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CATEGORIZATION OF THE SOURCES OF VARIATION ORDERS IN ROAD CONSTRUCTION PROJECTS IN GHANA

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DECLARATION

I hereby declare that, this thesis submission is my own work towards the MSc. Construction Management and that to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the university except where due acknowledgement has been made in the text.

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ABSTRACT

The road industry has inherent risks due to the complicated nature of the work. This subsequently leads to variations. Variations in the construction industry comprise of omission, addition and substitution. The main aim of this research is to categorize the sources of variation orders in road projects. The objectives were: to identify work sections in road projects that are predominantly affected by variations; to evaluate and categorize the sources of variation orders in road projects; to identify the effects of variation orders in road projects; and to propose strategies to minimize variation orders in road projects. Quantitative research strategy was employed. Questionnaires were used to gather data from respondents. Purposive sampling technique was adopted. The tools for analyzing the data consisted of descriptive statistics, mean score ranking, and Cronbach Alpha for testing reliability. The following were the work sections that had the most variations in descending order: *Roads and pavings; Pipe works; Concrete ancillaries; Drain and ditches; In-situ concrete*. The sources of variations were analysed. From client related source, *change in specifications by the owner; inadequate planning; owner's financial problems; delay in decision making*; *obstinate nature of the owner* were the most significant sources. From the consultant/designer related source, *change in specification by the consultant; inadequate design; design complexity; inaccurate cost estimation; slow decision making* were the most significant sources. From the contractor related source, *lack of strategic planning; reworks; contractor's financial difficulties; poor workmanship; lack of coordination between general contractors and subcontractors* were the most significant sources. From the miscellaneous related source, *inappropriate government policies; fluctuation in prices of materials; unavailability of equipment; shortage of skilled manpower; emergency works* were the most significant sources. *Completion schedule delay; Causes rework;*

Additional payments for contractor; Disputes among professionals; increasing Blemish firm's reputation were the most severe effects of variations on road projects. *Extensive planning is required by all parties before commencement of works; Consultant co-ordination is essential at the design stage; Supervision of works should be well undertaken; Consultants should produce designs and contracts that are conclusive; Enough time must be provided for pre-tender planning* were the most significant strategies to minimize variations in road projects. It is recommended that supervision of works should be well undertaken. This will prevent the need for reworks and variations.

Keywords: categorization, sources, variation, road projects

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DEDICATION

This thesis is dedicated to the Almighty God.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

According to Alzahrani and Eansley (2013), the construction industry is very crucial to a country achieving its social and economical developmental goals of providing jobs, accommodation and physical infrastructure. The construction sector however is quite complex and disjointed due to the project-based nature. Giritli and Oraz (2004) posit that construction projects are made up of different stakeholders and groups like contractors, clients, consultants, financiers, developers, managers among others. They work on a project for a temporary time in order to achieve the objectives of the tasks considering its complexities and tasks.

Variations refer to any deviation from the original scope and schedule of work (Acharya *et al*., 2006). According to Finsen (2005), the road industry has inherent risks due to the complicated nature of the work. This subsequently leads to variations. Variations in the construction industry comprise of omission, addition and substitution. This relates to the quantity, quality and work schedule. Market forces, client’s demand and technological advancement cause design changes and other project parameters (Abdi and Williams, 2010).

A plethora of studies have been advanced on variations in road projects and construction industry in general. Some of these studies were conducted by Jawad *et al.* (2009); Arain and Pheng (2005) and Hanna *et al.* (2002). Some of the sources of variations they found included technology use, changes in design, omissions and additions to original scope, errors in design, poor contractual process, mistakes in briefing as well as consultant errors. Enshassi et al. (2010) identified over sixty sources of variations in Gaza. The most severe cause was lack of construction materials. The severest source of variation identified by Oladopo (2007) was changes in project's scope while Alnuaimi *et al*. (2010) identified specifications changes ordered by clients. Majority of the sources of variations are generic. Jawad *et al.* (2009) conducted a study on variations in construction of education buildings. The significant causes of the variations were inaccurate interpretation of specifications and poor project coordination.

When there are frequent changes in scope and work parameters because of variations, this has an effect on road works quality (Dadzie *et al*., 2012). Changes can either be advantageous or disadvantageous (Asamoah *et al.,* 2013). Variations that are beneficial can cause cost reduction and enhanced work quality. Variations which are negative are seen to be the main reasons for disputes and conflicts occurring in the construction industry (Gambo *et al.,* 2012). These changes in the work were also reported to affect the labour productivity (Ogunsami, 2013).

Categorization is useful when comparing and contrasting. As much as possible, categories should be distinct from each other. Categories should also make sense and provide evidence where required. Categorization of variation orders is therefore needful.

1.2 PROBLEM STATEMENT

According to Dadzie *et al*., (2012), variation orders are a frequent problem in many construction projects. Variation orders have an impact on overall project performance (Oladopo, 2007). This is because variations can cause substantial adjustment to the contract duration, total direct and indirect cost, or both. Variations and variation orders have negative impact on the project if not considered by all the stakeholders.

Ogunsami (2013) posits that the main factors leading to disputes and delays are variation orders and they lead to substantial impact on cost and the environment. When there are variations in road projects, they cause negative impact on these projects.

No unique method has been identified for reducing variation orders in road projects effectively. However, the impact of variation can be reduced by appropriately identifying and categorising the sources of variation orders.

Variation orders involved alteration, addition, omission, and substitution in terms of quality, quantity and schedule of work (Ogunsami, 2013). Any addition, deletion, or any other revision to project goals and scope of work are considered to be variation, whether they increase or decrease the project cost or schedule (Dadzie et al., 2012). The work of Ogunsami (2013) mentioned that a variation in construction projects refers to an alteration to design, building works, project programs or project aspects caused by modifications of preexisting conditions, assumptions, or requirements.

This study is therefore undertaken to identify effects of variation orders in road construction projects and also to categorize their sources. This will aid project stake holders in putting the variation orders under the right work sections in order to identify work sections in road projects that experience the most variations so that proper attention is given to that work section during project preparation to minimise variation.

1.3 AIM AND OBJECTIVES

1.3.1 Aim

The aim of this study is to categorize the sources of variation orders in road projects.

1.3.2 Objectives

- To identify work sections in road projects that are predominantly affected by variations;
- To categorize the sources of variation orders in road projects;
- To assess the effects of variation orders in road projects; and
- To propose strategies to minimize variation orders in road projects.

1.4 SCOPE OF STUDY

The geographical scope of this study is Kumasi in the Ashanti region of Ghana. The contextual scope is limited to Ghana Road Fund and COCOBOD funded periodic maintenance contracts awarded by the Department of Feeder Roads, in the Ashanti region of Ghana between 2015 to 2018. Ashanti region was chosen because it is the second largest city in Ghana and abounds in many road construction projects.

1.5 METHODOLOGY

Quantitative research strategy was employed in this research. This approach built upon previous works which have developed principles that helped to decide the data requirements of this particular research. A critical review of useful literature was conducted. The study adopted questionnaires to collect relevant data with the view of achieving the aim and objectives. The targeted respondents included site engineers, Quantity Surveyors, supervisors and management staff of contractors and consultants of road construction sites. Respondents were asked to rate each variable on a Likert scale. Purposive sampling technique was adopted. The tools for analyzing the data collected consisted of descriptive statistics, mean score ranking, and Cronbach Alpha for testing reliability.

1.6 JUSTIFICATION

This research in particular is of much significance to the construction industry as it will assist construction professionals appreciate categorization of the sources of vaiations in road works and identify their proposed solutions. The findings of this study will enable stakeholders to ensure road projects have minimized variations. Furthermore, the Government of Ghana will be one of the vital beneficiaries of the findings of this study as it will bring about increased knowledge leading to good management of government road projects. This study is finally going to benefit academia as it will serve as a major and critical contribution to knowledge and this will consequently spur others on to engage in detailed and higher-level research on variation orders in road construction industry.

1.7 LIMITATIONS

Like any other similar research conducted, this research faced unavoidable limitations. These included getting access to data from all the regions in Ghana thereby focusing on only the Ashanti region. Lack of adequate finances and inadequate time were also limitations. These limitations are however expected to be a basis for recommendations for research works to be conducted in the future.

1.8 STRUCTURE OF STUDY

This study was structured into five main chapters. Chapter one was the introduction and gave a general overview of the study. Chapter two conducted an empirical and theoretical review of past literature. Chapter three examined the details of the research methodology. The fourth chapter analysed the data collected from the field and discussed them. Chapter five was the summary, conclusion and recommendations for the study. The figure below demonstrates the work flow of the study.

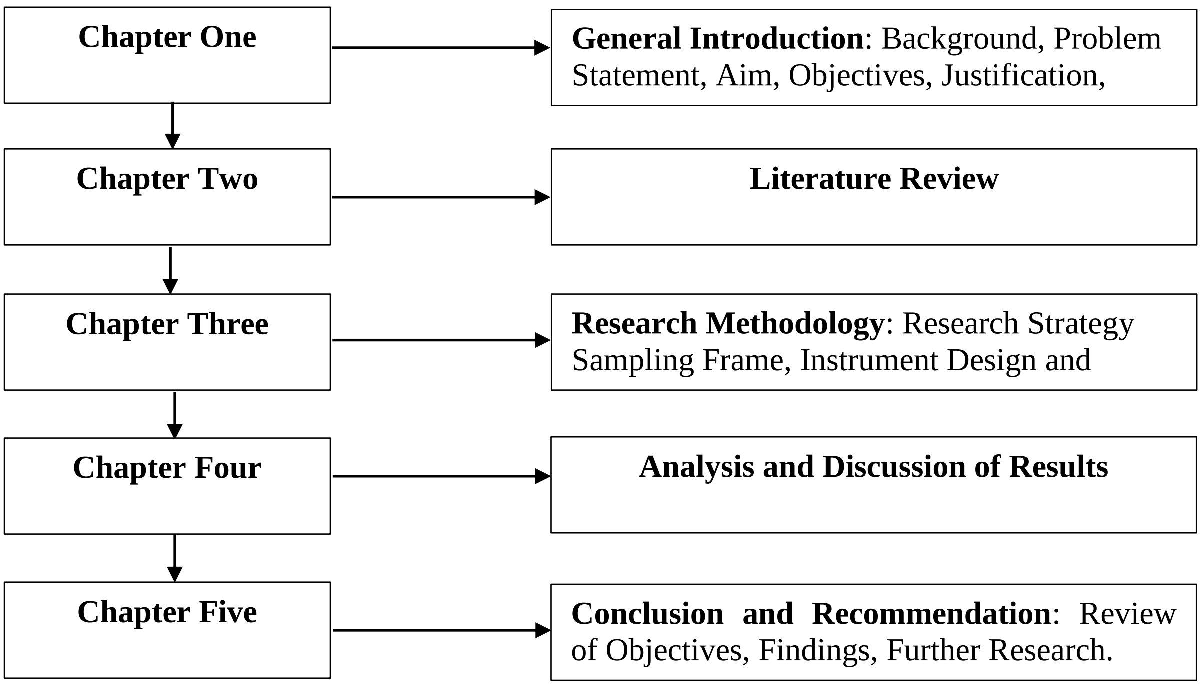

Figure 1.1: Summary of work flow of the study

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter seeks to review past literature on the categorization of the sources of variations of road construction projects. The chapter elucidates on categorization, variation, types of variation, causes of variations, effects of variations. The chapter ends by proposing recommendations and strategies to reduce variation on road construction projects.

2.2 CATEGORIZATION

Categorization is the process of putting things and materials into groups to help in differentiation. It also serves the purpose of bringing order and purpose. For example, a store or shop may be divided into categories into the different materials being sold (Clough and Sears, 1994).

Categorizations should be done in a simple way. Categorization could be in the form of colours, type of materials. Categorization is useful when comparing and contrasting. As much as possible, categories should be distinct from each other. Categories should also make sense and provide evidence where required (Bunge, 1983).

Figure 2.1 below shows a categorization chart.

Evidence:	Web-based Sources	Academic /Trade Sources	Gov. Doc Sources	Popular Sources	Hackers always bad	Hackers sometimes good	Enforce-ment/ fighting crime
Brenner, Susan cybercrimes.net, 01	XX	XX (Law school)			XX (Legal issues/laws against)		XX (courts, laws, etc.)
Cameron, Al "Fighting Internet Freud" *Business Credit*, 02		XX (Trade Pub)			XX (Money & business)		XX (cops, company software)
"Cybercrime.gov" US. Gov., 02	XX		XX (Dept. of Justice)		XX (terrorism, fraud)		XX (FBI, etc.)
"Cybercrime soars" *Info Management Jrnl*, 02		XX (Trade pub)			XX		
Markoff, John. "New Center..." *NYT*, 10/99				XX	XX (business)		XX (private business)
Neighly, Patrick "Meet the hackers" *America's Network*, 00		XX (??)				XX ("hanging out" with hackers)	

Figure 2.1 Categorization chart

Source: Bunge (1983)

Forms of categorizations:

- By location: Categorization can occur considering the geographical location of a material or work item (CII, 1994; CII, 1995).
- By class: There are various classification methods for works. CESMM3 classifies civil engineering works into their various classes. SMM7 also does same for building works (Bunge, 1983).
- By material: Since materials constitute objects, their surface qualities and physical nature can be used to classify them (ISO, 1994).
- By membership: Categorizations could be by professional membership or other forms of membership (Hayati, 2006).

- By general properties: Different work elements may combine together to form the general properties of the materials and can be used for differentiation purposes (ISO, 1994; CII, 1994).
- By specific properties: Unique properties of materials or item can serve as a basis for its categorization (Bunge, 1983).
- By function: The intended purpose of an item can determine its appropriate categorization (Hayati, 2006).
- By work section: ISO (1994) posits that work section depicts to a part of construction work including its assembly.
- By size: Size may serve as a factor for categorization. It is worthy to note that big projects may not necessarily make them complex (Hayati, 2006).

2.2.1 Classifications and categorizations

In the construction sector, classifications are undertaken in these ways (Bunge, 1983; CMAA, 1993):

1. Facility
2. Infrastructure unit
3. Space
4. Element
5. Composite element
6. Design of work element
7. Sections of work
8. Activities and their production
9. Final products
10. Aids in construction
11. Features and attributes

2.3 VARIATIONS IN THE CONSTRUCTION INDUSTRY

Variations are orders or instructions issued by the site's engineer (PPA, 2003). According to FIDIC (1999), variation implies changes to works that have been approved or instructed.

Variation does not have a single definition. It is defined and described by the different standard forms of contract but in principle, the definitions have similarities. Standard forms of building contracts contain the definition of variation in relation to activities and specific actions (Hayati, 2006).

'Variation' implies alteration to the extent the contract allows (Hayati, 2006). This implies that variation does not only change the work or matters pertaining to it as enshrined in the contract, but it refers to changes in the contract conditions too.

A study by Hayati (2006) describes variation to be any or combination or all of the following below:

i. Variations refer to the modification or alteration of the quality, and design as described in the bills and drawings. It included omission, addition or substitution of any work. It also implies altering materials and their standards used, removing the materials or goods brought on the site. It also includes goods that that not been originally included in the contract (Hayati, 2006).

ii. Changes that have issued accompanied with instructions in the project regarding the works involved which are not explicitly called variation in the contract documents (Hayati, 2006).

iii. When there are variations of the law guiding the contract. This occurs as the two parties mutually agree in altering the contract after the original contract has been executed (Hayati, 2006).

iv. Changes and variations in the clause regarding the prices used for the contract. This provides adjustments that takes care of the rising and falling of labour and material costs. Variation implies changes in the work quality and quantity as indicated in the contract document (Hibberd, 1986). Bin-Ali (2008) mentioned variation to be deviations in the contract works and includes addition, alteration, modification in relation to the specifications, contract drawings and bills of quantities.

According to Popescu (1995), change orders are variations that have been effected in the original contract document which has effects on work scopes. Change orders must have authorization from clients though most times the instructions are from contractors on site. Schexnayder *et al*., (2004) opined that change orders are instructions ordered by project clients to vary and modify the contract. This is done by adding or removing some features in the work scope. Changes that do occur outside work scope require agreement that is supplementary. Variation orders alter the conditions and details of projects thereby deleting or increasing the works.

Variations mainly imply the revising, modifying, changing and altering or amending of the works contract from their original scope. Change orders refer to formal documents that are used for modifying original contract agreements. This later constitutes the project's documents (Fisk, 1997). Change orders refer to written orders issued to site contractors subsequent to contract agreement with client that gives authorization to make changes to works and further make adjustments in both contract sum and time.

2.3.1 Variations in the road construction industry

Five forms of variations exist in road works as opined by Ibbs *et al.* (2007). These include: delays and interruptions; suspensions and postponements; project acceleration; new scope changes; and changes in site condition.

According to Ndihokubwayo and Haupt (2008), variations can be classified by their causes as well as effects. Arain and Low (2005) classified variation orders into useful variations and destructive variations. The beneficial ones aid in reducing project cost, time and complexity. They help in balancing costs, function and durability as well as satisfying clients leading to reduced project costs. Destructive variations lead to a reduction in owner value and cause poor performance (Arain and Low, 2005).

2.3.2 Past works undertaken

A number of research works have been undertaken on variations in the road sector. Awad (2001) discovered that the most significant sources of variations were engineers followed by project clients. It was also established that variations cause total time overrun to shoot up as well as time. The major reasons leading to variations were revising of designs, changes in site conditions and new works. Another study in South Africa by Ndihokubwayo and Haupt (2008) established that the major sources of variation orders were from consultants followed by clients. New works and omissions were the significant causes identified by Ssegawa *et al.* (2002). This was followed by substitutions in the works.

Another study conducted by Hsieh *et al.* (2005) in Taipei found that the major causes leading to variations were poor planning at the design level. Wu *et al*. (2005) conducted a study in Taiwan on road projects and found design changes and poor ground conditions to be significant causes of variations. Finally, Arain and Low (2006) also conducted studies in Singapore on variation orders.

2.4 TYPES AND NATURE OF VARIATION ORDERS

2.4.1 Nature of Variation Orders

Variations in projects are classified to be emergent variations and anticipated variations (Ming *et al.,* 2014). Variations that are emergent occur spontaneously and they are not planned for. They are not originally planned for or anticipated and intended. However, anticipated nature of variations on the other hand are predicted to occur hence provisions are made for them.

Project variations can also be viewed in terms of their necessity. Hence these variations can also be termed as elective and required variations. Elective leads to one having to choose to implement or not but in the required variation, there is no other option than to have the variation (Ming *et al.,* 2014). In spite of the carefulness with which a project is scheduled and planned, variations will occur before the project ends. Ruben (2008) indicated that the type of variation orders is determined by the reason for the variation and its impact. Variation orders exist in two forms. These forms are the variation orders that are beneficial and the variation orders that are detrimental and negative.

2.4.1.1 Beneficial variation orders

Arain and Pheng (2005) opine that variation orders that are beneficial are issued out to improve standards of quality, reduce costs and how difficult the project becomes. This type of variation eliminates project costs which are not unnecessary and this leads to optimum benefits for the owner. The implication is that this type of variation orders help when analysing value and leads to cost balance, functionality and longer life cycle of project. Kelly and Male (2002) explain value analysis as orderly ways used to identify and eliminate costs which are not necessary and which do not contribute to the project aesthetically or quality wise. Value analysis involves the value study of an already designed and built project and to see if there can be further improvement. A variation order is therefore beneficial if it enhances the value of the client. According to Kelly and Durek (2002), the value system of the client includes the elements of time, operational costs, capital cost, environment, resale, aesthetics. Beneficial variation orders therefore aim at optimizing the benefits of the client against resource input thereby avoiding unnecessary costs. The benefits encompass economic, social and commercial aspects.

Beneficial variations are initiated to add more value to construction projects. Non-value adding costs may also accrue no matter how beneficial it may be (Ruben, 2008). Variation orders may solve differences in contract documents involving aborting executed works.

2.4.1.2 Negative/detrimental variation orders

This type of variation order has a disadvantageous impact on the project with regards to both performance and value for money. A client with financial challenges will want to substitute higher quality materials or expensive materials for less expensive ones or lower quality. This leads to compromise.

2.5 SOURCES OF VARIATIONS IN ROAD CONSTRUCTION PROJECTS

2.5.1 Owner’s financial problems

The client’s financial challenges lead to an effect on progress (Clough and Sears, 1994). This results in changes to specifications and work schedules thereby impacting quality (O’Brien, 1998).

2.5.2 Obstinate nature of the owner

Building projects are the combined efforts of stakeholders involved and they work at various stages of the project (Wang, 2000). If the client is obstinate, it will lead to major variations occurring at the construction stages (Arain *et al.,* 2004).

2.5.3 Client's changes in specifications

When the objectives of a project are inadequate, changes especially to specifications become common place (O'Brien, 1998). When the changes are implemented, it causes variations when construction is ongoing.

2.5.4 Consultant's modifications to design

In contemporary practice, consultants make changes to design as a form of improvement (Arain *et al*., 2004). In situations where construction proceeds before designs are completed, variations occur a lot and leads to problems for the project.

2.5.5 Inconsistencies in contract document

When the contract documents are conflicting, this can lead to misinterpreting the real needs and requirements of the project (CII, 1986). Contract documents should ideally be concise, precise and clear. When details are not sufficient, this can cause delays to the completion time and eventually lead to variations.

2.5.6 Complexity in design and change in specification

According to Fisk (1997) and CII (1990), inadequate designs lead to frequent variations when undertaking construction projects. According to Arain *et al*. (2004), when designs are complex, it necessitates special methods and skills in construction. When specifications are effected with changes, it brings about problems. It causes an overall increase in the costs and inherently leads to delays (Arain *et al*., 2004).

2.5.7 Labour and plant shortage coupled with poor workmanship

Skilled labour is a major requirement for a number of construction projects (Arain *et al*., 2004). Changes or variations will arise when there is shortage in skilled manpower (Thomas and Napolitan, 1995). Poor and defective workmanship leads to demolitions and reworks in construction works (O'Brien, 1998). This has the effect of delays and increased costs (Fisk, 1997). Plant shortage is a procurement challenge. It affects the completion of the project and leads to variations (O'Brien, 1998).

2.5.8 Poor procurement process and slow decision making

Delays in the procurement process have adversarial and serious consequences on the cycle of construction (Fisk, 1997). Poor procurement process affects the other processes in construction thereby leading to variations. Slow decision-making serves as an impediment to the process of decision making. When decisions are not taken on time, it leads to delays and thereby leads to changes in change orders (Gray and Hughes, 2001; Savido *et al*., 1992).

2.5.9 Financial challenges faced by contractor

Construction requires labour force to work. During financial difficulties, resource may not be readily available. The lack of finances and unavailability of resources will compel the project team to make changes to the original design they had (Arain *et al*., 2004).

2.6 CATEGORIZATION OF SOURCES OF VARIATIONS IN THE CONSTRUCTION INSDUSTRY

Different authors and researchers have shared their views and opinions on variations and their categorization in the construction industry.

Table 2.1 below shows a summary of categorization of variations and cost overrun by past authors. The table indicates the names of the authors, the categorization groups and the number of categorizations.

Table 2.1 Summary of sources of variations

Citations	**Categorization groups**	**Number**
Le-Hoai *et al.* (2008)	Owner, consultant, contractor, material/labour, project and external	6
Ameh *et al.* (2010)	Environmental, construction, construction item, cost estimation and financing	5
Aziz (2013)	Owner, designer, contractor, miscellaneous	4
Derakhshanalavijeh and Teixeira (2017)	Owner, consultant, contractor, project and material/labour	5
Niazi and Painting (2017)	Client, contractor, consultant, labour, material/labour	6
Zwedu and Aregaw (2015)	Construction item, estimating, project stakeholders, financing and environmental	5
Polat *et al.* (2014)	Time, cost, contract, quality, human resource, risk and communications	7

2.7 EFFECTS OF VARIATIONS ON ROAD CONSTRUCTION PROJECTS

Variations have several negative effects in the construction industry and especially in road projects. According to O'Brien (1998), variations in the contract documents and drawings cause changes in the time schedule and price of contract. The presence of variations also causes disputes and litigation. Normally, variations bring about challenges to all the various project stakeholders. Variations arise from a plethora of causes and sources.

A number of variables do have an influence on the construction process and can lead to variations. These comprise resource availability, performance of the parties in the construction process, conditions of the environment and contractual occurrences. These sources and causes can lead to delays and late completion (Clough and Sears, 1994).

Kumaraswamy *et al.* (1998) conducted a study in Hong Kong. Civil and road projects were studied, and it was found out variations led to over twenty percent increase in time overruns. Cost overruns was also estimated around fifty percent. Kaming *et al*. (1997) found that variations led to huge time overruns as well as cost overruns. The major influencing factors of variation were errors in cost estimation, inflations, and complexity of project. The time overruns were influenced by shortage in labour and materials, low labour productivity, poor planning and changes in the design.

The effects of variations vary from project to project as well as country to country. It is a general fact that variations lead to distasteful impact on costs and time (CII, 1994; Ibbs *et al*., 2001). Variations slow down the pace of construction works and causes targets to be unmet (Ibbs, 1997). Zeitoun and Oberlender (1993) found that change orders cause delays up to ten percent in time.

CII (1990) established that the most severe effect of variation orders were escalated project costs. New works or modifications made to original design while constructing causes demolished works and reworks. This finally results in huge costs (Clough and Sears, 1994). The purpose of contingency sums is to take care of project variations (O'Brien, 1998). The process of making variation orders involves reviews and procedures. These processes too can constitute increased expenses (O'Brien, 1998).

Fisk (1997) stated that variations negatively affect work quality. CII (1995) also posits that work quality is negatively affected since the project contractors will have to make up for their losses incurred and therefore reduce quality. Clough and Sears (1994) indicated that variations cause reworks and demolitions. This is more pronounced if the project is ongoing or completed (CII, 1994).

At the design stage, variations do not require reworks or demolitions. This normally happens at the construction stage. Variations lead to frequent reworks and demolitions (Clough and Sears, 1994). Variations which happen while project is ongoing or completed cause project delays (CII, 1990). The occurrence of reworks and demolitions lead to negative effects. The impact is felt less at the design stage and felt more at the construction stage.

Fisk (1997) posits that variations causes the acquisition of new equipment and materials leading to logistic delay. Hester *et al*. (1991) established that logistic delays cause huge effects on the performance of contractors. Logistic delay may happen because the variations require new equipment and materials (Fisk, 1997).

Other negative effects of variations are interruptions, suspensions, delays as well as rededication of works. All these poses as threats to project productivity. This has impact on the costs of labour and monetary value (Ibbs, 1997). Hester *et al*. (1991) opined that the productivity of workers is negatively affected where the workers have to endure longer working hours to compensate for schedule delays. Thomas and Napolitan (1995) also established that variations cause project disruptions and causes negative effects on productivity. The severest impacts of the disruptions result from lack of information and materials and sequence of works. It should be noted that disruptive effects are unavoidable in several instances. Revised procurement requests are an impact of variations which occur while the project is still underway (O'Brien, 1998).

A major cause of construction disputes and claims is change or variation orders (Kumaraswamy *et al*., 1998). This adversely affects the reputation of the firm and this leads to insolvency in extreme cases. This also increases professional disputes in the future. Traditionally, variations are great challenges to project stakeholders.

According to Arain *et al*. (2004), variations have an impact on the safety of projects. This is because of changes in construction methods, equipment and materials leading to revised safety and health measures (Arain and Pheng, 2005). Construction variations lead to disputes (Fisk, 1997). Variations eventually affect professional relations. New and additional payments for contractors in an effect of variations in the construction industry. They serve as additional sources of works for contractors and because of this incentive, contractors normally look forward to variations (O'Brien, 1998). Disputes over the variation orders and claims lead to disagreements (CII, 1995). Frequent communication is essential in minimising disputes.

Project clients normally expect the construction project to be delivered within certain time limits. When projects are finished on time, they lead to monetary savings. Completion of schedule delay is an impact of variations. According to Koushki (2005), variation orders impact time and costs. Hanna *et al*. (2002) posits that variation orders lead to productivity losses.

2.8 STRATEGIES TO MINIMIZE VARIATIONS IN THE ROAD CONSTRUCTION INDUSTRY

Baharuddin (2005) suggested that change orders will be reduced if the stakeholders involved are made aware of preliminary work before tendering is undertaken. This includes detailed soil and site investigations. There cannot be a complete avoidance of design errors and omissions. There can be a minimization if the designers consider their workload before deciding to accept new contracts (Ruben, 2008). Designers and consultants should have adequate time and professionals who are well experienced to undertake sufficient designs.

Arain (2005) suggested that since variations occur less at the design stage, there must be control systems instituted to control the variations, so the project owners can ultimately benefit. Organizations into project design must be encouraged to have departments in charge of quality control. Their responsibility will be to verify the designs and ensure adequate sanctions meted out to defaulters. Structural engineers must be made to undertake structural analysis and design detailing before construction.

Civil engineers must not be allowed to perform roles outside their professional jurisdiction. Structural engineers must also adhere to using the right softwares for design in order to accurately estimate the right sizes and quantity of reinforcement for the designs. This will prevent variations as well as reduce project collapse. Ye *et al*. (2004) advised on proper implementation of management system for sites as a critical way of preventing reworks. Site supervisors can reduce the quantum of rework by giving attention to mistakes and improving workmanship quality (Hwang and Yang, 2004; Love and Edwards, 2004; Alwi *et al.*, 2001).

Another strategy to reduce variations is to enhance project communication. Effective communication is very essential. When communication is efficient, this reduces reworks (Hwang and Yang, 2014). Effective channels of communication aid the project stakeholders in predicting and estimating change processes that cause rework (Hwang and Yang, 2004; Love and Edwards, 2004; Alwi *et al.*, 2001).

Capacity building will lead to reduced variations. Governments must establish effective schemes to empower local contractors increase their capacity. This would lead to equipment being available every time. There must be specific policies put in place for consultants, contractors and clients. The benefits will reduce the low quality, cost over runs and time over runs (Hwang and Yang, 2014).

Past literature have identified strategies to minimize variation orders. These include works by Ruben (2008); Baharuddin (2005); Ming *et al*. (2004) and Bower (2000). These strategies include:

- Communication channels must be enhanced among the parties;
- Supervision of works should be well undertaken;
- Procurement procedures for materials and equipment must be well undertaken;
- Designs and specifications must be within approved budget;
- Budget team must be involved in works at the design stage;
- Detailed site investigations must be undertaken during tendering;
- Changes to specifications should be avoided;
- Underground cable routes must be confirmed by local authorities;
- Consultants should produce designs and contracts that are conclusive;
- Extensive planning by stakeholders is needed before commencement of project;
- Drawings must be finished and concluded at tender stage;
- Consultant co-ordination is essential at the design stage;
- Forecasting should be undertaken by all parties to have an idea of unforeseen circumstances;
- Land application and purchase must be completed before the award of contracts.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

The first two chapters constituted the introduction and literature review respectively. This chapter elaborates further on the methodology used for the study. It explains how the research objectives and aim were attained. The research design is tackled including instruments of data collection, sampling techniques and data analytical tools.

3.2 RESEARCH STRATEGY

According to Naoum (2002), research strategy means enquiring about the research questions and objectives. According to Baiden (2006), the research types are qualitative, quantitative and mixed method. Naoum (2002) opines that the choice in deciding a strategy is dependent on the purpose of the research as well as its type and information available. This study chose a quantitative approach and questionnaires were used in gathering data.

3.3 RESEARCH DESIGN

This matches with the outline for collecting and analysing data and also provides connection between raw data and its conclusion in a logical flow to the research objectives and questions (Baiden, 2006). The research adopts a questionnaire survey. An advantage of questionnaires is their ability to be used for generalization hence questionnaire survey was used for this study so as to generalize the findings. Questionnaire survey enhances consistency of observations (Oppenheim, 2003).

3.4 APPROACHES TO DATA COLLECTION

Approaches to data collection are two as noted by Naoum (2002). These are primary collection involving fieldwork and secondary collection normally involving desk study.

According to Naoum (2002) there are two approaches to data collection namely, fieldwork (primary data collection) and desk study (secondary data collection). Patton (2002) noted that using more than one data collection instrument strengthens and gives credibility to the study.

3.5 INSTRUMENT FOR DATA COLLECTION

3.5.1 Questionnaires

The nature of the questions in the questionnaires were scaled and close ended questions. The Likert scale of response was adopted to help in measuring the intensity and strength of the respondents. Self-administered questionnaires have a plethora of advantages. Some include it being an effective way of collecting data that can be statistically analysed. Several respondents can also be reached in a short spate of time (Naoum, 2002). The questionnaire for this study was designed to help achieve the research aim and objectives. Ideal length of a questionnaire should range from one side of A4 sheet to eight sheets of A4 paper (Oppenheim, 2003). The first section was on the respondents' profile while the second part tackled the specific objectives. All the questionnaires were distributed and retrieved in person.

3.5.2 Project Data Collection

This involved the collection of information on variation orders issued on fifteen (15) projects selected for the studies from The Department of Feeder Roads in the Ashanti Region.

Work sections such as General Items, Demolition and Site Clearance, Earthworks, In-situ Concrete, Concrete Ancillaries, Pipe work-Pipes, Pipe work – Support and Protection, Drains and Ditches, Roads and Pavings and Miscellaneous were considered for the collection of the data. A total of forty three (43) projects were considered.

Thirteen (13) out of the Thirty-two (32) COCOBOD funded projects and two (2) out of eleven (11) Ghana Road Fund Funded projects warded between 2015 and 2018 experienced Variations Orders and these projects were used as the sample for the study.

For each project the data collected related to the following elements:

1. Contract sum
2. Estimated cost of works without contingency
3. Physical contingency
4. Estimated cost of works plus contingency
5. Estimated cost of works plus variation orders

3.6 RESEARCH POPULATION AND SAMPLING TECHNIQUE

According to Naoum (2002), population is the totality or wholeness of collection of individuals or objects. Sample is a part of the whole population. Sampling implies the process of selecting a quota to represent the entire population. The population consisted of professionals in road construction firms. A list was obtained from the Ministry of Works and Housing, and also the Ministry of Transport. Contractors to be contacted were in good standing and practicing. Purposive sampling technique which is a non-probability sampling technique was adopted. In purposive sampling, the researcher targets an individual or organization due to the experience and knowledge the respondent possesses. The selection criteria were that the respondents should be working on road projects, knowledgeable in variations and should have been working for at least five years. This was used in selecting the respondents till a sample size of eighty (80) respondents was obtained.

3.7 DATA ANALYTICAL TOOLS

There exist two choices for statistical considerations. These are non-parametric and parametric tests. For this study, the tool used was non-parametric statistical testing. SPSS software aided in the inputting and editing of collected data. The respondents' profile was analysed with descriptive statistics. This comprised percentages and frequencies and were in the form of charts. The tools for analyzing the data from questionnaire collected consisted of descriptive statistics, mean score ranking and Cronbach Alpha for testing reliability. Project data collected were entered and analysed with excel spread sheet.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

The previous sections tackled the introduction, literature review and research methodology. This chapter is the analysis of data obtained from the field and discussion. Statistical Package for Social Sciences (SPSS) software was used. The respondent profile was analysed using descriptive statistics (simple frequencies) while the dependent variables were analysed by way of mean score ranking.

The analysis is divided into two sections. The first part tackles the demographic background of the respondents. The remaining part is the analysis of the research objectives. Out of eighty (80) questionnaires distributed to the respondents, sixty (60) questionnaires representing seventy-five (75) percent response rate was completed and returned. These questionnaires were the fulcrum of the research findings utilized in the analysis.

Lastly the project data collection on fifteen (15) road projects were analysed and the cost overrun as well as time overrun computed due to the effects of variation orders. The work section with the highest variation orders was also analysed.

4.2 ANALYSIS OF RESPONDENT PROFILE

The results of descriptive statistics is presented in this section. The goal of the section was to assist in giving the demographic background of the respondents for the study. Knowing the background of respondents is to ensure that data collected is reliable and was filled by the right people.

4.2.1 Category of profession

This question sought to know from the respondents their category of profession. From Table 4.1 below, 3 respondents representing 5.0 percent were architects. 20 respondents representing 33.33 percent were quantity surveyors. 18 respondents representing 30.0 percent were civil engineers. 9 respondents representing 15.0 percent were construction managers. 6 respondents representing 10.0 percent were roads engineer. 1 respondent representing 1.67 percent was a land surveyor. 2 respondents representing 3.33 percent were materials engineers. The remaining 1 respondent representing 1.67 percent was a lab technician. The majority of respondents for this study are quantity surveyors.

Table 4.1 Category of profession

	Frequency	Percentage	Cumulative Percentage
Architect	3	5.00	5.00
Quantity Surveyor	20	33.33	38.33
Civil Engineer	18	30.00	68.33
Construction Manager	9	15.00	83.33
Roads engineer	6	10.00	93.33
Land surveyor	1	1.67	95.00
Materials engineer	2	3.33	98.33
Lab technician	1	1.67	100.0
Total	60	100.0	

4.2.2 Experience of respondents

In this section, the respondents for the study were asked to indicate how long they had been working in the road sector. From Table 4.2 below, 32 respondents representing 53.33 percent had been working for less than 5 years. 11 respondents representing 18.33 percent had been working for 6-10 years. 13 respondents representing 21.67 percent had been working for 11-15 years. 3 respondents representing 5.0 percent had been working for 16-20 years. The remaining 1 respondent representing 1.67 percent had been working for above 20 years. It can be inferred that all the respondents for the study had adequate experience.

Table 4.2 Experience of respondents

	Frequency	Percentage	Cumulative Percentage
Less than 5 years	32	53.33	53.33
6-10 years	11	18.33	71.66
11-15 years	13	21.67	93.33
16-20 years	3	5.00	98.33
Above 20 years	1	1.67	100.00
Total	60	100.00	

4.2.3 Involvement in road projects that had variations

The respondents were asked if they had been involved in road projects that had experienced variations. From Figure 4.1 below, 96 percent of the respondents indicated yes while the remaining 4 percent indicated no. Therefore, it can be implied that majority of the respondents had been involved in a project that experienced variations. Hence their responses for this study can be trusted.

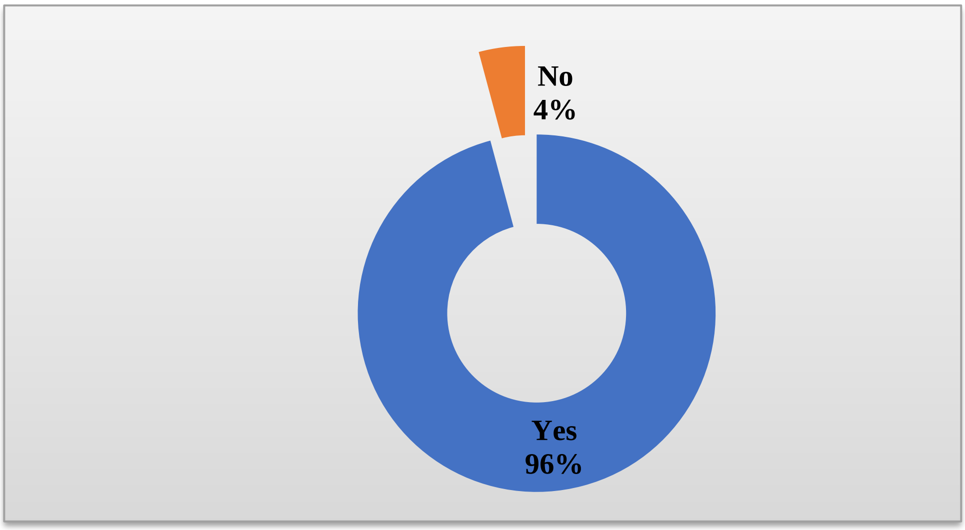

Figure 4.1 Involvement in road projects that had variations

4.2.4 Ways of categorization on project site

In this section, the respondents were asked to indicate the ways they categorize on their projects sites. From Figure 4.2 below, 33 percent of respondents indicated by work section. 17 percent of respondents indicated by location. 11 percent of respondents indicated by membership. 13 percent of respondents indicated by general properties. 33 percent of respondents indicated by specific properties. 10 percent of respondents indicated by function. It can be seen that majority of respondents indicated by work section.

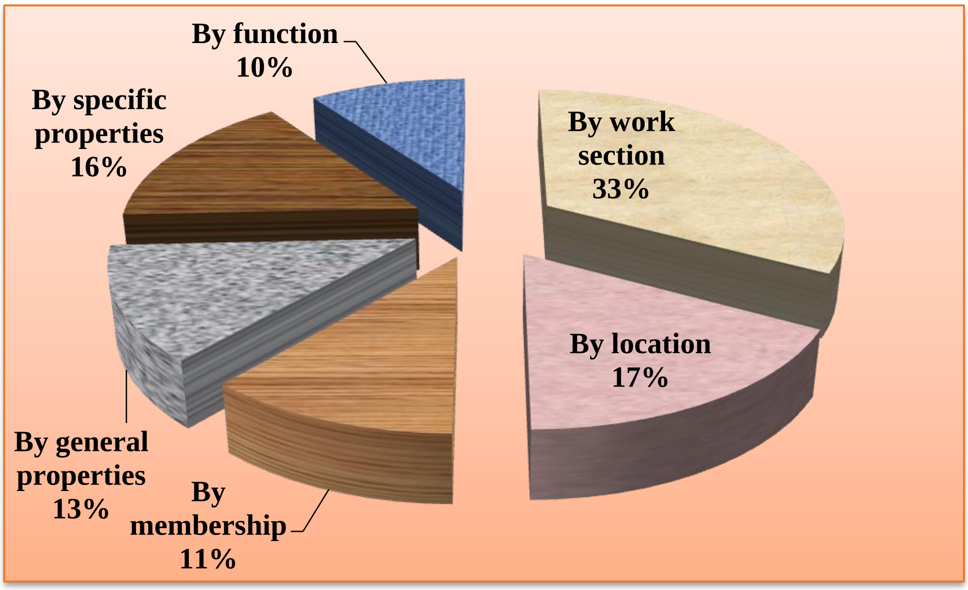

Figure 4.2 Ways of categorization on project site

4.2.5 Importance of categorization in road works

The respondents for the study were asked why it was important to have categorizations in road works. Their responses are documented in Figure 4.3 below, 30 percent of respondents said it brings differentiation. 24 percent of respondents said it brings about order. 32 percent of respondents said it brings about purpose. The remaining 14 percent of respondents said it indicates significance.

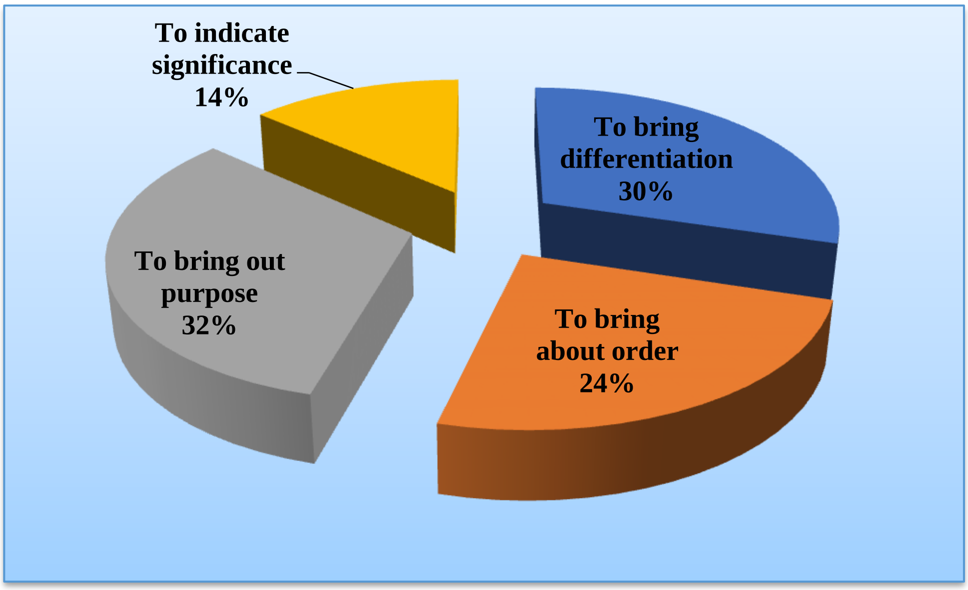

Figure 4.3 Importance of categorization in road works

4.3 CATEGORIZATION OF VARIATION ORDERS BY WORK SECTIONS IN ROAD PROJECTS

In this section, the respondents were asked to rank the work sections in road projects that experienced the most variation orders on a Likert scale of 1 to 5 where 1=Not severe at all; 2=Not severe; 3=Neutral; 4= Severe; 5=Very severe. Mean score ranking using the mean values and standard deviation were used in ranking the work sections. From Table 4.2 below, *Roads and pavings* was ranked 1st with mean of 4.32 and standard deviation of 1.023. *Pipe works* was ranked 2nd with mean of 4.28 and standard deviation of 0.867. *Concrete ancillaries* was ranked 3rd with mean of 4.22 and standard deviation of 0.773. *Drain and ditches* was ranked 4th with mean of 4.16 and standard deviation of 0.876. *In-situ concrete* was ranked 5th with mean of 4.13 and standard deviation of 1.007.

The findings agree with past literature.

Categorization is the process of putting things and materials into categories to help in differentiation. It also serves the purpose of bringing order and purpose. For example, a store or shop may be divided into categories into the different materials being sold (Clough and Sears, 1994). Categorizations should be done in a simple way. Categorization could be in the form of colours, type of materials. Categorization is useful when comparing and contrasting. As much as possible, categories should be distinct from each other. Categories should also make sense and provide evidence where required.

According to PPA (2006), variations are orders or instructions issued by the site's engineer. According to FIDIC (1999), variation implies changes to works that have been approved or instructed. Roads and pavings ranked first implying they suffered the most from variations. This is similar to past work undertaken by (Clough and Sears, 2014).

Table 4.3 Categorization of variation according to work sections

CATEGORIZATION	Mean	Std. Deviation	Ranking
Roads and pavings	4.32	1.023	1st
Pipe works	4.28	0.867	2nd
Concrete ancillaries	4.22	0.773	3rd
Drain and ditches	4.16	0.876	4th
In-situ concrete	4.13	1.007	5th
Demolition and site clearance	4.07	0.734	6th
Pipe work support and protection	3.98	0.985	7th
General items	3.91	0.993	8th
Earthworks	3.76	1.103	9th

4.4 SOURCES OF VARIATIONS IN ROAD PROJECTS

In this section, the respondents were asked to rank the sources of variation orders in road projects on a Likert scale of 1 to 5 where 1=Not important at all; 2=Not important; 3=Neutral; 4=Important; 5=Very important.

4.4.1 Client related source of variation

Mean score ranking using the mean values and standard deviation were used in ranking the client related source of variation. From Table 4.3 below, *Change in specifications by the owner* was ranked 1st with mean of 4.22 and standard deviation of 0.825. *Inadequate planning* was ranked 2nd with mean of 4.08 and standard deviation of 0.679. *Owner's financial problems* was ranked 3rd with mean of 4.01 and standard deviation of 0.734. *Delay in decision making* was ranked 4th with mean of 4.00 and standard deviation of 0.562. *Obstinate nature of the owner* was ranked 5th with mean of 3.89 and standard deviation of 0.913.

The client's financial challenges lead to an effect on progress (Clough and Sears, 1994). This results in changes to specifications and work schedules thereby impacting quality (O'Brien, 1998). When the objectives of a project are inadequate, changes especially to specifications become common place (O'Brien, 1998). When the changes are implemented, it causes variations when construction is ongoing.

Building projects are the combined efforts of stakeholders involved and they work at various stages of the project (Wang, 2000). If the client is obstinate, it will lead to major variations occurring at the construction stages (Arain *et al.*, 2004).

Table 4.4 Client related source of variation

Client related source	Mean	Std. Deviation	Ranking
Change in specifications by the owner	4.22	0.825	1st
Inadequate planning	4.08	0.679	2nd
Owner's financial problems	4.01	0.734	3rd
Delay in decision making	4.00	0.562	4th
Obstinate nature of the owner	3.89	0.913	5th
Inefficient communication	3.86	0.865	6th
Poor procurement process	3.72	1.023	7th
Conflicts among contract documents	3.66	0.867	8th
Selection of inappropriate contractors	3.54	1.220	9th

4.4.2 Contractor related source of variation

Mean score ranking using the mean values and standard deviation were used in ranking the contractor related source of variation. From Table 4.4 below, *Lack of strategic planning* was ranked 1st with mean of 3.95 and standard deviation of 0.568. *Lack of strategic planning* was ranked 2nd with mean of 3.92 and standard deviation of 0.956. *Reworks* was ranked 3rd with mean of 3.84 and standard deviation of 1.023. *Poor workmanship* was ranked 4th with mean of 3.81 and standard deviation of 0.785. *Lack of coordination between general contractors and subcontractors* was ranked 5th with mean of 3.77 and standard deviation of 0.884.

Construction requires labour force to work. During financial difficulties, resource may not be readily available. The lack of finances and unavailability of resources will compel the project team to make changes to the original design they had (Arain *et al*., 2004).

Skilled labour is a major requirement for a number of construction projects (Arain *et al*., 2004). Changes or variations will arise when there is shortage in skilled manpower (Thomas and Napolitan, 1995). Poor and defective workmanship leads to demolitions and reworks in construction works (O'Brien, 1998). This has the effect of delays and increased costs (Fisk, 1997). Plant shortage is a procurement challenge. It affects the completion of the project and leads to variations (O'Brien, 1998).

Table 4.5 Contractor related source of variation

Contractor related source	Mean	Std. Deviation	Ranking
Lack of strategic planning	3.95	0.568	1st
Reworks	3.92	0.956	2nd
Contractor's financial difficulties	3.84	1.023	3rd
Poor workmanship	3.81	0.785	4th
Lack of coordination between general contractors and subcontractors	3.77	0.884	5th
Poor financial control	3.73	0.769	6th
Inappropriate contractor's policies	3.62	0.734	7th

4.4.3 Designer/Consultant related source of variation

Mean score ranking using the mean values and standard deviation were used in ranking the Designer/Consultant related source of variation. From Table 4.5 below, *Change in specification by the consultant* was ranked 1st with mean of 4.54 and standard deviation of 0.823. *Inadequate design* was ranked 2nd with mean of 4.43 and standard deviation of 0.957. *Design complexity* was ranked 3rd with mean of 4.41 and standard deviation of 1.023. *Inaccurate cost estimation* was ranked 4th with mean of 4.32 and standard deviation of 0.932. *Slow decision making* was ranked 5th with mean of 4.21 and standard deviation of 1.232.

In contemporary practice, consultants make changes to design as a form of improvement (Arain *et al*., 2004). In situations where construction proceeds before designs are completed, variations occur a lot and leads to problems for the project.

According to Fisk (1997) and CII (1990), inadequate designs lead to frequent variations when undertaking construction projects. According to Arain *et al*. (2004), when designs are complex, it necessitates special methods and skills in construction. When specifications are effected with changes, it brings about problems. It causes an overall increase in the costs and inherently leads to delays (Arain *et al*., 2004).

When the contract documents are conflicting, this can lead to misinterpreting the real needs and requirements of the project (CII, 1986). Contract documents should ideally be concise, precise and clear. When details are not sufficient, this can cause delays to the completion time and eventually lead to variations.

Table 4.6 Designer/Consultant related source of variation

Designer/Consultant related source	Mean	Std. Deviation	Ranking
Change in specification by the consultant	4.54	0.823	1st
Inadequate design	4.43	0.957	2nd
Design complexity	4.41	1.023	3rd
Inaccurate cost estimation	4.32	0.932	4th
Slow decision making	4.21	1.232	5th
Change in design by the consultant	4.18	0.895	6th
Inadequate site investigation	4.14	0.865	7th

4.4.4 Miscellaneous related source of variation

Mean score ranking using the mean values and standard deviation were used in ranking the Miscellaneous related source of variation. From Table 4.6 below, *Inappropriate government policies* was ranked 1st with mean of 4.34 and standard deviation of 0.626. *Fluctuation in prices of materials* was ranked 2nd with mean of 4.32 and standard deviation of 0.129. *Unavailability of equipment* was ranked 3rd with mean of 4.28 and standard deviation of 0.672. *Shortage of skilled manpower* was ranked 4th with mean of 4.27 and standard deviation of 0.568. *Emergency works* was ranked 5th with mean of 4.21 and standard deviation of 0.956.

Delays in the procurement process have adversarial and serious consequences on the cycle of construction (Fisk, 1997). Poor procurement process affects the other processes in construction thereby leading to variations. Slow decision-making serves as an impediment to the process of decision making. When decisions are not taken on time, it leads to delays and thereby leads to changes in change orders (Gray and Hughes, 2001; Savido *et al*., 1992).

Table 4.7 Miscellaneous related source of variation

Miscellaneous related source	Mean	Std. Deviation	Ranking
Inappropriate government policies	4.34	0.626	1st
Fluctuation in prices of materials	4.32	0.129	2nd
Unavailability of equipment	4.28	0.672	3rd
Shortage of skilled manpower	4.27	0.568	4th
Emergency works	4.21	0.956	5th
Unexpected ground conditions	4.17	1.023	6th
Adverse effect of weather	4.09	0.785	7th
Force majeure	3.95	0.856	8th

4.5 EFFECTS OF VARIATIONS ON ROAD PROJECTS

In this section, the respondents were asked to rank the effects of variation orders on road projects on a Likert scale of 1 to 5 where 1=Not severe at all; 2=Not severe; 3=Neutral; 4= Severe; 5=Very severe. Mean score ranking using the mean values and standard deviation were used in ranking the effects. From Table 4.7 below, *Completion schedule delay* was ranked 1st with mean of 4.13 and standard deviation of 0.893. *Causes rework* was ranked 2nd with mean of 4.05 and standard deviation of 1.102. *Additional payments for contractor* was ranked 3rd with mean of 4.02 and standard deviation of 0.773. *Disputes among professionals* was ranked 4th with mean of 3.99 and standard deviation of 0.630. *Blemish firm's reputation* was ranked 5th with mean of 3.96 and standard deviation of 0.895.

Variations have several negative effects in the construction industry and especially in road projects. According to O'Brien (1998), variations in the contract documents and drawings cause changes in the time schedule and price of contract. The presence of variations also causes disputes and litigation. Normally, variations bring about challenges to all the various project stakeholders. Variations arise from a plethora of causes and sources. A number of variables do have an influence on the construction process and can lead to variations. These comprise resource availability, performance of the parties in the construction process, conditions of the environment and contractual occurrences. These sources and causes can lead to delays and late completion (Clough and Sears, 1994).

Kumaraswamy *et al.* (1998) conducted a study in Hong Kong. Civil and road projects were studied, and it was found out variations led to over twenty percent increase in time overruns. Cost overruns was also estimated around fifty percent. Kaming *et al*. (1997) found that variations led to huge time overruns as well as cost overruns. The major influencing factors of variation were errors in cost estimation, inflations, and complexity of project. The time overruns were influenced by shortage in labour and materials, low labour productivity, poor planning and changes in the design.

The effects of variations vary from project to project as well as country to country. It is a general fact that variations lead to distasteful impact on costs and time (CII, 1994; Ibbs *et al*., 2001). Variations slow down the pace of construction works and causes targets to be unmet (Ibbs, 1997). Zeitoun and Oberlender (1993) found that change orders cause delays up to ten percent in time.

Table 4.8 Effects of variations on road projects

Effects	Mean	Std. Deviation	Ranking
Completion schedule delay	4.13	0.772	1st
Causes rework	4.05	0.893	2nd
Additional payments for contractor	4.02	1.102	3rd
Disputes among professionals	3.99	0.630	4th
Blemish firm's reputation	3.96	0.895	5th
Leads to demolition	3.87	0.785	6th
Materials delays	3.82	1.232	7th
Quality of projects	3.77	0.895	8th
Productivity degradation	3.75	0.773	9th
Poor safety conditions	3.68	0.884	10th
Delay in completion	3.48	0.769	11th
Logistics delays	3.48	1.192	12th
Poor professional relations	3.33	0.956	13th
Plant and equipment delay	3.30	1.102	14th
Procurement delay	3.27	0.630	15th

4.6 STRATEGIES TO MINIMIZE VARIATIONS IN ROAD PROJECTS

In this section, the respondents were asked to rank the sources of variation orders in road projects on a Likert scale of 1 to 5 where 1=Not important at all; 2=Not important; 3=Neutral; 4=Important; 5=Very important. Mean score ranking using the mean values and standard deviation were used in ranking the effects. From Table 4.8 below, *Extensive planning is required by all parties before commencement of works* was ranked 1st with mean of 4.13 and standard deviation of 0.893. *Consultant co-ordination is essential at the design stage* was ranked 2nd with mean of 3.94 and standard deviation of 1.032. *Supervision of works should be well undertaken* was ranked 3rd with mean of 3.87 and standard deviation of 0.773. *Consultants should produce designs and contracts that are conclusive* was ranked 4th with mean of 3.82 and standard deviation of 0.825. *Enough time must be provided for pre-tender planning* was ranked 5th with mean of 3.76 and standard deviation of 0.679.

Baharuddin (2005) suggested that change orders will be reduced if the stakeholders involved are made aware of preliminary work before tendering is undertaken. This includes detailed soil and site investigations. There cannot be a complete avoidance of design errors and omissions. There can be a minimization if the designers consider their workload before deciding to accept new contracts (Ruben, 2008). Designers and consultants should have adequate time and professionals who are well experienced to undertake sufficient designs.

Arain (2005) suggested that since variations occur less at the design stage, there must be control systems instituted to control the variations, so the project owners can ultimately benefit. Organizations into project design must be encouraged to have departments in charge of quality control. Their responsibility will be to verify the designs and ensure adequate sanctions meted out to defaulters. Structural engineers must be made to undertake structural analysis and design detailing before construction.

Civil engineers must not be allowed to perform roles outside their professional jurisdiction. Structural engineers must also adhere to using the right softwares for design in order to accurately estimate the right sizes and quantity of reinforcement for the designs. This will prevent variations as well as reduce project collapse. Ye *et al.* (2004) advised on proper implementation of management system for sites as a critical way of preventing reworks. Site supervisors can reduce the quantum of rework by giving attention to mistakes and improving workmanship quality (Hwang and Yang, 2004; Love and Edwards, 2004; Alwi *et al.,* 2001).

Table 4.9 Strategies to minimize variations on road projects

Strategies	Mean	Std. Deviation	Ranking
Extensive planning is required by all parties before commencement of works	3.94	1.032	1st
Consultant co-ordination is essential at the design stage	3.91	0.895	2nd
Supervision of works should be well undertaken	3.87	0.773	3rd
Consultants should produce designs and contracts that are conclusive	3.82	0.825	4th
Enough time must be provided for pre-tender planning	3.76	0.679	5th
Designs and specifications must be within approved budget	3.71	0.734	6th
Changes to specifications should be avoided	3.65	0.562	7th
Detailed site investigations must be undertaken during tendering	3.62	0.786	8th
Drawings must be finished and concluded at tender stage	3.54	0.876	9th
Clients must provide a brief scope of works	3.48	1.007	10th
Budget team must be involved in works at the design stage	3.44	0.734	11th
Communication channels must be enhanced among the parties	3.39	0.985	12th
Forecasting should be undertaken by all parties to have an idea of unforeseen circumstances	3.37	0.993	13th
Procurement procedures for materials and equipment must be well undertaken	3.29	1.007	14th
Land application and purchase must be completed before the award of contracts	3.21	0.865	15th
Underground cable routes must be confirmed by local authorities before construction	3.18	0.734	16th

4.7 RELIABILITY OF THE RESPONSES RECEIVED

This section sought to check the internal consistency of the questionnaire responses of this study by conducting a reliability analysis. Tavakol and Dennick (2011) postulated that a Cronbach's alpha coefficient value between 0.700 and 0.900 is good for a research. From the Cronbach's Alpha coefficient value from the variables as shown in Table 4.10, the value was 0.786. This is above the cut-off limit of 0.700 thereby implying that all the responses are reliable.

Table 4.10 Reliability Statistics

	Number of Items	Cronbach's Alpha Coefficient
Variables	62	0.786

4.8 ANALYSIS OF VARIATION ORDERS BY WORK SECTIONS OF ROAD PROJECTS SUPERVISED BY FEEDER ROADS IN THE ASHANTI REGION

Table 4.11 details project data collection on fifteen projects in Ashanti region. The work sections considered were general items, demolition and site clearance, earthworks, in-situ concrete, concrete ancillaries, pipe works, pipe work support, drain and ditches, roads and pavings as well as miscellaneous.

Some new works items were also introduced within the work sections whereas some of the road lengths were also extended. Half of the provision for contingency amount (Physical Contingency) on each project goes into Variations

In the valuation of the variation orders, rates in the Bill of Quantities were used for work in the variation order that corresponded with an item description in the Bill of Quantities. If the Variation does not correspond with items in the Bill of Quantities, the

Contractor was requested to submit a quotation in the form of new rate for the related items of work.

Most of the variation orders in the work sections were positive which indicates an increase (additions) in the original scope of works. Those with negative were omissions indicating savings on the original scope of works.

After valuation, a variation order within the physical contingency is approved by the Director of Feeder Roads (Entity Head). If the variation Order amounts to an increase of up to 10% of the original contract price, it is approved by the Director of Feeder Roads after informing the Entity Tender Review Committee (Feeder Roads).

Also, any variation order with cumulative increase in the contract price by more than 10% receives approval from the Director of Feeder Roads but with prior information of the Central Tender Review Committee (PPA, 2003).

In summary, the tables below showed the contract sums in the BOQ, the amount of variations for the various work sections as well as the percentage cost overrun.

Table 4.11 Variation orders by work sections of 15 selected projects

		WORK SECTIONS IN VARIATION ORDERS											
NO.	**PROJECT NAME**	**GENERAL ITEMS (GH¢)**			**DEMOLITION AND SITE CLEARANCE (GH¢)**			**EARTHWORKS (GH¢)**			**INSITU CONCRETE (GH¢)**		
		BOQ	**Variation Order**	**% Cost Overrun**	**BOQ**	**Variation Order**	**% Cost Overrun**	**BOQ**	**Variation Order**	**% Cost Overrun**	**BOQ**	**Variation Order**	**% Cost Overrun**
1	BITUMEN SURFACING OF SUBRISO JN. - SUBRISO FEEDER ROAD (8.00KM)				65,686.00	9,434.00	14%	529,588.34	218,132.24	41%	341,546.03	199,231.87	58%
2	BITUMEN SURFACING OF ANYINASUSO - ABONSUASO - NYAMEADOM - DANYAME FEEDER ROAD (14.00KM)				147,320.00	-6,160.00	-4%	585,140.00	13,910.00	2%	102,781.80	10,586.10	10%
3	BITUMEN SURFACING OF SARFOKROM - DAABAN FEEDER ROAD (12.00KM)	1,068,175.00	9,150.00	1%	79,335.00	6,561.00	8%	858,399.50	962,475.91	112%	285,828.00	15,436.00	5%
4	BITUMEN SURFACING OF DAWUSASO - AYIEM - DAWENASE FEEDER ROAD (14.00KM)	3,350.85	420.00	13%	61,000.00	56,335.00	92%	1,035,069.00	338,064.70	33%	261,064.00	257,203.83	99%
5	REHABILITATION OF NFENSI - ASAKRAKA - KONTONMIRE - NEREBEHI FEEDER ROAD (10.00KM	240,825.00	92,500.00	0.38%	52,364.00	12,260.00	23%	419,367.02	-119,186.64	-28%	82,257.20	93,632.40	114%

		WORK SECTIONS IN VARIATION ORDERS											
NO.	**PROJECT NAME**	**CONCRETE ANCILLARIES (GH¢)**			**PIPE WORK – PIPES (GH¢)**			**PIPE WORK – SUPPORT AND PROTECTION, ANCILLARIES TO LAYING AND EXCAVATION (GH¢)**			**DRAINS AND DITCHES (GH¢)**		
		BOQ	**Variation Order**	**% Cost Overrun**	**BOQ**	**VARIATION ORDER**	**% Cost Overrun**	**BOQ**	**Variation Order**	**% Cost Overrun**	**BOQ**	**Variation Order**	**% Cost Overrun**
1	BITUMEN SURFACING OF SUBRISO JN. - SUBRISO FEEDER ROAD (8.00KM)	139,739.70	2,955.00	2%	321,264.00	-135,764.00	-42%	331,794.00	-127,563.00	-38%	1,621,960.89	397,891.66	25%
2	BITUMEN SURFACING OF ANYINASUSO - ABONSUASO - NYAMEADOM - DANYAME FEEDER ROAD (14.00KM)	36,365.00	-15,800.00	-43%	173,000.00	18,200.00	11%	190,000.00	6,487.70	3%	994,161.40	1,312,555.00	132%
3	BITUMEN SURFACING OF SARFOKROM - DAABAN FEEDER ROAD (12.00KM)	35,880.00	66,000.00	184%	40,052.00	149,048.00	372%	530,400.00	122,780.00	23%	3,109,310.00	-36,898.20	-1%
4	BITUMEN SURFACING OF DAWUSASO - AYIEM - DAWENASE FEEDER ROAD (14.00KM)	59,510.00	-13,563.00	-23%	443,120.00	112,742.00	25%	378,700.00	63,292.50	17%	1,55,945.10	1,477,224.94	140%
5	REHABILITATION OF NFENSI - ASAKRAKA - KONTONMIRE - NEREBEHI FEEDER ROAD (10.00KM)	16,348.00	8,697.00	53%	130,360.00	50,650.00	39%	113,460.00	48,490.00	43%	693,866.31	99,494.69	14%

NO.	PROJECT NAME	WORK SECTIONS IN VARIATION ORDERS						TOTAL VARIATION ORDER (GH¢)	REASONS FOR VARIATION ORDER	SOURCE OF VARIATION ORDER
		ROADS AND PAVINGS (GH¢)			MISCELLANEOUS (GH¢)					
		BOQ	Variation Order	% Cost Overrun	BOQ	Variation Order	% Cost Overrun			
1	BITUMEN SURFACING OF SUBRISO JN. - SUBRISO FEEDER ROAD (8.00KM)	3,322,067.28	1,037,036.92	31%	403,692.00	-261,344.00	-65%	1,340,010.69	Extension of the road length	Employer
2	BITUMEN SURFACING OF ANYINASUSO - ABONSUASO - NYAMEADOM - DANYAME FEEDER ROAD (14.00KM)	5,156,119.60	395,282.00	8%	555,000.00	-123,900.00	-22%	1,611,160.80	Addition of drainage structures	Consultant
3	BITUMEN SURFACING OF SARFOKROM - DAABAN FEEDER ROAD (12.00KM)	5,149,096.00	703,946.80	14%	358,230.00	-17,340.00	-5%	1,972,009.51	Extension of the road length	Employer
4	BITUMEN SURFACING OF DAWUSASO - AYIEM - DAWENASE FEEDER ROAD (14.00KM)	36,963,349.90	346,552.80	5%	727,022.00	-514,222.00	-71%	2,123,630.77	Addition of drainage structures	Consultant
5	REHABILITATION OF NFENSI - ASAKRAKA - KONTONMIRE - NEREBEHI FEEDER ROAD (10.00KM	466,750.00	90,611.88	19%				284,649.33	Extension of the road length	Employer

	WORK SECTIONS IN VARIATION ORDERS												
NO.	**PROJECT NAME**	**GENERAL ITEMS (GH¢)**			**DEMOLITION AND SITE CLEARANCE (GH¢)**			**EARTHWORKS (GH¢)**			**INSITU CONCRETE (GH¢)**		
		BOQ	**VARIATION ORDER**	**% COST OVERRUN**	**BOQ**	**VARIATION ORDER**	**% COST OVERRUN**	**BOQ**	**VARIATION ORDER**	**% COST OVERRUN**	**BOQ**	**VARIATION ORDER**	**% COST OVERRUN**
6	BITUMEN SURFACING OF NTORAKU JN. - NTORAKU FEEDER ROAD (4.90KM)	1,116,400.00	15,250.00	1%	4,745.00	56,930.00	1200%	548,991.00	304,250.00	55%	250,058.00	80,931.00	32%
7	BITUMEN SURFACING OFATAASE NKWANTA - OWUSUKROM FEEDER ROAD (16.40KM)				108,467	3,076.00	3%	150,068.80	214,140.05	143%	60,084.30	157,566.40	262%
8	BITUMEN SURFACING OF BEKWAI - ADANKRAGYA - HOMASE AND ADANKRAGYA TOWN ROADS (14.65KM)				51,903.00	12,600.00	24%	1,181,896.30	383,811.55	32%	169,401.60	102,576.00	61%
9	BITUMEN SURFACING OF MANFO - SUBRISO - FANTI FEEDER ROAD (18.80KM)	4,160,125.00	-499,250.00	-12%	124,355.00	60,548.00	49%	385,712.74	1,352,233.24	351%	104,583.40	63,374.00	61%
10	BITUMEN SURFACING OF (A) ATAASE NKWANTA - OWUSUKROM PH2 (KM 0.00 - 6.40) AND (B) DOMPOASE TOWN FEEDER ROAD (4.10KM)	1,630,357.00	28,750.00	2%	42,260.00	-185	-0.44%	613,691.40	147,493.80	24%	266,085.60	-43,316.34	-16%

		WORK SECTIONS IN VARIATION ORDERS											
NO.	**PROJECT NAME**	**CONCRETE ANCILLARIES (GH¢)**			**PIPE WORK – PIPES (GH¢)**			**PIPE WORK – SUPPORT AND PROTECTION, ANCILLARIES TO LAYING AND EXCAVATION (GH¢)**			**DRAINS AND DITCHES (GH¢)**		
		BOQ	**VARIATION ORDER**	**% COST OVERRUN**	**BOQ**	**VARIATION ORDER**	**% COST OVERRUN**	**BOQ**	**VARIATION ORDER**	**% COST OVERRUN**	**BOQ**	**VARIATION ORDER**	**% COST OVERRUN**
6	BITUMEN SURFACING OF NTORAKU JN. - NTORAKU FEEDER ROAD (4.90KM)	169,795.00	21,185.00	12%	82,000.00	80,702.00	98%	99,000.00	101,625.00	103%	1,439,077.70	241,014.80	17%
7	BITUMEN SURFACING OFATAASE NKWANTA - OWUSUKROM FEEDER ROAD (16.40KM)	12,883.00	22,240.00	173%	68,850.00	1,530.00	2%	90,000.00	2,000.00	2%	1,781,100.00	-29,298.60	-2%
8	BITUMEN SURFACING OF BEKWAI - ADANKRAGYA - HOMASE AND ADANKRAGYA TOWN ROADS (14.65KM)	52,152.00	8,333.00	-16%	271,200.00	762,800.00	97%	266,870.00	264,830.00	99%	3,588148.60	901,891.00	25%
9	BITUMEN SURFACING OF MANFO - SUBRISO - FANTI FEEDER ROAD (18.80KM)	21,958.00	3,339.00	15%	116,000.00	187,570.00	162%	145,000.00	160,740.00	111%	1,636,168.56	-88,400.00	-5%
10	BITUMEN SURFACING OF (A) ATAASE NKWANTA - OWUSUKROM PH2 (KM 0.00 - 6.40) AND (B) DOMPOASE TOWN FEEDER ROAD (4.10KM)	29,324.00	-3,990.2	-14%	545,600.00	129,120.00	24%	11,810.00	8,700.00	74%	3,508,893.98	1,396,908.90	40%

		WORK SECTIONS IN VARIATION ORDERS								
NO.	PROJECT NAME	ROADS AND PAVINGS (GH¢)			MISCELLANEOUS (GH¢)			TOTAL VARIATION ORDER (GH¢)	REASONS FOR VARIATION ORDER	SOURCE OF VARIATION ORDER
		BOQ	VARIATION ORDER	% COST OVERRUN	BOQ	VARIATION ORDER	% COST OVERRUN			
6	BITUMEN SURFACING OF NTORAKU JN. - NTORAKU FEEDER ROAD (4.90KM)	2,466,729.20	96,817.75	4%				983,455.95	Addition of drainage structures	Consultant
7	BITUMEN SURFACING OFATAASE NKWANTA - OWUSUKROM FEEDER ROAD (16.40KM)	5,812,867.40	949,336.40	16%	661,107.00	-422,644.00	-64%	897,946.25	Addition of drainage structures and filling at low lying sections	Consultant
8	BITUMEN SURFACING OF BEKWAI - ADANKRAGYA - HOMASE AND ADANKRAGYA TOWN ROADS (14.65KM)	5,691,814.80	289,823.40	5%	368,822.20	-147,900.00	-40%	2,062,098.95	Extension of the road length, addition of drainage structures and cut to widen	Consultant
9	BITUMEN SURFACING OF MANFO - SUBRISO - FANTI FEEDER ROAD (18.80KM)	8,122,432.60	-25,230.60	-0.31%	750,031.00	-141,563.00	-19%	1,572,570.64	Filling at low lying sections	Consultant
10	BITUMEN SURFACING OF (A) ATAASE NKWANTA - OWUSUKROM PH2 (KM 0.00 - 6.40) AND (B) DOMPOASE TOWN FEEDER ROAD (4.10KM)	4,096,329.80	628,381.83	15.34%	408,980.00	-96,080.00	-23%	1,947,433.49	Addition of drainage structures	Consultant

	WORK SECTIONS IN VARIATION ORDERS												
NO.	**PROJECT NAME**	**GENERAL ITEMS (GH¢)**			**DEMOLITION AND SITE CLEARANCE (GH¢)**			**EARTHWORKS (GH¢)**			**INSITU CONCRETE (GH¢)**		
		BOQ	**VARIATION ORDER**	**% COST OVERRUN**	**BOQ**	**VARIATION ORDER**	**% COST OVERRUN**	**BOQ**	**VARIATION ORDER**	**% COST OVERRUN**	**BOQ**	**VARIATIO N ORDER**	**% COST OVERRUN**
11	BITUMEN SURFACING OF EJISU - APROMASE FEEDER ROAD (17.25KM)				147,214.00	39,590.00	27%	1,347,878.20	-20,190.15	-1%	206,371.30	40,859.40	20%
12	BITUMEN SURFACING OF WORASO - AHINSAN FEEDER ROAD (5.40KM)				44,850.00	240.00	1%	1,127,485.40	507,802.00	45%	-	-	-
13	BITUMEN SURFACING OF BROFOYEDRU - KOKOBENG - FOASE FEEDER ROAD (18.0KM)				89,372.00	5,460.00	6%	1,407,528.00	408,697.00	29%	327,356.60	-45,515.20	-14%
14	BITUMEN SURFACING OF ASABI - BUOBAI FEEDER ROAD (4.00KM)	995,100.00	18,300.00	2%				712,403.90	351,275.24	49%	44,058.00	69,857.40	159%
15	BITUMEN SURFACING OF FIANKOMA - HIA FEEDER ROAD (14.52KM)							793,799.00	946,652.00	119%	130,746.20	295,029.60	226%

		WORK SECTIONS IN VARIATION ORDERS											
NO.	PROJECT NAME	CONCRETE ANCILLARIES (GH¢)			PIPE WORK – PIPES (GH¢)			PIPE WORK – SUPPORT AND PROTECTION, ANCILLARIES TO LAYING AND EXCAVATION (GH¢)			DRAINS AND DITCHES (GH¢)		
		BOQ	VARIATION ORDER	% COST OVERRUN	BOQ	VARIATION ORDER	% COST OVERRUN	BOQ	VARIATION ORDER	% COST OVERRUN	BOQ	VARIATION ORDER	% COST OVERRUN
11	BITUMEN SURFACING OF EJISU - APROMASE FEEDER ROAD (17.25KM)	35,950.00	5,750.00	16%	444,260.00	-60,2000	-36%	431,340.00	-177,570.00	-41%	8,341,726.80	2,026,718.10	24%
12	BITUMEN SURFACING OF WORASO - AHINSAN FEEDER ROAD (5.40KM)										1,583,935.80	443,452.40	28%
13	BITUMEN SURFACING OF BROFOYEDRU - KOKOBENG - FOASE FEEDER ROAD (18.0KM)	217,920.00	-97,000.00	-45%	368,700.00	195,300.00	53%	345,700.00	52,030.00	15%	6,397,578.80	3,873,591.0	61%
14	BITUMEN SURFACING OF ASABI - BUOBAI FEEDER ROAD (4.00KM)	5,603.00	8,697.00	155%	202,650.00	-2,364.00	-1%	3,931,220.20	-4,080.00	-0.1%	110,100.00	961,321.80	873%
15	BITUMEN SURFACING OF FIANKOMA - HIA FEEDER ROAD (14.52KM)	26,597.00	64,706.0	243%	123,400.00	263,280.00	213%	147,000.00	303,800.00	207%	2,005,077.70	1,722,876.7	86%

		WORK SECTIONS IN VARIATION ORDERS						TOTAL VARIATION ORDER (GH¢)	REASONS FOR VARIATION ORDER	SOURCE OF VARIATION ORDER
NO.	PROJECT NAME	ROADS AND PAVINGS (GH¢)			MISCELLANEOUS (GH¢)					
		BOQ	VARIATION ORDER	% COST OVERRUN	BOQ	VARIATION ORDER	% COST OVERRUN			
11	BITUMEN SURFACING OF EJISU - APROMASE FEEDER ROAD (17.25KM)	10,299,829.5	240,876.40	2%				1,995,833.75	Extension of road length	Employer
12	BITUMEN SURFACING OF WORASO - AHINSAN FEEDER ROAD (5.40KM)	2,443,820.80	-64,193.10	-3%				887,301.30	Cutting and filling at embankment sections to determine safe alignment of road	Consultant
13	BITUMEN SURFACING OF BROFOYEDRU - KOKOBENG - FOASE FEEDER ROAD (18.0KM)	10,710,406.6	188,095.70	2%				4,475,843.70	Addition of drainage structures	Consultant
14	BITUMEN SURFACING OF ASABI - BUOBAI FEEDER ROAD (4.00KM)	264,371.90	460,346.00	174%				1,772,943.04	Extension of road length	Employer
15	BITUMEN SURFACING OF FIANKOMA - HIA FEEDER ROAD (14.52KM	9,759,633.80	58,561.80	1%	1,157,792.0	-661,727.20	-57%	2,728,090.50	Addition of drainage structures and utting and filling at embankment sections	Consultant

4.8.1 Effects of variation orders on the cost of the fifteen selected road projects

This section sought to do an analysis of the fifteen projects and find out the effects of the variation orders on the cost of selected road projects. The parameters considered in the analysis included the initial contract sum of the project. The estimated cost of the projects without contingency were provided. After physical contingency was added to this value, estimated cost of the projects plus contingency was derived. After the estimated cost of the projects plus variations were calculated, it helped in deducing the percentage cost overrun of the projects. While majority of the projects had cost overruns to be positive implying the variations had caused the cost to increase, a few of the projects had negative percentage implying the costs savings had been made. This was due to omissions in the work items within the work section of the project.

Project no.13 which was Bitumen Surfacing of Brofoyedru – kokobeng -Foase Feeder Road (18.00km) had the highest cost overrun of 8.1 percent.

The analysis showed that 80% of the projects overrun their scheduled amount in the contract which indicates that even though those projects did not overrun their contract price, part of the price contingency was absorbed into the variation orders. Also savings were made on 20% of the projects. The investigation also revealed that 7% of the projects exceeded the initial contract sum.

Table 4.12 Effects of variation orders on cost of fifteen selected projects

PROJECT DATA			COST ANALYSIS					
NO.	PROJECT NAME	LENGTH	INITIAL CONTRACT SUM	ESTIMATED COST OF WORKS WITHOUT CONTINGENCY	PHYSICAL CONTINGENCY	ESTIMATED COST OF WORKS PLUS PHYSICAL CONTINGENCY	ESTIMATED COST OF WORKS PLUS VARIATION ORDERS	% OF COST OVERRUN
1	BITUMEN SURFACING OF SUBRISO JN. - SUBRISO FEEDER ROAD (8.00KM)	8	9,663387.21	7,488,413.24	1,087486.99	8,575,900.23	8,828,423.93	2.9%
2	BITUMEN SURFACING OF ANYINASUSO - ABONSUASO - NYAMEADOM - DANYAME FEEDER ROAD (14.00KM)	14	10,708,654.14	8,269,387.80	1,219,633.17	9,489,020.97	9,880,548.60	4.0%
3	BITUMEN SURFACING OF SARFOKROM - DAABAN FEEDER ROAD (12.00KM)	12	15,300,867.15	11,914,705.50	1,639,080.83	13,553,786.33	13,866,715.01	2.4%
4	BITUMEN SURFACING OF DAWUSASO - AYIEM - DAWENASE FEEDER ROAD (14.00KM)	14	14,700,274.75	11,339,865.00	1,68,204.75	13,020,069.75	13,463,495.77	3.3%
5	REHABILITATION OF NFENSI - ASAKRAKA - KONTONMIRE - NEREBEHI FEEDER ROAD (10.00KM)	10	2,838,843.79	2,215,687.53	311,578.13	2,527,265.66	2,500,336.86	-1.1%
6	BITUMEN SURFACING OF NTORAKU JN. - NTORAKU FEEDER ROAD (4.90KM)	4.9	8,103,501.17	6,401,000.90	851,250.14	7,252,251.04	7,384,456.85	1.8%
7	BITUMEN SURFACING OFATAASE NKWANTA - OWUSUKROM FEEDER ROAD (16.40KM)	16.4	12,0406,83.12	10,208,652.60	915,015.26	11,124,667.86	11,106,598.85	-0.2%
8	BITUMEN SURFACING OF BEKWAI - ADANKRAGYA - HOMASE AND ADANKRAGYA TOWN ROADS (14.65KM)	14.65	16,704,624.62	13,090,057.40	1,807,283.61	14,897,341.01	15,152,156.35	1.7%
9	BITUMEN SURFACING OF MANFO - SUBRISO - FANTI FEEDER ROAD (18.80KM)	18.8	17,803,939.55	15,566,365.80	1,238,786.59	16,805,152.39	17,138,936.44	1.9%
10	BITUMEN SURFACING OF (A) ATAASE NKWANTA - OWUSUKROM PH2 (KM 0.00 - 6.40) AND (B) DOMPOASE TOWN FEEDER ROAD (4.10KM)	10.5	15,200,129.48	11,962,522.00	1,618,803.40	13,381,325.40	14,129,355.49	3.9%
11	BITUMEN SURFACING OF EJISU - APROMASE FEEDER ROAD (17.25KM)	17.25	22,506,043.2	17,992,030.00	2,257,004.50	20,249,034.50	19,987,863.75	-1.3%
12	BITUMEN SURFACING OF WORASO - AHINSAN FEEDER ROAD (5.40KM)	5.4	7,800,234.6	6,123,642.00	838,296.30	6,961,938.30	7,010,943.30	0.7%
13	BITUMEN SURFACING OF BROFOYEDRU - KOKOBENG - FOASE FEEDER ROAD (18.0KM)	18	26,048,268.93	23,267,187.00	2,221,868.70	25,489,055.70	27,743,030.70	8.1%
14	BITUMEN SURFACING OF ASABI - BUOBAI FEEDER ROAD (4.00KM)	4	10,549,558.1	8,261,237.00	1,194,160.50	9,455,397.50	10,034,180.04	5.8%
15	BITUMEN SURFACING OF FIANKOMA - HIA FEEDER ROAD (14.52KM)	14.52	20,506,862.21	16,010,701.70	2,248,080.26	18,258,781.96	18,738,792.20	2.6%

4.8.2 Effects of variation orders on the time of the fifteen selected road projects

This section sought to do an analysis of the fifteen projects and find out the effects of the variation orders on the project time of the selected road projects. The parameters considered in the analysis included the award date, the month project started, intended completion date, actual completion date, contract duration, revised duration based on variations in months, percentage time overrun as well as percentage completion of the projects to date.

In all 60 percent of the projects had been completed and 27 percent of the projects were completed within the original contract duration. 47 percent of the projects received extention of time and 71 percent out of the total number of projects that received extension of time were completed within the extended time. Project one which was Bitumen Surfacing of Subriso Jn. - Subriso Feeder Road (8.00km) was originally intended for 12 months. The revised contract time based on variations was 16 months but actual completion took 24 months. The project is currently completed but the time overrun was 33.3 percent.

Extension of time was not received by 53% of the projects even though Variations were introduced. Project two had a time overrun of -25 percent implying the project was completed before the estimated completion time. This is evident in the completion time of 9 months instead of the estimated 12 months. This could possibly be due to variations being omissions.

A total of 73% of the projects had overrun their original contract duration.

Table 4.13 Effects of variations on time of fifteen selected projects

NO.	PROJECT NAME	LENGTH	AWARD DATE	START DATE	INTENDED COMPLETION DATE	REVISED COMPLETION DATE	ACTUAL COMPLETION DATE	CONTRACT DURATION (MONTHS)	REVISED CONTRACT DURATIONBASED ON VARIATION (MONTHS)	ACTUAL COMPLETION (MONTHS	% TIME OVER RUN	% COMP. TO DATE
1	BITUMEN SURFACING OF SUBRISO JN. - SUBRISO FEEDER ROAD (8.00KM)	8	30-10-2015	20-01-2016	21-01-2017	21-07-2017	22-01-2018	12	16	24	33.3%	100%
2	BITUMEN SURFACING OF ANYINASUSO - ABONSUASO - NYAMEADOM - DANYAME FEEDER ROAD (14.00KM)	14	30-10-2015	7-01-2016	8-01-2017	8-01-2017	01-09-2016	12	-	9	-25%	100
3	BITUMEN SURFACING OF SARFOKROM - DAABAN FEEDER ROAD (12.00KM)	12	23-06-2016	9-08-2016	8-08-2017	21-06-2018	7-06-2018	12	18	18	50%	100%
4	BITUMEN SURFACING OF DAWUSASO - AYIEM - DAWENASE FEEDER ROAD (14.00KM)	14	30-10-2015	28-01-2016	28-04-2017	8-04-2018	1-08-2017	15	24	18	20%	100%
5	REHABILITATION OF NFENSI - ASAKRAKA - KONTONMIRE - NEREBEHI FEEDER ROAD (10.00KM)	10	30-10-2015	26-01-2016	26-09-2016	26-06-2017	26-07-217	8	17	18	112.5%	100%
6	BITUMEN SURFACING OF NTORAKU JN. - NTORAKU FEEDER ROAD (4.90KM)	4.9	11-03-2016	21-04-2016	21-02-2017	26-06-2017	6-01-2017	10	14	9	-35.7%	100%

NO.	PROJECT NAME	LENGTH	AWARD DATE	START DATE	INTENDED COMPLETION DATE	REVISED COMPLETION DATE	ACTUAL COMPLETION DATE	CONTRACT DURATION (MONTHS)	REVISED CONTRACT DURATIONBASED ON VARIATION (MONTHS)	ACTUAL COMPLETION (MONTHS	% TIME OVER RUN	% COMP. TO DATE
7	BITUMEN SURFACING OFATAASE NKWANTA - OWUSUKROM FEEDER ROAD (16.40KM)	16.4	26-02-2015	29-05-2015	30-05-2016	-	22-05-2016	12	-	12	-	100%
8	BITUMEN SURFACING OF BEKWAI - ADANKRAGYA - HOMASE AND ADANKRAGYA TOWN ROADS (14.65KM)	14.65	10-02-2016	24-05-2016	24-11-2017	-	-	18	-	-	-	95%
9	BITUMEN SURFACING OF MANFO - SUBRISO - FANTI FEEDER ROAD (18.80KM)	18.8	20-02-2015	9-06-2015	20-12-2016	20-06-2017	30-03-2017	14	20	17	21.4%	100%
10	BITUMEN SURFACING OF (A) ATAASE NKWANTA - OWUSUKROM PH2 (KM 0.00 - 6.40) AND (B) DOMPOASE TOWN FEEDER ROAD (4.10KM)	10.5	11-03-2016	19-04-2016	20-04-2017	-	11-05-2017	12	-	12	-	100%
11	BITUMEN SURFACING OF EJISU - APROMASE FEEDER ROAD (17.25KM)	17.25	16-08-2016	18-09-2016	18-12-2017	9-04-2018		15	19	19	26.7%	55%

NO.	PROJECT NAME	LENGTH	AWARD DATE	START DATE	INTENDED COMPLETION DATE	REVISED COMPLETION DATE	ACTUAL COMPLETION DATE	CONTRACT DURATION (MONTHS)	REVISED CONTRACT DURATIONBASED ON VARIATION (MONTHS)	ACTUAL COMPLETION (MONTHS	% TIME OVER RUN	% COMP. TO DATE
12	BITUMEN SURFACING OF WORASO - AHINSAN FEEDER ROAD (5.40KM)	5.4	11-03-2016	27-04-2016	27-12-2017	27-06-2018		8	14	-	75%	77%
13	BITUMEN SURFACING OF BROFOYEDRU - KOKOBENG - FOASE FEEDER ROAD (18.0KM)	18	16-08-2016	16-09-2016	15-12-2017	6-04-2019		15	-	-	-	57%
14	BITUMEN SURFACING OF ASABI - BUOBAI FEEDER ROAD (4.00KM)	4	23-06-2016	19-08-2016	18-08-2017	-		12	-	-	-	67%
15	BITUMEN SURFACING OF FIANKOMA - HIA FEEDER ROAD (14.52KM)	14.52	23-06-2016	8-08-2016	17-02-2018	-		18	-	-	-	55%

4.8.3 Ranking of variations according to project work sections

After a close look at the fifteen road projects, the work sections having the most variations were sorted out as well as their percentages. For project one, In situ concrete had the highest percentage of 58. Project two had drains and ditches being the highest variation of 13 percent. Project three had pipe works-pipes having the highest percentage of variations of 372. The variations for the remaining projects are detailed out in Table 4.14.

From Table 4.15, it was seen that Drains and ditches had the highest percentage of variations on as many as 5 projects out of the fifteen. This was followed by in situ concrete having a frequency of 3. Earthworks and pipeworks both had frequencies of 2. It can be inferred that from the project data collected, drains and ditches were the main work sections that experienced most variations on road projects.

Looking at the responses obtained in the questionnaires from Section 4.3 when asked about work sections experiencing most variations, *Roads and pavings* was ranked 1st. *Pipe works* was ranked 2nd. *Concrete ancillaries* was ranked 3rd. *Drain and ditches* was ranked 4th. *In-situ concrete* was ranked 5th. This implies that there were some differences in the responses analysed from the questionnaires and the information from the project data collected.

Table 4.14 Work sections with the most variations

Project	Work section	Percentage %
1	In situ concrete	58
2	Drains and ditches	13
3	Pipe works-pipes	372
4	Drains and ditches	140
5	In situ concrete	114
6	Pipe works- support and protection	103
7	In situ concrete	262
8	Pipe works-pipes	97
9	Earthworks	351
10	Drains and ditches	40
11	Demolition and site clearance	27
12	Earthworks	45
13	Drains and ditches	61
14	Drains and ditches	873
15	Concrete ancillaries	243

Table 4.15 Number of times work section has most variations

Work section	Frequency	Ranking
Drains and ditches	5	1st
In situ concrete	3	2nd
Pipe works-pipes	2	3rd
Earthworks	2	3rd
Demolition and site clearance	1	4th
Concrete ancillaries	1	4th
Pipe works- support and protection	1	4th
Total	**15**	

CHAPTER FIVE

SUMMARY OF FINDINGS AND RECOMMENDATIONS

5.1 INTRODUCTION

This research which was on categorization of sources of variations in road construction projects was divided into five interdependent chapters. Chapter one was the general introduction. Chapters two was the literature review. Chapter three was the research methodology of the study. Chapter four was the data analysis and discussion of the results. This fifth chapter is the final chapter of the research. It details out the summary of findings, recommendations, and recommendations for future research.

5.2 ATTAINMENT OF RESEARCH OBJECTIVES

The aim of this research was to categorize the sources of variation orders in road projects. In a bid to accomplish the above stated aim, specific objectives were articulately set.

5.2.1 To identify work sections in road projects that are predominantly affected by variations

With background information from literature review conducted, nine work sections were identified. Respondents were asked to rate on a 5-point Likert scale. Mean score ranking was used to rank the factors.

The following were the work sections that had the most variations in descending order:

Roads and pavings; Pipe works; Concrete ancillaries; Drain and ditches; In-situ concrete.

5.2.2 To evaluate and categorize the sources of variation orders in road projects

Respondents were asked to rate the sources of variations in their categories on a 5-point Likert scale. Mean score ranking was used to rank these factors.

From client related source, *change in specifications by the owner; inadequate planning; owner's financial problems; delay in decision making*; *obstinate nature of the owner* were the most significant sources.

From the consultant/designer related source, *change in specification by the consultant; inadequate design; design complexity; inaccurate cost estimation; slow decision making* were the most significant sources.

From the contractor related source, *lack of strategic planning; reworks; contractor's financial difficulties; poor workmanship; lack of coordination between general contractors and subcontractors* were the most significant sources.

From the miscellaneous related source, *inappropriate government policies; fluctuation in prices of materials; unavailability of equipment; shortage of skilled manpower; emergency works* were the most significant sources.

5.2.3 To identify the effects of variation orders in road projects

Respondents were asked to rate these variables on a 5-point Likert scale. Mean score ranking was used to rank these factors.

Completion schedule delay; Causes rework; Additional payments for contractor; Disputes among professionals; increasing Blemish firm's reputation were the most severe effects of variations on road projects.

5.2.4 To propose strategies to minimize variation orders in road projects

Respondents were asked to rate these variables on a 5-point Likert scale. Mean score ranking was used to rank these factors. From the findings, *Extensive planning is required by all parties before commencement of works; Consultant co-ordination is essential at the design stage; Supervision of works should be well undertaken; Consultants should produce designs and contracts that are conclusive; Enough time must be provided for pre-tender planning* were the most significant strategies to minimize variations in road projects.

5.3 CONCLUSION

When there are frequent changes in scope and work parameters because of variations, this has an effect on road works quality. It is also concluded that variations can either be beneficial or detrimental. Variations that are beneficial can cause cost reduction and enhanced work quality. Variations which are detrimental are seen to be the main reasons for disputes and conflicts occurring in the construction industry.

On the work sections that are most affected by variations in road projects, the responses from respondents indicated roads and pavings while the desk review of fifteen selected projects indicated drains and ditches. In order to truly confirm the work section most affected by variation, it is expedient that the number of selected projects in future studies be increased so as to make room for generalization purposes.

5.4 RECOMMENDATIONS

Variations are a serious phenomenon in Ghanaian road construction projects. It is therefore prudent to have strategies to minimise their occurrence. The following recommendations are proposed:

- In order to minimize variations from occurring, the design team should undertake forecasting and brainstorming sessions to anticipate likely circumstances that can bring about variations;
- Supervision of works should be well undertaken. This will prevent the need for reworks and variations;
- Making changes to specifications in the bills should be avoided since they bring about changes hence leading to variations in the construction process;
- Detailed site investigations must be undertaken during the pre-tender stage. This will ensure changes are not made during the construction stage.

5.5 RECOMMENDATION FOR FUTURE RESEARCH

This adopted a quantitative approach. Future studies can explore categorization of variation sources in road approaches by adopting a qualitative approach. This study also focused on road projects. Building projects can be researched on in the future.

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APPENDIX

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

MSC CONSTRUCTION MANAGEMENT

DEPARTMENT OF BUILDING TECHNOLOGY

TOPIC: "CATEGORIZATION OF THE SOURCES OF VARIATION ORDERS IN ROAD CONSTRUCTION PROJECTS IN GHANA"

Dear Sir/Madam

RESEARCH QUESTIONNAIRE SURVEY

I am Rosemond Kusi, an MSc Construction Management student of the Kwame Nkrumah University of Science and Technology (KNUST) conducting a research on variation orders in road projects in Ghana.

This questionnaire is intended to assess the level of knowledge of Construction Professionals on Variation Orders in road projects in Ghana. The aim is to achieve the following objectives

- To identify work sections in road projects that are predominantly affected by variations
- To categorize the sources of variation orders in road projects.
- To assess the effects of variation orders in road projects.
- To propose strategies to minimize variation orders in road projects.

I would be very grateful to you if you could spend some time to participate in this survey. Your response would be highly appreciated for the success of the research.

This is purely for academic purposes and all information provided will be treated with strict confidentiality.

Kindly respond to the question by ticking the appropriate box for each item.

PART ONE: RESPONDENT PROFILE

1. Please indicate the category of profession you fall under

   [ ] Architect

   [ ] Quantity Surveyor

   [ ] Structural Engineer

   [ ] Construction Manager

   [ ] Consultant

   [ ] Others (Please specify)**………………………………**

2. How long have you been practicing?

   [ ] Less than 5 years

   [ ] 5 – 10 years

   [ ] 11 – 15 years

   [ ] 16 – 20 years

   [ ] Above 20 years

3. Have you ever been involved in a road project that had variations?

   [ ] Yes

   [ ] No

4. What are some of the ways you do categorization on your project site

   [ ] By work section

   [ ] By location

   [ ] By membership

   [ ] By general properties

   [ ] By specific properties

   [ ] By function

5. Why do you think categorization is important in road works?

[ ] To bring differentiation

[ ] To bring about order

[ ] To bring out purpose

[ ] To indicate significance

PART TWO: CATEGORIZATION OF VARIATION ORDERS BY WORK SECTIONS IN ROAD PROJECTS

Please indicate the level of severity of variations occurring on the following work sections in the road industry using the following scale. **[1=Not severe at all; 2=Not severe; 3=Neutral; 4= Severe; 5=Very severe]**. Please tick (√) in the space provided.

No	**CATEGORIZATION BY WORK SECTIONS**	**1**	**2**	**3**	**4**	**5**
1	General items					
2	Demolition and site clearance					
3	Earthworks					
4	In-situ concrete					
5	Concrete ancillaries					
6	Pipe works					
7	Pipe work support and protection					
8	Drain and ditches					
9	Roads and pavings					
	Any other, please state and rank					

PART THREE: SOURCES OF VARIATIONS IN ROAD PROJECTS

Please indicate the level of importance of the following sources of variations in the construction industry using the following scale. **[1=Not important at all; 2=Not important; 3=Neutral; 4=Important; 5=Very important]**. Please tick (√) in the space provided.

No	SOURCES	1	2	3	4	5
	Client Related Source					
	Owner's financial problems					
	Obstinate nature of the owner					
	Change in specifications by the owner					
	Poor procurement process					
	Conflicts among contract documents					
	Inadequate planning					
	Selection of inappropriate contractors					
	Delay in decision making					
	Inefficient communication					
	Contractor Related Source					
	Contractor's financial difficulties					
	Lack of strategic planning					
	Poor workmanship					
	Poor financial control					
	Lack of coordination between general contractors and subcontractors					
	Inappropriate contractor's policies					
	Reworks					
	Designer/Consultant Related Source					
	Inadequate design					
	Slow decision making					
	Change in design by the consultant					
	Design complexity					

	Change in specification by the consultant					
	Inadequate site investigation					
	Inaccurate cost estimation					
	Miscellaneous Related Source					
	Unavailability of equipment					
	Shortage of skilled manpower					
	Force majeure					
	Adverse effect of weather					
	Inappropriate government policies					
	Fluctuation in prices of materials					
	Unexpected ground conditions					
	Emergency works					

PART FOUR: EFFECTS OF VARIATIONS ON ROAD PROJECTS

Please indicate the level of importance of the following effects of variations on road projects using the following scale. **[1=Not important at all; 2=Not important; 3=Neutral; 4=Important; 5=Very important]**. Please tick (√) in the space provided.

No	**EFFECTS**	**1**	**2**	**3**	**4**	**5**
1.	Delay in completion					
2.	Quality of projects					
3.	Causes rework					
4.	Logistics delays					
5.	Productivity degradation					
6.	Procurement delay					
7.	Rework and demolition					
8.	Materials delays					
9.	Blemish firm's reputation					
10.	Poor safety conditions					
11.	Poor professional relations					
12.	Additional payments for contractor					
13.	Disputes among professionals					
14.	Completion schedule delay					
15.	Plant and equipment delay					
	Any other, please state and rank					

PART FIVE: STRATEGIES TO MINIMIZE VARIATIONS IN ROAD PROJECTS

Please indicate the level of importance of the following strategies to minimise variations in the construction industry using the following scale. **[1=Not important at all; 2=Not important; 3=Neutral; 4=Important; 5=Very important]**. Please tick (√) in the space provided.

No.	STRATEGIES	1	2	3	4	5
1.	Consultants should produce designs and contracts that are conclusive					
2.	Extensive planning is required by all parties before commencement of works					
3.	Drawings must be finished and concluded at tender stage					
4.	Enough time must be provided for pre-tender planning					
5.	Clients must provide a brief scope of works					
6.	Consultant co-ordination is essential at the design stage					
7.	Forecasting should be undertaken by all parties to have an idea of unforeseen circumstances					
8.	Communication channels must be enhanced among the parties					
9.	Supervision of works should be well undertaken					
10.	Procurement procedures for materials and equipment must be well undertaken					
11.	Designs and specifications must be within approved budget					
12.	Budget team must be involved in works at the design stage					
13.	Detailed site investigations must be undertaken during tendering					

14.	Changes to specifications should be avoided					
15.	Underground cable routes must be confirmed by local authorities before construction					
16.	Land application and purchase must be completed before the award of contracts					
	Any other, please state and rank					