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DEPARTMENT OF BUILDING TECHNOLOGY

"COST ESTIMATION MODEL FOR COST ANALYSIS OF CONCRETE WORKS AT THE INITIAL STAGES OF CONSTRUCTION PROJECTS IN GHANA"

By

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DECLARATION

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

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DEDICATION

This research work is dedicated to my entire family, whose moral and spiritual support, encouragement and love has brought me this far in my educational pursuit.

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ABSTRACT

The use of construction cost estimation model has gained worldwide recognition as a fast and a reliable means of predicting project cost. Cost models are developed for cost estimation at different stages of the construction process and for different work sections. This study focused on the development of regression cost model for estimating the cost of concrete works at the preliminary stage of construction where designs are not complete. It also sought to identify the factors which affect the accuracy of initial cost estimates, identify the dominant methods used for project cost estimation at the initial stages of construction projects in Ghana; and find out the extent of utilization of cost models for project cost estimation in Ghana. To achieve this, questionnaires were developed and administed to 30 cost estimation consultants operating within the Accra Metropolis. These respondents were purposively selected. Historical cost data for some construction projects were also gathered. The data collected were analyzed using Statistical Package for Social Scientist (SPSS) version 16 software package. Descriptive statistics such as mean, frequencies, percentages and Relative Importance Index (RII) were used to analyzed the data. The results revealed that even though a number of cost estimating techniques are in use however, the most dominant ones are the Superficial Area method, Unit cost method and Elemental cost method. Moreover, the significant factors which affects the accuracy of initial cost estimates are adequacy and accuracy of information required to prepare the estimate, level of experience of the estimator, complexity of the design, the time available to prepare the data and the method used for the estimation. The study also found that most cost estimators lacked adequate knowledge about the use of cost models and this consequently affected the extent of its utilization in the Ghanaian construction industry. **B**ased on the historical data collected a cost model was developed. It is recommended that, the use of cost models should be encouraged as they offer a fast and reliable means of estimating pro

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 Background of the Study

The estimation is one of the key activities in the design and planning of constriction projects. Gunayin and Dogan (2004) argue that cost estimate is a major significant criteria in making decisions at the early phases of a building construction process. In explaining this, they noted that in the traditional building process which involves designing, bidding and constructing, it is vital that cost estimation is done with high level of accuracy in every period of the construction especially at the initial stages. Building owners, contractors and designers or key people involved in the process uses cost estimation for different purposes. Owners/clients want an idea about how much capital is required for the project while designers also use cost estimates to decide on the type of design that will suit the budget. Moreover, contractor depends on the estimate control the tender price. Lastly, the contractor needs more detailed and reliable cost estimate to determine the tender price. Thus, reasonable accurate estimate of the likely cost of a project have to be made as clients have to be educated ahead of time on their future monetary-related commitments and charge as the design advances. Be that as it may, building cost estimation process encompasses dreary monotonous computational and arithmetic analysis which most of the times result in error in the initial estimates of the building. Laryea (2010) in his observed that consultants cost estimates in Ghana overrun on the average by 40%. Akintoye and Fitzgerald (2000) identified insufficient time and lack of historical data on past estimates as causes of inacurate cost estimate during the design stage. It is therefore necessary for a research into the development of a cost model for easy and fast cost estimation for building project in Ghana in order to overcome cost estimation problems in early phases of the building design.

1.2 Problem Statement

According to McCaffer *et al* (1984) the initial cost estimate of a building project often carries the burden of being the cost limit for a project. The determination of initial cost is therefore necessary in providing the basis for a client to decide on whether to commence a project or not. Any lapses in the estimation which will bring about inaccurate estimates usually bring about frustrations and dissatisfaction to clients. The cost of concrete works is one of the significant cost components of projects works especially with the rising in the prices of cement and iron irons. Lamudi (2015), noted that the high cost of building materials has become a problem for the construction industry in developing countries including Ghana. This means that, Quantity Surveyor and other cost estimators must put measures in place by applying various techniques to ensure that cost estimates especially at the initial stages of a project are very accurate. That is, the estimate should be close to the actual cost of the project as far as possible. As argued by Kim *et al* (2005), there is the need to use computerized estimation models for project cost estimation due to the increasing number, size and complexity of construction projects. Hence, the aim of the current study was to develop a cost estimation model for cost analysis of concrete works at the initial stages of construction projects in Ghana.

1.3 Aim and Objectives

1.3.1 Aim

The aim of this research was to develop a cost estimation model for cost analysis of concrete works at the early stage of construction projects in Ghana.

1.3.2 Objectives

The specific objectives were:

(i) To identify the dominant methods used for project cost estimation at the initial stages of construction projects in Ghana;

(ii) To ascertain the factors that affects the accuracy of initial cost estimate;

(iii) To find out the extent of utilization of cost models for project cost estimation in Ghana; and

(iv) To develop building construction cost estimation model for the preliminary stage cost appraisal of project.

1.4 Significance of the Study

The cost based model would help in preparing cost estimates more rapidly and with less effort at the preliminary stage of construction projects in the Greater Accra Region.

1.5 Scope

The study focused on the development of a model for cost estimation for reinforced concrete skeleton frame in the early stage of construction projects. This work section is usually one of the major cost components on construction projects hence the study deemed it necessary to look at it.

1.6 Methodology

The study commenced with an extensive litereture review on cost estimation. Pertinent literature on the subject were reviewed. The source of this information was mainly through journal publications, newspaper publications, books etc. After the review, questionnire was designed to collect primary data from the study respondents. Closed and open ended questions

were used. The questionnaires were self administered among cost estimation professionals such as quantity surveyors.. Investigation into the type of cost estmation being used and the development of the model were based on the historical cost data gathered on completed projects. The information was analysed by the use Statistical Package for Social Scientis (SPSS) software package. Descriptive statistics such as mean, frequencies, percentages and Relative Importance Index (RII) were used to analyzed the data. The results were presented in the form of tables and charts. Microsoft excel was used devloping the cost estimation model. Finally recommendations

1.7. Structure of the report.

The report have five main chapters as explained below: Chapter 1 presented an introduction to the study. It covered a stament of the research problem, the aim and objctives of the study, the research scope, methodology, justification of the study and a summary of the structure of the report. Reivew of exiting technical documents and literature on the topic is presented in chapter two. Chapter three described the process and methods used in carrying out the study. Chapter four discussed the results of the study. The last chapter presented conclusion and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Shehab and Abdalla (2001) defined cost estimation generally to mean the prediction of costs associated items to a set of activities before they have actually been completed. The model for cost analysis at initial stages of a project is valuable. Mislick and Daniel (2015) in their cost

estimation method and tools book, said cost estimation is the procedure of gathering and breaking down chronicled information and applying quantitative models, methods, devices and databases keeping in mind the end goal to anticipate an evaluation without bounds. Furthermore, he explains estimating to be the utilization of the workmanship and the innovation of approximating the likely value or cost in view of data accessible at the time. The cost estimate of a project is largely influenced by the choice of selected material and the design of the building (Arafa and Alqedra, 2011). The initial cost estimate of a building project frequently conveys the weight of being limit in the cost the task hence cost estimate is one of the key benchmarks in making judgement at the initial phases of a building design procedure (McCaffer et al 1984; Gunayin and Dogan, 2004). The precision of construction cost estimate is a vital variable in the achievement of the objectives of the project. According to Ashworth (2010) poor estimating procedures is one of the key bases for project cost overuns. Cost estimation models, at the point when accessible to managers supervisors, will encourage more viable and accurate cost estimation.

2.2 Overview of building cost estimation

Yaman (2007) has demonstrated that efforts have been made since 1950 to relate the design parameters and the cost of a construction projects and also to develop models that estimates the cost of construction projects. The historical development of cost models have also revealed that, Cost model is categorized into three sets as explained below: (i) the firstgeneration models. This was used widely for cost planning approach prior to 1950's. It involved using the functional elements of a building (ii) the second-generation models. They are based on regression principles. They have been utilized from mid-1970's to date. (iii) The third-generation models which are based on Monte Calo simulaion principles (McCaffer 1975; Yaman, 2007).

The estimation cost model can likewise be categorised into two types: probabilistic and deterministic models. In determinisic models, all the variables can be evaluated precisely. Howver in the case of the probabilistic models, only few variables known with certain degree of certainty.

Yaman (2007) also grouped the cost models according to their features. The main was the traditional cost estimation models grounded on quanities, example, mono-evaluated expense estimation models utilized as a part of the schematic design stage, (for example, unit, square, 3D shape and building envlope models). He aslo identified the second model as the untraditional model. The models consisting of new methods and practices example; the experimental models, regressionn models and simulation models (Ashworth, 2010; McCaffer, et al., 1984) Arafa and Alqedra (2011) also identified many cost estimation methods and intuitive judgments through experience and cost data from past projects. They are traditional detailed cost estimation, simplified breakdown cost estimation, cost estimation per activity, cost estimation in light of cost functions, index number estimate and expert systems are some of the methods of cost estimation identified.

2.3 Cost Estimating Models

Cost model have been defined by Ji *et al*, (2010) as a nominal expression of a systems which describes the factors that have high bearing on the cost. It normally helps project consultants and contractors to give a more reliable cost advice to their clients. However, Koo *et al,* (2011) explained the purpose of a estimating cost model as that which predicts the project cost in order to arrive at an appropriate decision.

2.4 Background to cost estimation models

According to Boehm, *et al* (200) and Singh (2014) a lot of cost model emmerged in the late

1970's. These include SLIM (Putnam and Myers, 1992). Checkpoint (Jones, 1997), PRICES (Park, 1988), SEER (Jensen, 1998) and COCOMO (Boehm, 1981). Even though a lot of these analysts began extensive engagements at the advancement of cost estimation models around the same time, they all went up against with the some challenges as programming developed in size and significance. This dynamic field of programming estimation maintained the enthusiasm of these specialists who succeeded in setting the springboard for programming designing expense modes in every other field of work.

2.5 The practice of modern estimation

So much importance was attached by Ashworth and Skitmore (1982) that the crucial importance of any estimation method, is the accuracy provided during prediction of the cost estimate. Ogunsemi (2006) proposed that a difference of 10 percent between the amount of the proposed cost and the final cost is considered an excellent performance in the cost estimation. Unfortunately, we cannot say that this statement is realistic by the various recent studies on this issue, especially in developing countries. Predicting final cost of the original cost relies on upon various components affecting the construction activity between the time of year and by the end of the reference period (Chua et al, 1999; Akintoye, 2000; Morrison 2004; and Enhassi et al, 2007). Traditional methods to estimate (Wu and Cheng 2005; Lowe et al 2006) and Marzok *et al,* 2008) confirmed that it is necessary to provide more accurate estimation model for cost prediction which will be a replacement to the current approach, which addresses the need for speed, accuracy and reliability, and reduce uncertainty to the best minimum level. As such, this study examines the alternative through the development of a model by the use of cost significant work package method which is seen to have an extraordinary potential in supporting the procedure of estimating.

2.6 The Need for a Cost Estimating Model

There is the need to use computerized estimation model for project cost estimation due to the increasing number, size and complexity of construction projects (Kim, et al., 2005). At the design stage of a project, the likely cost of the project can be established using cost models. However, it is turning out to be all the more difficult to accomplish the set goals in association with building cost estimation (Ashworth, 2010). Ashworth (2010), also stated that traditional building cost estimation strategy has ended up ineffective in time, since undertakings have gotten to be bigger and refined. The traditional system of cost estimating has been substituted with computer-based systems that are simpler, saves time and more accurate. Computer based estimating models depend extensively on database from past project information for its development. The technique has significantly improved cost estimation process in the industry. In request to get a more precise building estimate, cost datasheet which will be used in estimation should always be up to date and reliable before it is used to determine a current project cost

2.7 The accuracy of project cost estimation

Akintoye and Fitzgerald (2000), Oberlender and Trost (2001) and other researchers have surveyed the accuracy of cost estimation and have observed project cost overuns in most of their surveys. Laryea (2010) in his study demonstrated that cost estimate by consultants in Ghana usuall exceeds the final cost of project by an an average of 40%. It is becoming gradually obvious that, accurately predicting the cost of an item is a typical issue which is overwhelming all commercial ventures (Ashworth, 2010). All through the development business, there are additional challenges because of the expanding size of development ventures, many-sided quality and vulnerability of the sort of work in involeved from the early phase of the project. Leader and Prasad (1995) and McCaffer, et al (1984) have also observed project cost overun in their research works. It is clear that effort and energy should be devoted

into the methods of the determination of project cost estimation especially at the initial phase of a builing project.

2.8 The selection of estimating model

Briand et al (1998) among many other researchers have identified several underlying factors for the low implementation level of model-based approaches of cost estimation. Some of these reasons include;

- Inaccuracy of the models;
- Organizations inability to store data for the development of such models; and
- Most construction companies feel uncomfortable to use model-based estimation tools they don't understand very well.

Leader and Prasad (1995) have also underscored in their survey that projects estimators used master judgment to make estimations and not very many ventures, about 14%-26% use model-based techniques for project cost estimation.

2.9 The Types of Estimating Models

In the late 1980's new approaches to cost estimation were presented in view of the considerable commitment of client experience and in light of the build research into the capability of computerized reasoning, for example, master frameworks (Perara and Watson, 1998). Cost estimation models built on user's experience is vital in that estimation involves the forecast of the probable cost of a process or item so the experience of the estimator becomes very important. Due to the above Perara and Watson (1998) has proposed a casebased reasoning techniques as a substitute to an expert technique in cost analysis.

2.9.1 Multiple Regression Model

Kim *et al* (2004) and some researchers have identified some drawbacks of the regression estimating models as:

(1) The regression model does not have any clearly defined method that helps estimators to select the cost model which suits the chronicled information to a given expense in evaluating cost;

(2) A sure sort of different mathematical equation and its information are thought to be suitable for the relapse comparisons; and

(3) The variables having effect on the estimation must be revised in advance and they are also complex when using a substantial number of data variables. On the other hand, relapse cost estimation models have been utilized for evaluating expense subsequent to the 1970s in light of the fact that they have the benefit of a best unmistakable numerical premise. Multiple regressions generally come in this format:

$$C = \beta_o + b_1 X_1 + b_2 X_2 \ldots\ldots\ldots\ldots b_n X_n$$

Where C is the aggregate estimated cost of the project (the dependent variable) and X_1; X_2… … . X_n are measures parameters which helps in assessing C. For instance X_1 can be the gross floor zone, the number of stories etc., β_o constant, and b1; b2… … .. bn are the coefficients from the regression analysis.

2.9.2 Case-based reasoning model

A case-based reasoning model solves new problems by using solutions that were used to solve old problems (Singh, 2014). CBR frameworks have been produced as of late for all areas of construction, namely architectural and/or basic outline, term and expense estimation, development process, security arranging, offer choice making, choice of strategy, and administration, and so on. The CBR methodology is like the master judgments that relies on upon on the utilization of experience to take care of issues. According to Kim, *et al* (2004) the experts solve a problem using the procedure below:

(1) Observe the key qualities depicting an issue;

(2) Identify these qualities in past comparative issues they would say; and

(3) Estimating the heading of the new issue on the premise of the comparative experience issues with mental conformity.

A CBR framework, roused by the recalling of similitudes in specialists' thinking, comprises of four sub-forms:

(1) Old cases, which speak to encounters that the framework obtained, are put away for a situation base;

(2) When another case is displayed to the framework, the CBR framework recovers one or more put away cases like the new case as per the rate comparability;

(3) Users endeavor to illuminate the new case by adjusting the recovered case(s), and the adjustment is taking into account the contrasts between the put away cases and the new case, unless the recovered old case(s) is a nearby match, and this recovered case most likely must be changed; and

(4) The new arrangement is held as a piece of the put away cases all through the test.

2.9.3 Neural Network Model

Various researchers have made use of the neural network model as a means for prediction and optimization previously. But in the area of construction cost estimation there exist only few applications. The work of Shtub *et al,* (2002) cited in Gunayin and Dogan,(2004) in the manufacturing industry comprise alternative ANN models for cost estimating. A neural network (NN) is a computer system that reenacts the learning procedure of the human mind. NNs are widely connected in numerous industrial zones, not excluding construction. The operation of NNs to development has been broadly mulled over. Also, scientists have found the utilization of NNs to enhance the precision of expense assessing past that of the relapse model (Gunayin & Dogan, 2004). Results from several analysts show that NNs are better than the relapse model for expense estimation. The quantities of inputs and yields are not confined, which is leeway of NNs. Then the quantity of shrouded layers and the quantity of concealed neurons are characterized. Significant time must be spent in deciding the quantity of these neurons, which is one of the disadvantages of NNs, in light of the fact that it obliges a couple of experimentation procedures. Hegazy et al (n.d) recommended that one shrouded layer is adequate to produce a discretionary mapping in the middle of inputs and yields as demonstrated in the figure below by Arafa and Alqedra (2011).

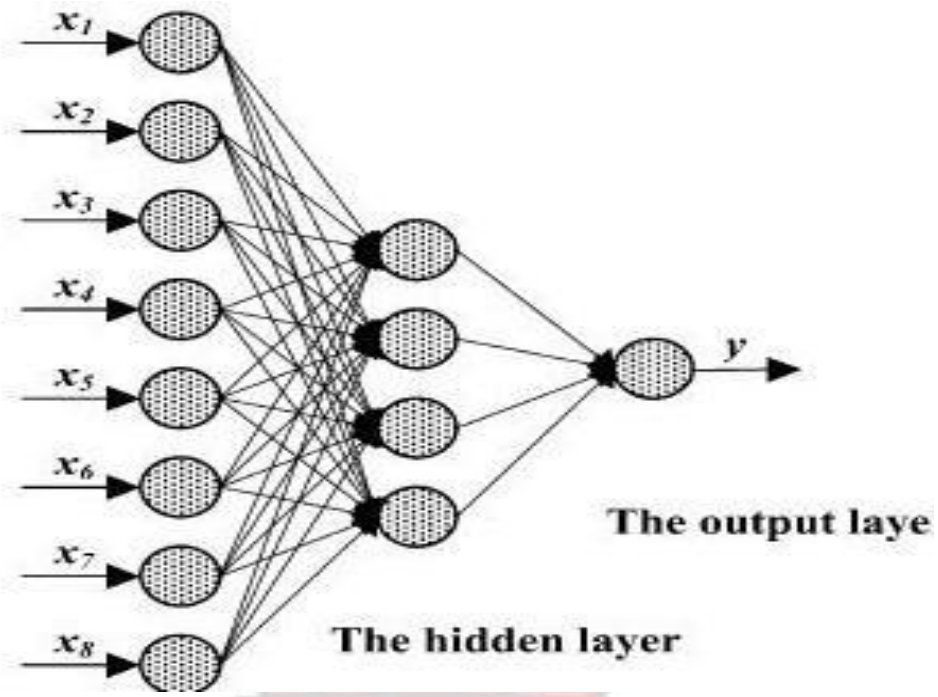

Fig 2.1: The architecture of the neural network model (Arafa and Alqedra, 2011)

2.9.4 Element-based floor-area models

The elemental method of cost estimation is a method used in calculating the total estimated cost of construction projects based on the elements of the building. It takes into consideration the major components of a building and breakdown the cost of each of them (Surveyors, 2013). A number of techniques of cost estimations have been developed by the use of past data on expenses as a component of variables normal for a construction projects. For instance the costs of a building as a function of the number of some variables for instance; area occupied by building, area of external wall and area covered by roofing. etc. (Surveyors, 1998)

2.9.5 Estimation model based on Cost Significant items

Cost significant method of estimating is by the use of historic bills of quantities from previously completed project. The cost of each element in the past project is compared to a new and a

similar proposed project. It is verifiable truth that the basic strides in the advancement of a building estimation cost model in light of cost sensitive work packages are:

- Looking out for the main cost items in the Bills of quantity (BOQ);
- sorting identical work items together to select work packages; and
- Computing the cost significant value factor (CSVF)

According to Horner and Zakieh, (1993) Cost Significant estimation usually neglect a bulk number of small work items. Vilfredo Pareto's principles hold that 80% of the effect is caused by 20 % of the causes. Pareto's principle which is widely refer to as 80:20 tenet in ordinary life allude to the way that 80% is accomplished by 20%. Relating it to construction sector, we can say 20 % of the work things add to 80 per cent of the cost of the project.

2.9.6 Estimation based on Bills of quantities

BOQ is the traditional system which is usually utilized by development organizations to figure the expense of a venture in the point by point outline stage and all through the development. BOQ frames a standout amongst the most essential piece of the delicate reports together with specialized drawings, details, states of agreement, and so on once a task is characterized in detail, each thing of work expected to finish the undertaking is recorded and evaluated by estimators (Akintoye and Fitzgerald, 2000). In the case of using the Bills of quanity to predict project cost, one may need a details drawings from which the the Bill of quantities (BOQ) are derived from. The challenge with this method of cost prediction is that the client may request for a prbable cost of the project before the detailed desing may begin.

2.10 At what time during the project phase do organizations make project cost estimate?

An exciting enquiry is to find out at what time do organizations generally prepare cost estimate? This question is good in order to help us to get understandings into the need for the usage of project cost estimation models in construction companies. According to Leader and Prasad, (1995) in connection to the above question, have found out that 77% of ventures prepares estimation amid introductory task organize, 64% projects plans cost estimation amid practicality examination arrange, 51% amid frameworks investigation, and 48% amid frameworks design.

2.11 Cost estimate

Various methods of construction cost estimating have been identified in literature. Some are different from the other in principle, while others are only different by way of terminology but their procedures are still the same (Ashworth, 2004)

2.12 Types of Cost estimates

Cost estimates can best be characterized into three noteworthy classifications as indicated by their capacities. A construction cost assessment serves one of the three fundamental capacities: design, bid and control. For building up the financing of a venture, the control assessment is utilized. Control assessment is utilized for monitoring and evaluation during the execution of the project. Edward *et al* (2010) have categorized construction estimates into the following;

2.12.1 Design Estimates.

For the customer or its assigned outline experts, the sorts of expense evaluations experienced run parallel with the arranging and configuration as takes after:

- Screening estimates (or order of magnitude estimates);
- Preliminary estimates (or conceptual estimates);
- Detailed estimates (or definitive estimates); and
- Control estimates based on plans and specifications (Badu & Owusu-Manu, 2010)

2.12.2 Bid Estimates

For the foreman, an offer appraisal submitted to the customer either for focused offering or transaction comprises of direct construction cost including field supervision, in addition to a markup to cover general overhead and benefits. The builder's offered gauges regularly mirror the yearning of the foreman to secure the employment and in addition the evaluating devices available to its. A few builders have entrenched expense evaluating methodology while others don't. Since just the least bidder will be the victor of the agreement in most offering challenges, any exertion gave to cost assessing is a misfortune to the foreman who is not a fruitful bidder. (Briand et al., 1998)

Thusly, the "ravenous" builder may put at all measure of conceivable exertion for making an expense gauge on the off chance that it trusts that its possibility of accomplishment is not high. On the off chance that a general foreman means to utilize subcontractors in the development of an office, it may request value citations for different errands to be subcontracted to forte subcontractors. In this manner, the general subcontractor will move the weight of expense evaluating to subcontractors. In the event that all or some piece of the development is to be attempted by the general builder, an offer appraisal may be arranged on the premise of the amount departures from the arrangements gave by the proprietor or on the premise of the development techniques conceived by the foreman for executing the venture.

2.12.3 Control Estimates.

As an instrument for checking the task amid construction, a control assessment is gotten from accessible data to build up:

- Budget estimate for financing;
- Budgeted cost after contracting but prior to construction; and
- Estimated cost to completion during the progress of construction.

2.12.4 Design Estimates

In the planning and design phases of a project, different configuration assessments mirror the advancement of the configuration. At the early stage, the screening gauge or request of greatness appraisal is typically assessment of development expense estimation strategy embraced (Badu and Owusu-Manu, 2010)

A preparatory appraisal or calculated assessment is in light of the theoretical outline of the office at the state when the essential innovations for the configuration are known. The point by point evaluation or authoritative assessment is made when the extent of work is unmistakably characterized and the nitty gritty outlined in advance so that the key components of the office are identifiable (Skitmore and Ng, 2003).

The engineer's appraisal is taking into account the finished arrangements and details when they are prepared for the proprietor to request offers from development foremen. In setting up these appraisals, the outline proficient will incorporate expected sums for builders' overhead and

benefits. The expenses connected with an office may be disintegrated into a progressive system of levels that are suitable with the end goal of expense estimation. The level of subtle element in breaking down the office into undertakings relies on upon the sort of expense evaluation to be arranged. For applied appraisals, for instance, the level of point of interest in characterizing errands is very coarse; for nitty gritty evaluations, the level of subtle element can be entirely fine. (Briand et al., 1998)

At the point when the definite configuration has advanced to a moment that the fundamental subtle elements are known, a nitty gritty evaluation is made on the premise of the very much characterized extent of the task. At the point when the definite arrangements and details are finished, an engineer's assessment can be made on the premise of things and amounts of work.

2.12.4 Control Estimates

Both the proprietor and the builder must receive some limit for cost control amid the construction. For the proprietor, a financial plan gauge must be embraced sufficiently early for arranging long haul financing of the office. Thusly, the detailed appraisal is frequently utilized as the monetary allowance gauge since it is adequate complete to mirror the task scope and is accessible much sooner than the engineer's evaluation (Laryea, 2010). As the work advances, the planned expense must be overhauled intermittently to mirror the evaluated expense to finish. A reexamined evaluated expense is fundamental either in light of progress requests started by the proprietor or because of sudden expense invades or reserve funds. For the foreman, the offer evaluation is typically viewed as the monetary allowance gauge, which will be utilized for control purposes and also for arranging development financing. The planned expense ought to additionally be upgraded intermittently to mirror the evaluated expense to fruition and also to safeguard sufficient money streams for the consummation of the project.

2.12.5 Bottom-up technique

Bottom-up strategy is by and large finished with work explanation and set of drawings known as working drawings. It involves calculation of project cost by breaking the cost into smaller components. The cost of equipment, labour cost and overhead expenses are determined and added to the material expense. Development venture can be pre-decided and anticipated. The evaluation is readied by separating the things of work in a methodical and sensible premise. The establishment for a fruitful appraisal depends upon solid distinguishing proof (departure) of the amounts of the different materials included in the task.

2.12.6 Parametric technique

This requires verifiable information in light of comparable frameworks or subsystems. Information is gotten from the chronicled data or is produced from building a model situation. Factual investigation is performed on the information to discover connections between cost drivers and other framework parameters, for example, design or execution parameters (Skitmore and Ng, 2003). The examination produce cost mathematical statements or expense assessing connections that can be utilized exclusively or gathered into more perplexing models. This method is helpful when the data accessible is not extremely point by point.

2.13 Methods of Estimating the initial Cost

The different routines for starting cost estimation at the preparatory stage exists. Be that as it may, the regular systems for constructing projects are the utilitarian unit strategy, the floor territory unit technique, the cubic strategy, the story fenced in area system and expense displaying.

2.13.1 The functional unit method

This technique is utilized when the estimator has enough recorded information accessible as a matter of fact on a specific sort of venture to relate some final item units to development costs. This permits an appraisal to be arranged for a comparable task when the main significant distinction between the ventures is their size. Seeley (1996) remarked that the shortcomings of this system lie in its absence of exactness, in the trouble in making remittance for an entire scope of variables, for example, the shape and size of the building, type of development, materials and finishings among others, and the low precision for the larger part of purposes. The utilization of this method is restricted to open ventures and/or to ahead of schedule phases of task definition, where next to no outline has been embraced.

2.13.2 Superficial floor area method

The system includes measuring the aggregate floor region of all stories between outside dividers without conclusions for things, for example, inside dividers, lifts and stairwells among others. By increasing the verifiable square-meter expense by the computed square meter of floor range for the proposed building, a pre-construction preparatory expense gauge for the building can be resolved. The significant shortcoming of this system lies in the failure to consider factors such as shape of the building, storey height and number of floors. Further, separate cost must be made for site work and outside administrations.

2.13.3 The cubic method

The cubic technique for assessment relates the expense of a building to its volume. Taken a toll for each cubic-meter appraisals are somewhat temperamental unless basically indistinguishable structures are thought about, as there does not exist a huge relationship between the volume of

a building and its expense. The essential shortcoming of this system is its misleading straightforwardness. It is truly a straightforward operation to ascertain the volume of a building; however the trouble lies in the joining of the few outline variables into the cubic unit-rate. This technique neglects to make remittance for arrangement shape, story tallness and number of stories, and for section separating, all of which impact cost; also, cost varieties emerging from contrasts, for example, elective establishment sorts are hard to fuse in single unit rate (Seeley, 1996).

2.13.4 The storey enclosure method

The storey enclosed system is in light of the zone of all the even and vertical planes of the building. The chief target of this technique is to devise an evaluating framework, which, albeit leaving the kind of structure and standard of finishings to be surveyed in the value rate, would consider building shape, aggregate floor range, vertical situating of floor territories in the building, story stature of structures and additional expense of sinking usable floor territory subterranean level. The system has had little application in industry in view of the volume of work included and the deficiency of distributed expense information for its application.

2.13.5 Cost Models

Cost models are numerical formulae utilized for anticipating the assessed expense of proposed development ventures (Ashworth, 1994). A model is constructed from right now accessible information and from elements identified with past execution. This data is broken down in model shape so that the patterns can be associated from which forecasts can then be made about what's to come.

2.14 Factors affecting the accuracy of cost estimates

Akinsiku et al (2011) recognized the accompanying as the variables influencing the precision of appraisals in Nigeria procedural blunders, human lapses and the unverifiable way of the venture. Procedural blunders identify with exactness in evaluating, expense included in estimating, availability and accuracy of project information. Moreover, human lapses identify with changes in configuration and fragmented data, inadvertent slips brought on by procedural oversights (counting excluding things, utilizing incorrectly measurements), judgmental blunders created by poor or wrong judgment with respect to the estimator (counting neglecting, poor valuing and not permitting wastage) and conscious mistakes created by the estimator. Unverifiable nature of the undertaking identifies with climate conditions, development delays, supervision arrangements, development systems, political and monetary varieties, changing nature of development innovation and expenses, distinction in upkeep innovation, contrasts in labor profitability and materials and gear accessibility.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter defines the procedures or methodology employed to develop the cost estimation model for a project at the early design stage. The proposed model uses the deterministic approach as discussed in the literature review to achieve the aim of the thesis. The development of the model was also carried out by the Regression modelling technique. The regression modelling is a standout amongst the most broadly utilized modelling strategy for fitting reaction (dependent) variable as an element of indicator (independent) variable.

3.2 Data Collection and Questionnaire Administration

Well-structured closed-ended questionnaires were designed, which have been vetted and piloted. These questionnaires were set in accordance to the specific objectives and the aim of the thesis. A total of thirty (30) questionnaires in all have been set and administered. The research covered the Greater Accra Region.

3.3 Sample Size

A good Thesis questionnaires is were to be distributed in such a way that the total respondents would be a fair representative of the total population. In order to achieve this, a sample size formula propounded by Kish, was used as follows:

Kish Formula (Kish, 1957) is given as:

$$n = \frac{n1}{1 + (n1/N)}$$

Where, n = sample size

N = total number of registered quantity surveying firms August 2015 is 38 (Quantity Surveyors, 20015).

Hence, N is 38. n1

$= S^2 / V^2$

V = the standard error of sampling distribution = 0.05 S = the maximum standard deviation of the population.

S = P (1-P) = 0.5 = 0.5 (1-0.5) = 0.25 35

P = the proportion of the population elements that belong to the defined class Therefore,

N = 38. n1 $= S^2/V^2 = 0.25 /$

$0.05^2 = 25$

$$n = \frac{25}{1 + (25/38)}$$

n = 15.08 ≈ 15.

Therefore, 15 quantity surveying firms were contacted.

A minimum of two (2) persons for a firm was used, thus a total of thirty-eight (30),

3.4 Data Collection and Questionnaire Administration

Well-structured closed-ended questionnaires were designed, which were vetted and piloted. These questionnaires were set in conformity with the specific objectives and the aim of the thesis. A total of thirty (30) questionnaires were set and administered. The research covers the Greater Accra Region due to the presence of most of the quantity surveying firms in the selected Region. The respondents to whom the questionnaires were administered to were Quantity surveyors of various registered Quantity surveying firms.

3.5 Data Analysis

Detailed questionnaires were prepared and answered by quantity surveying firms. The data collect was analyzed using the Statistical Package for Social Scientist (SPSS) software version 16. The data was analyzed into descriptive statistics such as frequency, percentages, means etc. The results were presented in the form of Tables and Charts. With respect to the cost estimation model, cost data from Eleven (11) completed project were used. Cost data was collated on concrete works such as tonnage of reinforcement, volume of concrete and formwork. The projects were purposively selected such that they were approximately constructed in the same time frame. Moreover profit margin charged on each project were the same. Using Microsoft excel (version 2010) linear regression analysis was used to establish the total cost of concrete works in terms floor area as follows:

$$C_w = \beta_0 + b_n X_n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3-1)}$$

Where $C_w$the total is estimated cost of the concrete works (the dependent variable) and X_n is the independent variable that may help in estimatingC_w. For example, X_1 is the measure for the gross floor. β_0 is the estimated constant, and b_1; b_2… b_n are the coefficients estimated from the regression analysis, given the availability of some relevant data.

CHAPTER FOUR

RESULT AND DISCUSSIONS

4.1 Introduction

This chapter entails the results of the study. It is organized under two main sections. The first section deals with the findings on the first three objectives i.e. the dominant methods used for project cost estimation during the initial stages of construction projects in Ghana ; factors which affect the accuracy of initial cost estimate and the extent of utilization of cost models for project cost estimation. Section two explains the development of the cost estimation model.

4.2 Section I: Initial Cost Estimation

As explained previously, a total of 30 consultants who work in Quantity Surveying/Cost Estimation Firms were purposively selected for the study. Fig 4.1 shows one of the demographic characteristics of these respondents. 46.67% of the respondents had 5-10years of working experience followed by another 30% who have worked for over ten (10) years. Only 23.23% had less than 5years of working experience. The above statistics shows that as high as 76.67% of the respondents have at least 5years of experience. As the popular saying goes "experience is the best teacher", we can draw from the above findings that the level of experience of the participants are very good enough to put them in the position to provide indepth information to aid the study.

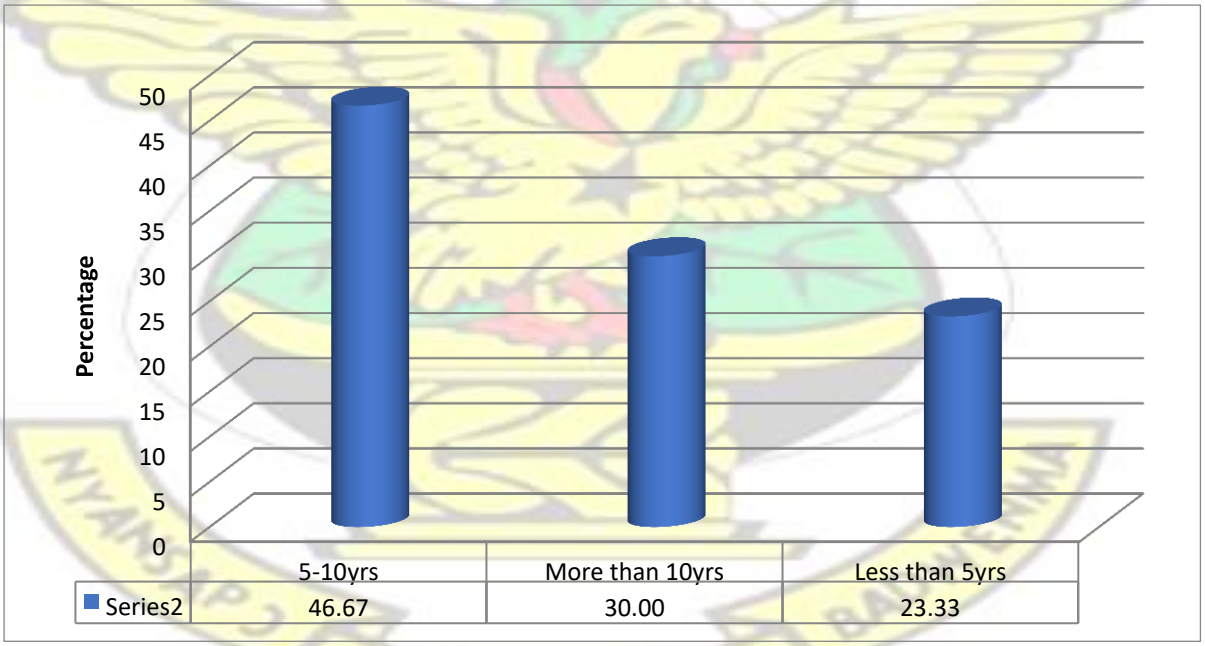

Fig 4.1: Years of working experience of respondents

4.2.1 Factors influencing the accuracy of cost estimate

As well experienced cost consultants, the respondents were asked about the general level of accuracy of initial cost estimates to the actual total cost of projects in Ghana. 63% of them indicated that the estimates are fairly accurate while 23% said it is accurate. The remaining 13% said it is near. Thus the respondents agreed that the level of accuracy of initial cost estimate to the actual cost varies and the variations are attributable to several factors. The above findings agrees with the study by Marr (1977) where he noted that most initial price estimates are fairly accurate but not very accurate. The study further observed that this becomes a sources of worry to clients who usually really on the estimate to take decision on whether to start a project or not. Ashworth (1994) also asserted that an early value estimate which is too high may dishearten a customer from continuing further with a project. Alternatively, if this is too low, it may bring about an unsuccessful design, disappointment with respect to the customer and shoddy works.

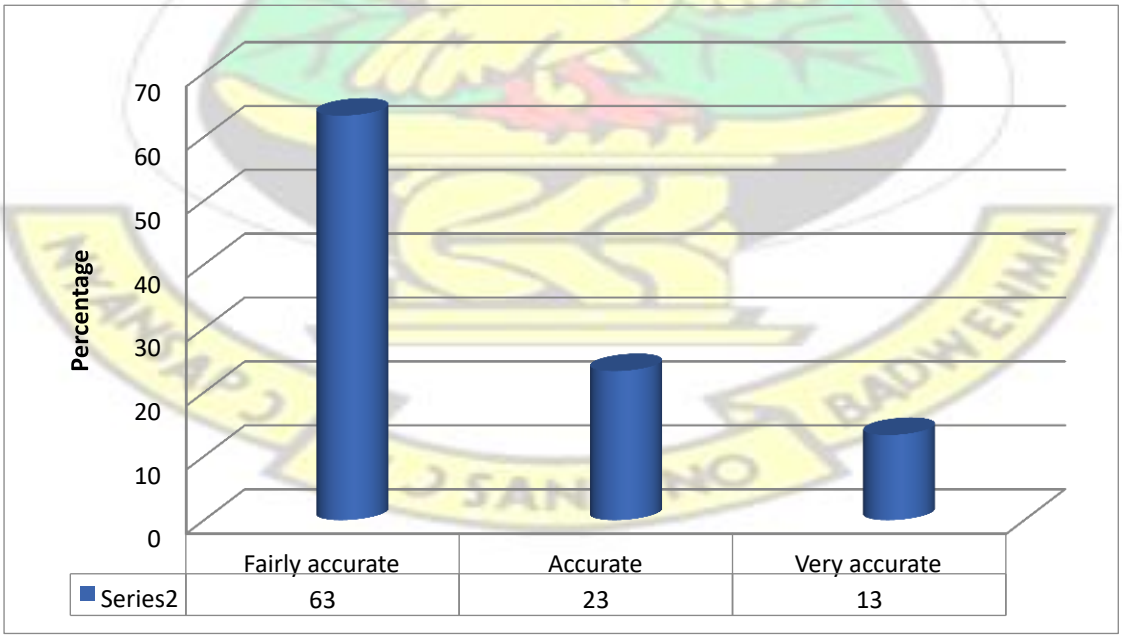

Fig 4.2: Respondents' assessment of the level of accuracy of initial estimates

To further delve into the issues, the study solicited from the respondents the factors which affect the level of accuracy of initial cost estimates. Six (6) factors were gathered from literature (Akinsiku *et al*, 2011), from which the respondents were solicited to demonstrate the level of significance of each of the factors in influencing cost estimates. The responses were analyzed using Relative Importance Index (RII) as shown on Table 4.1. From the results, the respondents expressed high level of agreement with Akinsiku. They indicated that all the factors listed on Table 4.1 affect the accuracy of cost estimate. However, in the order of importance the factors were ranked as follows: Adequacy and accuracy of information required to prepare the estimate (1st), Level of experience of the estimator (2nd), Complexity of the design (3rd); the time available to prepare the data (4th), Method used for the estimation (5th) and changes in design (6th). The factors were explained as follows:

(i) Adequacy and accuracy of information required to prepare the estimate

Preparation of preliminary cost estimate is usually based on the client's brief and historical cost data available to the estimator. The information or data provided should be adequate to assist the estimator come out with a reliable estimate. Moreover, the data should be accurate.

(ii) Level of experience of the estimator

Akinsiku *et al*, (2011) noted that, judgemental errors created by poor or wrong judgment with respect to the estimator (counting neglecting, poor evaluating and not permitting wastage) and purposeful slips in cost estimates are usually due to the inexperience of the estimator. In the

current study, the respondents strongly agreed with Akinsiku by indicating that, the level of experience of an estimator plays a significant role in the accuracy of cost estimates. This factor was rated 2nd with high RII value of 0.933.

(iii) Complexity of the design

The respondents explained that where the design of a project is complex it makes cost estimate difficult. There is the tendency for some elements to be omitted.

(iv) The time available to prepare the data

Cost estimation usually required some period of time to collect enough data for the estimation. However, if the period is short the estimator will be in a rush to carry on the work resulting in inaccuracies. The above finding agrees with Ashworth (1994).

(v) Method used for the estimation

Various methods exist for initial cost estimation of construction project. Each of them has its limitation and hence the estimator should know when to use a particular method. The choice of the wrong method for a particular project will result in inaccurate estimate.

Table 4.1: Ranking of the Factors affecting the accuracy of initial cost estimates

Factors	Rating							
	1	2	3	Total	∑W	Mean	RII	Rank

(i)	Adequacy and accuracy of information required to prepare the estimate	0	4	26	30	86	2.8667	0.9556	1st
(ii)	Level of experience of the estimator	0	6	24	30	84	2.8000	0.9333	2nd
(iii)	Complexity of the design	1	5	24	30	83	2.7667	0.9222	3rd
(iv)	The time available to prepare the data	1	6	23	30	82	2.7333	0.9111	4th
(v)	Method used for the estimation	2	6	22	30	80	2.6667	0.8889	5th
(vi)	changes in design	3	9	18	30	75	2.5000	0.8333	6th

Source: Author's Field data, 2015

4.2.2 Methods for preparing initial cost estimates

Several methods/techniques exist for the estimation of project cost at the preliminary stages of construction project where designs are not complete. The current study sought to find out from the respondents the most dominant method used in the Ghanaian construction industry. The methods were ranked based on their frequency of being used as shown on Table 4.2. The results revealed that three methods are frequently used. They are Superficial Area method (1st), Unit cost method and Elemental cost method. To the respondents, the techniques above are very easy to use. The superficial floor area method for occurrence includes measuring the aggregate floor range of all stories between outside dividers without findings for things, for example, inward dividers, lifts and stairwells among others. By reproducing the verifiable square-meter expense by the computed square meter of floor territory for the proposed building, a pre-development preparatory expense gauge for the building can be resolved. The unit cost system

likewise utilizes verifiable information accessible as a matter of fact on a specific sort of task to relate some final item units to development costs. This permits an assessment to be arranged for a comparative undertaking when the main significant

distinction between the tasks is their size.

Techniques such as Storey enclosure method, Cubic method, and Cost model were found to be hardly in use. Seeley (1996) noted that Cost-per-cubic-metre estimates are somewhat temperamental unless for all intents and purposes indistinguishable structures are looked at, as there does not exist a critical relationship between the volume of a building and its expense. Besides, another essential shortcoming of this system is its misleading effortlessness. It is truly a straightforward operation to figure the volume of a building, yet the trouble lies in the fuse of the few outline components into the cubic unit-rate. This strategy neglects to make recompense for arrangement shape, story stature and number of stories, and for section dividing, all of which impact cost; in addition, cost varieties emerging from contrasts, for example, elective establishment sorts are hard to fuse in single unit rate. With respect to the storey enclosure method, the respondent agreed with Seeley (1990) by explaining that the system has had little application in industry due to the volume of work included and the lack of distributed cost information for its application. Finally, for cost models majority of the respondents lacked knowledge about them and thus resulted in their low level of utilization in the construction industry.

Table 4.2: Ranking of the methods used for preliminary cost estimate in Ghana

	Methods	**Rating**							
		1	2	3	Total	∑W	Mean	RII	Rank

(i)	Superficial Area method	2	8	20	30	78	2.6000	0.8667	1st
(ii)	Unit cost method	5	8	17	30	72	2.4000	0.8000	2nd
(iii)	Elemental cost	6	10	14	30	68	2.2667	0.7556	3rd
(iv)	Storey enclosure	17	12	1	30	44	1.4667	0.4889	4th
(v)	Cost model	20	10	0	30	40	1.3333	0.4444	5th
(vi)	Cubic method	23	6	1	30	38	1.2667	0.4222	6th

Source: Author's Field data, 2015

Finally, the study also drew from the respondents the type of cost models they are familiar with. The results shown in Table 4.3 shows that the extent of utilization of cost models in the Ghanaian construction industry is very low. All the commonly used cost models globally were found to be less in use in the local industry. All the models had low RII values. The findings above confirms the report by Briand *et al* (1998) who noted that the implementation rate of model-based methods of cost estimation is very low. The study attributed this to reasons such as (i) Inaccuracy of the models (ii) inability of organizations to store data for the development of models and (iii) Most construction companies feel uncomfortable to use model-based estimation tools they don't understand very well etc. The reasons above sound logic however, in the modern computer age, the use of models offer a quip and reliable means of estimating project cost. As well-defined mathematical expressions, they are easy to use.

Table 4.3: Ranking of the level of knowledge and usage of some cost models by the

respondents

Rating

	Cost models	1	2	3	Total	∑W	Mean	RII	Rank
(i)	Element-Based floor Area Model	14	16	0	30	46	1.5333	0.5111	1st
(ii)	Multiple Regression Models	18	12	0	30	42	1.4000	0.4667	2nd
(iii)	Estimation model based on cost significant item	22	8	0	30	38	1.2667	0.4222	3rd
(iv)	Cost-Based Reasoning model	26	4	0	30	34	1.1333	0.3778	4th

4.3 Development of the Cost Estimation Model

The current model is regression based model. The choice of this is influenced by the fact that regression cost models have the benefit of a clear mathematical basis. Moreover, it is easy to use (Kim, et al., 2004). The analysis of data and the making of models was done utilizing excel. The clarification of created models is as follows:

The developed model for concrete works is of the following form:

$$C_w = \beta_0 + b_1 X_1 + b_2 X_2 + \cdots + b_n X_n \quad \text{..... (3-1)}$$

Where; C_w is the total estimated cost (the dependent variable)

X_1; X_2….. X_n Are the independent variables that may help in estimating C_w. The variable considered in this study was gross floor area since this is the information which is usually available at the initial stages. The total cost of the concrete works (C_w) which included the cost of reinforcement, formwork and concrete for each project was collated (See Appendix B).

This figure was analyzed against the floor area of each building. Using the data analysis tool pack in Microsoft excel (version 2010) regression analysis was used to help establish the relationship between the two variable as shown below:

$$C_w = \_ 0.0544x^2 + 693.22x - 67416$$

From Fig 4.3, it can be deduced that as the floor area increases, total cost also increases. This observation clearly reflects the general situation encountered.

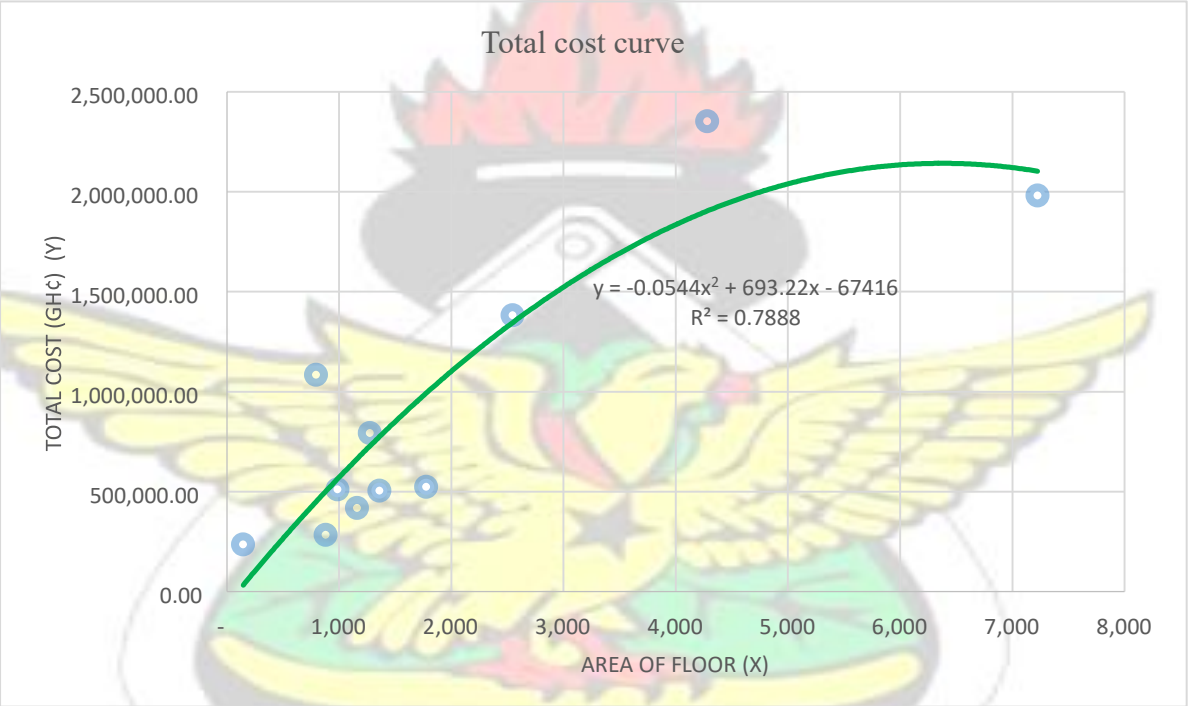

Fig 4.3: Relationship between Total cost and Floor area

4.4 Summary

In this chapter various issues regarding cost estimation at the initial stages of construction project have been discussed. It included discussions on the factors which affect the accuracy of initial cost estimates and identification of the dominant techniques used for initial cost estimates. Moreover, the level of knowledge and the extent of utilization of cost estimation models by consultants in the Ghanaian construction industry were solicited. Finally, regression

based cost estimation model was developed for concrete works. The main finding gathered from this chapter is presented in the subsequent chapter together with conclusions and recommendations.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Summary of findings and Conclusion

This present research was aimed at the development of a computer based regression cost estimation model for cost estimation at the preliminary stage of construction projects. Among its objectives were to identify the factors which affects the accuracy of initial cost estimates; To identify the dominant methods used for project cost estimation at the initial stages of construction projects in Ghana and to find out the extent of utilization of cost models for project cost estimation in Ghana. Consequently questionnaires were developed and administed to 30 cost estimation consultants. Historical cost data for 11 construction projects were also gathered. The data collected were analyzed. From the results, the following are the main and findings and conclusions drawn from the study:

Objective 1: To identify the dominant methods used for project cost estimation at the initial stages of construction projects in Ghana

(i) The study found that even though a number of techniques are in use however, the most dominant ones are the Superficial Area method, Unit cost method and Elemental cost method. According to the respondents, these methods are easy to use hence their extensive application in the construction industry.

(ii) On the other hands methods such as Storey enclosure method, Cubic method, and Cost model were found to be hardly in use. For the Cost-per-cubic-metre estimates, the respondents explained that they are problematic unless for all intents and purposes indistinguishable structures are thought about, as there does not exist a noteworthy relationship between the volume of a building and its cost. Moreover, the method does not take into consideration the shape of the building, storey height and the number of stories. With respect to the storey enclosure method, the respondent explained that the strategy has little application in the development business as a result of the volume of work included and the deficiency of distributed expense information for its application. Finally majority of the respondents lacked knowledge about cost models.

Objective 2: To identify the factors which affects the accuracy of initial cost estimates The study found the following are the key factors:

- Adequacy and accuracy of information required to prepare the estimate (1st);
- Level of experience of the estimator (2nd);
- Complexity of the design (3rd);
- the time available to prepare the data (4th);
- Method used for the estimation (5th); and
- Changes in design (6th).

Objective 3: To find out the extent of utilization of cost models for project cost estimation in Ghana.

(i) The study found that most of the consultants (cost estimators) lacked knowledge about the use of cost models and this consequently affected the extent of its utilization in the Ghanaian construction industry.

Objective 4: Development of a computer based regression cost estimation model for cost estimation at the preliminary stage of construction projects

(i) Based on the historical data collected, cost model was developed.

5.2: Recommendations

The study found that the level of knowledge of cost consultants (cost estimators) about the use of cost models is very low and this consequently affected the extent of its utilization in the Ghanaian construction industry. It is recommended that, in the modern computer age, the use of models offer a fast and reliable means of estimating project cost. As well-defined mathematical expressions, they are easy to use hence professionals in the industry should make an effort to upgrade their knowledge in that area.

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APPINDICES

QUESTIONNAIRS

KWAMNE NKRUMAH UNIVESITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF BUILDING TECHNOLOGY

Questionnaires to Practicing Consultants

"Development of Cost Estimation model for cost analysis at the initial stages of Construction Projects in Ghana"

Dear Respondent,

I am Michael Alorgli, a Master of Science in Construction Management student of the Kwame Nkrumah University of Science and Technology undertaking a thesis work which is a requirement for graduating from the MSc. programme of the university.

This questionnaire contains a series of questions regarding the subject of my thesis: "*Development of Computer-based model for cost estimation of Building Construction works in Ghana"*. This have to do with cost estimation of construction project at the early stage of the design where drawings and bills of quantities are yet to be provided.

The questionnaire consists of an array of questions ranging from ranking and checklists, and will take no longer than 30 minutes to complete. I understand that some of the information being asked might be found personal or intrusive. I assure you that any information acquired from this survey will be utilized with strict anonymity and confidentiality, and will be used only for the purposes of the research.

I hope for your full participation and responses that reflect your true opinion. For closedended questions, please tick [√] the most appropriate option that reflects your opinion.

Thank you.

Research Student: Michael Alorgli

Tel: 0243389508 / 0200113315

Please select by ticking (√) the most suitable to the question

1. How long have you been practicing this profession?

   (a) Less than 5 years (b) 5 -10 years (c) More than 10 years

2. From your experience how accurate are initial cost estimates in Ghana

   (a) Very accurate (b) Fairly accurate (c) Accurate

3. What in your opinion are the factors which affect the accuracy of initial cost estimates of a project? Use the scale below 1 = Not significant 2 = significant 3 = Very significant

S/n	Factors	1	2	3
i	Adequacy and accuracy of information required to prepare the estimate			
ii	The time available to prepare the estimate			
iii	Method used for the estimation			
iv	Level of experience of the estimator			
v	Complexity of the design			
vi	Changes in design			

4. Which of the following methods do you normally used for cost estimation during the early design stage? Use the scale where 1 = Not often 2 = often 3 = very often

S/n	Cost estimation technique	1	2	3
i	Unit cost method			
ii	Elemental cost			
iii	Superficial Area method			
iv	Cubic method			
v	Storey enclosure			
vi	Cost model			

5. Please rank your level of knowledge with the following types of computer based cost estimation models. Use the scale below: 1 = Not at all 2 = fair 3 = High 4 = Very high

S/n	Type of Model	1	2	3	4
i	Cost-Based Reasoning model				
ii	Multiple Regression Models				
iii	Neural Network Models				
iv	Element-Based floor Area Model				
v	Estimation model based on cost significant item				

Thank you.

PART TWO

Model development

Please you are required to give detailed information on one of the building types which have been constructed by you.

1. Type of building

.Commercial building 2. Industrial building ☐ 3. Institutional buildings ☐

2. Short Description of the Project including project title. ……

……

……

3a) Structural framing type 1. Steel Frame ☐ 2. Wood frame ☐ 2 Reinforced conc.

b).Building height (m) ……..

c). Average floor to floor height (m) …….

d). Number of Floors (including ground floor)……

e). Construction area in (m^2) ……

f). Number of Basement floors …….

4). Enter the following details for only Structural frame of the project (superstructure)

ELEMENT	UNIT	QUANTITY
(i) Ground floor slab	m^2	…….
(ii) Upper floor slabs (1sr, 2nd .etc..)	m^2	…….
(iii)Covering Wall Area	m^2	…….
(iv) Roof area	m^2	…….
(v) Floor height	m	……...
(vi) Volume of Reinforced concrete (superstructure)	m^3	…….
(vii) Tonnage of reinforcement	ton.	……..

(5) give a brief description of types and details about the following;

(i) Ground floor slab (thickness, strength etc) ……

……

(ii) Upper floors …….

(iii)Wall/ Cladding …….

(iv)Roof type and details ……

(v) Reinforcement …….

Thank you.

APPENDIX B

Table 1: Project information used to develop cost model

S/N	Project Title	Total Floor Area (m^2)	Formwork Area (m^2)	Volume of Conc. (m^3)	Quantity of Reinforcement (ton)	Total cost (Gh¢)
1	Construction of 3-Storey 18unit classroom block at O'reilly Senior High	1,776	2,685	339	47.2	523,529.46
2	Construction of 4-Storey Lecture theater for University of Ghana (City Campus)	2548	6,105	813	142.28	1,381,613.1

3	Construction of Administration block at College of Health Sciences - Legon	795	9,181	3115	225.77	1,082,848.7
4	Construction of 2-Storey food Court and Business Center	880	1,546	161	27.18	282,360.50
5	Construction of 2-Storey administration block for GRA	1360	2,363	254	55.53	503,081.21
6	Construction of graduate block for PHD Students phase I for University of Ghana	146	1,430	152	19.26	234,689.63

Table 1: Project information used to develop cost model continued

S/N	**Project Title**	Total Floor Area (m^2)	Formwork Area (m^2)	Formwor k Area (m^2)	Quantity of Reinforcement (ton)	Total cost (Gh¢)
7	Construction of 4-Storey administration block for University of Ghana - Legon (city campus)	988	2,558	325	47.12	510,227.07
8	Construction of 2-Storey Dormitory Block for 22 no students at Krobo Girls	1160	2,506	284.25	32.78	416,602.97

9	Construction of 4-Storey lecture Hall for Sunyani Polytechnic	4280	10,040	1708	207.16	2,350,647.9
10	Construction of 2-Storey Lecture Hall for Ho-poly	1274	2,352	513	85.54	791,218.81
11	Construction of Regional Study Centre for Continue Education for University of Cape Coast - Wa	7224	10,370	1248	180.70	1,980,094.8

Table 2: Rate built-up for Concrete

ITEM	DESCRIPTION	CONSTANT (A) (including Waste)	UNIT	BASIC PRICE (B)	A X B	SUM (A X B)
				¢	¢	¢
	Concrete 1:2:4-20mm aggregate reinforced in columns, beams, floor slab, foundations/m3					
	Materials					
	Ordinary Portland Cement	6.88	bag	32.00	220.16	
	Rough Sand	0.5	m3	40.00	20.00	
	20mm aggregate (Machine Crushed)	0.99	m3	60.00	59.40	299.56
	Labour					
	Mason Foreman -1	0.49	hr	8.69	4.26	
	Mason -3	1.469	hr	8.69	12.77	
	Mixer operator -2	0.98	hr	8.69	8.52	

	Dumper operator	0.50	hr	8.69	4.35	
	Labourer - 21	10.286	hr	5.39	55.41	85.31
	Plant					
	Concrete Mixer (10/7)	0.49	hr	31.25	15.31	
	Dumper (0.45m3 capacity)	0.5	hr	43.75	21.88	
	Wheel barrow (0.45m3 cap)	0.5	hr	1.88	0.94	
	Vibrator	0.44	hr	15.00	6.60	44.73
	Overheads & Profit	30	%		429.59	128.88
	RATE/M3					**558.47**

Table 3: Rate built up for Reinforcement

ITEM	DESCRIPTION	CONSTANT (A) (including Waste)	UNIT	BASIC PRICE (B) ¢	A X B ¢	SUM (A X B) ¢
	REINFORCEMENT					
	12mm Diameter mild Steel Bar					
	Reinforcement in floor, roof and landing (and wall) bent to shape, including all necessary tying-wire and spacers / Kg					
	Materials					
	12mm diameter m.s. bar	52.5	kg	2.80	147.00	
	Annealed tying-wire	0.53	kg	5.67	3.00	

	Spacers 1% of (a+b above)	1	%	150.00	1.50	151.50
	Labour					
	Steel bender/fixer	1.60	hr	7.54	12.07	
	Mixer operator		hr		-	
	Dumper operator		hr		-	
	Labourer	3.88	hr	5.39	20.90	32.97
	Plant					
	Concrete Mixer(10/7)		hr		-	
	Dumper		hr		-	
	Vibrator		hr		-	-
	Overheads & Profit	30	%		184.47	55.34
	RATE/Kg					**4.80**

Table 4: Rate built up for Formwork

ITEM	DESCRIPTION	CONSTANT (A) (including Waste)	UNIT	BASIC PRICE (B) ¢	A X B ¢	SUM (A X B) ¢
	Sawn Formwork to Suspended Floor, roof and landing /m2 (not exceeding 3.50metres high)					
	Materials					
	40mm Wawa boarding	1.12	m2	14.00	15.68	
	50mm x 100mm Props and Joists	0.06	m3	733.33	44.00	
	For 3 re-uses				59.68	19.89

	Nails	0.25	kg	4.17	1.04	
	Mould oil	0.05	litre	7.78	0.39	1.43
	Labour					
	1 Carpenter	0.74	hr	7.54	5.58	
	Dumper operator		hr		-	
	1 Labourer	0.74	hr	5.39	3.99	9.57
	Plant					
	Concrete Mixer(10/7)		hr		-	
	Dumper		hr		-	
	Vibrator		hr		-	-
	Overheads & Profit	30	%		30.89	9.27
	RATE/m2					**40.16**