to carry out the test were as follows:

- The Cronbach's alpha coefficient was calculated and the subsequent relationship between the individual items and the overall scale was examined.
- Where deemed necessary to increase the level of reliability, appropriate items were removed; subsequently improving the reliability marginally.

Table 5.2 Summary for reliability test

Question	Q10	Q14	Q19	Q23	Q24	All questions combined
Number of items	5	6	45	12	12	80
Deleted items	10.4	14.3	-	23.5	24.2	-
Cronbach's alpha	0.6	0.6	0.9	0.7	0.7	**0.9**

5.5 Findings

The open-ended questions allowed respondents to answer the same questions without restricting the manner in which they answered them. These questions sought clarifications to various responses. These responses were analysed using the Microsoft Excel software package. They were recorded and categorised such that similar reasons were grouped together and subsequently quantified. Closed-ended questions were formulated such that respondents chose one option from a limited list of possible answers. Data was captured and analysed using the Statistical Package for Social

Scientists (SPSS). The findings were in frequency tables that included relevant measures of central tendencies.

5.5.1 Prevalence of variation orders

5.5.1.1 Impact of variation orders on construction works

Variation orders involve additions, omissions and substitutions to the construction works. The frequency of their impact on construction works were ranked from the most frequent to the least frequent where 1st (most frequent) = 1, 2nd = 2 and 3rd (least frequent) = 3 by comparing the means as shown in Table 5.3. Additional works was reported to be the most frequent consequence with a mean of 1.1. Substitution works were ranked second with a mean score of 2.3 and omissions third with a mean score of 2.6.

Table 5.3 Frequency of consequence

Work impact	N	Mean scores	Std. deviation	Ranking
Additional works	23	1.1	0.2	1
Substitution works	21	2.3	0.6	2
Omission works	21	2.6	0.5	3

Table 5.4 Most frequent consequence of variation orders

Work impact	Reasons	Percentage	Clarifications
Additional	Brief scope of works	36%	Brief scope by the clients results in growth of demands during the construction stage and the clients keep on changing their mind
	Incomplete design	29%	Works start on site while the design is incomplete
	Procurement method	14%	In fast track projects additional requirements are only realised when works are in progress
	Budget consideration	14%	Clients usually add works if the budget permits it or if these are covered under contingency sum
	Total	**93%**	
Substitution	Design errors	**7%**	Substitution works are highest due to design errors

From Table 5.4, it is evident that 93% of respondents suggested that additional works was the most frequent consequence of variation orders. However, 7% of respondents reported substitution work as the most frequent consequence. Some respondents (36%) suggested that the main reasons for additional works were the poor

and inadequate scoping of the works by the client during briefing. Other respondents (29%) reported that incomplete designs resulted in the excessive occurrence of additional works.

Table 5.5 Lesser consequences of variation orders on projects

Work impact	Reasons	Percentage	Clarifications
Substitutions	Late changes	16%	Works or materials are substituted after more information is obtained, late idea/requirements or clients changing their mind
	Non availability of materials	11%	Substitutions are initiated due to specification change following the non availability of the original specified material or if the need arises to replace it with a better quality one
	Design errors	5%	Works are substituted following the architect's desire to change the design or to correct errors on the plans
	Unforeseen events	5%	Works are substituted due to unforeseen terrain conditions such as for example bearing capacity of the soil
	Project time pressure	5%	Works or materials are substituted because clients lack patience to wait if the required material is not at hand. Clients want the work to be done quickly then seek for alternative materials
	Technological change	5%	Works are substituted due to technological changes
	Total	**47%**	
Omissions	Budgetary considerations	27%	Omissions of works can be initiated to cut costs, eliminate unnecessary details or the budget does not permit it
	Incomplete design	11%	Works can be omitted because plans were incomplete at tender stage
	Procurement approach	5%	Omissions of works are initiated in fast track projects because the consultant may oversight the scope of works
	Unforeseen events	5%	Works can be omitted due to unforeseen site conditions
	Total	**48%**	
Additional	Unforeseen events	**5%**	Additional works occur due to unforeseen site conditions

In Table 5.5, 47% of respondents reported that the consequence of variation orders that occurred to a lesser extent were substitution works while 48% of respondents reported omissions as the least likely consequence of variation orders on construction projects. Respondents reported that works were substituted due to late changes (16%) and

non-availability of materials (11%). It was reported that omissions occurred largely due to incomplete designs (11%) and budget constraints (27%).

5.5.1.2 Frequency of site instructions

Variation orders are issued in the form of site instructions and these are classified under five categories as shown in Table 5.6 ranked by the means of responses. A 5 point Likert scale was used where Never = 1; Seldom = 2; Sometimes = 3; Often = 4; and Always = 5. Site instructions that vary the design, quality or quality of works were ranked first with a mean of 3.8 and instruction to resolve discrepancies were ranked next with a mean of 3.6.

Table 5.6 Frequencies of categories of site instructions

Instruction	N	Mean	Std. dev.	Rank
To vary the design, quality or quantity of the works	23	3.8	1.0	1
To deal with monetary allowance	21	3.7	1.2	2
To resolve discrepancies	22	3.6	0.9	3
To reiterate or enforce contractual provisions	22	2.6	1.0	4
To protect the interest of the client	23	2.6	1.3	5

5.5.1.3 Awareness of the outcome of variation orders

Variation orders are expected to occur on construction projects. A 5 point Likert scale determined to what extent respondents agreed with given statements, namely Strongly disagree = 1; Disagree = 2; Neutral = 3; Agree = 4; and Strongly agree = 5. The findings are presented in Table 5.7. Most respondents (91.3%) agreed that a clause permitting variation orders was an essential feature of any construction contract. More than a half (51.9%) of respondents reported that most variation orders could be avoided.

Almost all respondents (86.9%) acknowledged that complex operations led to variation orders. More than half of respondents (54.6%) admitted that the existence of a variation clause was an aspect that encouraged clients and/or consultants to change their

minds during the course of a project. Almost two-thirds of respondents (60.9%) reported that clients were fully aware that unnecessary costs accrued on variation orders. Several respondents (39.1%) disagreed that excessive occurrence of variation orders could potentially increase unethical practices; others (26.1%) remained neutral while more than a third of respondents (34.7%) reported that excessive variation orders yielded unethical practices.

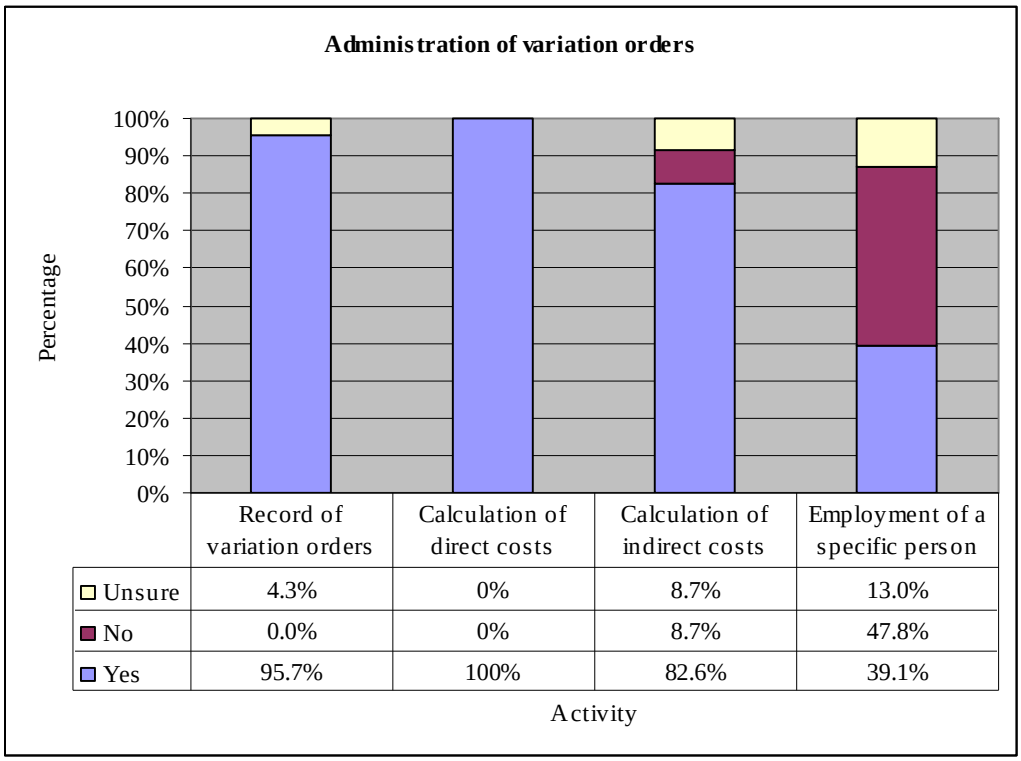
Table 5.7 Impact of variation orders

Instruction	N	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean
A clause permitting variation orders is an essential feature of any construction contract	23	0.0	4.3	4.3	34.8	56.5	4.4
A variation order clause is provided because construction projects involve complex operations which can not be accurately determined in advance	23	4.3	4.3	4.3	39.1	47.8	4.3
All clients are fully aware that there could be unnecessary costs that accrue due to a variation order	23	0.0	17.4	21.7	43.5	17.4	3.6
The existence of a variation order clause is an aspect that tends to encourage clients/consultants to change their minds during the course of a contract	23	0.0	31.8	13.6	27.3	27.3	3.5
Most variation orders can be avoided	23	0.0	30.4	17.4	34.8	17.4	3.4
The excessive occurrence of variation orders increases the possibility of unethical practices	23	13.0	26.1	26.1	30.4	4.3	2.9

5.5.1.4 Administration of variation orders

In practice, variation orders are typically recorded as they occur. Although it was found that there was no standardised method of recording variation orders, it was imperative to assess which essential information was recorded and whether this process required skills to administer variation orders. From Figure 5.3, it was evident that 95.7% of respondents were aware that their companies recorded variation orders. All respondents (100%) reported that their companies calculated direct costs of variation

orders. Most respondents (82.7%) also calculated the indirect cost. Several companies (39.1%) employed a specific person to administer variation orders while 47.8% did not. However, those who did not employ a specific person suggested that quantity surveyors had the required skills to manage variation orders.



	Record of variation orders	Calculation of direct costs	Calculation of indirect costs	Employment of a specific person
Unsure	4.3%	0%	8.7%	13.0%
No	0.0%	0%	8.7%	47.8%
Yes	95.7%	100%	82.6%	39.1%

Figure 5.3 Administration of variation orders

5.5.2 Cost implication of variation orders

Variation orders have cost implications. However, it was imperative to assess the awareness of construction industry actors with regard to the costs that were regarded as unnecessary. As shown in Table 5.8, respondents were requested to indicate to what extent they agreed with given statements using a 5-point Likert scale of agreement where Strongly disagree = 1; Disagree = 2; Neutral = 3; Agree = 4; and Strongly agree = 5. Most respondents (83.9%) reported that variation orders resulted in unnecessary costs while slightly less respondents (73.9%) reported that the reduction of the number of

variation orders could lower the overall construction delivery costs. An equal number of respondents (47.8%) either agreed or disagreed that time compression could significantly reduce unnecessary costs. Many respondents (60.9%) reported that the reduction of variability in construction operations could contribute to a significant reduction in unnecessary costs. Slightly more respondents (65.5%) reported that there could be indirect costs that accrued on variation orders. The majority of respondents (82.6%) reported that variation orders were the major cause of delays in construction projects.

Table 5.8 Cost implication of variation orders

Instruction	N	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean
The occurrence of variation orders is the major factor of delay in delivery of construction projects	23	0.0	8.7	8.7	43.5	39.1	4.1
Excessive variation orders result in incurring unnecessary costs	23	4.3	4.3	17.4	43.5	30.4	3.9
The reduction of the occurrence of variation orders can optimally lower construction delivery costs	23	4.3	4.3	17.4	52.2	21.7	3.8
The reduction of variability in construction operations can contribute to significant reduction of unnecessary costs	23	0.0	8.7	30.4	52.2	8.7	3.6
No matter how carefully a variation order is administrated, indirect costs accrue on it	23	4.3	13.0	13.0	65.2	4.3	3.5
Time compression in construction operations can contribute to significant reduction of unnecessary costs	23	4.3	43.5	4.3	47.8	0.0	3.0

5.5.3 Origin agents and causes of variation orders

5.5.3.1 Frequency of involvement of origin agents

The frequency of the involvement of four origin agents of variation orders, namely clients, consultants, contractors and unspecified “others” were investigated. The following ranking order was used, namely 1^{st} (most frequent involvement) = 1; 2^{nd} = 2; 3^{rd} = 3; 4^{th} (least frequent involvement) = 4. As shown in Table 5.9, the client was the origin-agent most frequently involved with a mean score of 1.6, followed by consultants

with a mean score of 1.7. Respondents were asked to clarify their ranking orders and their responses were set out in Tables 5.10 and 5.11.

Table 5.9 Ranking of origin agents of variation orders

Origin agent	N	Mean scores	Std. deviation	Ranking
Client	21	1.6	0.8	1
Consultant	20	1.7	0.8	2
Contractor	20	3.1	0.8	3
Others	19	3.5	0.6	4

Table 5.10 Origin agents most frequently generating variation orders

Origin agent	Reasons	Percentage	Clarifications
Client	Change of mind	18%	Clients change their mind or requirements
	Unclear brief	14%	Clients do not clearly state what they need then request for changes during the construction stage. Client clip is inevitable in the current market conditions
	Client satisfaction	10%	Clients pursue to achieve their dream as they wish. Since the projects ultimately belongs to them, even when they do not know what they wants, they are always right
	Budget constraints	7%	Budget constraints or the clients seek to make some savings
	Total	**49%**	
Consultant	Completeness of contract documents	18%	Variation orders originate from a consultant due to design changes or lack of detailed drawings
	Role/responsibilities into the contract	10%	Since the consultants act as an intermediate between the client and the contractor, they may initiate changes to suite the requirements of one of the parties
	Corrections	7%	A consultant usually issues instructions to correct a poor design
	Lack of understanding	4%	The lack of understanding of the requirements of the client by the consultant leads to variation orders
	Communication	4%	Lack of communication and coordination between the consultant team may lead to variation orders
	Unforeseen	4%	A consultant initiates a variation order due to unforeseen details at tender phase
	Total	**47%**	
Contractor	Forecast	**4%**	The contractor may be aware of the potential change and requests for instruction.

From Table 5.10, it is evident that clients (49%) and consultants (47%) were the most frequently involved origin agents in the generation of variation orders. Mind changes (18%) by the client, lack of detailed drawings (18%) by the designer, provision

of an unclear brief (14%) by the client and the consultant's role/responsibility as intermediate agent between the parties to the contract (10%) were reported as the dominant motivations for their choice of the most frequently involved origin agents.

From Table 5.11, it is evident that contractors (73%) and unspecified others (18%) were the origin agents that were least involved in generating variation orders. It was reported that contractors hardly contributed to variation orders as they carry out works according to the design and had no influence on the design. The dominant reasons reported were that the contractor had no influence on the design (55%) and unforeseen circumstances (18%) such as, for example, extreme weather conditions.

Table 5.11 Origin agents least frequently generating variation orders

Origin agent	Reasons	Percentage	Clarifications
Contractor	Procurement approach	55%	Contractor hardly contributes to variation orders as they carries out works according to the design and has no influence on design changes
	Construction methods	9%	Request by the contractor for alternative material/method for construction
	Remedial works	9%	Variation orders issued for corrective or remedial works following a faulty of the contractor
	Total	**73%**	
Others	Unforeseen	**18%**	Unforeseen problems such as for example revision for completion date due to excessive adverse weather conditions and strikes
Client	Responsibility	**9%**	Clients are not designers

5.5.3.2 Factors influencing variation orders

The factors that influenced the occurrence of variation orders were ranked from those that were the most dominant (1) to those that were the least dominant (3). The results are shown in Table 5.12 by the means of responses. The complexity of works was the most dominant influence with a mean score of 1.5, followed by nature of works with a mean score of 1.6 and then procurement method with a mean score of 2.3.

Table 5.12 Ranking of the factors influencing variation orders

Factors influencing variation orders	N	Mean scores	Std. deviation	Ranking
Complexity of works	19	1.5	0.6	1
Nature of works	20	1.6	0.6	2
Procurement methods	21	2.3	0.8	3

5.5.3.3 Origin agents versus causes

Table 5.13 shows the contribution of the origin agents to the occurrence of variation orders versus a given list of causes of variation orders where Client = 1; Consultant = 2; Contractor =3; "Others" = 4. Major findings of origin agent versus the causes are highlighted in grey colour. Most predominantly, it was revealed that clients initiated variation orders due to financial problems (76.2%) and change of scope of works (63.7%).

Table 5.13 Origin agents versus causes

Causes of variation orders repercussion	N	1	2	3	4
		%	%	%	%
Financial problems	21	76.2	9.5	14.3	0.0
Change of plans or scope	19	63.7	26.3	0.0	0.0
Impediment in prompt decision making process	20	55.0	40.0	5.0	0.0
Inadequate project objectives	19	47.4	36.8	10.5	5.3
Honest wrong beliefs of one or more of the parties to the contract	21	33.3	9.5	28.6	28.6
Errors and omissions in design	20	0.0	95.0	0.0	5.0
Change in specifications	18	5.6	94.4	0.0	0.0
Inadequate working drawing details	21	0.0	90.5	9.5	0.0
Ambiguous design details	21	4.8	85.7	9.5	0
Design discrepancies	21	4.8	85.7	9.5	0
Non-compliant design with owner's requirement	20	5.0	80.0	10.0	5.0
Design complexity	22	4.5	77.3	18.2	0.0
Non-compliant design with government regulations	20	10.0	75.0	15.0	0
Lack of involvement in design of one or more parties to the contract	19	26.3	63.2	5.3	5.3
Inadequate scope of work for one or more parties to the contract	19	21.1	63.2	15.8	0.0
Value engineering	20	15.0	60.0	20.0	5.0
Lack of coordination	21	0.0	57.1	38.1	4.8
Change in design	16	37.5	56.3	0.0	6.3
Conflicts between contract documents	16	12.5	56.3	31.3	0.0
Change of schedule	20	15.0	55.0	25.0	5.0
Lack of communication	17	17.6	52.9	23.5	5.9
Lack of required data	20	10.0	50.0	25.0	15.0
Poor procurement process	21	4.8	47.6	28.6	19.0
Lack of knowledge of available materials and equipment	19	10.5	47.4	31.6	10.5
Obstinate nature of one or more of the parties to the contract	18	22.2	33.3	22.2	22.2
Defective workmanship	21	0.0	0.0	95.2	4.8
Lack of a specialised construction management	20	0.0	5.0	90.0	5.0

Table 5.13 Continued

Causes of variation orders repercussion	N	1	2	3	4
		%	%	%	%
Unavailability of skills	20	0.0	0.0	90.0	10.0
Unavailability of equipment	23	4.3	0.0	87.0	8.7
Unfamiliarity with or unawareness of local conditions	18	11.1	5.6	77.8	5.6
Fast track construction	20	15.0	5.0	75.0	5.0
Speculation on desired profitability	19	21.1	5.3	63.2	10.5
Lack of judgment and experience	20	20.0	15.0	60.0	5.0
Health and safety considerations	19	5.3	0.0	57.9	36.8
Lack of strategic planning	17	17.6	23.5	52.9	5.9
Differing site conditions	21	0.0	9.5	52.4	38.1
Replacement of materials or procedures	21	9.5	38.1	47.6	4.8
Inadequate shop drawing details	22	0.0	40.9	45.5	13.6
Long lead procurement	19	5.3	26.3	42.1	26.3
Technology change	18	16.7	27.8	38.9	16.7
Socio-cultural factors	20	20.0	5.0	10.0	65.0
Unforeseen problems	20	10.0	15.0	15.0	60.0
Weather conditions	22	0.0	4.5	45.5	50.0
Change in government regulations	20	20.0	15.0	10.0	55.0
Change in economic conditions	21	28.6	9.5	14.3	47.6

Keys: 1. Client, 2. Consultant, 3 Contractor, 4. Others

Consultants initiated variation orders due to omissions in designs (95.0%), change in specifications (94.0%), inadequate working drawings (90.5%) and ambiguous design details (85.7%). It was believed that contractor originated variation orders were mainly due to defective workmanship (95.2%), lack of specialised construction management (90.0%) and unavailability of skills (90.0). It was revealed that unspecified “others” origin agents were caused by socio-cultural factors (65.0%) and unforeseen problems (60.0%).

5.5.3.4 Frequency of occurrence of causes of variation orders

The frequency of the occurrence of causes of variation orders were identified by using the following scale, namely Never = 1; Seldom = 2; Sometimes = Often = 4; Always = 5. From Table 5.14, it was possible to rank the causes of variation orders by comparing their means. The change of plans or scope (4.0), change of schedule (3.8) and change in specifications (3.8) were most ranking causes of variation orders.

Table 5.14 Frequency of occurrence of causes of variation orders

Causes of variation orders	N	Mean	Std dev.	Rank
Change of plans or scope	22	4.0	0.8	1
Change of schedule	22	3.8	0.7	2
Change in specifications	22	3.8	0.8	3
Change in design	22	3.7	0.8	4
Errors and omissions in design	22	3.6	0.9	5
Inadequate working drawing details	21	3.5	0.9	6
Design discrepancies	22	3.4	0.9	7
Impediment in prompt decision making process	21	3.4	0.7	8
Unforeseen problems	23	3.4	1.0	9
Replacement of materials or procedures	22	3.3	0.8	10
Inadequate shop drawing details	22	3.2	1.0	11
Lack of judgment and experience	22	3.2	0.9	12
Financial problems	22	3.2	1.0	13
Inadequate scope of work for one or more parties to the contract	21	3.1	0.9	14
Design complexity	22	3.1	0.8	15
Lack of communication	22	3.1	0.8	16
Defective workmanship	22	3.0	0.8	17
Ambiguous design details	22	3.0	0.9	18
Inadequate project objectives	22	3.0	0.8	19
Long lead procurement	22	2.9	0.6	20
Lack of coordination	22	2.9	0.8	21
Fast track construction	22	2.9	0.8	22
Lack of required data	22	2.9	0.9	23
Unavailability of skills	22	2.9	0.9	24
Weather conditions	23	2.9	0.9	25
Lack of strategic planning	22	2.9	0.6	26
Lack of knowledge of available materials & equipment	22	2.9	0.7	27
Lack of involvement in design of one or more parties to the contract	22	2.8	0.8	28
Non-compliant design with owner's requirement	22	2.8	0.9	29
Health and safety considerations	23	2.7	0.8	30
Lack of a specialised construction management	21	2.7	0.8	31
Obstinate nature of one or more of the parties to the contract	20	2.7	0.7	32
Differing site conditions	22	2.7	0.7	33
Poor procurement process	22	2.7	0.8	34
Conflicts between contract documents	22	2.7	0.8	35
Value engineering	22	2.7	0.9	36
Change in economic conditions	23	2.6	0.9	37
Non-compliant design with government regulations	22	2.6	0.7	38
Honest wrong beliefs of one or more of the parties to the contract	22	2.5	0.7	39
Unavailability of equipment	22	2.5	0.8	40
Unfamiliarity with or unawareness of local conditions	22	2.5	0.8	41
Socio-cultural factors	23	2.5	0.7	42
Change in government regulations	23	2.5	0.9	43
Speculation on desired profitability	21	2.4	0.7	44
Technology change	22	2.4	1.0	45

5.5.3.5 Reduction of occurrence of variation orders

It was suggested that the occurrence of variation orders could be reduced. Various opinions were categorised into 10 themes/groupings as shown in Table 5.15.

Several respondents suggested the occurrence of variation orders could be reduced if proper planning took place (25%), the consultants produced detailed drawings at the tender stage (17.5%), and adequate time was spent on pre-contract stage (12.5%) and the brief of clients was clear (10%).

Table 5.15 How to reduce the occurrence of variation orders (N=22)

Reason	Percentage	Clarification
Planning	25.0%	Adequate planning in advance is required by all involved parties before works start on site
Completeness of the design	17.5%	Consultant should do a thorough concluding design and working drawings and contract documents should be complete at tender stage
Time allocated to the pre-contract	12.5%	Adequate time should be spent on pre-contract planning phase
Clear brief	10.0%	Client should provide clear brief of the scope of works
Forecast	7.5%	All parties should forecast to overview unforeseen situations
Co-ordination	7.5%	Closer consultant co-ordination is required at design stage
Communication	7.5%	Enhance communication and all parties should be proactive at all times
Experience	5.0%	Works should be supervised with an experienced and dedicated supervisor
Budgetary considerations	5.0%	Consultant should ensure that the design/specifications fall within the approved budget and the budget team should be appointed and participate during the design phase
Quality of information	2.5%	Get accurate information and research with regard to procurement procedure, material and plant

5.5.4 Effects of variation orders on project performance

5.5.4.1 Nature of variation orders

Variation orders are classified as either beneficial or detrimental variation orders. A 5 point Likert scale was used to determine how frequently these occurred on construction projects, namely Never = 1; Seldom = 2; Sometimes = 3; Often = 4; and Always = 5. As shown in Table 5.16, respondents equally believed beneficial (mean 3.2) and detrimental (mean 3.3) variation orders occur on construction projects.

Table 5.16 Frequency of occurrence of variation orders by nature

Nature of variation orders	N	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Standard deviation	Mean
Beneficial variation orders	21	9.5	14.3	28.6	42.9	4.8	1.1	3.2
Detrimental variation orders	21	4.8	28.6	19.0	28.6	19.0	1.2	3.3

5.5.4.2 Problems encountered when negotiating variation orders

There are problems encountered when dealing with variation orders. These problems were categorised as shown in Table 5.17. Respondents reported that they mostly encountered problems associated with the determination of the costs involved (32%).

Table 5.17 Problems encountered with when negotiating variation orders (N=20)

Problem	Percentage	Explanation
Cost determination	32%	There are always difficulties to determine the involved costs, a disagreement between the contractor and the consultant with regard to the claimed amount, revised rates and additional preliminary and generals
Time determination	24%	There are difficulties and disagreement to ascertain the impact of a variation on the schedule of works and subsequent required time for extension
Reluctant nature of the client	8%	The client is reluctant to accept the order because in most cases variation orders involve additional budget and the client does not want to compensate related expenses
Lengthy approval process	8%	Contractors experience difficulties because works are delayed before the client accepts the variation order It takes long for a variation order to be approved by the whole team of relevant consultants
Difficulties to satisfy the contractor	6%	Contractors are rarely satisfied with allocated amount by the consultant as they feel this amount is not enough; consequently they bring in other issues not related to the variation order since they knows the claimed amount will not be certified in full
Lack of coherent practice process	6%	Different opinions and judgments or lack of understanding of the process
Impediment in decision making	6%	The client does not take timeous decisions for fear of repercussions especially in public sector works
Length of period payment	2%	Late payment or no payment at all to the contractor. The contractor get rarely in full the claimed amount
Accountability in covering cost	2%	There is a problem to know who covers the costs of a variation order
Logistic constraints	2%	Problems related to the availability of plant, experienced labour, quality and workmanship
Weather	2%	The occurrence of a variation order leads the project to facing constraints related to weather conditions
Disputes	2%	A variation order may be source of conflicts and disputes between parties to the contract

There was disagreement between the contractor and the consultant with regard to the amount being claimed, revised rates and additional preliminaries. There was also disagreement with determining the impact of a variation order on the works schedule and subsequent time extension (24%). The reluctant nature of the client, lengthy approval process, lack of coherent practice process, impediment in decision making were among the cited problems.

5.5.4.3 Outcome of variation orders on project performance

The frequency of outcomes of variation orders with regards to project performance were ranked using a 5 point Likert scale where Never = 1; Seldom = 2; Sometimes = 3; Often = 4; and Always = 5. From Table 5.18, it is evident from the ranking of the means of responses that time and cost overruns equally dominate with mean scores of 4.0. Disputes between parties to the contract followed with a mean score of 3.7 and then additional specialist equipment and personnel with a mean score of 3.4.

Table 5.18 Outcomes of variation orders

Impact	N	Mean	Std. dev	Ranking
Time overrun	23	4.0	0.5	1
Cost overrun	23	4.0	0.5	1
Disputes between parties to the contract	23	3.7	0.7	3
Additional specialist equipment/personnel	23	3.4	0.5	4
Complaints of one or more of the parties to the contact	23	3.2	1.0	5
Quality standards enhanced	23	3.1	0.7	6
Professional reputation of one or more parties adversely affected	23	3.1	0.9	7
Additional health & safety equipment/measure	22	2.8	0.7	8
Degradation of quality standards	23	2.7	0.8	9
Optimum cost reduction	22	2.6	0.9	10
Degradation of heath & safety	23	2.4	0.6	11
Time reduction	23	2.3	0.7	12

5.5.4.4 Adverse impact of variation orders

The adverse impact of variation orders on construction projects was established using a 3 point Likert scale where Major impact = 1; Slight impact = 2; and No impact =

3. By comparing the means shown in Table 5.19, cost overruns dominated (1.1), followed by time overrun (1.4) and then disputes between parties to the contract (1.7).

Table 5.19 Adverse impact of variation orders on project performance

Impact	N	Mean	Std. dev	Ranking
Cost overrun	23	1.1	0.3	1
Time overrun	23	1.4	0.6	2
Disputes between parties to the contract	23	1.7	0.5	3
Complaints of one or more of the parties to the contact	23	1.8	0.6	4
Professional reputation of one or more parties adversely affected	23	1.9	0.8	5
Additional specialist equipment/personnel	23	1.9	0.5	6
Quality standards enhanced	23	2.0	0.6	7
Additional health & safety equipment/measure	23	2.0	0.5	8
Optimum cost reduction	23	2.0	0.6	9
Degradation of quality standards	23	2.0	0.6	9
Time reduction	23	2.1	0.6	11
Degradation of heath & safety	23	2.3	0.7	12

Comments by respondents about the occurrence of variation orders included:

- *Variation orders should be kept to minimum.*
- *The way the procurement process is managed and all parties including the client and the consultant have an important role to play in reducing variation orders.*
- *The consultants should by all means try to minimise variation orders as they may be very costly. The contractor will always take the advantage of the situation to overcharge on a variation order.*
- *The clients have the ultimate say of what should be changed provided it falls within the building regulations and they are prepared to pay for the change.*
- *Most variation orders can be traced back to reduced time spent on project planning and design stages due to consultant accepting unreasonable time frame from clients.*

5.6 Analysis of site instructions

In practice, variation orders are merely understood as site or contract instructions. However, the analysis of the types of site instructions revealed that not all site instructions constituted variation orders. Empirical evidence was necessary to determine which site instructions constituted a variation orders or not. The cost implications, work

impact, the nature and apparent waste associated to site instructions were analysed. A list of queries used to audit site instruction is shown in Appendix B.

5.6.1 Projects particulars

Site instructions issued on 3 construction projects herewith named Projects I, II and III were analysed. The record of project particulars was possible by using the form shown as Appendix C. Summarised project particulars are provided in Table 5.20.

Project I consisted of the demolition of part of an existing six storey structure and construction of an eight storey reinforced concrete structure. Works involved the construction of the parking, office space and residential apartments. The main contractor was responsible for the building of the internal partitions and the management of the selected subcontractors. Subcontractors were responsible to fit out specialist works including electrical, plumbing, air conditioning ducting, and plastering. This project was 70% complete and a total number of 370 site instructions had already been issued when the data was collected. It was believed site instructions had impacted the project duration while cost was not affected. From the total amount of R776,874 claimed by the contractor, only 35% (R276,418) had been certified.

Project II was an apartment block consisting of 6 levels with a basement and lower basement level for parking and storage. The building comprised of a concrete portal framework with brickwork infill. The embankments (25m drop) of the site were treated with lateral support work (anchors that penetrated 45 – 70m vertically under the adjoining buildings). The top floor of these apartments levelled with the road adding to the privacy for the apartment owners. This project was almost complete (98%) and a total number of 102 site instructions had already been issued when the data was collected. It was believed site instructions impacted both project duration and cost increases. From the

total amount of R1, 437,744 claimed by the contractor, only 55% (R796, 205) had been certified.

Project III consisted of the refurbishment of a shopping centre and construction of a two deck parking space. This project was 100% complete and a total number of 188 site instructions had been issued during the contract duration and had resulted in the final contract sum changing. Site instructions had no impact on the project duration. Despite the impact of site instructions on cost escalations, clarifications were given that the reduction from the original tender sum of R109 million to the final R102 million resulted from savings provisional sums for various items of work not being executed. For example a new lift, chiller plant and standby station were not erected. It was decided to keep the old ones since they were still in good condition.

Several methods were combined for valuation of variation orders for fast track projects. Methods included bill rates, day works, negotiated rates and quotations. Arguably, the incompleteness of contract documents had the potential of adoption of several methods for valuation of variation orders. The complexity of the projects is one of the factors influencing the occurrence of variation orders. It was observed that all projects were complex in terms of both the management and technological complexity. Management complexity is evident given the number of subcontractors ranging from 21 to 61, the size of the consultant team ranging from 6 to 19 and work force on site ranging from 120 to 550 people. However, it was not at the scope of the study to determine the influence of management complexity on the occurrence of site instruction. The technological complexity was manifested through the scope of works. For example refurbishment works that involved the demolition of existing works while at the same

time new structures were erected and varied works had to be incorporated in the schedule.

Table 5.20 Project particulars

Description	**Project I**	**Project II**	**Project III**
Scope of the project	Refurbishment & extension	New	Refurbishment & extension
Purpose of the development	Shopping premises & residential flats	Residential flat	Shopping centre
Tender sum	R 258 million	R 105 million	R 109 million
Anticipated final contract sum	R 280 million	R 111 million	R 102 million
Impact of variation orders on final contract sum	Escalated	Escalated	Escalated
Original contract duration	25 months	24 months	12 months
Final/projected contract duration	25 months	33 months	12 months
Impact of variation orders on project duration	No impact	Escalated	No impact
Progress of works	70%	98%	100%
Methods used for valuation of variation orders	(1) Bill rates (2) Day works (3) Negotiated rates (4) Quotations	(1) Bill rates	(1) Bill rates (2) Day works (3) Negotiated rates (4) Quotations
Type of contract	Fluctuating	Fixed	Fixed
Existence of items falling under provisional (Yes/No)	Yes	Yes	Yes
Procurement method	Fast track	Traditional	Fast track
Completeness of contract documents at time of tender	Incomplete	Incomplete	Incomplete
Involved subcontractors	21 no	40 no	61 no
Workforce on site	550 no	450 no	120 no
Involved consultant team	8 no	19 no	6 no
Occurrence of site instruction	370 no	102 no	188 no

5.6.2 Presentation of data for analysis of site instructions

5.6.2.1 Screening variation orders from site instructions

As shown in Table 5.21, it was found that 85% of site instructions[17] constituted variation orders while 11% were not. Site instructions such as, for example, to make good or to proceed were not viewed as variation orders since they were issued to reiterate the contract conditions.

[17] Not all site instructions constitute variation orders; however, the analysis will be done on all site instructions regardless whether they are variation orders or not.

Table 5.21 Site instructions that constitute variation orders

	Project I		Project II		Project III		Summary	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Variation orders	327	88	100	98	132	70	559	85
Not variation orders	13	4	2	2	56	30	71	11
Unsure	30	8	0	0	0	0	30	4
Total	**370**	**100**	**102**	**102**	**188**	**100**	**660**	**100**

5.6.2.2 Work implication of site instructions

From Table 5.22, 71% of site instructions for combined projects resulted in additional works and 10% in substitution work. The predominance of additional works could be predictable as a result of the incompleteness of the contract document, the provision of provisional sums and the scope of works. Project II experienced 36% site instructions leading to substitutions mainly due to excessively revised designs. Project III was a shopping centre whereby each completed portion was immediately handed over to the shop tenants. As result, more than a quarter (27%) of site instructions was snag or 'make good' lists issued at various interim handovers of various sections of works. The analysis of these site instructions revealed problems related to quality workmanship.

Table 5.22 Work implication of site instruction

	Project I		Project II		Project III		Summary	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Additions	285	77	64	64	120	63	469	71
Substitutions	32	9	36	36	9	5	77	12
Omissions	3	1	0	0	2	1	5	1
On hold	1	0	0	0	0	0	1	0
Proceed	5	1	0	0	3	2	8	1
Snag	3	1	2	2	51	27	56	8
Unsure	41	11	0	0	3	3	44	7
Total	**370**	**100**	**102**	**102**	**188**	**100**	**660**	**100**

5.6.2.3 Cost implication of site instructions

It was found that 80% of site instructions involved cost adjustment while 12% did not.

Table 5.23 Cost implication of site instructions

	Project I		Project II		Project III		Summary	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Cost implication	300	81	98	96	132	70	530	80
No cost implication	28	8	2	2	47	25	77	12
Unsure	42	11	2	2	9	5	53	8
Total	**370**	**100**	**102**	**102**	**188**	**100**	**660**	**100**

5.6.2.4 Nature of site instructions/variation orders

Table 5.24 records the nature of site instructions. It was reported that most (95%) site instructions were beneficial. A beneficial variation is issued to add value to the product while the detrimental site instruction leads value degradation. Apparently, there were no variation orders issued that negatively affected the quality of the end product.

Table 5.24 Nature of variation orders

	Project I		Project II		Project III		Summary	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Beneficial	338	91	102	100	187	99	627	95
Detrimental	0	0	0	0	0	0	0	0
Unsure	32	9	0	0	1	1	33	5
Total	**370**	**100**	**102**	**102**	**188**	**100**	**660**	**100**

5.6.2.5 Waste associated with site instructions

Despite the non-occurrence of detrimental site instructions, waste accrued as a result of site instructions. From Table 5.25, it is evident that 14% of the site instructions had waste associated with them. Activities that constituted waste included, for example, demolitions of portions of works already erected in order to correct errors.

Table 5.25 Waste associated with variation orders

	Project I		Project II		Project III		Summary	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Yes	18	5	31	30	40	21	89	14
No	314	85	71	70	146	78	531	80
Unsure	38	10	0	0	2	1	40	6
Total	**370**	**100**	**102**	**102**	**188**	**100**	**660**	**100**

5.7 Discussion of findings

This section is a recapitulative discussion of the study findings for both the research instruments and site instructions. The prevalence, cost implications, origin agents, causes and adverse impact of variation orders are discussed.

5.7.1 Prevalence of variation orders

Both the research instrument and the analysis of site instructions found that the most frequent impact of variation orders was additional works. Both the incomplete and inadequate scoping of works by the client during briefing and incomplete design by the consultant were reported to be primary reasons behind additional works. As clients sought to minimise project delivery periods, they shortened the pre-tender period and expected the construction work to start on site as early as possible. Clients preferred works to start on site and initiated changes as work progressed. On the other hand, consultants hardly objected to the demands of clients. They allowed embarking on construction stage while the design was incomplete. This was observed in fast track projects and refurbishment works where additional requirements would be often realised when works were in progress.

It is common in fast track and refurbishment contracts to tender with incomplete contract documents. Provisional sums were allowed to cover items for which the accurate quantities could not be determined at time of tender. The presence of provisional sums items and the incompleteness of contract documents created uncertainty of the scope of contract. Uncertainty was a clear indication of the likelihood of the occurrence of variation orders. Though work substitutions had less frequent work impact, waste occurred on these projects. Waste arose from alterations to portions of works that had already been completed.

The administration of variation orders required a specific person with adequate skills. Typically, a quantity surveyor might have relevant skills to deal with variation orders. However, it was pointed out that the construction industry lacked a common understanding of the process of the administration of variation orders. Arguably, there could be a problem of interpretation of what constitutes direct cost or not. What a consultant calls indirect cost might be direct cost for a contractor. A failure to have a common understanding on costing options and time ascertainment might lead to disputes. The consultants complained that contractors took advantage of the occurrence of a variation order to overcharge by including in the valuation the items that were not related to the variation order. The analysis for records of variation orders revealed that there was no standard method of recording variation orders. As a result, there were discrepancies between the amount claimed by the contractor and the certified one. Given some situations where a cost consultant could not always discover where the contractor had overcharged, the overcharged amount would be typically transferred to the client; hence, the increase of the construction delivery costs. The discrepancies between the claimed and certified amounts suggest the need for improvements relative to variation order administration.

5.7.2 Cost implication of variation orders

The study found that some variation orders resulted in waste of resources or non value-adding costs. Impliedly, non value-adding costs result in higher construction delivery costs. While it could be possible to calculate direct waste associated with variation orders, the literature confirmed that it was problematic to accurately calculate indirect waste cost associated with variation orders. Findings suggested that the reduction of the occurrence of variation orders could optimally lower the construction delivery

costs. Impliedly, the occurrence of a variation order is associated with an amount of waste *w*. The more the occurrence of variation orders, the more waste increase. Then, the total cost of a variation order is a summation of necessary costs and waste *W*. On a period of time *D* spent on carrying out variation orders, there accrued some amount of time *d* contributing to delays.

From the statement above, the total cost *C* to carry out a variation order in a period of time *D* is the summation of effective costs E_D and waste W_D. $C_D = E_D + W_D$. Therefore, it is possible to identify waste associated with variation orders as follows:

$$W_D = w_{d1} + w_{d2} + \cdots + w_{dn-1} + w_{dn}$$

$$W_D = \sum_{d=1}^{dn} w$$

The above is a theoretical approach illustrating the quantification of direct and indirect waste associated with variation orders. A practical approach for quantifying the cost of direct waste associated with variation orders was designed and proposed in Chapter Four. This was possible through an origin-causes matrix that identified waste zones of variation orders. The practical approaches of quantifying indirect waste associated with variation orders were not at the scope of this research. However, there is a need for further studies to quantify indirect waste of variation orders.

5.7.3 Origin agent and causes of variation orders

The client and the consultant were found to be the most frequent originating agents of variation orders. It was reported by respondents that a failure to produce detailed drawings by the consultant together with change of mind by clients resulted in variation orders. Impliedly, the occurrence of variation orders was a consequence of the behaviour of the client and the consultant during the pre-tender stage. Moreover, this could have

been the reason to find that the contractor had least influence on variation orders during the construction stage.

By comparing the findings regarding the work impact and the origin agent of variation orders, there appears to be a link between the most predominant rankings shown in Figure 5.4.

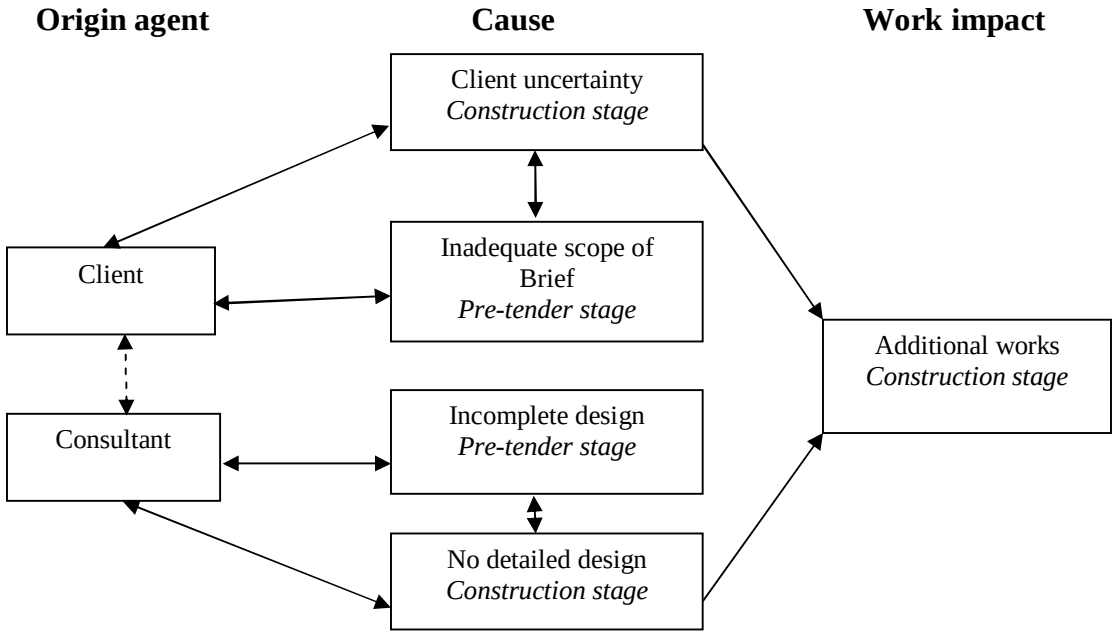


Figure 5.4 Relationships between the origin agents and the work impact

These linkages are discussed as follows:

- Additional works are the result of the failure of client to provide a clear and comprehensive brief with the result that client changes emerge during the construction stage;
- Additional works are the result of the failure of the consultant to produce a complete design resulting in more details being required during the construction stage;

The causes of variation orders were ranked in ascending order and the most frequent subsequent origin agent identified. From Table 5.26, it is evident that the most frequent causes of variation orders were change of schedule, specifications and design

and errors in design and inadequate working drawing details. These predominantly originated from the consultant.

However, it is argued that variation orders originating from the consultant included those originating from the client. In fact, since the change of plans or scope was the most predominant cause of variation orders originating from the client these encompass most of the changes originating from the consultant.

Experience and lack of experience were opposite causes generating variation orders but both originated from the contractor. On the one hand, the contractor with experience could propose replacement of materials or construction procedures. Such a variation order would enhance the value of the project. On the other hand, the lack of experience of the contractor had the potential to increase the number of variation orders on a project. The variation orders resultantly occurring adversely affected the value of the project. The fact that respondents suggested the reduction of the occurrence of variation orders could be admittance by the construction industry that excessive variation orders had some adverse impact on the project. Respondents suggested that adequate time should be spent on design and accurate information should be disseminated between parties to the contract.

Table 5.26 Causes of variation orders versus origin agents

Causes of variation orders repercussion	Ranking	Origin agent
Change of plans or scope	1	Client
Change of schedule	2	Consultant
Change in specifications	3	Consultant
Change in design	4	Consultant
Errors and omissions in design	5	Consultant
Inadequate working drawing details	6	Consultant
Non-compliant design with government regulations	7	Consultant
Impediment in prompt decision making process	8	Client
Unforeseen problems	9	Others
Replacement of materials or procedures	10	Contractor
Inadequate shop drawing details	11	Contractor

Table 5.26 Continued

Causes of variation orders repercussion	Ranking	Origin agent
Lack of judgment and experience	12	Contractor
Financial problems	13	Client
Inadequate scope of work for one or more parties to the contract	14	Consultant
Design complexity	15	Consultant
Lack of communication	16	Consultant
Defective workmanship	17	Contractor
Design discrepancies	18	Consultant
Inadequate project objectives	19	Client
Long lead procurement	20	Contractor
Lack of coordination	21	Consultant
Fast track construction	22	Contractor
Ambiguous design details	23	Consultant
Unavailability of skills	24	Contractor
Weather conditions	25	Other
Lack of strategic planning	26	Contractor
Lack of knowledge of available materials & equipment	27	Consultant
Lack of involvement in design of one or more parties to the contract	28	Consultant
Non-compliant design with owner's requirement	29	Consultant
Health and safety considerations	30	Contractor
Lack of a specialised construction management	31	Contractor
Obstinate nature of one or more of the parties to the contract	32	Consultant
Differing site conditions	33	Contractor
Poor procurement process	34	Consultant
Conflicts between contract documents	35	Consultant
Value engineering	36	Consultant
Change in economic conditions	37	Others
Non-compliant design with government regulations	38	Consultant
Lack of required data	39	Consultant
Unavailability of equipment	40	Contractor
Unfamiliarity with or unawareness of local conditions	41	Contractor
Socio-cultural factors	42	Others
Change in government regulations	43	Others
Speculation on desired profitability	44	Contractor
Technology change	45	Contractor

5.7.4 Effects of variation orders on project performance

Despite provision being made in contract conditions, variation orders resulted in problematic situations. Time and cost overruns and disputes between parties to the contracts were the most predominant adverse impacts of variation orders on project performance. Although there were several options to evaluate the cost of variation orders,

a lack of common understanding was found between parties to the contract and could be the source of disputes between them.

5.8 Chapter summary

This chapter analysed the findings from the research instrument and the empirical audit of site instructions. Closed-ended questions were interpreted by means of frequencies and descriptive statistics. A reliability test was done on scaled questions by calculating Cronbach's alpha coefficient. The value of the coefficient of reliability of 0.9 confirmed the responses to scaled questions to be reliable. Open-ended questions were summarised. The audit of variation orders was done on three projects and a subsequent comparative analysis was provided. The findings were discussed of both the research instrument and the site instruction audit linking them to the literature review.

It was found that consultants accepted time frames proposed by clients instead of proposing realistic timeframes to complete the design. As a result they embarked on tendering whether the design was completed or not because they knew other required changes would be permissible under the conditions of contract. It was therefore concluded that the client was the most predominant origin agent of variation orders. Most variation orders added value to the project. However, waste was still a consequence of them. It was found that variation orders were not realistically priced resulting in increased construction costs. Time and cost overruns and disputes had major impacts on project performance. There were no standard methods for recording and administering variation orders. While respondents suggested that variation orders should be kept to minimum, they acknowledged that clients had the right to initiate changes provided they were contractually permissible and were prepared to pay the associated costs.

CHAPTER 6
SUMMARY AND CONCLUSIONS

6.1 Introduction

This chapter discusses the hypothesis testing, draws conclusions, limitations and recommendations. In total seven hypotheses are tested against the findings. Conclusions constitutes the recapitulative of major findings from the exploratory study, interviews, research instrument and the analysis of site instructions linking them to the objectives of the research study. Recommendation section highlights the practical implications of the study and suggests further research studies.

6.2 Hypothesis testing

- H1. Variation orders are prevalent on all construction projects

The study found that more than 85% of site instructions constituted variation orders. It was found that the variation clause was an essential feature of a contract, given that building operations involved complex activities that could not be accurately determined in advance. Therefore, the hypothesis that variation orders are prevalent on all construction projects cannot be rejected.

- H2. Variation orders always increase the cost of construction

It was found that variation orders were the major contribution to cost overruns. However, while 80% of variation orders impacted cost, 12% had no cost impact on construction projects. In conclusion, variation orders do not always increase the cost

for construction. The hypothesis that variation orders always increase the cost of construction is rejected.

- H3. All variation orders add value to construction projects

The analysis of site instructions suggested that most variation orders (95%) were beneficial. However, the literature review highlighted cases of detrimental variation orders that contributed to value degradation. As a result not all variation orders added value to the construction project. The hypothesis that all variation orders add value to construction projects is rejected.

- H4. Variation orders may be regarded as waste

The audit of site instructions, findings of the case studies and the responses to the questionnaire found that there was a certain amount of waste accruing as a result of variation orders. The hypothesis that variation orders may be regarded as waste cannot be rejected.

- H5. Variation orders may be eliminated if their causes are identified

The study found identified the causes of variation orders, many of which had the potential to be either eliminated or reduced. The hypothesis that variation orders may be eliminated if their causes were identified cannot be rejected.

- H6. Variation orders negatively affect overall project performance

Responses to research instrument, the cases studies on construction projects and the analysis of site instruction confirmed that variation orders contributed to the cost and time overruns and increases in disputes. The hypothesis that variation orders negatively affect the overall project performance cannot be rejected.

- H7. The predominant origin agent of variation orders is the client.

Responses to the research instrument, case studies on the construction project showed that the client was the most predominant origin agent of variation orders. The hypothesis that client is the predominant origin agent cannot be rejected.

6.3 Conclusions

6.3.1 Prevalence of variation orders on construction project

A comparative analysis of two apartment complex projects confirmed the prevalence of variation orders on construction projects. By combining the two projects, a total number of 193 variation orders occurred in the space of 24 months. From the interviews, the contract surveyor involved in a fast track contract pointed out that variation orders should be expected since works started on site while the design was incomplete. A managing director of a construction contracting company involved in both design-build and traditional procurement projects concluded that fewer variation orders occurred on design-build contracts due to the involvement of the contractor at an early stage of the project. The analysis of the responses of the questionnaire found that most site instructions involved change of design, quality and quantity of works. Factors influencing variation orders included the nature and complexity of works and the selection of the procurement method; however, complexity of works had greater influence. From the analysis of site instructions, more than 85% of site instructions were variation orders and 11% were not. In conclusion, the occurrence of variation orders was prevalent on construction projects.

6.3.2 Cost impact of variation orders

From the case study of two combined projects, 79% (153 no) variation orders involved additional costs while 29% (40) contributed to reduction in cost. Variation

orders involving additional costs overweighed by far variation orders involving cost reduction. The interview with a construction manager confirmed that contractors overcharged on variation orders because they were not optimistic about whether the claimed amount would always be certified in full. Responses to the research instrument found excessive variation orders resulted in unnecessary costs. The audit of variation orders found that 80% of variation orders had cost implications in terms of cost adjustment. It was found that specific skills were needed to evaluate variation orders, and specifically quantity surveyors could contribute.

6.3.3 Value addedness of variation orders

A managing director of a construction contracting company indicated that there was nothing wrong with variation orders as long as they were initiated for project improvement purposes. There should not be any damage of relationships between parties to the contract following the occurrence of variation orders. From the analysis of the research instrument, it was found that there were more beneficial variation orders than detrimental ones. The empirical analysis of site instructions found that most site instructions added value to the contract. The presence of a variation clause was an indication of flexibility of contract arrangements in order accommodate changes to solve problems arising within the project.

6.3.4 Waste of variation orders

A practical tool for identification of waste zones within the activities of variation orders was designed. This was an origin-causes matrix that quantified direct waste associated with variation orders. It was applied on the case study that analysed the cost variation of two apartment projects. Waste was manifested through demolitions works following the construction errors. The interview with the contract quantity surveyor

involved in the fast track contract revealed the occurrence of non value-adding activities such as, for example, idle labour waiting for instructions on varied works. The interviewee pointed out that design errors and omissions contributed to waste. The responses for the research instrument confirmed that excessive variation orders had potential to increase waste. The analysis of site instruction revealed that 14% of site instructions had waste associated to them.

6.3.5 Origin agents of variation orders

From the case study, the consultant and the client combined generated more than 92% of variation orders. The predominant cause of cost variations was the design changes. The interviewed construction manager involved in a refurbishment project pointed out that the client was the main origin agent of variation orders. The client desired the works to start on site while the design was still incomplete. Some portions of works were put on hold where the construction overlapped the design. The research instrument revealed that the client was the most predominant origin agent of variation orders. The consultant was second to the client. The contractor and other unspecified events had lesser influences on the occurrence of variation orders.

6.3.6 The impact of the variation orders on the project performance

The study found that variation orders had an impact on overall project performance. From the case study, both projects experienced time overruns of 9% and 33% respectively. It was argued that variation orders contributed to time overruns. Consequently, the contractor was levied penalties for delays amounting to 3% of the contract sum. The interviewed contract quantity surveyor pointed out that late instructions, discrepancies in design and excessive site instructions disrupted the programme of works. The interviewee indicated that variation orders adversely impacted

costs. A managing director of a contracting company indicated that the contractor did not always recover fully the claimed amount. A construction manager involved into a fast track contract indicated that variation orders affected activities on the critical path and resulted in rescheduling. Respondents to the research instrument suggested that variation orders were the major factor in delays in delivery of construction projects. It was pointed out that the administration of variation orders was problematic with regards to the determination of cost and time and involved lengthy approval processes. As a result contractors were dissatisfied with the certified amounts which in most cases were less than what they had claimed. Arguably, such discrepancies stemmed from the absence of a standard method for recording and administering variation orders. What a consultant interpreted as indirect cost could be direct to the contractor. The major adverse impact of variation orders were time and cost overruns and disputes between the parties to the contract.

6.4 Limitations

One of the challenges faced during this research project was to get respondents to participate in the study. For example, it took at least two weeks to set up an appointment to meet interviewees. A limited number of construction projects were used for case studies and audit of site instructions because many companies were not willing to provide access to the information regarding site instructions despite the assurance of confidentiality.

A sample size of 30 companies operating in Western Cape metropolitan was targeted with an expectation of obtaining an equal representation in a stratified sample of contracting, cost consultant and architectural companies. Companies were asked to distribute as many as possible copies of the questionnaire to appropriate employees. Most

of companies returned only one completed questionnaire. Some respondents declined to complete the questionnaire given that they were not exposed to the issues being studied. There was a low response rate to questionnaires sent by post especially from architectural companies. While the findings may not be broadly generalisable they are indicative of the impact of variation orders on the performance of construction projects given that most of the key findings confirmed the findings of the literature review.

6.5 Recommendations

Comprehensive research studies of identifying waste or non value-adding activities within the entire construction development process were recently initiated in Sweden. The philosophy behind the study was to explore various activities within the accepted construction phases and a subsequent identification of those that were prone to generation of waste. It was argued that the amount of waste consumed resources while increasing the overall construction delivery costs. With reference to such concepts of waste, this research was a pilot one in South Africa confined to the impact of variation orders on project performance. The aim of the research was to identify the impact of variation orders on project performance in order to take a pro-active measure to reduce them.

Findings revealed that the client was the most predominant origin agent of variation orders due to unclear briefing of the scope of works. It was indicated that client did not clearly state their requirements. Therefore, studies are needed to determine how best clients can be assisted with regards to discovering their requirements.

While design errors and omissions can not be completely avoided, they can be reduced especially if designers assessed their workloads before committing themselves to new contracts. They should ensure enough time and experienced human resources to

deliver a sound design within the proposed time frames. Among others, recommendations to reduce the occurrence of variation orders were stated as follows:

- Adequate planning in advance is required by all involved parties before works start on site;
- Consultant to produce a concluding design and working drawings and contract drawings should be complete at tender stage;
- Adequate time should be spent on pre-tender planning phase;
- Clients should provide a clear brief of the scope of works;
- All parties should forecast to overview unforeseen situations;
- Closer consultant c-ordination is required at design stag;
- Enhance communication and all parties should be proactive all times;
- Works should be supervised with an experienced a dedicated supervisor;
- Consultant should ensure that the design/specifications fall within the approved budget and the budget team should be appointed and participate during the design phase; and
- Get accurate information and research with regard to procurement procedure, material and plant.

In order to avoid the discrepancies between the amount claimed and the certified amounts, the study hypotheses the development of a more equitable basis of valuation and cost recovery. Given the exploratory nature of the study, the issue regarding the development of a more equitable basis of valuation of cost recovery was beyond the scope of this research.

While the analysis of the responses by various stakeholders was treated homogenously, it is acknowledged that differences might be prevalent between them. A more detailed analysis is therefore necessary.

APPENDICES
APPENDIX A – QUESTIONNAIRE

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This research study titled "**An Analysis of the Impact of Variation Orders on Project Performance**" is undertaken by a team of researchers at the Southern Africa Built Environment Research Center (SABERC) to investigate the impact of variation orders on project performance. Please answer **all** questions.

SECTION A: PROFILE

1. Which of the following best describes your company?

No	Company description	Tick only one box
1.1	Contractor	
1.2	Architect	
1.3	Consulting engineering	
1.4	Cost consultant	
1.5	Project management	
1.6	Learning institution	
1.7	Client	
1.8	Developer	
1.9	Other	

2. If your answer above was other, specify: ……

3. How long have you worked in the construction industry? ……years……..months

4. How long have you worked for your present company? ……...years……..months

5. What is your current position in your organisation? ……

6. How long have you been in your present position? ……years……months

7. Have you ever been involved with the administration of variation orders?
   Yes □ No □

SECTION B: THE PREVALENCE OF VARIATION ORDERS

8. From your own experience, from the 1st (most frequent) to the 3rd (least frequent) **rank** the following impacts of variation orders on construction work.

No	Impact	1st	2nd	3rd
8.1	Additional works			
8.2	Omissions from works			
8.3	Substitution of works			

9. Please explain the ranking order you suggested above.

   9.1 Additional works: ……
   ……
   ……

   9.2 Omissions from works: ……
   ……
   ……..

   9.2 Substitution of works: ……
   ……
   ……

10. From your personal experience, how frequently are the following types of site instructions encountered on construction projects?

No	Instruction	Never	Seldom	Sometimes	Often	Always
10.1	To vary the design, quality or quantity of the works					
10.2	To resolve discrepancies (e.g. rectify errors, omissions)					
10.3	To reiterate or enforce contractual provisions (e.g. instruction to remove from site goods that do not conform to original specifications)					
10.4	To deal with monetary allowance (e.g. instruction indicating how to spend money budgeted under prime costs)					
10.5	To protect the client's interest (e.g. instruction to remove from site camp a worker who constitutes a nuisance)					

11. To what extent do you agree with the following statements where strongly disagree=1, Disagree=2, Neutral=3, Agree=4, Strongly agree=5?

No	Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly
11.1	A clause permitting variation orders is an essential feature of any construction contract					
11.2	Most variation orders can be avoided					
11.3	A variation order clause is provided because construction projects involve complex operations which can not be accurately determined in advance					
11.4	The existence of a variation order clause is an aspect that tends to encourage clients/consultants to change their minds during the course of a contract					
11.5	All clients are fully aware that there could be unnecessary costs that accrue due to a variation order					
11.6	The excessive occurrence of variation orders increases the possibility of unethical practices					

12. Indicate which of the following is true of your organisation.

No	Activity	Yes	No	Unsure
12.1	We record all variation orders			
12.2	We calculate the direct costs of variation orders			
12.3	We calculate indirect costs of variation orders			
12.4	We employ a specific person with relevant skills to manage variation orders			

13. If you answered "**No**" to any of the above, please explain your response below.

13.1 We record all variation orders:
.....……
……
13.2 We calculate the direct costs of variation orders:
……
……
13.3 We calculate indirect costs of variation orders:
……
……
13.4 We employ a specific person with relevant skills to manage variation orders:
……
……

SECTION C: COST IMPLICATION OF VARIATION ORDERS

14. To what extent do you agree with the following statements where strongly disagree=1, Disagree=2, Neutral=3, Agree=4, Strongly agree=5?

No	Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly
14.1	Excessive variation orders result in incurring unnecessary costs					
14.2	The reduction of the occurrence of variation orders can optimally lower construction delivery costs					
14.3	Time compression in construction operations can contribute to significant reduction of unnecessary costs					
14.4	The reduction of variability in construction operations can contribute to significant reduction of unnecessary costs					
14.5	No matter how carefully a variation order is administrated, indirect costs accrue on it					
14.6	The occurrence of variation orders is the major factor of delay in delivery of construction projects					

SECTION D: ORIGIN AGENT AND CAUSES OF VARIATION ORDERS

15. Please indicate the frequency of each as an origin agent by **ranking** from 1st (most frequent) to 4th (least frequent). NB**: "Others"** include situations beyond the control of the contractual parties that give rise to variation orders such as for example weather conditions, health and safety considerations, change in government regulations, change in economic conditions, socio-cultural factors and unforeseen problems.

No	Origin agent	1st	2nd	3rd	4th
15.1	Contractor				
15.2	Consultant				
15.3	Client				
15.4	Others				

16. Please explain your **choice of ranking** relative to **each** of the origin agents.

16.1 Contractor:

……..……

……..……

16.2 Consultant:

……..……

……..……

16. 3 Client:
……..……
……..……
16.4 Others:
……..……
……..……

17. Please indicate the frequency of each of the factors influencing the occurrence of variation orders by **ranking** from 1st (most frequent) to 3rd (least frequent).

No	Factors influencing variation orders	1st	2nd	3rd
17.1	Nature of works			
17.2	Complexity of works			
17.3	Procurement method			

18. The following are examples of causes of variation orders, tick the **most frequent** origin agent corresponding to **each** of them.

No	Causes of variation orders	Client	Consultant	Contractor	Others
18.1	Change of plans or scope				
18.2	Change of schedule				
18.3	Financial problems				
18.4	Inadequate project objectives				
18.5	Replacement of materials or procedures				
18.6	Impediment in prompt decision making process				
18.7	Obstinate nature of one or more of the parties to the contract				
18.8	Change in specifications				
18.9	Change in design				
18.10	Errors and omissions in design				
18.11	Conflicts between contract documents				
18.12	Inadequate scope of work for one or more parties to the contract				
18.13	Technology change				
18.14	Value engineering				
18.15	Lack of coordination				
18.16	Design complexity				
18.17	Inadequate working drawing details				
18.18	Inadequate shop drawing details				
18.19	Lack of judgment and experience				
18.20	Lack of knowledge of available materials and equipment				
18.21	Honest wrong beliefs of one or more of the parties to the contract				
18.22	Lack of required data				

Q18. Continued

No	Causes of variation orders (continued)	Client	Consultant	Contractor	Others
18.23	Ambiguous design details				
18.24	Design discrepancies				
18.25	Non-compliant design with government regulations				
18.26	Non-compliant design with owner's requirement				
18.27	Lack of involvement in design of one or more parties to the contract				
18.28	Unavailability of equipment				
18.29	Unavailability of skills				
18.30	Speculation on desired profitability				
18.31	Differing site conditions				
18.32	Defective workmanship				
18.33	Unfamiliarity with or unawareness of local conditions				
18.34	Lack of a specialised construction management				
18.35	Fast track construction				
18.36	Poor procurement process				
18.37	Lack of communication				
18.38	Long lead procurement				
18.39	Lack of strategic planning				
18.40	Weather conditions				
1841	Health and safety considerations				
18.42	Change in government regulations				
18.43	Change in economic conditions				
18.44	Socio-cultural factors				
18.45	Unforeseen problems				

19. Following are the examples of causes of variation orders, indicate how frequently each of them occur on construction projects.

No	Causes of variation orders	Never	Seldom	Sometimes	Often	Always
19.1	Change of plans or scope					
19.2	Change of schedule					
19.3	Financial problems					
19.4	Inadequate project objectives					
19.5	Replacement of materials or procedures					
19.6	Impediment in prompt decision making process					
19.7	Obstinate nature of one or more of the parties to the contract					

Q19 Continued

No	Causes of variation orders (continued)	Never	Seldom	Sometimes	Often	Always
19.8	Change in specifications					
19.9	Change in design					
19.10	Errors and omissions in design					
19.11	Conflicts between contract documents					
19.12	Inadequate scope of work for one or more parties to the contract					
19.13	Technology change					
19.14	Value engineering					
19.15	Lack of coordination					
19.16	Design complexity					
19.17	Inadequate working drawing details					
19.18	Inadequate shop drawing details					
19.19	Lack of judgment and experience					
19.20	Lack of knowledge of available materials and equipment					
19.21	Honest wrong beliefs of one or more of the parties to the contract					
19.22	Lack of required data					
19.23	Ambiguous design details					
19.24	Design discrepancies					
19.25	Non-compliant design with government regulations					
19.26	Non-compliant design with owner's requirement					
19.27	Lack of involvement in design of one or more parties to the contract					
19.28	Unavailability of equipment					
19.29	Unavailability of skills					
19.30	Speculation on desired profitability					
19.31	Differing site conditions					
19.32	Defective workmanship					
19.33	Unfamiliarity with or unawareness of local conditions					
19.34	Lack of a specialised construction management					
19.35	Fast track construction					
19.36	Poor procurement process					
19.37	Lack of communication					
19.38	Long lead procurement					
19.39	Lack of strategic planning					
19.40	Weather conditions					
19.41	Health and safety considerations					
19.42	Change in government regulations					
19.43	Change in economic conditions					
19.44	Socio-cultural factors					
19.45	Unforeseen problems					

20. How can the occurrence of variation orders be reduced?

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……

E. EFFECTS OF VARIATION ORDERS ON PROJECT PERFORMANCE

21. A beneficial variation order is one issued to improve the quality standards, reduce cost, schedule, or degree of difficulty in a project to the satisfaction of the client. A detrimental variation order is one that negatively impacts the client's value or project performance. Based on your past experience, indicate how frequently beneficial and detrimental variation orders occur on construction projects.

No	**Nature of variation orders**	**Never**	**Seldom**	**Sometimes**	**Often**	**Always**
21.1	Beneficial variation orders					
21.2	Detrimental variation orders					

22. When negotiating a variation order with the client/contractor, what kind of problems do you encounter?

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23. From your experience with variation orders, indicate how frequently variation orders resulted in the following:

	Outcome	Never	Seldom	Sometimes	Often	Always
23.1	Time overrun					
23.2	Time reduction					
23.3	Cost overrun					
23.4	Additional specialist equipment/personnel					
23.5	Optimum cost reduction					

Q23 Continued

	Outcome	Never	Seldom	Sometimes	Often	Always
23.6	Degradation of heath & safety					
23.7	Additional health & safety equipment/measure					
23.8	Disputes between parties to the contract					
23.9	Professional reputation of one or more parties adversely affected					
23.10	Complaints of one or more of the parties to the contact					
23.11	Degradation of quality standards					
23.12	Quality standards enhanced					

24. From your experience, what was the impact of variation orders on construction projects?

	Outcome	Major impact	Slight impact	No impact
24.1	Time overrun			
24.2	Time reduction			
24.3	Cost overrun			
24.4	Additional specialist equipment/personnel			
24.5	Optimum cost reduction			
24.6	Degradation of heath & safety			
24.7	Additional health & safety equipment/measure			
24.8	Disputes between parties to the contract			
24.9	Professional reputation of one or more parties adversely affected			
24.10	Complaints of one or more of the parties to the contact			
24.11	Degradation of quality standards			
24.12	Quality standards enhanced			

25. Do you have any further comment, suggestion or contribution relative to variation orders?

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Thank you

APPENDIX B – AUDIT OF SITE INSTRUCTIONS

1. Does this site instruction constitute a variation order or not?
2. What was the work implication associated with this site instruction?
3. Does this variation order have some cost implications?
4. Is this instruction beneficial or detrimental?
5. Is there any apparent waste associated with this site instruction?

APPENDIX C – FORM OF RECORD OF PROJECT PARTICULARS

No	Questions	Answer
1	Indicate whether the project was: **(a) new, (b) refurbishment or (b) extension** [Just select a letter(s) corresponding to your answer in the answer box]	a b c
2	Please provide a brief description of the scope of works including the structural elements, number of storey in the space below. (Write here)	
3	For what purpose was the project developed for? **(a) Shopping centre/commercial premises, (b) Hotel/guest house, (c) Housing development, (d) Residential flat, (e) Office apartment, (f) Others (specify)……..** [Just select a letter corresponding to your answer in the answer box]	a b c d e
4	How much was the original tender sum?	R
	How much was the final contract sum?	R
	Do you think the occurrence variation orders had the impact on the **final contract sum**? **(a) escalated, (b) reduced (c) No impact** [Just select a letter corresponding to your answer in the answer box]	a b c
5	What was the original contract duration?	months
	What was final contract duration?	months
	Do you think the occurrence of variation orders had the impact on the final **contract duration**? **(a) escalated, (b) reduced (c) No impact** [Just select a letter corresponding to your answer in the answer box]	a a c
6	What is the actual progress of works? For example 50%	%
7	Indicate all the methods that were used to ascertain the price of variation orders on this particular project. **(a) Day works, (b) Bill rates, (c) Negotiated rates, (c) The contractor submit first the quotation of the varied works before works start** [Just select a letter(s) corresponding to your answer in the answer box]	A b c d
8	Was it a **fixed price**, **fluctuating** contract or **other …….....**?	Fixed ; fluct.
9	Were there some items falling under provisional sums/quantities? **Yes, No**	Yes ; No
10	Was it a fast track contract? **Yes, No**	Yes ; No
11	Were all the plans and other contract documents complete at time of tender? **Yes, No**	Yes ; No
12	How many subcontractors were involved into the project?	…..no
13	What was the approximate number of workers on site?	…..no
14	How many consultant firms were involved into the project?	…..no

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BIOGRAPHICAL SKETCH

Ruben Ndihokubwayo was born on the 23rd December 1972 in Bujumbura Burundi. Both his names have a meaning relating to the circumstances under which he was born. As a first born, he was given a Christian name Ruben translated as 'to have a boy'. He was also given a Kirundi name in the mother tongue Ndihokubwayo translated as 'I am alive because of Him (God)' because his mother nearly died when she was pregnant.

Ruben holds a Bachelor Honours Degree in Quantity Surveying (2005) from the National University of Science and Technology in Bulawayo, Zimbabwe. Ruben has a blend experience as a teacher in secondary school and a Quantity Surveyor in construction contracting companies. During his research at masters degree level, Ruben published 7 conference papers and 2 journals at local (South Africa) and international venues. Five conference papers related to the main topic under research and others two related to an increased cost adjustment (ICA) formula, a formula he developed himself. While at the Cape Peninsula University of Technology in 2007 and 2008, Ruben was a team member that organised the 2nd and 3rd Built Environment Conferences on behalf of the Association of Schools of Construction in Southern Africa under the academic chair's office. Ruben has been part of leadership positions of various structures in academic environments and the communities and was awarded numerous certificates.

AN ANALYSIS OF THE IMPACT OF VARIATION ORDERS ON PROJECT PERFORMANCE

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The underlying objective of every project is to optimise the overall construction delivery costs. In order to achieve this objective, all parties to the contract have to be committed to optimum use of resources throughout all the stages of the development process through a continuous elimination of non value-adding activities. The current study was confined to the investigation of activities that give rise to waste of resources owing the occurrence of variation orders. The cognisance of such activities would increase the awareness to interested parties in orders to take proactive measure to reduce them. This study was significant in the South African context at this time the construction industry is at unprecedented boom where the optimum use of resource will contribute to saving of resources to meet societal and economical needs.