INVESTIGATION INTO ESTIMATION OF BUILDING PROJECTS VARIATION CONTRACT PERIOD

BY

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DECLARATION

This project is my original work and has not been presented for the award of a degree in this University or any other Institution of higher learning for examination.

………………………………… ……………………….

 Signature Date

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This project has been submitted for examination with my approval as the University Supervisor.

………………………………… ……………………….

 Signature Date

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I thank God, my maker, provider of knowledge for enabling me to study and complete the Masters program and even this project.

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I am grateful to my family members for their moral support in the period of this study. I wish to appreciate my classmates for their positive influence, support and positive criticism and for inspiration during the study.

May God bless you

DEDICATION

I dedicate this project work to my entire family, I particular sons Billbright Mutwiri who was born during the time of writing this research project, Master Victor Mwenda and my wife Sarah Kimathi for support and encouragement, to my parents Mr. Misheck Karani and Mrs. Loise Misheck for the value they put in my formative education and finally to God almighty for all his many blessings.

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ABREVIATIONS AND ACRONYMS

GDP   Gross Domestic Product

NEMA   National Environmental Management Authority

UK   United Kingdom

USA   United State of America

WBS   Work Breakdown Structure

CPT   Cost per Time Period

ABSTRACT

In Kenya, the construction industry has a big contribution to national economic growth and therefore the improvement in efficiencies of the industry through of effectiveness in timelines that would certainly contribute to an overall cost savings for the industry and the country as a whole. The aim of parties in a given construction project is to obtain a constructed facility within the specified time, budget and specifications, Kivaa, (2000). In developed countries of United States of America, United Kingdom and Germany, Mobbs (1982) document that 'construction time' is well achieved as it is well planned at the commencement of a project. In a developing country case in point Nigeria, the performance of the construction industry time wise is poor leading to increased costs, Odeyinka and Yusif (1997). It was also found out at that seven out of ten projects surveyed had delays in their execution. Documentation of quality and budget as a measure of success in construction has been documented by Chan and Kumaraswamy (1993) to show that delivery of projects within time, budget and expected quality standard as specified by the client is an index of for measuring successful project delivery. However, project variations aspects have been found to be a major contributing factor to non delivery of on time, cost and quality. Variations however do occur on the project and a cost is factored at the beginning of the project but time is not. Contract time is thus extends in the project and the objective of this project to find out how time is calculated at the commencement of project and how the time for carrying out the variations is calculated and by who and of those methods are effective and to satisfaction of the parties involved.

The study employed descriptive survey design while the target population consisted of developers, consultants and construction site managers of construction projects in Nairobi County. The study relied on primary data source and used purposive sampling technique. The study generated qualitative and quantitative data in which quantitative data was coded and entered into Statistical Packages for Social Scientists (SPSS Version 17.0) for analysis using descriptive statistics.

The conclusions of the study were that estimation of project time is done by the consultant whereas estimation of time for carrying out variation work is done by the contractor. A combination of mathematical and non-mathematical methods are used but non-mathematical is the most popular method used in calculating the time for projects and time for carrying out variation work. Mathematical methods, like the Bromilow's Time Cost (BTC) model is rarely

applied in the Kenyan construction industry as a model of estimating project construction time. Many projects experience extensive delays thus exceed initial set time. This leads to impairing the economic feasibility of capital projects and extensive delays provide ripe grounds for costly disputes and claims. According to the contractors and project supervisors, errors and omissions in design are a major cause of project variations that lead to delays as well as unavailability of new equipment introduced in variation since procurement problems affect the project completion, while owners ranked delays decision making process as hindering subsequent construction activities. Delays were noted to occur due to external factor like change in government, regulation and location.

The study recommended Contract Variation issued should always be accompanied by variation period and that the Project Managers should always cater for impacts which cause extension of time and/or increase in cost are frequent occurrences in project construction. At the commencement, contractors should regularly try to identify and to bring to the attention of the client project risks such as an ill defined scope in the early stages (tender clarification meetings) of a project. Whereas there is use of mathematical and non-mathematical methods of estimating time, the current methods applied do not satisfactorily achieve the expectations and it is recommended as an areas of further research that a model of estimating time should be developed to act as a guide the for the Kenyan construction industry.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Goal of parties in any given construction project is to obtain a product that is within specified time, cost and quality. Mbatha (1986) and Wachira (1996) have both observed that adherence to the contract period estimated at the tendering stage of a project has been rather elusive in construction industry in Kenya.

The characteristics of construction industry can be complex as they involve many human and non-human factors and variables. These characteristics are long durations, many uncertainties and complex relationships among the participants. There is thus need to make changes in a construction project as a matter of practical reality since even the most thoughtfully planned project may necessitate changes due to many factors (O'Brien, 1998). These characteristics results to the need to understand variations. Therefore, since variations occur in all manner of construction projects, the subject of variations in building projects is very significant for participants in building and construction management (Ibbs *et al.,* 2001). This area of variations and the related effects of delays, costs and time overruns have been researched before by various researchers such as Mbatha (1986), Kimani (2004), Bromilow (1969), Baradyana (1996), Kivaa (2000), Wachira (1996) Mbeche (1996) and Radujkvic (1999). Time management is thus a key factor to include in the project plan to cater for variations that occur and this ensure project runs according to the projected time plan. Whereas the variations are catered for in the initial stages of the construction process as a contingency cost by the quantity surveyor, the same is not catered for when the time schedule is developed by the team or even by the contractor or in the approved plan of work by the project team. This then leaves a gap open for abuse and leading to projects prone to time overruns and the related ripple effect being a cost overrun.

Various institutions in construction industry incorporate in their forms of contract provisions for variations in their documents. Colledge (1992) stated the need to insert provisions that offer guidance in the future as it is impossible to complete all aspects of the contract before commencement. Dorter (1991) defined variation as an alteration whether by extra or omission, to the physical work scope specified in the contract but which the contractor is required to undertake. In the contract document by the Joint Building Council Clause 26 deals with variations and it defines term 'variation' to mean the alteration or modification of the design,

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quality or quantity of the works. These provisions should contain detailed arrangements how the changes are to be made but also who will be vested with the power to decide the changes. The parties are thus able to adjust to future contingencies thus secure performance and continuation of the contract. Therefore the response has been to come up with ways to prevent or limit the occurrence of variations.

A number of strategies exist that can be implemented in the early stages of a project to help in reducing adverse impacts of variations in the construction process. These strategies were highlighted by Chan and Yeong (1995) and although useful, these strategies did not address an important issue, that is, that variations will always occur (Bromilow 1970). This meant that it is inevitable for changes to occur on the specification of the work in one way or another even for a very well-planned project. This is due to the reality in many commercial projects where the client dictates the pace of design by responding to external pressures (Latham 1994). This together with the rapidity of changes in the environment gives the limitations on the extent a design can be considered complete. As a consequence, the construction process should also have adaptability to respond appropriately to these external pressures so as to reap benefits of a contractual flexibility to changes to whatever has been originally agreed. However, the client still has other options whenever a change in circumstances from external stakeholders such as financiers, potential buyers or tenants that may renders the original design unsuitable.

The objective of this project is to investigate the practices in the Kenyan construction market, with focus on Nairobi County in terms of estimating the contract time, the methods that are used whether mathematical methods like the critical path method or the non-mathematical methods like application of past experience, then what methods are used to estimate the variations period that occur in the construction phase and find out how effective they are and give recommendations on the suitable method of estimating contract variations period.

1.2 Statement of the Problem

Many construction projects suffer variation, either to add more work to initial scope or reduce the scope of work. These variations are catered for in the forms of contracts and are not a strange occurrence. The contractual provisions provided have definitions on the conduct of the owner, consultants and contractor on how to participate and manage variations. In the process of construction, the construction period is filled by the contractor during tendering and this becomes

the contract period after the tender is accepted and after tender award, the contractor submits the project schedule.

The conditions of contract document by the Joint Building Council (1999) Clause 30 deals with variations and it sets as follows; The term 'variation' means the alteration or modification of the design, quality or quantity of the Works as shown upon the contract drawings and described by or referred to in the contract bills and specifications and includes:

   a) *The addition, omission or substitution of any item of work,*

   b) *The alteration of the kind or standard of any of the materials or goods to be used in the Works,*

   c) *The removal from the site of any work, materials, or goods brought upon the Works by the Contractor for the purposes of the Works other than work, materials, or goods which are not in accordance with the contract,*

   d) *The issue of instructions by the Architect in regard to the expenditure of prime cost and provisional sums included in the contract and of prime cost sums which arise as a result of instructions issued in regard to the expenditure of provisional sums and*

   e) *All instructions for variations shall be copied to the Employer,*

The same clause 30 also specifies that measurement and valuation of variations and of work executed by the Contractor for which a provisional sum is included in the contract bills (other than work for which a tender has been accepted as aforesaid) unless otherwise agreed, shall he made in accordance with the following:

   a) *The prices in the contract shall determine the valuation of work of similar character executed under similar conditions as work priced therein,*

   b) *The said prices, where work is not of a similar character or executed under similar conditions as aforesaid, shall be the basis of prices for the same so far as may be reasonable, failing which a fair valuation thereof shall be made,*

   c) *Where work cannot properly be measured and valued, the Contractor shall be allowed day-work rates on the prices prevailing when such work is carried out.*

JBC, (1999)

Radujkovic, (1999) also states that variations can be caused by design changes and the cause for these changes during the project execution is caused by either;

a) Decision to start project before total documentation is finished and accepted,

b) Addition demands for the functional changes,

c) Inaccuracy, incompleteness or late update documentation.

Past researched by Mbatha (1986), Kimani (2004), Bromilow (1969), Baradyana (1996), Kivaa (2000), Wachira (1996) Mbeche (1996) found out that the causes of project time overruns were due to;

a) Unresolved financing of the project,

b) Design changes during execution,

c) Unrealistic plan and short time for execution,

d) Materials, plant or labour shortages,

e) Unexpected subsoil conditions – underground water, rock, etc,

f) Poor organizational/managerial forms of ineffective communication, control and bureaucracy etc,

g) Industrial disputes mainly of wages, workers not paid as per agreement, leading to strikes or go slows;

h) Climate that is inclement weather and

i) Others like contractual claims, shortage of skilled or unskilled labour etc.

They conclude that contract time overrun is a real issue and to counter it measures need to be taken to solve and they include;

a) Training all construction industry participants in the most appropriate managerial skills like planning, scheduling, and control;

b) Employing better skilled constriction managers;

c) Being more real in construction time estimation and

d) Drawing realistic project budgets that consider *interalia,* inflation and available funds before indulging into a project.

These efforts to reduce time overrun are still inadequate as the occurrence is still prevalent in the Kenyan construction industry. Thus, this study investigated how time for building projects is calculated or estimated with a view of getting if they are adequate to influence performance and of the works.

1.2.2 Estimating time required for variations

At the design stage the consultants' estimation project time and during tender the contractor submits his estimated contract time. The level of planning done in order to estimate the correct time duration is in doubt as revealed by the causes of delays found out by the researchers documented above.

(Kimani, 2004) and Odeyinka and Yusif (1997) cited that seven out of ten projects surveyed suffered delays during execution. Chan and Kumaraswamy (1993) also cited that timely delivery of projects within budget and quality standard specified by the client is a good indicator of successful delivery of a project.

In the conventional practice, design construction teams as currently constituted in Kenya don't have a specialist to calculate the project time properly. That is the reason the contractor is given the responsibility to estimate his time of executing the works and when variations arise, he is thus best placed to give the estimate of the time needed to execute the varied added works. Whereas the cost aspect is direct and the contract documents have a way of calculating it, the estimation of time of executing the variation proposed is left to the calculation of the contractor. Whether his project time proposed is correct cannot be verified by the design team.

This project seeks to address the divide between design team and construction team on design scope and time estimation by reviewing the methods used to calculate contract period and make recommendations on how to manage the period for variations.

1.3 Objectives of the Study

The study was guided by the following research objectives:

i. To identify methods used to estimate construction contract period in Kenya,

ii. To identify methods used to estimate the construction variation work period,

iii. To identify the party responsible for the estimation of construction contract period in building projects.

iv. To formulate guidelines for the management and estimation of a variation works period.

1.4 Research Questions

This research sought to answer the following questions;

i. Which methods are used to estimate construction contract period?

ii. Which methods are used to estimate the construction variations period?

iii. Who has the responsibility to make project contract period estimation?

iv. What are the best guidelines for estimation of project contract period in the Kenyan construction industry?

1.5 Assumptions of the Study

The study assumed the following:-

i. The study assumed that construction developments in Kenya are determined by a number of key variables of time and cost that are directly related.

ii. That construction work and market growth will continue to rise and construction projects will continue to bear the burden of absorbing expanding population hence the need for adequate and effective solution to effect and causes variation in construction projects.

iii. The enforcement of construction policy and legal framework on construction sector in projects is maintained.

iv. The participants have equal level of understanding, knowledge and experience of construction industry.

1.6 Purpose of the Study

Purpose of this study is to investigate methods used to estimate construction projects contract period estimation and how variation period is estimated with focus to construction projects in Nairobi County, and to seek ways of include as a provisional a time to cater for variations at the initiation of the project.

1.7 Scope of the Study

Focus of the study is on selected construction projects in private sectors of the economy and sampled projects of contract sums of between 10million and 100million Kenya shillings. These selected projects were in the following fields;

(a.) Industrial projects like factories

(b) Commercial projects like shops, offices and warehouses, and

(c) Institutional buildings like schools, colleges and hostels.

1.8 Justification and Significance of the Study

This study was geared towards helping understand the methods used to estimate construction projects contract time, the methods used to estimate the time of subsequent variations and then come up with recommendation on the best model to estimate the construction period for variations.

1.9 Limitations of the Study

Since the study focused on constructruction projects of contruction cost of between 10million and 100million Kenya Shillings and only those in Nairobu county, the findings may not be generalizable to other market areas and project sizes. The projects in this level and handled by teams with similar understanding, knowledge and experince differing from others in other categories and sizes. Also the focus is on building projects and these could be different from civil projects. Nevertheless, the underlying theoretical assumptions and methodology of this study, as well as the findings of this study should be of assistance in other areas in assessing variation time estimation in Kenya.

1.10 Definition of significant terms used in the study

  a. **Contract period** – this is the time that has been agreed between the contractor and the client within which the construction work will be binding. The contract period of legally binding and is based on estimated construction period.

  b. **Project period** – this takes into consideration the construction period and the design period.

c. **Construction period** – this is the time between the date a contractor takes possession of the site to the date he completes the work in attaining practical completion

d. **Design period** – this starts from the time the building client conceives the idea to develop to the time when the contractor takes possession of site.

e. **Construction cost** – this is the cost of putting up a building associated with materials, transport, labour, equipment and plant. It is the cost incurred by contractors and subcontractors involved in the works.

f. **Project cost** – this is the costs involved in the building project including costs of finance, land acquisition, professional fees and the construction cost.

1.11 Organization of the study

The study is organized in five chapters. Chapter one the following are covered: Background of the study, statement of the problem, the purpose of the study, objectives, research questions, justification and significance, basic assumptions and definition of significant terms used in the study. Chapter two covers introduction into the project, project variations causes and their nature, delays in construction projects and risks inherent as well as the conceptual framework

In chapter three the following are included under Research Methodology: research design, Target Population, Sampling Procedure, Research instruments, Validity, Reliability and Data collection and data analysis. Chapter four presented the data analysis, presentation and interpretation while chapter five presented summary conclusion and recommendations of this study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Construction contract time is very important to an investor of a construction project and by extension to all the parties involved in the construction activity. The chapter covers a review of literature related to the study. It covers the following: methods for calculating contract time, methods used to calculate variation time, effects of variations on delay on building construction projects, the implications of construction project delay and the possible intervention mechanisms to control variation on construction project if any.

2.2 Construction Industry in Kenya

The Kenyan construction industry occupies an important position in the nation's economy even though its contribution is lower than the manufacturing or other service industries. This contribution to national economic growth necessitates improved efficiency in the industry through cost-effectiveness. One aspect is timelines adherence which would certainly directly contribute to cost savings for the economy as a whole.

In a research done on Kenya Central government projects executed between 1966 and 1984, Mbatha, (1986) found out that 73% of the projects are normally delayed while only 38% of them have cost overruns. The problem of variations in construction industry is a worldwide phenomenon, and its effects leads to friction among clients, consultants and contractors due to project cost overruns creating a significant financial risk to clients. Mbatha, 1986 went on to document that in Kenya, majority of government building contracts suffer cost and time overruns. Time overruns are more frequent than cost overruns and the two are not related. Big projects have been shown to be more prone to both time and cost overruns than the smaller ones although delays have been found to bear no relationship to contract sizes. One of the causes of poor time performance is the inadequacy of initial contract periods which have been found to be inconsistent and erroneously calculated.

Kivaa (2000) made a conclusion from his finding that either the cost estimates are more realistic than contract period estimates or project participants manage costs more carefully than they manage contract period. Wachira (1986) gives the main reason for the 'too optimistic' contract

time as being the insufficient data on productivity of labour for accurate analytical estimation of activity times on the project schedule whose sum gives the construction period.

Muli (1996) attributes the 'optimism' and poor time performance to the attitudes of project participants towards the project schedule, by the clients and consultants failing to appreciate the full importance of the schedule. He observed that in the traditional approach of the project implementation, there are no strict requirements for scheduling important things like the level of detail requirement, the method to be used and the frequency of schedule updates. He also observed that most contractors in Kenya view the requirement for schedule as an unnecessary expense and waste of time and fail to invest sufficient resources in preparing the schedule. Such attitudes ultimately lead to reduced chances of achieving the targeted completion time.

Delay is thus a situation where the contractor, consultant and the project owner jointly or severally contribute to the non-completion of the project within the original or stipulated or agreed contract period. Thus, the major criticism facing the Kenyan construction industry is the growing rate of delays in project delivery.

In developed countries like United States of America and United Kingdom, Mobbs (1982) found that 'construction time' is better than developing countries. Performance of time in construction industry is poor than in other sectors such as service industry. An investigation done by Odeyinka and Yusif (1997) for Nigerian market showed that seven out of ten projects surveyed suffered delays during their execution. Chan and Kumaraswamy (1993) also studied delays in Hong Kong's construction industry and they emphasized that delivery of projects within time, cost and quality standard specified by the client is a critical measure of successful project delivery.

Other developing countries, like Saudi Arabia (Assaf *et al.,* 1995), Libya (Saleh, 2009) and Malaysia (Yong, 1988), Kenya construction industry has suffered many setbacks in term of completion of the project on time and cost. In the 80'ss and 90's majority of the construction projects in Kenya, done by the government and government bodies, experienced time and cost overrun which in turn lead to several projects abandonment. Hover, incremental on cost and creep in time is not only caused by variations but could also be caused by involvement and

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performance of parties, contractual relations, environmental and site conditions, resources availability and natural disasters.

2.2.1 Estimation of project period in Kenya

Kivaa (2000) describes two methods of estimating time as;

a) Non-Mathematical method: in this method, estimators use their own intuition based on skill and past experience,

b) Mathematical method: in this method the estimator uses the mathematical formulae in predicting the construction time.

Mbatha (1986) noted that contractors relate the project scope to the expected expenditure per week to come up with the number of weeks required to complete the works. The ministry of public works of the central government has some guidelines of estimating contract periods based on past experience. The guidelines attempt to match the contract period with the contract value based on the finances set by the treasury for the project.

In the private sector, the use of non-mathematical method by the professionals has also been reported as being practiced and in only few instances do the clients have their way of dictating the timelines. In such instances, the initial time may be fixed but when the variations do occur, the time is open for debate.

2.3 Management of construction Period

The management of time is a key requirement for a successful project as time represents a big challenge in the construction industry. Problems arise because many projects are not well thought out and planned before starting work on site. They thus result in frustrations, delay and disruption, which are lead to disputes and claims. Some of the causes for these are; pressure from clients to finish, budgets that have to be spent before the end of a financial year or lack of money, slow progress of consultations and approvals especially for public sector projects and traditional method of design followed by short tendering period and award of contract to contractor. (Crooke & William, 1998)

Mbatha (1986) conducted a study on building contracts performance with an emphasis on government projects in Kenya. The aim of the study was to establish as to whether or not the performance of government building contracts in areas of cost and time was poor for the period of 1967 – 1981. It was shown that majority of government building contracts suffer cost and time overruns and that the two are not related. Big projects were shown to be more prone to both time and cost overruns than the smaller ones although delays were found to bear no relationship to contract sizes. One cause of poor time performance is the inadequacy of initial contract periods as they were erroneously calculated.

Kivaa (2000) developed a model for estimating construction period based on Kenyan scenario. He observed that in Kenya the time required to complete a construction project is estimated using the estimators' intuition based on skills and past experience. The method of predicting construction period is very likely to produce unrealistic time estimated because the method does not consider objectively and accurately all the factors that leads to time overruns of a construction project. He noted that the numerous factors that affect project time can thus be grouped into two categories; project related and environment related, and he categorized the managerial effectiveness as an environmental related factor as it will depend on the clients' decision making process and the appropriateness of the project organization structure adopted. His predictive model for assisting the design team and contractors come up with project time more effectively based on the three factors of; scope, complexity and environment.

To properly manage time, the Kenyan construction industry needs to embrace proper project planning. There is a strong indications that relationships of parties in constriction often is strained due to poor planning and design, poor communication, mistrust, self interests and disputes that often results in delays, disruptions, variations and extra cost. Continuous search for the solution to the problem of delay and cost overruns is therefore a priority in construction industry, (Kivaa, 2000)

Bromilow (1969) carried out an investigation of the contract time performance for 329 projects constructed in Australia between 1964 and 1969. One outcome of the study was development of an empirical relationship between the total cost and project duration.

Ireland (1983) (cited in Ahmed and Azhar, 2002) noted that there is a relationship between time, cost and quality in the following manner: time is a function of cost and quality; cost is a function of time and quality and quality if a function of time and cost. In studies covering 25 construction projects in Sidney Australia, he confirmed the model developed by Bromilow though with different constants. Bennett (1985) and Walker (1995) cited that scope, management and complexity are key factors determining the completion time. Ireland (1983) in the investigation of impact of management of project and client decisions making to decision making process found out that they have critical contribution to the inception and completion of the project.

2.3.1 Methods for Calculating Project Time:

a. Critical Path Method (CPM)

The Critical Path Method (CPM) is based on a mathematical algorithm used for scheduling a set of project activities in project planning stage. Any project with interdependent activities can apply this method of scheduling and thus its good use in construction projects planning. CPM in projects is made up of a number of individual activities that are interrelated and for one to start another has to finish. This method can be used to achieve;

- Provides a graphical view when the project will be completed
- Predict the time needed to complete the project,
- Show activities that are critical to maintain a schedule and which are not.

It models activities and events of a project as a network and these activities are depicted as nodes on the network with events that signify the beginning or ending of activities being represented by arcs or lines between nodes.

There are some key steps in critical path method planning

1. Specify the individual activities being undertaken,
2. Determining the sequence of the activities,
3. Draw the network diagram of the activities,
4. Estimate activities completion time,
5. Indentify which is the critical path that is the one with the longest duration in the network. This is the one that cannot be delayed without delaying the whole project.

Conversely, to accelerate the project by reducing the total time required for the activities in the critical path.

Limitation of this method is that it is for fairly routine projects with minimal uncertainty in the project completion times.

b. Program Evaluation and Review Technique (PERT)

Kerzner, 2003, cite that PERT is management planning and control tool with wide usage in large projects in their planning and coordinating. It can be considered as a road map for a particular program or project in which all of the major elements (events) have been completely identified, together with their corresponding interrelations. PERT charts are often constructed from back to front because, for many projects, the end date is fixed and the contractor has front-end flexibility."

Main features of PERT are network diagrams which provide visual depiction of project activities and sequence in which they should be completed. Activities are depicted as consuming time or resources.

The network diagram consists of arrows and nodes and is in two conventions where for activity-on-arrow convention the arrow represents activity and for activity-on-node convention the node represents activity. The path of activity is the sequence of those activities from the starting point to the finishing point. The amount of time to complete the work is summation of all activities along the path. The path with the longest total time is called 'the critical' path. The 'critical path' is the most important part of the diagram as a delay in completing an activity along the path will necessitate and extension of time of the final deadline of the project. Therefore the project manager must get ways of reducing the time involved in the activities along the critical path. Time estimate for the various activities is provided for with different degree of certainty. When it can be done with a high degree of certainty, they are called deterministic estimate and when they are subject to variation, they are called probabilistic estimates. When using probabilistic approach, managers provide three estimates for each activity: an optimistic or best case estimate; a pessimistic or worst case estimate; and the most likely estimate. Statistical methods can be used to get the extent of variability in these estimates, and thus the degree of uncertainty in the time

provided for each activity. Computing the standard deviation of each path provides a probabilistic estimate of the time required to complete the overall project.

c. Bromilow Time – Cost Model

Bromilow developed and empirical model for the prediction of construction time using project cost. The model referred to a Bromilow time-cost (BTC) model was developed in Australia in 1969 with aim of providing fact and construction schedule estimate using project cost. The model forecasts construction schedule using the estimated final project cost. The model disclosed that construction was time was related to project cost using a linear regression model. (Bromilow, 1969)

Hoffman et al., (2007) made further refinement and alterations to the BTC model and his first criticism was that it had limited usage outside the original sample study area of Australia and this made the efforts to calibrate it further for use across a variety of projects types and locations of projects. (Walker, 1995) raised a second criticism was that it failed to factor in additional costs when forecasting constriction time. This gave rise to a number of studies so as to refine the BTC model to include additional quantitative and qualitative factors. In support Nigel (2001) argued that even with all the criticism, BTC model is widely recognized as the standard too for estimating project time performance of construction projects.

One great contribution of BTC model by Bromilow, 1969 is it provides a quick and quantitative means of estimating project construction time by using estimated final cost and it is expressed as follows;

T = KCB.

     T represents project duration,

     C actual cost of the project including fluctuations and variations,

     K is a constant showing the level of time performance for a unit of C, and

     B is a constant describing how the time performance was affected by project size as measured by the cost.

Bromilow's (1969) study showed that time taken to construct a project is highly correlated to the size as measure by cost. Construction time is measure in days (T) and could be expressed as a function of the final contract sum in millions of dollars (C). However, one shortcoming of the BTC model is that it fails to consider factors other than cost when establishing the construction time (Walker 1994). Ireland, 1983, Laptali et al, 1996) did recommendations to improve the BTC model but the model based on construction cost, time, area and number of stories of the building yielded made errors thus halting the process. Walker (1994) effort using gross floor area of a building also yielded problems due to construction cost including a significant external works component presented difficulties in measuring construction per unit of construction time. Despite all challenges, it is good to note the recommendation by Ireland (1983) that BTC model is "the best predictor of construction time" and the advantage of using cost per unit time period as a measure of project scope.

2.4 Causes of Variation

Variations are alterations or modifications of the initial design, quality or quantity of the works as indicated in the contract drawings and described in the Bills of Quantities, and including addition, omissions or substitute work (Agreement and Schedule of Conditions for Building Contract, 1996).

Causes of variations are diverse from many problems that could occur in building contracts and are a source of increases in time and cost. Though impossible to eliminate variations, the standards of project design and contract supervision determine the number and magnitude of variations which vary between limits, Mbatha, (1986). Variations are unavoidable feature of building and their complete elimination is a virtual impossibility. The effects of variations tend to be an interruption to the planned progress. This implies that variations generated entirely from within a project organization should be seen as a failure, Kivaa, (2000). Whereas above statement tend to show that variations are bad for the project, Kimani (2004), notes that the sources of variation include;

(a) Client / architect needs or wishes to vary the design or specifications,

(b) Discrepancy is discovered between any two or more of the contract documents or with statutory requirements.

(c) When an omission or error is discovered in the contract documents,

(d) Variations as a means towards easy construction on site or improve buildability.

Variation and variation orders should be analysed effectively for a comprehensive understanding of the root cause. Hester et al (1991). The causes of variations can also be categorized according to originators (Arain et al 2004) as follows;

2.4.1 Owner Related Variation

This is when the owner initiates variations or the variations are required as the owner fails to meet requirements that may be critical for the project. Change of the scope or the project plan are the commonest changes in this category and the cause is insufficient planning of the project at definition stage or the owner was not involved in the design phase (Arain et al., 2004). Such changes affect the project severely at the latter stages. Kimani (2004), Master's thesis noted that a client may wish bring up an issue of variation if he wishes to vary the design or specifications of a project.

Such changes will affect the project schedule too and thus result in major resources reallocation too (O'Brien, 1998). Such change in schedule will be the contractor will have to provide more resources or leave some to idle and the result is incurred costs. The owner may also suffer financial difficulties forcing him to make change in an attempt to reduce costs. Thus owner financial position may affect the process and quality of works and in such cases, it is will force the owner to review his project cash flow so as to eliminate the problem. Inadequate project objectives are important caused of variations in construction projects (Ibbs and Allen, 1995). Due to this, the designer wouldn't be able to develop a comprehensive design thus lead to numerous design variations at construction phase.

Client promptness in decision making process is an important factor in project success (Gray and Hughes, 2001). A delay may hinder subsequent construction activities thus delaying the project progress. Since a building project is a combination of different professional efforts, who much work in interface in the project, (Wang, 2000, Arain et al, 2004), if the owner has no clear understanding of what need to be done and accommodate beneficial ideas, the project may suffer may variations latter in the project and affect if adversely. If changes in specifications are frequent in a construction project, and the project is in a multi-player environment, they changes

may require major variations and adjustments in project planning and procurement activities. (O'Brien 1998)

2.4.2 Consultant Related Variations

The consultant may directly initiate a variation if the consultant had a failure to captures some details initially. Fisk (1997) and Arain et al, (2004) have also cited that change in design for improvement purposes is a norm in professional practice. However, there are far reaching changes in design is a common practice in projects where construction start before design stage is completed. These design changes affect a project adversely depending on the timing of the changes. Design errors and omissions of design are major causes of project delays (Arain et al., 2004) and this leads to loss in productivity and project schedule delay hence adversely affecting the project. However, the severity of the effects will depend on the stage in the project of the occurrence of these errors. A conflict between the contract documentation can also result in misinterpretation of actual requirements of a project and so to convey complete project scope, they should be clear and concise as insufficient details may adversely affect the project leading to delay in project completion.

Traditional tendering process which is distinct from the design process makes assumptions that the designer should always keep in mind and they include;

    a) Design is completed before tender stage to ensure price is certain,

    b) Designer understands how the project will be undertaken to ensure buildability,

    c) Design changes should be limited during the construction process (Kimani, 2004)

In multi-player environment like construction, scope of work for all players must be clear and unambiguous so as to ensure the success of the project (Arain et al., 2004). Inadequate scope for the contractor can cause major variations that adversely affect the project leading to changes in construction planning. Technological changes could also be a potential source of variations and as such, project planning should be flexible to accommodate new beneficial variations (CII, 1990). This is because a new technological could contribute to the benefits of project life cycle for instance reducing the maintenance const of the project. For the consultant, value engineering should be done during the design phase as carrying it out during the design phase could be a

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costly exercise as variation in any design element would initiate a downstream of variations in other relevant design components. A lack of coordination between the parties could cause major variations thus impacting the project adversely (Arain et al 2004). These detrimental variations that affect the project adversely can be managed at early stages of the project by taking due diligence in coordination. Complexity affects the flow of construction activities and therefore, simple linear construction works procedures should be employed to avoid variations.

The working drawings should have sufficient details to avoid any misinterpretation of the actual requirements of the project (Arain et al., 2004). A thorough review of the design details would assist in minimizing variations. Shop drawings are usually developed for the construction work details for site professionals and these should have sufficient details as any inadequacy could lead to variations.

2.4.3 Contractor Related Variations

In some cases the contractor may suggest variations on a project or the variation may be required to enable to contractor fulfill certain requirements for carrying out the project. Involving the contractor at the design stage may assist in developing a better design by accommodating his creative and practical ideas (Arain et al, 2004). In the traditional building projects set up, there is no contractor involvement at design phase and this is a potential for variations of this form. Lack of these practical ideas in design may that eventually affect the project adversely.

Unavailability of equipment is a procurement problem that can affect the project delivery (O'Brien, 1998). This lack of equipment many cause major design variations or adjustments in project schedule to accommodate the replacement. Skilled manpower is also another major resource needed for complex technological projects (Arain et al., 2004). Shortage of skilled manpower in technological projects can be a cause for variations that may delay the project completion. Constriction is a labour intensive industry, whether the contractor had been paid or not, the wages for the workers must be paid. Therefore, contractor's financial difficulties may cause major project variations thus affecting quality and progress.

Contractors' desired profitability can be a potentials cause of variation in a project. This is because variations are taken as source of additional works by contractors (O' Brien, 1990). The contractor may this try and convince the project owner to allow certain variation leading to

additional financial benefits to himself. Where the site conditions differ from time to time can also be a potential for causes of variations and delays in a project (Assaf et al., 1995). The contractor may face difficult soil conditions as those in the tender documents and eventually this may affect his cost estimate and schedule.

The constriction manager has a duty to ensure that construction phase is well organized so as to eliminate risks to delays and variations. Lack of a specialized construction manager may lead to defective workmanship and delay in project. Where there is need to fast track work, an organized system would be needed to carry our interdependent project activities. This needs to be carefully handled especially when the public or private sectors have large funds and want to complete projects in a short time and plans and specifications may not be completed by the time the contractor starts work (Arain et al., 2004). Eventually, such a model may lead to major variations.

A delay in procurement has adverse affects too on the construction cycle. This delay may cause an entire change or replacement for originally specialized materials or equipment for the project. This may lead to the reworking of the project activities. Variations with potential to cause detrimental changes in the project can be managed in the early staged through strong and unambiguous communications. Lack of coordination and communication between the parties may cause major variations and eventually impact the project adversely (Arain et al., 2004)

2.4.4 Unpredictable Variation

Variations leading to cost overruns are caused by additions, fluctuations, adjustment of prime costs sums, provisional quantities, uncertain ground conditions, wrong design, claims due to delay from designers etc, (Mbatha, 1986). When weather conditions vary, the contractor will need to adjust his construction schedule accordingly and this may lead to adverse effects on the progress leading to overall project delay.

Safety considerations: with safety being a key factor in construction, non compliance with safety requirements may cause major variations in design. Lack of safety considerations may lead to serious accidents and delays in project completion.

Change in government regulations: Local authorities and county jurisdictions have specific codes and regulations that need to be accommodated in the design. Change in these regulations during the project construction phase may cause major variations in design and construction and affect the project adversely depending on the stage of the project of this occurrence of changes.

An economic condition of the country can affect the construction project as a whole and its participants. The effect and level of variations on the project will depend on the stage of this occurrence.

Professionals from different social-cultural backgrounds may face challenges due to perceptions and this may affect the working environment of the construction project (Arain et al., 2004). A lack of coordination between professionals with different social-cultural backgrounds is common (O'Brien, 1998). Eventually the project delays and ends up with vital changes in the entire project team.

Unforeseen conditions: these are faced by professionals in the construction industry (O'Brien, 1998). If these conditions are not solved, they may cause major variations in the construction project. Eventually this affects the project adversely leading to reworks and delays in project completion.

2.5 Effects of Variations

Much analysis and review has been done on construction projects by several authors such as (Clough and Sears, 1994; Thomas and Napolitan, 1995; Fisk, 1997; Ibbs *et al.*, 1998). Despite being affected, sometimes there is no delay in the progress but then variations in the project may at times alter both the quality and progress of the project (Assaf *et al.*, 1995).

Completion time: As much as the professional team attempts to maintain the project completion schedule intact, time has an equal monetary value. Nonetheless, just main variations during the project may have a direct effect on the completion time of the project. In fact, the contractor in most cases, try hard to accommodate the several variations through maximizing on the free floats in the schedules of construction time. For that reason, the variations have a direct effect on the progress without causing delays in the completion of the project. Contrary, this may not in most cases be realistic to accommodate and the contractor will, on several occasions, look for an extension of deadline when need.

Increase in project cost: Increase in the project cost is the most common influence of variation in the construction stage of a project. Major amendments to the project in terms of design would ultimately increase the cost of the project (Assaf *et al.*, 1995). A contingency sum is in most cases assigned to cater for the possible variations in project at the time of maintaining the whole project intact. Cost overruns are caused by additions, fluctuations, adjustment of prime costs sums, provisional quantities, uncertain ground conditions, wrong designs, claims due to delay from designers etc. In respect to this, the contractor cannot cause cost overruns, he can only exert his rights which may mean extra cost to the client, (Mbatha, 1986).

Hiring new professionals: There can be adverse effects on the project because of variations especially in complex technological projects. Highly experienced human resource serves as one of the significantly important resources needed for complex technological projects. The variations may at times need hiring new specialists or change the entire project team depending on the nature.

Increase in overhead expenses: Variations need processing procedures, paper work and reviews prior to implementation (O'Brien, 1998). Both the implementation and processing of variations in construction projects would in turn increase the overhead charges for all the participants in question. Usually, the charges are availed from the contingency fund assigned for the construction project.

Delay in payment: Payment delays that take place occasionally because of variation in construction project. The variations may block the project progress resulting in delays in attaining the targeted milestones in construction (CII, 1995). Ultimately, this may have an effect on payment to contractors. In most cases, the delay may cause several predicaments that result in delays in sub-contractors payment because main contractors may not pay the sub-contractors unless they get paid by the owner first.

Quality degradation: In case the variations are frequent, they may adversely affect the standard of work (Fisk, 1997). In regard to CII (1995), the standard of work was normally poor since frequent variations by contractors to make up for the losses by cutting corners.

Productivity degradation: Interruption, delays and redirection of work connected variation orders have a negative effect on labor productivity. These in the long run can result in labor cost or monetary value. Hester *et al.* (1991) claimed that productivity of workers was expected to impacted where they were needed to work overtime for longer times to make up for schedule

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delays. Thomas and Napolitan (1995) came to a conclusion that variations resulted in disruptions that led to degradation of productivity labor. The most important types of disruptions were because of insufficient information and materials including work out of sequence. Insufficient information was reported as the most serious disruption, thus, to handle variations, an individual required to manage the disruptions. However, the disruptive impacts could not be avoided in most cases.

Procurement delay: Variations imposed during project construction may need revised procurement requests (O'Brien, 1998). These delays can be because of need for new materials as well as highly experienced equipment. Hester *et al.* (1991) suggested that procurement delays were effects of variations associated to new resources of project constructions.

Rework and demolition: They are frequent incidences because of variations in projects (Clough and Sears, 1994). Variations imposed in projects result in delays and reworks in project completion. Demolition and rework are potential effects of variations depending on the timing of the occurrence of the variations. The effects are because of the variations in the construction stage. This is for the reason that variations in the stage do not need any rework on construction sites.

2.6 Control of Variation

Many researchers have suggested several controls for variations as well as variation orders (Mokhtar *et al.*, 2000; Ibbs *et al.*, 2001). The control measures can be categorized into 3 stages design, construction and design-construction interface stage. The groups helped in establishing a thorough covering enumeration of potential controls for variation orders

2.6.1 Design Stage Controls for Variations

Contract documents are the major source of info for projects and balanced as well as variation clause would assist in improving the quality of communication and coordination (CII, 1994). Conflicts in contract documents may lead to misinterpretation of the actual requirement of projects.

Freezing design: Variations in design may have an impact on projects depending on the timing of the happening of the changes. For that matter, freezing design is a strong control measure. Most owners freeze the design as well as close the door for variations after the completion of the

drawings (CII, 1990). Nonetheless, the control needs that the design of the construction project need to be thorough covering; lest it can affect the negatively affect the project.

Value engineering at conceptual phase: During the phase, value engineering can be a cost saving exercise, as at this stage, variation in any design element would not need rework or demolition at the site. This activity can help clarify project objectives as well as reducing design imbalances (Dell'Isola, 1982)

Involvement of professionals at initial stage of project: This may help develop better designs by accommodating practical and creative ideas, (Arain *et al.*, 2004). Participation of professionals helps to develop a well detailed design with minimum inconsistencies, (O'Brien, 1998). The project may be greatly affected by ideas not included during the design phase. Due to the numerous changes caused by variation during the construction activity it ends up being overly costly. The effects of variations are most severe during the construction stage thus this involvement helps to remove them.

Owner's involvement at planning and design phase: In order to clarify the project's objectives and identify noncompliance at early stages (Fisk, 1997) it is important to involve the owner during the design phase. Variations will therefore be eliminated at the construction stage where their effects are most severe.

Involvement of contractor at planning and scheduling process: Contractors bring to the table practical ideas which when incorporated at planning and scheduling helps in developing better plans and schedules, (Arain *et al.,* 2004). Major variations which would otherwise be severe will be ultimately prevented in the later stages of the project.

2.6.2 Construction stage Controls for Variation

Clarity of variation procedures: For effective management of variation orders clarity of variation is key (Mokhtar *et al.,* 2000). Procedures should be identified and clarified to all parties in the early stages of the project. This will assist to minimize processing time and other mishandling issues, (Ibbs *et al.,* 2001).

Written approvals: The owner should approve in writing any variation involving a change in the original price prior to execution of a variation order, (Cox, 1997). Where there is no authorization from the owner it is difficult to prove the right for compensation thus it is necessary for any party signing on behalf of the owner to have written authorization.

Variation order scope: A comprehensive scope goes a long way in helping professional teams to reduce negative effects of variation through appropriate planning (Ibbs *et al.*2001). In order to create a distinction between a variation of scope and a variation due to design development the original scope should be clear and well defined. According to CII (1994), frequent disputes between parties spring from variation scope definition. Proper definition of the scope is therefore vital in identifying and managing variations.

Variation logic and justification: This is one the principles of effective change management proposed by Ibbs *et al.* (2001). It required that a change be classified as either required or elective. **Required changes** needed to meet the original objectives of the project whereas **elective changes** were additional features that improved the project. Beneficial variations can be endorsed and detrimental ones eradicated through the knowledge of logic and justification behind the proposed variations.

Owner's involvement during construction phase: Owner's participation will help to detect noncompliance with the requirements and in prompt approval of the variations (Ibbs *et al.,* 2001). This also serves to keep the owner aware of ongoing activities and assist in quick decision making.

2.6.3 Design-Construction Interface Stage Controls for Variation

Prompt approval procedures: The period between the time when proposed contract modification is first announced and when the matter is finally rejected or approved as a variation order is very aggravating (Fisk, 1997). Prompt approval procedures help to minimize adverse effects of variations such as costly changes resulting from long periods between recognition and implementation.

Ability to negotiate variation: A key factor for effective control of variation orders is the ability to negotiate variation (Clough and Sears, 1994). This helps the professional team to curtail the negative effects of variation (Cushman and Butler, 1994). Skills such as the knowledge of contract terms, project details, technology, labour rates, equipment, methods and communication skills are essential for effective negotiation of variation.

Valuation of indirect effects: It is important to recognize the likelihood of significant effects occurring in the later stages of a project and establish the mechanism of evaluating the consequences, (Ibbs *et al.,* 2001). In the event of a complex project, indirect effects of variations

can be consequential in the following stages (Fisk, 1997). Therefore professionals should seek to evaluate the overall effects that may arise from a change to the downstream phases of a project, for effective management of the valuation order.

Utilize work breakdown structure: This refers to a management tool for identifying work (Hester *et al.,* 1991; Mokhtar *et al.,* 2000). The WBS should be used particularly for large projects as an evaluation tool. A variation that involves work not previously included in the WBS can be added and its relationship with other WBS element can be easily checked. WBS can also be used to trace ripple effects (Hester *et al.,* 1991).

Control the potential for variation orders to arise through contractual clauses: Effective management of variation orders requires selection of the appropriate contract form with essential and explicit variation clauses (Cox, 1997). Well prepared variation clauses lead to shifting risks as well as enhanced communication channels (CII, 1990a). Disputes can be resolved through negotiation rather than litigation with the help of clear procedures presented in the contract and fair allocation of risks.

2.7 Nature of Variations

There are variations in all types of construction projects (Ibbs *et al.,* 2001). Various factors determine how the frequency and nature of variations vary from a project to the other (Kaming *et al.,* 1997). In the event of variations in the construction project either total direct and indirect cost, adjustment to the contract duration or both are experienced, (Ibbs *et al.,* 1998). Therefore in order to minimize adverse effects of variations on projects teams must possess capability to efficiently react to variations. The impact of variations on individual construction projects has been subject of great concern in recent years. Variations are common in construction projects and because considerable changes to the cost and quality and to the project time. The task of variation management is hard for most clients because of how the diverse the causes of variation orders tend to be. However if a mechanism for handling variation orders and making better informed decisions with the help of past projects can be built into project management then this unfavorable situation can be alleviated. Whether there is variation orders should not be the litmus test for successful management, but rather, if variation orders were resolved on time for the benefit of all the parties in the project. (Ibbs et *al*., 2001). In order for a project team to utilize beneficial variations when the chance arises without unreasonable fear of negative effects, they need to have a clearer view of their causes, their effects and also the controls. Learning from past

experiences helps the project team to make better decisions for effective management of variation orders. However this can only be achieved with a clearer and more inclusive view of causes, their effects and probable controls based on past events.

2.8 Delay on construction project

It is well known how the construction industry is large and unpredictable it also requires great capital outlays .In as much as delay occurs in all construction projects the implication of this delay will be different for each particular project .According to Bramble and Callahan (1987) delay is deemed to be the time during which some part of the construction has been extended or not performed due to unforeseen circumstances.

According to the World Bank as reported by Mbatha (1986), delays in construction projects are caused by the following;

(a) Insufficient technical or economic appraisal,

(b) Poor estimates by the client,

(c) Lack of contract strategy,

(d) Badly written conditions of contract,

(e) Poor assessment and allocation of risks,

(f) Wrong type of contract,

(f) Inadequate tender evaluation,

(g) Excess variation, disruption,

(h) Poor contract management or control,

(I) Bad industrial relations,

(j) Lack of competence by contractors and suppliers

This global fact of construction delays is not only a menace in developing countries but also in other countries and is counted as   a common construction project problem. Some projects have few days delay while others delay for over a year. To avoid and minimize delays in construction projects, there is need to actualize the causes of delay. There are common phenomena such as time delays and cost overruns making Morris and Hugh (1980) examine records and found out that projects were never done on time or within the stipulated budget. Assaf et al. (1995) cited that both cost and time overrun are common occurrence across the world. Construction projects need to be done under proper management to prevent delays and disruptions. A study by

Kumaraswamy and Chan *(*1998) in Hong Kong has different reasons for differences in delay between participants of building and civil engineering works.

Noulmanee *et al., (*1999) investigated causes of delays in highway construction in Thailand and noted that delays are caused by all parties in the project though mainly by inadequacy of sub-contractors, organizations that lack sufficient resources, incomplete and unclear drawings and deficiencies between consultants and contractors. Other investigations found that main causes of delay are caused by designer, user changes, weather, site conditions, late deliveries, economic conditions and increase in quantity. Further a lack of qualified and experienced personnel, building permits approval, change order, changes in drawings, incomplete documents, inspections, changes in specifications, decision during development stage and shop drawings and approval are causes of delays. On contractor end, some causes include contractor's improper planning, contractor's poor site management, inadequate contractor experience, inadequate client's finance and payments for completed work, problems with subcontractors, shortage in material, labor supply, equipment availability and failure, lack of communication between parties, and mistakes during the construction stage.

Chan and Kumaraswamy (1997) identified main causes as poor risk management and supervision, unforeseen site conditions, slow decision making, client-initiated variations and work variations. Holt and Harris (1997) found main causes as being material cost increase due to inflation, inaccurate material estimation and degree of complexity. On the other hand, under time overrun, the most important factors causing delays are: design changes, poor labor productivity, inadequate planning, and resource shortages. Haseeb, Xinhai-Lu, Bibi, Maloof-ud-Dyian, and Rabbani (2011) pointed main causes as financial and payment problems, improper planning, poor site management, insufficient experience, and shortage of materials and equipment.

Aibinu and Jagboro (2002) said that time and cost overruns were found to be frequent effects of delay in Nigeria. The study conducted by Maura *et al*, (2007) in Portugal discovered several causes including design errors; client liability, project specification and direct change order by the client. Assaf *et al*., (1995) found out several causes in Saudi Arabia including approval of shop drawings, delay in contractors' payments, and cash-flow problems during construction, design changes, conflicts in work schedules of subcontractors, slow decision making, executive bureaucracy in the owners' organizations, design errors, labor shortage and inadequate labor

skills. Mezher *et al*., (1998) said that some causes of delay in Lebanon include perspective of the clients, contractors and architectural/engineering firms.

Accordingly Abdullah & Battaineh (2002) found out that delay is extensive: the average ratio of actual completion time to the planned contract duration is 160.5% for road projects and 120.3% for building projects. Al-Momani (2000) concluded that the main causes of delay in construction projects are designing, user changes, weather, site conditions, late deliveries, economic conditions, and increases in quantities. Ogunlana (1995) concluded that causes of delay include problem of shortages or inadequacies in industry infrastructure, mainly supply of resources; problems caused by clients and consultants; and problems caused by incompetence of contractors.

Kumaraswamy *et al*., (1998) said delays in the construction industry include differences in perception of the relative significance of factors between the three groups, indicative of their experiences, possible prejudices and lack of effective communication. Mansfield et al. (1994) and Odeyinka and Yusif (1997) said delays in construction projects include financing of and changes in site condition and shortages in materials. Odeyinka and Yusif (1997) classified the causes of delay via project participants and extraneous factors. Client-related delays identified include variation orders, slow decision-making and cash flow problems while contractor-related delays include financial difficulties, material management problems, planning and scheduling problems, inadequate site inspection, equipment management problems and shortage of manpower. Extraneous causes of delay identified were inclement weather, Acts of God, labour disputes and strikes.

2.8.1 Effect of Delay on Construction Project Delay

According to studies and researches, negative effects of delay on construction projects include disputes between clients and contractors, increased costs, loss of productivity and revenue, and termination of contract. Some effects may include dispute, arbitration, total abandonment and protracted litigation by the parties. When projects delay, to recover the lost time, their durations are extended or the work is accelerated. The tradition has been to include an extra cost in the percentage of the project cost to act as a contingency in the pre-contract budget. A study by Aibinu and Jagboro, (2002) highlight several effects of delayed construction in Nigeria as time overrun, cost overrun, dispute, arbitration, total abandonment and litigation. Sambasivan and

Soon (2007) that Malaysia experiences the same effects as Nigeria. However, in Pakistan, Haseeb*et al* (2011) says the effects include clash, claims, total desertion and slowing down the growth of the construction sector.

On another note, Ramabodu and Verster (2010) identify critical factors that cause cost overruns in construction projects as changes in scope of work on site, incomplete design at the time of tender, contractual claims (extension of time with cost), lack of cost planning and monitoring of funds, delays in costing variations and additional works. These critical factors in turn are the delay factors. Chileshe and Berko (2010) suggest the causes may include delay in monthly payments to contractors; variations; inflation, and schedule slippage.

2.8.2 Types of delay

Studies confirm that delays occur in almost every construction project. Bramble and Callahan (1987) claim that causes of the delay are sometimes beyond normal circumstances, can originate from the contractors organization or and they include the following;

Inexcusable delay or **Non- Excusable delay:** The delay is caused mainly by the contractor or suppliers of materials for building the structure. This delay the contractor is not entitled to relief and must make up for the lost time by accelerating the work or compensating the owner through liquidated damages.

Non-compensable delay: The delay is primarily caused by third parties or sometimes circumstances that are beyond the control of the contractor and the owner of the project. Such factors may include acts of God, unusual weather, strikes, fires, acts of government in its sovereign capacity among others. In this case the contractor is entitled to extension of time but no compensation for delay damages.

Compensable delay: This delay is directly caused by the owner or the agent of the owner of the project. The delay, in most cases, results a schedule extension as well as exposes the owner to financial damages claimed by the contractor. The contractor is compensated for the costs of running the field office and the home office overhead and unabsorbed home office overhead.

2.8.3 Implication of Delayed Construction Project

Construction is directly being used as a method to control the economies of countries; nonetheless, it is always strongly associated to politics, economics, sociology and the legal framework (Mogbo, 2004). Hillebrandt (1985) argued that in developed nations, construction is taken as unique thus it can trigger the growth of other industrial sectors. For that reason, improving construction efficiency by means of cost effectiveness and timeliness would certainly contribute to cost saving for the country as a whole. Effort directed to cost and time effectiveness is associated with managing time and cost. Chan and Kumaraswamy (2002) as well covered the various strategies needed in the compression of construction durations of various types of building projects. From their findings, the two experienced authors present the primary findings of three parallel investigations that sought out the critical contributors of faster construction procedures in Hong Kong.

2.9 Risks in Construction Projects and Delays

According to research, management of construction projects involves a number of several managing risks including planning, identifying, analyzing, developing risk handling strategies, monitoring and control. Cohen and Palmer (2004) cited that construction risks comprise changes in project scope and requirements; design errors and omissions; inadequately defined roles and responsibilities; insufficient skilled staff; force majeure; and new technology. Baloi and Price (2003) say construction risks may be technical, social, construction, economic, legal, financial, natural, commercial, logistics or political. On the other hand, Mills (2001) claim that the three most important risks comprise of weather, productivity of labor and plant and quality of material. Researchers Miller and Lessard (2001) have grouped same risks in addition to demand, supply, regulatory, operational, completion and sovereign.

Zou *et al* (2006) identified time related risks that have direct impact on project delivery as being tight project schedule, design variations, excessive approval procedures in administrative government departments, variations by the client, incomplete approval and other documents, unsuitable construction program planning and inadequate program scheduling. Aiyetan *et al* (2008) provides that there are three most significant factors that negatively affect construction project delivery time performance which are quality of management during construction; quality of management during design, and design coordination.

2.10 Conceptual framework

Independent Factors   **intervening variable**   **Dependent Factors**

```
┌──────────────────────────┐
│ Causes   of  variations  in │ ──→
│ construction project      │
└──────────────────────────┘

┌──────────────────────────┐
│ Effect   of  variation   in │ ──→         ┌──────────────────────────┐
│ construction project      │              │ Political Good will        │
└──────────────────────────┘              │ Country economy            │
                                           │ Time framework             │
┌──────────────────────────┐              │ Resources availability     │
│ Control measures of variation│ ──→        └──────────────────────────┘
│ in construction project   │
└──────────────────────────┘

┌──────────────────────────┐
│ Nature   of  variation   in │ ──→
│ construction project      │
└──────────────────────────┘

┌──────────────────────────┐              ┌──────────────────────────┐
│ Causes   of  delay     to │ ──→          │ Construction     project   │
│ construction projects     │              │ contract time              │
└──────────────────────────┘              └──────────────────────────┘

┌──────────────────────────┐
│ Implications  of delay  to │ ──→
│ construction projects     │
└──────────────────────────┘

┌──────────────────────────┐
│ Effect of delay on project to│ ──→
│ construction projects     │
└──────────────────────────┘

┌──────────────────────────┐
│ Roles  of   the  approving │ ──→
│ Authorities  on   delayed │
│ construction project      │
└──────────────────────────┘
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Figure 2.1 Variation on Building Project Contract

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter three outlines the methodology that was used to carry out this research. It describes the research design, the model, the study area, target population, sampling techniques, sample size, type and source of data, research instruments used, pilot study, data collection and data analysis.

3.2 Research Design

The research design employed in this research was a descriptive survey research. A descriptive research design is one that targets the pertinent and precise information focusing on the phenomenon under study and thus aid in getting the conclusive understanding of the issue being covered. Also the survey aimed at obtaining information which can be analyzed, patterns extracted and comparisons made. Cooper and Schindler (2003) cited that a descriptive study is concerned with finding out the what, where and how of a phenomenon. This idea prompted the researcher to choose the design and from this research questions were answered and thus able to get what is happening in the field without introducing treatments or controls over any of the interacting variables.

3.3 Target Population

(Mugenda & Mugenda, (2003) defines population as a complete set of individuals, cases or objects with some common observable characteristics to which the researcher intends to generalize the results of the study. It is the total collection of elements about which the study wishes to make some inferences (Cooper & Schindler, 2008). In this study the population of interest consisted of the owners of building construction developments, the building construction contractors and professional consultants who carry out the project design and supervision of building construction projects and only those ongoing or those completed within a 6 months period. Neuman (1994) argues that the main factor to take into consideration when determining the sample size is the need to keep it manageable. This fact enabled the researcher to get the detailed data at affordable costs in terms of time, finances and human resource available, (Mugenda and Mugenda 2003). Kivaa, (2000) used the same too in his research that the amount of money spent on data collection increased drastically with increase in the sample size. Alreck

and Settle (1985) observed that a sample size of less than about 30 cases provides too little certainty to be practical.

Based these this knowledge above from past researchers, a target of 115 respondents was considered since it is above practical minimum of 30 and it is maximum size financially affordable. Also according to Talukhaba 1996, in study of delays in building projects, a response rate of 40% had been achieved. Assuming the expected response rate in this study would be the same since the subject of study is similar, then from the target of 115 respondents it would ensure at least 46 respondents. The 115 respondents consisted of;

a) 45 consultants (15 engineers from Institution of Engineers of Kenya – IEK list of engineers, 20 architects from Architectural Association of Kenya - AAK records and 10 quantity surveyors from AAK list of members, all as at February 1st 2015.

b) 30 contractors from the contractor register with National Construction Authority, as at February 1st 2015,

c) 30 practicing construction project managers from professional bodies of those doubling as engineers, architects, quantity surveyors and project managers and secondly from directory contacts.

d) 10 construction field developers and clients of building project undertakings focus only on those will relevant knowledge in construction or their project or facility managers and these clients with projects were obtained from List with National construction Authority.

3.4 Sampling Techniques and Sample Size

According to Cooper, and Schindler, (2008) a sample size is a complete and correct list of population members only. Neuman (2000) cited that the researcher ought to select an 'economic sample', one that includes enough participants to ensure a valid survey and no more. For this reason, the population of this study was all the concerned parties' in construction projects and they include clients (with focus on those with technical knowledge in construction) of building construction developments, the building construction contractors and professional consultants.

A sampling frame thus exists for these target group and the specific ones to sample were selected using the random sampling method Also the information required was considered to be

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confidential by some interviewees and to have good response in the short research period, known data sources were targeted. This sampling method was also selected as the focus was in-depth information on time allocated for variations rather than generalised data.

3.5 Research Instruments

Primary data was collected through structured questionnaires. The questionnaires had both closed and open ended questions. The closed (structured) questions elicited data that could be analyzed using quantitative measures while the open (unstructured) questions provided data that was qualitative in nature.

3.6 Pilot Study

Pilot testing was preceded the questionnaires. The pilot testing was done with contractors involved in building construction projects planning and development and selection of this pilot group done through random sampling. The relevance of each question to this research was considered and all finally was included and deemed appropriate.

3.6.1: Validity

Validity is the degree to which results obtained from the analysis of the data actually represent the phenomena under study (Mugenda & Mugenda, 2007). Assessments of validity were subject to opinions based on the judgment of the researcher. Nevertheless, there are at least two types of validity that would be addressed and stated regarding what steps were taken to assess validity. These are:

a. **Face validity:** This was the likelihood that a question will be misunderstood or misinterpreted. Pre-testing of survey instruments was a good way to increase the likelihood of face validity and it was eliminated at pilot study.

b. **Content validity:** This looked at whether the instruments to be used would provide adequate coverage of the same study. In this research, this was achieved by use of expert opinions, literature study and pre-testing the open-ended questions.

3.6.2: Reliability

Reliability id the measure of degree that research instrument will measure and yield consistent result even after repeated trials (Nasubanga 200). The following three basic methods were used by the researcher to test reliability of the study instruments:

a. **Test-Retest:** A test-retest measure was done by administering the same instrument to the same group of respondents at two different points in time. The degree to which both administrations were in agreement was a measure of the reliability of the instrument.

b. **Internal Consistency:** In this method a series of questions designed to examine the same construct were arbitrarily split into two groups. The correlation between the two subsets of questions was tested by split-half reliability method. According to the findings a coefficient of 0.75 was obtained. The results established the extent to which the contents of the questionnaires were constant in eliciting the same response. According to Mugenda (2003), if Pearson's coefficient is closer to one the research tools are regarded as reliable.

3.7 Data Collection Procedure

Primary data was collected from the field since the study could not rely on desk top review of the literature on this subject of period of executing variations. Data collection was done systematically and closely monitored using questionnaires where the researcher prepared the questionnaire and interviewed principals of the selected firms. The questionnaires were sent to the companies in advance to allow adequate time for the firms selected to provide the required information. Only active or projects completed in the last six months were to be included in the questionnaire. These questionnaires contained both open-ended and closed-end questions. The instruments were administered personally by the researcher to ensure any clarification sought is done and thus enhance return rates and through well trained two research assistants.

Secondary data was also fundamental as a precursor to understanding the basic concepts and theories surrounding construction period for the overall project and that of variations and it helped in familiarization with the subject in the broader sense. This type of data highlighted what other scholars have written on the subject of construction period how it is calculated and monitored among many other issues. Waihenya, (2011) noted that the secondary data helps in

widening the researchers reasoning with regard to developing the conceptual model and the methodological approach to the study.

A sample of the questionnaire and the introduction letter used are enclosed in appendix 1 and appendix 2.

3.8 Data Analysis

The filled up questionnaires were checked and any inconsistencies eliminated, they were edited and then processed. The contents were analysed and descriptive analysis was used and then the data was coded to enable the responses to be grouped into categories to enable processing using Statistical Package for Social Sciences (SPSS version 17.0). Descriptive statistics were used mainly to summarize the data. Tables and graphs are used as appropriate to present the data collected for ease of understanding and analysis. Central tendency measures of mean, and standard deviations are used for quantitative variables.

CHAPTER FOUR: DATA ANALYSIS, FINDINGS AND DISCUSSIONS

4.1 Introduction

This chapter presents the findings on the topic 'investigation on estimation of building projects variation of contract period' with focus to construction projects in Nairobi County. This research has been conducted on sample size of 115 respondents spread among clients, design consultant, project manager and contractors in construction projects out of which 83 respondents completed and returned the questionnaires duly filled in making a response rate of 72%. For analysis, frequencies (absolute and relative) on single response questions has been used and on multiple response questions, the Likert scale in collecting and analyzing the data whereby a scale of 5 points were used in computing the means and standard deviations. These were then presented in tables, graphs and charts as appropriate attaching explanations.

4.2 Methods Used to Estimate Project Contract Period in Kenya

4.2.1 Estimation of Project Contract Time

The respondents were requested to state as to who does the estimation of project contract time. The findings are presented in the table below.

Table 4.1: Estimation of Project contract Time

|	Frequency	Percentage (%)
Design consultant	30	36
Client	12	14
The contractor	15	18
Project Manager	26	32
Total	**83**	**100**

The findings in table 4.1 above depict that most of the respondents (30) pointed out that the consultant does the estimation of contract time, 12 respondents said that the client does the estimation of contract time while 26 respondents said the project manager does the estimation of the contract time and the remaining respondents said that the contractor does the estimation of

project time. This implies that estimation of contract time is initially in the estimated and fixed mostly done by the design consultant.

4.2.2 Respondents Category of Methods Used to Calculate the Time for Projects

The study respondents were requested to indicate the category of methods they use to calculate the time for projects. The findings are as illustrated in figure 4.2 below.

Figure 4.2: Respondents Category of Methods Used to Calculate the Time for Projects
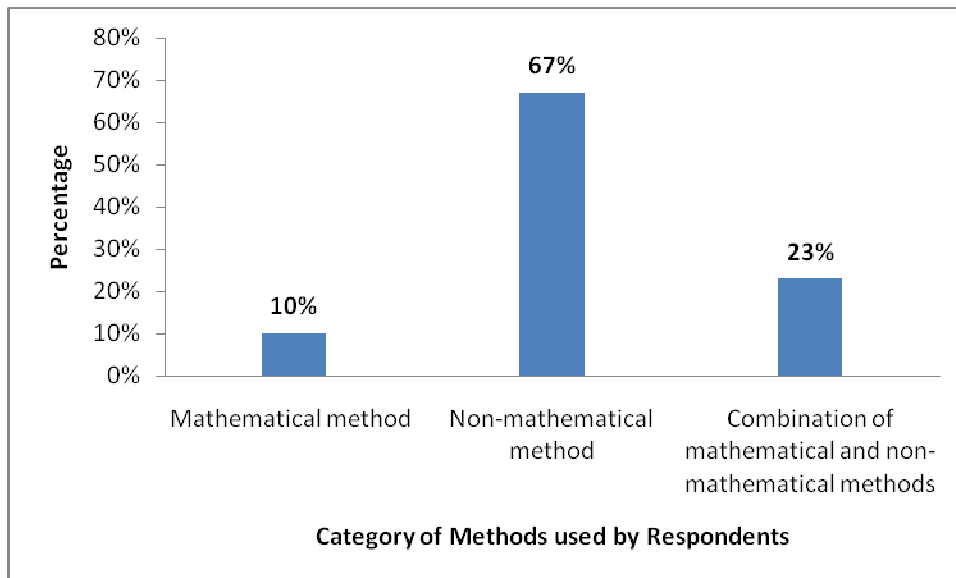
Majority (67%), of the respondents use non-mathematical methods to calculate the time for projects, 23% said they use a combination of mathematical and non-mathematical method and the remaining 10% use the mathematical method. This implies that non-mathematical method is the most popular method used in calculating the time for projects.

4.2.3 Types of Mathematical Methods of Estimation of Project Time

For the respondents who stated that they had used the combination of mathematical and non-mathematical methods to calculate the contract time for projects, the study probed them on the types of mathematical methods they have used to estimate the contract time for a project they have undertaken. The findings are as tabulated below.

Table 4.2: Types of Mathematical Methods of Estimation the Project Time

Method	Frequency level
Project Evaluation and Review Technique (PERT)	52
Critical path method (CPM)	28
Bromilow's time cost model	3

From the findings in table 4.2 above, Project Evaluation and Review Technique (PERT) was the most common method used with a frequency level of 52, this was followed by Critical path method (CPM) came next with a frequency level of 28 and finally Bromilow's time cost model with a frequency level of 3.

4.3 Methods Used To Estimate the Contract Variation Work Period

4.3.1 Estimation for Time for Carrying Out Variation Work

The study also requested the respondents to state who does the estimation for time for carrying out contract variation work. The findings are as portrayed in the figure below.

Figure 4.3: Estimation for Time for Carrying Out Variation Work
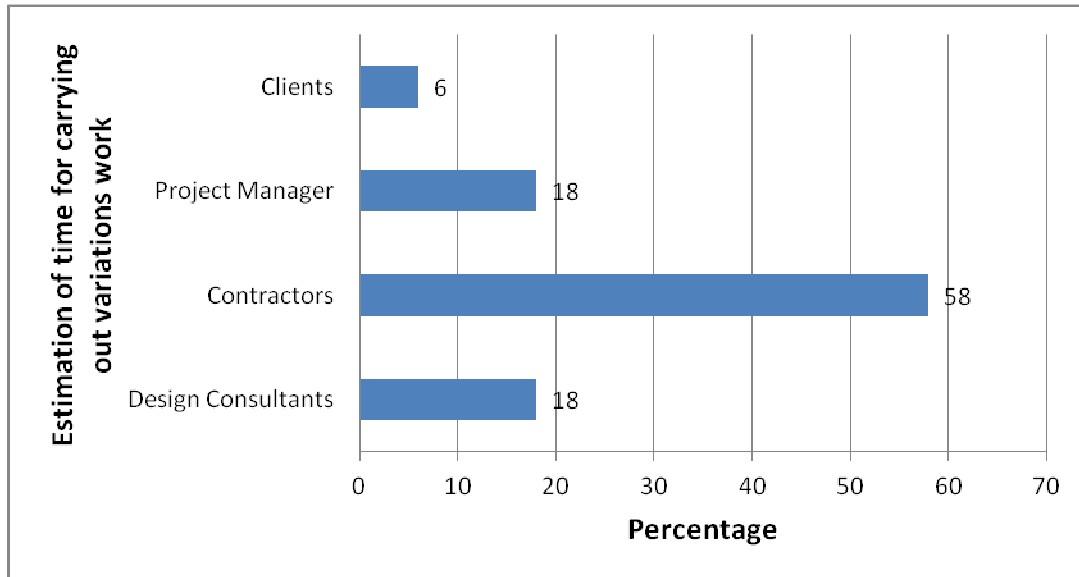
According to figure 4.3 above, majority of the respondents (58%) noted that the contractor does the estimation for time for carrying out variation work, 18% of the respondents said that the

consultant does the estimation for time for carrying out variation work while 6% of the respondents said that the client does the estimation for time for carrying out variation work and 18% said the project manager does the estimation. These findings depict that, estimation for time for carrying out contract variation work is mostly done by the contractor.

4.3.2 Usage of Non-Mathematical Methods to Estimate Contract Time

The respondents who stated that they apply non-mathematical methods in estimating the time for projects undertaken were requested to indicate the extent to which they do so. The study findings are presented in table 4.3.

Table 4.3: Extent of application of Non-Mathematical Methods to Estimate the Contract Time

	Mean	Std. Deviation
Past experience	4.64	0.102
Skills	4.63	0.099
Instincts	1.95	0.345

Majority of the respondents as shown in the table above agreed to a great extent that they apply past experience as a non-mathematical method in estimating the time for projects undertaken (mean=4.640, this was followed closely by skills (mean=4.63). However, the respondents disagreed that they apply instincts as a non-mathematical methods in estimating the time for projects undertaken (mean=1.95).

Asked of other non-mathematical methods respondents have used to estimate the time for variations in the projects undertaken, all the respondents did not mention any other. From these findings, it is clear that past experience and skills are the most common non-mathematical methods used in estimating the contract time for projects undertaken.

4.3.3 Relationship between Method Used to Calculate Time and Key Factors

The respondents were further asked whether the method they used to calculate time satisfactorily address the following key factors. Figure 4.4 presents the findings.

Figure 4.4: Relationship between Method Used to Calculate Time and Key Factors
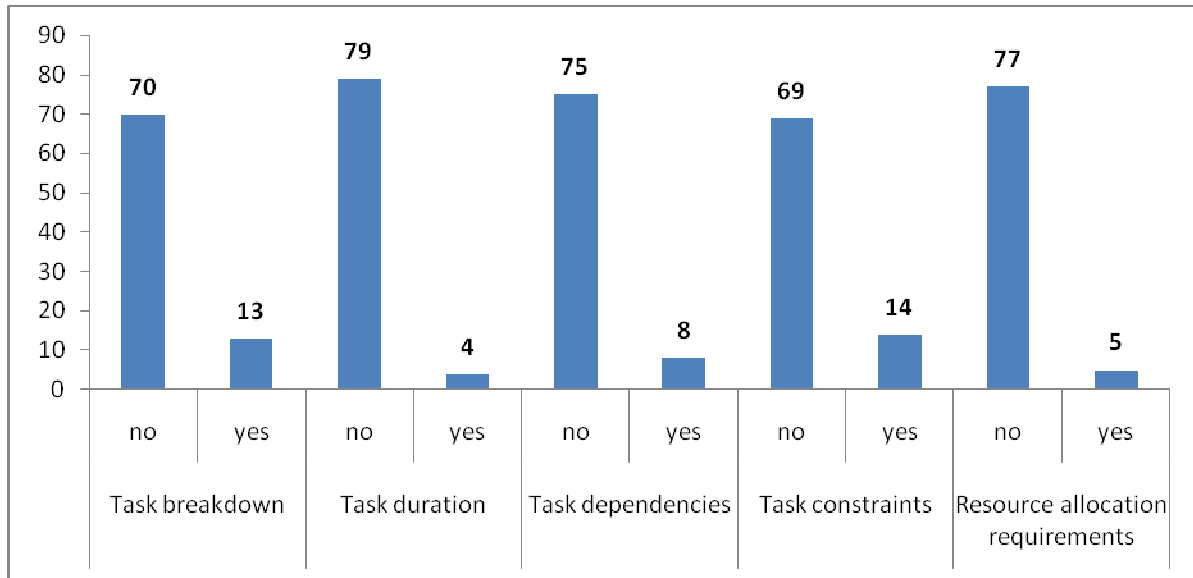
According to the findings, 79 respondents stated that the method they used to calculate contract time did not satisfactorily address the Task durations with only 4 saying that it did. 75 respondents agreed that the method they used to calculate time did not satisfactorily address the Task dependencies with only 8 saying that it did. 70 respondents stated that the method they used to calculate time did not satisfactorily address the task breakdown with only 13 saying that it did. In addition, 69 of the respondents further agreed that the method they used to calculate time did not satisfactorily address the Task constraints with only 14 saying that it did. Finally, 77 of the respondents were of the opinion that the method they used to calculate time did not satisfactorily address the Resource allocation requirements and task types with only 6 saying that it did. These findings illustrate that the method respondents used to calculate time did not satisfactorily address; task durations, task dependencies, task breakdown, task constraints as well as resource allocation requirements.

4.3.4 Level of Satisfaction in Calculation of Contract Time

The study also requested the respondents to show the level of satisfaction with the achievements derived from the method they use in estimation of contract time. The findings are tabulated below.

Table 4.4: Level of Satisfaction on method used in Calculation of Contract Time

Achievements	Mean	Std. Deviation
Factor in available workdays	4.62	0.09
Compensating the delays	4.51	0.34
Assist to track critical activities	4.49	0.45
Input estimate of productive hours per day	4.45	0.12
Achieve more accurate estimates of the true project length	4.42	0.17
Determine how much resources will be applied to each activity.	4.36	0.09
Calculate delays and lag-times	4.18	0.10
Aid to factor in work assumptions	4.09	0.38
Factor in concurrence work streams going on same time as variation work	4.07	0.14
Take into account any resources that are not available on time	3.76	0.09

As per the findings in table 4.4 above, higher level of satisfaction occurred when the method used in calculation of project time; Factor in available workdays (mean=4.62), Compensating the delays (mean=4.51), next came in Assist to track critical activities (mean= 4.49), Input estimate of productive hours per day (mean=4.45), Achieve more accurate estimates of the true project length (mean=4.42), Determine how many resources will be applied to each activity (mean=4.36) as well as calculate delays and lag-times (mean=4.18). In addition to this, satisfaction also occurs when the method used in calculation of project time; Aid to factor in work assumptions (mean=4.09), Factor in concurrence work streams going on same time as variation work (mean=4.07) and Take into account any resources that are not full time (mean=3.76).
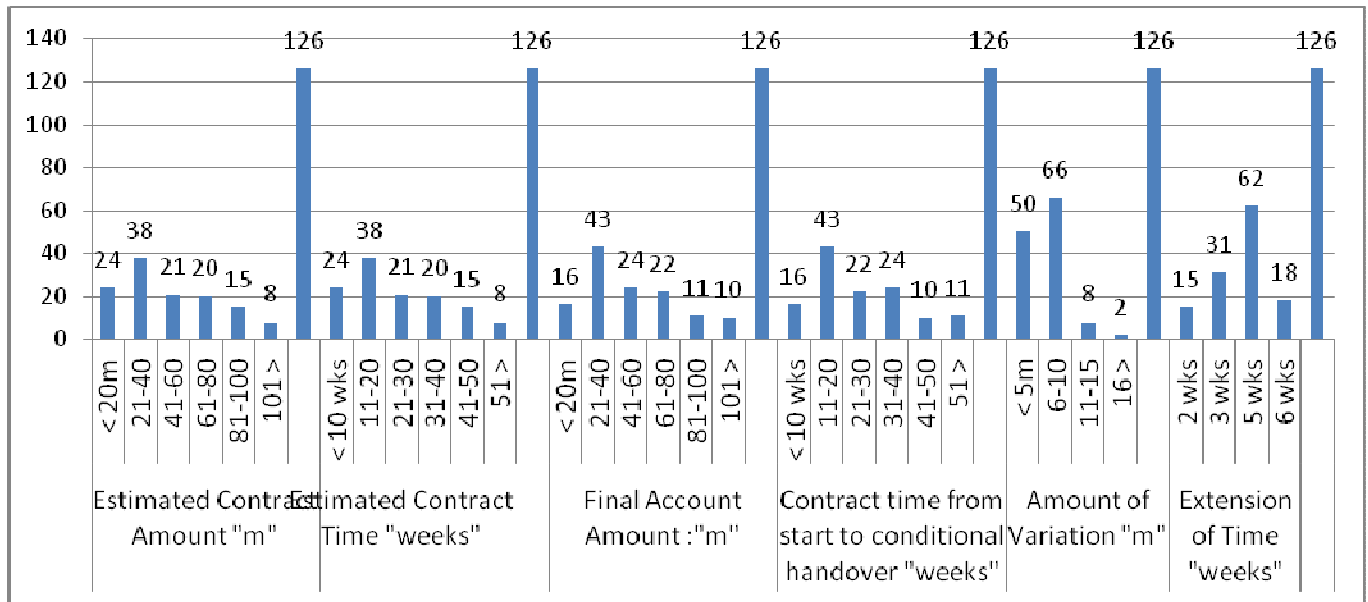
4.3.5 Respondents on completed Projects

A series of question were asked to the respondents in relation to projects they have done in the last 6 months of value Ksh. 10million to Ksh 100million. The findings are explained below.

Figure 4.5: Respondents on completed Projects

According to the findings in figure 4.5 above, 126 projects were returned complete from among the 83 respondents out of which 24 respondents had estimated awarded costs of less than 20m and an estimated Project Time of 10 weeks and below, 38 of the respondents estimated awarded costs of 21-40m and an estimated Project Time of 11-20 weeks, 21 respondents had estimated awarded costs of 41-60m and an estimated Project Time in range of 21-30 weeks, 20 respondents had estimated awarded costs of 61-80m and an estimated Project Time in range of 31-40 weeks, 15 respondents had estimated awarded costs of 81-100m and an estimated Project Time in range of 41-50weeks while 8 respondents had estimated awarded costs of 101m & above and an estimated Project Time of 51 weeks & above.

At the close of contract period, 24 of the respondents achieved final project cost at final account of 41-60m and project time from start to conditional handover of 21-30 weeks, 43 of the respondents achieved final project cost at final account of 21-40m and project time from start to conditional handover of 11-20 weeks, 22 of the respondents achieved final project cost at final account of 61-80m and 10 achieved 101m & above with a project time from start to conditional

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handover of 31-40 weeks and 51 weeks & above respectively, 11 of the respondents achieved final project cost at final account of 81-100m and 10 respondents achieved on project time from start to conditional handover of 41-50 weeks, while 16 of the respondents achieved final project cost at final account of less than 20m and project time from start to conditional handover of 10 weeks and below.

Final cost of variations were pointed out as; 6-10m by 66 respondents, less than 5m by 50 respondents, 11-15m by 8 and above 16m by 2 respondents. Extension of contract time awarded was stated as 3 weeks by 31 respondents, 2 weeks by 15 respondents, 5 weeks by 62 respondents and 6 week by 18 respondents.

4.5 Discussion of Findings

4.5.1 Methods Used to Estimate Project Contract Period in Kenya

The study found out that estimation of contract time is mostly done by the design consultant. The study also found out that non-mathematical method is the most popular method used in calculating the time for contract variations time in projects. This is in agreement with Kivaa (2000) who describes two methods of estimating time as; Non-Mathematical method: in this method, estimators use their own intuition based on skill and past experience and Mathematical method: in this method the estimator uses the mathematical formulae in predicting the construction time.

Project Evaluation and Review Technique (PERT) was found to be the most common mathematical method respondents have used to estimate the overall project time for a project they have undertaken. Critical path method (CPM) and Bromilow's time cost model were also used.

4.5.2 Methods Used To Estimate the Construction Variation Work Period

The study found out that, estimation for contract time for carrying out variation work is mostly done by the contractor. On the method applied, the study also found out that, that non-mathematical methods are the most popular method used in calculating the time for variation of projects and that the common of the skill applied is past experience. This reinforces the assertion

by Kivaa (2000) that in non-Mathematical methods, estimators use their own intuition based on skill and past experience.

As for mathematical methods of Project Evaluation and Review Technique (PERT) was found to be the most common method used to estimate the time for variations in the projects respondents have undertaken. Critical path method (CPM) and Bromilow's time cost model respectively were also utilized though in limited way. However, their use by contractors was not common and thus not relied on upon as method of evaluation variation work period.

The study has also found out that the method respondents used to calculate time did not satisfactorily address some key parameters and milestones that come in the project like task durations, dependencies, constrains, deadlines and allocation of resources and types of tasks.

In relation to the level of satisfaction with the achievements derived from the method respondents use in calculation of project time, higher level of satisfaction was found to occur when available workdays are factored in. Others were; compensating the delays, tracking of critical activities, estimating the productive hours per day (and not use of 24 hour day), determining how many resources will be applied to each activity, calculating delays and lag-times, identifying resource constraints, factoring in multi-tasking productivity loss for part-time resources and taking into account any resources that are not full time.

4.5.3 Respondents on completed Projects

From the analysis of past projects completed within 6 months, estimated contract period and the estimated contract amount have a direct relationship for building projects. Projects in the same range of price have almost similar range of time for execution. This shows that the methods used to estimate time which as seen earlier is by the design consultants and the method being non-mathematical based on skills and past experience is well thought out and there is thus a common acceptance that it is accurate.

At the close of the projects, variations have caused the contract time to extend and same for the final account amount as seen in figure 4.5. The categorization shows there are differences in the ranges of figures and this goes to show that the method used to arrive at the variation and the party that did the time estimation had done so without proper consideration of proper building construction ideals that are universal within those parties. In this the contractors who did most of

the estimation for the time for carrying out variations who based their time on non-mathematical methods of past experience and skills have a skill gap that will need to be closed by other parties.

When a comparison is done between the amount of variation and the extension of time that has been approved for the project, it was clear that there the variation amount did not equal to an increase of time as some variations can actually be absorbed within the contract time or lead to a limited extension of time.

These findings clearly indicate that, the estimated awarded contract amount and contract time both increase at the final project contract cost in final account and contract finish time at conditional handover of the works.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents summary, conclusion and recommendations of the study in line with the purpose of the study aimed at analyzing the causes and effect of contracts variation on building project contract period with focus to construction projects in Nairobi County.

5.2 Summary

5.2.1 Methods Used to Estimate Project Contract Period in Kenya

The study found out that non-mathematical method is the most popular method used in calculating the contract time for projects. The most common was use of past experience which has been accumulated by the estimator over time from running projects of similar scope and size.

Project Evaluation and Review Technique (PERT) was found to be the most common mathematical method respondents have used to estimate the overall project time for a project they have undertaken. However, use of mathematical methods was found to be uncommon among the contractors and its use was common for design consultants and the project managers. The study found out that estimation of contract time is mostly done by the design consultant

5.2.2 Methods Used To Estimate the Contract Variation Work Period

The study found out that, that non-mathematical methods are the most popular method used in calculating the time for variation of projects. The use past experience and skills are the most common non-mathematical methods used in estimating the time for projects undertaken. The study found out that, estimation of contract time for carrying out variation work is mostly done by the contractor.

The study went on and found out that the method respondents used to calculate time did not satisfactorily address; project start date, task durations, task dependencies, project calendars, task constraints and deadlines as well as resource assignments and task types.

In the effect the variations had on the projects, the study found out that contract variations costs were not directly proportional to the extension of time that was added to complete the works. This is deduced to be due to the inability of the design consultant is to ascertain the time that is presented by the contractor. The contractor has an upper hand in such time estimation since he

has the dependencies that are proceeding or succeeding or concurrent activities to variation item or those activities that are co-current. Secondly, when the variation is raised, the accompanying time for carrying out those variations is not proportional to the cost had been advanced by Bromilow (1969) when he developed the Bromilow-Cost-Time model. It is understood that not all extension of time is to variations, however, there is trend that is clear from figure 4.5

5.2.3 Responsibility for the estimation of construction contract period

Then study found out that all parties in the building construction projects have a role to play in deciding on the contract period. The client wants the shortest time to realize the return on the investment they are making where as the contractor seeks the most economical period that will ensure he has the maximum utilization of equipment and labour to realize maximum profits from the project. The design consultant seeks to keep his ethics of the work he has been employed to undertake and thus is the most sober to make a sound judgment the most feasible contract period. This study that has found out that the estimation of the contract period is mostly done by the design consultant. This has been found that design consultant has made a design and using mathematical methods, can arrive at an estimate time which he presents to the client for the approval. At the contract time, the contractors fit their program of works based on the time provided and in most cases with minimal changes.

For the variation period, the contractor has been found to be the party that does the estimation of time. Argument for this is that the contractor carrying out the works has the task dependencies, project calendars, task constraints and deadlines as well as resource assignments and task types on site and is the best party to come up with correct timing. The design team, client and the project manager could however have the role of ensuring the contractor is presenting as logical as possible time.

5.2.4 Management and estimation of variation works period

The study has shown to a large extent, the design consultant estimate the contract time for the building projects and the contractor fits his program of works within the set timelines. When variations occur within the contract period, to a large extent, the contractor provides the estimation of the time that will be used in carrying out the works. Extension of time at the end of the contract time is provided by the consultant based on the different variations that have thus been issued. It is therefore important for any variation of work that has been approved within the

contract period to be accompanied by correspondence of the time it will take to execute. This will ensure that where there are concurrent activities within the different tasks, they are noted so as at the end of the contract time, extension of time is a straight forward undertaking devoid of counter claims between design consultant or project manager or client and contractor.

5.3 Recommendations

Based on this study, some recommendations are given as follows:

1) Contract Variation issued should always be accompanied by time for carrying out the specific variations.

2) Project Managers must agree that delays or impacts which cause extension of time and/or increase in cost are a frequent occurrence in project construction and plan for their time.

3) Contractors should regularly try to identify and to bring to the attention of the client project risks such as an ill defined scope in the early stages like at tender clarification meetings of a project.

4) Regarding cost and time factors in project construction, if the employer intends to gain the most advantage from the program (optimization), the cost and time should be prepared jointly by the contractor and consultant and be accepted as the baseline program.

5) Use of non-mathematical method of past skills cuts across the different participants and is encouraged in projects to act as guideline for awarding time for variations.

5.4 Priority areas for further research

This research is in no way exhaustive and due to the evolution in the construction materials and methodologies, there is need for research into the areas of project time and into the time for variations. Areas for further research include:

1. There is a lack of proper use of mathematical methods of estimating time and so a model is thus needed to guide the Kenyan construction industry. This model should also be tested to include the mode to guide on time for variations.

2. What method of estimating construction project period that satisfies the construction varies related dependencies?

3. What is the level of construction knowledge and skills of the contractors, the key players in building construction projects?

4. Do contractors challenge the estimated contract time estimated by the project managers?

5. How does each particular method, whether mathematical or non-mathematical used to estimate construction time determines the contract period?

6. How does the use of past experience across the construction industry participants lead to the successful implementation of the project?

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A survey into estimation of building projects variation contract period

Candidate: Nelson Kimathi

Course: Master of Arts, Construction Management, University of Nairobi,

Study objectives

The study was guided by the following research objectives:

i.   To identify methods used to estimate project contract period in Kenya,

ii. To identify methods used to estimate the construction variation work period,

iii. To identify the party responsible for the estimation of construction contract period in building projects.

iv. To formulate guidelines for the management and estimation of a variation works period.

A. INTRODUCTION

Name of the firm……………………………………………………………………............

Name of interviewee……………………………………………………………………………

Business of the firm…………………………………………………Date…………………………….

Instructions: (*Please read the instructions given and answer the questions as appropriately as possible*). It is advisable that you answer or fill in each section as provided. Make an attempt to answer every question fully and honestly. You may make reference to any ongoing project or once completed within the last six (6) months.

1. Who does the estimation of construction contract time?

(a) Design consultant   [ ]

(b) Client   [ ]

(c) Contractor   [ ]

(d) Project Manager   [ ]

2. Which category of methods do you use to calculate construction contract time?

(a) Mathematical method   [   ] Got to 3

(b) Non-mathematical method   [   ] Got to 4

(c) Combination of mathematical and non-mathematical methods   [   ] Got to 3

(d) Not conversant with any method   [   ] Got to 4

3. Which of the following mathematical methods have you used to estimate period for a project you have undertaken?

Method	Tick appropriately
Critical path method (CPM)	
Bromilow's time cost model	
Project Evaluation and Review Technique (PERT)	

4. Who does the estimation of time for carrying out construction contract variation work?

(a) Design consultant   [ ]
(b) Client   [ ]
(c) Contractor   [ ]
(d) Project Manager   [ ]

5. To what extent do you apply the following non-mathematical methods in estimating the construction contract variation time in projects you have undertaken?

	No extent at all	Little extent	Moderate extent	Great extent	Very great extent
Past experience					
Skills					
Instincts					

6. Which other non-mathematical methods have you used to estimate the time for variations in the projects you have undertaken?

a) ……………………………………………………………………

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b) …………………………………………………………………………

c) …………………………………………………………………………

7. Does the method you used to calculate construction variation time satisfactorily address the following?

	Yes	No
Task breakdown		
Task duration		
Task dependencies		
Task constraints		
Resource allocation requirements		

8. To what level of satisfaction does the method you use in calculation of construction contract time achieve the following?

	Not satisfactory	less satisfactory	Moderately satisfactory	satisfactory	very satisfactory
Input estimate of productive hours per day.					
Factor in concurrence work streams going on same time as variation work.					
Determine how much resources will be applied to each activity.					
Factor in available working days					
Take into account any resources that are not available on time					
Calculate delays and lag-times					
Aid to factor in work assumptions					

Assist to track critical activities					
Compensating for the delays					
Achieve more accurate estimates of the true project length.					

9. For projects you have done in the last one year of value Ksh. 10mmillion to Ksh 100million, and answer the following;

	Project 1	Project 2	Project 3	Project 4	Project 5
Estimated awarded contract amount					
Estimated Contract Time					
Final account amount					
Project time from start to conditional Handover					
Final cost of contract variations					
Extension of time awarded					

Thank you for your time and participation

-END-