KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

C0LLEGE OF ARCHITECTURE AND PLANNING

USING BROMILOW'S MODEL AND OTHER REGRESSION MODEL TO PREDICT THE DURATION OF FEEDER ROAD PROJECTS IN GHANA

By

TAWIAH, MOSES BSc. (Hons)

A Dissertation Submitted to the Department of Building Technology,

Kwame Nkrumah University of Science and Technology Kumasi,

In Partial fulfillment of the requirements for the Degree of Master of Science in

Construction Management

NOVEMBER, 2014

DECLARATION

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

Tawiah Moses (PG 9112513) …………………… …………..………………

(Student) Signature Date

Certified by:

Prof. Edward Badu …………………… …………..………………

(Supervisor) Signature Date

Certified by:

Prof. Joshua Ayarkwa …………………… …………..………………

(Head of Department) Signature Date

ACKNOWLEDGEMENT

My deepest appreciation goes to the Almighty God who has made me who I am today. He is truly the Alpha and Omega and this thesis is a testimony of this attribute of God.

I wish to express my profound gratitude to my supervisors; Dr. Kwame Ofori Kuragu and Prof. Edward Badu who did not only team up to provide the guidance and constructive criticism required for the work but encouraged me at every stage of this research. I cannot forget the concern and support of my mother Martha Akuah and husband Samuel Tawiah for their encouragement and support throughout the period of study.

I am very grateful to the Operation Manager 2 in Kumasi, Mr. Amoako K. Boateng and the Operation Manager 1 in Sunyani, Mr. Alhassan Mohammed of the Department of Feeder Roads for their valuable contribution to this work. I cannot forget of their enormous assistance during the collection of the data from the Department of Feeder Roads in both Ashanti and Brong Ahafo regions in Ghana. The assistance of other senior quantity surveyors and engineers during data collection at Department is also acknowledged.

I appreciate the continual concern and support of my caring and God fearing wife, Margaret Yeboah and my boys Samuel Asamoah and Moses Adjei. They provided the home logistic for the success of the work.

Finally, I wish to thank my employer, the Department of Feeder Roads for granting me permission and support throughout the program of study.

DEDICATION

This work is dedicated to the glory of God and for the benefit of mankind.

ABSTRACT

Contract duration is the period from the commencement date to its scheduled expiration date. This duration could be determined using a scientific model when the cost of the project is available. The study sought to develop a model for predicting the duration of feeder road construction projects in Ghana. A case study involving COCOBOD and donor funded completed road projects of Department of Feeder Roads under the Ministry of Roads and Highways in Ashanti and Brong Ahafo regions in Ghana was used. The projects used for the study were extracted from the progress reports in the Department Data Base (Secondary Source). Using sample size of similar study (Kaka and Price, 1991), seventy projects extracted. Views of the Quantity Surveyors and the Engineers were also collected through interview survey.

The data was analysed using the ANOVA (Analysis of Variance) for both the linear and curve estimation regression models.

The result showed that Bromilow's time cost (BTC) model is applicable to the Department of Feeder Road (DFR) projects and is of the form $T = 64C^{0.134}$. The curve estimation regression models provided a much more useful equation for predicting duration for Department of Feeder Road (DFR) projects. The model, using the logarithm equation was found to be most appropriate and is of the form $T = -269.950 + 50.138\mathrm{Ln}C$. This provides an alternative for the BTC model for DFR projects. The developed models identified in this research serve as convenient and useful tools for quantity surveyors, engineers, project managers and contractors with the Ministry of Roads and Highways to predict the reasonable time required for the delivery of a feeder road construction projects in Ghana. The models provide a basis for these professionals to estimate the duration of projects to supplement the current practice based on individual's experience. The study has shown the models to be

useful in predicting duration of feeder road projects. Future work may incorporate other factors and explore the sensitivities of these factors to the duration of projects.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

BTC	Bromilow's Time - Cost
COCOBOD	Cocoa Board Division
DFR	Department of Feeder Roads
GDP	Gross Domestic Product
MRH	Ministry of Roads and Highway

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The Ghanaian construction industry plays an important role in the nation's economy. (Ministry of Finance 2009). According to Ogunsemi 2002, the contribution of the construction industry to national economic growth necessitates improved efficiency by means of cost effectiveness and timeliness. Similarly, Anaman and Osei – Amponsah (2007) contend that the Ghanaian construction industry is currently the third largest sector of the economy and therefore special attention should be given to this industry. They conducted a study to analyse the causality links between the growth in the construction industry and the growth in the macro-economy of Ghana, measured by the gross domestic product (GDP), to ascertain whether the construction industry can be used to lead the entire economy on a growth path. They concluded that the construction industry needs to be considered as one of the major drivers of economic growth in Ghana.

The industry has experienced an economic growth of 8.2% in 2006 to 14% in 2008 (Ministry of Finance 2009). In 2004 and 2005, the industry contributed 8.79% of the gross domestic product (GDP) with the average contribution being 8.78% between the periods of 2003 to 2005 (Government of Ghana 2005). The Government of Ghana plays a very important role in providing major infrastructure such as roads in meeting the socio-economic needs of the nation, and uplifting the quality of life and standard of living in the country. (Government of Ghana 2005). The Ghanaian roads and transport sector is, without doubt, seen as one of the key sectors critical to the successful implementation of programmes in achieving middle - income status (Ministry of Roads and Highways and Ghana Statistical Service 2008). As a result the sector takes a substantial part of government expenditure. (Ministry of Roads and Highways and Ghana Statistical Service 2008). A report by the Ministry of Roads and Highways and Ghana Statistical Service (2008) indicates that the government has consistently increased its contribution to maintenance of road works since 2004. The report indicates that, there was a 39% increase in government expenditure on road maintenance in 2007 compared to 2006. Development partners also tripled their expenditure on road maintenance from US$25.04 million in 2006 to US$77.65 million in 2007 (Ministry of Roads and Highways and Ghana Statistical Service 2008).

It is therefore important that road projects are completed on time to avoid any increases in cost for the limited budgets allocated. To prevent these increases, timely completion of road projects is essential. This is because late completion of projects increases the cost of the works (Aibinu and Jagboro 2002). According to Lim and Mohamed (1999), clients, users, stakeholders and the general public usually look at project success from the macro point of view of early completion.

1.2 PROBLEM STATEMENT

Attempts have been made to predict construction duration as it represents a problem of continual concern to both researchers and project managers (Ireland 1985, Nkado 1995, Ogunsemi 2002, Ogunsemi and Jagboro 2006, Hoffman et al 2007). Cost is a major predictor of project time (Bromilow et al 1980, Ireland 1985, Yeong 1994 and Walker 1994). Chan (1999) provided insight into the Bromilow's model and further studies carried out by other researchers were in the same direction such as Ng et al (2001) for Australia, Choudhury and Rajan (2003) for the United States of America (USA), Ojo (2001) and Ogunsemi and Jagboro (2006) for Nigeria, Kaka and Price (1991) for England, Skitmore and Ng (2003) amongst many others. Ghana has however seen very little research in the formulation of time – cost relationship for prediction of construction time for its industry, despite the huge amounts allocated to this industry and the road sector is no exception. The Government of Ghana and other stakeholders for road projects are increasingly becoming uncomfortable at seeing projects being completed after longer duration. This research therefore attempts to formulate a mathematical relationship between time and cost based on Bromilow's time – cost model which will be suitable for predicting the duration of feeder road projects in Ghana.

1.3 AIM OF THE STUDY

The aim of the study was to use a scientific model to predict the duration of feeder road projects in Ghana.

1.4 OBJECTIVES

The specific objectives for this research are:

(i) To formulate mathematical relationships between time and cost using Bromilow's Time –Cost (BTC) model and other Regression models for feeder road projects in Ghana; and

(ii) To identify which of the formulae derived could be used to predict the duration of feeder road projects in Ghana by validating the models that have been derived.

1.5 RESEARCH QUESTTIONS

(i) What is Bromilow's Time –Cost (BTC) model concept?

(ii) Can Bromilow's Time –Cost (BTC) model be used to predict the contract duration for feeder road projects in Ghana?

(iii) Is there any regression form of model that can be used to predict the contract duration for feeder road projects in Ghana?

1.6 HYPOTHESIS

Null hypothesis H_0: There is no significant difference between the observed (actual) and predicted values of duration.

Alternative hypothesis H_1: There is significant difference between the observed (actual) and predicted values of duration.

1.7 SCOPE OF STUDY

The research focused mainly on completed road projects funded by COCOBOD and partner institutions being supervised by Department of Feeder Roads. The study covered road projects completed from 2011 to 2012 in two regions, Ashanti and Brong Ahafo where most of the COCOBOD and donor funded projects are located. The type of interventions included are spot improvement, rehabilitation and surfacing. Routine maintenance projects were not considered in this study since the contract values were relatively low.

1.8 RESEARCH METHODOLOGY

This study reviewed the relevant literature and past findings of other researchers on the subject of this study. Emphasis was placed on time – cost relationships. Data for completed cocoa and donor funded road projects between the periods 2011 and 2012 was obtained from the Department of Feeder Roads (DFR) under the Ministry of Roads and Highways in Ashanti and Brong Ahafo regions. The progress reports for these two regions on the above mentioned road projects were collected from the regional offices. The reports contained the name of the project, the proposed start and completion dates, actual completion dates, contract sums and actual amounts certified on completion. In fact soft as well as hard copies of the progress reports were collected. Thirty-five (35) completed projects were extracted from progress report from each region, giving a total of 70 projects which were used for the study. A discussion was held with the regional engineers and regional quantity surveyors of these two regions about the kind of data needed for the study. In fact Kaliba et al (2008) carried out a study on schedule (time) delays for road construction projects in Zambia and found out that delay in payment is a major factor affecting duration of road projects. This finding reinforces that of Frimpong et al (2003) who conducted a research in Ghana for groundwater projects and concluded that payment difficulties by agencies were ranked first by both contractors and consultants.

Delay in payment is one of the factors which make it difficult for contractors to complete projects on time in Ghana. A report by the Ministry of Roads and Highways and Ghana Statistical Service (2008) indicated that the Ministry needs to address the issue of delay in payments. The COCOBOD and donor funded projects do not experience such delays in payments, therefore to reduce or eliminate this factor from the developed model, only projects funded by the COCOBOD, International Development Association (IDA) [Road Sector Development Programme] and Kfw (Kreditanstalt fur Wiederaufbau) were used in formulating the model. Apart from the issue of delayed payments, road contractors in Ghana often manage COCOBOD and donor funded projects more effectively than the GOG funded projects. This is because bonuses are given for early completion of the project. Unlike the GOG funded projects, liquidated and ascertained damages, are deducted from payments of the COCOBOD and donor funded projects in Ghana and so contractors tend to manage COCOBOD and donor funded projects better to ensure early completion. The model that was developed from these projects therefore served as a convenient tool for predicting duration of road projects. The linear and curve estimation regression models from the statistical package for social sciences (SPSS) were employed in the derivation of the models.

1.9 SIGNIFICANCE OF THE STUDY

The study developed a model for predicting the duration of feeder road projects in Ghana. The researcher aimed at developing a model which will be convenient and useful tool for quantity surveyors, engineers, project managers and contractors to predict the reasonable time required for the delivery of feeder road projects in Ghana.

The model provided a basis for these professionals to estimate the duration of projects to supplement the current practice based on individual experience.

1.10 ORGANISATION OF THE DISSERTATION

Chapter 1 provided an introduction to the area of research and background of the problem of study. It also highlights the aim and objectives of the study and provided a brief overview of the approached employed in achieving the research objectives. The literature review in Chapter 2 presented and discussed past findings and experience of previous researchers in the areas related to this present study such as the development of time – cost models and some of the factors affecting duration of construction projects.

Chapter 3 presented the research methodology employed for the analysis whilst Chapter 4 also presented the data that was collected for analysis, the formulation of the models and discussion of the results. Finally chapter 5 summarized the findings, draw the conclusions and give recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter briefly discusses time and cost as two factors for project success and reviews previous studies carried out on time – cost models around the world. The models formulated by researchers using the BTC model and other regression models were looked at whiles studies on factors affecting construction duration were also mentioned and briefly, the roles and types of interventions carried out by the Department of Feeder Roads in Ghana.

2.2 TIME AND COST

Time and cost are the two main concerns in construction projects (Burns et al, 1996). Contractors usually use previous experience to estimate the project duration of a new project (Choudhury and Rajan, 2003). Construction time is usually deduced from the client's brief or derived by the construction planner from project information such as design drawings, bill of quantities, method statements, specification, bar charts or network analysis (Chan and Chan 2004). According to Ogunsemi and Jagboro (2006), construction time has most often than not been seen to be one of the benchmarks for assessing the performance of a construction project and the efficiency of project organization. Thomas et al (1995) found out that one goal of the client and contractor is timely completion of a construction project since each party tends to incur additional cost and loose potential revenues when the project is delayed. Delays in projects increase contractor's cost (resource replanning and construction changes, overhead costs and other time-related costs) thereby reducing the contractor's profit margin and reputation (Bromilow and Henderson, 1976); and incur clients in additional holding charges, professional fees and income lost through late occupancy

(Ng et al, 2001). A project is said to be successful if it is completed on time, within budget and to the level of quality standard specified by the client at the beginning of the project (Frimpong et al 2003, Shr and Chen 2006 and Lock 2007). Ogunsemi and Jagboro (2006) realized that, of these three factors for project success, time and cost tend to be the most important. These two (2) factors, according to them, are considered to be critical because of their direct economic implications if they are unnecessarily exceeded. Cost has been found to be the most significant predictor of project time in Australian projects (Walker 1994 and Yeong 1994). In view of this, researchers have developed a relationship between the two variables and the next section reviews past studies on this subject.

2.3 PREVIOUS STUDIES ON TIME - COST RELATIONSHIP BASED ON BROMILOW'S MODEL

Since 1969, various models have been developed to predict duration of construction projects based on the cost of the project. Bromilow was the first researcher to establish a relationship between time and cost in Australia. In a survey of 370 building projects in Australia, Bromilow (1974) produced a model, which predicted construction duration $T = KC^B$ where T is the duration of the construction period from date of site possession to practical completion, in working days, C is the final cost of building, K is a constant describing the general level of time performance and B is a constant describing how the time performance is affected by project size, as measured by cost. He finally summarised his model as $T=313\ C^{0.3}$. This model indicates that one factor (project scope) as measured by cost determines the duration of construction projects. He further made use of mathematical models to show the relationship between cost and time, variation and pre-construction time. He also analysed overruns on time and cost, which provided a measure of the accuracy of the industry's time and cost prediction. In fact, Bromilow (1969) also found that the construction time for building does not depend "very strongly" on the type of building or its location.

In 1980, Bromilow et al (1980) further analysed 419 projects between the periods 1970-1976 to determine whether the model still holds. After using the Datana programme to perform the necessary analysis, they concluded that the model $T=KC^B$ still holds for the Australian situation. After the development of Bromilow's time cost (BTC) model, other researchers such as Ireland (1985), Kaka and Price (1991), Yeong (1994), Kumaraswamy and Chan (1995), Chan (1999, 2001), Ojo (2001), Choudhury and Rajan (2003), Love et al (2005), Ogunsemi and Jagboro (2006) and Hoffman et al (2007) around the world also carried out similar studies based on his model.

A similar research was undertaken by Ireland (1985) to predict the construction time of high rise commercial properties in Australia. From analysis of 25 high–rise buildings, he concluded that the best predictor of average construction time of high rise commercial buildings based on cost in millions which have been indexed to June 1979 was $T = 219\ C^{0.47}$ for R2 = 0.58 where R2 is the coefficient of determination.

Kaka and Price (1991) also conducted a similar research on buildings and road projects in the United Kingdom. They considered two different samples. Sample 1 consisted of 661 building projects with total value exceeding £695 million while sample 2 was made up of 140 road projects with a total value exceeding £120 million. They produced a similar relationship after adjusting the contract values to 1988 prices using the adjustment formula and tender price index available in the building cost information service manual. They obtained the following relationships for the UK situation: For Government building projects, $T = 486C^{0.205}$ for R = 0.68.

For private building projects, $T = 491.2C^{0.082}$ for $R = 0.61$. For road construction projects, $T = 436.3C^{0.437}$ for $R = 0.97$ where R is the coefficient of correlation. Kaka and Price (1991) also tested the influence of the type of client (public or private), type of tender, and the form of tender. Through their study, they arrived at the following conclusions: (i) the type of bid competition did not affect the reliability of the BTC model; (ii) the type of client (public or private) does influence the time-cost relationship with public building works generally taking longer than private works; (iii) the type of project affected the relationship considerably with civil engineering works taking less time to complete than buildings of the same value; and (iv) the form of the contract significantly influenced the time-cost relationship with adjusted price contracts being the largest (in dollars) and longest (in working days).

A study carried out by Yeong (1994) in Australia confirmed Bromilow's time cost model. 67 Australian public projects, 20 Australian private projects and 51 Malaysian public projects were analyzed. At the 0.00 level of significance, Yeong came up with the following models: For the Australian private projects, $T = 161C^{0.367}$. For the Australian public projects, $T = 287C^{0.237.}$ For Australian private and public (all) projects, $T = 518C^{0.352}$.

Kumaraswamy and Chan (1995) surveyed a combination of building and civil engineering projects and confirmed that the time – cost relationship for both types of project can be modelled in the form of $T = KC^{B}$. In a survey of 111 projects in Hong Kong, they obtained the K and B values for building and civil engineering projects which are shown in tables 2.1 and 2.2 respectively. The correlation coefficients showing a relationship between the two variables are also shown.

Table 2.1: Time- cost performance of Government building projects in Hong Kong.

Type of building	Estimated			Actual		
	K	B	R	K	B	R
Total building projects	182.3	0.277	0.81	216.3	0.253	0.79
Public (government) housing	188.8	0.262	0.77	178.8	0.279	0.70
Public (government) buildings	166.4	0.294	0.78	207.1	0.266	0.76

Source: Kumaraswamy and Chan (1995)

Table 2.2: Time- cost performance of Government civil engineering projects in Hong Kong

Type of civil works	Estimated			Actual		
	K	B	R	K	B	R
Total civil projects	252.5	0.213	0.80	291.4	0.205	0.78
Road works	233.1	0.248	0.89	301.4	0.215	0.80
Other civil projects	270.6	0.190	0.71	272.3	0.211	0.77

Source: Kumaraswamy and Chan (1995)

Kumaraswamy and Chan (1995) suggested the inclusion of other project characteristic macro variables such as construction cost, gross floor area, number of storeys and micro factors affecting productivity as well as other significant factors that may influence project duration.

To validate Bromilow's time-cost model (BTC), Chan (1999) carried out studies in Hong Kong using 110 building projects between 1980s and 1990s.Using the regression analysis of the SPSS package, the values of K and B were obtained at the 0.00000 level of significance. For the public and private situations, Chan (1999) obtained the following regression models: For all public projects, $T = 166C^{0.28}$ for R = 0.954 and $R^2 = 0.911$. For private projects, $T = 120C^{0.34}$ for R = 0.854 and

$R^2 = 0.715$. For all private and public projects, $T = 152C^{0.29}$ for R = 0.922 and R^2 =0.846 where R^2 is the coefficient of determination.

In 2001, Chan further confirmed the BTC model by surveying 51 public projects in Malaysia. His main aim was to identify whether the BTC model could be extended to the building projects for the Malaysian situation. With the aid of SPSS package, a regression analysis was carried out and the values of B and K determined. After adjusting the contract values to December 1992 prices using the building cost index, Chan confirmed the BTC model as $T = 269C^{0.32}$ for $R = 0.638$ and $R^2 = 0.407$.

The first study carried out in Africa on the BTC model was by Ojo (2001) in Nigeria. She carried out a survey in south western part of Nigeria and arrived at a similar relationship, $T = 27C^{0.125}$. The coefficients of correlation (R) and determination (R^2) for this model are 0.431 and 0.186 respectively. She attributed the low value of R^2 and for that matter poor performance of the BTC model in Nigeria to the unstable economic climate. Ogunsemi (2002) also attributed the poor performance of the BTC model in Nigeria to price fluctuation which he identified as the most prominent cause of cost overrun of construction projects in South-Western Nigeria.

Because the model formulated by Ojo (2001) had low predictive ability ($R^2 = 0.186$), Ogunsemi (2002), Ogunsemi and Jagboro (2006) also carried out studies in the same part of Nigeria as Ojo. After a survey of 87 building projects, their models based on the BTC are as follows: For private projects, $T = 55C^{0.312}$ for $R = 0.567$ and $R^2 = 0.322$. For public projects, $T=69C^{0.255}$ for $R = 0.443$ and $R^2 = 0.196$. For all projects, $T = 63C^{0.262}$ for $R = 0.453$ and $R^2 = 0.205$ .The above models were obtained after the cost data were adjusted to 2000 prices. Based on the coefficient of determination, Ogunsemi and Jagboro (2006) indicated that for all the projects, 20.5% of the variance in construction duration is explained by the project scope expressed in terms of the estimated final cost of construction. This according to them means that 79.5% of the variance in construction is explained by other variables that are not included in the model. They therefore indicated that the BTC model is not applicable to the Nigerian situation. They however developed another model using the piecewise linear model with breakeven point. The following models for the three categories were obtained as: For private projects, $T = 168.895 + 0.491C$ ($C \leq 557$) or $709.66 + 0.884C$ ($C > 557$). For public projects, $T = 98.01 + 0.357C$ ($C \leq 353$) or $567.967 + 0.283C$ ($C > 353$). For all projects, $T = 118.563 - 0.401C$ ($C \leq 408$) or $603.427 + 0.61C$ ($C > 408$).The coefficient of determination (R^2) for the private, public and all projects were 77.62%, 83.06% and 76.56% respectively. They therefore indicated that these models have high predictive abilities than the BTC model for the Nigerian situation.

In the city of the United States, Texas, Choudhury and Rajan (2003) carried out a study to validate the BTC model. In a survey of 55 residential buildings in Texas, Choudhury and Rajan (2003) confirmed the BTC model as $T = 18.96C^{0.39}$ for $R^2 = 0.745$ at the 0.000 level of significance. They found the predictive efficacy of this model to be quite high as the coefficient of determination (R^2) indicates.

Whereas other researchers (Bromilow et al 1980, Ireland 1985, Walker 1994 and Yeong 1994) opined that cost is the most significant predictor of project time in Australian projects, Love et al (2005) postulated that cost is a poor predictor of project time. They therefore suggested that, the Gross Floor Area (GFA) and the number of floors are better determinants of project time. In a survey of 161 construction projects in Australia, Love et al 2005 came up with the following model by including gross floor area (GFA) and number of floors. $\text{Log}(T) = 3.178 + 0.274 \log(\text{GFA}) + 0.142 \log(\text{floor})$. They indicated that Gross Floor Area and the number of floor levels are known before a project commences and so project managers and other professionals can use the above model to predict project time before it starts.

A more recent study on the BTC model was carried out by Hoffman et al (2007). Data were collected for 856 facility projects completed between the period of 1988 and 2004. The data were analyzed using the BTC model and multiple linear regression. Applying the BTC model, they came up with $T = 26.8C^{0.202}$. They indicated that majority of the variability was not explained by the model since $R^2 = 0.337$. They therefore attempted to explain the larger portions of this variability by considering other factors.

2.4 PREVIOUS STUDIES ON OTHER FORMS OF TIME –COST RELATIONSHIP

Other researchers have also developed models for predicting time duration of construction project based on other regression models other than the BTC model.

In the UK, Burrow et al (2005) carried out studies on predicting building construction duration. They collected the actual duration and cost of 1,500 projects completed between 1998 and 2002 from the Building Cost Information Service (BCIS) for analysis. Their finding showed a clear and significant relationship between total cost and duration. After adjusting the cost to 2nd quarter 2003 using the BCIS tender price index, they obtained the following model: $y = 23.3x - 97.855$ where y is construction duration in weeks and x is the cost.

Shr and Chen (2006) developed a time - cost relationship for highway projects in Florida. They explored the functional relationship between highway construction cost and time. Data from 21 projects of the Florida Department of Transportation (FDOT) in the US was utilized to develop and illustrate the quantifying model. They used nine different forms of regression models to analyse the data. They eventually found out that the quadratic and cubic regression models were suitable.

For the quadratic model: $T = 0.032 + 0.105C + 0.466\ C^2$ where C is the actual cost of the project and T is the project duration. For the cubic model, $T = 0.033 + 0.147C + 0.688C^2 + 0.283C^3$. The coefficient of determination (R^2) for both the quadratic and cubic regression models were 0.751 and 0.753 respectively indicating that 75% of the variability in the data is explained by these models.

In a survey of 132 reconstruction projects in Nantou County, Taiwan, Chen and Huang (2006) developed a similar relationship for predicting duration of projects. Using both cost and floor area, they investigated nine different regression models to identify the best format for their study. The analysed data categorised into central agency, local government and private sector yielded the following models: For central agency, the cubic model was found to be the best, $T = 131 + 0.018*A – (1.085E – 6)*A^2 + (3.675E – 11)*A^3$, where A = floor area in m^2 and T is duration in days. For both local government and private sector, the power regression model was found to be most suitable. Local government: $T = 42.280*A^{0.1966}$ and for the private sector,

$T = 18.085*C^{0.1942}$ where C is cost in dollars.

2.5 OTHER FACTORS INFLUENCING CONSTRUCTION DURATION

There are other factors affecting project duration apart from cost and there have been studies on some of these factors worldwide. Walker (1995) identified four (4) factors affecting time performance as construction management effectiveness, the sophistication of the client, the client's representative in terms of creating and maintaining positive project team relationship with the construction management and design team and the design team effectiveness in communicating with construction management and client's representative. His research indicated that construction management team performance plays a pivotal role in determining construction time performance. His study also revealed an important relationship between client's representative management effectiveness and good construction time performance.

Out of 33 specific factors, Nkado (1995) identified ten most significant factors affecting project duration in the UK. Some of these factors include client's specific sequence of completion, project complexity, location and availability of construction management team.

Chan (1998) categorised the factors affecting construction duration into project scope, project complexity, project environment and management attributes. He indicated that the factors under the project scope includes construction cost, building type, gross floor area, number of storeys, contract procurement and variations. The project complexity, according to him comprised of client's attributes, site conditions, buildability of project design and quality management. Under project environment, the factors were physical, economic, socio-political and industrial relations. The principal factors under management attributes include client/design team management, construction team management, communication management, productivity and organisational structures.

Chan and Kumaraswamy (2002) findings indicated that 'communication management' variables which is categorised under management attributes, have a significant influence on the duration of a project. For road projects, Jiang and Wu (2007) opined that construction duration of a highway project depends on many factors, such as type of project, project size, weather conditions, project location, manpower, equipment and construction management.

According to Chan and Kumaraswamy (2002), factors responsible for project delays can be regarded as adverse manifestations of general factors that affect construction duration. They indicated that a study of the delay factors could help identify many of the significant factors influencing project duration. It is therefore important to briefly review some of the factors affecting delays.

Out of 26 factors, Frimpong et al (2003) showed that monthly payment difficulties from agencies, poor contractor management, material procurement and escalation of material prices are major factors affecting project delays in ground water projects in Ghana. The problem of delay in monthly payment identified by Frimpong et al (2003) is confirmed by a report by the Ministry of Roads and Highways and Ghana Statistical Service (2008) which indicated that the Ministry needs to address this issue of delay in payments.

Kaliba et al (2008) carried out a study on cost escalation and schedule delays of road construction projects in Zambia. His findings showed that delayed payments, poor coordination on site, changes in drawing, materials procurement, changes in specifications and equipment unavailability are some of the factors leading to schedule (time) delays in road projects in Zambia. In Jordan, Sweis et al (2008), identified that financial difficulties faced by the contractor and too many change orders by the client are the leading causes (factors) of construction delay in the Jordanian construction industry.

2.6 ROLES AND TYPE OF INTERVENTIONS OF THE DEPARTMENT OF FEEDER ROADS IN GHANA

Before briefly explaining the type of interventions that are being used by the Department of Feeder Roads, it would be necessary to mention the roles played by this Department in road sector in Ghana.

2.6.1 Roles of Department of Feeder Road

The Department of Feeder Roads is one of the three agencies responsible for construction of roads in Ghana. The two other agencies are the Ghana Highway Authority and the Department of Urban Roads. The Department of Feeder Roads is responsible for the construction of rural roads providing access to rural communities and centers of socio-economic activities such as markets and health facilities.

2.6.2 Type of interventions

There are various type of interventions carried out on roads by the Department of Feeder Roads in Ghana and this section briefly explains the interventions adopted by this agency.

They include spot improvement, rehabilitation, re-gravelling, surfacing and upgrading.

(i) Spot Improvement

This involves site clearance, construction of culverts at low lying areas, filling and compacting the filled approaches. The entire length of the road is formed to camber with side earth drains. Sometimes sub –base material (gravels) are placed to strengthen the weak spots on some sections of the road. (Ministry of Roads and Highways and Ghana Statistical Service 2008).

(ii) Rehabilitation

The activities stated under spot improvement are also carried out under rehabilitation with the essential difference being the addition of gravelling (sub –base material) throughout the entire length of the road and not sections of it. (Ministry of Roads and Highways and Ghana Statistical Service 2008).

(iii) Re-gravelling

Roads occasionally lose their existing gravel over a period of time as a result of traffic volume and other likely factors. When the loss gravels (sub –base) are replaced, the term used is re-gravelling. It is worth mentioning that during the process of re-gravelling, other activities could be included if need be, to make the road attain its fully engineered status. (Ministry of Roads and Highways and Ghana Statistical Service 2008).

(iv) Surfacing/Upgrading

This involves improving the existing gravel surface of the road by tarring. Upgrading which is normally used by Highways and Urban roads involves improving the existing gravel surface of a road to bitumen or from bituminous-treated surface to asphaltic - concrete (Ministry of Roads and Highways and Ghana Statistical Service 2008).

2.7 CRITICAL APPRAISAL OF LITERATURE REVIEW

This chapter has reviewed studies on time – cost models for the construction industry worldwide as well as some factors affecting the duration of projects. After the development of the BTC model, other researchers have validated or improved upon the model. Bromilow et al (1980) showed that a relationship exists between construction duration and final cost of a project. This relationship and the form of the BTC model was also confirmed by Ireland (1985), Kaka and Price (1991), Yeong (1994), Kumaraswamy and Chan (1995), Chan (1999, 2001), Ojo (2001), Ogunsemi and Jagboro (2006), Choudhury and Rajan (2003), Love et al (2005) and Hoffman et al (2007) in Australia, UK, Hong Kong, Malaysia, Nigeria and USA. It can be seen from the literature review that project scope (in terms of cost) is a major parameter in predicting the duration of construction projects as virtually all the researchers included it in their formulated models. This is evident from table 2.3 below which has been adapted from Chan (1998).

Table 2.3: Summary of some statistical models for predicting project duration.

Proposer(s)	Year	Country	Main parameters included in the model.			
			Project scope	**Project complexity**	**Project environment**	**Management attributes**
Bromilow et al	1980	Australia	*			
Ireland	1985	Australia	*			*
Kaka and Price	1991	UK	*			
Nkado	1992	UK	*	*		
Walker	1994	Australia	*	*		*
Yeong	1994	Australia	*			
		Malaysia	*			
Blyth	1995	UK	*	*		*
Chan and Kumaraswamy	1995	Hong Kong	*			
Chan	1996	Hong Kong	*			
Khosrowshahi and Kaka	1996	UK	*	*		
Mackenzie	1996	UK	*	*	*	*
Chan and Kumaraswamy	1999	Hong Kong	*	*	*	*
Mackenzie et al	1999	UK	*	*	*	*
Walker and Vines	2000	Australia	*	*	*	*
Chan	2001		*			
Ng et al	2001		*			
Yousef and Baccarini	2001		*			

Source: Adapted from Chan (1998).

Despite the wide success of the BTC model, Ojo (2001), Ogunsemi and Jagboro (2006) results showed that the predictive ability of the model was low for the Nigerian situation (R^2 = 0.186 and 0.205 respectively). The low predictive ability was also evident with Hoffman et al (2007) whose coefficient of determination was 0.337. This means that only 33.7% of the variance in construction is explained by the model.

The implication of this is that 66.3% of the variance in construction duration is explained by other variables that are not included in the model.

In addition, the BTC model developed by Chan (2001) for the Malaysian situation had a coefficient of determination of 0.407. Although he indicated that the model holds well for the Malaysian building industry, the predictive ability which is determined by the coefficient of determination (R^2) as opined by Choudhury and Rajan (2003), and Montgomery et al (2006) , was not as high as that of Chan (1999) and Choudhury and Rajan (2003), who obtained R^2 values of 0.846 and 0.745 respectively. In effect the developed model by Chan (2001) explains only 40.7% of the variance of building construction in terms of cost leaving 59.3% unaccounted for by the model. This study would however develop models to explain much of the variability in road construction.

Furthermore it can be seen from the literature review that previous studies of the BTC model concentrated on the building industry with only Kaka and Price (1991), Kumaraswamy and Chan (1995) applying the BTC model to roads in the UK and Hong Kong respectively. A thorough search for materials on time - cost model for the road sector, produces very little results, implying that the sector has not seen much study in this regard.

According to Walker (1994), project complexity was not significantly correlated with the time performance of building projects. It therefore suffices to say that the complexity of a project would not have a significant effect on the duration of a project. This is because the larger and more complex a project is; the higher would be its costs (Chan and Chan 2004). According to Chan and Chan (2004), the cost could suggest a sense of scope, magnitude, buildability and complexity. This reinforces the findings of Jiang and Wu (2007) who indicated that construction costs are related directly to the magnitude and complexity of construction projects. Kaka and Price (1991) noted that time actually taken to construct a project of a given value did not depend very strongly on its location.

This study would therefore consider project scope (in terms of cost) as the main criterion for predicting duration of road projects since almost all the researchers acknowledged project scope as a major parameter (see table 2.3) for prediction of duration. In fact Jiang and Wu (2007) found that the total construction costs could be used as a reasonable common basis for construction duration comparisons for highway projects.

It is evident from the literature review that most of the researchers developed time – cost models based on the BTC model rather than exploring other regression forms. This study explored other forms of regression models with the aim of selecting one with a high predictive ability. The BTC model was also applied to determine whether it could be extended to the road sector in Ghana. In the next chapter, the research methodology employed in achieving the objectives and testing the hypothesis is presented.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Having carried out a thorough literature review of previous studies relating to the subject matter, it is intended in this chapter to consider an appropriate methodology for this study which can be used to achieve the specific objectives. The study uses a quantitative analysis to achieve the aim of this research. The aim was to develop scientific model for predicting duration of feeder road projects in Ghana. This chapter discusses the sampling population, data collection procedure and method of data analysis.

3.2 RESEARCH STRATEGY

The research strategies used in conducting the various research parameters are; case studies, surveys and experiments. However, experiments would not be an appropriate choice because they are carried out usually in a laboratory setting where the investigator can manipulate behaviour directly, precisely and systematically (Yin, 2003). Thus, in view of the nature of investigation associated with this research, experiment was discounted as an appropriate option. In surveys, samples are examined through questionnaires while case studies involve an empirical enquiry that investigates a contemporary occurrence within a real life context (Yin, 2003).

The case study research method is highly suited to bringing us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through previous research (Soy, 1997). Case studies emphasize detailed contextual analysis of a limited number of events or conditions and their relationships. Researchers have used the case study research method for many years across a variety of disciplines. Social scientists, in particular, have made wide use of these qualitative and quantitative research methods to examine contemporary real-life situations and provide the basis for the application of ideas and extension of methods.

The case study research method has been found to be an ideal methodology when a holistic, in-depth investigation is needed. There have been various investigations about the concept of case studies, particularly in sociological studies. It has also been noticeable increase in the construction field. Researchers such as (Yin, 2003; Gerring, 2006) and others who have investigated the concept of methodology have also proposed procedures that can be followed by researchers as well-developed and tested as any in the scientific field. The richness of the data to be collected may, however, limit the number of cases that can be studied. The selection is often based on their representativeness of cases (Fellows and Liu, 2003; Bryman 2004). Case studies, on the other hand, are designed to reveal the details of the experience and opinions of the participants by using multiple sources of data (George, 2005; Seidman, 2005; Gerring, 2006; Hancock, 2006). Two case studies were used in this research, namely: Ashanti region and Brong Ahafo region of Ghana.

3.3 RESEARCH APPROACH

According to Jean (1992) qualitative research is "….a form of social interaction in which the researcher converses with, and learns about the phenomenon being studied". In qualitative research, different knowledge claims, enquiry strategies, and data collection methods and analysis are employed (Creswell, 2003). Qualitative data sources include observation and participant observation (fieldwork), case studies, interviews and questionnaires, documents and texts, and the researcher's impressions and reactions (Bryman, 2004). Data is derived from direct observation of behaviours, from interviews, from written opinions, or from public documents (Sprinthall *et al.*, 1991). Written descriptions of people, events, opinions, attitudes and environments, or combinations of these can also be sources of data. Again, qualitative research examines the patterns of meaning which emerge from the data and these are often presented in the participants own words (Denzin and Lincoln, 1994). The goal of qualitative research is to discover patterns, which emerge after close observation, careful documentation, and thoughtful analysis of the research topic (Patton, 1987, 1990).

Drawing from the above literature, this study adopted a qualitative approach. The views from the Quantity Surveyors and Engineers were collected via an interview survey.

3.4 SAMPLING POPULATION

There are three agencies responsible for road construction projects under the Ministry of Roads and Highways in Ghana. These agencies included Ghana Highway Authority (GHA), Department of Feeder Roads (DFR) and the Department of Urban Roads (DUR). The target population for this study was DFR. Road construction projects (COCOBOD and other donor funded projects) that had already been completed in the Ashanti and Brong Ahafo regions in Ghana formed the basis for data collection.

3.4.1 Sample Size Determination

The number of cases in a case study goes beyond sampling logic and typical criteria regarding sample size are irrelevant (Yin 2003). The decision should rather be based on the number of case replications and is a discretionary matter. The selection should be guided by the number of replications that will provide you with an appropriate level of certainty. Two or three replications are, therefore, reasonable within such conditions. This research therefore selected two cases to reflect the reasonable replications put forward by Yin (2003).

3.5 DATA COLLECTION PROCEDURE

The regional offices of the two selected regions, Ashanti and Brong Ahafo are located in Kumasi and Sunyani respectively. These offices have data base in the form of progress reports of all the completed and on-going projects in the region. They are prepared by the Engineers and the Quantity Surveyors, who are in charge of the total network in their respective regions. The data required on the progress reports was obtained both electronically and in the form of hard copies from the Engineers and the Quantity Surveyors. The data can therefore be said to be reliable and can contribute immensely to the results of this research.

The reports that were collected covered projects completed between the periods 2011 and 2012 in the two selected regions. These had all the required data needed for the analysis. This time frame has been selected because it was within this period that most of the COCOBOD and the other donor funded projects were executed and experienced 100% completion.

All the costs that were used for the study were adjusted to January 2014 prices using monthly cost indices for January 2014 and the various base months for each programme using the price adjustment formula (see equation 1) from the Ministry of Roads and Highways. This took care of the fact that the cost data that was collected was based on different points in time and possibly different economic conditions and the effect of inflation was eliminated (Aibinu and Jagboro 2002, Burrows et al 2005).

The progress reports that were collected contained the following information; name of the project, the proposed start and completion dates, actual completion dates, contract sums and actual amounts certified on completion. Specifically the actual completion dates and actual amounts paid on completion were extracted from the reports and were used for the analysis in order to achieve the objectives of this research.

Specifically, 70 COCOBOD and other donor funded projects were deduced from the reports that were collected in the two regions. Only projects having the required information were selected. Out of the 70 projects that were selected, 35 representing 50% of the sample was taken from each region.

Table 3.1: Number of projects from the two regions.

Region	**No. of projects**	**% of sample**
Ashanti	35	50
Brong Ahafo	35	50
Total	**70**	**100**

Source: DFR – Ashanti and Brong Ahafo Regions Progress Reports (June 2014)

The two regions have almost the same total length of road network. From the Ministry of Roads and Highways and Ghana Statistical Service (2013) report, the total portfolio of roads in Ghana stood at 64,323km at the end of 2012. Out of these, 25% are trunk roads (GHA), 60% are feeder roads (DFR) and 15% are urban roads (DUR). Out of the 60% that are feeder roads, 15% and 13% are for Ashanti and Brong Ahafo regions respectively. [Ministry of Roads and Highways and Ghana Statistical Service 2013].

The number of projects selected for each of the regions can be seen in table 3.1 and the type of projects that were selected for the study for each region is also shown in table 3.2. Table 3.3 shows the various projects under the various funding from the two regions. This is to ensure that the formulated models represent a true picture of feeder road projects as a whole.

Table 3.2: Type of projects.

Intervention type	No. of projects	% of sample
ASHANTI REGION		
Spot Improvement	13	18.5
Rehabilitation	15	21.5
Surfacing	7	10
Sub total	**35**	**50**
BRONG AHAFO REGION		
Spot Improvement	19	27
Rehabilitation	12	17
Surfacing	4	6
Sub total	**35**	**50**
Grand Total	**70**	**100**

Source: DFR – Ashanti and Brong Ahafo Regions Progress Reports (June 2014)

Table 3.3: Various projects under various funding from the two regions.

Funding	Type of Intervention	Number of Project		Total Projects	% of sample
		Ashanti	Brong Ahafo		
CFRIP	Surfacing	7	4	11	15.7
CFRIP	Spot Improvement	13	19	32	45.7
IDA	Rehabilitation	9	9	18	25.7
Kfw	Rehabilitation	6	3	9	12.9
Total		**35**	**35**	**70**	**100**

Source: DFR – Ashanti and Brong Ahafo Regions Progress Reports (June 2014)

3.6 METHOD OF DATA ANALYSIS

Appropriate method of data analysis was very necessary to be able to accurately process the data that was collected. The simple linear regression adopted by Kaka and Price (1991), Yeong (1994), Kumaraswamy and Chan (1995), Chan (1999, 2001), Ojo (2001), Choudhury and Rajan (2003), Love et al (2005), Ogunsemi and Jagboro (2006) and Hoffman et al (2007) was used in formulating the BTC model. The regression curve estimation employed by Shr and Chen (2006), Chen and Huang (2006) was also used in developing the other forms of regression models for predictive purpose.

3.6.1 Regression models

Regression analysis is a technique that finds a formula or mathematical model which best describes a set of data collected (Ashworth, 1986). The simple linear regression models quantify the relationship between two variables. The variants of regression models that were used for this study included the following:

(a) Simple linear models

This is represented by the mathematical formula

$Y = a_0 + a_1X + e$ ---1

Where Y is the dependent variable

X is the independent variable, a_0 and a_1 are constants called regression parameters and e is the error term.

(b) Regression curve estimation

The curve estimation procedure produces curve estimation regression statistics and related plots for nine (9) different curve estimation regression models with a separate model being produced for each dependent variable. The various equation forms of regression models are shown in table 3.4.

Table 3.4: Equation forms of Regression models (Standard Equations)

No	Name of model	Regression model
1	Logarithmic	$T = b_0 + b_1 \ln C$
2	Inverse	$T = b_0 + b_1/C$
3	Quadratic	$T = b_0 + b_1C + b_2C^2$
4	Cubic	$T = b_0 + b_1C + b_2C^2 + b_3C^3$
5	Compound	$T = b_0b_1^C$
6	Power	$T = b_0C^{b1}$
7	S- curve	$T = \exp(b_0 + b_1/C)$
8	Growth	$T = \exp(b_0 + b_1C)$
9	Exponential	$T = b_0e^{b1C}$

Source: Shr and Chen (2006)

C denotes the independent variable; T denotes the dependent variable, and b_0, b_1, b_2, b_3 denote constants. The above regression models are standard equation forms (basic) for the various models.

3.6.1.1 Assessment of models

To choose the best out of the models generated in this study, the following assessment criteria were used.

(a) Correlation Coefficient (R)

This was the measure of the association between a dependent variable and independent variable (Ogunsemi 2002). It is an acceptable measure of the reliability of a regression equation. The coefficient ranges between zero and one ($0 \le R \le 1$).

b) Coefficient of Determination (R^2)

This was a measure of the proportion of variation in the dependent variable that is explained by the behaviour of the independent variable (Ogunsemi 2002 and Hoffman et al 2007).

The formula for calculating R^2 is

$$R^2 = \frac{\text{Regression sum of squares}}{\text{Total sum of squares}} \quad \text{-------------------------------------2}$$

The values also range between zero and one ($0 \le R^2 \le 1$). A high value of R^2 indicates a good model. R^2 gives an indication of the predictive capability of the regression model using new observations [Choudhury and Rajan (2003), Ogunsemi and Jagboro (2006), Montgomery et al (2006)]. It is usually expressed as a percentage by multiplying by 100.

(c) Significance of Regression (F- ratio)

This was used to determine the significance of a regression equation by testing whether the developed regression model is significant or not (Ogunsemi 2002, William 2008). To ascertain the significant level, F- calculated which is expressed as

$$\text{F- calculated} = \frac{\text{Regression mean square}}{\text{Regression mean square error}} \qquad \text{----------------------3}$$

is compared with the critical value of F (F-tabulated) at 5% level of significance. Where F-calculated is greater than F-tabulated, the developed regression model is significant and suitable for prediction (Ogunsemi 2002).

(d) Student t - test

According to Naoum (2008), the t - test is a test used to compare the difference between the mean scores of two samples and is given as:

$$\text{t-cal} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{SD_1}{N_1} + \frac{SD_2}{N_2}\right)}} \qquad \text{--4}$$

where X_1, X_2 are the mean values of the two samples

SD_1, SD_2 are the standard deviations of the two samples

N_1, N_2 are the number of samples. If t-calculated is less than t-tabulated, then the null hypothesis of no significant difference is accepted.

3.6.1.2 Validation of models

The purpose of model validation is to ascertain the performance of the model. According to Liou and Borcherding (1986), model validation can be achieved by using the following techniques:

(i) Analysis of model coefficients and predicted values in comparison with any outside knowledge;

(ii) Using fresh data to test the predictive models; and

(iii) Splitting the original data into two i.e. one set for model calibration while the other is used for validation.

The data splitting method was adopted for this study. Data splitting refers to the process by which the data population is divided into estimation and prediction data sets for regression analysis and validation (William 2008). According to William (2008), the set of estimation data is used to complete the statistical regression analysis while the prediction data set is used to validate the model and ensure that the models prepared reflect reality. 85% of the cost data was used for developing the models while the remaining 15% was also used for validation. This ratio was adapted from William (2008), Ogunsemi and Jagboro (2006) who used three-quarter of the original data for calibration and the remaining one for validation. This was applied to DFR projects. A t-test was then carried out between the observed (actual) and predicted values of duration to assess their significant differences. Specifically, table 3.5 shows the number of data that was used for calibration and validation of the models in this study.

The hypothesis was tested at 5% significance level and was as follows:

H_o: There is no significant difference between the observed (actual) and the predicted values.

H_1: There is significant difference between the observed (actual) and predicted values.

Where t-calculated is less then t-tabulated, H_o is accepted. This implies a valid model. The SPSS (2013) software package version 22 was used for the analysis of data relating to the regression models.

Table 3.5 Number of Projects that were used for calibration and validation

Region	**Total No. of Projects**	**No. for Calibration**	**No. for Validation**
ASHANTI	35	30	5
BRONG AHAFO	35	30	5
TOTAL	**70**	**60**	**10**

Source: DFR – Ashanti and Brong Ahafo Regions Progress Reports (June 2014)

3.7 SUMMARY OF CHAPTER

This chapter has briefly discussed the methodology used in achieving the objectives of the research. The regression models and the various assessment criteria which assisted in assessing the significance of the results were mentioned. The next chapter presents the application of these techniques to develop the required models.

CHAPTER FOUR

PRESENTATION OF DATA, ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

This chapter deals with the presentation and analysis of the data already collected from the Department of Feeder Roads in the two regions using the methodology in chapter 3. It also discusses and relates the results obtained with previous studies in the literature review while the summary of the findings have been clearly itemized.

4.2 PRESENTATION OF DATA

The data collected from the Department of Feeder Roads in the two regions and used for the analysis are shown in tables 4.1 and 4.2. They contain the name of the project, the actual duration in days and adjusted cost in Ghana cedis. The final costs were adjusted to January 2014 prices (Ireland, 1985; Kaka and Price, 1991; Yeong, 1994; Kumaraswamy and Chan, 1995; Chan,1999, 2001; Chan and Chan, 2004; Love et al, 2005; Ogunsemi and Jagboro, 2006 and Hoffman et al, 2007) using equations 5 and 6 for homogeneity reasons so as to have a fair basis for comparisons. This was necessary because it has been suggested that for accuracy of predictive models, homogeneity is very important (Aibinu and Jagboro 2002, Ogunsemi 2002). The price adjustment formula (clause 47 of the conditions of contract and contract data) used for the adjustment of the cost (see appendix 2) is:

$$P_c = A_c + a.\frac{LL}{LL_o} + b.\frac{PL}{PL_0} \times \frac{FE}{FE_0} + c.\frac{FU}{FU_0} + d.\frac{BI}{BI_0} + e.\frac{CE}{CE_0} + f.\frac{RS}{RS_0} + g.\frac{TI}{TI_0} + h.\frac{CH}{CH_0} + i.\frac{PC}{PC_0} + j.\frac{CO}{CO_0} \;\ldots\ldots\ldots\ldots\ldots\ldots 5$$

where “a”, “b”, “c”, “d”, “e”, “f ”, “g”, “h” “i” and “j” are coefficients representing the estimated proportion of each cost element (labour, equipment, materials, etc.,) in the works or sections thereof, net of provisional sums.

“LL”, “PL”, “FE”, “FU”, “BI”, “CE”, “RS”, “TI”, “CH”, “PC” and “CO” which are the current cost indices (in this case January 2014) corresponding to reference prices applicable respectively to the elements of local labour, provision and maintenance of construction plant, foreign exchange rate, fuel, bitumen, cement, reinforcing steel, timber, chippings, precast concrete pipes, and consumer index. Pc is the price adjustment factor and “LL_0”, “PL_0”, “FE_0”, etc., are the base cost indices (in this case month/year of completion of the selected projects) or reference prices corresponding to “LL”, “PL”, “FE”, etc. See appendix 2 for summary of computations of the price adjustment factors (PAF).

Adjusted cost = Final cost x P_c ……………………………………………………………6

Table 4.1: Actual time and adjusted cost for DFR projects – Ashanti Region

No	Project name	Original Contract sum GH¢ (000)	Contract Duration (Days)	Final Contract Cost GH¢ (000)	Mean Price Adjustment Factor (PAF)	Adjusted Final Contract Cost GH¢ (000)
1	Surfacing of Bepoase Jn – Bepoase (7.60Km)	2,962.00	542	5,125.00	1.097	5,622.13
2	Surfacing of Wuruyie Jn –K otwea Ph.2 (Km 8.5 – 13.0)	1,517.00	545	1,461.00	1.073	1,567.65*****
3	Surfacing of Wuruyie Jn –Kotwea Ph.3 (Km 13.0 – 17.0)	1,199.64	365	1,294.90	1.115	1,443.81
4	Surfacing of Camp –Berekete (3.50Km)	1,175.92	542	1,256.66	1.073	1,348.40
5	Surfacing of Nyameani –Beposo (6.0Km)	2,167.16	538	2,399.72	1.073	2,574.90
6	Surfacing of Nkwabrim Jn. – Aframso (5.50Km)	3,963.73	528	3,622.87	1.042	3,775.03
7	Surfacing of Wuruyie Jn –Kotwea Ph.1 (Km 0.0 – 8.5)	2,397.30	521	2,313.67	1.042	2,410.84
8	Spot Improvement of Fahiakobor - Kobriso-Dwenase (6.80Km)	294.29	277	270.63	1.054	285.24
9	Spot Improvement of Bepoase - Nobiso -Nobiso Jn Ph.1 (Km0.0 – 5.0)	184.04	260	172.36	1.054	181.66
10	Spot Improvement of Bepoase - Nobiso -Nobiso Jn Ph.2 (Km5.0 – 9.6)	246.09	295	225.92	1.042	235.40
11	Spot Improvement of Abodom-Kokotro Ph.1 1 (Km0.0 – 6.0)	257.46	261	244.62	1.054	257.82*****
12	Spot Improvement of Kokofu – Asamang (5.3Km)	169.35	261	126.47	1.054	133.29
13	Spot Improvement of Keteke – Supong (6.8Km)	294.81	548	261.54	1.015	265.46
14	Spot Improvement of Asankare -	222.80	299	168.51	1.042	175.69

	Dampong -Kwabeng Ph.4 (Km 10.0 – 13.6)					
15	Spot Improvement of Boamang-Bedumase Ph.1 (Km 0.0 – 6.0)	263.28	268	251.83	1.054	265.42*****
16	Spot Improvement of Mankraso – Mpaepaemo (2.8Km)	270.25	470	264.29	1.037	274.06
17	Spot Improvement of Abofour - Kyebi -Sabronum Ph.1 (Km 0.0 – 7.0)	464.90	359	443.02	1.037	459.41
18	Spot Improvement of Abofour - Kyebi -Sabronum Ph.3 (Km 14.0 – 21.0)	361.69	414	319.51	1.054	336.76
19	Spot Improvement of Ataase - Nkwanta -Hwediem Ph.1 (Km 0.0 – 5.0)	470.28	405	488.02	1.054	514.37
20	Spot Improvement of Odumase - Kyeremebabi Ph.2 (Km 5.4 – 10.8)	155.01	468	148.94	1.032	153.70
21	Spot Improvement of Kumawu – Drobonso (10.4Km)	429.75	354	255.59	1.186	303.12
22	Rehabilitation of Gyereso - Aboabo – Bibiani (12.6Km)	421.40	488	512.26	1.125	576.29
23	Spot Improvement of Bakame - Mamponteng – Ankaase (4.8Km)	339.86	381	231.76	1.128	261.42
24	Spot Improvement of Dansabonso – Yawsafo (8.0Km)	376.42	481	289.34	1.131	327.24
25	Spot Improvement of Tweapease Jn – Tweapease (4.0Km)	240.51	343	150.17	1.186	178.10
26	Spot Improvement of Sekyere – Akrokyere (4.7Km)	438.38	589	347.88	1.107	385.10
27	Rehabilitation of Fumso - Odemu – Anwhiam (10.0Km)	382.15	457	345.84	1.125	389.07
28	Spot Improvement of Adomfe-Tanokrom (10.3Km)	631.11	289	672.03	1.180	792.99
29	Rehabilitation of Kona - Brofoyedru-Adengensuagya (4.2Km)	681.07	383	672.03	1.152	774.18
30	Aframso - Nkyensie (8.34Km)	1,400.36	355	1,545.62	1.015	1,568.80
31	Rehabilitation of Kabre-Nyinasie (7.6Km)	692.65	380	812.01	1.037	842.05*****
32	Rehabilitation of Bosomkyekye-Ouagadugu (12.5Km)	1,780.21	549	1,562.79	1.054	1,647.18*****
33	Rehabilitation of Aframso-Kyeiase (14.1Km)	1,038.85	524	1,219.84	1.054	1,285.71
34	Rehabilitation of Ejura Nkwanta – Kabre (7.6Km)	862.85	358	785.51	1.015	797.29
35	Rehabilitation of Dome-Asasebonsa (9.8Km)	1,368.58	366	1,659.53	1.015	1,684.42

Source: DFR – Ashanti Region Progress Report (June 2014). Notes: GH¢ is Ghana Cedis,

£1 = GH¢ 4.50 (at June 2014).   Cost adjusted to January 2014 prices.

***** Used for validation.

Table 4.2: Actual time and adjusted cost for DFR projects – Brong Ahafo Region

No	Project name	Original Contract sum GH¢ (000)	Contract Duration (Days)	Final Contract Cost GH¢ (000)	Mean Price Adjustment Factor (PAF)	Adjusted Final Contract Cost GH¢ (000)
1	Spot Improvement of Subinso - Boase (4.6Km)	422.32	245	295.14	1.226	361.84
2	Rehabilitation of Adamu - Kwajilongo (6.0Km)	430.40	527	470.86	1.115	525.00
3	Rehabilitation of Wrukwai Jn - Wrukwa (9.1Km)	645.52	266	593.30	1.123	666.27
4	Rehabilitation of Hani-Namasa (8.0Km)	796.10	494	808.22	1.131	914.09
5	Rehabilitation of Kupongkrom-Kyekyewere (8.9Km) & YepimsoKm)	662.66	507	542.60	1.131	613.68*
6	Spot Improvement of Jinijini - Nifakrom (8.6Km)	515.00	602	375.62	1.107	415.80
7	Spot Improvement of Weila – Gumboi - Dwere (8.4Km)	361.50	245	360.00	1.226	441.36*
8	Rehabilitation of Kwame Tente – Jaro - Nsuhunu (9.6Km)	626.48	254	638.06	1.226	779.80*
9	Rehabilitation of Brohani - Namasa (8.0Km)	985.34	603	975.84	1.097	1,070.49
10	Surfacing of Odumase–Nkwabeng–Abuentem & Others Ph.1 (Km 0.0 – 2.8)	1,187.69	376	1,641.61	1.125	1,846.80
11	Surfacing of Mehami Jn – Dadiesoaba Ph.1 (Km 0.00-6.00)	1,419.24	272	2,093.34	1.180	2,470.14
12	Surfacing of Nyamebekyere-Sankore-Buako Ph. 1 (Km 0.00-6.0)	2,690.63	596	3,455.21	1.054	3,641.79
13	Surfacing of Odumase–Nkwabeng–Abuentem Ph.3 (Km 5.80 – 11.60)	1,779.09	426	1,831.89	1.097	2,009.58*
14	Rehabilitation of Hwidiem-Makyin Mabre (Km 0.00-10.40)	1,100.04	410	1,010.62	1.097	1,108.65
15	Rehabilitation of Makyin Mabre Jn-Yerepemso (Km 0.00-10.10)	1,328.22	364	1,061.04	1.015	1,076.95
16	Rehabilitation of Brahoho-Dompoase-Meta (Km 0.00-14.20)	1,308.00	278	1,370.32	1.125	1,541.61
17	Spot Improvement of Kosua - Jinijini (Km 0.0 – 3.30)	231.418	235	253.20	1.054	266.87
18	Spot Improvement of Kwanteng Jn - Kwanteng (Km 0.0 – 7.2)	323.90	295	241.26	1.042	251.39
19	Spot Improvement of Kojokumikrom - Kwakuanya (Km 0.0 – 16.8)	356.94	368	374.99	1.032	386.98
20	Spot Improvement of Rubi - Beposo (Km 0.0 – 11.2)	234.05	388	235.33	1.027	241.68
21	Spot Improvement of Kumagyamire Jn –	164.20	360	182.66	1.032	188.50

	Kumagyamire (Km 0.0 – 4.0)					
22	Spot Improvement of Pomaakrom – Manukrom (Km 0.0 – 4.5)	229.27	135	235.81	1.097	258.66*
23	Spot Improvement of Nkrankwanta – Yambediagoro (Km 0.0 – 4.8)	264.90	234	244.60	1.054	257.80
24	Spot Improvement of Wamanafo – Bofotire (Km 0.0 – 4.5)	221.20	222	229.23	1.054	241.60
25	Spot Improvement of Bomaa - Dwenase – Maabeng (Km 0.0 – 16.8)	195.87	225	177.42	1.054	187.00
26	Spot Improvement of Sekyerekrom – Krobo (Km 0.0 – 1.2)	73.61	433	73.45	1.014	74.47
27	Spot Improvement of Baanue Nkwanta – Wawasua (Km 0.0 – 7.8)	359.35	438	320.69	1.014	325.17
28	Spot Improvement of Ebetoda - Wam - Ogyam (Km 0.0 – 14.7)	200.84	425	161.33	1.014	163.58
29	Spot Improvement of Kwapong - Abeetewoa - Manhyia (Km 0.0 – 8.1)	223.96	434	154.33	1.014	156.49
30	Spot Improvement of Bitre Jn - Kwamepua (Km 0.0 – 26.6)	344.37	433	339.62	1.014	344.37
31	Spot Improvement of Kwaduakrom - Akwaboh (Km 0.0 – 2.0)	136.87	214	130.01	1.054	137.03
32	Spot Improvement of Antwirofo - Danyame Ph.1 (Km 0.0 - 9.0)	261.49	219	209.45	1.054	220.76
33	Spot Improvement of Gyaenkontabu Jn - Gyaekontabu (Km 0.0 – 1.0)	117.20	212	102.11	1.054	107.62
34	Spot Improvement of Terchire - Adrobaa (Km 0.0 – 6.1)	175.54	251	190.50	1.042	198.50
35	Spot Improvement of Antwirofo - Danyame Ph.2 (Km 9.0 - 17.3)	287.46	244	287.46	1.042	299.53

Source: DFR – Brong Ahafo Region Progress Report (June 2014). Notes: GH¢ is Ghana Cedis, £1 = GH¢ 4.50 (at June 2014). Cost adjusted to January 2014 prices.

***** Used for validation.

4.3 FORMULATION OF MATHEMATICAL RELATIONSHIP BETWEEN TIME AND COST

The collected data was used to develop the models. The BTC model was first employed after which nine (9) other equation forms of regression models were used.

4.3.1 Modelling construction time based on BTC model

The study used the data in tables 4.1 and 4.2 to establish the time - cost model developed by Bromilow (1969, 1974) which had been validated in other parts of the world such as the United Kingdom (Kaka and Price, 1999), Malaysia (Yeong 1994, Chan 2001), Hong Kong (Chan and Kumaraswamy, 1995; Chan 1999) and the United States (Choudhury and Rajan 2003, Hoffman et al 2007). This model which has been identified as a viable tool for assessing the duration of construction projects is expressed as follows:

$T = KC^B$ -- 7

Where T = duration from date of site possession to practical completion, in working days.

C = estimated final cost in thousands of Ghana cedis, adjusted to constant labour and material prices.

K = a constant describing the general level of time performance for a one thousand Ghana cedi project.

B = a constant describing how the time performance is affected by project size, as measured by cost.

Equation 7 is non-linear which can be linearized by applying the double – log,

i.e. $\text{Log}(T) = \text{Log}(KC^B) = \text{Log } K + B \text{ Log } C$.

$$\text{Log (T)} = \text{Log K} + \text{B Log C} \quad \text{------------------------------------} \quad 8$$

A simple linear regression technique was carried out to obtain the K and B values in the BTC model using data collected from the two regions. The SPSS software package produced the results shown in tables 4.3, 4.4 and 4.5.

4.3.1.1 Ashanti and Brong Ahafo Regions - DFR Projects

The coefficient of correlation (R) in table 4.3 shows a moderate relationship between the dependent variable T (time) and the independent variable C (cost). This does not give a very strong relationship as observed in the findings of Bromilow et al (1980), Ireland (1985), Kaka and Price (1991), Yeong (1994), Kumaraswamy and Chan (1995), Chan (1999, 2001), Choudhury and Rajan (2003) and Hoffman et al (2007).

Using equation 7 and table 4.5, B= 0.134 and log K = 1.804 $\Rightarrow$ K = 64. Using the BTC model in equation 7, the BTC model is formulated as:

$$T = 64C^{0.134} \text{ --- } 9$$

4.3.1.1.1 Assessment of developed model for Ashanti and Brong Ahafo Regions – DFR projects

Tables 4.3, 4.4 and 4.5 show the statistical parameters of the developed model in equation 7.

Table 4.3: Model summary for Ashanti and Brong Ahafo Regions - DFR projects

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	.433	.187	.173	.1224908

a. Predictors: (Constant), LOGC

An important aspect of a statistical procedure that derives model from empirical data is to indicate or show how well the model predicts results. A widely used measure of the predictive efficacy of a model is its coefficient of determination (R^2) (Chan, 1999; Chan, 2001; Aibinu and Jagboro, 2002; Ogunsemi and Jagboro, 2006; Hoffman et al, 2007; SPSS, 2013). If there is a perfect relation between the dependent and independent variables, R^2 is 1. Where there is no relationship between the dependent and independent variables R^2 is 0. From table 4.3, R^2 is 0.187. This means that a percentage of 19% of the variance in feeder roads construction in Ghana is explained by the project scope expressed in terms of the final cost of construction indicating a low predictive ability. This collaborates with Ojo (2001), Ogunsemi and Jagboro (2006) who obtained low predictive abilities for the BTC model in south western part of Nigeria as reported in the literature review.

The analysis of variance (ANOVA) in table 4.4 indicates that the developed DFR regression model is significant [with F = 13.368, p= 0.001<0.05]. This indicate that the BTC model can be extended to DFR projects in Ghana.

Table 4.4: ANOVA[b] for DFR model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.201	1	.201	13.368	.001[b]
	Residual	.870	58	.015		
	Total	1.071	59			

a. Predictors: (Constant), LOGC
b. Dependent Variable: LOGT

Table 4.5: Coefficients[a] for DFR model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.804	.209		8.635	.000
	LOGC	.134	.037	.433	3.656	.001

4.3.1.1.2 Validation of BTC model for Ashanti and Brong Ahafo Regions in Ghana - DFR Projects

The validity of the model is usually assessed in terms of predictive accuracy (Chan and Kumaraswamy 1999). That is, the predicted values obtained from the developed model are compared with the actual observed values to verify the predictive efficacy (Chan and Chan 2004). To further confirm the predictive ability of the model, the ten (10) projects (marked as * in tables 4.1 and 4.2) which were not used in the formulation of the BTC model were used for validation. This idea was adopted from Chan and Kumaraswamy (1999) as well as Chan and Chan (2004). Table 4.6 summarizes the comparison of the observed (actual) values from the collected data and the predicted values generated from the developed model. Two measures of accuracy dealing with percentage error were used to compare the forecasting performance of the model. The percentage error and the mean absolute error defined by Goh (2000) are:

$$\text{Percentage Error} = \frac{\text{Predicted duration} - \text{Actual duration}}{\text{Actual duration}} \times 100\%$$

$$\text{Mean Absolute Percentage Error (MAPE)} = \frac{\sum [PE]}{N}$$

Since feeder road projects in Ghana are stated in months, the predicted durations in days generated from equation 9 for the ten (10) projects, were rather converted into months. This was done to show how the performance of the developed model would be in practice (see table 4.6).

Table 4.6: Comparison of actual values and predicted values for DFR construction durations using the BTC model.

*Cost GH(000) (Adjusted)	Actual duration (months)	Predicted duration (months)	Percentage error	Absolute percentage error
1,567.13	17	14	-17.6	17.6
257.82	8	11	37.5	37.5
265.42	8	11	37.5	37.5
842.05	12	13	8.3	8.3
1,647.18	18	14	-22.2	22.2
613.68	16	13	-18.8	18.8
441.36	8	12	50	50
779.80	8	13	62.5	62.5
2,009.58	14	15	7.1	7.1
258.66	4	11	175	175
MEAN	**11.3**	**12.7**		**43.7**

*See tables 4.1 and 4.2

Mean absolute percentage error = 43.7%

Two of the durations predicted by the model are consistent with the actual durations of within ±10%. This implies the predictions of the model do not differ significantly from the actual (observed) values. In other words there is no major significance difference between the observed and the predicted values of duration. An alternative is to use the t-test. The hypothesis tested at the 5% level of significance is as follows:

H_o: There is no significant difference between the observed (actual) and the predicted values.

H_1: There is significant difference between the observed (actual) and predicted values.

Using equation 3.5, $X_1 = 11.3$, $X_2 = 12.7$, $SD_1= 4.76$ and $SD_2 = 1.42$

$N_1=N_2 =10$. Also degree of freedom (df) = $N_1+N_2 – 2 \Rightarrow df = 18$.

Equation 4 gives t-calculated as 1.19. From the t-distribution table, t critical = 2.92. Since t-cal is less than t-crit, H_0: of no significance difference between the observed and the predicted values of duration is accepted. This indicates that equation 9 is a good model and suitable for prediction for DFR projects in Ghana.

4.3.1.1.3 Searching for violations of assumptions

Residual search is conducted to test the validity of the linear regression model. A scatter plot is a good means of judging how well a straight line fits the data (Chan1999, 2001), Choudhury and Rajan (2003). Figure 1 shows a scatter plot of log T against log C.

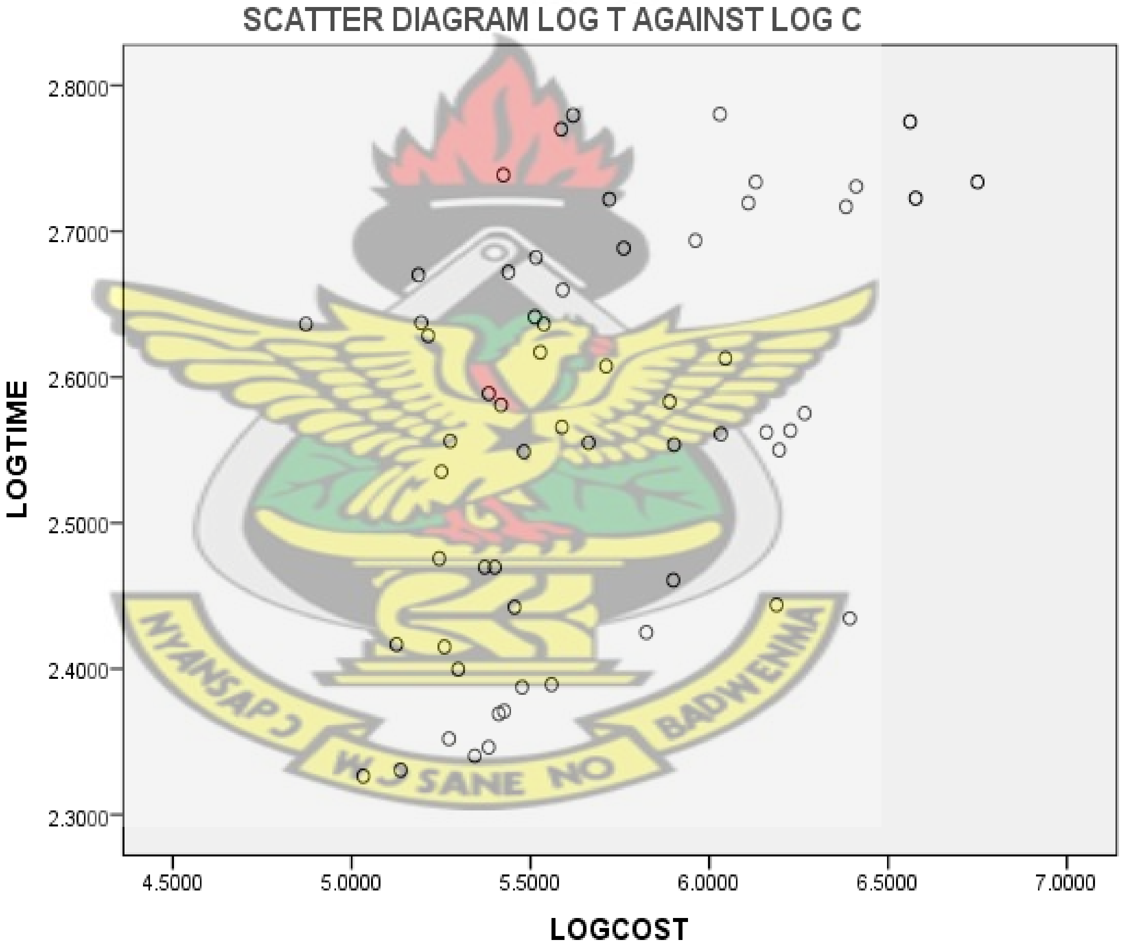

Figure 1: Scatter plot of log T against log C.

As can be seen in figure 1, a straight line fits the data well as there is a random distribution which is clustered around the horizontal line through the origin. This means that the assumptions of linearity and homogeneity have been achieved.

4.3.2 Modelling construction time using other forms of regression models

The following nine regression models adopted by Chen and Huang (2006), Shr and Chen (2006) were investigated to identify the best format for this study: logarithmic equation (LOG), inverse equation (INV), quadratic equation (QUA), cubic equation (CUB), composite equation (COM), power equation (POW), S-curve equation (S), Growth and exponential equation (EXP). Table 3.4 presents the basic forms of the equations for these regression models.

The coefficient of determination (R^2) was observed for each of the models in order to select the most appropriate one. With the aid of the SPSS package, the result of the analysis is shown in table 4.7.

Table 4.7: Model summary and parameter estimates for DFR projects in Ghana

	Model Summary					Parameter Estimates			
Equation	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Logarithmic	**.189**	**13.517**	**1**	**58**	**.001**	**-269.950**	**50.138**		
Inverse	.134	8.967	1	58	.004	437.319	-16620252.25		
Quadratic	.171	5.885	2	57	.005	338.863	6.854E-005	-5.561E-012	
Cubic	.174	3.929	3	56	.013	330.517	9.998E-005	-2.385E-011	2.404E-018
Compound	.149	10.121	1	58	.002	335.015	1.000		
Power	.187	13.368	1	58	.001	63.702	.134		
S	.140	9.411	1	58	.003	6.051	-45626.214		
Growth	.149	10.121	1	58	.002	5.814	1.147E-007		
Exponential	.149	10.121	1	58	.002	335.015	1.147E-007		

1. Bolded form of model is selected.
2. All regression models are significant except cubic model.

4.3.2.1 Discussion and interpretation of results

This section interprets and discusses the results of the analyses in table 4.7

DFR projects in Ashanti and Brong Ahafo Regions

It is evident from table 4.7 that the logarithm regression model is the most appropriate one among the nine forms of regression models examined. This is because it yields the highest R^2 value of 0.189 indicating that 19% of the variance in road construction for DFR in Ghana is explained by the project scope in terms of final cost.

It can also be seen that the model is significant: [with F= 13.517, p=0.001 < 0.001].

The logarithm model can be written as: T = -269.950 + 50.138 Ln C -----------10 where T is in days and C is in thousands of Ghana cedis.

The logarithm model has almost the same predictive ability (R^2 = 0.189) as BTC model (R^2 = 0.187). To determine whether there is significance difference between the predicted durations from both the BTC and logarithm models, the ten (10) projects which were not used in the calibration of the models were used. The predicted values from both models are shown below in table 4.8.

Table 4.8: Comparison of predicted values for DFR construction durations using the BTC and Logarithm models.

*Cost GH(000) (Adjusted)	Actual duration (months)	Predicted duration by BTC model (months)	Absolute Percentage Error	Predicted duration by logarithm model (months)	Absolute Percentage Error
1,567.13	17	14	17.6	15	11.8
257.82	8	11	37.5	11	37.5
265.42	8	11	37.5	11	37.5
842.05	12	13	8.3	13	8.3
1,647.18	18	14	22.2	14	22.2
613.68	16	13	18.8	13	18.8
441.36	8	12	50	12	50
779.80	8	13	62.5	13	62.5
2,009.58	14	15	7.1	15	7.1
258.66	4	11	175	11	175
MEAN	**11.3**	**12.7**	**43.7**	**12.8**	**43.1**

It can be seen from table 4.8, that there is no much significance difference between the mean of actual values and the predicted values of duration by the BTC model (11.3 and 12.7) and that of the logarithm model (11.3 and 12.8). Secondly, the means of the predicted values of duration by the BTC model and that of the logarithm model are almost the same (43.7 and 43.1). Engineers and quantity surveyors at DFR can therefore use either model in predicting duration for DFR projects in Ghana. However, since the logarithm model has a slightly higher R^2 value in comparison to the BTC model, it is more advisable to use the Logarithm model.

Figure 2 represents a plot of duration (time) against cost for all the regression models for the sixty projects selected (Ashanti and Brong Ahafo Region).

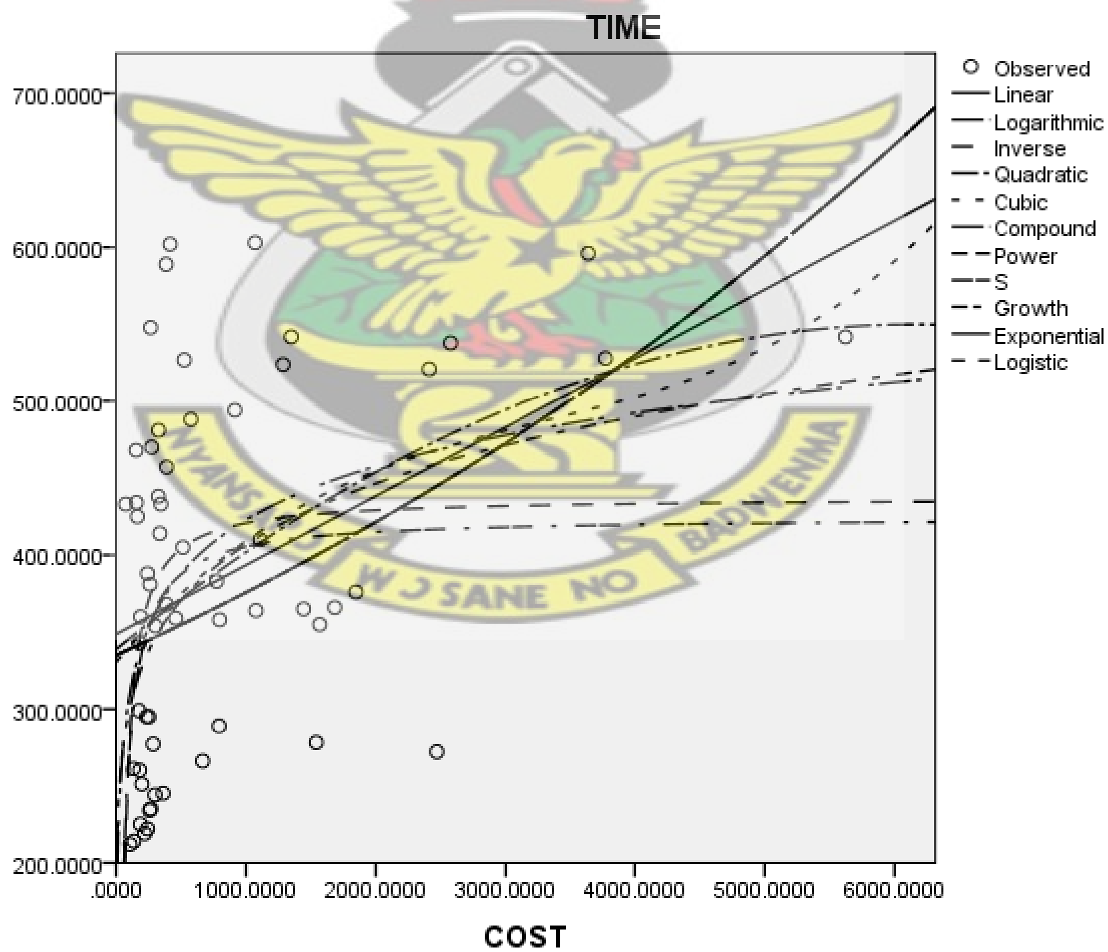

Figure 2: A plot of duration against cost for the sixty projects

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This study has dealt with the various aspects of time - cost models for construction projects with specific reference to road works. The main aim is to develop appropriate time –cost models for prediction of duration of feeder road construction projects in Ghana. This chapter summarizes the main conclusions of this study and the limitations. Specific recommendations are also proposed and the chapter concludes with possible areas for further research.

5.2 CONCLUSIONS

This section summarises the findings of the study. Based on the analysis carried out in the previous chapter, the results of the study are as follows:

5.2.1 Review of Objective One

The first objective is to formulate a mathematical relationship between time and cost using Bromilow's time-cost (BTC) model and other regression models. The Bromilow's time-cost model (BTC) which has been validated in many parts of the world was formulated as: $T = K\,C^{B}$

Based on this and using feeder road projects from Ashanti and Brong Ahafo regions, a time – cost model was derived as $T = 64C^{0.134}$.

Where T is Time and C is Cost.

Using other regression models, a logarithm model representing the relationship between time, T and cost, C was obtained as $T = -269.950+50.138\mathrm{Ln}C$, where Ln is the natural logarithm.

5.2.2 Review of Objective Two

The second objective is to identify which of the formulae derived could be used to predict the duration of feeder road projects by validating the models that have been developed. It was found that either of the derived formulae give the same results after using splitting method for validation. However some other factors must be considered and incorporated to increase its predictive ability. This result reinforces the findings of Ojo (2001) in Nigeria.

For each of the models developed, the hypothesis tested at the 5% level of significance indicated that the null hypothesis of no significance difference between the observed and the predicted values of duration is true. This indicates the suitability of the formulated models for prediction of road construction projects.

5.3 LIMITATION OF STUDY

It is evident from the literature review that the completion of construction projects is affected by numerous factors apart from cost. According to Ireland (1985) and Nkado (1995), there is a relationship between the attitude of the workforce and management practices to the duration of a construction project. Kumaraswamy and Chan (1995) derived a hierarchy of factors that can contribute to the duration of construction projects, some of which include location, productivity, type of contract and weather. This study is however, limited to the relationship between time and cost of a project with particular reference to feeder road projects in Ashanti and Brong Ahafo regions. It does not incorporate the implications of these likely factors that can influence the total time required for the completion of road construction projects.

5.4 RECOMMENDATIONS

Based on the above findings, it is recommended that

(i) Engineers and Quantity Surveyors in Department of Feeder Roads can apply the developed models to estimate duration of feeder road projects after estimating the final cost. The BTC or Logarithm models can be used as they give the same results. Engineers and Quantity Surveyors in Department of Feeder Roads generally use their individual experience to estimate duration of road projects in practice. These models therefore provide an alternative and objective method for estimating road construction time to supplement the current practice based on individual's experience. There is however the need to adopt the methodology of this study to update these models since the constants can vary under different economic conditions. The sample size could also be increased to regularly update these models in order to enhance the predictive abilities.

(ii) Methods of estimating COST for projects should be improved to ensure more accurate TIME prediction.

5.5 FURTHER STUDY

The areas for further investigation are being proposed as follows:

(i) Construction time is dependent on so many other factors apart from cost as reported in the literature review. For future research work, it may be necessary to incorporate other factors such as project location, weather conditions and management attributes among others to improve the model. This could be done by using the relative importance index to identify the most tactical options affecting the duration of feeder road projects in Ghana. The sensitivities of these significant factors to the duration of the projects can then be tested and their coefficients could be incorporated as appropriate.

(ii) The Logarithm expressions show linear relationships. There should therefore be further study into developing charts or graphs which will make it easy to use by all.

(iii) The study could be extended to other agencies such as Ghana Highway Authority (GHA) and Department of Urban Roads (DUR) so that similar models could be developed for their usage.

5.6 CONCLUSION

A review of literature on existing regression models provided a sound basis for investigation into feeder road projects in Ghana. Analysis of 70 completed projects was carried out for the exercise. Models were developed based on Bromilow's time – cost model and other Regression models. It was found that both the BTC model and the Logarithm model could be used for DFR projects. However, the Logarithm model has a higher coefficient of determination and therefore that model serve as convenient tool for estimating the durations of feeder road construction projects after the Engineer's estimate has been prepared. The model provide an alternative means for professionals in DFR to estimate the duration to supplement those based on individual quantity surveyor's or engineer's experience. Contractors can also use the model to estimate how long a project would take to be executed prior to tender with respect to feeder road projects. It can therefore assist them in preparing their works programme and where possible apply it during tendering especially where duration forms part of the requirement for award of contracts during evaluation of tenders.

REFERENCES

Aibinu, A.A. and Jagboro, G.O. (2002), *The effects of construction delays in Nigerian construction industry*. International Journal of Project Management 20(8): 593-599.

Ashworth, A. (1986), *Cost Models – Their History, Development and Appraisal*. Technical Information Service of the Chartered Institute of Building. No. 64, pp.1 – 6.

Anaman, A.K. and Osei – Amponsah C (2007), *Analysis of the causality links between the growth of the construction industry and the growth of the macro-economy in Ghana*. Construction Management and Economics, 25 (9): 951-961.

Bromilow, F.J. (1969), *Contract time performance expectations and the reality*. Build Forum, 1(3): 70-80.

Bromilow, F.J. (1974), *Measurement and scheduling of construction and cost performance in the building industry*. The chartered builder, 10(9), June –July, 57.

Bromilow, F.J. and Henderson, J.A. (1976), *Procedures for reckoning and valuing the performance of building contracts*. The Chartered Builder, 10(9): 57.

Bromilow, F.J., Hinds, M.F. and Moody, N.F. (1980), *AIQS survey of building contract time performance*. Build Economist 19(2):79-82.

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

Burns, S.A, Liu, L. and Feng, C.W. (1996), *The LP/IP hybrid method for construction time-cost trade-off analysis*. Construction Management and Economics 14 (3): 265 – 276.

Burrows, T.K, Pegg, I. and Martin, J. (2005), *Predicting building construction duration*. AACE International Transactions p14.1-14.9, 9p.

Chan (2001), *Time- Cost relationship of public sector projects in Malaysia*. International Journal of Project Management 19(4):223 -229.

Chan, A.P.C. and Chan, D.W.M. (2004), *Developing a benchmark model for project construction time performance in Hong Kong*. Building and Environment 39(3):339 -349.

Chan, D.W.M. and Kumaraswamy, M.M. (1999), *Forecasting construction durations for public housing projects: a Hong Kong perspective*. Building and Environment 34(5): 633-646.

Chan, D.W.M. and Kumaraswamy, M.M. (2002), *Compressing construction durations: Lessons learned from Hong Kong building projects*. International Journal of Project Management 20(1): 23 – 35.

Chan, D.W.M. (1998), *Modelling construction durations for public housing projects in Hong Kong*. Unpublished PhD thesis, the University of Hong Kong, Hong Kong.

Chan, A.P.C. (1999) *Modelling building durations in Hong Kong*. Construction Management and Economics, 17(2): 189–196.

Chen, W.T. and Huang, Y.H. (2006), *Approximately predicting the cost and duration of school reconstruction projects in Taiwan*. Construction Management and Economics 24 (12):1231 -1239.

Choudhury, I., Rajan, S.S. (2003),*Time-cost relationship for residential construction in Texas*. Amor R (editor) Proceedings of the CIB W78's 20th International Conference on Construction IT, Construction IT Bridging the Distance, CIB Report 284, New Zealand, 23-25 April 2003, pg.73-80. (http://itc.scix.net/data / works/att/w78-2003-73.content.pdf) -Accessed 15/4/2014.

Cresswell, J.W., (1994, 2003), "Research Design: Qualitative, Quantitative and Mixed Methods Approaches", 2 Ed, *Sage Publications.*

Denzin, N. K., & Lincoln, Y.S., (1994; 2000), "Handbook of Qualitative Research", 2nd edition, Thousand Oaks Publications, *CA: Sage Publication.*

Fellows, R., & Liu, A.M.M., (2003), "Research methods in construction", 2nd edition. Oxford: *Blackwell Science Ltd.*

Frimpong, Y., Oluwoye J., Crawford, L. (2003), *Causes and cost overruns in construction of groundwater projects in developing countries (Ghana as a case study),* International Journal of Project Management 21(5): 321-326.

George, A.L., Bennett, A., (2005), "Case Studies and Theory Development in the Social Sciences", The MIT Press.

Gerring, J., (2006), "Case Study Research: Principles and Practices), 1st ed, Cambridge University Press.

Goh, B.H. (2000), *Evaluating the performance of combining neural networks and genetic algorithms to forecast construction demand: the case of the Singapore residential sector*. Construction Management and Economics 18(2): 210 -217.

Government of Ghana (2005), *Growth and Poverty Reduction Strategy (GPRS11), Final Draft Report.* National Development Planning Commission, Government of Ghana.

Hancock, D.R., Algozzine, R., (2006), "Doing Case Study Research: A Practical Guide for Beginning Researchers", 1st ed. Teachers College Press.

Hoffman, G.J, Jr, A.E.T., Webb, T.S. and Weir, J.D. (2007), *Estimating performance time for construction projects.* Journal of Management in Engineering 23(4): 193-199.

Ireland, V. (1985), *The role of managerial actions in the cost, time and quality performance of high-rise commercial building projects*. Construction Management and Economics 3(1): 59-87.

Jean, K., (1992), "Livelihood strategies among farm youth in Rwanda", Michigan: *Michigan State University.*

Jiang Y and Wu H (2007), *A method for Highway Agency to Estimate Highway Construction Durations and set Contract Times*. International Journal of Construction Education and Research 3(3):199 – 216.

Kaliba, K, Muya, M and Mumba, K (2008), *Cost escalation and schedule delays in road construction projects in Zambia*. International Journal of Project Management, doi:10.1016/j.ijproman.2008.07.003.

Kaka, A.P. and Price, A.D.F. (1991), *Relationship between value and duration of construction projects*. Construction Management and Economics, 9(4): 383-400.

Kumaraswamy, M.M. and Chan, D.W.M. (1995), *Determinants of construction duration*. Construction Management and Economics 13(3):209-217.

Lim, C.S. and Mohamed, M.Z. (1999), *Criteria of project success: an exploratory re-examination*. International Journal of Project Management, 17(4): 243-248.

Liou, F. and Borcherding, J.D. (1986), *Work Sampling can Predict Unit Rate Productivity*. Journal of Construction Engineering and Management 112 (1): 90-103.

Lock, D. (2007), *Project Management*, 9th edition, Gower Publishing Ltd.

Love, P.E.D., Tse, R.Y.C. and Edwards, D.J. (2005), *Time –Cost relationships in Australian Building Construction Projects*. Journal of Construction Engineering and Management 131(2):187 – 194.

Ministry of Finance (2009), *Budget: Investing in a better Ghana*. Ministry of Finance and Economic planning. (www.mofep.gov.gh/documents/budget2009.pdf) – Accessed 22/4/2014.

Ministry of Roads and Highways and Ghana Statistical Service (2008), *Statistical and analytical report for 2000 -2007.* Transport sector programme support, phase II (TSPS II), transport indicators database project. (www.mrt.gov.gh/userfiles//Phase%20III_Statistical%20and%20Analytical%20Report_Final_Dec08_web.pdf) – Accessed 22/4/2014.

Montgomery, D. C, Peck, E. A. and Vining, G. G. (2006), *Introduction to Linear Regression Analysis*, 4th edition, John Wiley & Sons.

Monthly cost indices (2008-2009), *Ministry of Roads and Highways*, Ghana. **(www://67.228.85.54/pages.asp?page_Id=13&expandable=3**) – (Accessed 25/5/2014)

Naoum, S.G. (2008), *Dissertation Research and Writing for Construction students*, 2nd edition, Butterworth Heinemann.

Ng, S.T., Mak, M.M.Y., Skitmore, R.M., Lam, K.C. and Varnam, M. (2001), *The predictive ability of Bromilow's time-cost model.* Construction Management and Economics, 19 (2):165-173.

Nkado, R.N. (1995), *Construction time-influencing factors: the contractor's perspective*. Construction Management and Economics 13 (1): 81-89.

Ogunsemi, D.R. (2002), *Cost and time performance of construction projects in South Western Nigeria*. Unpublished PhD thesis, Federal University of Technology, Akure, Nigeria.

Ogunsemi, D.R. and Jagboro, G.O. (2006), *Time- Cost model for building projects in Nigeria*. Construction Management and Economics, 24 (3): 253 -258.

Ojo, G.K. (2001), *A study of the relationship between contract period and tender sum of construction projects in south-western Nigeria*. Unpublished MSc thesis, Obafemi Awolowo University, Ile-Ife, Nigeria.

Patton, M.Q. (1990), "Qualitative Evaluation and Research Methods", Second Edition Newbury park, CA: *Sage Publications.*

Progress Report (June 2014), *Department of Feeder Roads: Road Sector Development Programme (RSDP) [IDA], Kfw and Cocobod projects* in *Ashanti and Brong Ahafo regions* – Ghana.

Seidman, I., (2005), "Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences", 3rd ed. Teachers College Press.

Shr, J.F. and Chen, W.T. (2006), *Functional model of cost and time for highway construction projects*. Journal of Marine Science and Technology, 14(3): 127-138.

Skitmore, R.M. and Ng, S.T. (2003), *Forecast models for actual construction time and cost*. Building and Environment 38(8): 1075–1083.

Soy, S.K. (1997), "The case study as a research method", unpublished paper, University of Texas: Austin Strategy *Survival Guide.*

Sprinthall, R. C., Schmutte, G. T., & Sirois, L., (1991), "Understanding educational research", New Jersey: *Prentice Hall.*

SPSS (2013), *SPSS for windows*. Release 16.0.

Stoy, C., Dreier, F., Schalcher, H. (2007), *Construction duration of residential building projects in Germany*. Engineering, Construction and Architectural Management 14(1): 52 - 64.

Sweis, G., Sweis, R., Hammad, A. A. and Shaboul, A. (2008), *Delays in construction projects: the case of Jordan*. International Journal of Project Management 26(6): 665-674.

Thomas, U.R., Smith, G.R. and Cummings, D.J. (1995) *Have I reached substantial completion?* Journal of Construction Engineering and Management, 121(1):121–129.

Walker, D.H.T. (1994), *An investigation into the factors that determine building construction time performance*. Unpublished PhD thesis, Royal Melbourne Institute of Technology, Melbourne, Australia.

William, R. C. (2008), *The development of mathematical models for preliminary prediction of highway construction duration*. Ph.D. thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA.

(http://scholar.lib.vt.edu/theses/available/etd-11062008 085348/unrestricted/RCW_Dissertation_ETD2.pdf) – (Accessed 25/5/2014)

Yeong, C.M. (1994), *Time and cost performance of building contracts in Australia and Malaysia*. MSc thesis, University of South Australia, Adeliade, Australia.

Yin, R.K. (2003), "Case study research: design and methods", 3rd edition, Thousand Oaks, California: *Sage Publications, Inc.*

APPENDICES

APPENDIX 1: COMPUTATION OF ADJUSTED COST

COMPUTATIONS OF ADJUSTED COST FOR DFR PROJECTS - ASHANTI REGION

NO	NAME OF PROJECT	BASE MONTH/YEAR OF COMPLETION	ACTUAL COST GH¢ (000) - A	MEAN P.A.F INDICES - B	ADJUSTED COST (JAN 2014) - (000) AxB	ACTUAL DURATION (T) IN DAYS	LOG ADJUSTED COST	LOG ACTUAL DURATION T
1	Surfacing of Bepoase Jn – Bepoase (7.60Km)	February 2013	5,125.00	1.097	5,622.13	542	6.7499	2.734
*2	Surfacing of Wuruyie Jn –K otwea Ph.2 (Km 8.5 – 13.0)	March 2013	1,461.00	1.073	1,567.65	545	USED FOR VALIDATION	
3	Surfacing of Wuruyie Jn –Kotwea Ph.3 (Km 13.0 – 17.0)	October 2012	1,294.90	1.115	1,443.81	365	6.1298	2.734
4	Surfacing of Camp –Berekete (3.50Km)	March 2013	1,256.66	1.073	1,348.40	542	6.4108	2.7308
5	Surfacing of Nyameani –Beposo (6.0Km)	March 2013	2,399.72	1.073	2,574.90	538	6.5769	2.7226
6	Surfacing of Nkwabrim Jn. – Aframso (5.50Km)	June 2013	3,622.87	1.042	3,775.03	528	6.3822	2.3365
7	Surfacing of Wuruyie Jn –Kotwea Ph.1 (Km 0.0 – 8.5)	June 2013	2,313.67	1.042	2,410.84	521	5.4552	2.3404
8	Spot Improvement of Fahiakobor - Kobriso-Dwenase (6.80Km)	May 2013	270.63	1.054	285.24	277	5.2593	2.2967
9	Spot Improvement of Bepoase - Nobiso -Nobiso Jn Ph.1 (Km0.0 – 5.0)	May 2013	172.36	1.054	181.66	260	5.3718	2.1847
10	Spot Improvement of Bepoase - Nobiso -Nobiso Jn Ph.2 (Km5.0 – 9.6)	June 2013	225.92	1.042	235.40	295	5.1248	2.5682
*11	Spot Improvement of Abodom- Kokotro Ph.1 1 (Km0.0 – 6.0)	May 2013	244.62	1.054	257.82	261	USED FOR VALIDATION	

***Used for validation. £1 = GH₵ 4.50 (at June 2014)**

COMPUTATIONS OF ADJUSTED COST FOR DFR PROJECTS - ASHANTI REGION

NO	NAME OF PROJECT	BASE MONTH/YEAR OF COMPLETION	ACTUAL COST GH¢ (000) - A	MEAN P.A.F INDICES - B	ADJUSTED COST (JAN 2014) - (000) AxB	ACTUAL DURATION (T) IN DAYS	LOG ADJUSTED COST	LOG ACTUAL DURATION T
12	Spot Improvement of Kokofu – Asamang (5.3Km)	May 2013	126.47	1.054	133.29	261	5.2447	2.5465
13	Spot Improvement of Keteke – Supong (6.8Km)	November 2013	261.54	1.015	265.46	548	5.4378	2.5453
14	Spot Improvement of Asankare -Dampong -Kwabeng Ph.4 (Km 10.0 – 13.6)	June 2013	168.51	1.042	175.69	299	5.6622	2.5539
*15	Spot Improvement of Boamang-Bedumase Ph.1 (Km 0.0 – 6.0)	May 2013	251.83	1.054	265.42	268	**USED FOR VALIDATION**	
16	Spot Improvement of Mankraso – Mpaepaemo (2.8Km)	August 2013	264.29	1.037	274.06	470	5.7113	2.6702
17	Spot Improvement of Abofour - Kyebi - Sabronum Ph.1 (Km 0.0 – 7.0)	August 2013	443.02	1.037	459.41	359	5.1867	2.5490
18	Spot Improvement of Abofour - Kyebi - Sabronum Ph.3 (Km 14.0 – 21.0)	May 2013	319.51	1.054	336.76	414	5.4816	2.6884
19	Spot Improvement of Ataase -Nkwanta - Hwediem Ph.1 (Km 0.0 – 5.0)	May 2013	488.02	1.054	514.37	405	5.7606	2.5809
20	Spot Improvement of Odumase - Kyeremebabi Ph.2 (Km 5.4 – 10.8)	September 2013	148.94	1.032	53.70	468	5.4173	2.6821
21	Spot Improvement of Kumawu – Drobonso (10.4Km)	March 2012	255.59	1.186	303.12	354	5.5149	2.5353
22	Rehabilitation of Gyereso - Aboabo – Bibiani (12.6Km)	August 2012	512.26	1.125	576.29	488	5.2507	2.7701
23	Spot Improvement of Bakame - Mamponteng – Ankaase (4.8Km)	June 2012	231.76	1.128	261.42	381	5.5856	2.6599

24	Spot Improvement of Dansabonso – Yawsafo (8.0Km)	September 2012	289.34	1.131	327.24	481	5.5900	2.6075
25	Spot Improvement of Tweapease Jn – Tweapease (4.0Km)	March 2012	150.17	1.186	178.10	343	5.8993	2.4609
26	Spot Improvement of Sekyere – Akrokyere (4.7Km)	December 2012	347.88	1.107	385.10	589	5.8888	2.5832
27	Rehabilitation of Fumso - Odemu – Anwhiam (10.0Km)	August 2012	345.84	1.125	389.07	457	6.1956	2.5502
28	Spot Improvement of Adomfe- Tanokrom (10.3Km)	April 2012	672.03	1.180	792.99	289	6.1091	2.7193
29	Rehabilitation of Kona - Brofoyedru-Adengensuagya (4.2Km)	May 2012	672.03	1.152	774.18	383	5.9016	2.5539
30	Rehabilitation of Aframso - Nkyensie (8.34Km)	November 2012	1,545.62	1.015	1,568.80	355	6.2265	2.5635
*31	Rehabilitation of Kabre-Nyinasie (7.6Km)	August 2013	812.01	1.037	842.05	380	**USED FOR VALIDATION**	
*32	Rehabilitation of Bosomkyekye-Ouagadugu (12.5Km)	May 2013	1,562.79	1.054	1,647.18	549	**USED FOR VALIDATION**	
33	Rehabilitation of Aframso- Kyeiase (14.1Km)	May 2013	1,219.84	1.054	1,285.71	524	6.1956	2.5502
34	Rehabilitation of Ejura Nkwanta –Kabre (7.6Km)	November 2012	785.51	1.015	797.29	358	6.1091	2.7193
35	Rehabilitation of Dome-Asasebonsa (9.8Km)	November 2012	1,659.53	1.015	1,684.42	366	5.9016	2.5539

COMPUTATIONS OF ADJUSTED COST FOR DFR PROJECTS - BRONG AHAFO REGION

NO	NAME OF PROJECT	BASEMONTH/YEAR OF COMPLETION	ACTUAL COST GH¢ (000) - A	MEAN P.A.F INDICES - B	ADJUSTED COST (JAN 2014) -AxB	ACTUAL DURATION IN DAYS	LOG ADJUSTED COST	LOG ACTUAL DURATION T
1	Spot Improvement of Subinso - Boase (4.6Km)	January 2012	295.14	1.226	361.84	245	5.5585	2.3892
2	Rehabilitation of Adamu - Kwajilongo (6.0Km)	October 2012	470.86	1.115	525.00	527	5.7202	2.7218
3	Rehabilitation of Wrukwai Jn - Wrukwa (9.1Km)	July 2012	593.30	1.123	666.27	266	5.8237	2.4249
4	Rehabilitation of Hani-Namasa (8.0Km)	September 2012	808.22	1.131	914.09	494	5.9610	2.6937
*5	Rehabilitation of Kupongkrom-Kyekyewere (8.9Km) & YepimsoKm)	September 2012	542.60	1.131	613.68	507	**USED FOR VALIDATION**	
6	Spot Improvement of Jinijini - Nifakrom (8.6Km)	December 2012	375.62	1.107	415.80	602	5.6189	2.7796
*7	Spot Improvement of Weila – Gumboi - Dwere (8.4Km)	January 2012	360.00	1.226	441.36	245	**USED FOR VALIDATION**	
*8	Rehabilitation of Kwame Tente – Jaro - Nsuhunu (9.6Km)	January 2012	638.06	1.226	779.80	254	**USED FOR VALIDATION**	
9	Rehabilitation of Brohani - Namasa (8.0Km)	February 2013	975.84	1.097	1,070.49	603	6.0296	2.7803
10	Surfacing of Odumase–Nkwabeng–Abuentem & Others Ph.1 (Km 0.0 – 2.8)	August 2012	1,641.61	1.125	1,846.80	376	6.2664	2.5752
11	Surfacing of Mehami Jn – Dadiesoaba Ph.1 (Km 0.00-6.00)	April 2012	2,093.34	1.180	2,470.14	272	6.3927	2.4346
12	Surfacing of Nyamebekyere-Sankore-Buako Ph. 1 (Km 0.00-6.0)	April 2013	3,455.21	1.054	3,641.79	596	6.5613	2.7752
*13	Surfacing of Odumase–Nkwabeng–Abuentem Ph.3 (Km 5.80 – 11.60)	February 2013	1,831.89	1.097	2,009.58	426	**USED FOR VALIDATION**	

NO	NAME OF PROJECT	BASEMONTH/YEAR OF COMPLETION	ACTUAL COST GH¢ (000) - A	MEAN P.A.F INDICES - B	ADJUSTED COST (JAN 2014) -AxB	ACTUAL DURATION IN DAYS	LOG ADJUSTED COST	LOG ACTUAL DURATION T
14	Rehabilitation of Hwidiem-Makyin Mabre (Km 0.00-10.40)	January 2013	1,010.62	1.097	1,108.65	410	6.0448	2.6128
15	Rehabilitation of Makyin Mabre Jn-Yerepemso (Km 0.00-10.10)	November 2012	1,061.04	1.015	1,076.95	364	6.0322	2.5611
16	Rehabilitation of Brahoho-Dompoase-Meta (Km 0.00-14.20)	August 2012	1,370.32	1.125	1,541.61	278	6.1880	2.4440
14	Rehabilitation of Hwidiem-Makyin Mabre (Km 0.00-10.40)	January 2013	1,010.62	1.097	1,108.65	410	6.0448	2.6128
15	Rehabilitation of Makyin Mabre Jn-Yerepemso (Km 0.00-10.10)	November 2012	1,061.04	1.015	1,076.95	364	6.0322	2.5611
16	Rehabilitation of Brahoho-Dompoase-Meta (Km 0.00-14.20)	August 2012	1,370.32	1.125	1,541.61	278	6.1880	2.4440
17	Spot Improvement of Kosua - Jinijini (Km 0.0 – 3.30)	May 2013	253.20	1.054	266.87	235	5.4263	2.3711
18	Spot Improvement of Kwanteng Jn - Kwanteng (Km 0.0 – 7.2)	July 2013	241.26	1.042	251.39	295	5.4003	2.4698
19	Spot Improvement of Kojokumikrom - Kwakuanya (Km 0.0 – 16.8)	September 2013	374.99	1.032	386.98	368	5.5877	2.5658

COMPUTATIONS OF ADJUSTED COST FOR DFR PROJECTS - BRONG AHAFO REGION

NO	NAME OF PROJECT	BASE MONTH/YEAR OF COMPLETION	ACTUAL COST GH¢ (000) - A	MEAN P.A.F INDICES - B	ADJUSTED COST (JAN 2014) -AxB	ACTUAL DURATION IN DAYS	LOG ADJUSTED COST	LOG ACTUAL DURATION T
20	Spot Improvement of Rubi - Beposo (Km 0.0 – 11.2)	October 2013	235.33	1.027	241.68	388	5.3832	2.5888
21	Spot Improvement of Kumagyamire Jn – Kumagyamire (Km 0.0 – 4.0)	September 2013	182.66	1.032	188.50	360	5.2753	2.5563
*22	Spot Improvement of Pomaakrom – Manukrom (Km 0.0 – 4.5)	February 2013	235.81	1.097	258.66	135	USED FOR VALIDATION	
23	Spot Improvement of Nkrankwanta – Yambediagoro (Km 0.0 – 4.8)	May 2013	244.60	1.054	257.80	234	5.4113	2.3692
24	Spot Improvement of Wamanafo – Bofotire (Km 0.0 – 4.5)	May 2013	229.23	1.054	241.60	222	5.3831	2.3464
25	Spot Improvement of Bomaa - Dwenase – Maabeng (Km 0.0 – 16.8)	May 2013	177.42	1.054	187.00	225	5.2718	2.3522
26	Spot Improvement of Sekyerekrom – Krobo (Km 0.0 – 1.2)	December 2013	73.45	1.014	74.47	433	4.8719	2.6365
27	Spot Improvement of Baanue Nkwanta – Wawasua (Km 0.0 – 7.8)	December 2013	320.69	1.014	325.17	438	5.5121	2.6415
28	Spot Improvement of Ebetoda - Wam - Ogyam (Km 0.0 – 14.7)	December 2013	161.33	1.014	163.58	425	5.2137	2.6284
29	Spot Improvement of Kwapong - Abeetewoa - Manhyia (Km 0.0 – 8.1)	December 2013	154.33	1.014	156.49	434	5.1945	2.6375
30	Spot Improvement of Bitre Jn - Kwamepua (Km 0.0 – 26.6)	December 2013	339.62	1.014	344.37	433	5.5370	2.6365
31	Spot Improvement of Kwaduakrom - Akwaboh (Km 0.0 – 2.0)	May 2013	130.01	1.054	137.03	214	5.1368	2.3304

NO	NAME OF PROJECT	BASEMONTH/YEAR OF COMPLETION	ACTUAL COST GH¢ (000) - A	MEAN P.A.F INDICES - B	ADJUSTED COST (JAN 2014) -AxB	ACTUAL DURATION IN DAYS	LOG ADJUSTED COST	LOG ACTUAL DURATION T
32	Spot Improvement of Antwirofo - Danyame Ph.1 (Km 0.0 - 9.0)	May 2013	209.45	1.054	220.76	219	5.3439	2.3404
33	Spot Improvement of Gyaenkontabu Jn - Gyaekontabu (Km 0.0 – 1.0)	May 2013	102.11	1.054	107.62	212	5.0319	2.3263
34	Spot Improvement of Terchire - Adrobaa (Km 0.0 – 6.1)	June 2013	190.50	1.042	198.50	251	5.2978	2.3997
35	Spot Improvement of Antwirofo - Danyame Ph.2 (Km 9.0 - 17.3)	June 2013	287.46	1.042	299.53	244	5.4764	2.3874

APPENDIX 2: COMPUTATION OF PRICE ADJUSTMENT FACTORS

BASE MONTH :	JANUARY, 2012				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		19,131.42	840.75	16,293.00	177,090.00	534,600.00	119,230.65	50,659.35	19,014.18	5,570.99	1,000.00	379.30	-
INDICES		1.22	1.36		1.32	1.31	1.46	1.04	1.15	1.11	1.00	1.26	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.04*	*0.88*		*0.15*							*0.14*	1.301
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.85*		*0.17*							*0.15*	1.301
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.05*	*0.07*		*0.01*		*0.51*		*0.39*			*0.14*	1.271
FORMWORK		0.15								0.50		0.25	
	0.10	*0.18*								*0.55*		*0.31*	1.151
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.05*	*0.08*		*0.03*			*0.68*				*0.16*	1.098
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.23*		*0.07*		*0.01*				*0.52*	*0.16*	1.119
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.31*		*0.04*	*0.38*			*0.23*			*0.16*	1.250
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.79*		*0.24*							*0.15*	1.299
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.10*	*0.30*		*0.05*		*0.07*	*0.02*	*0.09*	*0.02*		*0.49*	1.247
											AVERAGE	→	1.226

BASE MONTH :	MARCH, 2012				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	**X**	**a. LL LLo**	**b. PL PLo**	**x FE FEo**	**c. FU FUo**	**d. BI BIo**	**e. CE CEo**	**f. RS RSo**	**g. CH CHo**	**h. TI TIo**	**I. PC PCo**	**j. CO COo**	**Total PAF**
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		19,131.42	848.26	17,165.00	172,360.00	607,770.00	133,400.00	52,612.50	20,575.00	5,038.58	1,000.00	389.80	-
INDICES		1.22	1.28		1.36	1.16	1.31	1.00	1.06	1.23	1.00	1.22	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.04*	*0.83*		*0.15*							*0.13*	1.249
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.80*		*0.18*							*0.15*	1.251
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.05*	*0.06*		*0.01*		*0.46*		*0.36*			*0.13*	1.179
FORMWORK		0.15								0.50		0.25	
	0.10	*0.18*								*0.61*		*0.31*	1.201
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.05*	*0.08*		*0.03*			*0.65*				*0.16*	1.065
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.22*		*0.07*		*0.01*				*0.52*	*0.16*	1.101
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.29*		*0.04*	*0.33*			*0.21*			*0.16*	1.165
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.74*		*0.24*							*0.15*	1.255
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.10*	*0.28*		*0.05*		*0.07*	*0.02*	*0.09*	*0.02*		*0.48*	1.204
											AVERAGE	→	**1.186**

BASE MONTH :	MAY, 2012				APPLICABLE MONTHS:		JANUARY, 2014						

WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		19,131.42	851.67	18,518.00	172,360.00	640,710.00	135,922.58	48,300.00	20,590.83	5,146.60	1,000.00	403.90	-
INDICES		1.22	1.18		1.36	1.10	1.28	1.09	1.06	1.20	1.00	1.18	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.04*	*0.77*		*0.15*							*0.13*	1.181
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.74*		*0.18*							*0.14*	1.184
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.05*	*0.06*		*0.01*		*0.45*		*0.36*			*0.13*	1.161
FORMWORK		0.15								0.50		0.25	
	0.10	*0.18*								*0.60*		*0.29*	1.177
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.05*	*0.07*		*0.03*			*0.71*				*0.15*	1.111
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.20*		*0.07*		*0.01*				*0.52*	*0.15*	1.079
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.27*		*0.04*	*0.32*			*0.21*			*0.15*	1.119
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.68*		*0.24*							*0.14*	1.193
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.10*	*0.26*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.46*	1.166
											AVERAGE	→	**1.152**

BASE MONTH :	JUNE, 2012				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		19,131.42	852.92	19,033.00	172,360.00	640,710.00	152,950.00	48,300.00	21,565.67	5,293.21	1,000.00	409.50	-
INDICES		1.22	1.14		1.36	1.10	1.14	1.09	1.01	1.17	1.00	1.16	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.04*	*0.74*		*0.15*							*0.13*	1.157
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.72*		*0.18*							*0.14*	1.161
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.05*	*0.06*		*0.01*		*0.40*		*0.34*			*0.13*	1.091
FORMWORK		0.15								0.50		0.25	
	0.10	*0.18*								*0.58*		*0.29*	1.157
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.05*	*0.07*		*0.03*			*0.71*				*0.15*	1.107
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.19*		*0.07*		*0.01*				*0.52*	*0.15*	1.069
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.26*		*0.04*	*0.32*			*0.20*			*0.15*	1.100
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.66*		*0.24*							*0.14*	1.172
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.10*	*0.25*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.45*	1.140
											AVERAGE	→	1.128

BASE MONTH : **AUGUST, 2012** **APPLICABLE MONTHS** **JANUARY, 2014**

WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		19,131.42	854.63	19,244.00	172,360.00	640,710.00	152,950.00	48,300.00	21,550.83	5,216.05	1,000.00	409.20	-
INDICES		1.22	1.13		1.36	1.10	1.14	1.09	1.01	1.18	1.00	1.16	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.04*	*0.73*		*0.15*							*0.13*	1.148
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.71*		*0.18*							*0.14*	1.152
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.05*	*0.06*		*0.01*		*0.40*		*0.34*			*0.13*	1.091
FORMWORK		0.15								0.50		0.25	
	0.10	*0.18*								*0.59*		*0.29*	1.165
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.05*	*0.07*		*0.03*			*0.71*				*0.15*	1.107
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.19*		*0.07*		*0.01*				*0.52*	*0.15*	1.067
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.26*		*0.04*	*0.32*			*0.20*			*0.15*	1.097
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.65*		*0.24*							*0.14*	1.163
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.10*	*0.25*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.45*	1.138
											AVERAGE	→	**1.125**

BASE MONTH :	SEPTEMBER, 2012			APPLICABLE MONTHS	JANUARY, 2014								
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		19,131.42	852.47	19,250.00	172,360.00	640,710.00	152,950.00	48,300.00	21,450.67	5,092.59	1,000.00	402.90	-
INDICES		1.22	1.13		1.36	1.10	1.14	1.09	1.02	1.21	1.00	1.18	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.04*	*0.74*		*0.15*							*0.13*	1.151
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.71*		*0.18*							*0.14*	1.156
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.05*	*0.06*		*0.01*		*0.40*		*0.35*			*0.13*	1.095
FORMWORK		0.15								0.50		0.25	
	0.10	*0.18*								*0.61*		*0.30*	1.184
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.05*	*0.07*		*0.03*			*0.71*				*0.15*	1.109
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.19*		*0.07*		*0.01*				*0.52*	*0.15*	1.070
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.26*		*0.04*	*0.32*			*0.20*			*0.15*	1.101
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.66*		*0.24*							*0.14*	1.167
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.10*	*0.25*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.46*	1.147
											AVERAGE	→	1.131

BASE MONTH :	OCTOBER, 2012				APPLICABLE MONTHS	JANUARY, 2014							
WORK SECTION	**X**	**a. LL LLo**	**b. PL PLo**	**x FE FEo**	**c. FU FUo**	**d. BI BIo**	**e. CE CEo**	**f. RS RSo**	**g. CH CHo**	**h. TI TIo**	**I. PC PCo**	**j. CO COo**	**Total PAF**
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		19,131.42	855.54	19,088.00	172,360.00	640,710.00	152,950.00	48,300.00	21,450.67	7,098.77	1,000.00	399.00	-
INDICES		1.22	1.14		1.36	1.10	1.14	1.09	1.02	0.87	1.00	1.19	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.04*	*0.74*		*0.15*							*0.13*	1.156
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.72*		*0.18*							*0.14*	1.161
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.05*	*0.06*		*0.01*		*0.40*		*0.35*			*0.13*	1.096
FORMWORK		0.15								0.50		0.25	
	0.10	*0.18*								*0.43*		*0.30*	1.016
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.05*	*0.07*		*0.03*			*0.71*				*0.16*	1.111
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.19*		*0.07*		*0.01*				*0.52*	*0.16*	1.072
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.26*		*0.04*	*0.32*			*0.20*			*0.16*	1.103
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.66*		*0.24*							*0.14*	1.172
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.10*	*0.25*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.47*	1.145
											AVERAGE	→	**1.115**

BASE MONTH :	NOVEMBER, 2012.				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		19,131.42	861.00	18,977.00	172,360.00	640,710.00	152,950.00	48,300.00	21,450.67	4,683.64	1,000.00	401.10	-
INDICES		1.22	1.14		1.36	1.10	1.14	1.09	1.02	1.32	1.00	1.19	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.04*	*0.74*		*0.15*							*0.13*	1.155
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.72*		*0.18*							*0.14*	1.159
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.05*	*0.06*		*0.01*		*0.40*		*0.35*			*0.13*	1.095
FORMWORK		0.15								0.50		0.25	
	0.10	*0.18*								*0.66*		*0.30*	1.239
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.05*	*0.07*		*0.03*			*0.71*				*0.15*	1.110
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.19*		*0.07*		*0.01*				*0.52*	*0.15*	1.071
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.26*		*0.04*	*0.32*			*0.20*			*0.15*	1.103
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.66*		*0.24*							*0.14*	1.171
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.10*	*0.25*		*0.05*		*0.06*	*0.02*	*0.08*	*0.03*		*0.46*	1.152
											AVERAGE	→	1.139

BASE MONTH :	**DECEMBER, 2012**				**APPLICABLE MONTHS**		**JANUARY, 2014**						
WORK SECTION	**X**	**a. LL LLo**	**b. PL PLo**	**x FE FEo**	**c. FU FUo**	**d. BI BIo**	**e. CE CEo**	**f. RS RSo**	**g. CH CHo**	**h. TI TIo**	**I. PC PCo**	**j. CO COo**	**Total PAF**
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		19,131.42	862.70	19,001.00	172,360.00	640,710.00	152,950.00	52,612.50	21,450.67	6,728.40	1,000.00	404.00	-
INDICES		1.22	1.13		1.36	1.10	1.14	1.00	1.02	0.92	1.00	1.18	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.04*	*0.74*		*0.15*							*0.13*	1.152
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.71*		*0.18*							*0.14*	1.156
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.05*	*0.06*		*0.01*		*0.40*		*0.35*			*0.13*	1.094
FORMWORK		0.15								0.50		0.25	
	0.10	*0.18*								*0.46*		*0.29*	1.036
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.05*	*0.07*		*0.03*			*0.65*				*0.15*	1.050
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.19*		*0.07*		*0.01*				*0.52*	*0.15*	1.070
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.26*		*0.04*	*0.32*			*0.20*			*0.15*	1.101
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.66*		*0.24*							*0.14*	1.167
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.10*	*0.25*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.46*	1.138
											AVERAGE	**→**	**1.107**

BASE MONTH :	JANUARY, 2013				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	866.57	19,040.00	172,360.00	640,710.00	152,950.00	48,300.00	21,450.67	6,728.40	1,000.00	412.60	-
INDICES		1.00	1.13		1.36	1.10	1.14	1.09	1.02	0.92	1.00	1.15	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.73*		*0.15*							*0.13*	1.138
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.71*		*0.18*							*0.14*	1.144
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.06*		*0.01*		*0.40*		*0.35*			*0.13*	1.083
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.46*		*0.29*	0.997
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.07*		*0.03*			*0.71*				*0.15*	1.096
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.19*		*0.07*		*0.01*				*0.52*	*0.15*	1.061
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.26*		*0.04*	*0.32*			*0.20*			*0.15*	1.091
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.65*		*0.24*							*0.14*	1.156
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.25*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.45*	1.111
											AVERAGE	→	1.097

BASE MONTH :	FEBRUARY , 2013				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	868.84	19,061.00	172,360.00	640,710.00	152,950.00	52,612.50	21,467.10	5,493.83	1,000.00	423.40	-
INDICES		1.00	1.12		1.36	1.10	1.14	1.00	1.02	1.12	1.00	1.13	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.73*		*0.15*							*0.12*	1.132
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.71*		*0.18*							*0.14*	1.138
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.06*		*0.01*		*0.40*		*0.35*			*0.12*	1.079
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.56*		*0.28*	1.093
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.07*		*0.03*			*0.65*				*0.15*	1.034
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.19*		*0.07*		*0.01*				*0.52*	*0.15*	1.056
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.26*		*0.04*	*0.32*			*0.20*			*0.15*	1.086
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.65*		*0.24*							*0.14*	1.150
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.25*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.44*	1.101
											AVERAGE	→	1.097

BASE MONTH :	MARCH, 2013				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	868.95	19,254.00	189,040.00	640,710.00	152,950.00	52,612.50	22,107.60	6,250.00	1,000.00	430.50	-
INDICES		1.00	1.11		1.24	1.10	1.14	1.00	0.99	0.99	1.00	1.11	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.72*		*0.14*							*0.12*	1.109
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.70*		*0.16*							*0.13*	1.113
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.06*		*0.01*		*0.40*		*0.34*			*0.12*	1.065
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.49*		*0.28*	1.020
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.07*		*0.02*			*0.65*				*0.14*	1.028
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.19*		*0.06*		*0.01*				*0.52*	*0.14*	1.046
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.26*		*0.04*	*0.32*			*0.20*			*0.14*	1.072
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.64*		*0.22*							*0.13*	1.119
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.24*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.43*	1.081
											AVERAGE	→	1.073

BASE MONTH :	**APRIL, 2013**				**APPLICABLE MONTHS**		**JANUARY, 2014**						
WORK SECTION	**X**	**a. LL LLo**	**b. PL PLo**	**x FE FEo**	**c. FU FUo**	**d. BI BIo**	**e. CE CEo**	**f. RS RSo**	**g. CH CHo**	**h. TI TIo**	**I. PC PCo**	**j. CO COo**	**Total PAF**
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	871.11	19,469.00	206,832.00	640,710.00	152,950.00	54,337.50	22,365.67	6,327.16	1,000.00	438.20	-
INDICES		1.00	1.09		1.13	1.10	1.14	0.97	0.98	0.98	1.00	1.09	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.71*		*0.12*							*0.12*	1.086
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.69*		*0.15*							*0.13*	1.087
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.05*		*0.01*		*0.40*		*0.33*			*0.12*	1.057
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.49*		*0.27*	1.010
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.07*		*0.02*			*0.63*				*0.14*	1.002
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.19*		*0.06*		*0.01*				*0.52*	*0.14*	1.035
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.25*		*0.03*	*0.32*			*0.20*			*0.14*	1.060
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.63*		*0.20*							*0.13*	1.089
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.24*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.42*	1.064
											AVERAGE	**→**	**1.054**

BASE MONTH :	MAY, 2013				APPLICABLE MONTHS		JANUARY, 2014						

WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	871.23	19,624.00	206,832.00	640,710.00	152,950.00	50,025.00	21,920.51	6,466.05	1,000.00	447.90	-
INDICES		1.00	1.09		1.13	1.10	1.14	1.06	1.00	0.95	1.00	1.06	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.71*		*0.12*							*0.12*	1.077
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.68*		*0.15*							*0.13*	1.079
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.05*		*0.01*		*0.40*		*0.34*			*0.12*	1.061
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.48*		*0.27*	0.993
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.07*		*0.02*			*0.69*				*0.14*	1.053
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.18*		*0.06*		*0.01*				*0.52*	*0.14*	1.031
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.25*		*0.03*	*0.32*			*0.20*			*0.14*	1.059
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.63*		*0.20*							*0.13*	1.081
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.24*		*0.05*		*0.06*	*0.02*	*0.08*	*0.02*		*0.41*	1.056
											AVERAGE	→	1.054

BASE MONTH :	JUNE, 2013				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	872.25	19,865.00	208,971.55	640,710.00	152,950.00	50,025.00	21,790.67	7,083.33	1,000.00	455.40	-
INDICES		1.00	1.07		1.12	1.10	1.14	1.06	1.00	0.87	1.00	1.05	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.70*		*0.12*							*0.12*	1.065
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.68*		*0.15*							*0.13*	1.066
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.05*		*0.01*		*0.40*		*0.34*			*0.12*	1.060
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.44*		*0.26*	0.947
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.06*		*0.02*			*0.69*				*0.14*	1.050
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.18*		*0.06*		*0.01*				*0.52*	*0.14*	1.026
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.25*		*0.03*	*0.32*			*0.20*			*0.14*	1.055
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.62*		*0.20*							*0.13*	1.069
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.24*		*0.04*		*0.06*	*0.02*	*0.08*	*0.02*		*0.41*	1.044
											AVERAGE	→	1.042

BASE MONTH :	**JULY, 2013**				**APPLICABLE MONTHS**	**JANUARY, 2014**							

WORK SECTION	**X**	**a. LL LLo**	**b. PL PLo**	**x FE FEo**	**c. FU FUo**	**d. BI BIo**	**e. CE CEo**	**f. RS RSo**	**g. CH CHo**	**h. TI TIo**	**I. PC PCo**	**j. CO COo**	**Total PAF**
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	873.16	19,927.00	212,406.37	640,710.00	152,950.00	51,750.00	21,790.67	6,373.46	1,000.00	459.40	-
INDICES		1.00	1.07		1.10	1.10	1.14	1.02	1.00	0.97	1.00	1.04	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.69*		*0.12*							*0.11*	1.059
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.67*		*0.14*							*0.12*	1.060
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.05*		*0.01*		*0.40*		*0.34*			*0.11*	1.059
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.48*		*0.26*	0.994
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.06*		*0.02*			*0.66*				*0.13*	1.025
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.18*		*0.06*		*0.01*				*0.52*	*0.13*	1.023
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.25*		*0.03*	*0.32*			*0.20*			*0.13*	1.052
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.62*		*0.20*							*0.12*	1.062
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.23*		*0.04*		*0.06*	*0.02*	*0.08*	*0.02*		*0.40*	1.040
											AVERAGE	→	**1.042**

BASE MONTH :	AUGUST, 2013				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	873.16	19,974.00	213,788.00	640,710.00	152,950.00	51,750.00	21,790.67	7,006.17	1,000.00	454.90	-
INDICES		1.00	1.06		1.10	1.10	1.14	1.02	1.00	0.88	1.00	1.05	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.69*		*0.12*							*0.12*	1.058
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.67*		*0.14*							*0.13*	1.059
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.05*		*0.01*		*0.40*		*0.34*			*0.12*	1.060
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.44*		*0.26*	0.952
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.06*		*0.02*			*0.66*				*0.14*	1.026
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.18*		*0.05*		*0.01*				*0.52*	*0.14*	1.023
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.24*		*0.03*	*0.32*			*0.20*			*0.14*	1.052
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.62*		*0.20*							*0.13*	1.060
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.23*		*0.04*		*0.06*	*0.02*	*0.08*	*0.02*		*0.41*	1.042
											AVERAGE	→	**1.037**

BASE MONTH :	**SEPTEMBER, 2013**				**APPLICABLE MONTHS**		**JANUARY, 2014**						
WORK SECTION	**X**	**a. LL LLo**	**b. PL PLo**	**x FE FEo**	**c. FU FUo**	**d. BI BIo**	**e. CE CEo**	**f. RS RSo**	**g. CH CHo**	**h. TI TIo**	**I. PC PCo**	**j. CO COo**	**Total PAF**
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	873.16	19,990.00	219,023.95	702,000.00	152,950.00	56,062.50	21,665.17	6,466.05	1,000.00	450.20	-
INDICES		1.00	1.06		1.07	1.00	1.14	0.94	1.01	0.95	1.00	1.06	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.69*		*0.12*							*0.12*	1.055
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.67*		*0.14*							*0.13*	1.056
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.05*		*0.01*		*0.40*		*0.34*			*0.12*	1.063
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.48*		*0.26*	0.992
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.06*		*0.02*			*0.61*				*0.14*	0.976
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.18*		*0.05*		*0.01*				*0.52*	*0.14*	1.023
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.24*		*0.03*	*0.29*			*0.20*			*0.14*	1.026
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.62*		*0.19*							*0.13*	1.056
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.23*		*0.04*		*0.06*	*0.02*	*0.08*	*0.02*		*0.41*	1.045
											AVERAGE	→	**1.032**

BASE MONTH :	NOVEMBER, 2013				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	873.73	20,608.00	221,498.66	702,000.00	152,950.00	56,062.50	21,539.67	7,268.52	1,000.00	453.60	-
INDICES		1.00	1.03		1.06	1.00	1.14	0.94	1.02	0.85	1.00	1.05	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.67*		*0.12*							*0.12*	1.032
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.65*		*0.14*							*0.13*	1.033
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.05*		*0.01*		*0.40*		*0.35*			*0.12*	1.062
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.42*		*0.26*	0.937
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.06*		*0.02*			*0.61*				*0.14*	0.973
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.18*		*0.05*		*0.01*				*0.52*	*0.14*	1.016
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.24*		*0.03*	*0.29*			*0.20*			*0.14*	1.018
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.60*		*0.19*							*0.13*	1.034
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.23*		*0.04*		*0.06*	*0.02*	*0.08*	*0.02*		*0.41*	1.033
											AVERAGE	→	**1.015**

BASE MONTH :	DECEMBER, 2013				APPLICABLE MONTHS		JANUARY, 2014						
WORK SECTION	X	a. LL LLo	b. PL PLo	x FE FEo	c. FU FUo	d. BI BIo	e. CE CEo	f. RS RSo	g. CH CHo	h. TI TIo	I. PC PCo	j. CO COo	Total PAF
COMPUTED AVERAGE		23,298.42	879.86	21,101.00	234,256.06	702,000.00	174,387.13	52,875.00	21,867.14	6,172.84	1,000.00	476.40	-
MONTHLY COST		23,298.42	874.75	21,101.00	226,000.00	702,000.00	152,950.00	56,062.50	21,539.67	6,172.84	1,000.00	458.32	-
INDICES		1.00	1.01		1.04	1.00	1.14	0.94	1.02	1.00	1.00	1.04	
SITE CLEARANCE		0.03	0.65		0.11							0.11	
	0.10	*0.03*	*0.65*		*0.11*							*0.11*	1.012
EARTHWORKS		0.02	0.63		0.13							0.12	
	0.10	*0.02*	*0.63*		*0.13*							*0.12*	1.013
CONCRETEWORKS		0.04	0.05		0.01		0.35		0.34			0.11	
	0.10	*0.04*	*0.05*		*0.01*		*0.40*		*0.35*			*0.11*	1.059
FORMWORK		0.15								0.50		0.25	
	0.10	*0.15*								*0.50*		*0.26*	1.010
REINFORCEMENT		0.04	0.06		0.02			0.65				0.13	
STEEL	0.10	*0.04*	*0.06*		*0.02*			*0.61*				*0.14*	0.969
		0.02	0.17		0.05		0.01				0.52	0.13	
PRECAST CONC PIPES	0.10	*0.02*	*0.17*		*0.05*		*0.01*				*0.52*	*0.14*	1.009
		0.02	0.23		0.03	0.29			0.20			0.13	
SURFACING	0.10	*0.02*	*0.23*		*0.03*	*0.29*			*0.20*			*0.14*	1.011
		0.02	0.58		0.18							0.12	
HAULAGE OF AGG	0.10	*0.02*	*0.58*		*0.19*							*0.12*	1.015
		0.08	0.22		0.04		0.05	0.02	0.08	0.02		0.39	
GENERAL ITEMS	0.10	*0.08*	*0.22*		*0.04*		*0.06*	*0.02*	*0.08*	*0.02*		*0.41*	1.025
											AVERAGE	→	**1.014**