KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI

COLLEGE OF ART AND BUILT ENVIRONMENT

DEPARTMENT OF BUILDING TECHNOLOGY

PLANNING AND SCHEDULING TECHNIQUES ADOPTED BY FINANCIAL CLASS A1B1 AND A2B2 ROAD CONSTRUCTION FIRMS IN GHANA

By

TENGEY JOSEPH KWASI A., B.Sc. (Hons)

NOVEMBER, 2015

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI

COLLEGE OF ART AND BUILT ENVIRONMENT

DEPARTMENT OF BUILDING TECHNOLOGY

PLANNING AND SCHEDULING TECHNIQUES ADOPTED BY FINANCIAL CLASS A1B1 AND A2B2 ROAD CONSTRUCTION FIRMS IN GHANA

BY

TENGEY JOSEPH KWASI A., B.Sc. (Hons)

A dissertation submitted to the Department of Building Technology, Kwame Nkrumah University of Science and Technology, Kumasi in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN CONSTRUCTION MANAGEMENT

NOVEMBER, 2015

DECLARATION

I hereby declare that this submission is my own work towards the award of MSc Construction Management and that, to the best of my knowledge, it contains no material previously published by another person or 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.

TENGEY, Joseph Kwasi A. …… ……

(PG: 9128813) Signature Date

(Student Name & PG)

Certified by:

Dr. T. Adjei-Kumi …… ……...

(Supervisor) Signature Date

Certified by:

Dr. B. K. Baiden …… ……

(Head of Department) Signature Date

DEDICATION

This work is dedicated to GOD Almighty, my wife Mrs. Lydia Obimpeh Tengey and my children, through whose immerse support I have been able to reach this far in my education.

ACKNOWLEDGEMENT

I wish to express my profound gratitude to the Almighty GOD for the guidance and help given me throughout this programme. A special appreciation also to my supervisor Dr. Theophilus Adjei – Kumi who guided and helped me greatly to make the completion of my thesis possible despite some initial problems encountered. My

heartfelt thanks go to my uncle who supported my education from sixth form to tertiary. My sincere thanks go to my work colleagues and contractor friends who through their prayers, encouragement and financially support to finish the course.

To my MSc class mates, I thank you all as you always boosted my morale to move on by checking on me regularly to find out how I was faring with my work. Lastly my sincere thanks go to all Ghana Highway Authority Regional Quantity Surveyors who distribute my questionnaire and collected it on my behalf. Finally my heartfelt thanks go to all who in various ways have helped to make my research work complete especially construction workers who were respondents to my questionnaire.

May the Almighty GOD richly bless you all.

ABSTRACT

Planning and scheduling of construction works are fundamental to successful project delivery. Planning and scheduling is useful in the delivery of construction projects within budget; judicious use of resources such as labour, plants and equipment and time. In spite of their usefulness in the construction of projects such as roads, planning and scheduling has not been a smooth process and the construction industry for that matter road contractors have not achieve much success. Clearly, poor road construction planning and scheduling has resulted into waste of resources leading to delayed project completion. Furthermore poor planning and scheduling has led to the idleness of key road construction resources notably labour, plant and equipment and increase in

construction cost as a result of delay in project completion. Similarly, the planning and scheduling of construction activities using inappropriate planning and scheduling techniques is common among planners and schedulers in the industry. In the light of this, the conduct of this study was to explore construction planning and scheduling among class A1B1 and A2B2 road contractors in Ghana in order to improve upon the existing planning and scheduling techniques. To attain this aim, a quantitative approach was adopted using structured survey questionnaire to collect data from respondents which yielded a response rate of 79%. The study uncovered existing planning and scheduling tools in the road construction sector as bar charts/Gantt chart; programme evaluation and review technique (PERT); critical path method (CPM); and flow charts. Also the study found Microsoft Project as the main computer software for planning and scheduling road construction works while the resources needed for successful planning and scheduling were found to be the bills of quantities; designs and drawings; construction method statements; specification; site conditions; local resources; market survey; project planning data; and technical and commercial studies documents. In view of the findings of this study, it is recommended that the findings of this study in relation to the processes for planning and scheduling must be adhered to during road construction planning and scheduling. Also documents and resources required for road construction planning and scheduling must always be made available before the commencement of planning and scheduling. Likewise, there should be proper record and document management in order to effective plan and schedule road construction activities. Finally, higher level tools such as mathematical programming; heuristic models; and evolutionary algorithm are employed for effective and precision planning and scheduling of road construction works.
Keywords: Road, Construction, Contractors, Planning, Scheduling, Techniques

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Construction projects are for specific duration which requires contractors to deliver their contract within the specified duration. The desire to deliver projects within a specific duration has cost and other implications for both clients and contractors. In order to deliver to the satisfaction of all project stakeholders planning and scheduling techniques are employed to deliver to specified duration. The two methods of scheduling works consist of both activity-focused concentrated and location-focused scheduling techniques. According to Gordon and Tulip (1997), the activity-focused scheduling is the most used, which was developed in the 1950s. Activity scheduling depends on logical network of activities; and dependency constraints (Dawson and Dawson, 1995).

Planning and scheduling tools have been used by engineers and other construction professionals to document plans for construction project execution (Tetsuya *et al*., 1993). Meticulous planning and scheduling of construction projects are prerequisites for successful project completion (Li *et al*., 2009). Planning and scheduling culminates into sequence of activities referred to as plans while scheduling produces sets of activities with indicted starting times, durations and resources.

Over the years, different types of planning and scheduling techniques have been adopted by construction professionals to manage construction projects. Notable among these planning and scheduling techniques are bar chart also known as Gantt

Chart (Idoro, 2010); the line of balance (Badukale & Sabihuddin , 2014); and flow charts (Hegazy & Kassab, 2003). Others include critical path method (CPM)

(Shi *et al*., 2000), network diagrams, Program Evaluation and Review Technique (Cottrell *et al*., 1999; and Lu *et al*., 2002). These construction planning and scheduling techniques are classified as linear scheduling method (Trofin, 2004).

Every construction project is in phases namely: concept, development, execution and transfer (Wideman, 2001). A perusal of tasks required at these phases of a project revealed that planning and scheduling of activities are necessary to achieve the ultimate goal of construction projects. Planning and scheduling techniques have been used in the delivery of different types of construction projects of varied nature. Repetitive constructions are the commonest of all construction projects that planning and scheduling tools have been used to deliver. Key among such project is multistory building projects requiring rhythmic planning (Mendes and Heineck, 1998).

The type of the planning tool to be used is based on the nature of the works to be done. In general construction works vary from simple buildings to complex ones and other civil works in the form of roads, dams, airports etc. The activities to be carried out under all these can be one – off or repetitive, or being linear or non – linear and complex or simple. Using a wrong planning tool for a piece of work can have negative consequences in terms of determining project duration and allocating resources and cost. Planning and scheduling have been identified as key ingredients to project success. For instance, large projects require special services notably financial accounting among others (Wideman, 2001).

Many studies have been conducted on construction scheduling and planning. Notable ones include planning and scheduling of high rise building using primavera (Subramani *et al*., 2014); the overall management of complex projects through

performance improvement by using modern techniques (Wideman, 2001); multistory building construction using linear techniques (Mendes and Heineck, 1998); among others. In spite of the substantial works done on construction planning and scheduling, road construction planning and scheduling is lagging behind (Dawood and Castro, 2009). Hence the conduct of a study focused on the planning and scheduling of road construction projects is relevant and appropriate.

1.2 Problem Statement

Construction planning and scheduling has been challenging to contractors and other project stakeholders in the management and control of construction projects. Poor scheduling has resulted in considerable waste as labourers and equipment become idle due to delayed completion of preceding tasks, limited availability of needed resources, or other space and time constraints. Recent planning and scheduling practices in the road construction sector are inefficient, which has resulted into budget overrun and time overrun (Castro and Dawood, 2005). Additionally, project leaders have depended largely on previous experiences and personal feelings in construction projects planning and scheduling notably roads and others alike (Dawood and Castro, 2009). Also, the use of planning and scheduling techniques in construction for that matter road works has not penetrated much in the construction industry (*c.f.* Kamat and Martinez, 2001; Hajar and AbouRizk, 2000). Majority of construction works are mostly carried out without the deployment of planning and scheduling techniques, a practice which has resulted into dire consequences for both clients and contractors in terms of value for money. Environmental factors and other constraints are not considered in construction projects planning and scheduling as it has the potential of delaying the project (Mohd,

2006). This phenomenon affects the profitability of the contractor thereby shrinking their chances of survival in construction business.

1.3 Research Questions

Pursuant to section 1.2 above, the questions were advanced to guide this research:

1. What benefits exist in the planning and scheduling road construction activities?
2. What planning and scheduling techniques are used in the Ghanaian road construction subsector?
3. What are the key resources required for planning and scheduling road construction works?
4. What are the processes of planning and scheduling of road construction activities?
5. What are the challenges confronting the planning and scheduling of activities in road construction?

1.4 Aim and Objectives of the Study

1.4.1 Aim of the Study

The aim of this study was to explore construction planning and scheduling practices among class A1B1 and A2B2 road contractors in Ghana in order to suggest/propose improvement in the use of existing planning and scheduling techniques.

1.4.2 Objectives of the Study

The attainment of the above aim is dependent on the following objectives:

1. To identify the benefits of planning and scheduling road construction activities;

2. To identify the planning and scheduling techniques used in the Ghanaian road construction subsector;
3. To identify the key resources required for planning and scheduling road construction works;
4. To identify the planning and scheduling processes of road construction firms; and
5. To identify the challenges confronting the planning and scheduling of road construction works.

1.5 Scope of the Study

Geographically, this study covered road contractors in the financial class of A1B1 and A2B2 who have undertaken road construction contracts in Ghana. The specific regions of Ghana involved in the study consisted of Volta Region, Central Region, Greater Accra Region, Western Region, Northern Region, Eastern Region and Upper West Region. The consideration of A1B1 and A2B2 for the study has made the conduct of the study to cut across the entire country.

These category of Road Contractors are expected to construct high value projects normally of a complex nature making planning and scheduling very relevant in their scheme of things.

1.6 Methodology of the Study

This study adopted the quantitative approach. In using the quantitative approach, the survey process was adopted survey questionnaires to gather data from respondents. Participants were chosen by using purposive sampling because the study categorically focused on A1B1 and A2B2 road contractors who are well informed and visible in the industry. The data collected was sorted, edited and prepared for analysis. The main

package for the analysis was statistical packages for social sciences (SPSS). Descriptive statistical tools were mainly used in the analysis of data. The chi square which is a non-parametric tool was also used to ascertain the significance of the results collected.

1.7 Significance of the Study

This research is of potential benefit to the road construction projects by ensuring efficiency gains in the delivery of road projects on time and within budget. This provides much needed advantage for the national economy as more money will be left to develop other sectors of the economy. Construction infrastructure is very instrumental in boosting the gross domestic product (GDP) of Ghana. This study which provided the needed impetus to effective planning and scheduling is therefore useful in relevant to the national economy as it enhances the acumen of road construction planners and schedulers to complete project on time and within budget. This study has the potential of igniting the penetration of planning and scheduling techniques deployment in road construction sector of Ghana. This study is relevant to the development of this country in terms of construction improvement and resource overrun mitigation in the industry. The situation where professionals deliberately delay projects to benefit through corrupt practices can also be checked by the massive adoption of the findings of this study. The fact that this project is geared towards road construction planning and scheduling means that its contribution to the reduction of construction disputes relating to projects duration is significant.

1.8 Organization of the Study

This study in its conduct consisted of five distinct but interrelated chapters.

1. Chapter one consisted of the background of the research, problem statement, research questions and aim an objectives of the research. Additionally, chapter one encompassed the scope of the research, methodology of the research; and significance of the research.
2. Chapter two of this study dealt on the review of relevant literature on issues regarding construction planning and scheduling.
3. Chapter three consisted of the methodology of the study. This chapter provided extensive background on the conduct of the study.
4. Chapter four involved the analysis of data collected while
5. Chapter five concluded this study with summary of findings,

recommendations, future research agenda and conclusion of the entire study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Explanation of Construction Planning and Scheduling

Planning is an integral part of project management (Chua *et al*., 1999). It is mainly to provide a construction operation that is more manageable. Construction planning builds a masterpiece for the representation of strategic construction methods and

resource deployment (Tetsuya *et al*., 1993). Successful construction planning produces strategies and timelines that are achievable and dependable. Meticulous preconstruction principal planning and scheduling is a necessity for the attainment of the various construction phases. Tetsuya *et al*. (1993) conceded that planning and scheduling processes churn out plans herein referred to as sequence of activities; and schedules.

Planning is making decisions using information gathered by identifying activities. It also involves creativity; flexibility; and interrelationships. While to Naoum *et al.* (2004) planning is a means of achieving success in construction. Kharbanda and Pinto (1996) conceded that the failure of projects connected to inadequate and inaccurate planning and inability to take cognizance of changes in the environment. Planning has been highlighted as one of the key ingredients of successful project management. In this direction several studies have found that the delivery of projects is dependent on adequate planning (Arditi, 1985; Mauricio & Carlos, 2002). Furthermore, inadequate planning has been found to be one of the key factors that influence project cost overrun (Kaming *et al.*, 1997; Cox *et al.*, 1999; Radujkovic, 1999). Construction planning is a precursor to scheduling (Muir, n.d). Construction planning involves task description; sequencing of activities; construction methods; and allocating responsibility.

Ensuring reliable planning leads to stability of construction flow resulting in to high productivity and improved product superiority. Three levels of planning have been recognized by Chua *et al.* (1999) in their work. These include planning of the project; look-ahead planning, and planning commitment. The planning of the project provides the main schedules which are panoramic to project managers. Project planning is

intended to aid analysis of cost and allocation of resources. In look-ahead planning, the focus is on detailing, adjusting and optimizing the initial schedule and future scope of work while commitment planning concentrates on works regarding resource capacity and completion of basic activities. Nomenclatures of planning exist according to the phases of construction contracts (Oxley & Poskitt, 1971; Ward, 1979).

Schedules are set of activities that have been assigned time, durations and resources. Schedules enable construction professionals to execute their activities effectively. Mawdesley (2001) conceded a good scheduling facilitates smooth project delivery and eliminate all unnecessary encumbrances in the construction procurement process. The achievement of high output in construction is highly dependent on the meticulous design and effective accomplishment of work schedules (Chua *et al*., 1999).

Scheduling process consists of planning, scheduling, monitoring and controlling. According to Muir (n.d) the real benefits of good scheduling include identifying items to be fabricated in advance; assessing the resources needed among others. Construction firms use formal procedures for allocating activities whenever the intricacy of activities are of humongous and complicated by difficulty in coordinating works and tradesmen to deliver projects in a progressive manner (Hendrickson and Au, 1989). With the assignment of activity timelines during scheduling to improve the allocation of resources notably equipment, materials and labour to reduce project bottlenecks in order to complete projects on time (Colin and Retik, 1997). Scheduling has eliminated some of the challenges posed by project complexities through computerized planning.

Documents necessary for planning and scheduling in construction include construction and contract documents (Sheba, n.d). Other key activities to construction planning and scheduling involve technical and commercial studies and investigations with their associated documents. The primary function of planning and scheduling is to enhance production by the simultaneous management of crew flow and work flow (Huber and Reiser, 2003).

Three main planning and scheduling processes identified are core processes, facilitating processes and controlling processing. The core processes encompass various construction activities which are largely planning and scheduling tasks. The smoothing processes involve quality planning; organizational planning, staff acquisition; communication planning; risk identification and quantification; risk response development; procurement planning and solicitation planning. Controlling processes comprise of performance measurement of the execution process and provision of feedback on planning process. Activities during the monitoring process include controlling changes in scope, schedule, cost, quality and performance reportage.

2.2 Types of Planning and Scheduling Techniques

Generally, Trofin (2004) categorized planning and scheduling techniques according as linear, mathematical and probabilistic. These classifications are according to the formulation or the nature of these techniques when depicted. Scheduling techniques in the construction industry are well known and described in detail (Conlin and Retik, 1997).

Existing Scheduling tools comprise of bar chart (Gantt chart); network diagrams; CPM scheduling originally developed by duPont in the 1950s (Muir, n.d). In addition, Li et al. (2009) identified established techniques for construction scheduling to consist of critical path method and bar charts. Computer aided technology which provides improved visualization of activities through virtual prototyping is one of the techniques for planning and scheduling in construction (Li *et al*., 2009). The use of virtual prototyping optimizes construction planning schedules by analyzing resource allocation and planning with integrated construction models, resource models, construction planning schedules and site-layout plans (Li *et al*., 2009). Computers have also been identified as efficient tools for planning and scheduling in construction (Li *et al*., 2008). Hegazy and Kassab (2003) using genetic algorithm demonstrated the effectiveness of flowcharts for the planning and scheduling of construction activities.

The Critical Path Method (Shi *et al*., 2000; Lu and AbouRizk 2000; Galloway *et al*., 2006; Ibbs *et al*., 2007; and El-Rayes *et al*., 2009), Program Evaluation and Review Technique (Cottrell *et al*.,1999; AbouRizk *et al*., 2000; Lu *et al*., 2002 and; and Lee *et al*., 2006), and graphical evaluation and review technique (Pena-Mora and Park, 2001) are two main items for regulating projects consist of durations and budgets. Also computerized software and mathematical techniques have been involved in the allocation of construction activities (Tavakolan, 2011).

Sheba (n.d) outlined various planning techniques require for some critical stages of construction while Badukale and Sabihuddin (2014) conceded that different types of planning and scheduling methods are deployed for depending on the type and nature of projects. In this direction, notable techniques include linear approaches such as

critical path method; linear scheduling method; and line of balance. According to Badukale and Sabihuddin (2014) the line of balance is a method of displaying the recurring nature construction activities using line. The line of balance permits faster performance (Badukale & Sabihuddin, 2014).

In their work, Badukale and Sabihuddin (2014) espoused numerous advantages and disadvantages of line of balance. Similarly, Kankainen and Seppänen (2003) identified the advantages of line of balance as less schedule risk by keeping subcontractors on site; productivity benefits because the crews are less likely to interfere with each other and more realistic schedules as buffers can be easily planned and analysed. However, Arditi *et al*. (2002) noted that the line of balance is not effectively used in construction planning and scheduling internationally because of its lack of easy-to-use software solution. Additionally, Seppänen and Aalto (2005) noted that one of the weaknesses of line of balance as variability of production rates and inadequate control mechanisms on site. Computer software and enhanced graphic presentation media have been some of the techniques used for the planning and scheduling of construction project activities (Colin and Retik, 1997).

Several works have proposed measures to improve the application of line of balance in construction. Some of these measures include: using color graphics to improve its visualization (Arditi and Albulak, 1986); and limited amount of information must be shown (Neale and Neale, 1989). Currently, Subramani *et al*. (2014) maintained that the common planning and scheduling techniques in the construction industry include bar chart and critical path method.

The inability of the bar chart and CPM to model repetitive linear activities has necessitated the introduction of line of balance; the vertical production method; the linear scheduling method; the repetitive project modelling; and the linear and repetitive methods (Subramani *et al*., 2014) to cater for the scheduling of repetitive linear activities in construction. Several advantages and disadvantages of linear scheduling method were espoused in the work Leong and Kass (n.d) some of which consist of:

- easily understood and graphical;
- easy identification of activity by planners and schedulers;
- clear identification of connections between activities;
- easy identification of resources linked to linear tasks;
- it also makes possible, the identification environmental and contract difficulties;
- modifications to linear techniques are easy;

2.3 Factors that affect the choice of planning and scheduling techniques/tools

Design factors for consideration during planning and scheduling include 3D computer aided design (CAD), elevation and section drawings, space volumes and functional requirements. According to Warner Construction Consultants (n.d), factors for consideration before choosing a particular construction project planning and scheduling technique include project size; contract requirements; scope of work; construction execution approach; project work breakdown structure; project budget appropriated to planning and scheduling; and, other reports and useful project data. Critical factors for consideration in the choice of planning and scheduling tools involve clear understanding of strategic project goals; commitment by top management; the desire for excellent project management; availability of implementation team for a

particular technique; accuracy of data; education and training; and availability of performance measures to assess the impact of the planning and scheduling technique (Umble *et al*., 2003). Similarly, the choice of a planning and scheduling technique also depends on the availability of knowledge procedures and the ability to choose techniques that suits them (Ghraizi and Al-Azzaz, 2005).

2.4 Rationale for using planning and scheduling techniques in construction

Planning and scheduling techniques in the construction industry are commonly utilized to ensure that activities are carried out in a systematic manner (Li *et al*., 2009). The rationale of planning and scheduling are to provide an overall view of project activities especially highly interdependent ones; smooth flow of work; labour - resource matching; harmonization of interdependent activities; to reduce duration and resource levelling; *inter alia* (Mendes and Heineck, 1998).

Additionally, Hildreth and Munoz (2005) put forward the need for scheduling as follows: to envisage project duration; provide effective project control tool; to escape liquidated damages; manage money by forecasting cash flows; to ascertain activity time; to manage subcontractors and client-supplied information. Other include exposure of conflicts among trades; to prediction of resource demand and improved allocation of resource; mitigation of supply-demand conflicts; create an asbuilt record; and to compute progress payments.

Schedules are treasured approaches provide advantages for managing construction oactivities (Muir, 2005). The preparation of schedules requires deep thinking from managers in a comprehensive manner. A Comprehensive schedule makes

communication easy for all stakeholders on-site and off-site to achieve value for projects. A good schedule which is easy to update becomes a valuable tool. Mattila and Abraham (1998) focused their work on appropriate resource allocation and concluded indicated value for money is hinged on appropriate planning and scheduling of activities.

2.5 Construction Activities or Works Requiring Planning and Scheduling Techniques

Construction activities requiring planning and scheduling techniques include contract documents and key design information. Also identified construction site preparation activities that require planning and scheduling techniques to execute according to the contract documents and other necessary information exist.

In the road construction sector, scheduling preparation process has been detailed by Shah *et al*. (2008) as follows:

- choose an activity;
- collect data on site and road design including sections and profiles;
- identify required interval of chainages at each section;
- compile the location of each activity;
- locate access to soil profile using the site information gathered;
- determine the quantity of activities chosen at various chainages;
- ascertain the input required for activities at various locations;
- determine the duration of each activity at various places or chainages; and
- establish the connections among the various activities using the site information gathered.

2.5.1 Linear Activities in Construction

Linear construction projects comprise of a set of activities that are repeated in each location for the duration of a job. After an activity is started and/or completed in one location, that activity is repeated in another location. Typically linear construction including roadways, tunnels and pipelines; and high-rise construction activities are classified as linear and repetitive respectively (Callahan *et al*., 1992; Halpin and Riggs 1992). Stradal and Cacha (1982) used graphic method to schedule linear construction activities using the horizontal axis to represent time and the vertical axis for location to depict interaction with ostensible activities. Charzanowski and Johnson (1986) in their study on the application of linear scheduling methods noted that it should be supported by critical path method (CPM). Graphic symbols such as bars, lines and blocks are used to illustrate linear activities in construction planning and scheduling (Vorster and Parvin, 1990). Three factors identified by Vorster and Parvin for planning linear activities include provision of time and space for crews to perform their tasks; performing working in sequential order; and reduction of delays and changes. Bafna (1991) noted that linear scheduling techniques in construction ensure better communication among all project parties. One of the techniques for linear scheduling identified by Bafna is crew movement chart (CMC).

The CMC is used to portray an activity including information regarding crew, location and date (Trofin, 2004). Similarly, Selinger (1980) developed a technique for linear construction scheduling based on labour requirement permits continuousness amongst activities. This technique is suitable for construction activities in a simple bridge construction project (Trofin, 2004). Additionally, Perera (1982) used linear programming to schedule resource sharing for construction activities while Russell and

Caselton (1988) used dynamic programming to minimize the project duration of a linear project. Other linear techniques for construction scheduling include minimum moment algorithm for resource leveling of liner construction (Russell and Dubey, 1995); and Critical Path Method (CPM) and the project evaluation and review technique (PERT); Bar/Gantt chart; line of balance (LOB). Yamin and Harmelink (2001) have provided several scheduling tools and their suitability for construction activities as demonstrated in Table 2.1 below.

Table 2.1: Scheduling tools and their suitability for construction activities

Type of project	Scheduling technique/method	Main Characteristic
Linear projects: pipelines, railroads, tunnels, highways)	Linear Scheduling Method	activities are not many
Multiunit repetitive projects: housing complex, buildings	Line of balance	Final product a group of similar units
High-rise buildings	Line of balance and vertical production method	• Recurring activities • Huge amount of activities • Every floor is a production unit
Complex projects: refineries	PERT/CPM	• a lot of activities • design is complex • Keeping project critical path is important

Simple projects:	Bar/Gantt chart	• Designates only time dimension • Relatively few activities

Source: Yamin and Harmelink (2001)

Trofin (2004) clearly identified linear construction activities in various construction elements which are demonstrated in Table 2.2 below.

Table 2.2: Construction activities generated by construction activities

Construction Element	Linear Activities
1. Foundation	excavating forming placing concrete for the abutment's foundations
2. concrete abutment construction	scaffold erection rebar assembly concrete placing curing
3. Placement of east concrete beams	beams of 20 m lengths
4. Pavement	hand poured concrete pavement over prefabricated slabs removing existing pavement sub-base relaying, leveling and paving

Source: Adapted from Trofin (2004)

2.5.2 Repetitive Activities

One of the scheduling techniques for repetitive activities is work-space scheduling. It is also suitable for multi storey construction activities. Similarly, highway construction, housing projects, long bridges among other types of construction projects are composed of repetitive construction activities (Trofin, 2004). Linear scheduling techniques are suitable for these repetitive construction techniques, among them are Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), and bar chart (*see for instance* Sarraj, 1990).

Some research works and practitioners have pointed out the pitfalls of critical path method for planning and scheduling repetitive activities. Some of these pitfalls include vulnerability to unforeseen circumstances (Rahbar and Rowing, 1992); it is plagued by a blunder called out-of-sequence progress (Suhail, 1993); its application is complicated (Clough and Sears, 1991); and lack of continuity (Selinger, 1980).

2.6 Bar chat (Gantt chart)

Bar chart as a planning procedure was originally established by Karol Adamiecki who did not publish the chart (Idoro, 2010). Its popularity in usage soared when Henry Gantt and published in 1910 as a procedure for scheduling and monitoring in the military during the First World War (Gantt, 1974). The bar chart is widely used in the construction industry to prepare programme of work (Idoro, 2010). According to Harris and McCaffer (2001), the bar chart is extensively used planning tool. Idoro(2010) observed that, when the network analysis is used, the scheduling is presented using bar chart. Ogunlana and Olomolaiye (1990) also found that majority of construction project planning is done using bar chart. Similarly, Idoro (2008) found that contractors use bar chart more than network analysis.

The bar chart is mostly used for scheduling work activities during construction operations. It is a graphical representation employed since the early 1900s (Muir, n.d). The advantages of the bar chart include: readability; provision of effective communication; and ease of updating. Similarly Harris and McCaffer (2001) enumerated the advantages of the bar chart as suitability for small projects; useful and successful tool for conveying planners' intentions and serves as effective means of communication between engineers and foremen. The bar chart also makes the monitoring of progress easier; and makes the determination of ordering dates and materials extraction to be less cumbersome. Similarly, in a more recent work by Subramani *et al*. (2014), the advantages of the bar chart were noted as follows: taking into cognizance time duration of activity; and providing clarity for understanding.

However, the pitfalls of the bar chart include its inability to demonstrate interrelationship; inability to evaluate the effects of delays; and its inability to provide the documentation for claims. Bar charts are limited in planning and scheduling of construction activities as they cannot provide spatial construction features or resource and working space requirements (Koo & Fischer, 2000 and Chau *et al*., 2002).

2.7 Challenges confronting the use of planning and scheduling tools in construction

According to Li *et al*. (2009), the inherent uncertainty and complexity of construction projects are some of the challenges confronting planning and scheduling in the industry. The task of anticipating future events during planning and scheduling also makes the process challenging for construction managers, planners and schedulers during the preconstruction phase.

Furthermore, design errors and mismatch of what is planned and actually needed also contribute challenges (Li *et al*., 2008). In addition, mistakes in the construction planning schedule are frequent due to narrow knowledge and experience (Waly & Thabet, 2002). The complex nature of construction has made it difficult for all factors to be considered in the planning and scheduling process (Chua *et al*., 1999). Poor construction plans and change orders of work scope by clients; incorrect design; and frequent equipment breakdown are some of the challenges confronting construction planning and scheduling (Shah et al., 2008).

Chapter Summary

Chapter two focused on the review of extant literature. It addressed existing issues in project planning and scheduling. some of the key issues reviewed included conceptual explanation of construction planning and scheduling; types of planning and scheduling techniques; factors that affect the choice of planning and scheduling techniques/tools; construction activities or works requiring planning and scheduling techniques; and tools and techniques for construction planning and scheduling. The next chapter focused on the methodology adopted for the study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This part of the research dealt with the methodology of the study. It discusses core issues related to the conduct of the study notably research design; data collection and instrumentation. Other aspects of this chapter include sample size and sampling; design of questionnaire; distribution of survey instrument to respondents and data preparation and statistical tools for analysis.

3.2 Research Design

Research design is concerned about the steps taken to collect and analyse data. It is a process which aids the researcher to link empirical data to conclusions in a manner that is logical to the research questions of the study **(**Bryman, 2004). This study used the survey process and structured questionnaire in gathering information from respondents. The survey design was chosen because of the wider scope of the study involving seven administrative Regions of Ghana namely Volta Region, Central Region, Greater Accra Region, Western Region, Northern Region, Eastern Region and Upper West Region. The choice of a survey was to ensure the reliability of measurement, generalization, and sampling procedures (Oppenheim 2003). In using the survey design, structured questionnaires were administered to various quantity surveyors, engineers and project managers in road construction firms for planning and scheduling in the management of road construction projects.

3.3 Data Collection and Instrumentation

3.3.1 Data collection

Largely, data for this research were gathered via desk and field survey. The desk survey enables the identification and filtering of relevant variables for the development of structured questionnaire for field survey. This strategy for data collection is in consonance with the assertion of Fadhley (1991). The field work (survey) used the survey questionnaire as an instrument for collecting empirical data for analysis on the planning and scheduling techniques adopted by financial class

A1B1 and A2B2 contractors in Ghana.

3.3.2 Sampling and Sample Size Determination

The object of sampling is to select a representative sample from a population for the conduct of a research study. Also, the study population consisted of professionals notably quantity surveyors, project managers and site engineers handling projects in road construction firms for A1B1 and A2B2 contractors. The choice of these contractors was based on the availability of contractors executing works on various road construction sites of the regions covered in this study. The desire to collect data on projects that are on-going has made the adoption of purposive sampling to be appropriate for the study. In using purposive sampling, questionnaires were distributed to thirty-nine (39) professionals in various constructional firms, this constitute the sample of the study.

3.3.3 Questionnaire Design

Questionnaires are very important to survey processes. Well-designed questions help respondents' to easily recall facts. Based on this the questions were crafted in a manner

that made it easy for respondents in this study to respond to the questions. In doing this, key factors such as readability, avoidance of technical terms or jargons in the wording of questions were considered. Similarly, the questionnaire was designed in such a way that it enhanced the appeal of respondents. Ethically, respondents were provided the purpose of this study in the introductory part of the questionnaire. This gave respondents a clearer idea of what is involved in the study to assuage their fears. The questionnaire consisted of eight (8) main questions which were pre-coded and structured.

The questionnaire fitted on to a 3-page A4 sheet and the questions were sectioned as follows:

- Question one to three dealt with the background of respondents focusing on their work experience; the rate of work acquisition; and the frequency of planning and scheduling road construction works.
- The next section of the questionnaire concentrated on the importance of planning and scheduling road construction works. This question consisted of seventeen variables meant for respondents to react to.
- The subsequent sections comprising of identification of planning and scheduling techniques used in Ghana; documents or resources for road construction planning and scheduling; planning and scheduling processes in road construction; and challenges of road construction planning and scheduling had a question each.

3.4 Instrument Administration

The questionnaires were hand delivered to respondents by the researcher in the various regions. It was possible to retrieve some of the questionnaires on the spot due to the

positive corporation from some of the respondents while others were collected later for analysis to begin. In all thirty-nine (39) questionnaires were distributed while thirty-one collected which gave a response rate of 79%.

3.5 Preparing the Data for Statistical Analysis

The data collected were sorted and processed for analysis by coding of variables. The data was then entered into the database of Software Programme for Social Sciences spread sheet for analysis to commence. In terms of descriptive analysis, the statistical tools used consisted of mean score, standard deviation and indexes. The chi square test was also used to ascertain the significance of the results.

Chapter Summary

Chapter three concentrated on the methodological and design of the study. It dealt with research approach; data collection methods and data analysis. The next chapter focused on the analysis and discussion of results.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This part of the study focused on the analysis and discussion of results. It first of all delved into the background of respondents comprising of years of experience in road construction and how frequent do you secure road construction projects. The subsequent sub-sections addressed research objectives; to uncover the existing planning and scheduling techniques, uncover the resources required for planning and scheduling, discover the processes for planning and scheduling and identify the challenges confronting the planning and scheduling of road construction works. The statistical tools used for the analysis were descriptive statistics and non-parametric analysis: chi-square test.

4.2 Background of Respondents

4.2.1 Experience of Respondents

The work experience of respondents in collecting data for this study is important. The work experience of respondents is related to the amount of rich information they have acquired in relation to planning and scheduling of road construction works. Hence, in relation to the conduct of this study, respondents were asked to indicate the number of years they have had experience in road construction. Figure 4.1 showed that, 36 percent of the respondents have had working experience less than 10 years, 33 per cent had work experience between 11-20 years while 24 per cent of respondents had 21-30 years of work experience; and 6 percent represent over 30 of work experience. It can be deduced from the above results that the work experience of respondents is largely distributed among in less than 10 years, 11-20 years and 21-30 years. This implies that majority of professionals involved in the study had enough experience in planning and

scheduling of construction. This means that the information provided by respondents were gathered by experience over a considerable period of time.

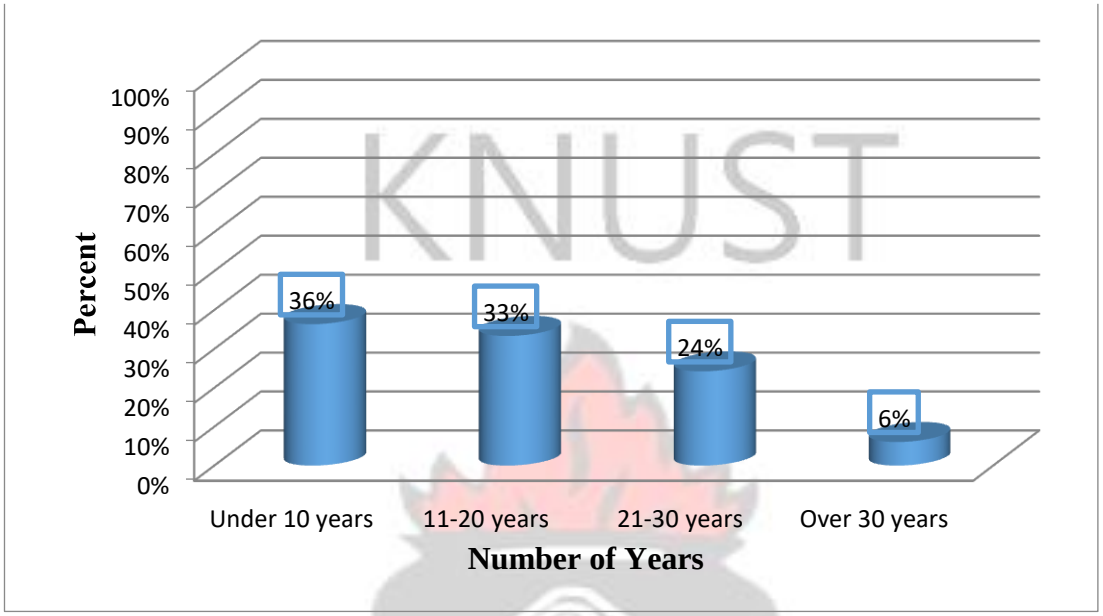

Figure 4.1 : Years of experience in road construction

Source: Field Study, 2014

4.2.2 Rate of Work Acquisition

Work experience alone does not guarantee the quality of information gathered on planning and scheduling. It is equally important to consider the rate of work acquisition within the perspective of their work experience. The frequency of work acquisition is related to experiences that respondents had as far as planning and scheduling of road construction works are concerned.

In measuring rate of work acquisition, respondents were asked on how frequent they secured road construction projects. It was observed from Figure 4.2 that, majority of the respondents said they secure projects less frequent representing 42 per cent. Thirty nine (39) per cent of the respondents said they secure projects moderately frequent, 9 per cent and 3 per cent respectively secure project frequently and very frequently. It

can be deduced that the rate of work acquisition by the respondents' firms is largely between less frequent and moderately frequent.

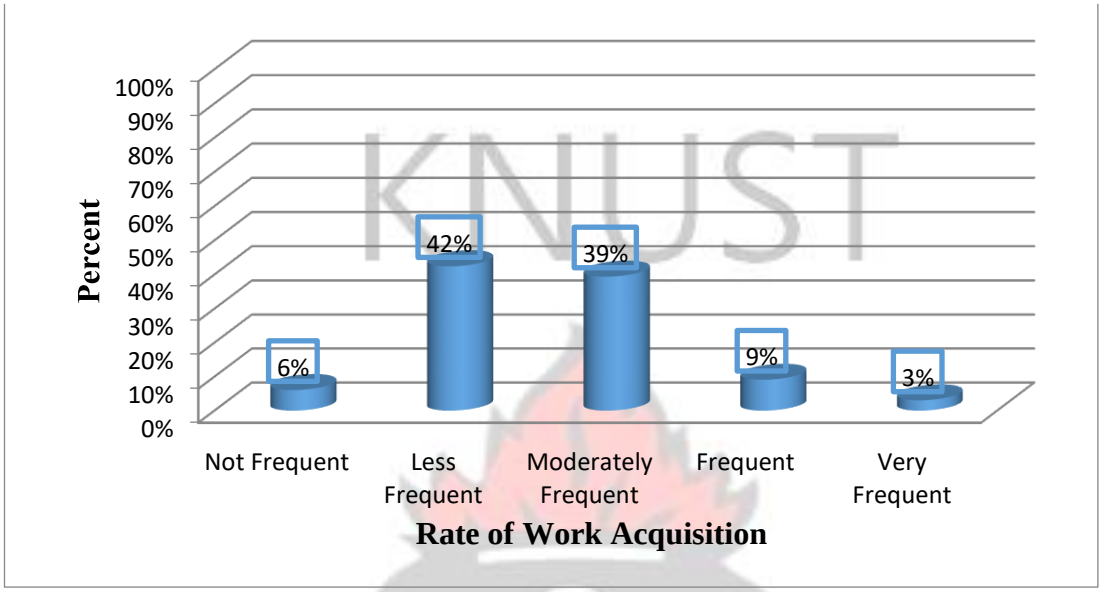

Figure 4.2 : How frequent do you secure road construction projects

Source: Field Study, 2014

4.2.3 Frequency of planning and scheduling road construction works

Having considered the work experience of works and the rate of work acquisition of their firms, it is now important to consider the frequency of road work planning and scheduling within the years of experience and rate of work acquisition. In this direction, Figure 4.3 demonstrates the frequency of planning and scheduling of road construction works in the respondent's firms. Majority of the respondents representing 64 per cent in terms of frequency of planning and scheduling moderately plan and schedule road construction works. Few percentages of the respondents showed that they plan and schedule road construction activities frequent and very frequent (9 per cent and 3 per cent respectively). Considering the fact that 64 per cent of respondents moderately plan and schedule their road construction activities and while the majority

of work acquisition rate is less frequent of 42 per cent and moderately frequent being 39 per cent, it is proper to deduce that the frequency of planning and scheduling of road construction activities is almost in tandem with the rate of work acquisition.

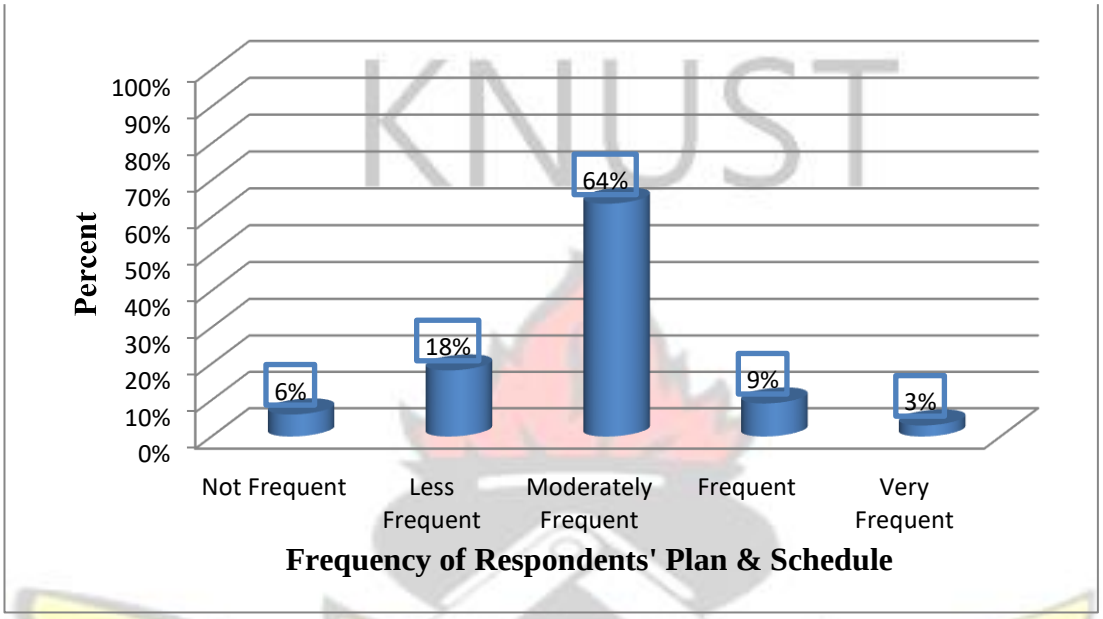

Figure 4.3 : Frequency of respondents plan and schedule road construction activities

Source: Field Study, 2014

4.3 Benefits of Planning and Scheduling Road Construction Activities

Respondents ranked the importance and results have been presented in Tables 4.1 and 4.2.

Four variables were averagely ranked as important having mean value from 4.034.18. The most important benefit of planning and scheduling road construction activities observed were, to ensure that activities are carried out in a systematic manner with mean value of 4.18, to enable the planning of work method for the whole construction operation and to serve as an effective project control tool with mean value of 4.09 each and to manage money by predicting cash flows with mean value 4.03. The standard

deviation of each showed that the mean values were representative. They all showed significant difference in ranking. The variables with mean values ranging from 3.23-3.36 were ranked averagely moderately important and variables with mean values ranging from 3.5-3.9 were approximately ranked averagely as importance.

Table 4.2 showed relative importance index expressed in percentages. The first four variables showed benefits of planning and scheduling road construction activities. The indexes of these variables ranged from 81 per cent to 84 per cent showing that respondents ranked these variables as very important. From ranking 5-14 also showed that respondents ranked these variables as important and the rest were ranked as moderately important.

Table 4.1: Benefits of Planning and Scheduling Road Construction Activities

Importance of planning and Scheduling	N	Mean	Std. Error	Std. Deviation	Chi-Square	df	*p*values
1. To ensure that activities are carried out in a systematic manner	33	4.18	0.171	0.98	31.697[a]	4	0.000
2. Planning and scheduling provide an overall view of interdependent project activities	33	3.97	0.147	0.85	20.697[b]	3	0.000
3. To ensure the smooth flow of work	33	3.97	0.134	0.77	15.848[b]	3	0.001
4. Match labour teams and related resources	33	3.94	0.179	1.03	5.424[b]	3	0.143
5. To enable the planning of work method for the entire construction activities	33	4.09	0.147	0.84	11.000[b]	3	0.012
6. Complete tasks for each group of activity at construction phases	33	3.94	0.168	0.97	6.879[b]	3	0.076

7. Identification of activities for joint planning by multiple trades	33	3.58	0.138	0.79	13.667[b]	3	0.003
8. Providing sub-contractors with progress of work	33	3.36	0.212	1.22	5.636[a]	4	0.228
9. predicting completion date of the project	33	3.88	0.183	1.05	14.121[a]	4	0.007
10. To serve as a tool for effective control of project	33	4.09	0.176	1.01	20.788[a]	4	0.000
11. To prevent liquidated damages	33	3.85	0.218	1.253	13.818[a]	4	0.008
12. To successful manage money by using cash flows	33	4.03	0.134	0.77	16.333[b]	3	0.001
13. To determine the duration of an activity	33	3.79	0.149	0.857	9.303[b]	3	0.026
14. Coordination of subcontractors	33	3.24	0.222	1.275	6.545[a]	4	0.162
15. To expose conflicts among trades	33	3.24	0.19	1.091	13.515[a]	4	0.009
16. To predict resources and to improve on their allocation	33	3.91	0.181	1.042	20.182[a]	4	0.000
17. To serve as an effective communication tool	33	3.55	0.205	1.175	9.879[a]	4	0.043

Source: Field Study, 2014

Table 4.2: Benefits of planning and scheduling of Road Construction Activities

Importance of planning and scheduling	**N**	**Sum**	**RII**	**Ranking**
1. To ensure that activities are carried out in a systematic manner	33	138	84	1
2. To enable the planning of work method for the whole construction operation	33	135	82	2
3. To serve as an effective project control tool	33	135	82	3
4. To manage money by predicting cash flows	33	133	81	4
5. Planning and scheduling provide an overall view of interdependent project activities	33	131	79	5
6. Shape work flow in the best rhythm for achieving project objectives	33	131	79	6
7. Match labour teams and related resources	33	130	79	7

produce assignments for each group of activities at construction phases	33	130	79	8
8. To predict resource demand and improve resource allocation	33	129	78	9
9. To predict the project completion date	33	128	78	10
10. To avoid liquidated damages	33	127	77	11
11. To determine the "time window" of an activity	33	125	76	12
12. To identify operations to be planned jointly by multiple trades	33	118	72	13
13. To serve as an effective communication tool	33	117	71	14
14. Providing sub-contractors with progress of work	33	111	67	15
15. To coordinate subcontractors	33	107	65	16
16. To expose conflicts among trades	33	107	65	17

Source: Field Study, 2014

4.4 Planning and Scheduling techniques used in Ghanaian Road Construction Firms

The various planning and scheduling techniques adopted by the Ghanaian road construction subsector were explored. Table 4.3 presented statistics of planning and scheduling techniques and computer aided techniques/software. Bar charts/Gantt Chart had the highest mean value under planning and scheduling techniques with mean value of 3.67. It has significant difference in ranking. Microsoft Project was ranked with mean value of 3.15 under computer aided techniques/software. The other techniques under computer aided techniques were ranked as less frequent.

As was observed from Tables 4.3, bar charts/Gantt chart was ranked with highest mean values. It has index of 73 per cent indicating respondents ranked this variable as frequently used planning and scheduling techniques for road construction project. The second ranked techniques was PERT with index of 68 per cent, followed by critical path method (CPM) with index of 67 per cent, flowcharts, Microsoft project, etc. The *p*-values of line of balance (LOB); PERT; graphical evaluation and review technique

(GERT); work breakdown structure. (WBS); crew movement chart; mathematical programming; heuristic models; evolutionary algorithms are above 0.05. This implies that these results are not significant. This implies that these planning and scheduling techniques are not used in the planning and scheduling of road works in Ghana. However, the critical path method, bar charts/Gantt chart, and flowchart are significant since they have p-values less than 0.05. This means that, these planning and scheduling techniques are the main tools used in the planning and scheduling of road construction activities. Similarly, all the variables in the category of computer aided techniques/software except Primavera are not significant.

Techniques that were ranked as less frequently used under planning and scheduling techniques were evolutionary algorithms with index of 50 per cent, followed by mathematical programming with index 52 per cent, etc. Microsoft project was ranked first under computer aided techniques/software with index of 63 percent. Virtual prototyping and primavera were ranked with index of 53 per cent each.

Table 4.3: Planning and Scheduling Techniques

Planning and Scheduling Techniques	**N**	**Mean**	**Std. Error**	**Std. Deviation**	**Chi-Square**	**df**	***p*-values**
Planning and scheduling techniques							
1. Critical path method (CPM)	33	3.36	0.245	1.410	2.606[a]	4	0.626
2. Bar charts/Gantt Chart	33	3.67	0.188	1.080	10.788[a]	4	0.029
3. Flowcharts	33	3.30	0.187	1.075	13.212[a]	4	0.010
4. Line of balance(LOB)	33	3.03	0.252	1.447	1.697[a]	4	0.791
5. Program Evaluation and Review Technique	33	3.42	0.218	1.251	5.939[a]	4	0.204
6. Graphical Evaluation and Review Technique	33	3.09	0.223	1.284	3.212[a]	4	0.523
7. Work breakdown structure (WBS)	33	3.12	0.198	1.139	7.758[a]	4	0.101
8. Crew movement chart	33	2.76	0.226	1.300	2.606[a]	4	0.626

9. Mathematical programming	33	2.58	0.238	1.370	3.212[a]	4	0.523
10. Heuristic models	33	2.61	0.254	1.456	4.424[a]	4	0.352
11. Evolutionary algorithms	33	2.52	0.235	1.349	6.545[a]	4	0.162
Computer aided techniques/software							
12. Virtual prototyping	33	2.67	0.253	1.451	2.606[a]	4	0.626
13. Primavera	33	2.64	0.264	1.517	8.970[a]	4	0.062
14. Microsoft Project	33	3.15	0.222	1.278	4.424[a]	4	0.352

Source: Field Study, 2014

4: Planning and Scheduling Techniques

Planning and Scheduling Techniques	N	Sum	RII	Ranking
Planning and scheduling techniques				
1. Bar charts/Gantt Chart	33	121	73	1
2. Program Evaluation and Review Technique	33	113	68	2
3. Critical path method (CPM)	33	111	67	3
4. Flowcharts	33	109	66	4
5. Work breakdown structure (WBS)	33	103	62	5
6. Graphical Evaluation and Review Technique	33	102	62	6
7. Line of balance(LOB)	33	100	61	7
8. Crew movement chart	33	91	55	8
9. Heuristic models	33	86	52	9
10. Mathematical programming	33	85	52	10
11. Evolutionary algorithms	33	83	50	11
Computer aided techniques/software				
12. Microsoft Project	33	104	63	12
13. Virtual prototyping	33	88	53	13
14. Primavera	33	87	53	14

Source: Field Study, 2014

4.5 Resources for Road Construction Planning and Scheduling

Table 4.5 showed the statistics of variable of resources for road construction planning and scheduling. A bill of quantities was averagely ranked as very frequent with mean value of 4.21. The rest of the variables were averagely ranked as frequent with mean values ranging from 3.06-3.91. The variable with mean value of the lower mean was ranked averagely as moderately frequent.

Bills of quantities, was ranked first among the other variables of the resources for road construction planning and scheduling with index of 84 percent. It was the most

Table 4.

frequently used document. The second ranked resource for road construction planning and scheduling was designs and drawings with index of 78 percent, then construction method statements with index of 77 percent. All the documents from ranking number 2 to 8 were indicated as frequently used documents. Technical and commercial studies document was ranked last with index of 61.

Table 4.5: Resources for Road Construction Planning and Scheduling

Planning and Scheduling Documents/Resources	N	Mean	Std. Error	Std. Deviation	Chi-Square	df	*p*-values
1. Designs and drawings	33	3.91	0.244	1.400	19.879[a]	4	0.001
2. Bills of quantities	33	4.21	0.183	1.053	28.061[a]	4	0.000
3. Construction method statements	33	3.85	0.175	1.004	24.424[a]	4	0.000
4. Project planning data	33	3.52	0.200	1.149	9.273[a]	4	0.055
5. Specification	33	3.73	0.227	1.306	12.303[a]	4	0.015
6. Information on Site conditions	33	3.73	0.214	1.232	11.394[a]	4	0.022
7. Market survey	33	3.55	0.157	0.905	6.879[b]	3	0.076
8. Local resources	33	3.61	0.179	1.029	6.879[b]	3	0.076
9. Technical and commercial studies documents	33	3.06	0.234	1.345	2.606[a]	4	0.626

Source: Field Study, 2014

6: Resources for road construction planning and scheduling

Planning and Scheduling Documents/Resources	N	Sum	RII	Ranking

1. Bills of quantities	33	139	84	1
2. Designs and drawings	33	129	78	2
3. Construction method statements	33	127	77	3
4. Specification	33	123	75	4
5. Information on Site conditions	33	123	75	5
6. Local resources	33	119	72	6
7. Market survey	33	117	71	7
8. Project planning data	33	116	70	8
9. Technical and commercial studies documents	33	101	61	9

Source: Field Study, 2014

4.6 Planning and Scheduling Processes in Road Construction

The mean value of the rankings of the variables of planning and scheduling processes in road construction ranges from 3.24-3.73. Planning and scheduling processes with the highest mean value was observed to be choosing an activity; identifying the various locations at necessary interval of chainage and then Collection of road design data with index 3.73, 3.61 and 3.55 respectively. Approximately, the other scheduling process were also ranked as frequent, showing that respondents undertake these steps in planning and scheduling of road construction activities. The select an activity, collection of road design data, list of locations of the selected activity and determine the productivity of selected activity at each location showed significant difference in ranking. The standard deviation showed significant representative of the mean values for all the variables. Similarly, the *p*-values of the various planning processes in Table 4.7 below are significant except in the case of identifying the list of location at required interval of chainage; identification of access points and soil profile from site survey information; and the calculation of quantity at chainage of selected activity. However other planning and scheduling processes in Table 4.7 are significant since their p-values are less than 0.05. This implies that these particular planning and scheduling processes should be adopted by road construction planners and schedulers.

Table 4.

The three steps were ranked as frequent with index ranging from 71-75 indicating that respondents ranked these variables; choosing an activity; identifying the various locations at necessary interval of chainage and collection of road design data as frequently undertaken steps in planning and scheduling of road construction as frequent. From the 4th ranked to the 10th ranked with index ranging from 65 per cent to 69 per cent showed these steps were moderately frequent.

Table 4.7: Planning and scheduling processes in road construction

Planning and Scheduling processes	N	Mean	Std. Error	Std. Deviation	Chi-Square	df	*p*values
1. Choosing an activity	33	3.73	0.205	1.18	9.879[a]	4	0.043
2. Collection of road design data	33	3.55	0.222	1.277	9.879[a]	4	0.043
3. Identifying the various locations at necessary interval of chainage	33	3.61	0.174	0.998	5.424[b]	3	0.143
4. List of locations of the selected activity	33	3.39	0.179	1.029	11.697[a]	4	0.020
5. Identification of access points and soil profile from site survey information	33	3.39	0.213	1.223	5.636[a]	4	0.228
6. Calculation of Quantity at chainage of selected activity	33	3.45	0.227	1.301	5.333[a]	4	0.255
7. Determine the productivity of selected activity at each location	33	3.3	0.182	1.045	18.970[a]	4	0.001
8. Calculate duration of the selected activity at required interval of chainage	33	3.33	0.203	1.164	8.061[a]	4	0.089
9. List duration of selected activity	33	3.24	0.2	1.146	8.061[a]	4	0.089
10. Link all activity with logical relation to develop detailed schedule	33	3.33	0.193	1.109	8.667[a]	4	0.070

Source: Field Study, 2014

8: Planning and scheduling processes in road construction

Planning and Scheduling processes	N	Sum	RII	Ranking
1. Choosing an activity	33	123	75	1
2. Identifying the various locations at necessary interval of chainage	33	119	72	2
3. Collection of road design data	33	117	71	3
4. Calculation of Quantity at chainage of selected activity	33	114	69	4

5. List of locations of the selected activity	33	112	68	5
6. Identification of access points and soil profile from site survey information	33	112	68	6
7. Calculate duration of the selected activity at required interval of chainage	33	110	67	7
8. Link all activity with logical relation to develop detailed schedule	33	110	67	8
9. Determine the productivity of selected activity at each location	33	109	66	9
10. List duration of selected activity	33	107	65	10

Source: Field Study, 2014

4.7 Challenges confronting the planning and scheduling of road construction works

Respondents were asked to scale how the challenges of planning and scheduling of road construction projects level of severity. The mean ranking of poor construction plans and change orders of work scope by clients was the highest mean value among the challenges. The next observed challenge with high mean value was design errors with mean value of 3.91. Discrepancy in resources planned and actually needed; and the inherent uncertainty and complexity of construction projects were ranked with mean values of 3.67 and 3.55 respectively showing that these challenges were severe compare to the rest. All these variables showed significant difference in ranking and standard deviations were representative. Considering the p-values of the challenges confronting planning and scheduling in the road construction sector, Limited knowledge and experience of project team members and frequent equipment breakdown are not significant. However, the *p*-values of other challenges indicate a strong significance of the variables. This means that these challenges are impeding the planning and scheduling of road construction works. Table 4.10 showed index of the scaling of challenges of planning and scheduling. The challenge ranked first was poor construction plans and change orders of work scope by clients with index of 80 per

Table 4.

cent. The second ranking was the inherent uncertainty and complexity of construction projects with index of 71 per cent, then the task of anticipating future events during planning and scheduling with index of 67, etc as shown in tables 4.10.

Table 4.9: Challenges of planning and scheduling

Challenges of planning and scheduling	N	Sum	Mean	Std. Error	Std. Deviation	Chi-Square	df	*p*-value
1. Poor construction plans and change orders of work scope by clients	33	132	4.00	0.195	1.118	17.152[a]	4	0.002
2. The inherent uncertainty and complexity of construction projects	33	117	3.55	0.157	0.905	9.545[b]	3	0.023
3. The task of anticipating future events during planning and scheduling	33	111	3.36	0.114	0.653	24.333[b]	3	0.000
4. Design errors	33	129	3.91	0.192	1.100	15.333[a]	4	0.004
5. Discrepancy in resources planned and actually needed	33	121	3.67	0.207	1.19	8.364[a]	4	0.079
6. Limited knowledge and experience of project team members	33	115	3.48	0.200	1.149	7.152[a]	4	0.128
7. The complex nature of some construction projects	33	113	3.42	0.195	1.119	8.061[a]	4	0.089
8. Frequent equipment breakdown	33	113	3.42	0.204	1.173	6.848[a]	4	0.144

Source: Field Study, 2014

10: Challenges of planning and scheduling

Challenges of planning and scheduling	N	Sum	RII	Ranking
1. Poor construction plans and change orders of work scope by clients	33	132	80	1
2. The inherent uncertainty and complexity of construction projects	33	117	71	2
3. The task of anticipating future events during planning and scheduling	33	111	67	3
4. Design errors	33	129	78	4

5. Discrepancy in resources planned and actually needed	33	121	73	5
6. Limited knowledge and experience of project team members	33	115	70	6
7. The complex nature of some construction projects	33	113	68	7
8. Frequent equipment breakdown	33	113	68	8

Source: Field Study, 2014

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This study was necessitated by the problems confronting the planning and scheduling of road construction works. Poor planning and scheduling of road construction works has resulted in to the idleness of labour and equipment during construction operations. This phenomenon has led to delay in project completion, limited availability of construction resources on site during project execution among others. Similarly, recent

Table 4.

planning and scheduling processes in the road construction sector have been inefficient in delivering the necessary task as far as road construction is concerned. This is the final chapter in the investigation of the above problems within the perspective of road construction. It consisted of the review of research objectives and findings; recommendations of the study; future research agenda; and conclusion of the study.

5.2 Review of Study Objectives and Findings

Objective 1: To identify the benefits of planning and scheduling road construction activities

The study identified the benefits of planning and scheduling as it is important for road construction professionals to be abreast with such benefits. In relation to objective 1 of the study, the key benefits planning and scheduling identified by the study include:

- To ensure that activities are carried out in a systematic manner;
- To enable the planning of work method for the whole construction operation;

  To manage money by predicting cash flows;
- To serve as an effective project control tool;
- To ensure the smooth flow of work;
- Planning and scheduling provide an overall view of interdependent project activities

Objective 2: To identify the Planning and Scheduling techniques used in the Ghanaian road construction subsector

Objective 2 sought to uncover the various planning and scheduling techniques used by the road construction subsector of the construction industry. Several techniques were uncovered which will be useful in adopting them in the planning and scheduling of works. Among the key techniques identified in this regard consisted:

- Bar charts/Gantt chart
- PERT
- critical path method (CPM)
- flowcharts,
- Microsoft project

The result of the study clearly indicated that other advanced planning and scheduling techniques which are of significant advantage are not been utilized as compared to their counterparts above. The study also uncovered that key computer aid techniques are not extensively used in the planning and scheduling of road construction works in Ghana. Among the notable techniques in this category are:

- Virtual prototyping; and

- Primavera

Objective 3: To identify the key resources required for planning and scheduling road construction works

Effective planning and scheduling of road construction works require key resources or documents. This study explored the resources needed for successful planning and scheduling and found them to include:

- bills of quantities;
- designs and drawings;
- construction method statements;
- specification;
- site conditions information;
- local resources;
- market survey;
- project planning data; and
- technical and commercial studies documents.

The identification of these documents and resources as necessities for planning and scheduling of road construction works is useful to practitioners in the sense that they will adapt them in their planning and scheduling endeavours.

Objective 4: To identify the planning and scheduling processes of road construction activities

Planning and scheduling processes are important for successful road construction project execution. This study was intended to identify the processes involved in the planning and scheduling of construction resources. The study therefore identified the following planning and scheduling processes in the road construction sector:

- Selection of an activity;
- Collection of road design data;
- Identification of the location at required interval of chainage;
- Preparing the list locations of the selected activity;
- Identification of access points and soil profile from site survey information;
- Calculation of quantity at chainage of selected activity;
- Determine the productivity of selected activity at each location;
- Calculate duration of the selected activity at required interval of chainage;
- List duration of selected activity; and
- Link all activity with logical relation to develop detailed schedule.

Objective 5: To identify the challenges confronting the planning and scheduling of road construction works.

The challenges confronting planning and scheduling identified by the study consist of:

- poor construction plans and change orders of work scope by clients;
- inherent uncertainties and complexities of construction projects;
- the task of anticipating future events during planning and scheduling;
- design errors;
- mismatch of planned activities and actuals;
- limited knowledge and experience of project team members; and
- frequent equipment breakdown.

5.3 Recommendations of the Study

The conduct of this study was to explore construction planning and scheduling among class A1B1 and A2B2 road contractors in Ghana in order to improve upon the existing planning and scheduling techniques. This study recommends that:

- The findings of this study in relation to the processes for planning and scheduling must be adhered to during road construction planning and scheduling;
- Documents and resources required for road construction planning and scheduling must always be made available before the commencement of planning and scheduling;
- There should be proper record and document management in order to effective plan and schedule road construction activities; and
- Higher level tools such as mathematical programming; heuristic models; and evolutionary algorithm are employed for effective and precision planning and scheduling of road construction works.

5.4 Future Research Agenda

This study like any other study of its kind has its limitations due to circumstances beyond its control. The following future studies are therefore proposed to address the limitations of the study:

- A study into a model development of models for planning and scheduling road construction works;
- A study to identify the key success factors responsible for road construction planning and scheduling;
- A study to devise strategies for mitigating challenges confronting road construction planning and scheduling; and

- A study to identify suitable software for construction planning and scheduling.

5.5 Conclusion of the Study

This study which was towards the planning and scheduling of road construction activities is useful to practitioners and researchers. When the findings and recommendations of this study are adopted by practitioners, it will improve the planning and scheduling of road construction activities which will eventually ensure a steady flow of resources and works to ensure timely completion of project. The effective use of planning and scheduling tools in the road construction sector of Ghana has the potential of smooth delivery of road projects. It would also provide the opportunity for the government of Ghana to ascertain the probable duration for road projects. Thus this goes to help in proper budgetary planning and allocation of funds and resources for the construction of road projects in Ghana.

REFERENCES

Arditi, D., Tokdemir, O.B and Suh, K. (2002). Challenges in Line-of-Balance Scheduling, *Journal of Construction Engineering and Management*, ASCE, New York, NY, Vol. 128, No. 6, pp. 545–556

Arditi, D and Albulak, M.Z. (1986). Line of balance scheduling in pavement construction, *Journal of Construction Engineering and Management*, ASCE, Vol. 112, No. 3, pp. 411-424.

Arditi, D. (1985). Construction Productivity Improvement, *Journal of Construction Engineering and Management*, Vol. 111, No. 1, pp.1-14.

Badukale, P.A and Sabihuddin, S. (2014). Line of Balance, *International Journal of Modern Engineering Research (IJMER)*, Vol. 4, No. 3, pp. 45-47.

Bafna, T. (1991). Extending the range of linear scheduling in highway construction, Master's Thesis, Department of Civil Engineering, Virginia Polytechnic Institute and State University, Blackburg, VA.

Bernard, H.R. (2002). *Research Methods in Anthropology: Qualitative and quantitative methods*. 3rd edition , California: AltaMira Press.

Bryman, A. (2004). *Social research methods*, 2nd edn. Oxford: Oxford University Press.

Callahan, M.T., Quackenbush, D.G and Rowings, J.E. (1992). *Construction project scheduling*, New York, NY: McGraw-Hill.

Castro, S and Dawood, N. (2005). RoadSim: A Road Construction KnowledgeBased Simulation System, *Proceedings of the CIB W102 Conference*, May 19-25, Lisbon, Portugal.

Charzanowski, E.N., Jr. and Johnson, D.W. (1986). Application of linear construction, *Journal of Construction Engineering, ASCE*, Vol. 112, No. 4, pp. 476-491.

Chau, K.W. , Anson, M and Zhang, J.P. (2003). Implementation of visualization as planning and scheduling tool in construction, *Building and Environment*, Vol. 38, No.1, pp. 713–719

Clough, R.H. and Sears, G.A. (1991). *Construction project management*, 3rd Ed., New York, NY: John Wiley & Sons.

Conlin, J and Retik, A. (1997). The applicability of project management software and advanced IT techniques in construction delays mitigation, *International Journal of Project Management* Vol. 15, No. 2, pp. 107-120.

Cottrell, W.D. (1999). Simplified Program Evaluation and Review Technique (PERT), *Journal of Construction Engineering and Management*, Vol. 125, No. 1, pp. 16-22.

Cox, I D, Morris, J P, Rogerson, J H and Jared, G E. (1999). A quantitative study of post-contract award design in construction, *Construction Management and Economics*, Vol. 17, No. 1, pp. 427-439.

Dawood, N and Castro, S. (2009). Automating Road Construction Planning with a

Specific-Domain Simulation System**,** *Journal of Information Technology in Construction*, Vol. 14, pp.556- 573.

Dawson, C.W and Dawson, R.J. (1995). Generalized activity-on the-node network for managing uncertainty on projects, *International Journal of Project Management*, Vol. 13, No. 6, pp.353-362

El-Rayes, K and Jun, D.H. (2009). Optimizing Resource Leveling in Construction Projects, *Journal of Construction Engineering and Management*, Vol. 135, No. 11, pp. 1172-1180.

Fadhley, S.A. (1991). *A Study of Project Finance Banking with Special reference to the Determinants of Investment Strategy.* Unpublished Doctoral Theses, submitted to the Loughborough University.

Galloway, P. (2006). Survey of the Construction Industry Relative to the Use of CPM Scheduling for Construction Projects, *Journal of Construction Engineering and Management*, Vol. 132, No.7, pp. 697-711.

Ghraizi, F and Al-Azzaz, F. (2003). Planning and Scheduling Techniques used by Elseif Engineering Contracting Company. King Fahd University of Petroleum and Minerals, College of Environmental Design, Department of Construction Engineering and Management.

Gordon, J and Tulip, A. (1997). Resource Scheduling, *International Journal of Project Management*, Vol. 15, No. 6, pp. 359-370.

Halpin, D.W. and Riggs, L.S. (1992). Planning and analysis of construction operations, New York, NY : John Wiley and Sons.

Harris, F and McCaffer, R (2001). *Modern construction management*, 5th edition, Blackwell Science, London.

Hajjar, D and AbouRizk, S. M. (2000). Application Framework for Development of Simulation Tools, *Journal of Computing in Civil Engineering*, ASCE, vol. 14 (3), pp. 160-167.

Hegazy, T., and Kassab, M. (2003). Resource Optimization Using Combined Simulation and Genetic Algorithms, *Journal of Construction Engineering and Management*, ASCE, Vol. 129, No. 6, pp. 698-705.

Hendrickson, C and Au, T. (1989). *Project management for construction*, UK: Prentice-Hall.

Hildreth, J.C and Munoz, B.P. (2005). An Introduction to the Management Principles of Scheduling. A report presented to the Virginia Department of Transportation and the VDOT-VT Partnership for Project Scheduling Advisory Board

Hendrickson, C and Au, T. (1989). *Project management for construction*, UK: Prentice-Hall.

Huber, B and Reiser, P. (2003). The marriage of CPM and lean construction, 11th Annual Conference on Lean Construction, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Ibbs, W and Nguyen L.D. (2007). Schedule Analysis under the Effect of Resource Allocation, *Journal of Construction Engineering and Management*, Vol. 133, No. 2, pp. 131-138.

Idoro, G.I. (2010). Evaluating the Content of Bar Chart and its Impact on Project Performance in the Nigerian Construction Industry, *International Journal of Project Planning and Finance*, Vol. 1, No. 1, pp. 84-101.

Idoro, G. I. (2008). The State of Project Planning in the Nigerian Construction Industry, *The Lagos Journal of Environmental Studies*, Vol. 6, No.2, pp.20-29.

Kharbanda, O. P and Pinto, J. K. (1996). *What made Gertie gallop? Learning from Project Failures.*1st edition. New York: Von Nostrand Reinhold,

Kankainen, J and Seppänen, O. (2003). A Line of Balance based schedule planning and control system". *Proceedings of the 11th international conference of Lean Construction (IGLC11)*. Blacksburg, Virginia.

Kamat, V. R and Martinez, J. (2001). Visualising Simulated Construction Operations in 3D, *Journal of Computing in Civil Engineering*, ASCE 15 (4) pp. 329337.

Kaming, P.F., Olomolaiye, P. O., Holt, G. D., and Harris, F. C. (1997). Factors influencing construction time and cost overruns on high rise project in Indonesia, *Construction Management and Economics*, Vol. 15, No.1, pp. 83 – 94.

Koo, B and M. Fischer, M. (2000). Feasibility study of 4D CAD in commercial construction, *Journal of Construction Engineering and Management*, Vol. 126, No. 4, pp. 251–260

Leong, M.W and Kass, D.E. (n.d). Linear Schedules for Tunnel Projects. Jacobs Associates Seattle, WA.

Li, H., Chan, N., Guo, H.L., Lu, W and Skitmore, M. (2009). Optimizing construction planning schedules by virtual prototyping enabled resource analysis, *Automation in Construction*, Vol. 18, No.7, pp. 912-918.

Li, H., Guo, H.L., Skibniewski, M. J and Skitmore, M. (2008). Using the IKEA model and virtual prototyping technology to improve construction process management, *Journal of Construction Engineering and Economics*, Vol. 26, pp. 991-1000.

Lu, M., and Abourizk, S. (2002). Simplified CPM/PERT Simulation Model, *Journal of Construction Engineering and Management*, Vol. 127, No.6, pp. 513-515.

Mattila, K and Abraham D. M. (1998). Resource Leveling of Linear Schedules Using Integer Linear Programming, *Journal of Construction Engineering and Management*, Vol. 124, No. 3, pp. 232- 242.

Mauricio, M. S. B and Carlos, T. F. (2002). Contribution to the evaluation of Production Planning and Control System in Building Companies. *Proceeding of IGL Conference*. Granado, Brazil. 12 August.

Mawdesley, M. (2001). Planning and Controlling Construction Projects, *Journal of Engineering Management*, Vol. 143, No. 2, pp. 196-203.

Mendes Jr., R and Heineck, LF.M. (1998). Preplanning Method For Multi-Story Building Construction Using Line of Balance. *Proceedings of IGLC, Guaruja, Brazil.*

Mohd, K .B. A. K. (2006). Construction Planning and Scheduling: A Case Study of "Cadangan Membjna Dan Menyiapkan Kejll1yyah Sains Untuk Universiti Islam Antarabangsa Malaysia." A final year project report submitted to the Faculty of Civil and Environmental Engineering, Kolej Universiti Kejuruteraan dan Teknologi Malaysia.

Muir, B. (n.d). Construction planning and scheduling. University of Delaware Department of Civil and Environmental Engineering, CIEG 467-013.

Muir, B. (2005). Challenges Facing Today's Construction Manager. University of Delaware Department of Civil and Environmental Engineering.

Naoum, S, Fong, D. and Walker, G. (2004). Critical Success Factors in Project Management. *Proceedings of International Symposium on Globalization and Construction. CIB 2004. W107, TG23*. School of Civil Engineering, Asian Institute of Technology, Thailand. 17 – 19 September

Neale, R.H. and Neale, D.E. (1989). Construction planning, 1st Ed., Thomas Telford LTD., London, England.

Ogunlana, S. O and Olomolaiye, P. D. (1990). Improving Contract Planning Practice in the Nigerian Construction Industry, *The Nigerian Engineer*, Vol. 25, No. 4, pp. 1-7.

Oppenheim, A.N. (2003). *Questionnaire Design, Interviewing and Attitude Measurement*, New York: Basic Books.

Oxley, R and Poskitt, J. (1971). *Management techniques applied to the construction industry*, 2nd edition, London: Withham Chowes & Sons Limited.

Pena-Mora, F., and Park, M. (2001). Dynamic planning for Fast-tracking Building Construction Projects, *Journal of Construction Engineering and Management*, Vol. 127, No. 6, pp. 445-456.

Perera, S. (1982). Network planning of projects comprising repetitive activities, IAHS Conference on impact of economy and technology, International Association of Housing Science, Vienna, Austria, 927-985.

Radujkovic, M. (1999). The causes of Time and Cost Overruns in Construction Projects. In Bowen P and Hindle R (eds) *Proceedings of the CIB W55 & W56. Joint Triennial Symposium on Customer Satisfaction. A focus for research and practice.* Cape Town 5-10 September

Rahbar, F.F. and Rowing, J.E. (1992). Repetitive activity scheduling process, AACE Transportation, 36th Annual meeting, Orlando, Fl., O.5.1.-O.5.8.

Russell, A. and Caselton, W. (1988). Extensions to linear scheduling optimization, *Journal of Construction Engineering and Management, ASCE*, Vol. 114, No. 1, pp. 36-52.

Russell, A. and Dubey, A. (1995). Resource leveling and linear scheduling, Proceedings, Second Congress, Computing in Civil Engineering, ASCE, Nashville, TN., (ed. J.P. Mohsen), 1134-1141, ASCE, Nashville, TN.

Sarraj, Z.M. A. (1990). Formal development of line of balance technique, *Journal of Construction Engineering and Managemen*t, ASCE, Vol. 116, No. 4, pp. 689-704.

Sheba, P. (n.d). Lecture notes for Construction Planning and Scheduling. Department of Civil Engineering, Noorul Islam College of Engineering.

Seppänen, O and Aalto, E. (2005). A Case Study of Line-of-Balance Based Schedule Planning and Control System. Proceedings of IGLC, Sydney, Australia, 13th July, 2005.

Selinger, S. (1980). Construction planning for linear projects, *Journal of Construction Division, ASCE*, Vol. 106, No. 2, pp. 195-205.

Shah, R. J., Dawood, N. N and Castro, S. (2008) 'Automatic generation of progress profiles for earthwork operations using 4D visualisation model', *International Journal of Information Technology in Construction*, 13, pp.491-506.

Shi, X.H., Liang, Y.C, Lee, H.P., Lu, C., and Wang, L.M. (2004). An Improved GA and a Novel PSO-GA based Hybrid Algorithm, *Information Processing Letters*, Vol. 93, No. 5, pp. 255-261.

Stradal, O. and Cacha, J. (1982). Time space scheduling method, Journal of the Construction Division, ASCE, Vol. 108, No. 3, pp. 445-457.

Subramani, T Sarkunam, A and Jayalakshmi, J. (2014). Planning and Scheduling of High Rise Building Using Primavera, *International Journal of Engineering Research and Applications, Vol. 4, pp.134-144.*

Suhail, S.A. (1993). Out-of-logic progress, *Journal of Construction Engineering and Management, ASCE*, Vol. 35, No. 4, pp. 23-28.

Tetsuya, M., Kunz, J and Velline, A. (1993). Construction planning and manageability prediction. Technical Report, Number 87, Center for Integrated Facility Engineering.

Trofin, I. (2004). Impact of Uncertainty on Construction Project Performance Using Linear Scheduling. MSc Dissertation, Graduate School, University of Florida.

Umble, E. J., Haft, R.R and Umble, M.M. (2003). Enterprise resource planning: Implementation procedures and critical success factors, *European Journal of Operational Research* , Vol. 146, pp. 241–257.

Vorster, M.C. and Parvin, C.M. (1990). Linear scheduling for highway contractors and state DOT's, Richmond, VA: P. & W, Publications.

Ward, P.A. (1979). *Organisation and procedure in the construction industry*, 1st edition.

London : MacDonald & Evans Limited.

Waly, A.F and Thabet, W.Y.(2002). A virtual construction environment for preconstruction planning, *Automation in Construction*, Vol. 12, pp. 139–154.

Warner Construction Consultants. (n.d). Scheduling Best Practices. Warner Construction Consultants, Inc. 2275 Research Boulevard Suite 100, Rockville, Maryland 20850-3268

Wideman, R.M. (2001). Total Project Management of Complex Projects Improving Performance with Modern Techniques. A Presentation to the Construction Industry in the cities of Bangalore, Bombay, Calcutta, Madras and New Delhi on behalf of the Consultancy Development Centre.

Yamin, R.A. and Harmelink, D.J (2001). Comparison of linear scheduling method (LSM) and critical path method (CPM), Journal of Construction Engineering and Management, ASCE, 127 (5), 374-381.

APPENDIX

APPENDIX 1: SURVEY QUESTIONNAIRE

This research is a Postgraduate level research entitled "Planning and Scheduling Techniques Adopted by Financial Class A1b1 and A2b2 Road Contractors in Ghana" and intends to identify the planning and scheduling techniques being used by road contractors in Ghana. **Please , kindly respond to the questions by ticking(√) the appropriate box for each item. Please note that all information provided will be strictly treated as confidential as this work is for academic purposes.**

1. How many years of experience do you have in road construction?

[ ] under 10 years [ ] 11 – 20 years [ ] 21 – 30 years [ ] over 30 years

Rate of work acquisition

2. How frequent do you secure road construction projects?

[ ] Not frequent [ ] moderately frequent [ ] frequent [ ] very frequent

3. How frequent do you plan and schedule road construction activities?

[ ] Not frequent [ ] moderately frequent [ ] frequent [ ] very frequent **Importance of planning and scheduling in road construction**

4. What would you say about the importance of the following reasons for the choice of a particular planning and scheduling technique? Use the scale: 1= Not important 2= Less important 3= Moderately important 4= Important 5= Very important

s/no	Importance of planning and scheduling road construction activities	1	2	3	4	5
1	to ensure that activities are carried out in a systematic manner					
2	Planning and scheduling provide an overall view of interdependent project activities					
3	shape work flow in the best rhythm for achieving project objectives					
4	match labor teams and related resources					
5	to enable the planning of work method for the whole construction operation					

6	produce assignments for each group of activities at construction phases					
7	to identify operations to be planned jointly by multiple trades					
8	provide information about the construction progress for the sub-contractors and suppliers					
9	to predict the project completion date					
10	to serve as an effective project control tool					
11	to avoid liquidated damages					
12	to manage money by predicting cash flows					
13	to determine the "time window" of an activity					
14	to coordinate subcontractors					
15	to expose conflicts among trades					
16	to predict resource demand and improve resource allocation					
17	to serve as an effective communication tool					

To identify the planning and scheduling techniques in use in Ghana

6. How frequent do you use the following planning and scheduling techniques for road construction projects? Use the scale: 1= Not frequent 2= Less frequent 3= Moderately frequent 4= Frequent 5= Very frequent

	Planning and scheduling techniques	**1**	**2**	**3**	**4**	**5**
1	critical path method (CPM)					
2	bar charts/Gantt Chart					
3	flowcharts					
4	line of balance(LoB)					
5	Program Evaluation and Review Technique					
6	Graphical Evaluation and Review Technique					

7	work breakdown structure (WBS)					
8	crew movement chart					
9	mathematical programming					
10	heuristic models					
11	evolutionary algorithms					
	Computer aided techniques/software					
12	virtual prototyping					
13	Primavera					
14	Microsoft Project					

Documents or resources for road construction planning and scheduling

7. How frequent do you use the following in planning and scheduling road construction projects? Use the scale: 1= Not frequent 2= Less frequent 3= Moderately frequent 4= Frequent 5= Very frequent

	1	**2**	**3**	**4**	**5**
1. designs and drawings					
2, bills of quantities					
3. construction method statements					

4. project planning data					
5. specification					
6. site conditions					
7. market survey					
8. local resources					
9. technical and commercial studies documents					

Planning and scheduling processes in road construction

8. How frequent do you undertake the following steps in the planning and scheduling of road construction activities? Use the scale: 1= Not frequent 2= Less frequent 3= Moderately frequent 4= Frequent 5= Very frequent

	1	**2**	**3**	**4**	**5**
1. Select an activity					
2. collection of road design data					
3. Identify the list of Location at required interval of chainage					

4. List of locations of the selected activity					
5. Identification of access points and soil profile from site survey information					
6. Calculation of Quantity at chainage of selected activity					
7. Determine the productivity of selected activity at each location					
8. Calculate duration of the selected activity at required interval of chainage					
9. List duration of selected activity					
10. Link all activity with logical relation to develop detailed schedule					

Challenges of road construction planning and scheduling

9. What would you say about the severity of following challenges in the planning and scheduling of road construction projects? Use the scale: 1= Not severe 2= Less severe 3= Moderately severe 4= Severe 5= Very severe