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CONSTRUCTION PLANNING AND SCHEDULING PRACTICES IN ROAD CONSTRUCTION FIRMS IN GHANA

BY

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DECLARATION

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

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DEDICATION

This research study is dedicated to the almighty Allah.

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ABSTRACT

Planning and scheduling techniques are indispensable in delivering successful projects. Successful projects also are tied with profit making and in consequence survival in the construction industry. Unfortunately, planning and scheduling can be very difficult, arduous and time-consuming. The good news is that there have been attempts over the past years to streamline planning and scheduling. However, these practices have not been well integrated into the Ghanaian Construction Industry and especially the Road Construction Industry (RCI). The aim of this study is anchored to explore the construction scheduling techniques and methods adopted in the Road Construction Industry in Ghana. The study utilises survey questionnaire to elicit responses from the professionals in the Road Construction Industry. The findings basically identified the various planning and scheduling techniques employed in the RCI and the challenges impeding the adoption of these techniques in the industry. It was revealed that the industry is inclined to the use of traditional techniques as opposed to ‗modern' 4-D CAD scheduling tools. The significant challenges identified are: *Complexity of Tools*

Cost of Modern planning and scheduling tools (Cost of Software), Technological Challenges. To improve the likelihood of affording these modern 4-D CAD visualisation software and hardware, small companies should consider forming amalgamations and cartels to increase their purchasing power. The findings on the challenges of planning and scheduling; and also the usage also provide an avenue for Continuous Professional Development. This will ensure that professionals are able to manipulate advanced and sophisticated to improve project performance.

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CHAPTER ONE GENERAL INTRODUCTION

1.1 BACKGROUND

Successful projects invariably lead to increase in profit in a construction company. Delivering projects successfully is one of the key responsibilities of construction project management, and it involves planning and scheduling of construction projects (Li et al., 2012; Hancher, 2003). In addition, thorough planning and scheduling is of utmost significance to both building and civil works (Chau et al., 2005). Planning is the mother-activity of all construction works from which all other tasks follow or depend (Li et al., 2012). However, planning is onerous, complicated and above all time-consuming. Due to its complex nature project plans are flexed to accommodate future changes. This is perhaps summarised by Li et al. (2012; p2) in the statement ―even experienced construction planners find it impossible to build/design a comprehensive and faultless master construction plan at the first attempt‖.

Compared to buildings, road construction has fewer activities and crews. Notwithstanding, the degree of complexity in road construction is similar to buildings (Li et al., 2012). Additionally, highway projects of any magnitude have become increasingly difficult due to the highly competitive environment and complexity of the decisions of management involved (Shah, 2008). Therefore, for many years, efforts have been made to plan, direct and control project activities to ensure success (Hancher, 2003). Until recently, there was no generally accepted procedure of managing projects. The management depended on the level of experience of Project Managers and their personal judgments. As a result, each Project Manager had a different system, which usually included the use of the Gantt chart or bar chart (Hancher, 2003). However, as projects became more complex the need to develop complex tools that encapsulate the complex demand of projects became apparent. The network analysis was consequently

developed. Since then there have been several attempts to even develop more complex tools that satisfy modern project

requirements.

However, much research in recent years has focused on simulating and visualizing construction plans to reduce the time and problems involved in road construction. For instance, El-Rayes (2001) and Hassanein and Moselhi (2004) have developed an object-oriented model for planning and scheduling highway construction. Also, Liapi (2003) has applied 4D CAD to actual highway projects to provide a better understanding of the aspects and spatial constraints involved compared with the traditional 2D format. Classified as repetitive construction project, road construction projects involve repeating the same work in various locations of the projects (Hyari and El-Rayes, 2006). As a result available schedule methods focused on crew work continuity that enabled each crew to finish work in one location of the project in order to minimize interruptions (Hyari and El-Rayes, 2006). Surprisingly, it was later observed that methods that allowed interruptions on projects have the ability of achieving early project completion i.e. minimised durations.

From the foregoing, it is obvious that strive to obtain undisturbed construction plans and schedules from the onset of project continues unabated. Construction planning and scheduling has been there over the years, however, the general shortage of skill has brought it into sharper focus (Allen and Smallwood, 2008). Conferring to this, Allen and Smallwood (2008) aptly opined that construction planning will provide an increasingly critical role in the construction industry, and even more due to the unprecedented industry growth.

1.2 PROBLEM STATEMENT

In advanced countries, the last decade has seen research in the field of construction planning and scheduling. These extensive research, according to Chau et al. (2003), have been made on the development of computerized forms of planning and scheduling, such as 4D and visualization of construction processes. The reason for these developments is revealed in the fact that developing construction plans is a critical task in the management of a construction projects (Hendrickson, 2000 cited from Heesom and Mahdjoubi, 2004). The planning obviously requires competent and experienced personnel (Illingworth, 2000). Unfortunately, the emerging trends suggest a skill shortage in the area of construction planning (Heesom and Mahdjoubi, 2004). Allen and Smallwood (2008) observed that the number of competent planners available falls far short of that which is required. Compounding this problem of skill shortage is the limited time experienced project managers have to plan on most construction projects (Kelsey et al., 2000).

Additionally, construction processes are becoming more complex and logistically challenging (Allen and Smallwood, 2008). The intense period of earthworks and the topography involved in road construction projects further makes the construction process, although seemingly simple, yet more complex (Li et al., 2012). Unlike building projects that contained discrete time-linked objects such as columns and slabs (Platt, 2007), in road construction clear identification and linkage with such discrete schedule activities is not possible (Li et al., 2012; Hancher, 2003). With these gaps identified, the study will seek to explore construction scheduling practices and methods identified in the Road Construction Industry.

1.3 AIM AND OBJECTIVES

1.3.1 Aim

The aim of the study is to explore the construction scheduling techniques and methods adopted in the Road Construction Industry in Ghana.

1.3.2 Objectives

In order to realise the above aim, the following objectives are set:

- To identify the various construction scheduling techniques and methods used in the Road Construction Industry
- To identify the challenges construction planners and project managers face in the use of construction scheduling techniques and methods.

1.4 SCOPE OF THE STUDY

The study would be delineated geographically to the Greater Accra and Ashanti Regions of Ghana. Both empirical and anecdotal evidence suggest the two regions to be the major hubs of construction. The focus of this study will be the Road Construction Industry in Ghana. However, it is expected that the study will draw from studies on construction industries of other countries. The entirety of construction scheduling practices and methods is not covered under this study. Also since construction project managers and planners are usually the major personnel involved in construction planning, they are the main focus for data collection.

1.5 RESEARCH DESIGN

From the research objectives it is evident that the study is laden with measurement/assessment. And studies of such nature relate to positivism. Positivism is noted to deal with studies of observation, phenomenon, or reality involving assessments

or measurements (Manu, 2012). In this research, positivism would thus be adopted as the overarching paradigm and that dictated a mainly quantitative inquiry which also implied a largely deductive reasoning for the study (Sutrisna, 2009). Within the overall positivist framework, an element of qualitative inquiry was incorporated to facilitate understanding of the current trend of construction scheduling practices. This was particularly necessary for the achieving of objective two of the study which follows a more review of literature. This resulted in an overall mixed method research design, in particular the sequential exploratory mixed method where a quantitative inquiry is preceded by a qualitative inquiry (Creswell, 2009).

The results will largely be collected using quantitative research strategy methods involving survey and questionnaire. Subsequently the data would be analysed using quantitative data analytical tools in the form of descriptive statistics (measures of central tendencies and dispersion) and inferential statistics.

1.6 SIGNIFICANCE OF THE STUDY

Throughout extant literature there is enough convincing reasons to undertake this study. This is mostly evident in the overarching theme of efficiency and productivity in the increasing complexity of construction industry. So in view of this the advanced countries have dedicated the last decade to finding ways of streamlining construction activities, especially in bridges and highways construction. However, study of such nature is lacking in our part of the world. The results from the advanced countries are more convincing to ignore. But its application in the construction industry in Ghana is not practical because of differences in cultural background, among other things.

Therefore the need to study this inevitable phenomenon. This notion fueled this study.

It is expected that participants of the construction industry would be beneficiaries of this studies. Construction Planners and Project Managers would be major beneficiaries.

The study may stimulate policy directions towards the implementation of scheduling practices in the industry.

1.7 PROJECT ORGANISATION

The structure of the study talks about how the work is organized into chapters. This work is divided into five chapters. Chapter one which is on introduction begins by describing the background to the study, research questions, problem statement, the objective of the study, research methodology, its significance, scope, limitations and organization. It moves on to literature review in Chapter two. Research Methodology is discussed in chapter three; the work presents how data was analyzed. Research Findings is discussed in chapter four. Finally, chapter gives the conclusion remarks and recommendations.

CHAPTER TWO LITERATURE REVIEW

2.1 INTRODUCTION

Theoretical framework is imperative in studies of this nature as it provides an understanding of the developments in the discipline or the theory underpinning the studies. As the construction industry continually strives to achieve accuracy and attempts to overcome the traditional cost and time overruns associated with construction delivery, it is indispensable to seek for innovative ways of achieving these objectives. Essentially, achieving these objectives requires the utmost planning and scheduling of construction activities (Chau et al., 2005) since planning and scheduling impacts on all other tasks (Li et al., 2012). In spite of these assertions, construction planning and scheduling can be very daunting, owing to its complex nature.

To situate the study in the right context or perspective and elucidate construction planning and scheduling, this chapter is dedicated to reviewing extant literature on the topic and other similar or related topics.

2.2 THE ROAD CONSTRUCTION INDUSTRY

The Road Construction Industry (RCI) is necessary for momentous development of an economy. For example, the last few years saw the Indian economy in a phase of unparalleled growth of about 8-10% per year, making it one of the fastest growing economies in the world. Sustaining this rate of growth invariably demands huge investments in physical infrastructure such as roads (Chilipunde and Kadangwe, 2013; Bandyopadhyay et al, 2008). Such investments in roads further underscore the significance of the RCI. The RCI is categorised under the engineering division of the overall construction industry (ABS, 2003). In most developing countries, roads are the dominant mode of transport and constitute the single largest government asset as a large amount of money is invested in this endeavour (Chilipunde and Kadangwe, 2013; Thillai et al., 2010; Addo-Abedi, 1997). In addition to the construction of new roads, other roads are rehabilitated or routinely maintained, in order to accelerate development. It is estimated that over 90% of all international freight and passenger traffic is handled by road transport, while 70% of internal freight and 99% of passenger traffic relies heavily on road transport (Ministry of Transport and Public Infrastructure, MOTPI, 2011). In spite of the significance of the road networks, development of the road sector contributes towards environmental degradation and global warming (Chilipunde and Kadangwe, 2013).

Owing to its significance, governments in developing countries especially Africa are continually looking for ways of rehabilitating road networks, maintaining existing ones and building new road networks (Brushett and Kumar, 2001). According to a

World Bank report, Ghana‘s road transport indicators are strong (Foster and Pushak, 2011). Same can be made about the RCI because the two are inextricably linked.

Ghana meets almost all of the best practice guidelines for road sector institutions (Foster and Pushak, 2011). In contrast to other African countries, Ghana allocates its road fund resources much more evenly across the different road networks—rural and urban roads receive 30 and 25 percent of the total, respectively. Overall, Ghana has allocated substantial resources to the road sector in recent years; it spends on average

1.5 percent of GDP on roads, one of the highest shares in West Africa (Foster and Pushak, 2011).

The Indian road construction industry is highly unorganized and fragmented (Bandyopadhyay et al, 2008). According to them, an insignificant number of contractors in India can be classed as medium to large firms (based on the number of people employed per firm). They further argued that many of the medium and large construction firms are still family owned and lack professional management and work culture. This situation in India is similar across many developing countries which

Ghana is not an exception. This situation has fueled the _inefficiency‘ associated with the Road Construction Industry. The industry is noted for delays and cost overruns. According to Ubani and Ononuju (2013) concerted and efficient management

processes are required for the avoidance of delays and cost overruns.

2.3 OVERVIEW OF CONSTRUCTION PLANNING AND SCHEDULING

2.3.1 Introduction

Project success ultimately is the key to successful profit making in any construction organisation (Hancher, 2003). In view of this, efforts have been made over the years, to direct, plan, and control the numerous construction activities to achieve optimum

project performance. However, the incessant abandonment and the proliferation of delays and cost overruns on construction projects (see Ahiaga-Dagbui et al., 2014) only suggest a lack of integration of advanced construction planning and scheduling in the construction industry. This might be the reason for Allen and Smallwood (2008) assertion that clients and stakeholders alike are not satisfied with the results of the industry. Accurate cost estimating and control are the essential elements to ensuring project success (Elbeltagi et al., 2014). Essentially, the controlling cost and the accurate estimating of projects is intertwined with planning and scheduling. This places a demand on project planners and in some instances, project managers to integrate planning and scheduling in the Road Construction Industry. More so, the unprecedented growth and the general shortages of skills (Allen and Smallwood, 2008) in the industry further underscore the need for a more rethinking of construction planning and scheduling in the Road Construction Industry, since the existing practices are failing to produce the desired results (Allen and Smallwood, 2008).

Owing to the fragmented and unorganized nature of the industry, the roles of construction planners in the realm of construction are not appreciated (Allen and Smallwood, 2008). Indeed, in the Road Construction Industry in Ghana such a title is virtually non-existing. The role of construction planners is mostly assumed by the project managers. This confirms the assertion by Allen and Smallwood (2008) that the Industry is limited in terms of the number of competent construction planners and in consequence less qualified personnel is being thrust the responsibility of construction planning. Throughout history the construction industry‘s clients have consistently and progressively demanded for higher standards, and as a result construction planners are at the forefront of these developments (Proverbs et al., 1996). Unfortunately, it appears the industry has not planned adequately to meet the competing demand of the clients.

Hence the clients are dissatisfied with the outputs of the industry and the productivity of the industry is low (Allen and Smallwood, 2008; Proverbs et al., 1996).

The unpredictability of the construction delivery time, budgets, *inter alia* are the manifestations of the gaps that exists in the current practice of planning and scheduling in the industry. Accordingly, making the industry attractive to both investors and potential recruits requires the stringent application or integration of technology to improve working efficiency and existing practices (Allen and Smallwood, 2008). The thrust of this achievement is the construction planning process. And this has been the focus of this section. The succeeding subsections highlight the theoretical developments of construction planning and scheduling and the techniques.

2.3.2 Difference between Planning and Scheduling

Planning and Scheduling, most often are used concurrently and as a joint term. However, the two tasks are distinct. This is manifested in the argument of Fischer (2002). Fischer (2002) pointed out the apparent differences between a construction plan and construction schedule. He contends that a plan shows the logical relationships of construction project activities. However, on a plan that start and end dates are missing because activities do not communicate that. Whereas a schedule shows the start and end dates that helps in the definition of project duration.

Planning, according to Hancher (2003), includes the consideration of the existing constraints and available resources that impact on project execution. Planning is essential in the following support functions: project, materials storage, office space, temporary utilities, etc. Planning involves;

- Identification of the activities for a project

- Ordering of these activities with respect to each other, and
  Development of a logic relationship.

Development of a construction plan is critical to the success of projects (Heesom and Mahdjoubi, 2004), however, it is by far the most difficult task (Hancher, 2003). Here, the project is built on paper.

Scheduling, although distinct, is commonly acknowledged as part of the construction planning process. According to Heesom and Mahdjoubi (2004), in scheduling, planners, project managers and site mangers altogether simulate various construction processes required to build the project. It is this stage of the construction process that requires the adoption of computer-based tools. Scheduling basically involves the determination of the timing of each work item, activity, in a project within the overall project duration (Hancher, 2003).

Altogether, planning and scheduling are two separate processes involving the performance of different tasks. However, the planning and scheduling processes normally overlap (Hancher, 2003).

2.3.3 Theoretical developments of Construction Planning and Scheduling

The last two decades have seen a growing interest in technological advancement (e.g. four-dimensional computer aided design, 4-D CAD) for construction planning and scheduling (Heesom and Mahdjoubi, 2004; Chau et al., 2003). Hitherto, construction planning and scheduling was mundane involving basic tools and practices. There was no generally accepted formal procedure to help in the management of projects (Hancher, 2003). The procedure varied from project to project and from manager to manager. However, there was one thing peculiar to all projects or sites. Construction professionals on a typical project communicated through paper-based working

drawings, and the planning staff formulated their schedules in the same way involving paper-based working drawings (Chau et al., 2003). This presented the planning team with an unenviable and herculean responsibility of formulating project schedules. The arduous task was the consideration of resource requirements for human, plant, materials, etc. Not only that, planners also faced the challenge of incorporating in their minds logical construction sequence, and economic resources utilization (Chau et al., 2003). The construction industry is multifarious, and involves huge number of resources. Achieving the desired results using human intuition was bound to fade out.

The increasing complexity of construction fueled the obsolescence of the heavy reliance on _human intuition‘ in planning and scheduling.

This development led to the adoption of computer-based tools for planning and scheduling. Chau et al. (2003) argued that where computer-based tools were utilised they were utilised as bar charts or critical path networks. This was limited in that they were not able to show spatial construction features as well as the detailed resource and workspace requirements. This had to be envisioned in the minds of the planners (Chau et al., 2003). So although there have been improvements in the form of computerbased tools, the critical tasks were still left to the intuition of the planners. Moreover, their intuition was only limited to the extent of information that can be gleaned from the design documents. As a result, Chau et al. (2003) concluded that the computer has not been explored enough.

Exploiting the optimal assistance from computers fueled the upsurge of concerted research efforts on the concept of visualisations (i.e. 4-dimensional models). The fourth dimension has to do with time. As aforementioned, the research focus in the last two decades has been on the development of more stringent approaches to effective

construction planning and scheduling. For instance, Retik et al. (1990) developed and outlined possible features of tools for construction scheduling using computer graphics. Also, Williams (1996) graphically represented construction plan with a 4-D Planner to improve project visualisation, simulation and communication needs. In the same way, McKinney et al. (1996) developed a 4-D CAD tool that also enhances visual communication, but was limited to the construction design process. Adjei-Kumi and Retik (1997) using a library-based 4-D model, PROVISYS, for planning reported visualisation of construction plan in a virtual reality. Moving on, Kamat and Martinez (2001) proposed a general purpose 3D visualisation system on construction operations.

In spite of the fact that there have been improvements, incorporating visualisations of construction processes to aid planning and effective decision making, the developments are often limited to building level. Chau et al. (2003) argued that the application lacks pragmatic site management features. They consequently proceeded to furnish a 4-D graphical visualisation capability for construction planning purposes. Currently, 4-D CAD has been found to have a profound impact on communication in construction. It allows a more comprehensible intuition of the construction processes than the traditional 2-D drawings and schedule information (Bergsten 2001 cited from Heesom and Mahdjoubi, 2004).

Surprisingly, the construction industry in developing countries including Ghana has historically neglected modern practices in planning and scheduling. This is evident in the conventional cost and time overruns, and lack of literature on the discipline in that regard.

2.4 CONSTRUCTION PLANNING AND SCHEDULING TECHNIQUES

2.4.1 Traditional Planning Techniques

The era of traditional planning techniques dates back to the time of Henry Gantt's _Work, Wages and Profits' in 1916.

2.4.1.1 Gantt Chart

The Gantt chart otherwise known as the bar chart is useful for the illustration of work items and their estimated times (Hancher, 2003). It was named after Henry Gantt, hence the name _Gantt Chart'. However, it was originally developed by Karol Adamiecki in 1896 (Bokor et al., 2011). He named it the harmonogram. Bokor et al. (2011) argued that the contradictory may come from the fact that the harmonogram was only popular in Poland, and until 1936 Karol Adamiecki had not published his work.

Basically, the Gantt chart is a bar graph with time on the horizontal axis and resources on the vertical axis. The chart has the advantages of easy to prepare, easy to interpret and understand. Compare to most planning tools, the Gantt chart is a very good communicative tool, especially in the industry where most of the artisans are not highly educated. In view of this it is the most widespread way of displaying project plans (Bokor et al., 2011). In spite of these advantages the Gantt chart has some limitations. First, relationships or logic between activities cannot be shown on the chart. Also, the effect on the schedule is difficult to determine.

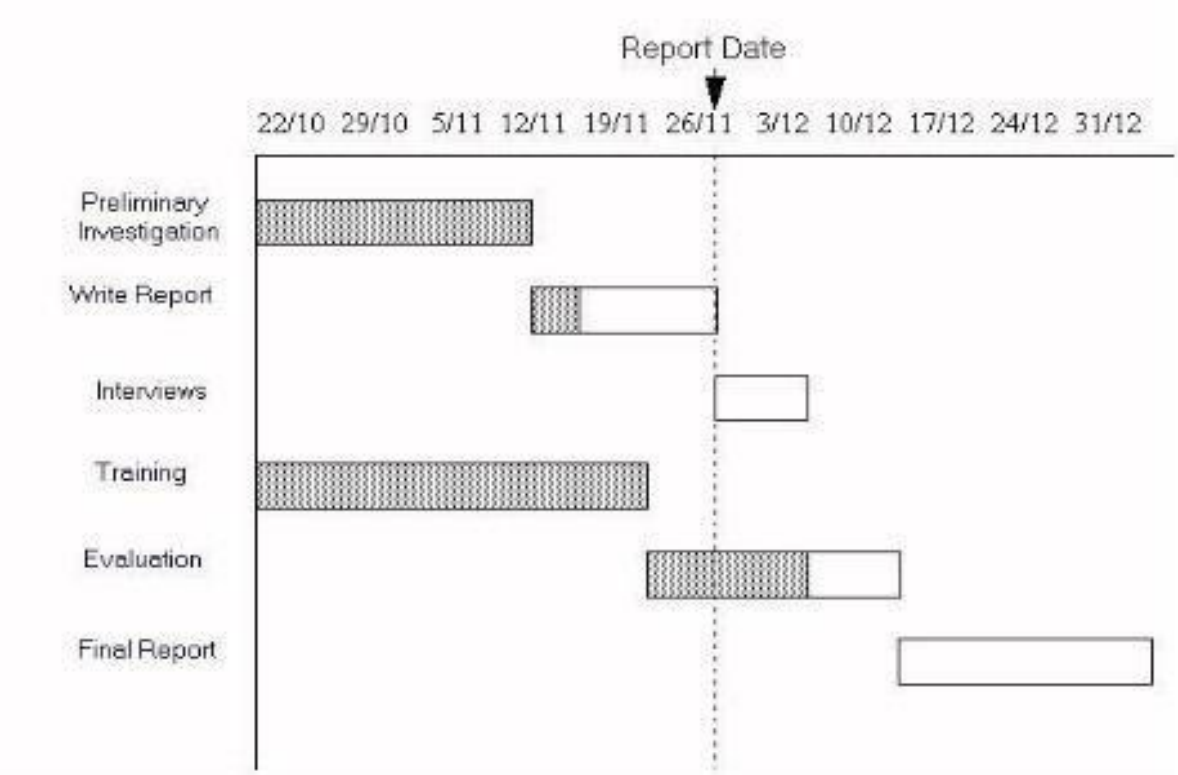

Figure 1: Gantt Chart

Figure 2.1 Gantt chart

2.4.1.2 Cyclogram

The shortfalls of the Gantt Chart led to the development of a more sophisticated tool that incorporates the downsides of the Gantt Chart (Bokor et al., 2011). The Cyclogram was developed to overcome the technological challenges and spatial troubles. It has on the vertical axis the percent completion as the function of time. It is mostly used for displaying project plan for infrastructural projects like highway construction, etc. (Bokor et al., 2011). In such cases, cross-sections are represented on the vertical axis.

2.4.2 Network Planning Techniques

The growing complexity of projects fueled the need for a more advanced method of displaying project plans. In response the network planning techniques were developed. The techniques evolved with modern project management in 1959 (Bokor et al., 2011).

A characteristic of the Network Planning Techniques is that the activities duration are given in a deterministic way.

2.4.2.1 Critical Path Method

With the Gantt chart relationships between activities could not be displayed, they were only implied (Hancher, 2003). Hancher further noted that the complexity of the project even makes the displaying of the relationship virtually impossible. So the development of the Critical Path Method (CPM) provided a more formal and systematic way to project management (Hancher, 2003). Additionally, the critical activities could be determined using the Critical Path Method (CPM). The Critical

Path is the longest path through the project, and that determines the project‘s duration. In a CPM network, events are represented by circles and activities are showed as arrows (Bokor et al., 2011). They are sometimes referred to as Activity-on-the-arrow diagrams.

Events represent the finishing and starting times of activities directed to and from them. For instance in the Figure 2.2 the numbers in the nodes show the early and late occurrence of the events. The red line also indicates the critical path of the project. Bokor et al. (2011) contend that the CPM is capable of storing logic that has been created, and in consequence allows easy modifications to the original plan. The CPM has been implemented successfully on several projects. Hancher (2003) noted that the success was not only peculiar to the construction industry, but project management in other disciplines. In summary, Hancher (2003) concluded that ―Today‘s construction manager who ignores the use of critical path methods is ignoring a useful and practical management tool‖. Surprisingly, Bokor et al. (2011) had a different view about the CPM. They noted its deficiency in handling multiple relationships.

2.4.2.2 Program Evaluation and Review Technique (PERT)

Program Evaluation and Review Technique (PERT) works the same way as the CPM and in fact evolved about the same time i.e. in the late 1950. However, the task durations, unlike, the CPM are determined stochastically (Bokor et al., 2011). Today, as in the past, project managers and planners have been preoccupied with PERT (Ika, 2009). Academics argue that uncertainties abound on projects and that is the major advantage of the PERT, and also the difference between the PERT and CPM – details of PERT are not known with certainty. In PERT the duration of the project is assumed to have a beta probability distribution given by the formula below:

$$\frac{O + 4M + P}{6}$$

Where *O*= the Optimistic duration

M= the Most likely duration

P= the Pessimistic duration

Precedence Diagramming Method

It was developed in response to the deficiencies arising out of the Critical Path Method. Precedence Diagramming Method (PDM) offers the users the flexibility of more than one and complex dependencies between activities (Bokor et al., 2011).

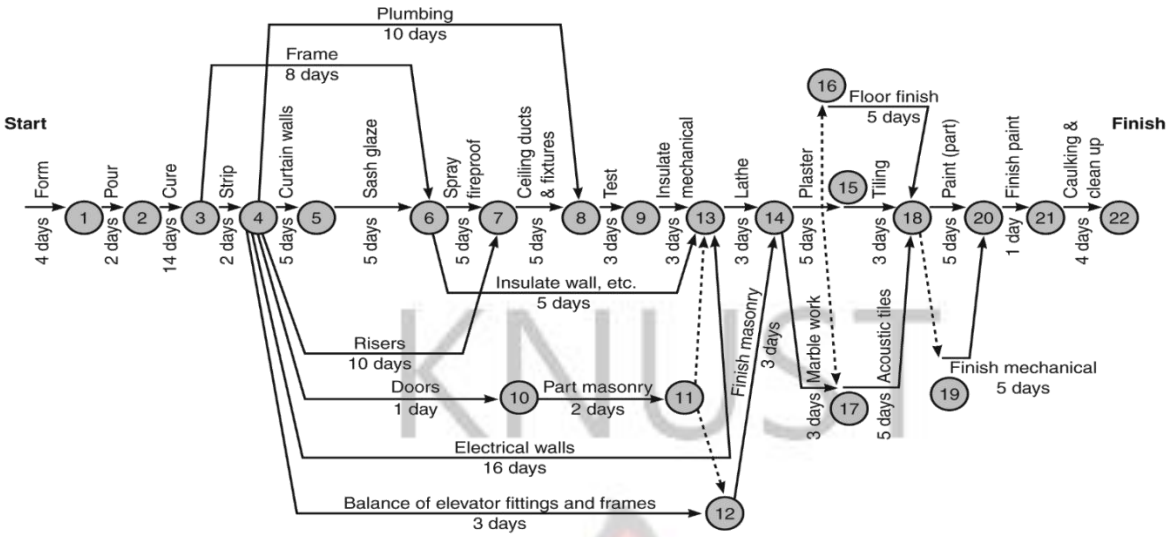

Fig. 2.2 CPM Chart (Barr, n.d)

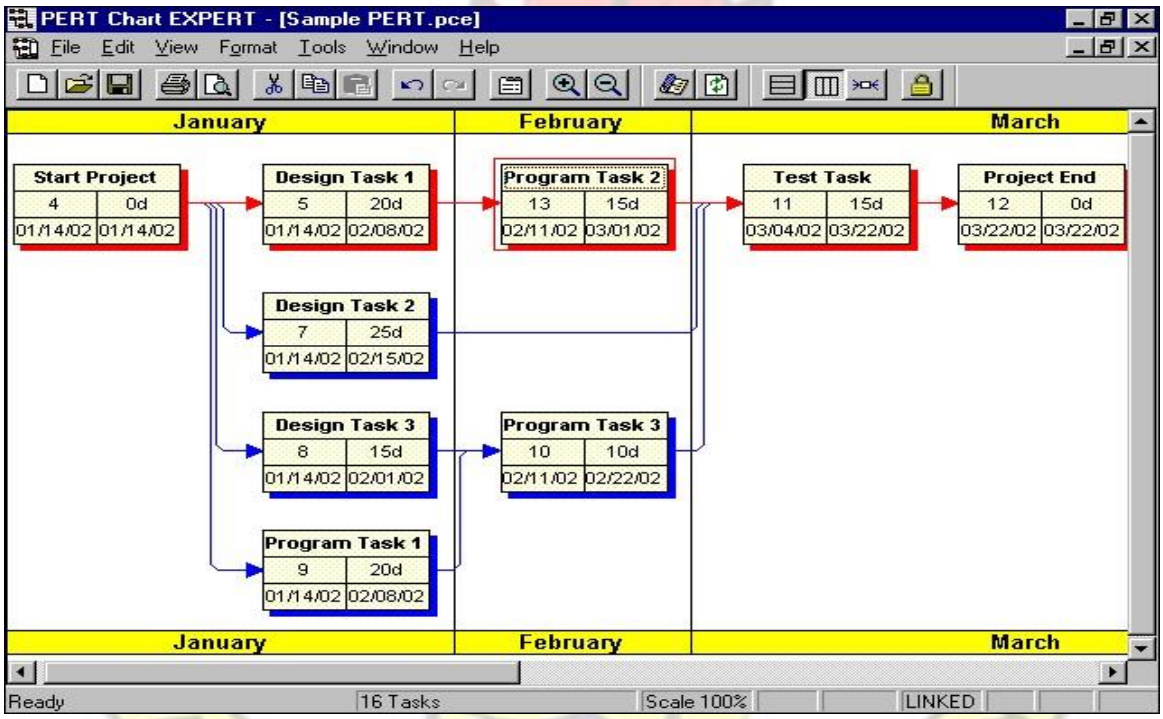

Fig 2.3 PERT Chart (Pert Chart Expert, n.d)

2.4.3 4-D CAD Visualisation Techniques

Conventional project planning techniques such as CPM, PERT, Gantt Chart, etc. are disadvantaged in terms of adequate communication of the conceptual planning of the modern manager (Allen and Smallwood, 2008; Koo and Fisher, 1998). Additionally,

relating information through these conventional techniques is more difficult and mistake prone. The result is that some problems remain inherent and elude the project planning stage. This phenomenon explains why variations or changes are commonplace in construction (Koo and Fisher, 1998). If project information could be visualized there is high possibility that most of these elusive problems would be detected at the planning stages. Advancing this principle evolved the theory of Visualisation techniques in project planning and scheduling in construction. This subsection discusses the various visualisation techniques in project planning and scheduling.

Of particular importance in the 4-D CAD Visualisation Techniques is the fact that the benefits cuts across the board. Designers and builders are able to communicate through design and construction information, which enhances collaboration and improves communication between the two entities (Koo and Fisher, 1998). In Contrast to the conventional techniques, users can also use the 4-D CAD to assess the cost, health and safety issues, or allocation of resources even before the completion of the facility. Below are the underlisted types of 4-D CAD Visualisation techniques:

2.4.3.1 Schedule Simulator

The software emerged from the technology developed by Jacobus Technologies. The 4-D CAD combines 3D graphic of the construction process with schedule data from either Primavera or Microsoft Project. According to Heesom and Mahdjoubi (2004), the fusion of the data from these packages is done with OLE2 (Object linking and embedding) Automation, dynamically linking schedule data. A unique feature of the tool is that any variation to the schedule is immediately reflected and thus visualized in the 4D environment. The greatest disadvantage is perhaps the inability to link or connect tasks to the 3D objects automatically (Heesom and Mahdjoubi, 2004).

2.4.3.2 Smart Plant Review –Intergraph Incorporated

Advancing the Schedule Simulator evolved Smart Plant Review. The tool contains a ScheduleReview, an engine that allows a 4D simulation through linking tasks (information from the project schedule) to the 3D CAD. Though it has similar functions with the schedule simulator, it however, allows the automatic connection of tasks and 3D objects (Heesom and Mahdjoubi, 2004).

2.4.3.3 FourDviz – Balfour Technology

Virtual reality display of objects allows the creation of visual scenes. As a result a real time environment is created which can be manipulated by the user through any direction of the visual scene (Heesom and Mahdjoubi, 2004).

2.4.3.4 Common Point 4 D

This tool was developed by the Center for Integrated Facility Engineering at Stanford University, USA. The project ended in 1998. The limitations of the conventional planning and scheduling tools may have stimulated this work, since the authors compare this tool with the conventional tools (cf. Koo and Fisher, 1998). This tool, as in the tools aforementioned, also relies on AutoCAD; specifically 3D IFC complaint models (Heesom and Mahdjoubi, 2004). As in the case of the Schedule Simulator, the linking of tasks to 3D CAD objects is done manually. However, a unique feature of the software is that it allows the grouping of objects manually and attached to one or group tasks (Heesom and Mahdjoubi, 2004).

2.4.3.5 Visual Project Scheduler

2.4.3.6 Project Navigator 2000 – Virtual STEP

2.5 BENEFITS OF CONSTRUCTION PLANNING AND SCHEDULING TECHNIQUES

Throughout this study, it has been demonstrated that planning and scheduling is indispensable to project success, and ultimately the profit of construction companies. As a result interest in construction planning and scheduling techniques has grown considerably over the years, with academics and practitioners alike developing interest in the discipline. Surging interest in the discipline further reflected in the plethora of construction planning and techniques tools evolved over the years – from conventional to modern tools. The continuing trend toward the betterment of the available tools and techniques suggests a lot of inherent and explicit benefits. Under this section the benefits are highlighted. These benefits include but not limited to the following.

2.5.1 Allows visualization of information

Construction planning and scheduling techniques, particularly the 4D models, allows the information to be visually interrogated in advance before construction (Allen and Smallwood, 2008). This benefit is not only peculiar to the construction industry, but to other industries as well. Evidence exists in other disciplines such as sales and operation where planning and scheduling techniques provided a similar benefit (see Ivert and Jonsson, 2010). Due to the relatively large number of semi-literates on construction sites, it is important that information be visually presented to the understanding of all; and this is what planning and scheduling techniques offer. One site engineer, during the piloting of 4DSMM is reported to have accounted the importance of visualisation in construction: locating equipment, analyzing carnage etc. (Chau et al, 2005).

2.5.2 Easy access to information

To some extent mental model possesses advantages over computer or graphical model in terms of its flexibility and processing of wide range of information presented in any form (Sterman, 1992). Nevertheless, mental models suffer from great disadvantages, particularly the interpretation of the mind. This is where graphical presentation of construction plans is imperative in particular with projects of high complexity.

Construction planning and scheduling tools like Gantt Chart, CPM, etc. present the construction idea into forms that are easily appreciated by the teams (Barati et al., 2013). In the absence of any of team members, information about the project may be accessed and in consequence ensure workflow.

2.5.3 Makes it possible to identify unexpected future outcomes

The traditional forms of construction planning and techniques made it difficult to discover problems at the initial stages and therefore variations are pervasive on construction projects (Koo and Fisher, 1998). However, recent advances in planning and scheduling make it possible to identify the inherent problems from the onset of the projects (Heesom and Mahdjoubi, 2004). For instance with the visualisation tools such as the 4D CAD highlights minutes inconsistencies and problems that could have inherently been hidden from the experts.

2.5.4 Makes it possible to analyze unexpected future outcomes

This benefit is inextricably linked with the benefit immediately aforementioned. The identification of the unexpected future outcomes precedes the analysis of the outcome. Unlike the conventional planning tools that leaned much towards imagination and intuition, modern planning and scheduling tools provide users with interactive

manipulation that enable the easy analysis of unexpected future outcomes that erupts (Chau et al., 2005; Koo and Fisher, 1998).

2.5.5 Results in a reliable delivery plan

The success of a project inevitably relies on a very realistic project plan (Heesom and Mahdjoubi, 2004). Corroborating to this, Hendrickson (2000 cited from Heesom and Mahdjoubi, 2004) argued that planning is a critical task in a project. That is to say chances are that a reliable delivery plan would lead to a successful project. It is of no secret that competent and experienced personnel are needed for the development of effective plans (Heesom and Mahdjoubi, 2004). Experienced managers are able to visualize the process in their heads (Koo and Fisher, 1998). However, they further argued that there is always a missing link from conveying the visualized information to second parties i.e. planners and other artisans. This is where planning and scheduling tools fit into the problem. The experience and conceptualization of such information is carried out using planning and scheduling tools.

2.6 CHALLENGES IN THE ADOPTION OF CONSTRUCTION PLANNING AND SCHEDULING

Construction planning and scheduling techniques present mouthwatering potentials (Azhar et al., 2008). Surprisingly, the construction industry in Ghana is lagging behind in terms of construction and planning techniques. For instance, 4D CAD is almost alien to many practitioners and academics in the construction industry. Many factors account for this slow adoption of construction and planning techniques. And that is the purpose of this section. In consequence the succeeding subsections discuss the challenges that impede the successful integration of construction planning and scheduling techniques.

2.6.1 Complexity of the tools

Complexity of the planning and scheduling tools serves as an impediment to the successful integration of planning and scheduling tools. Extensively this problem has been studied by many authors and indeed the problem is prevalent in any identified challenges studies across the world. For instance, Woo (2006) observed the difficulty students especially beginners faced in the use of similar construction planning tools. This barrier is not peculiar to the class alone, it transcends to sites. The difficulty in inputting data and the time involved in handling data are some effects of the complexity of tools (Chau et al., 2005).

2.6.2 Unable to take into account spatial planning

Existing project planning and scheduling tools do not take into consideration the spatial needs of the construction sites (Winch, 2002). As a result, Heesom and Mahdjoubi (2004) argued that these planning and scheduling tools are considered one-dimensional. In research, integration of site-related practices of planning and scheduling has received little attention (Retik and Shapira, 1999). Over a decade, development in this field is still in the preliminary stages. This development led to the heavy reliance on intuition and personal experience of the professionals.

2.6.3 Technological challenges

In order to fully exploit the benefits of construction planning and scheduling tools interoperability is indispensable (Thurairajah and Goucher, 2013). Interoperability refers to the smooth exchange of information across all disciplines. However, the fragmented and solitude nature of the construction industry (Arayici et al., 2012) impede this integration and inconsequence such incompatibility aggravate the adoption of modern construction planning and scheduling tools including 4D CAD (Olatunji,

2011). The conventional nature of the road industry makes it more difficult to implement these practices.

2.6.4 High computer illiteracy rate (High Skill is required)

Skill is relevant in the accurate and realistic development of construction plans and schedules using visualisation tools (Chau et al., 2005). Modern construction planning and scheduling techniques require much knowledge in the manipulation of the tools.

In the Ghanaian Construction Industry, most professionals are not modern construction tools savvy partly because the computer has not been fully integrated in the course. More so, there are limited reference materials on the discipline.

2.6.5 Fragmented nature of the Ghanaian Construction Industry

Today, as in the paste, construction projects experience major conflicts that in most cases plunge the project into delays and cost overruns. Khosrowshahi and Arayici (2012) explained that the fragmented nature of the construction industry is partly a contributing factor. Although, this characteristic of the industry cuts across all countries there have been attempts to successfully integrate collaboration in the construction industry of the developed economies. This has fueled the implementation of many sophisticated planning and scheduling techniques. Surprisingly, the industry in developing countries is still battling with the issues of collaboration and fragmentation. Khosrowshahi and Arayici (2012) argued that technology alone is not capable of changing the widespread problem in the industry. Collaboration is indispensable in the adoption of these techniques.

2.6.6 Traditional tools forces minds visualisations

A greater challenge with the conventional planning and scheduling tools is the heavy reliance on mind modeling (Chau et al., 2005). Although cognitive processes and

intuition are indispensable in construction site co-ordination, situations such as complexity and multi-interrelated factors limit the capabilities of human in cognitive, reflective and analytical skills (Chau et al., 2005). Pervasive cost and time overruns, the ―90% syndrome‖ among others are some of the highlights of the disadvantages of mental visualisation (Sterman, 1992). To overcome this construction planning and scheduling tools evolved. However, those employed in the Construction Industry of Ghana has not been the solution to the problem but the problem itself. The reason is that the industry relies on conventional tools such as Gantt Chart, etc that is onedimensional (Heesom and Mahdjoubi, 2004) and in consequence forces mental visualisation.

2.6.7 Cost of Modern planning and scheduling tools (Cost of Software)

Software and hardware upgrades are considered as significant barriers to planning and scheduling techniques, particularly for SMEs (McGraw-Hill Construction, 2012). Thurairrajah and Goucher (2013) observed that considerable resources are expended on the implementation of these techniques in the form of strong training requirement which in some situation turn out to be time-consuming.

CHAPTER THREE RESEARCH METHODOLOGY

3.1 INTRODUCTION

The chapter essentially highlighted the research strategy, research design and development process that were adopted prior the administration of the questionnaires. The sampling technique and the characteristics of the sample size; also the statistical tool adopted for the data analysis are accordingly discussed in this chapter.

3.2 RESEARCH DESIGN

Finding a lasting solution to a problem, particularly in research studies requires differentiating the relationship between or among variables in a situation and analyze the relationship devoid of extraneous influences (Nenty, 2009). Consequently, Nenty (2009) argued that to do so research design is used. Research design is a set procedures that analyze the relationship among the variables involved in a problem and eventually select the appropriate procedures. Essentially, research design is a blueprint that shows how the research is to be conducted. This research therefore utilised a questionnaire survey in an attempt to explore planning and scheduling techniques and practices in the Road Construction Industry. Survey questionnaire was used because, to Janes (1999), survey questionnaires provides a true or current picture of a group, profession, organisation, etc. This assertion is corroborated by Cresswell (2005) cited in Ayyash et al. (2011), and he mentioned that survey helps to provide trends in the population. Additionally, survey questionnaire requires less resources as compared to other research designs (Ayyash et al., 2011).

3.3 RESEARCH STRATEGY

Research strategy is somewhat the direction of the research. The explanation is more important to the researcher (Bryman, 1992; Baiden, 2006). Naoum (1998) defined

research strategy as the inquiry into research objectives. Adding to this, Baiden (2006) argued three main types of research strategies. These are:

- Quantitative,
- Qualitative, and
- Triangulation.

However, many factors influence the choice of any particular strategy. These include, but not limited to: the purpose of the study, the type, as well as availability of information for the research (Naoum, 1998 cited from Baiden, 2006). Considering these factors, this research adopted a quantitative strategy because the study is interested in determining the planning and scheduling practices and techniques in the Road Construction Industry. In order to do so, the challenges, the existing tools and techniques needed to be identified; the severity of the challenges and the extent of the usage must be analysed and in an attempt to do so numerical values were assigned.

3.4 POPULATION AND SAMPLING

Population, generally, refers to a group or units of interest within the same geographic location of interest during the time of interest (Taylor-Powell, 1998). The focal point of the research was on the professionals in the Road Construction Industry, particularly those that have to do with planning and scheduling. Here, Professionals within A1B1 and A2B2 road construction firms and consultancies were targeted. The preliminary searches revealed that most of these firms are either in Accra or Kumasi, but their operations covered across the country. This confirms the argument put forward by Ahadzie (2007) and Assah-Kissiedu et al. (2010) that the metropolises have the highest population of contractors and consultants. In view of this these locations were selected. The population in this study as aforementioned were professionals that in their line of operation plan and schedule projects. These include Planners, Project Managers,

Construction Managers, Quantity Surveyors, etc. In order to get the total population, Google search engine was relied on. The engine provided a total of 204 A1B1 and A2B2 road construction companies.

Sample refers to representing a whole with a part. The thinking is that inferences can only be used to generalize only to the population from which the sample was taken (Taylor-Powell, 1998). In sampling, consideration is given to certain factors – population size, information needed and the resources available. These factors influence the sample size. Owing to the nature and kind of information needed; and also the resources available for this research surveying the entire population is not feasible. Accordingly, a sample was used to generalize the sample. In selecting a representative sample, a sampling technique was adopted. In order to determine the suitable sampling size for the sample, the following formulae (cf. Manu, 2012) was used:

$$SS = \frac{z2\ x\ p\ (1-p)}{c2}$$

Where; SS = sample size z = standardized variable p = percentage picking a choice, expressed as a decimal c = confidence interval expressed as a percentage

Here the confidence interval was set at 95% based on the reasons argued by Maisell and Persell (1996) as seen in Manu (2012). They argue that 95% confidence interval is used to find a balance between the level of precision, resources available and usefulness of the finding. The percentage picking a choice was also assumed to be 50% which according to Manu (2012) represents the worst case scenario. Based on these assumptions the sample size is calculated as:

$$SS = \frac{1.96\ ^2 x\ 0.5\ (1-0.5)}{0.1^2}$$

$$=96.04$$

3.5 SAMPLING TECHNIQUE

In order to get a representative sample of the population, probability sampling is used. However, probability sampling heavily rely on a very accurate size of the population. Owing to the less accurate nature of the population gathered probability sampling was difficult, especially simple random sampling. Non-probability sampling technique was thus used. In sampling from the population, the study utilised purposive sampling.

Purposive Sampling is a sampling technique whereby the researcher decides who to involve in the research. It was selected because of the reasons ascribed to its usage including, allowing information-rich issues that are important to the study to be added and also focusing on specifics rather than generics (Tuuli *et al*., 2007; Taylor-Powell, 1998). The choice was based on the professionals within the study. Hence their input was imperative in exploring planning and scheduling techniques and practices within the Road Construction Industry.

3.6 SOURCES OF DATA AND DATA COLLECTION

Basically, there are two types of data in research – primary and secondary. In this research both were considered. The primary data were from the field survey, whereas the secondary data were from literature review. Primarily, both data covered every aspect of the study. Neville (2007) argued that research should contain empirical research data. To him empirical data are essentially data from the field survey or the primary data, and they are imperative to any research endeavour. The primary data sources in this research include the information gathered from the professionals indicated in this study. Throughout literature, scientific methods of data collection dominate the field of evaluation (Taylor-Powell and Steele, 1996) fundamentally because they establish cause-effect relationships and provide quantitative data. Data

were collected through a questionnaire survey targeting these professionals. The response structure on the questionnaire included both close-ended question and openended question. Closed-ended questions were included because of its simplicity and ease in analysis.

The questionnaire sought to establish, the scheduling and planning techniques in the Road Construction Industry. The questionnaire was broken down into Parts A and B. The Part A covered largely the general information and background of the respondent. Part B was tailored to address the specific objectives and thus included questions on the planning and scheduling in the Road Construction Industry. A 5-point Likert scale was used to rate these factors. The questionnaire was designed using plain and simple language to facilitate easy understanding.

3.7 DATA PRESENTATION AND ANALYSIS

Questionnaires retrieved were coded and analysed using simple statistical tools such as the Statistical Package for Social Sciences (SPSS) version 21.0 and Microsoft Excel. The interpretation of the data was consequently done by these two tools. Data were mostly presented in Tables to aid easy comprehension, and only one in chart.

The outcome of the study was assessed with the research objectives. Relative Importance Index (RII) and descriptive statistics were used to analyse the data.

3.8 ETHICAL ISSUES CONSIDERED IN THIS STUDY

Issues of ethics are central to any research. Therefore, the study was compiled with principles which aimed at protecting the privacy of every individual who, in the course of the research work was requested to provide personal or commercially valuable information about themselves (hereinafter referred to as a subject of the research).

Before an individual becomes a subject, the person was notified of, the aims, methods, anticipated benefits and potential hazards of the research.

No person becomes a subject unless the person is fully abreast or cognizant of the notice referred to in the preceding paragraph.

CHAPTER FOUR

ANALYSIS OF DATA AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

The previous chapter, as already indicated the questionnaire queried respondents on planning and scheduling employed on the projects they were engaged on in the Road Construction Industry in Ghana. The ensuing sections first present the demographic characteristics (i.e. expertise and experience) of the respondents in order to demonstrate the credibility of the responses. The analysis of the key objectives is subsequently presented. As can be seen from the questionnaire (Appendix A) there was a mixture of nominal, ordinal and scale data. Hence, a variety of statistical procedures were employed in the analyses of the data starting with basic descriptive statistics to more complex procedures that were appropriate.

4.2 DEMOGRAPHIC INFORMATION

This section presents the analysis on the demographic characteristics of the respondents, the purpose of which is to provide an overview of the expertise and experience of the respondents. Various issues regarding the demographic information were assessed because of the potential to affect the overall findings of the study as the demographic

information somewhat provides credence to the research findings (see Manu, 2012; Ankrah, 2007). Analyses of these demographic characteristics are shown below.

4.2.1 Position in Company

Table 4.1 summarises the various positions that were captured in the questionnaire survey. As can be seen from the Table 4.1, the positions mostly were associated with planning and scheduling on projects. Generally as shown in Table 4.1 most of the respondents (i.e. 82.02%) are project managers, construction managers, quantity surveyors, and engineers. The positions of the remaining 17.94% respondents include Architects, Managers and Planners. Further observation of the results indicates that the planners were least among the respondents. This confirms the observations by Heesom and Mahdjoubi (2004), and Allen and Smallwood (2008) that there is generally a shortage in the personnel and expertise in construction planning and scheduling. Notwithstanding, the majority of the respondents (i.e. about 85%) are in direct planning and scheduling roles. The respondents are therefore the kind of participants which were targeted for the survey.

Table 4.1 Position of Respondents

Position	Frequency	Percentage
Quantity Surveyor	17	20.2
Project Manager	22	26.2
Construction Manager	21	25.0
Planners	2	2.4
Engineers	12	14.3
Architect	3	3.6
Managers	7	8.3
Total	84	100.0%

Source: Survey data, 2015

4.2.2 Years of Experience

Table 4.2 presents a summary of the respondents‘ years of experience in construction projects indicates that on the average, the respondents have 16.30 years of experience (with Std. Dev. of 10.45) and 24.31 years of experience (with Std. Dev. of 11.97) in their roles in construction and road construction projects respectively. This shows that majority of the respondents are experienced in road construction projects and construction projects generally.

Table 4.2 Years of experience

Statistic	Years of experience in Construction projects	Years of experience in Road construction industry
Respondents	84	84
Mean	16.30	24.31
Std. Error of Mean	.770	.88
Std. Deviation	10.45	11.97

Source: Survey data, 2015

4.2.3 Level of Qualification

The highest level of educational qualification ranges from HND to PhD. Majority of the respondents (38.1%) hold a BSc in a construction related discipline. Some of the respondents have also acquired additional qualification (i.e. Masters and PhD), 21.4% and 14.3% hold Masters and PhD respectively. The qualifications of the remaining 26.2 per cent of the respondents are detailed in Table 4.4. A cursory look at the results shows that about 98% of the respondents have higher diploma and above. This suggests that the respondents have good academic background and satisfactory knowledge for providing sufficient information for the outcome of this study.

Table 4.3 Qualification of Respondents

Highest Level of Education	Number of Respondents	Percentage (%)
Others	22	26.2
Bachelors Degree	32	38.1
Masters Degree	18	21.4
PhD	12	14.3
Total	84	100

Source: Survey data, 2015

Table 4.4 Details of Other Qualifications

Highest Level of Education	Number of Respondents	Percentage (%)
HND	20	90.9
City and Guilds	2	9.1
Total	22	100

Source: Survey data, 2015

4.2.4 Company Specialization

The Demographic data also show the companies' involvement in different infrastructure projects. This mainly includes Road and Civil construction. It is not farfetched to conclude that the reason is because the respondents were basically road construction companies.

4.2.5 Complexity of the Projects

Respondents were asked to provide an assessment of the level of complexity of the projects engaged in. This characteristic of the projects was very important because the assumption was that in very complex projects professionals are more likely to employ very sophisticated techniques in planning and scheduling. As evident in Fig. 4.1 almost 60% of the respondents considered the projects engaged in to either be simple or moderately complex.

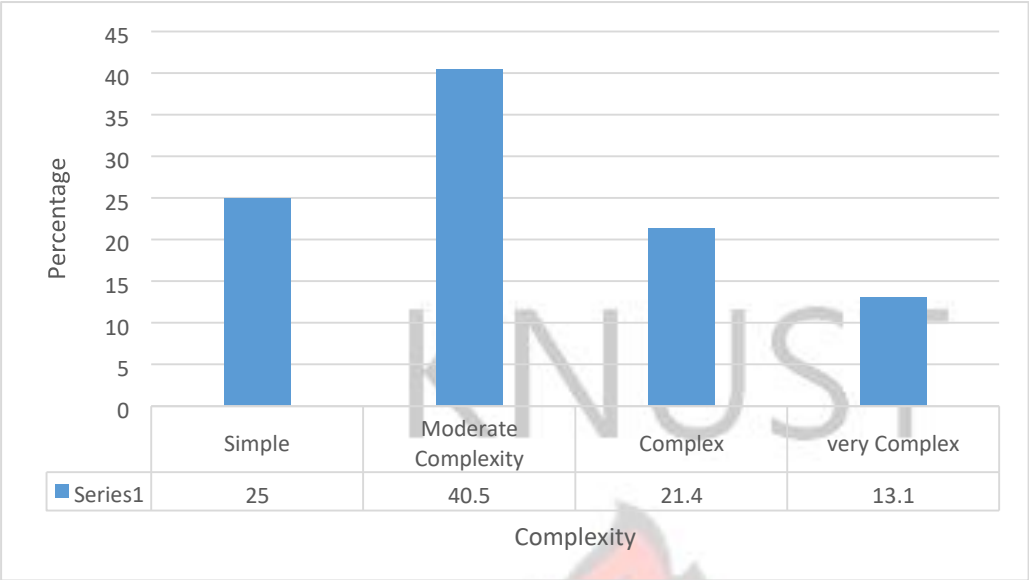

Figure 4.1 Level of Complexity

Source: Survey data, 2015

4.3 ASSESSMENT OF THE USAGE OF PLANNING AND SCHEDULING TECHNIQUES IN THE ROAD CONSTRUCTION INDUSTRY

Table 4.5 provides a summary of the assessment of the usage of planning and scheduling techniques in the Road Construction Industry. For each of the planning and scheduling techniques the ratings by the respondents ranged from 1 (Not at all Often) and 5 (Very Often). In the analysis of the extent of the agreement of respondents on the usage of the tools and techniques, the Relative importance index cum standard deviation was utilised. The idea was to establish the usage of the various factors. The score of each tool or technique is calculated by summing up the scores given to it by the respondents (for instance see Waris et al., 2014; Badu et al., 2013; Fugar and Agyakwah-Baah, 2010). For a five-point response item, RII produces a value ranging from 0.2 – 1.0 (cf Badu et al., 2013; Ugwu and Haupt, 2007). In the calculation of the Relative Importance Index (RII), the following formula was used

(Badu et al., 2013):

$$RII = \frac{\Sigma W}{A * N}$$

Where, W: weighting given to each statement by the respondents and ranges from 1 to 5; A – Higher response integer (5), and N – total number of respondents. Where variables have the same RII values the variable with the lowest standard deviation is assigned the highest ranking (Ahadzie, 2007). Standard deviation values of less than 1.0 indicate consistency in agreement among the respondents of the reported level of results (see for instance, Field, 2005). The comparison of RII with the corresponding level of usage is measured from the transformation matrix as proposed by Chen et al. (2010) as seen in Waris et al. (2014). Here the transformation was adapted to compare the level of usage as against the level of importance as proposed by the authors.

Hence, the following derived usage levels from RII are used:

- High (H) $0.8 < RII < 1.0$;
- High-Medium (H-M) $0.6 < RII < 0.8$
- Medium (M) $0.4 < RII < 0.6$
- Medium-Low (M-L) $0.2 < RII < 0.4$
- Low (L) $0.0 < RII < 0.2$

4.3.1 Discussion

From the Table 4.5 it is obvious that Gantt Chart was the most widely used Scheduling tool in the Road Construction Industry. The plausible explanation is that majority of the artisans in the Ghanaian Construction Industry are not well educated, so the need to adopt a technique that displays scheduling in a more easy-to-understand way. This perhaps corroborates the findings of Bokor et al. (2011) that the usage of Gantt Chart is widespread especially in developing countries for obviously the same reason as aforementioned.

Although, the challenges associated with the Gantt Chart led to the development of

Cyclogram it appears; at least from the survey that the tool is not popular in the Road Construction Industry in Ghana and hence the low level of usage among the participants. Despite Bokor et al. (2011) argument that the tool is useful for road construction projects, the tool is rarely used on road construction.

The Critical Path Method was the second most widely used scheduling technique after the Gantt Chart as agreed by the respondents' altogether. The popularity in the industry might be ascribed to the successes of the tool in the project management discipline. To the extent that Hancher (2003) concluded on the essence of the tool and consequently advised its usage in construction. The findings thus corroborate the position of Hancher (2003) that the tool is popular in the construction industry.

Surprisingly, with the advent of sophisticated scheduling tools that display scheduling in 4-D the Ghanaian Road Construction Industry is yet to exploit the full potentials that come with these tools. The industry players rarely use these 4-D CAD visualisation techniques and tools. This is evident in the responses by the respondents. It is apparent from the Table 4.5 that the 4-D CAD tools all ranked low. The low level of usage perhaps is rooted in the fact that such practices or techniques require high proficiency in Information Communication Technology (Chau et al., 2005) which is lacking in the Road Construction Industry in developing countries including Ghana.

Table 4.5 Level of Usage of Scheduling Techniques and Methods

SCHEDULING TECHNIQUES	RII	SD	Ranking	Level of Usage
Traditional Planning Techniques	**0.586**		**2**	**M**
Gantt Chart	0.886	.811	1	H
Cyclogram	0.286	1.434	9	M-L
Network Planning Techniques	**0.832**		**1**	**H**
Critical Path Method	0.848	.944	2	H

Program Evaluation and Review Technique (PERT)	0.819	.831	4	H
Precedence Diagraming Method	0.829	.792	3	H
4-D CAD Visualisation Techniques	**0.340**		**3**	**M-L**
Schedule Simulator	0.433	.966	5	M
FourDviz – Balfour Technology	0.293	.811	7	M-L
Common Point 4 D	0.283	1.007	10	M-L
Visual Project Scheduler	0.401	1.062	6	M
Smart Plant Review – Intergraph Incorporated	0.291	1.000	8	M-L

Source: Survey data, 2015

4.4 CHALLENGES CONFRONTING PLANNING AND SCHEDULING IN THE ROAD CONSTRUCTION INDUSTRY

Table 4.6 summarises the challenges confronting the application of modern scheduling and planning techniques in the RCI. The ratings of the challenges ranged from 1 (i.e. Not Severe) to 5 (i.e. very Severe). Altogether, the respondents agreed that ―Complexity of the tools‖ is the major challenge hindering planning and scheduling in the Road Construction Industry with a mean rating of 4.143 (Std. Dev = .96362). Similarly, the aggregated ratings indicated that ―unable to take into account spatial planning‖ is the least challenge with a mean rating of 3.238 (Std. Dev. =.6249).

From Table 4.6 the standard deviations are less than 1.00 and also very small when compared with the mean rating indicating that there is less variability in the responses of the respondents. More so, they mean the data are fit for the study (Field, 2005 cited from Manu, 2012).

4.4.1 Discussion

As aforementioned, the major challenge is complexity of tools. The challenge cuts across the learning divide, and also both practice and academia. Woo (2006) identified the challenge in the classroom as impeding the operation of planning and scheduling tools. Conversely, Chau et al. (2005) identified the challenge among practitioners. It would therefore not to be farfetched to conclude that the challenge is prevalent in the industry. The finding therefore corroborates the studies by both authors – Woo (2006) and Chau et al. (2005), and by extension the problem is also persistent in the Road Construction Industry.

Complexity of tools is an association of technological challenges. It was therefore not surprising that the respondents ranked the challenge second after complexity of tools. Generally, the construction industry is considered to be fragmented and it is even worse in the developing countries. The challenge obtained a mean rating of 3.9048, and a standard deviation less than 1.00. The finding largely concurs what is in literature that technological challenge is a major issue to deal with in planning and scheduling (cf. Olatunji, 2011).

With about 90% of the construction companies within the category of Small Medium Enterprises (SMEs) (Owusu-Manu et al., 2014), it was not therefore surprising that the cost of modern planning and scheduling tools is a challenge facing planning and scheduling in the Road Construction Industry. This partially explains the overreliance of the traditional planning and scheduling tools that are not highly sophisticated and thus not expensive. McGraw-Hill Construction (2012); and Thurairrajah and Goucher (2013) noted the considerable resources needed for such tools and how the SMEs struggle with it. This finding therefore confirms the studies by these authors.

Table 4.6 Descriptive statistics of Challenges facing Planning and Scheduling in the Road Construction Industry.

Challenges	N	Mean		Std. Deviation	Ranking
	Statistic	Statistic	Std. Error	Statistic	
High Computer Illiteracy Rate	84	3.7619	.24789	.3599	4
Complexity of Tools	84	4.1429	.21028	.96362	1
Unable to take into account spatial planning	84	3.2381	.13636	.62488	7
Traditional tools forces minds visualisations	84	3.7143	.17103	.78376	5
Cost of Modern planning and scheduling tools (Cost of Software)	84	3.8095	.22487	.3049	3
Technological Challenges	84	3.9048	.19401	.88909	2
Fragmented nature of the Ghanaian Construction Industry	84	3.5714	.16288	.74642	6

Source: Survey data, 2015

CHAPTER FIVE CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

Globally, there has been a continual attempt to automate the Construction industry. This recurring theme has even led to the establishment of Automation in Construction Journal. However, the Construction Industry in developing is noted for notoriously lagging behind in terms of such recent development and participants are still glued to the _rudimentary‘ tools of planning and scheduling. This study has explored planning and scheduling in the construction industry, particularly focusing on the Road Construction Industry in Ghana.

This final chapter presents the summary of the main findings and the limitations of the study. Recommendation for future studies and industry practitioners are accordingly provided.

5.2 SUMMARY OF THE RESEARCH

The chapter one of this dissertation set the tone for the study. In Chapter one the aim was introduced to explore the planning and scheduling tools and methods used in the Road Construction industry. To help realise this end, some objectives were put forward. Under this section, how the objectives were realised have been outlined.

5.2.1 Various construction scheduling techniques and methods used in the Road Construction Industry

In achieving this objective, a review of the various scheduling techniques and methods in the project management discipline was undertaken. The review revealed various categories of construction scheduling and techniques, and the theoretical developments of planning and scheduling from the traditional method to a more realistic way of visualizing planning and scheduling. Although many planning and scheduling methods are present in the Road Construction Industry there was the need to contextualize and hence know the usage level of such planning and scheduling methods. This was addressed in then Chapter Four of the study. Hitherto, participants or professionals were asked to rate the usage of the identified planning and scheduling methods and techniques. It was revealed that the Industry is still glued to the use of traditional technique and tools in the form of Gantt Chart, Critical Path Method,

Precedence Diagramming method, etc. The tools that at best depict 2-D visualisations. The industry was found to be doing badly in terms of the usage of 4-D CAD visualisation techniques.

5.2.2 The challenges confronting planning and scheduling tools usage in the Road Construction Industry.

The second objective demanded the review of literature to identify the challenges that existed in other disciplines and also in other regions. Here, a number of challenges were identified. The consensus of views, established through the review of the challenges and subsequently the questionnaire survey highlighted the persistence and pervasiveness of some key challenges, what is considered as _technology-related‘. These challenges are: *Complexity of Tools* and *Technological Challenges*.

5.3 CONCLUSIONS OF THE RESEARCH

The main conclusions drawn from the study are:

- Planning and Scheduling are indispensable to the success of projects, and the success somewhat depends on the tools and techniques available to the planners and managers. It was seen that Traditional techniques and by extension Network planning techniques are the most used planning and scheduling techniques and tools in the Road Construction Industry.
- The usage of the _modern‘ planning and scheduling techniques (i.e. the 4-D CAD visualisation techniques) was found to be medium to low. The reason may be ascribed to the sophisticated nature of the tools given the level of computer knowledge in the Construction Industry.
- Several Challenges plague the smooth usage of planning and scheduling techniques and tools, particularly the 4-D CAD Visualisation techniques. Bridging the gap requires the identification of these challenges. The challenges largely center on technology.

In summary, planning and scheduling in the Road Construction Industry is still in the preliminary stages with almost stakeholders relying heavily on _rudimentary‘ tools and techniques of planning and scheduling. Improving project performance requires the adoption of planning and scheduling tools that exposes inherent problems, otherwise could not be detected by the simple planning and scheduling tools.

5.4 LIMITATIONS OF THE STUDY

Beyond the limitations highlighted in the previous sections, there are other limitations that must be borne in mind when interpreting the results of this study. Given that the study was only conducted in Ghana, and also in the Road Construction Industry it is plausible that the results when replicated in another jurisdiction will have different results or there would be significant differences in the findings. The limitations noted here, however, do not undermine the validity of the research undertaken.

5.5 PRACTICAL IMPLICATION OF THE STUDY

As observed earlier, profit margin is tied with timely delivery of projects. Successful projects delivery is one of the arduous tasks of project managers, and that involves planning and scheduling (Li et al., 2012). Within the study, the insights given have implications for planning and scheduling in the Road Construction Industry. These recommendations are:

- To improve the likelihood of affording these modern 4-D CAD visualisation software and hardware, small companies should consider forming amalgamations and cartels to increase their purchasing power.
- The findings on the challenges of planning and scheduling; and also the usage also provide an avenue for Continuous Professional Development. This will

ensure that professionals are able to manipulate advanced and sophisticated to improve project performance.

- The challenges identified, especially those that had to do with technology revealed that the situation is not only common to practitioners but also beginners. This supposes that the curriculum is weak in these aspects. By integrating CAD courses in the curriculum, the thinking is that the would-be practitioners would have the fundamentals that can aid them build on it.

5.6 RECOMMENDATIONS FOR FUTURE

The findings of this study and the limitations identified provide avenue for further studies. These recommendations are as follows:

- The research has revealed that 4-D CAD visualisation techniques are not well integrated into the Ghanaian Road Construction Industry. It is therefore recommended that further studies should be conducted into the integration of such tools in planning and scheduling.

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APPENDIX

QUESTIONNAIRE SECTION A: BACKGROUND INFORMATION

1. Company Name:……
2. Position in Company

   ☐ Project Manager ☐ Quantity Surveyor

   ☐ Construction Manager ☐ Manager

   ☐ Architect ☐ Engineer

   ☐ Planners
3. Respondent‘s years of experience in construction projects?

   ...(Years)…(Months)
4. Please mention your level of education

   ☐ Bachelor ☐ MSC/MBA/Master ☐ PhD

   ☐ Others

5. Your experience in Road construction projects? ..... (Years)…….. (Months)
6. What type of projects do your company specialize in? (You may select more than 1) ☐

☐ Road ☐ Building ☐ Civil ☐

Others

SECTION B: PLANNING AND SCHEDULING IN ROAD CONSTRUCTION

1. Please rate your option on a 5 point Likert scale on the usage of the following construction planning and scheduling techniques on road construction projects.

Techniques	**Very Often**	**Often**	**Neutral**	**Not Often**	**Not at all Often**
	5	**4**	**3**	**2**	**1**
Traditional Planning Techniques					
Gantt Chart					
Cyclogram					
Network Planning Techniques					
Critical Path Method					
Program Evaluation and Review Technique (PERT)					
Precedence Diagramming Method					
4-D CAD Visualisation Techniques					
Schedule Simulator					
Smart Plant Review –Intergraph Incorporated					
FourDviz – Balfour Technology					
Common Point 4 D					
Visual Project Scheduler					

Project Navigator 2000 – Virtual STEP					
Others (Kindly indicate others not included above)					

2. How would you rate the following challenges confronting planning and scheduling in the Road Construction Industry? Use the scale: 1= Not Severe 2=Less severe 3=Neutral 4=Severe 5= Very severe.

CHALLENGES	**5**	**4**	**3**	**2**	**1**
Complexity of the tools					
Unable to take into account spatial planning					
Technological challenges					
High computer illiteracy rate (High Skill is required)					
Fragmented nature of the Ghanaian Construction Industry					
Traditional tools forces minds visualisations					
Cost of Modern planning and scheduling tools (Cost of Software)					

THANK YOU