CONSTRUCTION PLANT MANAGEMENT PRACTICE ADOPTED BY D1K1 AND D2K2 CONTRACTORS

By

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DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma at Kwame Nkrumah University of Science and Technology, Kumasi or any other educational institution, except where due acknowledgment is made in the thesis.

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ABSTRACT

A number of organizations involved in the construction industry have conceded that plant and machineries are one of the most important resources required to complete the construction phase of a project. However, the unprofessional plant resource management of construction processes among our local contractors' ends up in delays, abandoning a project, shoddy works and making them uncompetitive to the foreign contractors in the sector of construction. The Ghanaian construction sector is declining as a result of it not being considering plant management as a major aspect of its projects. The issue of plant management has been without recognition of its importance. It is of this reason therefore that proper plant management for the local contractors to be taken seriously and measures put in place for these companies to see Plant management as the hallmark of increasing productivity and executing projects to its requirements. The study thus aimed to evaluate the standard project plant management practices amongst D1K1 and D2K2 category of contractors in the Ghanaian construction industry. The objectives set to guide the study were to identify the selection criteria for onsite plant in the Ghanaian construction industry; determine the effect of plant management on D1K1 and D2K2 contractors; and identify possible ways of improving construction plant management practices on Ghanaian construction sites. The study adopted the quantitative research approach to address its objectives. The SPSS version 19 was used to process the data gathered from 51 construction professionals from the D1K1 and D2K2 in Ghana. Descriptive statistics as well as the multiple linear regression analysis were used to present findings from the field. Twenty-two (22) selection criteria for onsite plant in the Ghanaian construction industry were identified -and out of that, five (5) were considered significant, sixteen (16) as moderately significant, and only one (1) was considered as less significant. Also, it was revealed that all the identified plant management practices had positive effect on project delivery by D1K1 and D2K2 contractors after the regression. That is to say plant management practices were consistent with construction project delivery. Finally, twelve (12) possible ways were identified to improve plant management practices on site, where constant maintenance and repair of plants and equipment was considered the most significant factor whereas using automation and robotic plants and equipment before selection was considered the least. The recommended that plant management practices like those identified in this document must be adhere to as they are consistent with construction project delivery.

Keywords: *Plant management; Onsite productivity; D1K1 and D2K2 contractors etc.*

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DEDICATION

I dedicate to God Almighty

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Most construction projects are the cautious coordination of a lot of moving parts. Overseeing individuals and equipment and the interrelated cost among various project and areas can be hard to monitor. At the point when a bit of the puzzle is missed in the ideal spot it can cause a ripple impact of difficulties which can bring about an absence of profitability, inactive equipment or squandered materials. Accordingly, plant management issues make organizations lose resources in the forms of money and time on projects. Along these lines, it is significant that the correct resources must be at the opportune spot and at the perfect time.

As new small and medium sized construction companies continue to emerge in the construction space -with the government being the major drive in this sector, various projects are being carried out by Ghanaian contract in every corner of the country. These companies tend to compete with foreign companies in both local and international markets of the sector. With several distinctive and complex characteristics, plant management plays an important role in terms of advancing efficient use of project resources being manpower, material or money. With a number of construction firms having conceded that plant constitute one of the most important project resources needed for the delivery of construction project (Bahaman, 2011), it is significant to note that having the right plant and machinery at the right time and place gives one firm an edge over another.

Projects life cycles are often seen to follow a series of events that are regularly repeated in the same order. These cycles include various phases like project initiation, project development, project implementation and the final phase, project completion/closure

(Turner and Muller, 2005; Meredith and Mantel, 2009). Consequently, projects are limited by time as it is planned to end on a set date (Attakora-Amaniampong, 2016). This is mostly achieved by the effectiveness of plant management.

Efficient plant management in all phases of a project remains a significant task throughout the project as failure in managing it result in project delays which thus causes cost and time overrun or total project failure. According to Manaf et al. (2007) proper plant management include training and educating operators on plant; having work schedule for plant; adhering to guidelines set on the use of plant; choosing specific plant manager; periodic maintenance of plant by operators; and making choice on most appropriate plant.

The importance of plant management in project execution comes from the reality that it is capable of destroying contractor client relationship, hence souring the willingness from the parties in the course of the building phase (Gransberg and Elliot, 1997 as cited in Rogers, 2012). In addition to that, it also has the tendency to amplify the project cost to the two parties, therefore developing a monetary burden. This therefore means that it is important for contractors to consider managing project resources so as to keep away from any economic burden and preserve client-contractor relationship which could generate monetary returns ahead. Nevertheless, the query stays that "what is the greatest means to control plant resources so as to do away with time and cost overruns"? Plant management is the duty of both the contractor as well as the project client. That is, it is managed in manner of overseeing and making certain the client commits adequate resources to the task whiles the contractor also has to commit resources to balance the good and bad effect of his recourse administration to the project. The capability to control correctly and successfully plant resources to avoid any extend whatsoever relies also on the consultants whose drawings are used as source of information to the

contractor. However, in the confines of the study the researcher limits the study to solely contractors because of the limited time for the research. This means that plant carefully managed during the construction stage is our focal point. If plant resources are not effectively managed at the construction planning phase, project closure later becomes discouraging task to the entire team of the project.

The Ministry of Works and Housing (MWH) is mandated by Section 11 and 13 of the civil service act 1993, (PNDL327) and Executive Instrument (E128, 2017) to devise policies in the sector of works and housing, and to coordinate, monitor and evaluate as well plans, programs, performance for implementation for the country's development. The MHW through the Office of Management Service Division (MSD) and the Head of Civil Service (OHCS) working through its mandate to ensure internationally best practices and also allow for response from management and staff, and clients of the MHW. The Client Service Charter per its guidelines performs its function in a transparent manner alongside ensuring the monitoring of delivery of services for consistency with its timelines. The primary aim of the Charter was to emphasize to their clients, lists of services provided by MHW. The service charter which is divided into several sections has one of its sections that deals with the classification of contractors and the issuance of a certificate to contractors with classifications based on their approved ceiling in Ghana cedis' equivalent of USD for both local and foreign contractors.

The purpose of the research is to assess the plant management practices that ensure completion of project in the most effective and efficient way, derive any lessons learned and best practices to be applied to future projects. This paper aims to institute a viable ground work for additional research on weighing the impact of plant management on the economics of construction projects for small scale construction companies. The study

evaluates plant management data and recognizes the utilization of the related management perspective to the construction industry. Furthermore, the study uses the data analyzed to describe the essence of plant management with specific reference to D1K1 and D2K2 constructors. Distinctively, the probing detailed in this document recognizes economic performance factors in the administration of plant management practice in national building projects. This study also recognizes the collective achievements of plant management practices.

1.2 Problem Statement

For a successful project in the built environment, the key to profitability is proper management (Ofori, 2006). The unprofessional plant resource management of construction processes among our local contractors' ends up in delays, abandoning a project, shoddy works and not making them uncompetitive to the foreign contractors in the sector of construction. The Ghanaian construction sector is declining as a result of it not being considered as a major challenge (Ofori, 2006). The issue of plant management has been without recognition. Thus, a proper plant management practices for the local contractors has to be taken seriously and measures put in place for firms to see construction management as the hallmark of increasing productivity and executing projects to its requirements. Subsequently, in order to ascertain the most realistic and effective application of current structures among them, it is necessary for a study to be conducted so as to establish the extent to which these structures stand significant to our local contractors -making it necessary for research on plant management roles as practiced by Ghanaian construction firms.

1.3 Research Aim and Objectives

1.3.1 Aim

This study aims at evaluating the standard project plant management practices amongst D1K1 and D2K2 category of contractors in the Ghanaian construction industry.

1.3.2 Objectives

The subsequent objectives were set to achieve the preceding research aim:

1. To examine the selection criteria for onsite plant in the Ghanaian construction industry;
2. To determine the effect of plant management on the D1K1 and D2K2 contractors; and
3. To suggest possible ways of improving construction plant management practices on Ghanaian construction sites.

1.4 Research Questions

To gain better understanding, the subsequent questions have been formulated to broaden the empirical information on the research theme:

1. What criteria are used in selecting onsite plant in the Ghanaian construction industry?
2. How do plant management practices affect project delivery for D1K1 and D2K2 contractors in Ghana?
3. What are the ways to improve construction plant management practices on Ghanaian construction sites?

1.5 Significance of the Study

The significance of this study is to emphasize on the need for proper plant management system to aid productivity in the Ghanaian primarily based construction companies. The norm now is that most of the developmental projects are being handled by foreign construction companies. This is because most of the development carried out by locals ends up being abandoned. The function of project managers and organizational cultures will be studied as it will help stakeholders evaluate the organizational cultures on-site administration practices of foreign and local construction firms in Ghana. The study will also benefit academia as it will encourage others to conduct additional research in this area. It will also serve as future reference material for researchers.

Understanding the cultures of firms in the construction industries will allow organizations to fine-tune their operations to compete in the world construction market. Knowledge about cultures assists project managers to recognize the categorizations and inform them about the way forward in adopting new plant management practices and its possible effect on the organization's environment.

1.6 Limitation of the Study

Scanty germane literature specific to the Ghanaian setting was experienced. However, the study relied on evaluating pertinent literature, some of which have been conducted in other African countries in order to follow to the settings of the country. Secondly, considering that the study was conducted completely among the D1K1 and D2K2 firms, the findings of the study would be limited to these firms and specifically the construction sector. Thus, the results of the study can exclusively be applied in other sectors following similar procedures of the findings. Finally, the study's participants were reluctant to give full statistics owing to the fact of enterprise confidentiality. This problem used to be

solved with the aid of assuring the personnel that the facts used to be to be handled with confidentiality and only used for tutorial purposes.

1.7 Research Method

The research is aimed to examine construction plant management practices of D1K1 and D2K2 contractors in Ghana's construction sector. This research adopted the survey strategy of D1K1 and D2K2 contractors to obtain the required data which allowed the accurate data organization, analyses, and interpretations of findings. The concept of the population constituted the total number of all units of a kind that fall in the area of the investigation. D1K1 and D2K2 category were selected accidentally in the capital city Accra, in Ghana and questionnaire given to the targeted respondents. Thus, Quantity Surveyors, Project Managers, Architects, Construction Managers, and Civil Engineers on site became the research target and subsequently relevant information was gathered from them. This defined the scope of the research. A well-structured questionnaire was developed to aid the survey. The survey done was based on the literature review conducted to draft the questionnaire. The respondents were assessed by their perception on the plant management philosophy that identifies the stage of technical expertise in Ghana's construction industry and also ascertain measures to bridge research gaps. Data were gathered from the study through the response from respondent –as they were asked to rank some variables according to Likert scale of 1-5. The analytical tool used for perusing the data collected consisted of descriptive statistics, mean score, relative important index (RII) and linear regression analysis. The analytical tool used was SPSS version 19.

1.7 Structure of the Report

This research has been categorized into five independent but complementary chapters. Chapter one being the introduction to the whole thesis and it is subdivided into six sections: the six sections of the introduction start with the background of the study, the statement of the problem, research aim and objectives, research questions, the significance of the study and summary of the research method used. Chapter two also approaches the literature review of the problem statement, review (expect) opinions on research at hand. Chapter three, which consisted of the methodological approaches to the research, included the research design, sample and sampling procedure, and data collection process. Chapter four on the other hand also consisted of the data analysis and discussion of results. Chapter five being the last chapter lunched the summary of the major findings, conclusion and finally the recommendation, which suggested the best course of action for the discovery.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Since the invention of the wheel, plant, and machinery has aided the construction industry in a tremendous way. The utilization of types of machinery like crushers, excavators, cranes, dumpers, and others in the construction industry enables the companies to work more effectively (Prajeesh and Sakthivel, 2016). According to Prajeesh and Sakthivel (2006), construction plant and machinery form a major part of the resources of the contractor in the construction process. The contractor effectiveness in managing construction project ought to be vigorous toward pursuing efficient usage of equipment, labour, and material. Manaf et al. (2007) aver that proper plant management include training and educating operators on plant; having work schedule for plant; adhering to guidelines set on the use of plant; choosing specific plant manager; periodic maintenance of plant by operators; and making choice on most appropriate plant. Utilization of innovative strategies alongside new equipment has made viable extensive adjustments in construction technologies for current times. The choice of the suitable equipment as Manaf et al. (2007) posits regularly influences the required effort including project time –consequently affecting project productivity. It is thus important for managers on site and project planners to be acquainted with the typical varieties of equipment most often used on site. With the previous chapter giving us an overview of what to expect, this chapter discuss in details the factors affecting plant management and also its effect on the local construction industry.

Plant and machinery must have operatives who have received certified training to ensure the safe usage and operation of the equipment. They need to understand the key principles, safety procedures, working, and the needs, of a project. Plant and

machinery enhance work practices and improve productivity when the proper care and correct use of the machine is undertaken. The equipment bears a lot of pressure as it is changed over time from one job to another. There is a need for ensuring full utilization of equipment to gain greater profitability. The issue of proper maintenance also has to be given great importance as it can enhance the life of the equipment.

The worldwide plant and machinery market is anticipated to increase at a decent rate. This rate of growth is possible owing to various factors. Firms need to keep pace with the great growth that is happening all around. In the future, like today, it is expected to have an increased in demand. There is an ever-increasing need for the appropriate plant and machinery management because there is a thrust for infrastructure development (Prajeesh and Sakthivel, 2016).

2.2 The Construction Industry

The construction industry constitute one of the foremost sectors of every economy (Ofori, 2012) and as such, the industry plays a key role in the overall economy of any given country (Foulkes and Ruddock, 2003). Ofori (2012) went ahead to state that the construction sector is vital due to the results and outputs of the sector's activities. It contributes to socio-economic growth of countries by providing the structures needed for production of all services and goods in an economy. Additionally, physical infrastructure –built through the activities of construction, is the backbone of a country's economic as it constitutes the channel for the acceleration of productive endeavor by way of enabling services and goods to be disbursed in the country and even beyond. The industry is also known for conservatism, that is, construction professionals stick to the practices and norms of the industry and that any changes are considered threat as slack resources is not acceptable (Nam and Tatum, 1997).

Civil Engineering companies in Ghana carry out some of the preceding projects which involve huge engineering characters like railways, bridges, dams, roads, whereas the Building Construction companies (BCF) carry out similar projects like hospitals, hotels, schools, health centres, hospitals, offices etc. According to Danso (2010) the BCF carry out external works as well which sometimes include clear cut engineering construction like drive ways.

2.2.1 Classification of contractors

The Ministry of Works and Housing (MWH) is mandated by Section 11 and 13 of the civil service act 1993, (PNDL327) and Executive Instrument (E128, 2017) to devise policies in the sector of works and housing, and to coordinate, monitor and evaluate as well plans, programs, performance for implementation for the country's development. The MHW through the Office of Management Service Division (MSD) and the Head of Civil Service (OHCS) working through its mandate to ensure internationally best practices and also allow for response from management and staff, and clients of the MHW. The Client Service Charter per its guidelines performs its function in a transparent manner alongside ensuring the monitoring of delivery of services for consistency with its timelines. The primary aim of the Charter was to emphasize to their clients, lists of services provided by MHW. The service charter which is divided into several sections has one of its sections that deals with the classification of contractors and the issuance of a certificate to contractors with classifications based on their approved ceiling in Ghana cedis' equivalent of USD for both local and foreign contractors. Table 2.1 presents the various certificates with the conforming permitted ceiling for the local contractors including their foreign counterparts.

Table 2.1 Classification of Contractors

No.	Building, Civil, Electrical and Plumbing Categories	Approved Ceiling in Ghana Cedis Equivalent Of US$
1	D1/K1	OVER USD$ 500,000.00
2	D2/K2	USD$ 200,000.00 - USD$ 500,000.00
3	D3/K3	USD$ 75,000.00 - USD$ 200,000.00
4	D4/K4	UP TO USD$ 75,000.00
5	E1	OVER USD$ 200,000.00
6	E2	USD$ 75,000.00 - USD$ 200,000.00
7	E3	UP TO USD$ 75,000.00
8	G1	OVER USD$ 75,000.00
9	G2	UP TO USD$ 50,000.00

Source: The Ministry of Works and Housing (MWH)

2.3 List of Major Construction Plant and Equipment

There are various distinct types of heavy construction equipment, each with its very own set of uses. As one considers the kind of projects one is taking on, one may also determine its time to add to one's fleet. While some pieces of equipment serve one particular purpose, there are others that overlap -for example, if you are searching for heavy equipment that can assist you to move soil or carry materials, you have a few different options (Holt of California, 2018). Proper equipment is imperative for effective setup of all construction sites. Providing construction site with the appropriate equipment constitute a significant function in attaining timely and excellent results. For all construction activities there exist optimal blend of labour, equipment and tools. Bound by content and nature of works on site, the technical workforce requires to understand which equipment to make use of and how to efficiently coalesce them with the help of

the workforce. The main reason behind selection of equipment is to attain greater productivity, viable financial considerations, and greater operational suppleness. Starting from the concept that construction equipment needs to be selected by using its overall performance on site, the first stage in this project will be to pick the proper method for measuring this performance. For each of the distinctive types of equipment, a unique technique had to be selected (Casals et al. 2003).

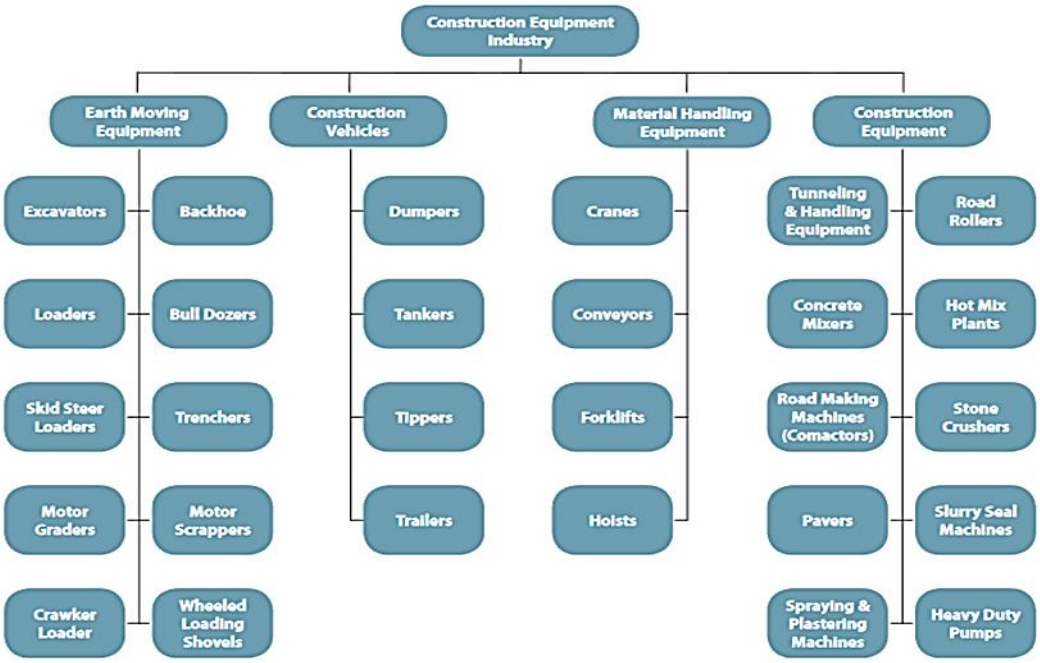

Figure 2. 1 List of Major Construction Plant and Equipment

(Source: Ohkawa, 2000)

2.4 Criteria for Selecting Construction Plant and Equipment

A contractor's income is significantly impacted on by means of the size of investments in equipment managing system and policies. Construction equipment managers have had to figure out on when, how, and which equipment to be used and disposed-off after project completion (Gunnar, 2011). Innovations in construction equipment represent a spark for construction industry's advancement (Arditi et al. 1997).

Equipment selection in the construction sector constitute a significant part for effective project completion in all civil projects. Consequently, equipment selection including the planning aspect of it is imperative for efficient utilization with the least cost. As Thete and Baviskar (2016) posits, it is the responsibility of the engineer to assign specific equipment for the completion of a task according to site conditions.

Selecting desirable construction equipment is a challenging assignment in the building industry due to the vast array of available equipment in the market and a massive variety of standards that are required to be taken into account during choice making process. In order to overcome the challenge, multi standards selection making techniques have been proposed to choose the suitable equipment by means of ranking the alternatives. Temiz and Calis (2017) posits that in selecting the appropriate plants for a construction site contractors ought to think about qualitative and quantitative criteria together with technical specifications, buying cost, fuel consumption, service conditions, secondary and replacement components markets, the comfort of the operator.

With the achievement of higher productivity being the basic aim of the selection process of equipment, it is significant as well to consider viable economic conditions and operational suppleness. Most previous researches suggest that the right choice of construction equipment has constantly been regarded as tactical choice throughout the phases of a construction project (Tatari and Skibniewski, 2006). With advancement in mechanization and industrialization, the situation is getting greatly vital and complicated for firms in determining and making excellent choice from several options (Schaufelberger, 1999). It is as result of this motive that has caught the attention of many researchers as several academic research been undertaking to enhance mechanized practices of the construction industry (Shapira and Goldenberg et al. 2006). Equipment selection is generally carried out through matching tasks with fleet of equipment. The

matching task ensure equipment capacity, cost and productivity (Gransberg et al. 2006). The matching includes the choice of satisfactory alternative amongst other choices primarily based on method and criteria that could be engaged in the process of making the choice. Gates and Scarpa (1980) cited that any time a contractor tries selecting equipment for a tasks on site, he must considered the following: logistical consideration, spatial relationships, contract provision, and soil characteristics. The researchers indicate that, spatial relationship is categorized further into 7 factors which in most cases belong to geographic records of the site of the project. Gates and Scarpa (1980) put construction duration; working constraints like dust, hours, and noise; legal limitations; traffic in contract provisions; quantities of excavation, moving and fill; mode of payment; and weight and size of equipment. The logistical considerations primarily cover experience of the operator, availability of equipment, and cost. Also Chan et al. (2015) carried out another research and they established a database software for the selection of equipment. Their study identified technical, strategic, performance measure, and monetary aspects as criteria for evaluation. Haider et al. (1999) cut up the choice of equipment procedure into optimization genetic and know-how-based algorithms. The later part includes techniques for screening the preferred equipment from the listing based totally on problem know-how whiles the former refines the choice using criteria. The criteria consist of running cost, production rate, equipment characteristics, ownership cost, and finally operating life. Bascetin (2003) established a choice aide system through utilization of quantitative and qualitative factors for choosing open pit equipment. Bascetin (2003) categorized his criteria for choosing into operational and cost requirements. Shapira and Goldenberg (2005) in their study listed intangible (soft) and tangible (hard) factors. The tangible elements consist of site conditions, specification, as well as cost consideration. On the other hand, the intangible elements are qualitative as they consist of market conditions,

safety considerations, environmental constraints, and employer policies related to the acquisition of the equipment. It is vital issue that Chamzini and Yakhchali (2012), after their study raised the trouble of faint consideration in choosing construction equipment for constructing projects. They also identified 9 point criteria as they labelled them into two categories i.e. price criteria and gain standards based on technical performance

Aforementioned criteria/factors show that researchers' attention is more on technical and cost elements in the selection process. This indicates that social and environmental concerns in equipment selection are overlooked. Again, studies have shown that safety, health, and environmental concerns are kept at low priority all through the selection process in Malaysian construction sector (Waris et al. 2013). Contrary to this, the agenda on green construction or sustainable construction emphasize the assessment of equipment choice ought to be in line with environmental, technical, and socio-economic functions. The subsequent section describe in detail the specific approach for developing sustainable criteria in the selection of equipment for construction.

2.5 Criteria in the Selection of Plant and Equipment for Effective Management

The choice of standards for the evaluation framework generally relies upon on a wide variety of elements. It may additionally consist of the intricacy of analysis and accessibility of data (Azapagic and Perdan, 2000). For sustainability, it ought to tackle a vital approach which includes appropriate measures reflecting environmental, economic, and social elements (Singh et al. 2009).

Prescott (1995) proposed a mechanism to integrate social and environmental factors of sustainability. In the mechanism, Prescott (1995) emphasized that the integration of human and ecosystem well-being is equally needed for attaining sustainable growth.

Guy and Kibert (1998) ascertains that standards should furnish a logical process so as to measure sustainability in effortless and simple manner. Guy and Kibert (1998) again

argued that the factors of sustainable standards will place a focal point on land troubles beside water, material and electricity use. In the opinion of the researchers, the quantitative measurements of the factors presents framework for examining construction sustainability.

Wackernagel and Rees (1996) came up with an ecological criterion which is linked to environmental and economic mechanisms of sustainability. It comprises water, food, waste disposal, and electricity on per capita basis. Bourdeau (1999) recognized cultural, social, and economic as key factors of their framework on sustainability. They in addition asserted that precedence of sustainable standards have the geographical range and it may additionally differ globally.

Singh et al. (2009) mentioned that the indices of sustainability are getting substantial attention as they are tremendous tool for strategies formulation. The sustainability indices is appreciated for making policy with respect to socio-economic, environment, and technological advancement. Their study similarly asserted that sustainable development indicators ought to be cautiously refined, selected, and revisited for the purpose of preserving the effectiveness of its context.

According to Labuschagnea et al. (2005) the United Nations Commission on Sustainable Development (CSD) devised 4 essential classes for the assessment of the effort of government toward sustainable growth. The Commission's sustainability model consist of environmental, financial, institutional, and social elements which is further divided into two. The Institution of Chemical Engineers (IChemE) added sustainability metrics consisting of three essential criteria, that is, financial, social, and environmental. The metrics may further be broken down into 9. The motive behind the model is to measure the sustainability of the process industries. One particular framework developed by the Wuppertal Institute is made of 4 elements of sustainable growth including social,

environment, institutional, and economic indicators. In this particular framework, all 4 essential standards as proposed by means of CSD are tied to each other via a number of sub-indicators.

Table 2.2 Criteria for Effective Selection of Plant and Equipment

Criteria	**References**
Ownership cost	Budhbhatti (1999); ILO (1999)
Operational cost	LeBlond et al. (1998)
Equipment age	Arslan et al. (2004)
Equipment capacity	Maxwell (1996); ILO (1999)
Equipment reliability	Allan (2005)
Equipment efficiency	Bahaman (2011)
Equipment operational life	Obiegbu (2012)
Equipment productivity	Manu et al. (2010)
Fuel efficiency	Bascetin (2003)
Traction system	Bamisile (2004)
Easy maintenance and repairs	Holt (2005)
Spare parts availability	Holt (2005)
Greenhouse gas emission	Rooks (2005)
Fossil fuel consumption	Bamisile (2004)
Energy saving	Labuschagnea et al. (2005)
Noise control	Singh et al. (2009)
Vibration control	Obiegbu (2012)
Quantity of particulate matter	Bahaman (2011)
Oil/Lube leakage control	Bahaman (2011)
Use of sustainable fuel	Manu et al. (2010)
Use of biodegradable lubricants/hydraulic oil	Singh et al. (2009)
Environmental statutory compliance	Obiegbu (2012)
Availability of local skilled operator	Labuschagnea et al. (2005)
Operator health	Obiegbu (2012)
Operator view and comfort	Bamisile (2004); ILO (1999)
Safety features	Labuschagnea et al. (2005)
Operator proficiency	Manu et al. (2010)
Training needs for operator	Singh et al. (2009)
Relationship with dealer and supplier	Bamisile (2004)

Source: Researcher's Construct

2.6 Challenges Associated with the Use of Plant and Equipment on Construction

Some of the challenges related with the use of plant on construction sites consist of however not restricted to: absence of safety and health committees; insufficient welfare facilities; unawareness of health and safety matters amongst the employees; insufficient personal and protective equipment; insufficient enforcement mechanisms; lack of equipped first aid kits on the construction sites; bad maintenance of personal protective gear; and finally lack of top management support in the administration of health and safety (Manu et al. 2010). Furthermore, welfare amenities and personal protective equipment are additionally cited as big challenges due to the fact that the two are not thoroughly supplied (Lam, 1999). Some supervisors on sites point out lack of monitoring and evaluation, lack of enough funds, lack of PPE implementation programs amongst others are additionally key challenges (Manu et al. 2010).

Vorster (2007) stated that commonly managers spend an excessive time to control the expenses however managers do not practice any endeavor to reduce it. Productivity typically defines the utilization of equipment; where downtime indicates the machine is not functioning (i.e. cannot carry out any task) –and when in operation maximum use of the machine correlate with maximum machine output. Zakeri et al. (1996) made the following rankings concerning equipment failure (3^{rd}) and the scarcity of suitable equipment (5^{th}), and consecutively amongst the pinnacle five motives for the decline in productivity on construction sites. It is important to pick out the appropriate equipment and suitable management choices have to be carried out so as to increase work output on site. The automated or robotic operation of the equipment or plant commonly defines health (Rooks, 2005), safety as well as well-being of personnel on site (Koivo, 1994). There are several research according to (Cabahug et al. 2004) proven that the operation of plants have substantial impact on specific equipment operations. They include

operator's ability, operator's competence, and operator's skill capability. LeBlond et al. (1998) avers that the safety issues of the project is guaranteed as long as the plant is properly managed. The researchers further indicated that productivity on site gets improved as long as plant is again managed properly.

Table 2.3 Challenges Associated with Plant and Equipment

Challenges	References
Poor maintenance of personal protective gear	Bamisile (2004)
Inadequate enforcement mechanisms	Manu et al. (2010)
Insufficient working space	Holt (2005)
Lack of monitoring and evaluation	Singh et al. (2009)
Lack of top management support	Labuschagnea et al. (2005)
Absence of safety and health committees	Manu et al. (2010)
Lack of equipped first aid kits	Arslan et al. (2004)
Inadequate personal and protective equipment	Maxwell (1996)
Unawareness of health and safety matters among workers	Allan (2005)
Insufficient storage area	Bamisile (2004)

Source: Researcher's Construct

2.7 Strategies to Improve Effective Management of Plant and Equipment on Sites

Bamisile (2004) state that the effective management of production process is not attained economically by using force, however, it demands the advent of onsite conditions that inspire self-motivation alongside conveying team spirit. Site management entails a light of activities that turn primary resources to finished goods or services (Mohammed and Anumba, 2006). Obiegbu (2012) posit that the construction process can be considered as converting raw useful resources as inputs into distinct operational output, through the use of managed process. Construction sites are considered as key areas where the money is either made or it is lost and again it is area where there is significant scope for enhancing quality, efficiency, and productivity. According to Obiegbu (2012) the following motives underpin why practicing of proper management of site is of essence: maintaining high

excellence of safety and health on construction sites; ensuring the most environment friendly and superb use of resources; Putting up trust and excellent relationship with project suppliers, different experts, and support companies that leads fewer disruptions, problems, and delays; and maintaining a high standard of excellence and workmanship.

To acquire suitable site management, Obiegbu (2012) indicated the subsequent areas be taken seriously: planning and programming the execution of work ought to guaranteed; project drawings, specification and contract files ought to be interpreted correctly; construction processes ought to be monitored and managed and corrective measures taking when a deviation occurs; resources for the project should be effectively determined and properly allocated; functional site layout ought to be assessed and provided; execution of the work ought to be properly planned and scheduled whilst not forgetting the institution of first-class control measures; compliance to statutory regulations ought to be ensured; ensuring that the proper caliber of experts is engaged with clearly defined roles; and all the projects necessities ought to be completely understood.

Construction IP (cited by Mohammed and Anumba, 2006) divided up site administration practices into 6 processes:

1. Administration, supervision, and management of sites: They include minutes, instruction, correspondence, notices/claims, labour allocations, growth report, technical information, payroll, and drawing register.
2. Commercial management: They include estimating, payment, closing accounts, valuation, day works, sub-contracting, variations, cost-value reconciliation, day works, and cash flow management.

3. Safety, health, and legal: They include management of safety, health and legal requirements on project site. It involves building regulations, insurance, and safety policy.
4. Planning, monitoring, and control: They include activities linked to planning and scheduling of projects, normally the production of network analyses, Gantt charts, development reviews, method statements, resource levelling, and exception reports.
5. Delivery and materials' handling: These are set of activities that are linked to delivery management and the following managements of materials on project site. They include purchase orders, requisitions, plant returns, and material call off.
6. Production on-site and off-site: These are set of activities that assist in production like testing, plant maintenance, setting out, and dimensional checks.

Table 2.3 Strategies to Improve the Effective Management of Plant and Equipment

Strategies	**References**
Constant maintenance and repair of plants and equipment	Arslan et al. (2004)
Spare parts availability to decrease downtime	Maxwell (1996)
Operators for plant and equipment should be competent	Allan (2005)
Identifying the most favorable situation and decision making to increase plants productivity	Mohammed and Anumba (2006)
Using automation and robotic plants and equipment before selection.	Obiegbu (2012)
Ensure the effectiveness of the operator's health and safety to increase productivity	Holt (2005)
Ensure the proper collection of data to increase plants and equipment performance.	Singh et al. (2009)
Operators should be highly motivated to raise productivity.	Labuschagnea et al. (2005)
Periodic control and serviceability of plants and equipment to increase productivity	Manu et al. (2010)
Training persons who are involved in plants and equipment to increase productivity	Labuschagnea et al. (2005)
Employ expert mechanics to increase the repair quality	Holt (2005)
Gasoline and petrol availability to decrease the wasting time	Manu et al. (2010)

Source: Researcher's Construct

2.8 Site Operatives

Operatives on site are concerned in a list of practical duties that assist professional construction personnel. They may additionally consist of drills and pumps, operate machinery, move load and off load materials, digging trenches, use equipment like cement mixer, and mix and lay concrete. The work may include also the use of forklift truck and different vehicle for site. Site operations are more often physically arduous (Construction Industry Training Board-CITB, 1964).

Site Operatives are additionally regarded as building or construction operatives, or labourers. Operatives are mostly accountable for maintaining tidiness on site, and take charge of equipment and tools. Again, following directions from professional workers from important part of the construction process. Operatives put on PPEs like safety boots, hard hat, overalls and high visibility jacket (Construction Industry Training Board, 2018). The ILO (1999) additionally states that each firm irrespective of the size have to employ a suitable certified personnel whose exceptional and most important duty is promoting health and safety on site.

2.8.1 The Role of Site Operatives in the Use of Construction Plant and Equipment

The advantages of a competent plant operator have been properly documented. They include better health and safety overall performance (Health and Safety Executive, 2007; Holt, 2005) and financial reserves in plant overhaul expenses (Stewart, 2001) even though some dissatisfaction of UK plant training programs has been brought up (Cabahug and Edwards, 2002). It has been identified that not all suitable operator performance or proficiency are associated to competency, but, individual attributes like motivation and intelligence have additionally been associated to the preceding individualities (Edwards et al. 2005). A number of research surrounding this theme has

been limited geographically like Elazouni and Basha (1996) performance assessment of operators; whilst other research have been limited to plant type like Bernhold (2007) which centered on measuring and comparing skill levels amongst excavator operators. The enhancement of operator's competence stands to be a natural sub-theme right here, thus, a number of researchers investigate this aspect. For instance, Atkinson et al. (2004) undertook an empirical examination of equipment and plant simulators; Edwards and Holt (2002) examined AI as a method to improve the maintenance proficiency of operator; and Wang and Dunston (2005) regarded huge equipment coaching the usage of virtual modelling procedures. The ILO (1999) also went further to explain that whoever is appointed as site operative must have straight access to the director general of the firm. His or her responsibilities ought to include but not limited to these: safety provisions peculiar to every trade; emergency and evacuation plans; inspection and rectification of access amenities like ladders and scaffolds; participating in pre-site planning; inspection and cleaning of welfare amenities like clothing, canteens, accommodation, and toilets; testing of lifting accessories like shackles and ropes, and lifting machinery like goods hoists and cranes; construction, maintenance, and provision of safety facilities like overhead protection, pedestrian routes, barricades, and access roadways; installation of safety signs; and transmission of important components of safety plan to every work group.

CHAPTER THREE

RESEARCH METHODOLGY

3.1 Introduction

The documentation of the research methodology constitute a very significant part of research work for the reason that decision makers can only weigh up the research integrity by examining the suitability of the methods adopted in collecting and analyzing data. According to Creswell (2003), methodology includes set of methods, procedures, tools, and assumptions that determines the processes of data collection and analysis. For instance, the quantitative design requires the use of inferential statistical tools in data analysis. In this chapter, the methodology adopted for the study is documented and justified. Components of this chapter are the research design, study population, sample size and sampling, instrumentation, validity and reliability, data collection process, and data analysis method.

3.2 Research Design

Kallet (2004) aver that research design refers to the guidelines that direct a research to the extent that the research variables can be controlled to make available answers to the research questions. Malhotra and Burks (2007) also states that research design provides procedural information needed to attain information required to solve the research problem. This study adopted the descriptive research design so that the clear picture of the situation as it naturally happens get presented in this document. That is to say, situations are in most cases described using this type of research design. Descriptive research design is used to make judgement and as well develop theories. For this study, descriptive survey was used by asking participants the same question set relating to key standard project plant management practices amongst D1K1 and D2K2 contractors in Ghana.

3.3 Research Approach

Fellows and Liu (2015) posits that research approach defines the measures and ethics of logical thought relating to scientific investigation. Thus, research approach stands to be an important component in the conduct of research. The three types of research approach commonly used are: quantitative, qualitative and mixed/triangulation methods. As Chan et al. (2015) indicates several contradictions have been made on which among the three is the most reliable. Chan et al. (2015) continued to indicate that, in the mid nineteenth and twentieth century, the qualitative research approach thrived as it provided sound evidence to the field. Cheng (2001) also indicates that, some researchers focused on using the mixed research method to gather relating information with practice as these researchers look for success factors, like formulation of concepts and practical models.

This study adopted the quantitative research approach to assess key standard project plant management practices amongst D1K1 and D2K2 contractors in Ghana. This approach was adopted on the basis that the researcher wanted to generalize findings of the study, it was necessary to use inferential statistical tools in computing these practices. Walliman (2017) has reported that any study that uses inferential statistical tools in analyzing its data is a quantitative study. For this reason, the current study was carried out as a quantitative research, as opposed to the qualitative research that employs textual and thematic analysis (Creswell, 2003).

3.4 Research Strategy

Saunders et al. (2009) draws no clear distinction with regards to research design and research strategy. Nevertheless, their study made a precise emphasis indicating how the choice of research strategy is guided by the research questions including the set objectives for the study. That is, research strategy constitute the plan which provide answers to the listed set of research questions. Likewise, Remenyi et al. (2000)

emphasized that, research strategy provides a direction along which research is conducted. Saunders et al. (2009) and Yin (2003b) made it clear that, there are similarities considering the various types of research strategies. However, the thought would be one choosing the appropriate type. Saunders et al. (2009) aver that, research strategy can be categorized into the following: case study; action research; grounded theory; archival research; experiment; survey; and ethnography. Like aforementioned, the choice of these strategies has more to do with the research objectives in addition to the research questions. This study adopted the survey strategy as a result of its strong relation with the deductive logic (Saunders et al., 2009). Survey research allows a large number of data to be gathered from a sizable population at a least cost. This according to Saunders et al. (2012) is obtained by the usage of questionnaire administered to a sample which are then standardized to allow easy comparison. The use of Likert scales which are popular methods of collecting information for surveys was employed. Again, the researcher gathered information from respondents through posting of questionnaires to those who could not be met face to face, and case of a survey research strategy for those the researcher was able to reach out to.

3.5 Study Population

With the study's main focus being to evaluate the standard project plant management practices amongst D1K1 and D2K2 contractors in Ghana, the study population included professionals in the construction industry (i.e. Civil Engineers, Architects, Quantity Surveyors, Project Managers and Construction Managers). The general population which Asiamah et al. (2017b) defined as all individuals about which an enquiry is to be made – the study population was therefore all Civil Engineers, Architects, Quantity Surveyors, Project Managers and Construction Managers working in D1K1 and D2K2 firms in Accra, Ghana.

3.6 Sample and Sampling Procedure/Techniques

Basically, the idea was to select some elements in a population so that conclusions can be drawn on the whole research population. Several reasons underpin sampling and they include greater accuracy of results, availability of population elements, lower cost of the research, and greater accuracy of results (Copper and Schindler, 1995). The population for the study was all Civil Engineers, Quantity Surveyors, Project Managers and Construction Managers working in D1K1 and D2K2 firms in Accra, Ghana. The non-probability sampling techniques, accidental sampling procedure was used to administer questionnaires to the targeted professionals who were deemed the best respondents to answer the set questions in the research questionnaires. This would mean that there is the chance that every professional chanced upon was chosen which would reflect the general situation on the ground. A total of fifty-one (51) respondents constituted the sample size for the study after using the accidental sampling procedure.

3.7 Research Instrumentation

Xiao (2008) indicated that, response to research on construction management in the context of the construction industry is relatively low. Thus, using questionnaire as a data collection tool it must be designed to be friendly towards respondents to enhance their involvement and to also maximize their response rate. Again, questionnaire should be designed in a way to be devoid of technical words as the use of plain language yields maximum response. According to Babbie (1990), flexibility in questionnaire design alongside the avoidance of monotony enhance questionnaire to be interesting for the respondents. Consequently, the design of the survey questionnaire was such that the aforementioned thoughts were considered and also at the start of every part for answering the questionnaire are set of instructions to direct the respondents.

The survey questionnaire consisted of four sections, that is, Part 'A', 'B', 'C' and 'D'. The first section (i.e. part 'A') captured the profile of respondents as it looked at the respondents' contextual background information. The second section being part 'B' was designed to capture questions regarding the selection criteria for onsite plant in Ghanaian construction industry. The part 'C' was designed to capture questions on the effect of plant management on the D1K1 and D2K2 contractors. And lastly, the part 'D' was designed to capture questions on possible ways of improving construction plant management practices on Ghanaian construction sites. Knowing the variables through the review of literature, the Likert scale Ratings was used except for open-ended questions for exploration.

3.8 Data Analysis Method

Data obtained from questionnaire administered to participants was analyzed with SPSS version 19. The software assisted in breaking down the raw data that was collected from the field into simpler quantitative and tabular form for easy understanding and assimilation. The normal frequency distribution, mean score, relative important index, and linear regression analysis were used to analyse the data on respondents' demographic characters, selection criteria for onsite plant, possible ways of improving construction plant management practices, and effect of plant management on the D1K1 and D2K2 contractors respectively. Again, together with the SPSS, the Microsoft Excel was used to generate diagrams from some of the tables obtained. The goal of data analysis is to ask questions about the data that answer the research questions on which the study was based.

3.8.1 Analytical model

Linear regression model using ordinary least square stepwise method was applied to determine the effect of plant management practices on project delivery by D1K1 and D2K2 contractors. The regression model is as listed below and is used to come up with the required variables including training and educating of plant and machinery operators, work schedule for plant and machinery, adherence to rules and guidelines pertaining to use of plant and machinery, specific plant and machinery manager, systematic maintenance of plant and machinery operators, and choosing the right and most appropriate plant and machinery.

$Y = \alpha 0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon$

Where:

Y = effect on project delivery, and

X_1 = training and educating of plant and machinery operators

X_2 = work schedule for plant and machinery

X_3 = adherence to rules and guidelines pertaining to use of plant and machinery

X_4 = specific plant and machinery manager

X_5 = systematic maintenance of plant and machinery operators

X_6 = choosing the right and most appropriate plant and machinery

$\beta_1 - \beta_6$ are the regression co-efficient or change introduced in Y by each independent variable.

ε is the random error term accounting for all other variables that affect delivery of project but not captured in the model.

3.8.2 Test of significance

The study adopted the one-way ANOVA for testing significant levels of independent variables against the dependent variables at 95 percent significant level. The preceding was adopted for testing whether there exist significant differences between the variables for the study. For testing the model's significance, the coefficient of determination was adopted for measuring the degree to which the variation in project delivery is explained by the variations in determinants of plant management practices. F-statistic was computed at 95 percent confidence level to test whether there is any significant relationship between plant management practices and project delivery by D1K1 and D2K2 contractors.

3.8.3 Relative important index (RII)

In the case of a five-point response item, RII produces a value ranging from 0.2 to 1.0 (Ugwu and Haupt, 2007). The equation for the analysis is given as follows:

$RII = \Sigma W / A*N$

Where, W = the weight given to each factor by the respondents and ranges from 1 to 5; A = the highest response integer (5); and N = the total number of respondents.

3.9 Ethical Standards

It is important that in research, the welfare or rights of the people involved are not harmed but the research be done justly (Hickey, 2018). According to Nayeem (2017) research ethics are the common denominator for researchers' relations with respondents and colleague researchers are responsible for all ethical conducts of their research. The researcher indicated to the study's respondents the purpose of the survey to their professions. Respondents prior to the interview were informed about the maximum time required for the exercise. The confidentiality of the respondents were assured and before

meeting with respondents they were made aware and their consent was sought. Literature sources have been duly acknowledged both in the text and bibliography.

3.9.1 Internal and external validity

The study considered all Quantity Surveyors, Construction Managers, Civil Engineers, and Project Managers in D1K1 and D2K2 firms in Accra as respondents in the data collection. This was done to ensure uniformity in the responses retrieved. External validity has been ensured by a representative sample of construction professionals considering a 95% confidence level and fulfilling 46 respondents; representing 90.20% response rate in the case of the fifty-one (51) construction professionals sampled.

CHAPTER FOUR

PRESENTATION OF FINDINGS AND DISCUSSIONS

4.1 Introduction

In this chapter, the following sections and subsections were highlighted: presentation and interpretation of demographic data, and the analysis of questions tied to the study's objectives. The study was limited to Quantity Surveyors, Construction Managers, Civil Engineers, and Project Managers in D1K1 and D2K2 firms in the Accra metropolis. The analytical tools used included normal frequency distribution, mean score, relative important index, and linear regression analysis. These tools allow for a good analysis of the data collected due to the nature of the questionnaire. Results for the study were presented in tables to elicit easy interpretations.

4.4.1 Questionnaire response rate

The target for the study concerning the sample size was fifty-one (51) participants out of which forty-six (46) were completely filled making a response rate of 90.20%. The response rate being a representative of the sample size was considered satisfactory to draw conclusions for the research. According to Mugenda and Mugenda (1999) a response rate of 50% is adequate for analysis and reporting; a rate of 60% is good and a response rate of 70% and above is excellent. The response rate for the research was thus excellent on the basis of Mugenda and Mugenda (1999) assertion.

4.2 Demographic Characteristics of Respondents

It is significant for this research to identify its respondents' background information as they aided the researcher to know the weight to put on the data gathered from all the respondents. Data gathered under this section included position in the office, years of

experience in the construction industry, highest educational qualification, age category of respondent's organization, how firms' acquire plant and equipment, and how firms' manage plant and equipment not in use.

4.2.1 Position in office

Respondent's position in the office was considered by the researcher as a momentous character as it determines the weight to place on the information elicited. For purpose of confidentiality positions were classified as Civil Engineers, Quantity Surveyors, Construction Manager, and Project Managers. Table 4.1 subsequently present the findings after the analysis.

Table 4.1 Position in office

Valid	Frequency	Percent	Cumulative %
Construction Manager	11	23.91	23.91
Project Manager	15	32.61	56.52
Civil Engineer	9	19.57	76.09
Quantity Surveyors	11	23.91	100.00
Total	**46**	**100**	

Source: Field Data (2019)

From Table 4.1 fifteen (15) of the respondents representing 32.61% were Project Managers. They represent the majority as far as participants of the study is concern. Eleven (11) of the respondents representing 23.91% each were Construction Managers and Quantity Surveyors respectively. The two categories was next in majority of the study's participants. Last but not the least, nine (9) of the respondents were Civil Engineers; they represented 19.57% of the entire respondents. Although participants were classified as such, however, their contribution toward answering the questionnaire

did not exhibited anything of the sort. That is, be it Civil Engineer or Project Manager or any of the positions all participants contributed immensely to the study.

4.2.2 Respondent's years of experience in the construction industry

The study demanded respondents to indicate how long they have been in the construction industry. The emphasis laid on this demographic character was that respondent's experience in the industry is parallel a way to providing answers to the questions centered on the research theme. Table 4.2 present findings on this character.

Table 4.2 Respondent's years of experience in the construction industry

Valid	Frequency	Percent	Cumulative %
Under 5 years	7	15.22	15.22
5-10 years	13	28.26	43.48
11-15 years	9	19.57	63.05
Over 15 years	17	36.95	100.00
Total	**46**	**100**	

Source: Field Data (2019)

From Table 4.2 seventeen (17) of the respondents representing 36.95% had over 15 years working experience in the construction industry. They represent the majority for the study. Thirteen (13) of the respondents representing 28.26% had between 5 to 10 years working experience in the industry. Finally, nine (9) and seven (7) of the respondents representing 19.7% and 15.22% had 11 to 15 years and under 5 years working experience in the industry respectively. It can be deduced that practically all the participants had enough experience in the sector making them eligible enough to provide answers to the questions tied to the study's objectives.

4.2.3 Highest educational qualification

On respondent's highest educational qualification, it was revealed that most of the respondents were first degree holders as shown by 45.65%. Also, 30.43% and 13.05% were Masters' degree and PhD holders respectively. Finally, 10.87% of the respondents had HND qualification. They represent the minority for the study. The preceding findings proof that all the respondents had enough education to read and understand questions set in the questionnaire and consequently provide relevant information. Table 4.3 presents summary of the preceding discussions.

Table 4.3 Highest educational qualification

Valid	Frequency	Percent	Cumulative %
HND	5	10.87	10.87
First degree	21	45.65	56.52
Masters	14	30.43	86.95
PhD	6	13.05	100.00
Total	**46**	**100**	

Source: Field Data (2019)

4.2.4 Age category of respondent's organization

On the age category of respondent's organization, the study revealed that most of the firms had 11 to 20 years' experience in the sector as shown by 36.95%. Also, 26.09% and 21.74% had 5 to 10 years and over 20 years' experience in the construction sector respectively. Finally, 15.22% of the firms had under 5 years' experience and their category represented the minority. It is clear that approximately 85% of the firms had over 5 years' experience in the Ghanaian construction sector which signals their competitiveness in the sector and consequently their capacity in project management including onsite plant and equipment. Table 4.4 summarizes the preceding discussions with statistics.

Table 4.4 Age category of respondent's organization

Valid	Frequency	Percent	Cumulative %
Under 5 years	7	15.22	15.22
5-10 years	12	26.09	41.31
11-20 years	17	36.95	78.26
Over 20 years	10	21.74	100.00
Total	**46**	**100**	

Source: Field Data (2019)

4.2.5 How firms' acquire plant and equipment

On how firm's acquire plant and equipment, the study revealed that more than half of the firms acquire their plant and equipment through hiring as shown by 58.70%. Similarly, 26.08% of the firms acquire their plant and equipment through buying and hiring. Finally, 15.22% of the firms acquire theirs through buying. That is to say, majority of the firms prefer hiring of equipment than buying them. A key observation made from the field was that most firms see the buying aspect as waste of firm's scarce resources. According respondents, once the project is completed the equipment or plant become of less use and are left as white elephants in most cases and thus firms would rather hire when the need arises. Also, some of the respondents indicated that their firms do not have the capital to purchase the equipment or plant and thus would have to resort to hiring them. Table 4.5 presents summary of the preceding discussions.

Table 4.5 How firms' acquire plant and equipment

Valid	Frequency	Percent	Cumulative %
Buy	7	15.22	15.22
Hire	27	58.70	73.92
Both	12	26.08	100.00
Total	**46**	**100**	

Source: Field Data (2019)

4.2.6 How firms' manage plant and equipment not in use

On how firm's manage plant and equipment not in use, it was revealed that most of the firms pack them down as shown by 80.43%. Also, 15.22% of the firms rather resort to renting them out to fatten the company's purse. Finally, 4.35% of the firms resort to other means like selling them as liquidity. According to some respondents packing them would increase the chances of getting them faulty or damaged. However, majority of the respondents (i.e. 80.43%) indicated otherwise, stating that once they are packed the contractor can go for it anytime while it is needed. Table 4.6 presents summary of the preceding discussions.

Table 4.6 How firms manage plant and equipment not in use

Valid	Frequency	Percent	Cumulative %
Pack them down	37	80.43	80.43
Rent	7	15.22	95.65
Other	2	4.35	100.00
Total	**46**	**100**	

Source: Field Data (2019)

4.3 Selection Criteria for Onsite Plant

As part of the research endeavour, the study sought to identify the selection criteria for onsite plant in the Ghanaian construction industry. Descriptive statistics was conducted to examine the mean values and standard deviations of all the identified criteria. In establishing the significance of the variables, a criterion was considered significant on the basis that it had a mean value greater than 3.0 and moderately significant if it mean is between 2.0 and 3.0 and less significant when it mean is less than 2.0 (see Kline 1998).

Table 4.7 Selection Criteria for Onsite Plant

	Selection Criteria	Mean	SD
Socio-Economic Criteria	Ownership cost	3.23	0.121
	Operational cost	3.11	0.127
	Availability of local skilled operator	3.03	0.141
	Operator proficiency	2.97	0.149
	Relationship with dealer/supplier	2.75	0.161
	Training needs for operator	2.41	0.178
	Operator view and comfort	2.24	0.195
	Operator health	2.13	0.203
	Safety features	1.89	0.214
Engineering Criteria	Equipment productivity	3.07	0.132
	Equipment efficiency	2.94	0.146
	Fuel efficiency	2.67	0.151
	Equipment reliability	2.54	0.173
	Equipment age	2.32	0.179
	Meet job/operational requirements	2.17	0.193
	Easy repair and maintenance	2.11	0.212
Environmental conditions	Energy saving	3.14	0.127
	Greenhouse gas emissions	2.98	0.134
	Noise control	2.67	0.161
	Fossil fuel consumption	2.49	0.174
	Oil/lube leakage control	2.26	0.188
	Vibration control	2.18	0.193

Source: Field Data (2019)

While explaining selection criteria for onsite plant, criteria were categorized into three (3), namely: socio-economic criteria, engineering criteria and environmental conditions. For socio-economic criteria nine (9) selection criteria were identified and they are ranked as follows: ownership cost (mean = 3.23; SD = 0.121); operational cost (mean = 3.11; SD = 0.127); availability of local skilled operator (mean = 3.03; SD = 0.141); operator

proficiency (mean = 2.97; SD = 0.149); relationship with dealer/supplier (mean = 2.75; SD = 0.161); training needs for operator (mean = 2.41; SD = 0.178); operator view and comfort (mean = 2.24; SD = 0.195); operator health (mean = 2.13; SD = 0.203); and safety features (mean = 1.89; SD = 0.214). Out of the nine (9), three (3) of the criteria were considered significant (i.e. ownership cost, operational cost, and availability of local skilled operator), five (5) as moderately significant (i.e. operator proficiency, relationship with dealer/supplier, training needs for operator, operator view and comfort, and safety features), and one (1) considered as less significant (i.e. safety features).

For engineering criteria seven (7) selection criteria were identified and they are ranked as follows: equipment productivity (mean = 3.07; SD = 0.132); equipment efficiency (mean = 2.94; SD = 0.146); fuel efficiency (mean = 2.67; SD = 0.151); equipment reliability (mean = 2.54; SD = 0.173); equipment age (mean = 2.32; SD = 0.179); meet job/operational requirements (mean = 2.17; SD = 0.193); and easy repair and maintenance (mean = 2.11; SD = 0.212). Out of the seven (7), one (1) of the criteria was considered significant (i.e. equipment productivity) and the remaining six (6) were considered as moderately significant (i.e. equipment efficiency, fuel efficiency, equipment reliability, equipment age, meet job/operational requirements, and easy repair and maintenance). That is, none of the criteria was considered less significant.

Finally, for environmental conditions six (6) selection criteria were identified as follows: energy saving (mean = 3.14; SD = 0.127); greenhouse gas emissions (mean = 2.98; SD = 0.134); noise control (mean = 2.67; SD = 0.161); fossil fuel consumption (mean = 2.49; SD = 0.174); oil/lube leakage control (mean = 2.26; SD = 0.188); and vibration control (mean = 2.18; SD = 0.193). Out of the six (6), one (1) of the criteria (i.e. energy saving) was considered significant. The remaining five (5) (i.e. greenhouse gas emissions, noise control, fossil fuel consumption, oil/lube leakage control, and vibration control) were

considered moderately significant by respondents. The above findings concur with Temiz and Calis (2017) –they posits that for the contractor to select the appropriate plants for a construction he or she ought to think about qualitative and quantitative aspects like technical specifications, buying cost, fuel consumption, service conditions, secondary and replacement components markets, and the comfort of the operator. Temiz and Calis (2017) considered the preceding criteria significant –this study does same as none of the variables presented to respondents was considered less significant.

4.4 Effect of Plant Management on Delivery of Projects

The study adopted the linear regression analysis to estimate relationship among variables. This included a number of techniques for modeling and analyzing several variables, when the focus is actually on the relationship between a dependent variable and one or more independent variables. The linear regression analysis was conducted to test influence among predictor variables. The research used statistical package for social science (SPPSS version 19) to code, enter and compute the measurements of the linear regressions. The model summary is presented in the Table 4.8.

Table 4.8 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.833	.751	.661	.36716

The study used coefficient of determination to evaluate the model fit. The adjusted R^2 also called the coefficient of multiple determinations, is the percent of variance in the dependent variable explained jointly or uniquely by the independent variables. The model had an average adjusted coefficient of determination (R^2) of 0.751 which implies

that 75.1% of the variations in project delivery by contractors (i.e. D1K1 and D2K2) are explained by the independent variables understudy (i.e. training and educating of plant and machinery operators, work schedule for plant and machinery, adherence to rules and guidelines pertaining to use of plant and machinery, specific plant and machinery manager, systematic maintenance of plant and machinery operators, and choosing the right and most appropriate plant and machinery). This therefore means that other variables not studied in this research contribute 24.9% of the variables affecting project delivery by the preceding contractors.

4.4.1 Analysis of variance

The significance of the model was further tested using the analysis of variance technique. The findings are tabulated in Table 4.9.

Table 4.9 Summary of One-Way ANOVA Results

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	32.371	9	6.547	5.431	.003
Residual	84.872	78	1.342		
Total	117.218	86			

Critical value = 2.44

From the analysis of variance statistics, the study established that the regression model had a significance level of 0.3% which is an indication that the data was ideal for making a conclusion on the population parameters as the value of significance (p-value) was less than 5%. The calculated value was greater compare to the critical value (6.547 > 2.44) an indication that proper management of plant on site has effect on D1K1 and D2K2 contractors in the Accra Metropolis. The significance value was less than 0.05 indicating that the model was significant.

4.4.2 Coefficients

In addition, the study used the coefficient table to determine the study model. The findings are presented in Table 4.10.

Table 4.10 Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	1.14	.2184		4.332	.003
Training and educating of plant and machinery operators	.335	.172	.627	2.412	.022
Work schedule for plant and machinery	.321	.163	.631	2.267	.015
Adherence to rules and guidelines pertaining to use of plant and machinery	.423	.132	.567	2.934	.021
Specific plant and machinery manager	.337	.161	.439	3.151	.017
Systematic maintenance of plant and machinery operators	.422	.174	.426	3.214	.013
Choosing the right and most appropriate plant and machinery	.332	.165	.521	3.312	.022

Per the SPSS generated output as presented in table 4.10 the equation becomes:

$Y = 1.14 + 0.335X_1 + 0.321X_2 + 0.423X_3 + 0.337X_4 + 0.422X_5 + 0.332X_6$

The regression equation above has established that holding all independent variable (i.e. training and educating of plant and machinery operators, work schedule for plant and machinery, adherence to rules and guidelines pertaining to use of plant and machinery, specific plant and machinery manager, systematic maintenance of plant and machinery operators, and choosing the right and most appropriate plant and machinery) constant, other variables on site affecting D1K1 and D2K2 contractors will be 1.14.

From the regression model obtained above, a unit increase in training and educating of plant and machinery operators while holding the other variables constant would lead to an increase in project delivery by a factor of 0.335. Also, a unit increase in work schedule for plant and machinery while holding the other variables constant would lead to an increase in project delivery by a factor of 0.321. Similarly, a unit increase in adherence to rules and guidelines pertaining to use of plant and machinery while holding the other variable constant would lead to an increase in project delivery by D1K1 and D2K2 contractors by a factor of 0.423. A unit increase in specific plant and machinery manager, and systematic maintenance of plant and machinery operators, while holding all other variables constant would lead to an increase in project delivery by factors of 0.337 and 0.422 respectively. Finally, a unit increase in choosing the right and most appropriate plant and machinery while holding all other variable constant would lead to an increase in project delivery by a factor of 0.332. The preceding findings concur with Manaf et al. (2007) assertion. According to Manaf et al. (2007) efficient plant management in all phases of projects is the most critical task in the project life cycle since the inability to manage it could delay the project resulting into time and cost overrun and or result into outright failure of the project. Plant management as Bahaman (2011) posits play significant role in promoting the efficient use of complex resources being manpower, materials or money. According to Bahaman (2011) it is significant to note that having the right plant and machinery at the right time and place and ensuring proper management like the preceding findings of the study gives a firm an edge in the market. It is therefore not surprising seeing all the variables having a positive effect on D1K1 and D2K2 contractors.

A particular observation made was that, all the identified variables (i.e. the independent variables) had positive effect on project delivery by D1K1 and D2K2 contractors after

the regression. According to Prajeesh and Sakthivel (2016) efficient management of onsite equipment or plant enhance work practices and improve productivity. That is, there is always positive relationship between plant management and improving onsite productivity. Prajeesh and Sakthivel (2016) assertion confirms findings of this study. It is important to note that this analysis was undertaken at 5% significance level. The criteria for comparing whether the predicator variables were significant in the model was through comparing the obtained probability and $\alpha = 0.05$. If the probability value was less than α, then the predictor variable was significant if not the variable remain insignificant. All the predictor variables were significant in the model as their probability were less than $\alpha = 0.05$.

4.5 Possible Ways of Improving Plant Management on Site

While explaining possible ways of improving plant management on site, constant maintenance and repair of plants and equipment ranked first (RII = 0.857), operators for plant and equipment should be competent ranked second (RII = 0.839), periodic control and serviceability of plants and equipment to increase productivity ranked third (RII = 0.830), operators should be highly motivated to raise productivity ranked fourth (RII = 0.800), training persons who are involved in plants and equipment to increase productivity ranked fifth (RII = 0.791), ensure the proper collection of data to increase plants and equipment performance ranked sixth (RII = 0.770), eemploy expert mechanics to increase the repair quality ranked seventh (RII = 0.770), identifying the most favorable situation and decision making to increase plants productivity ranked eighth (RII = 0.752), ensure the effectiveness of the operator's health and safety to increase productivity ranked ninth (RII =0.735), ensure the effectiveness of the operator's health and safety to increase productivity ranked tenth (RII = 0.709), gasoline and petrol availability to decrease the wasting time ranked eleventh (RII = 0.700), and using

automation and robotic plants and equipment before selection ranked twelfth (RII = 0.683).

Respondents hold constant maintenance and repair of plants and equipment as the most significant factor to consider in improving plant management on sites. According to respondents, plant and equipment function efficiently when they are maintained on regular basis. Thus, productivity on site augments especially for huge projects when plant and equipment are in full operation. To respondents, this can only be assured when they are properly serviced and maintained recurrently. According to Obiegbu (2012) and Mohammed and Anumba (2006) construction equipment are efficient as you maintain and repair them. The findings of the study concurs with Obiegbu (2012) and Mohammed and Anumba (2006) assertion. Finally, using automation and robotic plants and equipment before selection, respondents ranked it as the least significant factor for consideration for improving plant management on sites. The researcher observed that such technology is rear in our part of the world and thus was not surprising seeing it ranked last. Table 4.9 presents summary of the preceding discussions.

Table 4.11 Ways of Improving Plant Management on Site

		Frequency of ranking							
No.	**Ways of Improving**	**1**	**2**	**3**	**4**	**5**	**Weighting**	**RII**	**Rank**
1	Constant maintenance and repair of plants and equipment	0	2	7	13	24	197	0.857	1
2	Operators for plant and equipment should be competent	1	3	6	12	24	193	0.839	2
3	Periodic control and serviceability of plants and equipment to increase	1	3	7	12	23	191	0.830	3

	productivity								
4	Operators should be highly motivated to raise productivity	2	4	7	12	21	184	0.800	4
5	Training persons who are involved in plants and equipment to increase productivity	2	5	7	11	21	182	0.791	5
6	Ensure the proper collection of data to increase plants and equipment performance	2	6	9	11	20	177	0.770	6
7	Employ expert mechanics to increase the repair quality	2	6	8	11	19	177	0.770	7
8	Identifying the most favorable situation and decision making to increase plants productivity	3	7	7	10	19	173	0.752	8
9	Ensure the effectiveness of the operator's health and safety to increase productivity	4	7	7	10	18	169	0.735	9
10	Ensure the effectiveness of the operator's health and safety to increase productivity	7	6	6	9	18	163	0.709	10
11	Gasoline and petrol availability to decrease the wasting time	7	6	7	9	17	161	0.700	11
12	Using automation and robotic plants and equipment before selection	6	9	7	8	16	157	0.683	12

Source: Field Data (2019)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Introduction

The study was aimed at evaluating the standard project plant management practices amongst D1K1 and D2K2 contractors in the Ghana. Consequently, the following objectives were established to consummate the research aim: identify the selection criteria for onsite plant in the Ghanaian construction industry; determine the effect of plant management on the D1K1 and D2K2 contractors; and identify possible ways of improving construction plant management practices on Ghanaian construction sites. This chapter gives a summary to the research findings and as well establish evidence based recommendations of the research.

5.2 Summary of Findings

The research objectives were visited once more to stress on the extent to which they are achieved. Preceding this was a methodological approach involving literature review process, questionnaire design phase, questionnaire administration stage, and finally analysis of data gathered using frequency distribution, mean score, multiple regression analysis and relative important index.

5.2.1 Selection Criteria for Onsite Plant

Selection of construction equipment plays a very crucial role in the effective completion of any civil project. Thus selection and planning of equipment are essential for its utilization with minimum cost. It is the responsibility of the contractor to assign particular equipment to complete a task as per site conditions (Thete and Baviskar, 2016). As the first objective of the study, the study sought to identify the selection criteria for onsite plant in the Ghanaian construction industry. Descriptive statistics was

conducted to examine the mean values and standard deviations of the twenty-two (22) criteria identified from literature and subsequently from the field. The study categorized the various criteria into three (3), namely: socio-economic criteria, engineering criteria and environmental conditions.

For socio-economic criteria nine (9) selection criteria were identified and they are ranked as follows: ownership cost (mean = 3.23; SD = 0.121); operational cost (mean = 3.11; SD = 0.127); availability of local skilled operator (mean = 3.03; SD = 0.141); operator proficiency (mean = 2.97; SD = 0.149); relationship with dealer/supplier (mean = 2.75; SD = 0.161); training needs for operator (mean = 2.41; SD = 0.178); operator view and comfort (mean = 2.24; SD = 0.195); operator health (mean = 2.13; SD = 0.203); and safety features (mean = 1.89; SD = 0.214). Out of the nine (9), three (3) of the criteria were considered significant (i.e. ownership cost, operational cost, and availability of local skilled operator), five (5) as moderately significant (i.e. operator proficiency, relationship with dealer/supplier, training needs for operator, operator view and comfort, and safety features), and one (1) considered as less significant (i.e. safety features).

For engineering criteria seven (7) selection criteria were identified and they are ranked as follows: equipment productivity (mean = 3.07; SD = 0.132); equipment efficiency (mean = 2.94; SD = 0.146); fuel efficiency (mean = 2.67; SD = 0.151); equipment reliability (mean = 2.54; SD = 0.173); equipment age (mean = 2.32; SD = 0.179); meet job/operational requirements (mean = 2.17; SD = 0.193); and easy repair and maintenance (mean = 2.11; SD = 0.212). Out of the seven (7), one (1) of the criteria was considered significant (i.e. equipment productivity) and the remaining six (6) were considered as moderately significant (i.e. equipment efficiency, fuel efficiency, equipment reliability, equipment age, meet job/operational requirements, and easy repair and maintenance). That is, none of the criteria was considered less significant.

Finally, for environmental conditions six (6) selection criteria were identified as follows: energy saving (mean = 3.14; SD = 0.127); greenhouse gas emissions (mean = 2.98; SD = 0.134); noise control (mean = 2.67; SD = 0.161); fossil fuel consumption (mean = 2.49; SD = 0.174); oil/lube leakage control (mean = 2.26; SD = 0.188); and vibration control (mean = 2.18; SD = 0.193). Out of the six (6), one (1) of the criteria (i.e. energy saving) was considered significant. The remaining five (5) (i.e. greenhouse gas emissions, noise control, fossil fuel consumption, oil/lube leakage control, and vibration control) were considered moderately significant by respondents.

5.2.2 Effect of Plant Management on D1K1 and D2K2 Firms

According to Prajeesh and Sakthivel (2006), construction plant and machinery form a major part of the contractor's resource in the building process for a construction project. The contractor effective project management in construction ought to vigorously pursue the efficient utilization of labor, material, and equipment. And as research objective, the study sought determine the effect of plant management on the D1K1 and D2K2 contractors. The study adopted the linear regression analysis to estimate the relationships among variables. It was revealed that all the identified variables (i.e. training and educating of plant and machinery operators, work schedule for plant and machinery, adherence to rules and guidelines pertaining to use of plant and machinery, specific plant and machinery manager, systematic maintenance of plant and machinery operators, and choosing the right and most appropriate plant and machinery) had positive effect on project delivery by D1K1 and D2K2 contractors after the regression. That is to say plant management practices are consistent with construction project delivery on sites.

5.2.3 Possible Ways of Improving Construction Plant Management Practices

Bamisile (2004) drew interest to the truth that the effectiveness of managing production process cannot be economically attained by using force, however, requires the advent of conditions that will inspire self-motivation and convey about team spirit that is essential to an efficient projection execution. Site management in accordance with Mohammed and Anumba (2006) entails a combination of activities, which turn primary resources into a finished product. That is, as research objective the study sought identify possible ways of improving construction plant management practices on Ghanaian construction sites. Twelve (12) possible ways of improving plant management practices were identified from literature and subsequently subjected to the study's respondents for ranking purposes. After the analysis using RII, the study revealed the following: constant maintenance and repair of plants and equipment ranked first (RII = 0.857) whereas using automation and robotic plants and equipment before selection ranked twelfth (RII = 0.683). That is, respondents held constant maintenance and repair of plants and equipment as the most significant factor to consider in improving plant management on sites. Conversely, using automation and robotic plants and equipment before selection, respondents ranked it as the least significant factor for consideration for improving plant management on sites. The researcher observed that such technology is rear in our part of the world and thus was not surprising seeing it ranked last.

5.3 Conclusion

The study has identified twenty-two (22) selection criteria for onsite plant in the Ghanaian construction industry. Out of the twenty-two (22), five (5) were considered significant, sixteen (16) as moderately significant, and only one (1) was considered as less significant. For the second research objective, it was revealed that all the identified plant management practices had positive effect on project delivery by D1K1 and D2K2

contractors after the regression. That is to say plant management practices were consistent with construction project delivery. Finally, twelve (12) possible ways were identified to improve plant management practices on site. However, constant maintenance and repair of plants and equipment was considered the most significant factor whereas using automation and robotic plants and equipment before selection was considered the least.

5.4 Recommendation

For a successful project in the built environment, the key to profitability is proper management (Ofori, 2006). The unprofessional plant resource management of construction processes among our local contractors' ends up in delays, abandoning a project, shoddy works and not making them uncompetitive to the foreign contractors in the construction industry. The construction industry in Ghana is declining as a result of it not being considered as a major challenge (Ofori, 2006). It is thus important that proper plant management for the local contractors especially be taken seriously. On this background together with the findings of the study, the researcher thus recommends the following:

1) The selection criteria of plant for onsite projects must embrace the environmental aspect in as much as contractors embrace the socio-economic and the engineering aspects –it was observed that for the six variables identified as environmental aspect of plant selection criteria, only one was considered significant by the respondents.
2) Plant management practices like identified in this document must be adhere to as they are consistent with construction project delivery.

3) Contractors must inculcate the maintenance habit in their operation to maximize the use of plants on site and at the same avert the situation of endangering the lives of personnel on sites.

5.4.1 Recommendations for further study

The study focused on assessing the standard project plant management practices amongst D1K1 and D2K2 category of contractors in the Ghanaian construction industry. Thus, a study can be carried out using the remaining category of contractors (i.e. D3K3 and D4K4) or those from the other sectors (i.e. civil works contractors). That is, the recommended study would focus solely on these contractors for distinct results as compared to this current study.

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APPENDIX 'I'

SURVEY QUESTIONNAIRE

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DEPARTMENT OF BUILDING TECHNOLOGY

TOPIC: CONSTRUCTION PLANT MANAGEMENT PRACTICE ADOPTED BY D1K1 AND D2K2 CONTRACTORS

Dear Sir/Madam,

Many thanks in advance for your participation. The aim of this questionnaire survey is to examine the standard project plant management practices amongst D1K1 and D2K2 category of contractors in the Ghanaian construction industry. We believe this will only take you about 10 to 15 minutes. Please note that all the information you provide will remain anonymous and will be used solely for academic purpose. Thank you once more for your precious time.

SECTION 'A' – DEMOGRAPHIC BACKGROUND OF RESPONDENTS

1. Position in the Company?
[ ] Project Manager [ ] Construction Manager [ ] Others…….
[ ] Engineer [ ] Quantity Surveyor

2. How long have you been in the construction industry?
[ ] Under 5 years [ ] 5-10 years
[ ] 11-20 years [ ] Over 20 years

3. What is your highest educational qualification?
[ ] HND [ ] First degree [ ] Masters [ ] PhD

4. How old is your organization?
[ ] Under 5 years [ ] 5-10 years
[ ] 11-20 years [ ] Over 20 years
5. How does your firm acquire your plant and equipment?
[ ] Buying [ ] Hiring [ ] Both buying and hiring

6. How does your firm manage plant and equipment not in use?
[ ] Packing them down [ ] Renting
[ ] Other (please indicate)……

SECTION 'B' - SELECTION CRITERIA FOR ONSITE PLANT

7. Please indicate your opinion on a five point Likert scale on the following criteria in terms of their importance in the selection of onsite mechanized equipment in relation to the categories under which they are listed. ***1 =Not all important; 2 =Important; 3 =Neutral; 4 =Very important; 5 =Extremely important***

No.	SELECTION CRITERIA	RANKING SCALE				
	Socio-Economic Criteria	1	2	3	4	5
1	Availability of local skilled operator	1	2	3	4	5
2	Operational cost	1	2	3	4	5
3	Operator health	1	2	3	4	5
4	Operator proficiency	1	2	3	4	5
5	Operator view and comfort	1	2	3	4	5
6	Ownership cost	1	2	3	4	5
7	Relationship with dealer/supplier	1	2	3	4	5
8	Safety features	1	2	3	4	5
9	Training needs for operator	1	2	3	4	5
	Engineering Criteria					
10	Easy repair and maintenance	1	2	3	4	5
11	Equipment age	1	2	3	4	5
12	Equipment efficiency	1	2	3	4	5
13	Equipment productivity	1	2	3	4	5
14	Equipment reliability	1	2	3	4	5
15	Fuel efficiency	1	2	3	4	5
16	Meet job/operational requirements	1	2	3	4	5
	Environmental Conditions					
17	Energy saving	1	2	3	4	5
18	Greenhouse gas emissions	1	2	3	4	5
19	Noise control	1	2	3	4	5
20	Oil/lube leakage control	1	2	3	4	5
21	Fossil fuel consumption	1	2	3	4	5
22	Vibration control	1	2	3	4	5

SECTION 'C'- PLANT MANAGEMENT PRACTICES FOR THE D1K1 AND D2K2 CONTRACTORS

8. On a scale of 1-5, please indicate how significant the following plant management practices are to your firm. ***1 =very significant; 2 =significant; 3 =moderately significant; 4 =slightly significant; and 5 =insignificant***

NO	PLANT MANAGEMENT PRACTICES	RANKING SCALE				
1	Training and educating of plant and machinery operators	1	2	3	4	5
2	Work schedule for plant and machinery	1	2	3	4	5
3	Adherence to rules and guidelines pertaining to use of plant and machinery	1	2	3	4	5
4	Assigning specific plant and machinery manager	1	2	3	4	5
5	Systematic maintenance of plant and machinery operators	1	2	3	4	5
6	Choosing the right and most appropriate plant and machinery	1	2	3	4	5
Other(s); Please indicate						
7		1	2	3	4	5
8		1	2	3	4	5

SECTION 'D' - POSSIBLE WAYS OF IMPROVING CONSTRUCTION PLANT MANAGEMENT PRACTICES

9. On a scale of 1-5, please indicate the extent to which you agree to the following as to improving construction plant management on site. ***1 =Strong agree; 2 =Agree; 3 =Moderate; 4 =Disagree; and 5 =Strongly disagree***

NO	WAY OF IMPROVING PLANT MGT. ON SITE	RANKING SCALE				
1	Constant maintenance and repair of plants and equipment	1	2	3	4	5
2	Ensure the proper collection of data to increase plants and equipment performance	1	2	3	4	5
3	Identifying the most favorable situation and decision making to increase plants productivity	1	2	3	4	5
4	Operators for plant and equipment should be competent	1	2	3	4	5
5	Ensure the effectiveness of the operator's health and safety to increase productivity	1	2	3	4	5
6	Periodic control and serviceability of plants and equipment to increase productivity	1	2	3	4	5
7	Employ expert mechanics to increase the repair quality	1	2	3	4	5
8	Operators should be highly motivated to raise productivity	1	2	3	4	5
9	Training persons who are involved in plants and equipment to increase productivity	1	2	3	4	5
10	Gasoline and petrol availability to decrease the wasting time	1	2	3	4	5
11	Using automation and robotic plants and equipment before selection	1	2	3	4	5
12	Gasoline and petrol availability to decrease the wasting time	1	2	3	4	5
Other(s); Please indicate						
13		1	2	3	4	5
14		1	2	3	4	5

THANK YOU!