DEVELOPING A PROACTIVE COST MANAGEMENT MODEL FOR BUILDING PROJECTS IN NIGERIA

BY

YUSUF JOE GANDU

DEPARTMENT OF BUILDING
AHMADU BELLO UNIVERSITY ZARIA,
NIGERIA.

JUNE, 2015

DEVELOPING A PROACTIVE COST MANAGEMENT MODEL FOR BUILDING PROJECTS IN NIGERIA

BY

Yusuf Joe GANDU

BSc. QS (ABU, 1989), MSc. Const. Mgt. (ABU, 2005)

(PhD/ENV- DESIGN/08917/2006-07)

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA

IN FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTORATE OF PHILOSOPHY IN CONSTRUCTION MANAGEMENT

DEPARTMENT OF BUILDING
FACULTY OF ENVIRONMENTAL DESIGN
AHMADU BELLO UNIVERSITY ZARIA, NIGERIA

JUNE, 2015

DECLARATION

I declare that the work in this thesis entitled **DEVELOPING A PROACTIVE COST MANAGEMENT MODEL FOR BUILDING PROJECTS IN NIGERIA** has been carried out by me in the Department of Building under the supervision of Prof. I. Mbamali, Prof. I. K. Zubairu and Dr. Y. G. Musa-Haddary.

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or at any other institution.

Yusuf Joe GANDU	_____	_____
Name of student	Signature	Date

CERTIFICATION

The thesis titled "**DEVELOPING A PROACTIVE COST MANAGEMENT MODEL FOR BUILDING PROJECTS IN NIGERIA**" by Yusuf Joe GANDU meets the regulations governing the award of the degree of Doctor of Philosophy of the Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literal presentation.

_____ _____

Professor I. Mbamali — Date
Chairman, Supervisory Committee

_____ _____

Professor I. K. Zubairu — Date
Member, Supervisory Committee

_____ _____

Dr. Y. G. Musa-Haddary — Date
Member, Supervisory Committee

_____ _____

Dr. D. Kado — Date
Head of Department

_____ _____

Prof. K. Bala — Date
Dean, Post Graduate Studies

DEDICATION

This work is dedicated to my late younger brother, dad, mum and wife, in persons of Barrister Jebo J. Gandu (2000), Mr. Gandu Fain (2001), Mrs. Kpotong Gandu (2013) and Mrs. Debora Yusuf Gandu (2015) respectively.

ACKNOWLEDGEMENTS

My profound gratitude goes to Professor I. Mbamali, the Chairman of the Supervisory Committee and Professor I. K. Zubairu, Member of the Supervisory Committee for their tremendous guidance and support throughout the course of this work. So much of their time they offered and patiently guided me to complete this work. Dr. Y. G. Musa-Haddary, who joined the committee at a later date also did extensively well in going through my work and guiding me on how best to analyse and present the findings. I remain grateful to you all.

I will not forget the encouragement of the former Head of Building Department Professor Kabir Bala, the contributions of Dr. S. A. Bustani who was a member of the supervisory team at the initial stage, my head of department and all colleagues in the Department of Building and Quantity Surveying, ABU Zaria. I thank you all.

Accept my gratitude my late wife Mrs. Debora Yusuf Gandu. You understood why I had to keep several hours off your presence just because of this work. You encouraged me so much and provided the moral and material support to finish the thesis. However you short lived the time of award of this degree by few months. I remain grateful to you and will not forget the time we spent together. I thank my children Tikwain, Kure, Shuro and Sharo for their understanding also. My brothers Rev. Sani Magaji, Pastor Andrew Gandu and Mr. Aminu Gandu; and my sisters Mrs. Fatu Rabo and Mrs. Victoria Friday, together with their spouses, I appreciate your prayers and support.

The memory of my late Dad, Mum and Younger Brother still reminds me of kind words, encouragement and assurance for support in every of my goals. I cannot say when it will fade. Thank you once again Late Dad, Mum and Younger Brother. You

wielded great influence in my life. Finally, many friends and relatives, internal and external examiners, too numerous to mention in this little space, I thank you all.

ABSTRACT

Scholars posit for the reengineering of the traditional management concept that is still significantly applied in managing building projects. Blending with the conventional understanding of the theory of production and the uniqueness of construction projects, the concept clogs the wheel of progress in the practice of construction art. Apart from being late, the traditional management model, which is reactive in nature, responds to management challenges sub-optimally. This underscores poor cost and time efficacy in building contracts. While it is widely recommended that proactive management is a feasible way of addressing cost escalation (cost growth), the subject has so far received poor research attention. Synthesis suggestsan array of existing remedies to diverse cost management challenges, but with dearth of proactive tendencies. This thesis developed a proactive cost management model (PCMM) for building projects in Nigeria. Being proactive is essentially being preemptive in management. Theorising also is that cost growth which culminates from the dual dimensions of market forces and process flaws is fueled if not caused by poor prediction techniques. This work established four sub models, including: Lessons Learnt Mechanism, Graphical Models, Best Practice Modules and a Mathematical Model which formed the components of the PCMM. The Grubb's Method test of outliers, ANOVA, Kolmogorov-Smirnov Test of normality, Geometric Mean and Linear Correlation were applied to mass historical cost data collated over ten years. Analyses established the validity of the cost data as research samples. Computed were the historical total cost and the cost growth factors of various elements of a specified building design. Findings established annual elemental cost growth factors as: Substructure-0.1540; Frames-0.1580; Upper Floors-0.1180; Roof-0.1100; Staircase-0.0236; External Walls-0.3260; Internal Walls and Partitions-0.1720; Wall Finishes-0.0525; Floor Finishes-0.0810; Ceiling Finishes-0.0760 and Fittings and

Fixtures- 0.0710. Cost growth in construction projects in Nigeria was found to be significant over short period. Construction materials were classified into two categories, each category exhibiting a unique pattern of response to market forces. A mathematical model developed was used to predict the cost of a prototype building at various milestones. Values were compared with estimates obtained from first principle. A strong positive linear correlation coefficient of 0.92571 and a "no significant difference" between the samples were established. These pieces of information were fused into a PCMM that should be used to predict cost changes due to market forces and process flaws in ongoing building projects. Managers should also be mindful in the sequence of the assembly process, and the choice of inventory keeping and consumption, putting into cognisance the varying response levels of materials to market forces towards cost efficacy. A computer programme can be developed to implement this concept better. More historical cost data can be collated for another timeframe so as to compute and compare the cost growth factors towards establishing permanent values.

TABLE OF CONTENTS

Page no.

Title Page- - - - - - - - - ii

Declaration- - - - - - - - - iii

Certification- - - - - - - - - iv

Dedication- - - - - - - - - v

Acknowledgement- - - - - - - - - vi

Abstract- - - - - - - - - viii

Table of Contents- - - - - - - - - x

List of Tables- - - - - - - - - xiv

List of Figures- - - - - - - - - xvi

List of charts - - - - - - - - - xviii

List of modules- - - - - - - - - xix

List of Appendixes - - - - - - - - - xx

Abbreviations- - - - - - - - - xxi

CHAPTER 1: INTRODUCTION - - - - - 1

1.1 Background of the Study- - - - - - - - 1

1.2 Statement of Research Problem - - - - - 3

1.3 Justification for the Study - - - - - - 4

1.4 Aim and Objectives - - - - - - - - 5

1.4. 1 Aim - - - - - - - - - - 5

1.4.2 Objectives - - - - - - - - - 5

1.4.3 Research questions - - - - - - - - 6

1.6 Scope and Limitations- - - - - - - 6

Page no.

1.6.1 Scope - - - - - - - - - 6

1.6.2 Limitations - - - - - - - - 7

CHAPTER 2: LITERATURE REVIEW - - - - 9

2.1. Introduction of the Literature - - - - - - 9

2.1.1 Management of construction projects - - - - - 10

2.1.2 Construction projects process - - - - - - 11

2.1.3 Projects performance and challenges - - - - 12

2.1.4 Nature of cost growth in construction projects - - - 15

2.1.5 Project management process - - - - - - 19

2.2 Challenges to Construction Cost Management - - - 25

2.2.1 Effect of construction project characteristics - - - - 26

2.2.2 Wrong conceptualisation of construction production philosophy - 49

2.2.3 Poor planning and control of resources - - - - 57

2.2.4 Effect of the choice of procurement path - - - - 63

2.2.5 Poor estimating techniques - - - - - 88

2.2.6 The effect of change in construction projects - - - 101

2.3 Proffered Solutions to Cost Management Challenges - - 121

2.3.1 Process management - - - - - - - 122

2.3.2 Managing procurement options - - - - 129

2.3.3 Operational and technical techniques - - - - - 132

2.3.4 Strategic initiatives - - - - - - - 141

2.3.5 Quantitative techniques - - - - - - 154

2.4 Summary of the Literature Review - - - - - 159

Page no.

CHAPTER 3: RESEARCH METHODOLOGY - - - - 162

3.1 Research Design - - - - - - - 162

3.1.1 Theoretical framework - - - - - - 162

3.1.2 Data need for the research and their sources - - - - 163

3.2 Research Methods - - - - - - - 165

3.2.1 Data collection - - - - - - - 165

3.2.2 Treatment of empirical data - - - - - - 166

3.2.3 Data analysis - - - - - - - - 170

3.3 Model Development - - - - - - - 181

3.3.1 Process Monitoring Mechanism - - - - - 181

3.3.2 Mathematical Model Development - - - - - 181

3.3.3 Application of the mathematical model - - - - 185

3.3.4 Framework for proactive cost management - - - - 190

CHAPTER 4: DATA PRESENTATION, ANALYSIS AND DISCUSSION- 191

4.1 Data Presentation - - - - - - - 191

4.1.1 Challenges and remedies to construction project cost delivery - 191

4.1.2 Quantified standard design - - - - - - 202

4.1.3 Empirical cost data - - - - - - - - 202

4.2 Analysis of Data - - - - - - - 203

4.2.1 Analysis of classified impediments - - - - - 203

4.2.2 Analysis of cost data - - - - - - - 207

4.3 Discussions on the Results - - - - - - 231

4.3.1 Results of classified factors - - - - - - 231

Page no.

4.3.2 Results of graphical analysis - - - - - - 233

4.3.3 Results of statistical analysis - - - - - - 236

4.3.4 The framework for proactive cost management - - - 240

4.3.5 The proactive cost management model - - - - 242

CHAPTER 5: SUMMARY CONCLUSIONS AND RECOMMENDATIONS- 246

5.1 Summary of findings- - - - - - - - 247

5.2 Conclusions - - - - - - - - - 248

5.3 Recommendations - - - - - - - - 250

5.4 Areas for Further Research - - - - - - 252

REFERENCES - - - - - - - - - 253

APPENDIXES - - - - - - - - - 270

LIST OF TABLES

Page no.

Table 2.1: Factors affecting cost - - - - - - 18

Table 2.2 Stakeholders' "stake" in a construction project - - - 31

Table 2.3 Important causes of delay in Saudi Arabia - - - - 62

Table 2.4 Cost estimation process - - - - - - 90

Table 2.5 Cost estimation management process - - - - 91

Table 2.6 Change classification - - - - - - 105

Table 2.7 Stages, sources and impacts of construction changes - - 106

Table 2.8 Major decisions during project procurement - - - 210

Figure 2.9 Major decisions and the period change occurs - - - 115

Table 2.10 Waste in construction projects that should be eliminated- - 124

Table 2.11 Sources of variability in construction projects and control methods- 125

Table 2.12 Description of services provided by knowledge management system- 140

Table 3.1The Royal Institution of Chartered Surveyors Elemental Format - 175

Table 3.2 Elements adapted for the research - - - - - 176

Table 3.3 Yearly elemental cost growth ratio - - - - - 180

Table 4.1 Profile of respondents on classified factors impeding cost objectives- 192

Table 4.2 Classification of impediments to project cost objective - - 193

Table 4.3Classified impediments with high impact on project cost - - 195

Table 4.4 Classified impediments with moderate impact on project cost - 196

Table 4.5 Classified impediments with low impact on project cost - - 197

Table 4.6: Classification of items based on extent of cost growth - - 208

Table 4.7: Test for outliers on the historical cost data - - - 213

Table 4.8: Test for normality - - - - - - - 214

Page no.

Table 4.9 Historical composite unit rates (HCUR) - - - 216

Table 4.10: ANOVA Table single factor - - - - - 220

Table 4.11 Historical elemental cost schedule of a standard building - 221

Table 4.12: Yearly incremental rate of change of elements - - - 223

Table 4.13: Estimated and computed cost - - - - - 225

Table 4.14: Test of variance between estimated and the computed cost - 226

Table 4.15: Linear correlation coefficient - - - - -

226Table 4.16: Elemental cost information of a new building design- -

- 227

Table 4.17: Variance test for a new design- - - - - - 228

Table 4.18: Correlation test for the new design- - - - - 228

Table 4.19: Quarterly cost of the standard design - - - - 230

Table 4.20 Descriptive statistics of historical total cost - - -

230Table 4.21: The proactive cost management variables-

- - - 243

LIST OF FIGURES

Page no.

Figure 2.1: Construction stakeholders in a public works department - 32

Figure 2.2: Framework for successful management of construction stakeholders- 39

Figure 2.3: The conventional view of a production process - - - 50

Figure 2.4: Modern view of production as a flow process - - - 53

Figure 2.5: Historical development of procurement options - - - 65

Figure 2.6: Linear or sequential process of the traditional procurement system- 66

Figure 2.7: Communication paths in traditional procurement method - 67

Figure 2.8: Nature relationships in the traditional procurement method - 68

Figure 2.9: Structure of the integrated (Design and Build) procurement method- 71

Figure 2.10: The integrated process (Design and Build) procurement system- 72

Figure 2.11: The bridging procurement method - - - - 76

Figure 2.12: Planning model for building construction projects - - 86

Figure 2.13: Scope of change - - - - - - 103

Figure 2.14 Effects of delayed and changed decisions on cost and time - 117

Figure 3.1: Steps followed in the research work - - - - 164

Figure 4.1 Lessons learnt mechanism - - - - - - 203

Figure 4.2: Extent of cost growth in construction items - - - 207

Figure 4.3: Trend in highest values in fast cost grown items - - - 209

Figure 4.4: Trend in highest values in slow cost grown items - - - 209

Figure 4.5: Trend in lowest values in the fast group- - - - 210

Figure 4.6: trend in lowest values in the slow group - - - - 210

Figure 4.7 Yearly seasonal growths for fast group - - - - 212

Figure 4.8: Yearly seasonal growths for slow group - - - 212

Page no.

Figure 4.9: Proactive cost management framework - - - - 241

Figure 4.10: The proactive cost management model - - - - 244

LIST OF CHARTS

Page no.

Chart 3.1: Incremental rate in cost of projects - - - - 187

Chart 3.2: Proposed programme of work - - - - - 188

Chart 3.3: Cash flow of each element at the end of the completion schedule- 189

LIST OF MODULES

Page no.

Module 4.1: Cost management best practice - - - - 198

LIST OF APPENDICES

Page no.

Appendix I: Types of programs in the project lifecycle - - - 270

Appendix II: Causes of delay in construction projects - - - 272

Appendix: III: Alliance procurement process and success factors - - 273

Appendix IV: Factors causing cost escalation of projects - - 275

Appendix V: Earned value management process - - - - 278

Appendix VI: Historical cost data - - - - - - 281

Appendix VII: Critical values of z for various sample sizes of N - - 283

Appendix VIII: Questionnaire - - - - - - 284

Appendix IX: Elemental bill of quantities - - - - - 287

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
APSEC	Asia-Pacific Structural Engineering and Construction Conference
ARCOM	Association of Researchers in Construction Management
ASCE	American Society of Civil Engineers
BOQ	Bill of Quantities
BSc.	Bachelor of Science
CAD	Computer Aided Design
CIFE	Center for Integrated Facility Engineering
CCD	Construction Change Directives
CEM	Cost Estimation Management
CEP	Cost Estimation Practice
CF	Commitment Factor
CIC	Computer Integrated Construction
CIDB	Construction Industry Development Board
CII	Construction Industry Institute
CIOB	Chattered Institute of Building
CO	Change Order
CPI	Continuous Process Improvement
CRC	Cooperative Research Center
D&B	Design and Build
DBB	Design Bid and Build
DoT	Department of Transport
ECM	Engineering Change Management
EJCDC	Engineering Joint Contract Document Committee
EPRSC	Engineering and Physical Sciences Research Council
EV	Earned Value
EVA	Earned Value Analysis
EVM	Earned Value Management
FAT	Federal Transit Administration
FCG	Fast Cost Growth
FDP	First Data Point
FFC	Federal Facilities Council

FOS	Federal Office of Statistics
FTA	Federal Transit Administration
HCD	Historical Cost Data
HCUR	Historical Composite Unit Rates
HEC	Historical Elemental Cost
HND	Higher National Diploma
HTC	Historical Total Cost
IBS	Industrialized Building System
ICCIDC	International Conference on Construction in Developing Countries
ICT	Information and Communication Technology
IDEF	Integrated DEFinition language
IPT	Integrated Project Team
IT	Information Technology
JCT	Joint Contract Tribunal
KLICON	Knowledge Learning in Construction
KM	Knowledge Management
LDP	Last Data Point
MSc	Masters of Science Degree
NAO	National Audit Office
NASA	National Aeronautics and Space Administration
NCHRP	National Cooperative Highway Research Programme
NIQS	Nigerian Institute of Quantity Surveyors
NRC	National Research Council
NIST	National Institute of Research and Technology
OTT	Operational and Technical Techniques
PCMM	Proactive Cost Management Model
PCMV	Proactive Cost Management Variable
PCO	Proposed Change Order
PhD	Doctor of Philosophy
PLM	Product Life-Cycle Model
PM	Project Management
QS	Quantity Surveyor
RIBA	Royal Institute of British Architects
RCI	Relative Causes Index

RICS	Royal Institute of Chartered Surveyors
RII	Relative Importance Index
RLV	Ratio of Lowest Values
RHV	Ratio of Highest Values
SCG	Slow Cost Growth
SCM	Supply Chain Management
SR	Seasonal Ratio
STO	Specialist Task Organizations
TPM	Traditional Procurement Method
UK	United Kingdom
UKCG	United Kingdom Contractors Group
US	United States
USA	United States of America

CHAPTER 1: INTRODUCTION

1.1 Background of the Study

The construction industry delivers construction products like houses, hotels, hospitals, roads, dams and schools among others and plays very dominant role in the economy of nations (Oswald, 2001; Khan, 2008; Olusegun & Michael, 2011). The construction sector is viewed as the regulator/stimulator of national economic development (Szoke, 1977); the engine that drives the overall economy (Halpin & Woodhead, 1998); a barometer to gauge the economic performance of a country (Bustani *et al*., 2000), and the societies' wealth engine (Oswald, 2001). Khan (2008) capped it all by stating that the industry plays an essential role in the socio economic development of any country. However, uncertainty, variability, interdependence and complexity according to Harrison & Lock (2005), still bedevils the sector, thus making the management of construction projects difficult.

According to Fleming(2009), every project conceived has a set of objectives it seeks to attain which do also vary from project to project. Furthermore, Management at any time,as opined by Fleming (2007), seeks to achieve successful attainment of the identified objectives in projects. Bayraktar *et al.* (2011) included budget and schedule in the list of four goals identified as frequently forming part of project objectives. Cost, time and quality are found to form fundamental priorities of most project objectives (CIOB, 1997; Constructing Excellence, 2004; Muriro & Wood, 2010). However, the pair of cost and time frequently proves more difficult to manage when it relates to construction projects (Arditi *et al*., 1985; Raftery, 1993), and has become a long lingering problem in construction projects management practice.

To achieve the predetermined project objectives of cost, time, quality and function, great effort has been expended in the discipline of proper management (Williams, 2002), time, planning, material development (Bariga *et al*., 2005), procurement (Oyegoke, 2006; Rashid *et al*., 2006; Federal Facilities Council [FFC], 2007), life cycle costing, modeling and forecasting (Emley *et al*., 2002, Wong & Cheung, 2005). Despite these concerted management efforts, experts' assessment of the sector's performance still leaves much to be desired (Oglesby *et al*., 1989; Alarcon & Ashley, 1992; Mbachu, 1995; Wright 1997; Nguyeh *et al*., 2004; Anigbogwu *et al*., 2007). Literature is awash with stakeholders' lamentations on the poor performance of most construction projects including Nigeria (Thompson & Perry, 1992 in Willoughby, 2005; Anderson *et al*., 2007; Abanda *et al*., 2011). Unlike other sectors of the economy (e.g. manufacturing), success in achieving predetermined cost plans are often difficult to meet in construction (Arditi *et al*., 1985; Giwa, 1988a; Raftery, 1993; Flyvbjerg *et al*., 2003; Shane *et al*., 2009). These projects are often completed well beyond acceptable budget limits, a phenomenon best referred to as cost growth by Merrow *et al*. (1981). This undesirable surge in project cost has variedly been described in diverse terminologies like cost overruns, cost increase and cost escalation (Brook, 1998; Creedy, 2006). These terms, as used in this work, mean the same, and define the positive change between the previous and later cost of an item, component or facility over a certain change in time and circumstance. Such growth in cost poses enormous challenges that often result to poor and unsatisfactory performance in the construction procurement process. Better and more effective mechanism is thus, needed to manage these cost growths to enhance the overall project success. Harrison and Lock (2005) and Bal *et al.,* (2013) buttressed this when they emphasised that management of construction projects be proactive in nature if more successful procurement must result.

This concurred with Harrison (1992) earlier argument that projects success should be assessed based on whether the project sponsor and other stakeholders are satisfied with the final outcome of the project rather than with a preset objective of the product. Being proactive in management(Arrow, 2008), involves a preemptive practice in formal discussion, documentation, tracking and reporting of project events by the project team in a consistent and structured way using a recognised and common language. Johnson (2010) acknowledged that such enables the detection of flaws in advance. This study has successfully developed a cost management model that satisfied this proactive demand in curbing projects' undesirable cost growth.

1.2 Statement of Research Problem

Cost management of construction projects is still largely traditional in Nigeria. This is so despite incessant calls for a switch to a more effective proactive model (Harrison & Lock, 2005; Arrow, 2008; Johnson, 2010;Bal *et al.*, 2013). The traditional model, as Creedy (2006) rightly observed, responds to flaws only when they occur. To Kern and Formoso (n.d), such a model is lacking in transparency and always belated in response to management challenges, thus, preventing the right identification and correction of production flow inefficiencies. Beeston (1987) added that the model responds inadequately to construction challenges especially at the early developmental stage (cited in Ogunsami & Fasoranbaku, 2000). Such traditional management practice is characterised by late delivery of projects, overran budgets, reduced functionality and unsatisfactory quality (Creedy, 2006). Lack of a better, effective and efficient proactive model to aid the ineffective and poor performing traditional cost management model forms the central challenge of this study.

1.3 Justification for the Study

It is agreed that procurement of construction facilities is generally capital intensive, and consumes a big chunk of the national capital budgets (Bustani *et-al*., 2000; Oswald, 2001). Managing cost in the sector therefore becomes very important as it creates savings for reinvestment and rapid development of the economy.Creedy (2006), Arrow (2008), Johnson (2010) and Gambo and Ashen (2012) have argued that since the traditional cost management model has outlived its time, models that are more proactive in nature should be developed. When construction cost objective fails, it often results in great economic loss. Both government and other owners of construction projects, contractors and construction workers are affected in one way or another. Unnecessary and incessant acrimony do also persist, resulting in avoidable dispute and dissatisfaction. Eventually, the project integrity is severely compromised.

Managing in a proactive way involves a lot of tenets some of which include proper general assessment, documentation and reporting of events during procurement (Arrow, 2008). The identification of those factors causing cost to grow; and the understanding of the pattern of the changes will add value to proactive management. Furthermore, there must be effective flow of information or communication among team members involved in the system. Therefore, apart from bringing project participants into close collaboration, the proactive model developed herein reduces risks and uncertainties that trail management activities by preempting the kind of challenges affecting management for proper andadequate response to them. The model is not intended to substitute the traditional way of project management, rather it is to complement the observed aspects of deficiencies inherent in it by injecting a proactive component in cost management. The model relates cost to time for the purpose of predicting changes vital in planning, monitoring and controlling of building construction projects. Vast information made

available also enables stakeholders' the proper understanding of how diverse building materials respond to market dynamics. When management effort is based on in-depth understanding of analysed trends, success in project procurement can better be guaranteed.

1.4 Aim and Objectives

1.4. 1 Aim

The aim of this research is to develop a proactive cost management model for building construction projects in Nigeria**.**

1.4.2 Objectives

The objectives of this research are to:

i. Identify impediments against successful construction cost management in the view of organising a lessons learning mechanism.
ii. Appraise proffered solutions to procurement challenges in the view of deriving best practice modules.
iii. Depict trends of cost growth from historical cost data for better understanding of how items respond to market forces.
iv. Establish a process framework for a proactive cost management model.
v. Derive a mathematical cost forecasting model for the prediction of cost changes during building procurement process.
vi. Develop a proactive cost management model.

1.4.3 Research questions

Three research questions that helped to keep this study within the original focus are:

i. Whether forces of change acting on prices of labour and materials do cause significant cost growth in Nigeria.

ii. Whether changes in market prices of labour and materials do cause significant cost growth in building cost in Nigeria.

iii. Whether building materials can be associated according to the level of cost growth occasioned by changes in their market prices.

iv. Whether significant cost growth in building projects occasioned by changes in their corresponding material prices can be retarded by deploying the proactive cost management model developed in this study.

1.5 Scope and Limitations

1.5.1 Scope

This work centers essentially on building construction projects in which a set of historical cost data of selected building materials were collated. The data on labour was collated along with that of materials to enable a complete cost analysis covering a time frame of ten years, from 1998 to 2007. Statistically, ten years is considered a long period and sufficient time enough to capture all significant influences on the trend in this kind of data behavior.This period data was collatedwas when the research began, and after then the consistency of the historicalcost data was no longer available to update from 2007 to a more recent timeframe. The elemental bill format was adapted in the research.

1.5.2 Limitations

The organisations reached out by this researcher to obtain historical cost data include practicing quantity surveying firms, marketers of building materials, published sources and the Federal Bureau for Statistics. The essence of consulting several organisations was to obtain vast data from varying sources that can be compared and sorted. However, obtaining the history of cost of materials and labour from all other sources contacted proved unattainable due to poor record keeping. By implication, there is a challenge of data keeping in many organisations in Nigeria, as such, consistent record of cost history of materials and labour was not found except in the Nigerian Institute of Quantity Surveyors (NIQS) quarterly publications. A consistent cost history from market survey reported for ten years, the kind of data desired, was found in the NIQS magazines published between 1998 and 2007. Quarterly market prices of labour and materials were reported within the period. After then, the institute fell into internal crises and failed in publishing further market survey. It was therefore not possible to update the data to a more recent timeframe beyond 2007. Building materials and labour prices were therefore extracted from the NIQS magazine'squarterly reports from market survey on several building items for the ten years found. The accuracy of predictions by the mathematical model derived in this work is therefore affected by the accuracy of the market prices the magazine documented. Information on services, and doors and windows components were found to be either insufficient or lacking at all in the NIQS publication. External works in building projects do not relate directly to the scope of the permanent structure. The works relate more to the space left out after construction than to the main structure, and also depends on the extent of investor's demand for it. The following elements: services, external works, doors and windows were therefore excluded from the items considered in this research. For the fact that not

all elements along with the associated materials were considered for developing the proactive model, it can be argued that those materials absent, though of less significant value in a building, could affect the result of the study. Therefore, all the excluded materials and elements are presumed to remain constant. Furthermore, the elemental format of bill preparation was used in developing the mathematical model. The model therefore cannot apply to other formats of bill preparations like the work sections, trades,sectionalised trades, operational and activity bills.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction of the Literature

A survey by the Building Cost Information Service (BCIS) of the Royal Institute of Chartered Surveyors [RICS] (2009) reported that the traditional procurement system is the method most widely employed to procure building projects in Nigeria as well as in many parts of the world. Coupled with the conventional management practice, building procurement was found to lag (Johnson, 2010; Gambo & Ashen, 2012) in cost and time efficacy. In order to develop a management model that will be proactive in nature and meets the desire of the building industry as set out to achieve in this work, it became imperative to explore widely the literature to understand what management seeks to achieve in building construction projects and what challenges in the current management art are. Understanding the recommended best practices posited by scholars, the inherent weaknesses in the current management practices and new directions in management are all prerequisite for an appropriate but feasible articulation of an alternative model to the existing one. This literature explored essentially on these areas, while not leaving out the need to understand the general concept of management; and as it relates to the management of building construction projects. This understanding offered the capacity to develop a new model that will fill the gap left open by the conventional management model, thus, impeding construction cost management processes. A proactive management model as discussed in this work, should manage knowledge properly, offer better understanding of how events occur in a process and contain aspects of predictive tendencies. It is along this direction that the literature exploration emphasised in order to achieve the desired objectives.

2.1.1 Management of Construction Projects

A project has been described as "a group of interrelated work activities constrained by a specific scope, budget, and schedule to deliver capital assets needed to achieve the strategic goals" (Fleming, 2009); and management has since been recognised as an art of rational pursuit of these goals (Fryer, 1990; Hugill& Ross, 2008). Others have viewed management differently; the concept of which has attained a multifaceted dimension and defies a simple universally accepted definition. While many argue that there is nothing special about management because it is not different from normal human routine, several others have attempted to define management, and yet no widely acceptable definition emerged (Fryer, 1990). Fryer (1990) then reviewed many definitions of the concept and showed how scholars identified the things managers do, how they do them and the management principles that should apply to all organisations. The author argued that the definitions reviewed fail to be specific about how and why managers do things and the task or processes involved in doing them, which should be made explicit in a wider definition. The author then defined management as "the process of steering an organisation towards the achievement of its objectives by means of technical skills for planning and controlling operations, and social skills for directing and coordinating the efforts of employees". This definition clearly stated the tasks of managers as to plan, coordinate and control with the aim of achieving set goals through the use of technical skills.

However, Fryer (1990) did not only omit clear explanation on what those objectives are, but those intrinsic impediments that deserve management actions were not clearly stated also. Other fundamental concepts which are yet to be explicit in all the definitions include relationships in terms of cooperation between a site manager and the site team, variances in planning techniques for different industries like factory and

construction, or if the same techniques can be used, and what the changing faces of management are- because many organisations like the construction firms have grown and their activities more complex compared to their past. Fryer (1990) agreed that some projects operate in a changing environment where "the ratio of managers to workers have increased, more specialists involved, many rules and procedures brought in to observe, the roles of participants more tightly defined, and more external controls affecting the system when compared to the past". This situation therefore makes a universal definition of management difficult. Koskela (1992) believes that poor conceptualisation of a theory leads to wrong or suboptimal responses to challenges. Even though a unified concept of management is still difficult, highlighting these factors discussed however, make managers aware of the kind of challenges to face at the onset of a project.

2.1.2 Construction projects process

Like any other production undertaking, construction projects pass through a process from the beginning to the end. The process is mostly viewed in light of its whole life-cycle, and four stages were given by Lockyer and Gordon (1996) to include concept, development, realisation and termination, and for each stage there are a set of steps involved. However, the procurement of a construction facility is achieved when the project is realised at the third stage. At this stage, production activities are completed and the project is said to have been procured. Handing over then takes place and the project either adjudged as properly managed or otherwise. It is in this light that Oyegoke (2006) and Seeley (1996) broadly divided the procurement process into planning and implementation stages. Planning involves conceiving, setting up the

supply chain, briefing them and the translation of the project concept into designs solutions, while implementation involves the assembly process until handover.

Koskela (1992) divided a project process into the design and the construction sub processes. A construction process consists of both planning and construction stages. The design sub process refers to the planning stage where specifications are refined, vague needs and wishes transformed into requirements and several steps result to detailed designs solutions. Koskela (1992) further sub divided the construction sub process into material process where materials flow to site, processed and assembled into products, and the work sub process which involves the construction team on site. There are other processes identified as means of control; and are only supportive processes to the two main sub processes of design and construction. These are-Project management process by the owner, Design management process by the engineer or design project manager, and Construction management process which includes plan for construction/fabrication, day-to-day coordination and control of processes on site or in a factory. This research considered construction process and its management in terms of design and construction.

2.1.3 Projects performance and challenges

2.1.3.1 Projects performance

Performance of construction projects has been measured against certain variables like time, budget and quality standards; and success is dependent on, amongst other factors, the performance of the contractor(s) who is/are entrusted to carry out a project (Ng. Thomas *et al.*, 2002). The performance of a constructed facility, scope requirements, acceptable risk, safety, and security levels have been accorded some level of importance in the success criteria by some scholars (Construction Excellence, 2004;

Fleming, 2009; Muriro & Wood, 2010). However, this concept of success was described as conventional. It was argued that the criteria for success should be wider than mere attainment of standards. It should include whether the project stakeholders (sponsor, owner or client and other parties) are satisfied with the final outcome of the project, and not to base success on meeting any preset objectives like time, cost, quality or performance (Harrison, 1992). Arguing on two grounds, the author first posited that the standards might be too optimistic and unachievable, or deliberately high just to achieve some other desires at the beginning of the project like to obtain approval for commissioning. Secondly, conditions in construction projects are non-static in nature apart from high risk and uncertainty. Initial standards or objectives can change or become unfeasibly based on new realities. With these, the author concluded that it is wrong to judge success on meeting standards initially specified.

The conceptualisation of successful projects on satisfaction by Harrison (1992) shifts the success judgment criteria from initial target at inception to the final outcome of a project. This conceptualisation will not only enable the incorporation of stakeholders' actual experiences into the judgment process, but will mindset stakeholders' work towards satisfactory project delivery other that overwhelmed by failing initial objectives. Stakeholders will be more ready to respond adequately to challenges other that pursuing outmoded objectives. Cost management is therefore a PM technique developed specifically to balance and optimise the cost of project's resources.

The unmitigated/unresolved failure in achieving objectives arising from diverse complex interrelationships of challenges in PM have brought about a need for an improved management method to enhance performance in construction projects delivery in the general. The traditional or conventional project management theories have been found to lack the requisite capacity to respond adequately to the persistent

challenges (Kern & Formoso, n.d; Creedy, 2006; Johnson, 2010). Lockyer and Gordon (1996) recommended proactive management as best practice to achieve success in construction procurement in which this researcher became interested. Arrow (2008) reported the tenets of a proactive approach to projects management to include:

i. Management committed to performance.
ii. Starting the management process early in the project lifecycle.
iii. All key stakeholders included in the process.
iv. Evaluating and updating responses periodically during the project life.
v. Following through with actions until risks are acceptable.
vi. Align a project's level of risk with cost and schedule contingencies and
vii. Effectively communicate to all key stakeholders the progress, changes and response plans.

This research is set to develop a model that will offer the possibility of achieving these tenets during building projects implementation.

2.1.3.2 Challenges to project performance

The goals of project management (PM) often require the utilisation of numerous resources in different challenging levels and measures of difficulties. Many of these difficulties lie in the availability and knowledge of means and ways to navigate forward; however, there is array of other important but less visible obstacles or constraints that block or misdirect/derail the good effort directed towards realisation of goals.

Array of factors have been identified as impediments to PM success. Researchers in the US and the UK identified major factors impeding smooth PM practice, and causing failure in achieving projects, vis-à-vis cost objectives. As reported by Harrison (1992),

findings in the UK identified eight significant pitfalls. The author also identified principal areas where shortcomings in management practice cause delay and subsequent cost growth in projects. A large number of factors were also identified in the US and classified into those factors affecting success, affecting failure and affecting both success and failure (Harrison, 1992). Bala (2000) also identified similar challenges in Nigeria. The findings in the UK, US and Nigeria presented much semblance in the kind of challenges which relate to:

a. Organisational structure (like communication structure, delegation of responsibilities).
b. Strategic reasons (Planning and control, realistic estimate, schedule).
c. Attitudinal or Human factors (commitment of participants, public interest, cordial relationship, personal interest).

These challenges exert pressure on building projects and cause significant cost growth above budgets.

2.1.4 Nature of cost growth in construction projects

Factors that pressure cost estimates of construction projects to change after the estimates have been prepared and agreed are many and complex (Kapano and Karshenas, 2003 cited in Gambo and Ashen, 2012). Changes can occur in the upward or downward directions (Anderson *et al*., 2007). However, the upward change causes greater concern. An estimate documented during placement of a contract (initial contract figure) remains the basis of implementation of the entire contract. The expectation of stakeholders is that the estimate should complete the project as specified. More succinctly, "estimates prepared by consultants are expected to forecast the anticipated actual cost of projects, give clients reliable idea of the financial outlay and also guide the implementation of projects" (Anigbogu *et al*., 2007). However, change

in the actual cost of labor, materials and components often occur over time. Many changes that occur in the market conditions including other factors identified by Anderson *et al*. (2007) are either from internal or external sources and often cause estimated cost to change and become unreliable. Their impact has forced initial contract figures, according to Brook (1998) and Abanda *et al*. (2011), to overrun. These overruns can only be mitigated with extra cost.

2.1.4.1 Extent of cost growth

Historical evidence suggests that the problems associated with project cost and time spans over a long period and is devastating; affecting all kinds of construction projects, and spreading across nations. For example:

i. Year 1869, Suez Canal was completed 3 times its estimate. (Flyvbjerg *et al*., 2003)
ii. Year 1914, the panama canal was completed 200% above budget (Flyvbjerg *et al*., 2003)
iii. Year 1974-1988, 1778 projects funded by the World Bank were found to overshoot their cost by 63%. About 1627 projects were also studied and 83% completed late (Thompson & Perry, 1992 in Willoughby, 2005)
iv. Year 1983-1988, 37 building projects that extended their time were studied in Nigeria, initial estimate was N2.55billion but completed at N5.55billion, that is about 117.65% cost growth (Giwa, 1988b).
v. Year 1988-2000 in Nigeria, the price of cement, a major building material has escalated by about 2000% (Bala, 2000)
vi. Nigeria has spent $5bn on the Ajaokuta Steel Complex project which was supposed to cost $650m (Omotoso, 2012).

Eight main ways for the client to avoid cost overruns as listed by the Office of Government Commerce (OGC, 2003) are to have:

a. objectives that are realistic and not changed during the course of the project
b. estimates for project approval that are realistic – that is, not unduly optimistic
c. a project brief that is complete, clear and consistent
d. a design that meets planning and statutory requirements
e. a design that is coordinated and takes account of buildability, maintainability, health and safety and sustainability
f. risk allocation that is unambiguous and clear to all parties involved
g. clear leadership and appropriate management controls
h. simple payment mechanisms that incentivise all parties to achieve a common and agreed goal.

However, other project team members have roles to play to mitigate cost growth and were considered in the later parts of this attestation.

2.1.4.2 Cost growth factors

The factors that cause cost to change have also been identified by scholars and categorised into those that stakeholders have greater influence and control, and those stakeholders have little or no influence at all (Nicholas and Steyn, 2008). Damnjanovic *et al.* (2009) described it as internal and external factors. In the first category, improper planning, delay, change and poor estimating do result from poor handling of the sub-processes by those involved. Project implementers handling sub-processes have greater control over and can influence their frequency of occurrence and impact on projects. Azhar (2008) described it as management related factors and can be controlled. The scholar believes that this category of factors can be foreseen, and also recommended some strategies to control some of the factors. Damnjanovic *et al.* (2009) gave further

examples of factors affecting cost and categorised their nature as either internally or externally controlled (Table 2.1).

Table 2.1: Factors Affecting Cost

Control	Factors Affecting Cost
Internal	Design
	Specifications
	Physical layout
	Project duration
	Project scope
	Size of the project
	Contract provisions
	Timing of the letting
	Communication
	Unique or complex design
	Accuracy of design and estimates
External	Competition
	Macroeconomic factors
	Local project conditions

(Source: Damnjanovic *et al*., 2009)

In the second category, stakeholders have little or no control over the occurrences of the factors, and the factors relate more to external conditions. Macroeconomic factors like forces of demand and supply affect them and cause inflation or price fluctuations (Stewart, 1995). Stewart (1995) concurred and defined inflation as "a time-oriented increase in costs brought by rising prices and rising costs of materials, sub-contracts, parts, supplies, goods and services and is entwined with the political, geographical and social government policies trends". The author stated further that inflation is a major source of cost growth in the construction sector and can hardly be controlled.

Even in the developed economies like the United States (US) economy, inflation remains an important factor in cost growth and posing great difficulty to cost estimators to understand and deal with. However, two ways of dealing with inflation was suggested by Stewart (1995). The first is through the use of cost indices or some form

of cost adjustment indices to predict and account for inflation in construction projects. The second is that trends can be observed, recorded, and used in estimating the cost of new works. This thesis was carried out in line with the later suggestion.

2.1.5 Project management process

2.1.5.1 Project management functions

Identified are several challenges that impede the project, or management, or stakeholders' objectives and cause failure in projects procurement efforts (Stewart, 1995, Damnjanovic *et al*., 2009, Abbasnejad & Nejati, 2013). The challenges which often affect all management aspects relating to budget, time and quality; and scope, human resource and equipment among others, are those PM seeks to overcome (Fleming, 2009; Muriro & Wood, 2010). There is a desire in management to achieve efficacy in the use of resources and ensure timely delivery of projects as budgeted and at the right quality specified. Many times, these objectives compete with each other and require skillful balancing throughout the project life cycle by the project manager (Bala, 2000; OGC, 2003; Aretoulis *et al.*, 2006;Carbasho, 2009; Fleming, 2009). However, delay is common in the Nigerian construction projects (Olusegun & Micheal, 2011). When management eliminates all forms of delay in the use of resources and controls the sequence of activities, it cushions the time and cost overruns (Sambasivan & Soon, 2006). Adesiyan (2014) listed four key functions of project management as follows:

a. Project integration and scope management: - where the achievement of a synergetic management of all the other functions and to balance the needs of

the organisation with the demands of the external environment requires deft political skill.

b. Project organisation and communications: - It is important to ensure that all team members remain focused on the task at hand. Communication will ensure that all the team members understand the goals of the team and the projects.

c. Risk, time and cost: - high uncertainty avoidance and a problematic and less stable social-political environment mean that parties are likely to use risk avoidance rather than minimisation strategies. Project managers should be aware of the influence of high rate of inflation on the projects.

d. Procurement and quality: - focus here should be on value in local terms. Local technologies should be encouraged at this point.

2.1.5.2 Process of project management

Project management process is contained in the general management functions of planning, forecasting, organising, coordinating, directing, communicating, monitoring and control (Nicholas & Steyn, 2008). PM process has been described variously, such as involving the overall planning, control and coordination of a project from inception to completion aimed at meeting client's requirements in order that the project will be completed on time, within authorised cost and to the required quality (Adesiyan, 2014). It involves planning and monitoring of the procurement process and taking corrective actions with the aim of achieving desired objectives of a project (Harris & McCaffer, 2001; Bala, 2000; Cooke & Williams, 2004; Nicholas & Steyn, 2008).

2.1.5.3 Project management techniques

According to Cooke and Williams (2004), "planning precedes any activity intended to be carried out in a project, and often concentrates early in the project lifecycle". However, plans must be controlled to make meaning. Planning and control activities therefore, are often carried out simultaneously and cannot be separated from each other. Without plan there can be nothing to control and without control a plan is a waste. As such, proper management involves planning, and then controlling what was planned (Harris & McCaffer, 2001).

Four stages in the construction process where planning programme is required have been recommended (see Appendix I). Some common planning tools were discussed by Harris and McCaffer (2001) and Cooke & Williams (2004), the choice of a tool should match the kind of project for the fact that the right tool can facilitate advantages to management. Among the most commonly used tools described by the Authors are the Bar Charts, Linked Bar Charts, Arrow Diagrams, Precedence Diagrams, Line of Balance, and Time-Chainage Diagrams; the choice depending largely upon the user and the project.

Primarily, the bar chart indicates time progress of projects. When delay occurs, it easily manifests and corrective measures taken to recover the lost periods in the subsequent tasks, as a result, plan is constantly brought back on course. Projects can therefore be completed in good time which translates into cost savings. The effect of delay in any activity is easily seen in the linked bar; and the time available for every activity also displayed more clearly. The arrow and precedence diagrammes (network) usually link activities by arrows. Relationships between activities are often clearly shown and critical ones indicated. While the networks offer an insight into resource requirement

which is important for planning, monitoring and control of projects, the bar charts offer simple but good information on work progress, especially when it relates to time lost or time gained (Haris & McCaffer, 2001; Cooke & Williams, 2004).

A critique of these tools reveals some extant common deficiencies in them. Management information are only derived from preceding activities or completed tasks within the project environment and considers little or nothing on long historical records, trends and the wider external economic environment that influences cost during execution. These techniques derive most lessons from immediate environment and latest experiences. Control therefore also centers on the succeeding task and offer less for the management of future trends of events across the entire project. Ayegoke (2006) also observed that planning and control techniques concentrate on setting milestones and comparing achievements against the milestones using the experiences obtained on completed tasks. Even though the practice of learning from completed tasks for the control of succeeding ones is an established norm in management (Halpin & Woodhead, 1989), there are limitations in such practices, especially in internal applications because the succeeding task may not share the same characteristics with the preceding one where the performance indicators were derived. If the performance of the preceding task is used to manage the succeeding task it can result to false warning. Finally, the tools can succinctly be described as being more reactive than proactive in nature, which calls for more research work on getting management tools that will offer the desired proactive tendencies for the benefit of construction projects.

2.1.5.4. Planning and controlling resources

Resources in construction constitute anything put into the production process to achieve the desired end product. Cooke and Williams (2004) listed time, money, equipment, material, and personnel as construction projects resources. Management of these resources according to the authors brings about successful procurement.

Time resource: Time is an intangible resource and the factor of time in construction projects is an important aspect of job management (Hugill& Ross, 2008). All projects have time constraints imposed on them, sometimes so inadequate to be realistic for the achievements of tasks (Willoughby, 2005; Ren, *et al.*, 2008).

Time as a resource is usually presented in a schedule of activities indicating the start and finishing time of projects tasks (Harris & McCaffer, 2001; Cooke & Williams, 2004; Nicholas & Steyn, 2008). According to Chan (n.d), this is the number of days/weeks from start to practical completion of a project and given as construction time equals practical completion date minus project commencement date. Time management therefore, is "toestablish a timeline with schedule milestones to be followed in delivering the projects in order to avoid schedule slippage" (Oyegoke, 2006). Milestones (dates) are set as a control tool in the construction phase to keep track of the work progress. It interfaces directly with scope, cost, and quality management when team members' roles and activities are defined (Oyegoke, 2006).

Equipment resource: Equipment used in construction projects constitute an important cost component that must be controlled to achieve better productivity, balanced budget and sequential flow of activities (Hugill & Ross, 2008). The term equipment refers to items the contractor uses to aid quick accomplishment of tasks like motor graders, power shovels, and pile drivers, etc. The use of equipment must match the need of the task to be carried out. Serious scrutiny must be made to identify the best equipment that

matches tasks in terms of efficiency and economy**.** When areas of excessive cost of production are identified, the kind of equipment recommended should be reassessed which might finally translate into reduced cost of that section of work (Hugill& Ross, 2008).

Personnel resource: For every task, there are perceived level of productivity expected from workers that can meet up with cost and time objectives. Where personnel perform below expectations, the time and cost overruns can result.According to Munroe (n.d), there are many factors that reduce productivity and are categorised under four headings as inefficiency, low morale, progress delayed and overtime. Proper management can eliminate most of the problems and achieve better time and budget control.

Money resource: Construction cost managementis a process ofensuring that a construction project is completed within approved budget (Oyegoke, 2006). There are various kinds of risk factors in construction that affect cost. Apart from inflation, when there are flaws in managing time, productivity, material, or equipment, the end effect contributes to additional money for production. Cost management is therefore linked to every sub-process in construction projects (Hanid *et al.*, 2010). According to Harris and McCaffer (2001), and Hugill and Ross (2008), cost management of construction projects involves the management of all other resources in the construction process.

Oyegoke (2006) subdivided cost management into the design and the construction phases. At the design phase, costs are planned, estimated, evaluated and analysed as design progresses in order to determine the most cost effective solution. At the construction phase, costs are controlled in order to deliver the project within budget. However, the lack of standard costing system in the construction sector, due to its unique characteristics, makes it lags behind in high productivity and efficiency. These

characteristics cause difficulties in effective management and control leading to failed cost objectives **(**Carbasho, 2009)**.** Muriro and Wood (2010) agreed that cost and time is more difficult to manage when compared to other project objectives.This instigates keen interest and needs to continuously probe into finding better ways of managing cost and time of construction projects.

2.2 Challenges to Construction Cost Management

The kinds of challenges to construction projects cost are multidimensional. Many factors have been found to cause cost to grow. Laryea (2010) documented main challenges as related to financial, political, organisational and the economic factors. These factors referred to as challenges impede successful projects cost objectives, and have been well studied in diverse forms (Rashid *et al.,* 2006; Yusof *et al.,* 2011). Various attempts have also been made to proffer solutions that cover the planning and implementation sub processes in the procurement process. Yet, the desired success level is still below expectations as projects still fail (Anderson *et al*., 2007; Abanda *et al*., 2011). Special management attention during procurement is therefore required if the level of success is to achieve (Aretoulis *et al.,* 2006).This work underwent a critical appraisal of the impediments vis-à-vis their proffered solutions which facilitated the possibility of developing a proactive way of managing construction projects. The proactive management model attempted to reengineer the entire management concept towards predictive tendencies. This section identified major impediments and discussed each of them in line with the objectives of this thesis. While the list might not be exhaustive, the key areas considered are as follows:

i. Effect of construction projects characteristics
ii. Wrong conceptualisation of construction production philosophy

iii. Poor planning and control of resources

iv. The effect of the choice of procurement path

v. Poor estimating techniques

vi. Effect of change in construction projects

These key areas are broad enough to capture widely major identified impediments to construction projects cost objectives in Nigeria.

2.2.1 Effect of construction project characteristics

Characteristic as defined by the Encarta Dictionary (2007) mean the features or qualities that make somebody or something recognisable. Without characteristics, it is difficult to describe or identify a person or an item, or to be able to distinguish something from another. A wide range of characteristics do exist and distinguish in a unique way all objects, processes and sub process in life (Koskela, 1992). According to Koskela (1992), some characteristics add value to a product and process while others don't. Most characteristics of construction as an industry and as a product differ tremendously from other industries in the national economy. The characteristics give the industry its unique features and distinguish it from others, thus, the unique characteristics have offered an arm of challenge to production performance (Abdelhamid and Salem, 2008; Khan, 2008). The challenges do impede successful production in diverse ways (Kokela, 1992; Abdelhamid & Salem, 2005; Khan, 2008; Nicholas & Steyn, 2008). Furthermore, these characteristics are found to be changing continuously and, in most cases imposing greater challenges to procurement activities **(**Carbasho, 2009**).**

The unique characteristics of construction as an industry or as a product, which are numerous can act individually or in combination against the success criteria. A wide range of the characteristics have been identified among which are:

i. It is a complex undertaking.
ii. High risks and uncertainty involved in the undertaking.
iii. Construction is strongly linked to national economy and has wide ranging linkages with other areas of activity such as manufacturing and the use of materials, energy, finance, labor and equipment.
iv. Long time can be involved in producing a single product.
v. Each product is unique.

These characteristics have been studied and the way they impact on cost of construction projects documented (Kokela, 1992; Abdelhamid & Salem, 2005; Khan, 2008; Nicholas & Steyn, 2008; Chinyo, 2009).

2.2.1.1 The Complex Nature in the Undertaking

The construction project is a complex undertaking, and more complex than projects in the other sectors of the economy (Khan, 2008; Nicholas & Steyn, 2008); and building procurement is faced with growing complexity because the "construction industry is ever changing,… differing needs and priorities of the clients, differing sites and surroundings, and differing views of designers on the best design solution are making the nature of each building or facility as "one-of-a-kind" (Warszawski, 1990 in Afolarin, 2013).

The complexity has been defined and viewed along several factors. Among other factors is the number of processes and sub processes involved in the assembly, and the risk profile bracket like project size (in terms of bulk of work, length of time or

moneyto complete). Others include multidisciplinary requirement in terms of the number of diverse trades and specialists to engage in one project, head count of people that will be required or involved in the assembly, kinds and number of equipment or scientific technology that will be employed in the assembly, level of innovations or how much is really new in the project, level of standardisation and the interdependence of the parts, growing challenges in client's demandforming key factors that make a project complex (Tueninzen, 2007; Khan, 2008; Nicholas & Steyn, 2008).This complexity is also growing **(**Carbasho, 2009). The complexity of projects exerts significant influence on cost escalation; the more the complexity of a construction project the larger the costmay escalate **(**Flybjerg*et al.*, 2004), thus requiring special management attention during procurement (Aretoulis *et al.,* 2006).

2.2.1.2 Multitasking nature of projects

Multitasking in this regard refers to the several myriads of activities in construction to be undertaken by a set of people having the requisite qualifications or competence to bring the conceived product to actual existence (Ikeguru, 2006).Usually, a construction operation is so complex that it encompasses several distinct processes and sub-processes, each having its own technology and task sequences (Halpin & Woodhead, 1998). The "industry is one of the most dynamic, risky and challenging business sectors" (Bal*et al.*,2013). The sub processes are often reduced further into a hierarchical work breakdown structure in which accomplishment of tasks at the lower level in the structure helps to accomplish tasks at the higher level. Pohl and Chapman (1987) cited in Azi (2008) identified over 1000 activities involving a single construction project. Furthermore, Ikeguru (2006)believesthat construction projects/organisations are non-static, rather, are fast changing and becoming more turbulent than ever before. Thus

indicates a progression in the complexity of the construction system/subsystems **(**Carbasho, 2009)**.**

There are new entrances into the list of participants due to expanding specialties; new technologies are invented for better production, and new kinds of materials produced and incorporated into construction production, with the desire to meet some forms of objectives (Tueninzen, 2007). Rapid expansions in information and communication technology and automotive sub systems find ways for incorporation into the construction system (Ma *et al.*, 2010, Begum *et al*., 2010) example is the internet communication networking (Zou & Seo, 2006). Sheffer (2011) described a number of new technologies incorporated into a construction product and into the production process. Technologies like sensory and automated components,information and communication technology,and optical gadgets are either employed for incorporation into construction products to achieve certain objectives or into the production process toimprove productivity. Some elements are also industrialised (Sheffer, 2011), and most come along with new specialists to install them. This changing environment therefore creates continuously, a new complex atmosphere in which managers must learn. One of the main challenges to production management is that some aspects of specialisation are often lost due to changing experience in the changing environment. When lessons are lost project experiences starts all over again. Changes during project processes pose detrimental effects to successful procurement(Brown *et al.*, 1996; Williams II *et al*., 2004; Carbasho, 2009; Ma*et al*., 2010; Begum *et al.*, 2010). Activities generally interdependent such that any interruption in the sequence affects the interdependency and must be managed properly to allow smooth production flow for successful attainment of goals (Kern &Formoso, n.d). Lack of proper management can create conflict in the assembly sequence and clog the flow process leading to

failure in production delivery which in-turn affects cost. Conventional management has failed to respond properly to the challenges.

2.2.1.3 Multidisciplinary nature of production

Chinyio (2009) understood the multidisciplinary nature in terms of the number of stakeholders with diverse specialties often involved in the assembly process of construction. The scholar defined a stakeholder as "a person important to the project for either being a source of funds, personnel or materials, or can impact on the success or failure of the project through either an action or inaction". Earlier definition by Weiss (2006)defined stakeholder as "an individual with an interest or a share in an undertaking" (cited by Chinyio & Vogwell, 2007).

Identification of stakeholders: Going by the definitions of a stakeholder, a wide range of interests can be identified in a single construction project. Alarge number of stakes and people with vested interestsare involved in construction projects (CRC for Construction Innovation, 2009). The extent of interest or share of any person or organisation in a construction project does influence the level of his involvement, attitude to work or commitment in the production process (Harris and McCaffer, 2001). This affects the entire flow process and also affects the outcome of the product which can either add value or otherwise. Improper management of these personnel or groups of personnel called stakeholders with their vested and diverse interests tends towards non value adding production activities (Chinyio & Vogwell, 2007).

The degree of impact exerted by a stakeholder in construction projects depends upon the kind of stakeholder also.According to Bourne (2010), not all stakeholders are relevant or can impact significantly in a project at a time. The identification ofrelevant stakeholders; understanding their level of involvement and level of influence in a

project is important so as to manage them properly (Chinyo, 2009; Bourne, 2010). Six ways to properly identify a stakeholder in a construction project as put forward by Chinyo (2009) includes that person's interest in the project, his rights, ownership, knowledge, impact or influence, and contribution to the project (see Table 2.2).

Table 2.2 Stakeholders' "stake" in a construction project

The stake can be one of the examples below or a combination	
Interest:	A person or group of persons is affected by decisions related to the work or its outcome: • Street closure for a car racing event • Temporary closure of a supermarket for renovation
Rights:	To be treated in a certain way or to have a particular right protected: • Legal right: Occupational health and safety Privacy • Moral right: Heritage protection activists Environmentalists
Ownership:	A circumstance where a person or group of persons has legal title to an asset or a property: • Resumption of property for road works • Intellectual property • Shareholders' "ownership" in an organisation
Knowledge:	Specialist knowledge or organisational knowledge
Impact or influence:	Impacted by the work or its outcome: • Staff, customers • Shareholders Impact (or influence) on the work or its outcomes: • Sponsor • Government (legislation, regulation) • Public
Contribution:	Supply of resources: i. People, Material Allocation of funding: Advocacy for objectives or work success: Buffer between organisation and work teams or the work performance:

(Source: Chinyo, 2009)

Based on this understanding, Chinyio and Vogwell (2007) and Bal *et al.*(2013) listed a number of stakeholders in construction projects which include clients (both owners and users); project managers; facilities managers; designers; shareholders; legal regulators; employees; subcontractors, suppliers and process or service providers; competitors; banks; insurance companies; community representatives, neighbors, general public; government/local authority; visitors and customers (both current and potential); regional development agencies, etc.The CRC for Construction Innovation (2009) depicted relevant construction stakeholders in a public works department in a diagramme as in Figure 2.1.

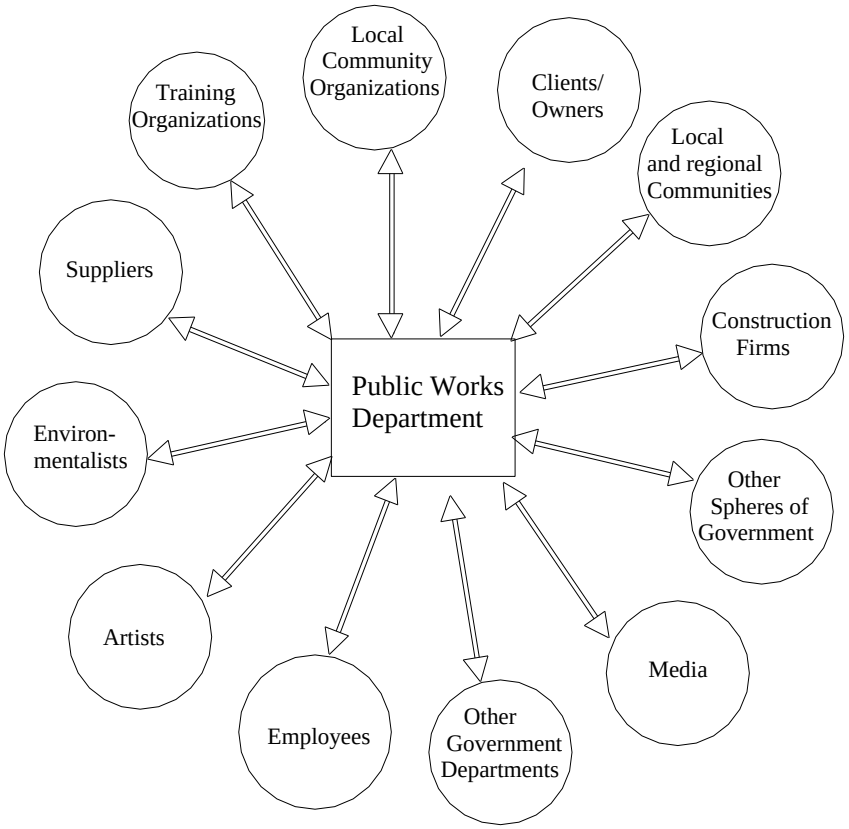


Figure 2.1: Construction stakeholders in a public works department (Source: CRC for Construction Innovation, 2009)

While having its origin in strategic management, stakeholder theory has found its way into a number of fields of enquiry including construction. Management of stakeholders in construction projects is not only difficult but has ignited increasing general interests

and covered in academic texts, media and government publications. With individual stakeholders having different characteristics and desperate needs, management becomes complex. Stakeholders have power to be either a threat or a benefit to an organisation (Chinyior & Vogwell, 2007; CRC for Construction Innovation, 2009).

Stakeholder management and communication is complex and usually takes more time than actually planned (Bourne, 2010).The large number of stakeholders involved in a single construction project and the diversity of interests of each of them to satisfy remain a major challenge to management. Each stakeholder involved in a construction project has desperate needs to satisfy and a role or roles to play to bring a construction product to actual reality. The level of interest of each stakeholder as stated by Walker *et al*. (2008) affects the level of his commitment to tasks accomplishment. Since success of the whole depends largely on the successful accomplishment of the varying sub systems, actions and inactions of any of the stakeholders within a subsystem affect the success level of the whole production system.Walker *et al*. (2008) identified different attitudes in stakeholders to a project. Harris and McCaffer (2001) identified attitudes and motivation among factors affecting worker output. Clement and Gido (2009) also found ethical and unethical behaviours among stakeholders during work operations. While ethical behaviour adds value, unethical behaviour does not. A client who chooses not to honour an interim payment, or the consultants failing to deliver designs on time, or the builder fails to mobilise to site, a statutory authority restrictions or protest by neighbors or the immediate community, each of these cases will impede project implementation. These challenges can be more pronounced whenever a stakeholder understands that his interest is no longer being addressed or properly served.

Understanding and meeting the needs of stakeholder: Understanding and meeting the disparate needs of stakeholders is critical to the success of construction projects and for the construction industry overall (Seaden & Manseau, 2000 cited in CRC for Construction Innovation, 2009; Bourne, 2010; Malkat & Byung-Gyoo, 2012). In support of this statement:

> "The identification and classification of stakeholders is important in construction because it helps in the proper understanding of stakeholders, thus facilitatingboth initial and subsequent engagement with them in a timely, planned and coordinatedmanner. This makes it easy to gatherinformation about them; identify their missions in a project; determining their strengthsand weaknesses; identify their strategies; predict their behaviour and develop and implement a stakeholder management strategy" (Chinyio & Vogwel, 2007).
>
> "…effective stakeholder management begins with the identification of key stakeholders before determining what the nature of the stakeholder management strategies should be' (CRC for Construction Innovation, 2009). In desperate desire to understand how best to meet the needs of stakeholders, attempts have been made to categorise the numerous stakeholders based on how they influence the outcome of construction projects in the efforts to properly identify and understand them" (TramStore21, 2012).

Chinyio and Vogwel (2007) believe that some stakeholders can influence the project internally while some do it externally. The scholars therefore classified stakeholders into internal stakeholders (those who are members of the project coalition or who provide finance); and external stakeholders (those affected by the project in a significant way). Other similar classifications according to Chinyio and Vogwel (2007)are the inside and outside stakeholders; direct and indirect; primary versus secondary, social versus non-social; and core, strategic or environmental. CRC for Construction Innovation (2009) makes an important classification as:

i. Dormant stakeholder
ii. Discretionary stakeholder
iii. Demanding stakeholder
iv. Dominant stakeholder

v. Dangerous stakeholder

vi. Dependent stakeholder

vii. Definitive stakeholder

Thislast classification portrays the kind and level of influence of stakeholders on the project outcome, vis-à-vis their interests. Each kind of influence isin turn capable of impacting on the cost outcome in a unique way.

A review of literature by Chinyio and Vogwell (2007) and CRC for Construction Innovation (2009) indicated that stakeholders' interests and expectations can be in conflict with each other, and that competing relationships and interests among them exist also. The interests of stakeholders in construction projects can vary over the life of a project also, as can alliances between stakeholders. The rationale for the changing interests according to CRC for Construction Innovation (2009) is found to include organisational learning, changing values, and specific experiences which differ. External reasons cited byCRC for Construction Innovation (2009) as causing changes in the objectives of stakeholders are a modification of community preferences which in turn influences political, environmental and community stakeholders, government policy, and the position of other stakeholders. Therefore, managing stakeholders' expectations and the changing concerns becomes crucial to construction projects. According to TramStore21 (2012), failure in addressing these has resulted in countless project failures, primarily because construction stakeholders tend to have the resources and capability to stop construction projects. Successful completion of construction projects vis-à-vis cost success therefore, depends so much on meeting those expectations of stakeholders.

Managing stakeholders: The challenges in stakeholder management have led to several proposals by researchers on best practices. Each proposal attempted to solve some identified problems. According to Chinyio and Vogwell (2007), "Managing stakeholders essentially is to manage relationships and encourage trust, and stimulate collaborative efforts that do lead to increased organisational assets arising from familiarity and teamwork. It will improve the final outcome of projects and ensure the commitment of stakeholders to project success". The key issue in Chinyio and Vogwell(2007) is trust, confidence and commitment in the process of procurement. In this light, Newcombe (2003) cited in CRC for construction innovation (2009) and TramStore21 (2012) believe that the first step in effective management of stakeholders begins with the identification and understanding of key stakeholders.

Two elements of stakeholders' management, namely- stakeholder analysis and stakeholder planning were identified. Three steps involved in stakeholder analysis include identifying stakeholders, prioritising stakeholders in terms of influence/interest map, thus, showing the degree of attention and information required by the stakeholder, and lastly, understanding key stakeholders(TramStore21, 2012). To understand key stakeholders, TramStore21 (2012) posed a set of questions:

a. What financial or emotional interest do they have in the outcome of your work? Is it positive or negative?
b. What motivates a stakeholder most of all?
c. What information do they want or need?
d. How do they want to receive information? What is the best way of communicating messages to them?
e. What is their current opinion of your work? Is it based on good information?

f. Who influences their opinions generally and who influences their opinion of you? Do some of these influential people become important stakeholders in their own right?
g. If they are not likely to be positive, what will win them over to support your project?
h. If it is not able to win them over, how can their opposition best managed?
i. Who else might be influenced by their opinions? Do these people become stakeholders in their own rights?

With these questions properly answered, it is expected that those stakeholders critical to project success will be identified**.**

Chinyio and Vogwell (2007) suggested that stakeholders should be categorised based on those that are more or less critical at a particular point of time. A twofold matrix was used by the scholars to map stakeholders on the basis of the power they exert on a project or firm and their level of interest in an undertaking. These come in form of questions as: "How is this stakeholder important? What is their stake?" and "What does this stakeholder require from the success or failure of the project?"

Some negative consequences of improper stakeholders' management are conflicts with the local community; complicated decision-making processes; time delays and associated cost overruns while assessing and responding to claims; negative publicity for the companies involved; and difficulty in prioritising and responding to stakeholders' claims (Chinyio & Vogwell, 2007). These consequences are capable of significant negative impact on project cost.

In the management of relationships of stakeholders, two main approaches were proposed by Hoegl*et al*. (2004) as buffering and bridging. The two approaches tend to

have opposing concepts. While bufferinginvolves establishing barriers between an organisation and its stakeholders in an attempt to limit the effect and influence of stakeholders, bridging in contrast,seeks to forge a partnership with a stakeholder by establishing common ground and action. The bridging approach to stakeholder management was argued by Hoegl *et al*.(2004) to build competitive advantage. It provides additional resources to the firm, and the quality of teamwork increases performance in both single and multi-team projects. This position aligns with partnering principle of team spirit in projects delivery. The teamwork quality facets identified by Hoegl *et al.*, (2004), are communication, coordination, and balance of members' contributions, mutual support, efforts and cohesion. Walker *et al.*, (2008) rather discussed how a stakeholder's behaviour can be modeled and/or analysed to help project teams visualise abstract threats or opportunity in a meaningful and graphic way.

Yang *et al*., (2009) explored the critical construction projects success factors in managing stakeholders in Hong Kong. Out of 15 critical success factors ranked, the top 3 most important factors in order of priority were: managing stakeholders with social responsibilities(economic, legal, environmental and ethical), exploring the stakeholders' needs and constraints to theproject, and thirdly, communicating with/engaging stakeholdersproperly and frequently. The scholars then developed and diagrammatically presented a framework on how best to manage stakeholders in construction projects as in Figure 2.2.

Stakeholder's alignment: "This is a condition where appropriate project participants are working within tolerances to develop and meet a uniform, defined and understood set of project objectives" (Construction Industry Institute [CII, 2012]). Each member is focused on the same set of project objectives. The objectives must therefore not only be properly developed, but must be clearly understood by team members. CII (2012) also

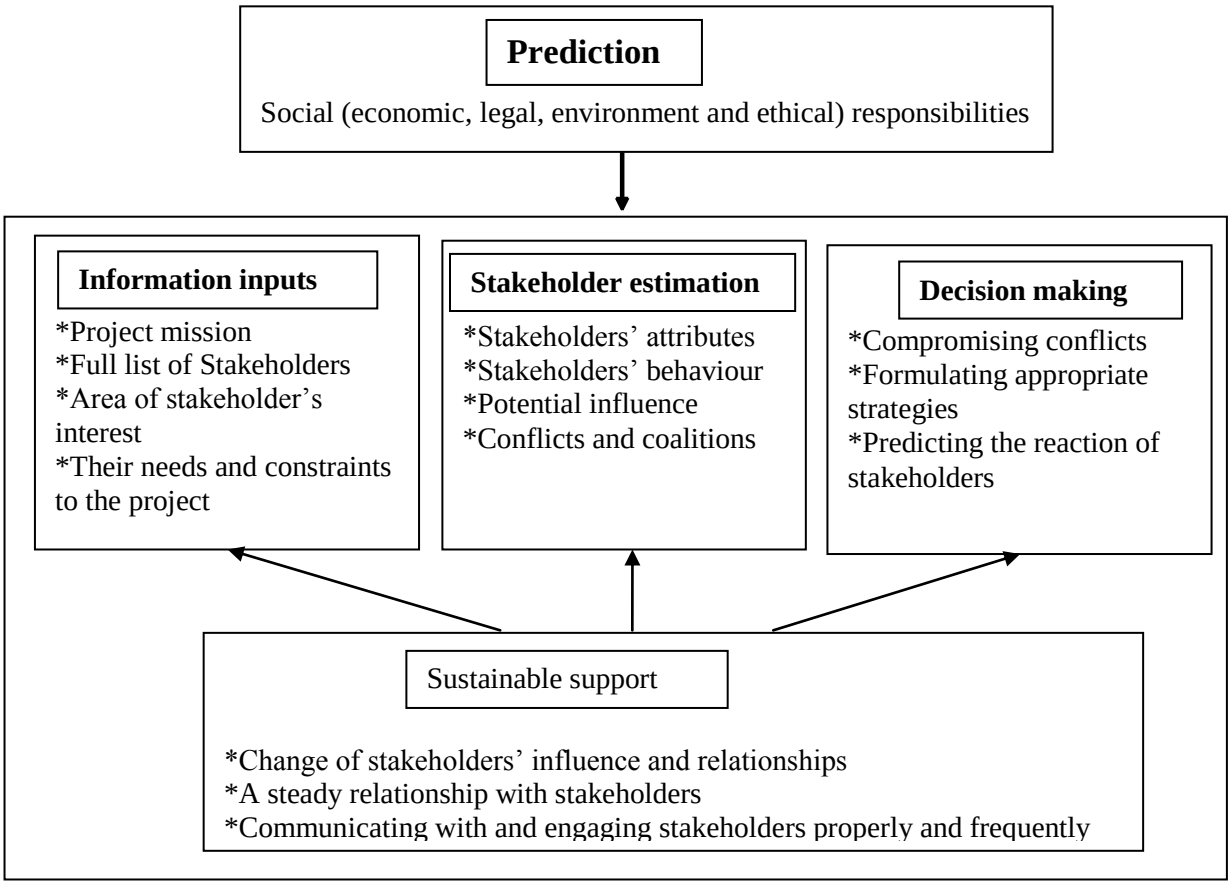


Figure 2.2: Framework for successful management of construction stakeholders (Source, Yang *et al*., 2009)

recommended a vertical, horizontal and longitudinal alignment dimensions.Five key areas were identified as affecting alignment. For a project team to operate effectively; the alignment must affect the five areas, namely, culture, execution, information, project planning tools and barriers. Management must also ensure (CII, 2012) that:

i. Stakeholders are appropriately represented on the project team.
ii. Project leadership is defined, effective, and accountable.
iii. The relative priorities among safety, required project features, schedule, and cost are clear.
iv. Communication within the team and with stakeholders is open and effective.
v. Team meetings are timely and productive.The team culture fosters trust, honesty, and shared values.

vi. The front end planning process includes sufficient funding, schedule, and scope to meet the project objectives.

vii. The reward and recognition system promotes meeting or exceeding the project objectives.

viii. The teamwork and team building programs are effective.

ix. Planning tools (e.g., checklist, simulations, and work flow diagrams) are effectively utilised.

With these, it is believed that the alignment will be enhanced.

2.2.1.4 Diverse materials involved in the assembly process

Materials refer to the tangible items acquired and assembled into positions on site to bring about a tangible product that gives the requisite satisfaction to the client or end users. Material management has been defined as a complex and comprehensive process that consists of people, organisations, technology, and processes used to manage the definition, sourcing planning, quantification, supplier qualification, purchasing, expediting, transportation, logistics, and controlling of materials and associated information across the lifecycle of a capital project (Construction Industry Institute, CII, 2012).While other resources like humans, plant, time and money are not visible on the product after production, materials remain behind to form a permanent visible featureas evidence of project undertaking which calls for diligence in handling.

Management of material has been noted by scholars as an important element in the management of construction projects,and that material constitutes a major expense component, accounting for 60 to 70 percent of the direct cost of a project or a facility, the remaining 30 to 40 percent being the labour cost (Kasim, 2011; Patel &Vyas, 2011;

CII, 2012). Therefore, managing material involves the management of a large portion of the cost of a construction project.

The essence of managing materials is to ensure its presence at the point of use when required and delivered at the right quality and cost (Patel & Vyas, 2011; Karathodoros, 2012; CII, 2012). It increases productivity, enhances profits and avoids delays (Kasim, 2011). Implementation of a comprehensive materials management program contributes to predictable project outcomes, reduced costs, improved productivity and quality, and a safer working environment (CII, 2012). The implication is that, poor material managed can challenge project outcomes. Patel and Vyas (2011) identified three challenges that give rise to the need for material management, believing that the:

i. Purchase of materials too early does hold up capital and incur interest charges on the excess inventory.
ii. Materials may deteriorate and can be stolen during storage.
iii. Delays and extras expenses may be incurred if materials required for particular activities are unavailable.

The scholars then advised that managers should ensure timely flow of materials by constantly measuring performance. Coupled to that, managers must also understand components encompassing material management. These components worth noting here, these as listed by Patel & Vyas (2011) are:

i. Material estimation, budgeting, planning and programming.
ii. Scheduling , purchasing and procurement
iii. Receiving and inspection.
iv. Inventory control, storage and warehousing
v. Material handling and transport
vi. Waste management

Kasim (2011) similarly discussed material management in terms of managing activities like planning, taking-off materials, vendor evaluation and selection, purchasing, expenditure, shipping and material receiving. By including shipping, Kasim (2011) suggests an international component in the management of materials, which was also reflected by CII (2012). It means managers of materials must take cognisance of materials that cannot be sourced locally and might likely have to be shipped from far distances or other countries.

The time allowed for a particular construction project depends to a larger extent on the quantity of materials and components to be assembled on site. A large construction project implies large quantity of materials to be assembled; likewise a small project implies less quantity of materials. The last material assembled on site usually points to the end of construction project assembly process. The variety of materials and components used in the assembly of a building project are many. The situation is also non static in nature. Apart from the introduction of new materials in the system,a large variety of products are needed to be purchased and thus many suppliers are getting involved. These challenges combine to increase the complexity and risks in a construction project undertaking (Karathodoros, 2012).

According to Kasim (2011), identifying and understanding the kinds of challenges affecting materials beforehand will assist in better material management. Some challenges affecting material in the UK were listed as follows:

i. Lack of site storage space
ii. Problems with tower cranes
iii. Problems on logistics of materials
iv. Small loading area
v. One point access to site

vi. Difficulty in delivery of materials on site during aircraft operation

vii. Operation limitation due to security considerations

viii. Inadequate loading area at consolidation center

ix. Congestion time at loading area.

Materials employed in construction exhibit distinct characteristics, and respond differently to market conditions. Yet, estimates are always prepared and presented for the whole project at the same time with different assembly schedule. While the first element of substructure is assembled at the start, the last element waits in the sequence to the last period. In between these periods materials can respond to market forces. This poses another management challenge in cost management if the final cost of construction must remain within budget. Veronika *et al.* (2006)therefore recommended a knowledge based management system to be employed in material management where a "Comprehensive understanding of field issues and problems are required before giving corrective actionsrecommendation". Knowledge management concepts in construction must therefore not divulge materials in the list of priorities.

2.2.1.5 High risks and uncertainty of procurement

Zuo *et al.* (2004) reviewing other scholars stated that the construction industry is subject to more risks when compared with other industries, due to the unique features of construction activities, such as long period, complicated processes, abominable environment, financial intensity and dynamic organisation structures. Risks according to Creedy (2006)are unknowns, the probability of occurrence of which can be statistically assessed (and usually insurable). Uncertainties are unknowns that cannot be predicted (uninsurable). Both cases characterise situations where the actual outcome for a particular event or activity is likely to deviate from the estimate or forecast value.

Risks in construction projects are either internal or external in nature (Rezakhani, 2012). Internal risks originate inside the project, and project managers and stakeholders have some control over them. Examples,according to Nicholas and Steyn (2008)include:

i. Market risk where the contractor or developer misread the market environment thus, cannot fulfill the market needs or requirement of a customer.

ii. Assumption risk which is associated with numerous implicit or explicit assumptions regards projects during conception and planning. Examples are assumptions on cost, time and technical needs, the success of which depends so much on accuracy and validity of the assumptions.

iii. Technical risk relates to technical problems that prevent meeting objectives and is found to be high in the kinds of projects involving unfamiliar activities or requiring new ways of integration. A project with familiar activities done in customary ways is most likely to have low technical risk.

External risks originate from sources outside the project and stakeholders usually have little or no control over them (Nicholas & Steyn, 2008; Rezakhani, 2012). External risks which also have the capacity to exert pressure on cost of building construction projects include (Nicholas & Steyn, 2008):

i. Market condition

ii. Competitors' actions

iii. Government regulations

iv. Interest rates and exchange rates

v. Customer needs and behaviour

vi. Supplier relations and business failures

vii. Physical environment (weather, terrain)

viii. Labor availability (strikes and walkouts)

ix. Materials or labor resources (shortages)

x. External control by customers or subcontractors over project work and resources

xi. Decisions by senior management or customer regarding project priorities, staffing or budgets.

The risks and uncertainties further aggravate for the fact that each construction project is unique by nature. There is no construction undertaking that is the same with another, even if implementing the same design (Afolarin, 2013). Seven characteristics were listed by Abbasnejad and Nejati (2013) as distinguishing a construction project from a repeated and common activity, namely:

i. It has a certain goal to reach a specific result

ii. It has starting and ending points (reaching planned goals in a certain time)

iii. It includes factors of cost, source (human, technical, managerial) and time

iv. It has a measurable result

v. Reaching quality in a certain time with a certain cost

vi. It is done by certain group, person or organisation

vii. There is a certain coordination and succession in all its activities

These variables differ from project to project depending upon the type, time and quality of activities (Abbasnejad& Nejati, 2013). With these factors, the learning process becomes difficult and poses difficulty in standardisation (Koskela, 1992).

2.2.1.6 Linkage to national economy

One of the main characteristics of the construction industry is its interdependence with the national economy (UK Construction Group, UKCG, 2009). The interdependency with the national economy has been found to affect the performance of the sector significantly and contributes so much to instability to the cost and time of procurement. On one hand, whenever changes occur in the economy, the construction sector responds directly and rapidly. On the other, changes in the industry affect the economy at all levels and in virtually all aspects or sectors (UKCG, 2009). For reasons of large employment of labour and income generation of a large work force, whatever happens to the sector either directly or indirectly influences other economic sectors, and ultimately the general economy of a country (Field & Ofori, 1988; Smith 1999; Khan, 2008; UK Construction Group, UKCG 2009).

When construction responds to changes in the economy, it is believed to be caused principally by the unbalance in the law of supply and demand (Stewart, 1995). Moyo (2010) reported Runeson (2000) who provided empirical evidence of economic theory that applies to the construction industry. The theory links the sector to the economy in a strong case. Study in the UK also linked the industry to the UK economy. The study according to the UKCG (2009), found out that construction is still:

1. A major contributor to UK GDP and a driver of historical GDP growth.
2. An important driver of growth for other sectors, without which there would be a loss of domestic production capacity and skills.
3. Employs a range of labor force from skilled to unskilled one.

As a result of these factors, there was pronounced decline in construction activity in the UK during the onset of the 2008 economic downturn. Theconstruction sector

experienced sharp increases in company closures, in individual bankruptcies andin redundancies, which were the highest amongst UK industries. There was decline in private construction activity also, construction output fell and employers held up employment (UKCG 2009). A tightly linked scenario between the construction sector and the British economy was therefore depicted by the UKCG (2009) and this condition, according to Khan (2008) affects the market environment wherefinance, labor and materials resources operate causing change in prices during procurement.Khan (2008) observed similar linkages in Pakistan that the construction sector provides substantial employment opportunities; contributing through a higher multiplier effect with a host of beneficial forward and backward linkage in the economy. Bala (2000) found in Nigeria an unstable market condition affecting building resources.

The main effect of the relationship between the construction sector and the economy is inflation which has been described as the time oriented increase in costs driven by rising prices and rising cost of materials, subcontracts, parts, supplies, goods, and services(Stewart, 2005). The sector is often, readily and rapidly affected by inflationary trends. Ladipo (1982) cited in Oyediran (2006) observed four economic policies that affects the construction sector in Nigeria, namely: increase in the price of petroleum, government absorbing more resources than are released by the private sector at the existing price level, increasing income through increasing the prices of the goods and services offered without increasing production, and lastly the demand for goods and services rising more rapidly than the economy can supply due to income arrears from increase in wages and salaries inclusive.Billi & Kahn (2008),believes that,there is a general consensus among the public, economists and policymakers that inflation is bad for the economy (cited in Moyo, 2010).

The effect of inflation on projects has been discussed severally in literature. Smith (1999), observed that for several years, the industry in Britain present very poor reputation for coping with the adverse effects of inflation. The effect being that many projects fail to meet deadlines and costs and quality targets. At extreme cases, the risk of cost and time overruns invalidates the economic case for a project, turning a potentially profitable investment into a loss-making venture.

Inflation causes changes in construction prices often referred to as fluctuations and makes it difficult for cost estimators to accurately estimate construction project costs. When prices fluctuate it affects the accuracy of engineering cost estimates for owners and, therefore, the accuracy of the owners' budgets (O'Haren, 2004; Dayton *et al*., 2006; Gallagher, 2008; RICS, 2010). Approximately two-thirds of participant contractors in a study in the US indicated that inflation in construction costs is one of the most important risks that impact their profits. In addition, construction projects are delivered with higher costs, schedules are delayed and, in the worst cases, organisations are forced into insolvencies. Fewer contractors are willing to bid for projects and the bids that are received often have large hidden pricing contingencies or extremely short bids price guarantees and are often substantially greater than the client organisation's own estimate. This causes particular problems for public sector organisations and is in conflict with the public interest (RICS, 2010).

In a general sense, the rapidly fluctuating inflationary pattern creates high degree of instability in an economy. Where the structure of the economy is weak, the effect could be much more devastating. Oyediran (2006) observed that the case of Nigerian calls for research attention. According to the scholar, there exists no reliable source of information on the rate of inflation of construction prices. The negative effect of this is not only on the local stakeholders alone, but may hamper foreign investors that may

seek to explore the Nigerian market. With globalisation and the country's drive to attract foreign investors such information will require and be readily available to enable investors take informed investment decision in construction activities (Oyediran, 2006).

2.2.2 Wrong conceptualisation of construction production philosophy

The philosophy of production is not properly understood in construction, as a result, many flaws that hamper smooth production of construction products result. "Many problems of construction have led to various developmental efforts, but deficiency in conceptualisation has led to suboptimal or counter-productive conclusions and actions" (Koskela, 1992). Construction industrialisation and computer integrated construction are examples where serious efforts in the field lack conceptualisation and became barrier for progress (Koskela, 1992). For proper understanding of this concept, Koskela (1992) drew analogy from production theory and benchmarked relevant ideas from manufacturing to conceptualise construction production philosophy. The conventional understanding of production was first discussed and how the model hampers smooth production outlined. The scholar then propounded a new model. How the new model enhances production objectives was properly articulated. Both theories are illustrated as in the following discussions:

2.2.2.1 The conventional (traditional) model

The conventional model sees production as a conversion process. Production as defined by this model is "the conversion of an input to an output" (Koskela, 1992). This definition connotes a two steps system where raw materials are keyed into production and conversion of raw materials into finished products occurs. A complete production process is therefore divided hierarchically into sub-processes as depicted in Figure 2.3.

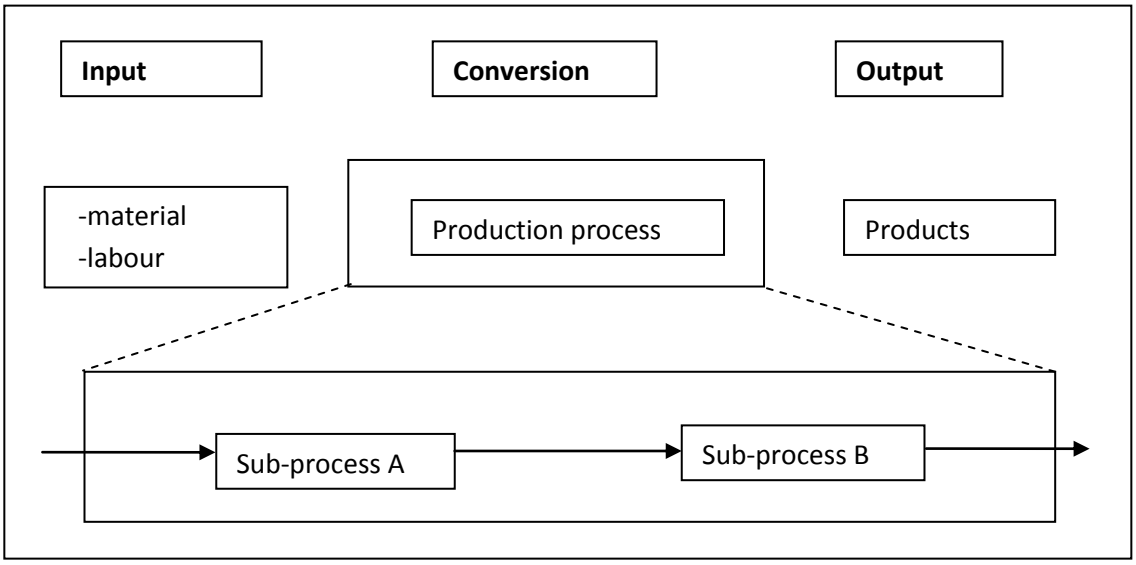


Figure 2.3: The conventional view of a production process (Source: Koskela 1992)

Figure 2.3 indicates that there is an input of resources (material and labour) which is processed (converted) into a product (an output). Within the conversion process, there recognised sub-processes (sub-process A and B) that the conversion passes through before the end product is achieved and these sub-processes are also conversion processes on their own.The conventional model contributes to the production process in two key positive aspects as recognised by Koskela (1992). These are:

i. The ratio of output to input in a given time period can easily be measured. This allows for convenient measurements such as measurement of productivity.

ii. It relates activities to theories of control in a hierarchical organisation. Proper control of any sub process enhances control of the overall process.

However, Koskela (1992) was mainly concerned with the deficiency multiplied in production by the conversion model. Three major flaws associated with the model were identified. The researcher opined that, by dividing the production system into two stages:

a. “There are other processes not identified within the conversion process called the physical flow. Focusing on conversion alone, the model abstracts away those physical flows between conversions. Examples include moving, waiting and inspecting activities. In a more complex production process, major parts of total cost are caused by the physical flow activities rather than conversions. Notably, by moving materials or labour, inspecting or by waiting in the production process, no permanent or direct value is added to the product for the satisfaction of the client, yet the flow consume considerable resources (time and money in particular).

b. ‘The conversion model not only neglects, but also deteriorates the overall flow efficiency. Since these flow activities are not identified in this model, there is no way they can be addressed in the management activities (Koskela, 1992).

c. ‘The model therefore directs improvement efforts more on efficiency rather than being effective; products are therefore produced more efficiently but poorly satisfy customer requirements and expectations”.

Marchensan and Formoso (2000) used the idea to identify those flow activities in a construction process. The scholars studied a highly complex refurbishment hospital project which was carried out without disruption of the hospital operations and discovered that the cost for the physical flow activities was high. According to Marchensan and Formoso (2000), over 18% of the contractor’s workforce cost was put into cleaning activities and over 27% resulted from moving operations. These are activities that cannot be identified in the conventional model due to wrong conceptualisation., yet, was found to have a high ratio when compared with the conversion sub process. Koskela (1992) suggested the need for a comprehensive theory of production management for construction that will identify all sub processes so as to be properly managed; the essence of which is not to substitute rather that complement the existing model. Along this backdrop, a new philosophy was put forward by the researcher as a new production model.

2.2.2.2 The new production model

Koskela (1992) believes that there is deficiency in conceptualisation of the construction production process which has led to suboptimal or counterproductive conclusions and actions in construction. According to the researcher, there is a mismatch between the conceptual models of construction management and the observed reality on projects. This underscores the lack of robustness in the existing constructs of Construction Management and therefore, signals the need for a comprehensive theory of production management in construction. Koskela (1992) proposed a new production philosophy applicable to construction by tracing its origin and presenting the most prominent application of the concept in real life situations. The new model was found to complement the old model by viewing production consisting of conversion and flows.

Deriving from the existing principles found in manufacturing, Koskela (1992) sought to improve construction performance, mainly through proper conceptualisation of the construction production process. The new philosophy was developed using a basic idea that focused on, according to Koskela (91992) "elimination of inventories and other wastes through small lot production, reduced set-up times, semiautonomous machines, cooperation with suppliers, etc" which has been referred to as lean construction. Since Koskela's thesis, there had been several interests on the field of production philosophy relating to construction. A new definition of production was therefore proposed in the new philosophy as; it is "the flow of material and/or information from raw material to the end product". Production is now seen as a flow process where materials pass through several stages in contrast to the conversion theory. Koskela (1992) clearly divided production in the new theory into conversion and flow sub-processes. Material

input is either being processed- which represents the conversion aspect of production, or being inspected, moving or waiting- which represent the flow aspect (Figure 2.4).

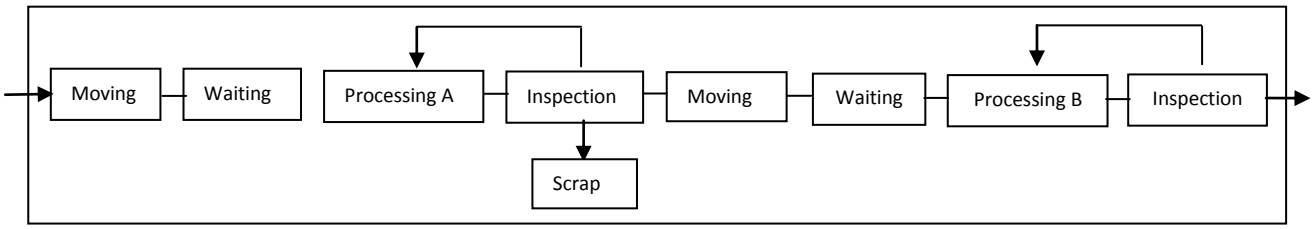


Figure 2.4: Modern view of production as a flow process (Source: Koskela 1992)

Abdelhamid and Salem (2005), understood the new theory of production as conceptualised in three complementary ways:

a. Transformation (T) of raw materials into standing structures,
b. Flow (F) of the raw material and information through various production processes, and
c. Value (V) generation and creation for the owners through the elimination of value loss (realised outcome versus best possible).

This Transformation-Flow-Value (TFV) theory according to Abdelhamid and Salem (2005) "integrated the efficacious qualities of craft, mass and Lean Production Paradigms, as well as the inclusion of the value management perspectives". The new theory complemented the old model by identifying process wastes in production. It was observed that the conversion and the flow sub processes consume resources during production, but only the conversion activities leave behind real or permanent value to customer satisfaction (Koskela, 1992; Abdelhamid & Salem, 2005). In the case of erecting a concrete column, the erection and removal of formwork do not leave behind permanent value. In contrast, the conversion or the processing activities like pouring

concrete, rendering or painting the structure leave behind permanent values which add to the satisfaction of the customer. These are therefore, value-adding activities. This value achieved after transformation should aim at satisfying the customer (internal or the external customer) and the needs of each customer, in the new theory, must be properly identified for adequate responses to those needs towards production efficacy.

The flow (non-value adding) activities remain the main concern in production. Like conversion, the flow is also characterised by time, cost and value concept; value having being defined by Koskela (1992) as the fulfillment of customer requirements. Reducing the share of the flow and enhancing the share of conversion should bring about cost efficacy (Koskela, 1992; Bertelsen, 2004; Abdelhamid & Salem, 2005). Bertelsen (2004) identified waste in processes that should be eliminated. Hanid *et al.* (2010) defined waste as the "uses of resources that do not involve transformation or generating value for the customer". Failure to overcome waste in construction processes becomes a major challenge in cost management objective. Hanid *et al.* (2010) reviewed 99 research works and publications and concluded that the issues on waste are not often taken into account in improving cost management systems. This is possibly for the fact that the traditional management model fails to identify them due to wrong conceptualization that still dominates management of construction projects. "Among 16 issues discussed in all the research articles found, no research work on waste problem was carried out" (Hanid *et al*., 2010). "It is noted that waste is an important issue that needs to be tackled in construction cost management" (Hanid *et al*., 2010, Forgues *et al.*, 2013).

Project circles from planning to production; especially in the traditional procurement system are based on the conversion model. The system is fragmented; there is separate

responsibility between the consultants and the contractor. During production, the consultants constantly check and monitor the activities of the contractor. This system was also referred to as conventional or conversion procurement approach (Koskela, 1992). This traditional (conversion) procurement approach was found dominant during building procurement in Nigeria and in many parts of the world (RICS, 2009). Koskela (1992) then observed that, apart from making the process of construction unnecessarily fragmented, the traditional system is more complex, in-transparent and variable, and there is a total neglect of the flow sub-process aspects of construction. The conventional approach therefore demonstrates clearly a significant amount of waste, loss of value and non-value-adding activities which are borne in the cost of construction. The industry (construction) therefore, is still striving towards improvements in a number of areas, but apparently with little success (Kagioglou *et al*., 2000).

The Latham report (1994) then focused on the fragmented nature of the industry as a major contributing factor to poor communication between all parties working on a construction project. "The main outcome and recommendation of the Latham report was its call for significant cost savings by the utilization and formulation of effective construction processes, which will in turn lead to increased performance" (Kagioglou *et al*., 2000). The scholar further identified five key recommended areas for departure from the traditional system in the Latham report (1994) as follows:

a. committed leadership;
b. focus on the customer;
c. integrated processes and teams;
d. quality-driven agenda; and

e. commitment to people

These qualities were found oppressed in the traditional model (Kagioglou *et al*., 2000), the absence of which can lead to waste and finally overruns.

Koskela (1992) believes that the new theory (the flow process) advocated leads to a better theoretical understanding of the whole production process by pinpointing the generic process problems, their origin and some peculiarities that have not been adequately handled; and enables practical guidelines for improving the process. By identifying these processes, it appreciates the fact of the complexity, variability and the segmentation nature of the traditional procurement organizational structure. Even so, Kagioglou *et al*. (2000) still saw the need

> "…for a model that is capable of representing the diverse interests of all the parties involved in the construction process or that is able to provide a complete overview. In addition, the design and construction operations need to form part of a common process (model) best controlled by an integrated system. This has been achieved successfully in manufacturing and other industries through process modeling and the reengineering of those processes (Rosenau 1996). In order for construction to utilize such a model/ process approach, there is a need for a coherent and explicit set of process-related principles, a new process paradigm, which can be managed and reviewed across the breadth and depth of the industry and which focuses on changing and systematising the strategic management of the potentially common management processes in construction whilst accommodating the fragmentary production idiosyncrasies".

Kagioglou *et al*. (2000) then broke down the design and construction process into ten distinct phases and then regrouped the phases into four broad stages, namely pre-project, preconstruction, construction and post-construction, in effort to develop a management process protocol for construction. In this respect, the scholar defined the process management as "responsible for facilitating and co-coordinating the participants required to produce the necessary deliverables. Acting as the development

management's 'agent', it will ensure the enactment of each phase as planned, culminating with the presentation of the deliverables at each end of phase review".

2.2.3 Poor planning and control of resources

Proper planning and control of construction resources have been found to enhance cost and time performance (Olusegun & Micheal, 2011); planning enhances cost and time performance according to Olusegun & Micheal (2011) by:

i. Facilitating control.
ii. Establishing realistic standards and identifying key dates or gateways to critical stages of the project.
iii. Facilitating the monitoring of performance in terms of output, time and money.
iv. Enabling constant review and actions taken when necessary to correct the situation.

With proper planning and control therefore, there is high expectations that projects should achieve cost and time objectives more readily. However, this is not the case because, for long these objectives have been unable achieve despite feasible planning activities. Cases are still widely reported about delayed and over expended budgets despite these efforts. Gunduz *et al.* (2013) reported that project delays are common in the construction industry; and this creates major concerns regards project performance. This delay is often attributed to planning deficiencies (Gunduz *et al.*, 2013). These deficiencies underscore lack of cost efficacy in building construction projects. According to Moris (1990) and Sambasivan and Soon (2007), among several factors causing cost over-runs in construction projects, inadequate project planning which often leads to delay was ranked highest in the order of severity. It might imply that

many projects are not properly planned leading to serious delay. Ahmed *et al.* (2002) rather opined that the delay in construction projects are universal phenomenon and often impede cost and time objectives; which also occurs without distinction of whether projects are properly planned or not. The later part of this assertion connotes that planning alone cannot solve the problem of construction. The negative effect of the scenario among many includes (Ahmed *et al.*, 2002) the creation of adversarial relationships among stakeholders like distrust, litigation, arbitration, cash-flow problems, total abandonment and a general feeling of apprehension towards. Each of these challenges has a cost component attached to it; therefore, the end result often leads to extended procurement time and over budget expenditure.

Ahmed *et al.* (2002), Sambasivan and Soon (2007) and Abdullah *et al*. (2009) believe that understanding the nature of delay, their causes and effects will assist managers to achieve better planning results. This elicited many researchers to subject the nature of delay into profound study and has been succinctly discussed in four main areas (Ahmed *et al.*, 2002; Sambasivan & Soon, 2007; Abdullah *et al*., 2009; Tumi *et al*., 2009) and summarised as follows:

a. **Non-excusable delays**: this type of delay is usually caused by the contractor or its supplier (Tumi *et al.*, 2009) who assumes responsibility and bears the risk. The delay is foreseeable and within the control of the contractor and in some instances the client is entitled to claims and liquidated damages. Some of these kinds of delay listed by Ahmed *et al*. (2002) are:
    i. Underestimates of productivity
    ii. Inadequate schedule or mismanagement
    iii. Construction mistakes
    iv. Change management problems

v. Weather effect

vi. Equipment breakdown

vii. Staffing problems

viii. Bad luck

ix. Late order or delivery of material and equipment

x. Failing to submit shopping drawings for approval in time

xi. Not coordinating the work of domestic sub-contractors

xii. Financial difficulties faced by the contractor

It is worth noting that since contractors bear the penalty, they should proactively manage these kinds of delay to save cost.

b. Excusable non-compensable delays: this kind of delay is usually caused by factors beyond the contractor's reasonable control. Most natural occurrences fall within this category (Ahmed *et al.*, 2002). In this case, neither party is at fault under the terms of contract. The parties have agreed to share the risk and consequences when excusable events occur. It means that time will be extended for the contractor without penalty of liquidated damages but to no compensation for lost or expense. These types of delays often termed force "majeure" (Ahmed *et al.*, 2002; Tumi *et al*., 2009) include:

i. Act of God

ii. Act of public enemy

iii. Act of the owner or those under his control

iv. Act of the owner's independent contractors

v. Fire

vi. Flood

vii. Epidemics

viii. Quarantine restrictions

ix. Strikes

x. Freight embargoes

xi. Unusually severe weather

The excusable non-compensable category of delay is difficult to predict. In most cases factors under it do not have any pattern of occurrences causing difficulty in prediction. This is least to suggest that there are no indices at all that point to their occurrences. Diligence, careful observations and analysis of events accord more reliable predictions on some of them. However, the client, contractor and consultants should be responsible in tracking down events that might lead to their occurrences since there's effect on both parties.

c. Excusable compensable delays: The contractor in this kind of delay is entitled to extension of time and compensation. It occurs when the owner or his representative cause delay in the contract proceeding. Most times, this occur in:

i. Delay in providing access to all or part of the work site

ii. Delay in review and approval of shop drawings

iii. Failure to properly coordinate the activities of other contractors on site

iv. The order for changes in the contractor's sequence of performing the work.

The excusable compensable category of delay might not be keenly prevented by most contractors even if they have the chance because of the opportunity in putting claims. Client or his representatives should therefore be keen and be very watchful on this.

d. Concurrent delays: the owner and the contractor are responsible in this type of delay. In most of the time it involves both excusable and non-excusable delay.

Generally, it is where the delays are inextricably intertwined; the contractor cannot be held responsible and cannot recover damages from the owner due to the delay. This delay may lead to disputes between contractor and client.

As a general note from the discussions, the prevention of delay is not an exceptional responsibility of any member of the team neither is it for one aspect of management practice. The client, his representative and the contractor have responsibilities to prevent delay and must therefore plan and monitor construction events properly. Apart from that, every aspect of management must be synthesised to obtain optimum results.

The causes of delay have also been found to be an important subject of profound study. Sambasivan and Soon (2007) identified ten important causes of delay from a list of factors in Malaysia as:

i. Contractor's improper planning.
ii. Contractor's poor site management.
iii. Inadequate contractor experience.
iv. Inadequate client's finance and payments for completed work.
v. Problems with subcontractors.
vi. Shortage in material.
vii. Labor supply.
viii. Equipment availability and failure.
ix. Lack of communication between parties, and
x. Mistakes during the construction stage.

Assaf and Al-Hejji (2006) ranked 73 causes of delay in Saudi Arabian construction projects and reported ten most prominent causes by owner, contractor and consultants in Table 2.3.

Table 2.3: Important causes of delay in Saudi Arabia

Owners	Contractors	Consultants
1. Shortage of labors	Delay in progress payments by owner	Type of project bidding and award
2. Unqualified work force	Late in reviewing and approving design documents by owner	Shortage of labors
3. Ineffective planning and scheduling of project by contractor	Change orders by owner during construction	Delay in progress payments by owner
4. Low productivity level of labors	Delays in producing design documents	Ineffective planning and scheduling of project by contractor
5 Hot weather effects on Construction activities	Late in reviewing and approving design documents by consultant	Change orders by owner during construction
6. Conflicts encountered with sub-Contractors schedule in project execution	Difficulties in financing project by contractor	Low productivity level of labors
7. Poor site management and supervision by contractor	Mistakes and discrepancies in design documents	Difficulties in financing project by contractor
8. Inadequate contractor's experience and supervision by	Late procurement of materials	Poor site management contractor
9. Effects of subsurface conditions (soil, existing of utilities, high water table, etc)	Inflexibility (rigidity) of consultant	Poor qualification of the contractor's technical staff
10. Change orders by owner during construction	Slowness in decision making process by owner	Delay in material delivery

(Source: Assaf and Al-Hejji, 2006)

Olusegun and Micheal (2011) studied the causes and effects of abandonment of construction projects in Nigeria. Relative importance index of 18 factors ranked revealed twelve most important causes of delay in Nigeria as:

i. Inadequate planning.

ii. Inadequate fund/financing.

iii. Inflation.

iv. Bankruptcy of contractor.

v. Variation of project scope.

vi. Political factor.

vii. Death of client.

viii. Incompetent project manager.

ix. Wrong estimates.

x. Inadequate cost control.

xi. Faulty design, and

xii. Delayed payments

These factors affect both planning and implementation of projects by causing delays to the process; adequate planning can subdue them in great measure. In order to respond better to those factors, Olusegun and Micheal (2011) recommended better understanding of the whole procurement process first. It will enable managers to be able to plan and reduce the incidence of delay more appropriately.

It can therefore be understood from this thesis that delay is broadly categorised into delay that project implementers have great influence and control over them; and those they can less influence and control. From the list of findings in Malaysia, Saudi Arabia and Nigeria, inadequate planning featured more frequently. With proper plan, the effect of other factors in the list can also be reduced extensively. It is imperative to accept that the main cause of delay is improper planning. Appendix II is a summary of findings that identifies the main causes of delay in construction projects from different countries. Planning and control should be concerned about them during project delivery process.

2.2.4 Effect of the choice of procurement path

The choice of procurement path when acquiring a construction product has been found to contribute immensely to failure in achieving projects objectives (Idoro, 2011). Each procurement path, while having strengths to rely upon for better attainment of project objectives, equally has weaknesses that impede the attainment of those objectives.

Proper understanding of these strengths and weaknesses by projects implementers will enable the right choice of option and optimal responses to challenges against impeding factors in them adopted to enhance successes.

Oyegoke (2006) reported Love *et al.* (1998) as having defined procurementas an organisational system that assigns specific responsibilities and authorities to both the people and the organisations and further defines the relationships of the various elements in the construction of a project. According to Rashid *et al.* (2006), "procurement is concerned with the organised methods or process and procedure of obtaining or acquiring a construction product….It does not only involve the organisation of materials and components alone, but also involves arranging and coordinating people to achieve prescribed goals or objectives". Oyegoke (2006) stated that project procurement establishes the contractual framework that determines the nature of the relationship between the project team within the duration of their interaction. These definitions were explicit in identifying materials and personnel involved in project procurement processes. Also made clear is that, to procure successfully, there must be systematic coordination of materials and people involved. Several procurement options have evolvedin construction projects history with unique ways of interrelationships and coordinating systems that organise people and resources for successful procurement. Rashid *et al*. (2006) reported the classification made by Masterman (1994) based on the relationship and critical interaction between design and construction responsibility.Oyegoke (2006) andLahdenpera (2009) succinctly described the evolution of four procurement systems in order of development as:

i. Separated and cooperative system

ii. Integrated system

iii. Management oriented system

iv. Collaborative system

The classes in the evolution are clearly summarised in Figure 2.5. Each of these classes exhibit varying degree of coordination and interrelationships, thus, offering unique strengthsfor management exploit. Weaknesses that constitute challenges in construction cost management are also noticeable along the strengths in each system.

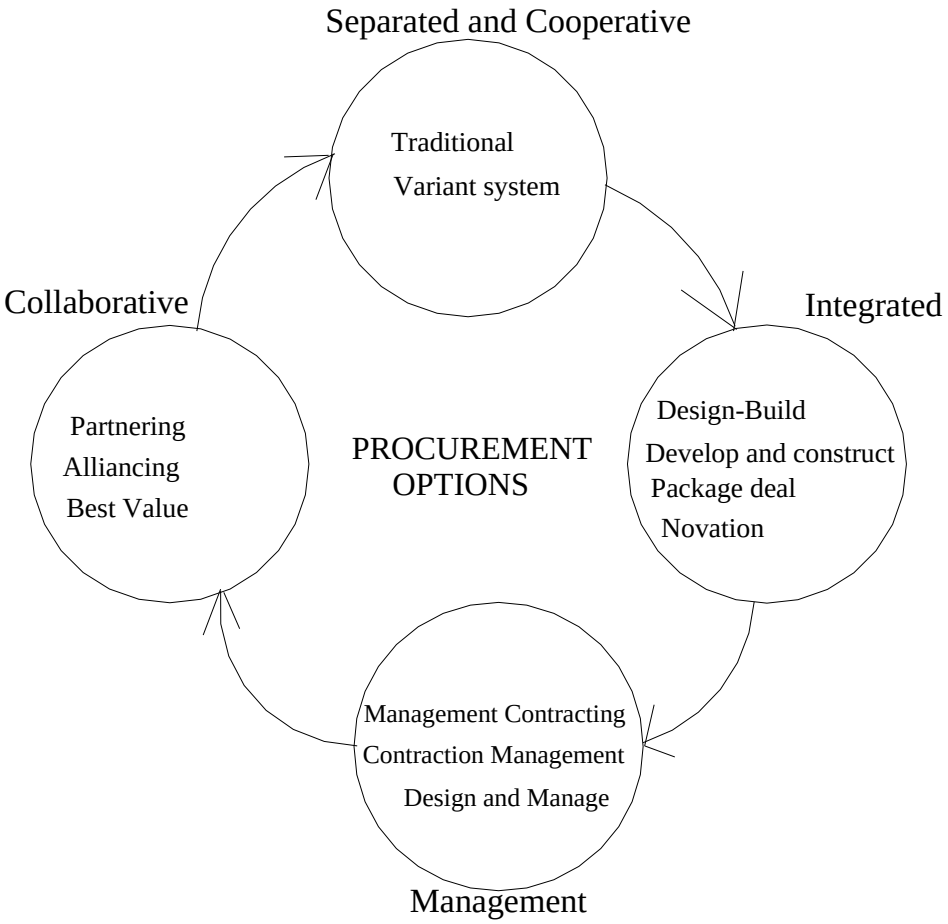


Figure 2.5: Historical development of procurement options (Source: Adapted from Rashid *et al*., 2006; Oyegoke, 2006;Lahdenpera, 2009)**.**

2.2.4.1 The Separated and Cooperative system

The Traditional Procurement Method (TPM) falls under separated and cooperative procurement system. The TPM had been described as fragmented approach, linear or sequential contracting system, multiple responsibilities contracting approach or design

bid and build (DBB)(Rashid *et al.,* 2006;Oyegoke, 2006). Brook (1998) and Oyegoke (2006) described the features of the TPM as a form of contract where the client appoints independent consultants to act on his behalf. The flow of activities in the TPM is in series and one completes after another, thus giving this system a long planning period. This was depicted by Rashid *et al*. (2006) in Figure 2.6.

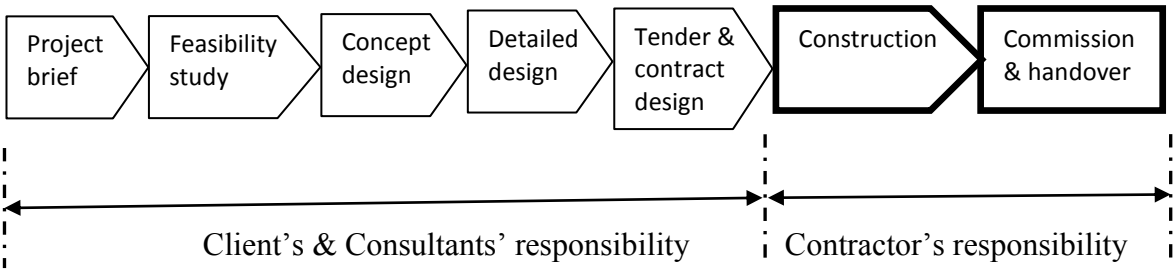


Figure2.6: The linear or sequential process of the traditional procurement system (Source: Rashid, 2006)

The roles of the consulting team are to produce the design and to supervise the construction work. Design in this case encompasses the planning activities from the brief to tender action, and supervision entails monitoring and controlling all activities so as to keep the work within the planned budget, timeframe and quality standards, or any other requirement covering the construction period. The design team often produces complete design documents before engaging the contractor (Oyegoke, 2006; DVPM, 2013).

The planning period is longer in the TPM when compared to other procurement methods. More discrete spots are involved which results to long project duration also. The characterised long planning duration and fragmented procurement process is the bane of the TPM (Rashid *et al*., 2006; Oyegoke, 2006; Yusof *et al*., 2011; DVPM, 2013). In support of this view, Koskela (1992) reasoned earlier that "every time a task becomes more discrete, or sub-divided and executed by different specialists, the value

of the flow process increases. In this way, the traditional path contributes naturally to expanding non value-adding activities". For example, the process of accountability and communication transmission in the TPM is generally slow. Figure 2.7 is a simple linear order demonstrating client-consultants-constructor communication relationships in the TPM. Communication from the client passes through the consultants before reaching the constructor andin that order backward.

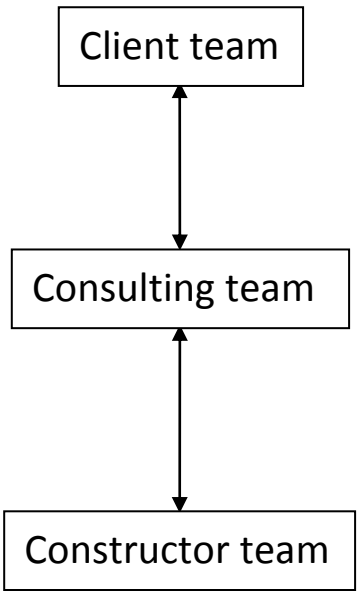


Figure 2.7: Communication paths in traditional procurement method(Source: Adapted from Rashid, 2006; Oyegoke, 2006)

Conflict does exist inherently or overtly between the client, consultants and constructor in the TPM as shown in Figure 2.8. Bala (2000) found a key cause of dispute between client and the consultants as"clients often neglect successful project management in favorof successful projectin a construction process".Successful project involves activities carried out inthe site assemblythat adds direct and permanent value to the end productwhich is more the responsibility of the constructor.In the other hand, successful project management refers to the consulting team supervisory role of inspections and instructions whichdo not add direct tangible value to the end product.

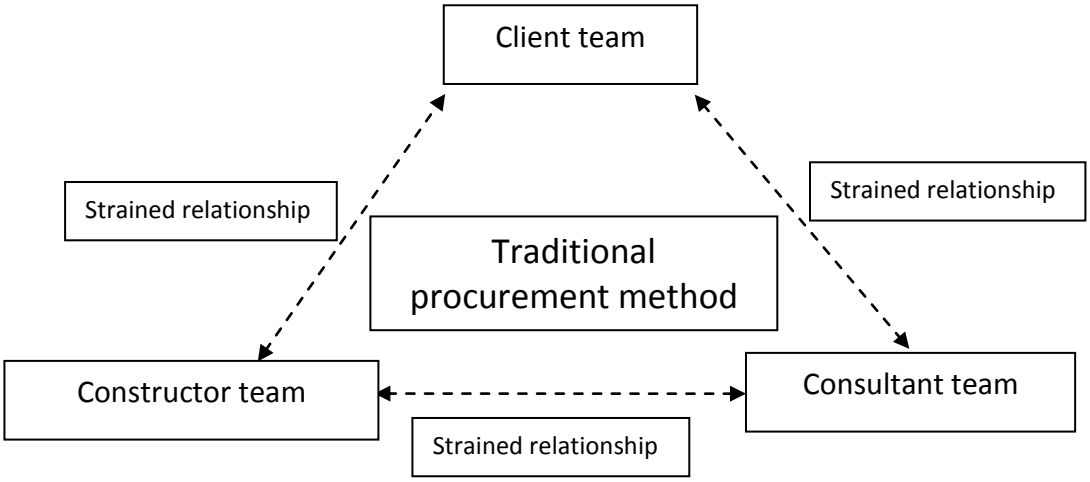


Figure 2.8: Nature of relationships in traditional procurement method(Source: Adapted from Bala, 2000; Lock, 2001; Gray & Larson, 2008).

The client therefore, is most likely to pay for the direct value adding activities likeconcreting which is a conversion process than to pay for the non-value adding activities carried out by the consultants like inspection orgiving instructions which does not add direct value to the end product.

The client could be right in the understanding and choice of enhancing the share of conversion (constructor's work) as against flow process (consultant's work). However, Bala (2000) in this case advised that "the two distinct sub processes are both important and should be accorded equal attention. It means that neglect of one aspect can affect the entire project significantly". Koskela (1992) earlier warned of turbulence in process management through excessive oppression of the flow sub process. Neglecting project management success therefore is an over suppression of the flow which could describe a turbulence case in improper management of the flow activities in construction. It can lead to lack of commitment by the consulting team and capable of causing low productivity with strained relationships which will result to increased cost of construction.

Change is generally common in construction projects (Ssegawa *et al.,*2002); the communication of change often passes through a long bureaucratic channel with multiple handling in multiple sub channels to reach its final destination. Distortions and loss of vital partsof the information being passed is therefore possible (Lock, 2001; Gray & Larson, 2008). This causes misunderstanding of the true meaning of the maiden message leading to either delayed action, inaction or wrong action. In most cases, new instructions have to be issued to achieve results.

In the contrary, there are strengths in the traditional procurement system that fundamentally helps in better attainment of project objectives which cannot be ignored. Since, poor planning was identified to cause delay in project implementation (Moris, 1990; Olusegun & Micheal, 2011), the relative long planning period in the TPM enables better time to plan and to establish clear project objectives as well as clear responsibility for every stakeholder. Within this long planning period the project is properly defined and specifications detailed before the contractor is engaged. Clear responsibility reduces confusion and prevents clashes of interests in the order of project implementation. This offers smooth production operations flow. The Royal Institute of British Architects (RIBA) plan of work reported in Gandu and Haddarry (2007) described the comprehensive planning stages in a traditional setting. The TPM therefore offers the opportunity to plan properly before any commitment into production.

Furthermore, TPM facilitates an atmosphere of better competition when selecting the constructor. The competitive element in procurement creates a possibility of obtaining an optimum offer from competitors, vis-à-vis cheap initial construction cost. Investors are often satisfied and enthusiastic in the sponsorship when value is seen to equate investment. Since competition is based on comprehensive set of information on the

project, the contractor becomes aware and puts into consideration any difficulty in resource management specified and makes contingency plans for timely acquisition. Any bidder, who offers, is an indication that he appreciates the scope of work involved, the difficulty in getting resources, and the time value set for the project to complete. There is therefore a higher tendency for a better and efficient end product acquisition. Better arrangement to achieve smooth production flow by the construction team can be made. The role of consultants representing the client is another virtue that serves as check and balance to the activities of the constructor during construction. Apart from pressing the constructor on quality control, consultants pressure on time control also, and certify the work packages including any financial claim before it is paid. With checks and balances, the constructor is most likely to be more alert, prudent and committed to the course of the product assembly.

With these strengths of the TPM, there exists a chance that cost and time successes should be achieved more easily from the planning to the implementation of a project cycle. This is not the case with this system, which has often been associated with delay and described as prone to dispute (Yusof *et al.*, 2011), and subsequent cost and time over-runs. It became the main drive to develop alternative procurement systems to replace the traditional system.

2.2.4.2 The integrated (Design and Build) approach

For any alternative system to adequately replace the TPM, it should eliminate the major constraints observedin theTPM while retaining the strengths associated with it. Hanscomb.means (2004) reported a research that found the integrated (design and build or D&B) method emerged as an alternative to the fragmented method (TPM), and has

increased in acceptability and application in construction projectsprocurement more than other alternative methods. There is steady acceptability and application of the D&B to many projects procurement in many countries.

The design and build (D&B) method is a fast-track system due to the integration of the design and construction phases.No separate consulting team is involved in the whole procurement arrangement (see Figure 2.9).

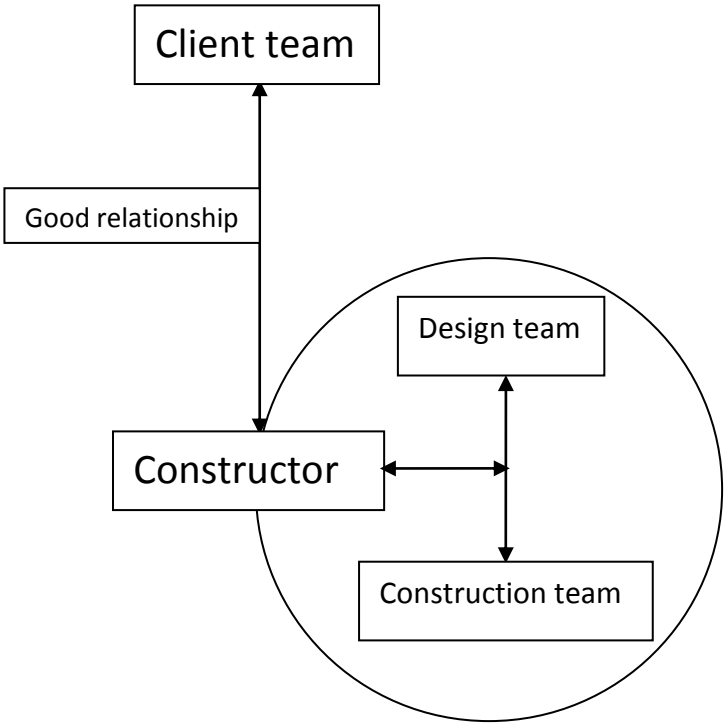


Figure 2.9 Structure of the integrated (Design and Build) procurement method
(Source: Adapted from Rashid *et al.*, 2006; Lahdenpera, 2009)

Theclient signs a contract with only one constructor and also communicates with him alone throughout the project development life-cycle. This addresses the major constraints associated with the traditional method. For example, communication channel has grossly been shortened and the adversarial tendencies between client and consultant eliminated. Since there is no separate consultant involved, the issue of

project management neglect apparent and raised in the TPM is eliminated. Change originates from only two sources, namely, the client and the contractor (no consultants) with shorter bureaucratic channels. Where change initiates internally within the constructor's organisation there is the likely hood of better cost, time and quality management. Client's initiated change is also quick to handle.

Figure 2.10 demonstrates how activitiesoverlap in the pre and post contract periods which compress the long procurement cycle time in D&B. The contractor is engaged very early in the project life cycle and prior to detailed designs. In contrast to the TPM, the responsibilities of the concept and detailed designs shift to contractor's office; his experience can be put into design solutions for better output.

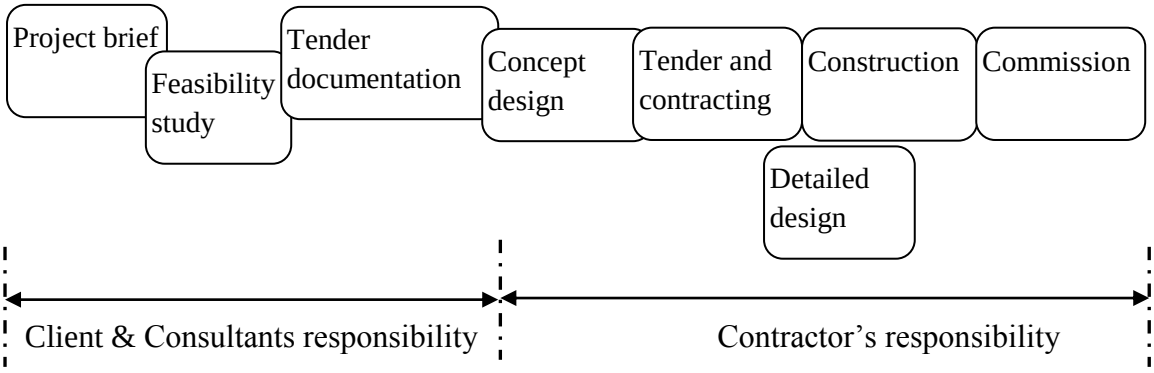


Figure 2.10: The integrated process (Design and Build) procurement system
(Source: Rashid 2006)

While the D&B successfully contained the disadvantages of the TPM, it scarcely maintained the advantages. The contractorin the D&B is engaged based onincomplete information. The full project information develops only after his engagement.The main problem with this practice according to Rashid *et al.* (2006) is that the initial cost is most likely to be high because at the time of engagement the contractor is still confronted with much uncertaintyabout the project. The competitive element inbidding

is also often played down in this system, and where there is competition at all, Lahdenpera (2009) believes that:

> …competitors do that at higher risks and therefore quote higher to cover for the risk element. When a successful bidder finally emerges, works are executed without checks and balance on the builder's performance. Even if the cost is fixed, any change that occurs affords the contractor opportunity to hike up prices to enhance profit.

The FFC (2007) summarised the disadvantages of the design and build (D&B) system more succinctly in three points as follows:

a. There is inherent conflict of interest between the owner and the architect-engineering (A/E) team.
b. It can be difficult for the owner to obtain "apples-to-apples" prices among the competing bidders for a project.
c. The owner only has three tools to control a project: competition; contract documents, and the purse strings; competition is the most valuable yet the least appreciated of those tools in the D&B system.

The FFC (2007) therefore believes that these disadvantages are dysfunctional factors that prevent project success. With this, the D&B therefore fails to offer the desired cost management success level which calls for new procurement methods in the construction sector.

2.2.4.3 New procurement options

The fact thatsome procurement options developed behind the D&Bmethod testifies the existence of a gap that needs to be filled. It suggests that better level of satisfaction in the sector is still desired. Newer methods of procurement proposed through research works tried to cover the vacuum left out in the existing ones.Le Masurier *et al.*(2006)

andLahdenpera (2009) succinctly identified the gap in the existing systems and believing that the need for new procurement systems arises more from:

i. dynamics in the construction industry that affect the types of client and new construction processes due to new techniques, and changes in the organisational structures to satisfy a variety client's objectives
ii. uncertainty related to demanding projects
iii. implementation of projects in the built environments resulting into many interfaces and demands putting into consideration different interest groups and obstructions as well as the need for the arrangements during site work
iv. uncertainty of conditions and input data and the need to minimise nuisances during construction
v. technological development that brings opportunities that are not always known at the time of launching a project

Existing systems have been unable to respond adequately to the challenges. New methods must therefore offer better management responses to these challenges to be considered feasible. However, the list suggests a non-static characteristic of challenges that impact on projects, thus, contributing to the demand for newer procurement options. More succinctly, "It is clear, however, that there are still largegaps in 'conventional wisdom' and so the construction industry continues tolook for significant solutions…several different types of procurement systems have evolved over the years…"(DVPM, 2013). Management systems must therefore continuo to shift grounds and become proactive to be capable of containing new realities and enhance success in procurement processes. Four procurement paths developed more recently and experimented in attempt to address the failure in the existing methods have been reported:

a. Bridging Procurement Method believed to have developed in 2007,
b. Specialist Task Organisations (STO) proposed in 2006,
c. The Best-Value Procurement Method believed to have developed in 2006) and
d. The Alliance Procurement Path developed in 1999.

Each of these methods is discussed along the major virtues that add value to cost objective.

Bridging Procurement Method: The Federal Facilities Council (FFC) is a US agency, which issued a technical report in 2007 known as Technical Report No. 149. The reportdescribed a new procurement path that was used in the US (FFC, 2007). It was noted that the D&B procurement method has generally been accepted as the best alternative to the traditional system and its share in construction projects increased when compared toall other methods(Hanscomb.means, 2004). Having discussed the advantages of the D&B over the TPM, the FFC (2007) appraised the disadvantages that impede projects timely completion and budgetary allocations to justify the need for an alternative method. A new method that can be used to resolve the lingering issues in D&B called Bridging was proposed. Bridging was therefore developed to improve on the weaknesses of the D&B method by combining the TPM with the D&B methods of procurement. In practice, the TPM is strictly observed at the planning stage and the D&B at the implementation stage (FFC, 2007).

The main feature of “bridging” is that the design team works in a traditional way in the planning stage and then invites builders for a D&B system in the construction stage. Bridging has a two-step award process as in Figure 2.11.

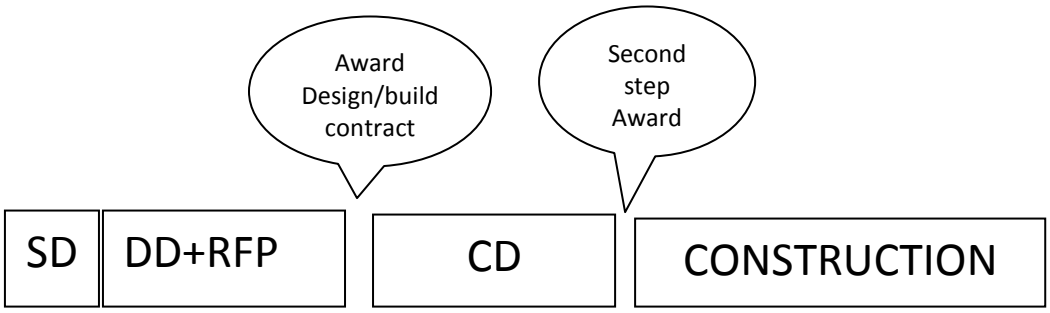


Figure 2.11: The bridging procurement method (Source: FCC, 2007)

Key:
SD- Schematic design
DD-Design development
RFP-Request for proposal
CD-Preparation of the Contract Documents, consisting of working drawings and specifications

The first step is to complete the construction documents by the design-build contractor (including drawings and specifications used to obtain building permitting and for construction). The owner is entitled to everything stated in the design development/RFP contract documents and in the construction documents. In case of a conflict, the contract documents prevail. When and if the owner wants to proceed with the project, the authorisation for construction is given which constitutes the second step in the award process. During the construction phase, the programme manager and the owner's design consultant (who is completely separate from the design-build contractor's A/E) carry out construction in the standard fashion.

In the D&B system, the architectural design is often about 45 percent complete and the engineering design about 25% complete when the RFP is solicited. In contrast, the architectural design is 60 to 70 percent complete, while the engineering is only about 10 percent complete when the bids are solicited in bridging. It means tender documents are closer to completion in the bridging as compared to the D&B when the builder is engaged, except in the engineering design (FFC, 2007).

The FFC (2007) also discussed the advantages of bridging as it allows the owner to complete whatever aspect of the design that is desiredbefore the RFP is issued,and yet leaves other items open for the builder to complete. For example, the biddocuments might include the performance specifications and requirements related to the foundation of thebuilding so that the owner's representatives can review contractors' bids and compliance with codes, butnot include the actual design plans for the foundation. According to FFC (2007), if there are very specific requirements, such as detailed cabinet work, the owner would include those specific designs in the contract bid documents. Furthermore, the owner will invest about the same time and effort under bridging as in a traditional design development, butthat the design is more complete in bridging while the engineering less complete compared to the traditional D&B method. With these features of bridging, FFC (2007) believes that bridging provides a number of cost benefits to the project owner such as: a more enforceable fixed price contract is obtained in about half the time and at about half the front-end cost compared to any other method that truly provides an enforceable fixed price contract; there is a net overall construction cost savings for an equal product, typically in the range of 5 to 10 percent; significant reduction in exposure to claims and unexpected change orders from sources other than the owner; and clear and single responsibility for correcting post-construction problems and glitches thus saving time with its cost consequences.

However, carefully observing the bridging method, major problem still lies in long planning period. Client takes time to plan before engaging the builder to complete some aspects and starts implementation. There is no special focus in the fast-tracked of the project except in a case of partial completion of the designs. Furthermore, the incomplete contract documents which are left for bidders to complete still poses some

degree of risks and uncertainties in the bidding process similar to the D&B method. Finally, while the project enjoys proper planning, the client's supervisory role is subsequently watered down.

The Specialist Task Organisations (STO): Oyegoke (2006) developed a new procurement method known as Specialist Task Organisations (STO). The modelattempted matching the integrated and the fragmented procurement methods into a single system. In the process, full fragmentation was maintained in the construction contract implementation stage. The STO apply the principles of specialisation and innovation in carrying out the core task/activities throughout product/project development, implementation, and possibly finished product maintenance.

Despite the problems associated with fragmentation, the researcher impliedly acknowledged the need and accepting the value adding nature of independency consultancy services in project delivery in his model. The model casts confidence on separate roles of the contractor and the consultants at the implementation stage.

From the discussion, the STO route utilises semi-autonomous integration in product/project development processes (planning stage) and full fragmentation in the implementation processes (construction stage). Essentially, the total scope of the product/project in question is procured from among organisations that are specialised in the various development/design, manufacturing, supply, installation, construction and maintenance tasks. With this, Oyegoke (2006) believes that the STO route added value over the prevailing procurement systems as:

i. Early availability of information from the preceding tasks, i.e. short feedback loops

ii. Improvements based on expertise knowledge
iii. Immediate feedback on the performance of tasks under execution
iv. Improvements in product quality via healthy competition based on, besides prices, different designs, life-cycle costs, materials, construction means, techniques and technologies
v. Immediate monitoring of actual costs, schedule and quality
vi. High certainty of the scope of a given task under consideration ensured during the detailed engineering phase that reduces claims, disputes, variations, extra works etc. in later phases.

This research observes some challenges implementers might encounter in this system. The STO method refers back to the non-valueadding concept of the flow processes in the fragmented tasks management approach denounced by researchers like Koskela (1992), Rashid *et al.* (2006) and Lahdenpera (2009). Despite the advantages enumerated, the coordination and dealings with various package contractors on site is often more difficult than dealing with one. Failure in one package can have a chain effect on others because most packages in a construction system are naturally interrelated and interdependent and correction more difficult. The corrective system of delay also becomes more complex. In change management, it is more difficult with multiple constructors on site than with a single one. Sometimes, design decisions on later parts affect previous decisions and may demand review in the previous. For example, the need for cantilevered superstructure may demand better support in frames starting from foundations. In such instances where the substructure is advanced in execution before such decisions are reached, corrections process can prove more complex, difficult and or expensive due to multiple handlers within the process.

Fundamentally, the STO method maintains the competitive element, a separate supervisory role on contractors and detailed specification before packages are contracted, yet compressed the long planning period. This offers a cost advantage in procurement.

The Best-Value procurement method: One of the key elements to successful construction procurement is getting the right builder to award the job. The NCHRP, (2006) through a research work conducted along this line, developed tools for use in awarding best-value construction contracts. The research investigated best-value concepts in use in the construction industry in the US, evaluate their relative effectiveness, and recommend a best-value system or systems that may be used in conjunction with a TPM delivery system for highway construction. Even though conducted in highway projects, this model becomes relevant to building construction projects.

According to NCHRP (2006), legislation in most states in the US requires that construction contracts for public works projects be procured using a competitive sealed bidding process and to be awarded to the responsive bidder submitting the lowest bid. In Nigeria, due process follows this concept as stipulated in (The Nigerian Public Procurement Act, 2007, section 55.1). Therefore, majority of public sector construction contracts continue to be awarded solely based on the lowest price as a result of this policy. The main concern however, is that low bid, while promoting competition and a fair playing field, may not result in the best value for money expended or the best performance during and after construction. One of the main problems (NCHRP, 2006) is that the method encourages contractors to implement cost-cutting measures just to

earn the lowest bid. The consequence of cost cutting, apart from poor quality job by the builder, he also reduces the total cost of construction so as to enhance the profit margin.Furthermore, there is high tendency of indiscriminate claims which can cause delay and high cost of implementation. The Best-Value Method therefore deemed it necessary to use not only the quantitative measure of low bid, but to introduce qualitative measures in the bid selection process. It is intended to motivatecontractors to improve performance for whoever finally wins the job, and also build in value into the end product. Other parameters in conjunction to lowest bid were developed and considered in choosing the best bidder. A succinct definition of best-value by the NCHRP (2006) is" a procurement process where price and other key factors are considered in the evaluation and selection process to minimise impacts and enhance the long-term performance and value of construction".

While best value procurement looks a vital method, its main focus is to establish the competence of the lowest bidder without which a more suitable alternative is identified and the contractawarded.It is believed that if a competent contractor is awarded a contract, the chances of cost and time success will be higher because of his experiences which will be used to handle any problem that might arise to jeopardising success. However, the method has failed to address the issue of long procurement cycle time caused by long planning period. There is also no mention of improved communication need between participants being a vital tool for successful projects implementation.

Alliance procurement method: Project Alliance was first employed in Queensland in 1999 and developed to care for deficiencies in other procurement activities especially the TPM (Le Masurier *et al,* 2006). The Alliance "is a project/programme delivery strategy where the client's and commercial participants' objectives are aligned to

maximise performance, proactively manage risk, reduce cost and achieve outstanding outcomes" (Creedy, 2006). Alliance is aimed at making the contractor to implement a project at the lowest possible cost (The Queensland Government, 2008). Two key philosophies arising from the TPM that led to the development of project alliance are; first, collaborative production is a key factor in an improved sector performance and increase innovation when projects are implemented under demanding conditions; and secondcompetitiveness remains the starting point that produces the needed stimulus to pursue an excellent level of performance. In essence, while the need for a new collaborative procurement method is inevitable, the competitive element in the traditional method should be maintained (Lahdenpera, 2009).

These philosophies lead to the emergence of project alliances process where openness and transparency are mainfeatures that build confidence aiming at cost efficacy. Risk is borne jointly and reward is shared on the basis of the entire project success. Thismotivates the parties into commitment, taking each other's views in good faith and collaborating more efficiently.

An alliance has therefore been defined as "an agreement between two or more entities, which undertake to work cooperatively, on the basis of a sharing of project risk and reward, for achieving agreed outcomes based on principles of good faith and trust and an open-book approach towardscosts" (Queensland Government, 2008). It is "a project delivery method based on a joint contract between the key actors to a project whereby the parties assume joint responsibility for the design and construction of the project to be implemented through a joint organisation, and where the actors share both positive and negative risks related to the project and observe the principles of information accessibility in pursuing close cooperation"(Lahdenpera, 2009). The basic principles of alliances listed byQueensland Government (2008) are:

i. A focus on project outcomes
ii. Innovative contractual arrangements
iii. Success of projects measured against key performance indices
iv. An emphasis on openness and communication between participants
v. An equitable risk/reward balance that aligns the commercial interests of the parties.
vi. Access to and contribution by the best resources of each participant with an emphasis onworking together efficiently

Alliance therefore relies so much on vigorous identification and selection of the alliance partners and partners observing some basic features to sustain the collaboration (Le Masurier, *et al*, 2006; Queensland Government, 2008; Lahdenpera, 2009) such as:

a. Mutual trust between team members and parties.
b. Honest and direct communication.
c. Generous listening to each other.
d. Mutual support and respect for others.
e. An atmosphere of integrity.
f. Accepting and maintaining a level of stretch or discomfort in declared targets.
g. Focus on achieving results.
h. Working on the basis of no blame if someone fails.
i. Individuals taking ownership of their actions and inactions.
j. Working in an environment where problems are not seen as negative, but as avenues to new possibilities.

A comprehensive process of alliance procurement activities with success factors is tabulated in Appendix III: However, some procurement arrangements like partnering emphasised similar features asthe alliance with minor difference:

> "…partnering focuses on improving cooperation but is based on traditional contractual frameworks such as traditional contracting or Design-Build (DB). It is an arrangement that can fit into other procurement options. This is not the same with project alliance. The partnering charter signed by the parties is, however, a deviation from traditional models. It basically lists the proper agreed main principles of cooperation but is not a legally binding document. Second, Project Alliance, promotes procedures that stimulate cooperation through contractual means while, partnering is merely a collaborative procedure, not an actual construction procurement method (or project delivery system). Project Alliance, on the other hand, is both a collaborative procedure and a procurement method" (Lahdenpera, 2009).

The main virtue in Project Alliance is that the fundamental interests of all stakeholders are brought together into common focus. Each team member takes the project personal with passion. Each participant makes project success a dominant factor in the list of his interest due to the incentive. With that, client's interest indirectly gets adequate attention by the team members.

From the discussions, it can only be appreciated that the embodiment of procurement option is yet to achieve. Weaknesses are still apparent even with the new procurement paths. The cost of construction usually bears the brunt at the end. More work is therefore needed so as to come up with a method that will combine the advantages and eliminate or at least reduce the identified weaknesses in diverse methods. From the literature, a list of identifiedvalue adding factors believed to be important in a feasible and a more reliable procurement option may include:

i. Proper project definition before committing the builder
ii. Early builder involvement
iii. Reduced project cycle time for a fast tracking approach
iv. High competition among bidders based on sufficient information
v. Collaborative production in team spirit
vi. Less discrete spots in the whole procurement process

vii. Better communication flow among stakeholders

viii. Open information exchange (no hording of information)

ix. Better client monitoring procedure

x. Shared risk between client and contractor

xi. Shared vision of success in a way that is mutually beneficial

xii. Transparency and opennessto critical views of other team members

xiii. Improvements based on expertise knowledge

xiv. Mutual trust, support and respect for others

xv. Working on the basis of no blame if someone fails

xvi. Individuals taking ownership of their actions and inactions

xvii. Quality-based implementer selection

xviii. Activities undertaken to boost team spirit

xix. Regular cooperation and feedback meetings

xx. Use of an impartial facilitator

xxi. Defined problem-solving method

xxii. Application of economic incentives

Based on these findings, a planning model proposed in this work and shown in Figure 2.12 incorporates the main features in the value adding list.This model follows after the traditional design evolution.

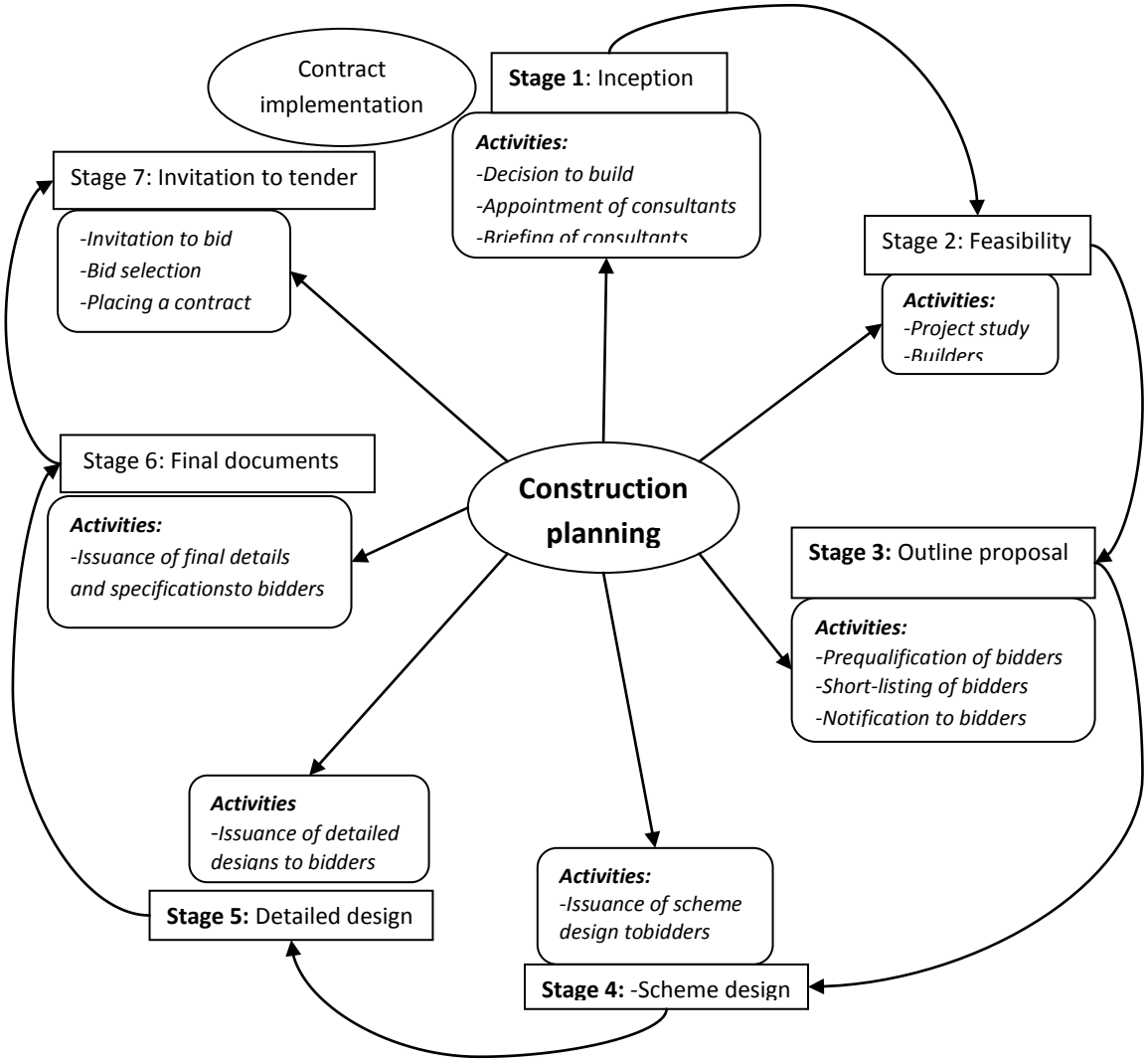


Figure 2.12: Planning model for building construction projects(Source: Adapted from Gandu *et al*., 2010)

The model indicates modified activities in the various stages of the design evolution. The basic concept is that after the feasibility stage, prospective bidders are involved in every future the planning process. Bidders are issued with any further information about the project in the developmental process and their input solicited at any point. With this, bidders appreciate their contributions to the design evolution, become better informed about the project and any successful one can take responsibilities of some variances during implementation. During design development, bidders are expected to also develop their bids along with the design. The bidding period in this case can be

shortened since prospective bidders are already familiar with the project. Bidders might need only few days to tidy their offers for submission since it evolved along with bid documents.With this model, bidders have longer time to bid yet the planning period from stages 1 to 7 is reduced.

The model therefore achieves early involvement of builder and benefit from his participation, creates a partnering feeling, maintains the competitive element, allows client's supervisory role, detailed scope and specifications developed before engaging the bidder, and yet shortens the planning period. Further proactive tendency in this mode of selecting a builder is that, during the project design evolution (planning period); rapports are established through longer interactions among the design team and the prospective contractors. Since other factors in the partnering chatter other than the bid figure alone will influence the final selection of a contractor, the longer interactions enjoyed will reveal further the ability of the contractors to work under the chatter. It means the lessons learning process on the construction team starts early enough in the procurement process. The general attitudes of bidders to work under collaborative arrangement; and any change in their previous competent status unannounced to the client can be exhibited and learnt before decisions on who to engage. The contractor on the other hand, who is not just bidding for the sake of it, will also learn more about the kind of client and members of the design team regards the seriousness or commitment to the project and may decide to opt out of the bidding process along the way if not satisfied. The lessons learnt therefore form part of the decision criteria for both teams in the prospective contract, i.e. for the builder as well as the client.

2.2.5 Poor estimating techniques

2.2.5.1 Estimating concept and its accuracy

Poor management of cost estimating process results to poor estimates which also affect project performance (Anderson *et al.,* 2007).Estimating as defined by Johnson and Mansfield (2001) "is a process which involves generating, analysing and summarising projected costs by combining the experience and judgment of a team of construction professionals. The estimating process brings specific information on cost and methods together, the essence of which is to produce an initial cost called estimate."The result from an estimating process is the estimate. An estimate was described as a forecast i.e. it is a future happening visualised today or brought to reality at the present (Baccarini, 2006), the scholar further stated that, in construction, the estimate is often relied upon as true representation of a future happening. For justification of projects on economic grounds and for efficient capital planning andfinancing, accurate forecasts of final costs of construction projects are needed and these forecasts need to be as reliable as possible at relatively early project planning stages before capital commitments are made(Baccarini, 2006).

The accuracy of the cost forecast known as estimate is often judged by comparing the estimate with the final figure committed into the project referred to as project cost (Anderson *etal.*, 2007). The closer the estimate is to the project cost the better the estimate is considered. Where the project cost variessignificantlyfrom the estimate, the accuracy of the estimate is considered poor. Cost growth often makes estimates poor and unreliable. In most instances the costs of construction projects do grow and overshoot the initial estimates (Stewart, 1995; Ikegwuru, 2006; Hugill& Ross, 2008). Awide literature search identified and categorised 18 factors that cause cost of

construction projects to grow and responsible for final contract sum to vary significantly from estimates in the US (Anderson *et al.,* 2007).

Shane *et al*. (2009) added that the factors that cause cost to growshould be addressed by engineers when assessing future project cost. If the influences of these factors are mitigated, it can improve the accuracy of cost estimates.The factors have been grouped into internal and external factors shown in Appendix IV.

In order to mitigate the negative impact of poor estimating practice two aspects related to estimating must be properly handled. These were outlined by Anderson*et al.* (2007) as cost estimation practice (CEP) and Cost Estimation Management (CEM) processes. According to Anderson*et al.* (2007), the two aspects should not be viewed in isolation, but be viewed as interdependent processes. Both CEP and CEM span the entire project development process and must be properly handled during construction assembly for final cost to succeed and tally with estimates.

Stewart (1995) defined Cost Estimation Practice as a process of predicting or forecasting the cost of a work activity or work output, and constitutes a look forward into future occurrences. For better clarity,Anderson*et al*. (2007) presented the concept of CEP in four main steps shown in Table 2.4:

The steps in Table 2.4 suggest that adequate planning and proper understanding of the work should ensure before the practical estimating activity is started. The final figure should not also end on what was seen or understood, but should include risk factors. Finally, cross checking what has been prepared before presentation was found to be necessary.

Table 2.4 Cost estimation process

	Cost Estimation Steps	Description
1.	Determine estimate basis	Document project type and scope, including: -scope documents; -drawings that are available (defining percent engineering and design completion); -project design parameters; -project complexity; -unique project location characteristics; and -disciplines required to prepare the cost estimate.
2.	Prepare base estimate	Prepare estimate, including: -documentation of estimate assumptions, types of cost data, and adjustments to cost data; -application of appropriate estimation techniques, parameters, and cost data consistent with level of scope definition; -coverage of all known project elements; -coverage of all known project conditions; and -checking of key ratios to ensure that estimates are consistent with past experience.
3.	Determine risk and set Contingencies	Identify and quantify areas of uncertainty related to: -project knowns and unknowns, -potential risks associated with these uncertainties, -appropriate level of contingency congruent with project risks.
4.	Review total estimate	Review estimate basis and assumptions, including: -methods used to develop estimate parameters (e.g., quantities) and associated costs; -completeness of estimate relative to the project scope; -application of cost data, including project-specific adjustments; -reconciliation of current estimates with the baseline estimate (explain differences); and -preparation of an estimation file that compiles information and data used to prepare the project estimate

(Source: Anderson*et al.*, 2007)

Anderson*et al.* (2007) further defined CEM as "a process for evaluating changes in scope or other issues that affect project cost". The concept is also described in details in five steps and summarised in Table 2.5:

Table 2.5 Cost estimation management process

Cost EstimationManagement Step	Description
1. Obtain appropriate approvals	Obtain management authorisation to proceed by: -review of current project scope and estimate basis; -securing of approvals from appropriate management levels; -approval of current estimates, including any changes from previous estimates;and -release of estimate for its intended purpose and use
2. Determine estimate communication approach	Communication approach is dependent upon the stakeholder who is receiving theinformation, but should consider: -mechanism for communicating the cost estimate for its intended purpose, -level of uncertainty to be communicated in the estimate given the informationupon which it is based, and -mechanism to communicate estimate to external parties.
3. Monitor project scope and project conditions	Identify any potential deviation from the existing estimate basis,including: -changes in project scope; -changes due to design development; -changes due to external conditions; -the nature and description of the potential deviation; and -whether the deviation impacts the project budget and/or schedule (potentialincrease or decrease).
4. Evaluate potential impact of Change	Assess potential impact of change, including: -cost and time impact of the deviation and -recommendation as to whether to modify the project scope, budget, and/orschedule due to change.
5. Adjust cost estimate	Document changes to the baseline estimate, including: -appropriate approval of the deviation; -the new project scope, new budget, and/or new schedule; and -notification of the change to project personnel.

(Source: Anderson *et al.,* 2007)

2.2.5.2 Challenges in cost estimation practice (CEP)

Researchers have identified two main challenges that are fundamental to construction cost estimates that worth serious concern. These arethe fundamental reliability question of estimates and the traditional approach in cost estimation(Creedy, 2006;Ahmad *el al*., 2012).

a. **Reliability question of estimates:** Apart from quality and timely completion of projects, according to (Creedy, 2006), completing projects within initial estimate is a major success criterion and constitutes an essential task of the project manager. Johnson and Mansfield (2001) believe that all estimates must therefore, faithfully represent all the information provided in bid documents to ensure successful procurement. Molenaar (2005) supported and stated that "cost estimates should transparently convey the true nature of uncertainty involved with the project at each stage of the process. Therefore, estimating procedure according to Molenaar (2005) "must model both the technical and non-technical nature of the challenges in quantifying capital costs early in the project's life cycle". In other words, estimates should be comprehensive, reflecting in money terms the technology involved in carrying out the work, the methods and resources involved, and the benefit of getting into the project (Anderson *et al.*, 2007). When the cost items are poorly represented, it results to wrong estimates, which will subsequently constitute a major management challenge during the construction assembly process. When cost estimates are wrong, the final sum of a project after execution will differ from the estimate. Lock (2001) believes that the more a project is defined at the outset, the more accurate the estimate will be. The level of details also often depends on the project developmental phase. Molenaar (2005) posits that cost estimating technique and tools must relate and

adapt to the various phases of project development to attain a better level of accuracy. Efforts have therefore been dedicated in search of accurate estimate in diverse ways (Ahmad *el al*., 2012). Part of the practice is to ensure that a reasonable contingency amount is added to the estimate. The essence is to subdue over expenditure and make the final sum the same with estimates.

However, in most construction projects, error in estimates has been found to be common and cause differences between the final sum and the initial estimates. In most cases the error is underestimation (Shane *et al.*, 2009), construction projects often procured above budget. This have led to the fundamental reliability question being asked on whether cost experts involved in forecasting the cost of construction projects are competent at all, of predicting correctly the actual cost of proposed projects (Skitemore & Patchell, 1992). Research works have offered some explanations on why projects are often underestimated which was referred to as error (Flyvbjerg *et al*., 2009). The reasons for estimating errors were categorised into delusion or honest mistake, deception or strategic manipulation of information or process and bad luck (Flyvbjerg *et al*., 2009). While some of these cases might be deliberate, others are unintentional. Scholars have also explained this phenomenon in light of:

i. **Technical Explanations:** Most studies that compared actual cost at completion and estimated costs at the beginning of bid award of construction contracts explain what is call "forecasting errors." in technical terms, it includes issues such as the use of imperfect techniques, inadequate data, honest mistakes, inherent problems in predicting the future, lack of experience on the part of forecasters, etc. (Wachs, 1990, cited in Flyvbjerg, 2005).

ii. **Economical Explanations:** Economic explanations consider cost underestimation in terms of economic rationality. According to Flyvbjerg (2003), two types of economic explanations exist; the first explained in terms of economic self-interest, the other in terms of the public interest. As regards the economic self-interest, when a project goes forward, it creates work for engineers and construction firms; and many stakeholders make money. As regards the public interest, project promoters and forecasters may deliberately underestimate costs in order to provide public officials with an incentive to cut costs and thereby to save the public's money. Empirical studies by Wachs (1990) identified respondent promoters and forecasters who agreed that they do underestimate costs in order to save public money (Flyvbjerg, 2005).

iii. **Psychological Explanations:** Psychological explanations attempt to explain biases in forecasts by a bias in the mental makeup of project promoters and forecasters(Fouracre *et al*., 1990, Flyvbjerg, 2009). Politicians may want a monument complex or museums, and transportation officials sometimes have the mentality of building roads and bridges. The most common Psychological explanation is probably 'appraisal optimism...' According to this explanation, promoters and forecasters are held to be overly optimistic about project outcomes in the appraisal phase, when projects are planned and decided. An optimistic cost estimate is a low one. The existence of appraisal optimism in promoters and forecasters would result in actual construction costs being higher than estimated costs (Fouracre *et al*., 1990).

iv. **Political Explanations:** Political explanations interpret cost underestimation in terms of interests and power (Flyvbjerg,2002). A key question for political explanations is whether forecasts are intentionally biased to serve the interests of project promoters in getting projects started. For any legal, economic, moral, and other reasons, if promoters and forecasters have intentionally fabricated a deceptive cost estimate for a project to get it started or sponsored, they are unlikely to reveal to researchers.

b. The traditional approach in cost estimating: The traditional estimating techniques still dominate the construction sector (Raftery, 1993; Odeyinka & Iyagba, 2000; Skitmore, 2002). Kern and Formoso (n.d) described it as a transformation bases system usually containing activities that are measured according to the quantification of finished elements. Kern and Formoso (n.d) identified three weaknesses in the traditional estimating practice. The first weakness is that the system cannot provide accurate cost product because costs are distributed to products in a simplistic and arbitral manner that does not often represent the real product demand imposed on investors. Second, the management system doesn't stimulate decisions that can affect the overall production results because "managers are sometimes encouraged to accomplish short term goals by reducing expenses with training and investment or even produce to stock". Finally, the past-oriented and too aggregated information impedes mangers' effort to improve production performance.

Baccarini (2005) discussed three other challenges in the traditional estimating techniques. First, estimates are always presented in the form of a 'single-point' or in discrete values. The client is told of a figure to procure a given facility with little or no

emphasis attached to thelikely changes that may affect the figure in the process of procurement. The figure which is just an estimate scarcely emphasises the element of uncertainty that should be looked forward as time passes during implementation. This portrays the notion that the future trend in cost behavior is certain. The second challenge is the addition of a contingency sum to the estimate to make up the tender figure. The contingency figure, whilesuggesting that there exist some risks in the estimate, equally informs that, according to Baccarini (2005), the riskfactor has been addressed.

The way the contingency figure is computed is the third challenge. PMI (2004) in Baccarini (2005) broke down estimates into two main components namely- the baseline estimate and the cost contingency. Cost Contingency was defined in broad terms by Baccarini (2005) as "The amount of funds, budget or time needed above the estimate to reduce the risk of overruns of project objectives to a level acceptable to the organisation". It "...covers both anticipated costs—due to the project's phase—and unexpected costs" (KPMG, 2012).Strictly, contingency is a risk cushion in these definitions.Contingency has been described further as,

> "… it is a reserve of money; represents the total financial commitment for a project which should avoidthe need to appropriate additional funds and reduces the impact of overrunning the cost objective; and it reflects the existence of risk and uncertainty in projects so the provision of project cost contingency is a risk management tool" (Baccarini, 2005).

> "Project contingency is an amount included in the construction budget to cover unknown conditions, allowance for design growth, errors in the contract drawings, inaccurate pricing, price escalation, and minor changes within the project scope. The optimal amount of project contingency permits the owner to adequately address project risks while not restricting the use of capital funds that can be assigned to other projects. The contingency fund is to absorb additional project costs within the project scope without the necessity of preparing multiple funding requests and obtaining authorisation for every change encountered during the project" (KPMG, 2012).

Therefore, the contingency figure added in estimates buttresses the reliability concept of an estimate and communicates that estimates should be relied upon as true representation of future cost of proposed projects because unforeseen risks have been addressed. However, the ways of computing contingency is a point of concern. While there exists many ways to compute contingency sums according to Baccarini (2005), the traditional percentage remains the most commonly used contingency estimating method in practice.

The traditional contingencies calculation is an across-the-board percentage addition on the base estimate, typically derived from intuition, past experience and historical data. Several serious flaws with this estimating method of contingencies highlighted are that it is judgmental and arbitral in nature. The method of calculation therefore is difficult to justify or defend by the estimator. Furthermore, the percentage addition results in a single-figure prediction of estimated cost, which implies a degree of certainty that is simply not justified. It does not encourage creativity in estimating practice, and promoting a routine and mundane administrative approach requiring little investigation and decision making (Baccarini, 2005). Cost growththerefore, often overshadows contingencies in construction projects and brings about the cost overrun thatwas aimed atpreventing. When cost overruns, doubts on estimates are common and the task of quantity surveyors whose responsibility is to prepare pre-contract estimates is challenged.

Ashworth (2010) and Smith (1999) reported that estimating in construction is a probabilistic activity and all chances could occur- including cost growth. However, Brook (1998) observedthat cost estimators have placed more emphasis on the success

of their estimates and have not given proper attention on the probability of their estimates failing.

According to Brook, (1998) stakeholders in the construction sector are well aware that cost and time do over-run, only that less emphasis is placed on overruns during placement of contracts. While clients are often more interested and demand for estimates based on the present worth with little or no interest on the future, cost advisors have not equally seen the need to press on the client to care for the cost growth risk that affect estimates. The interest is often over laid on thetenderfigure.Changes that might occur and affect the figure during project implementation is hoped to be contained in one way or the other. Clients therefore know and anticipate the changes except that there's no clear understanding and guide on the extent and how the changes might occur(Brook, 1998;Ashworth, 2010; Smith, 1999). This is not a good practice according to Brook (1998).

The main problem in this situation is that when the changes finally occur, clients are caught off-guard which cause frustration because little or no preparation was made against the changes. Therefore, the traditional estimating approach has reached its limit of development; and is inadequate for cost advice at the early stage of projects placement (Beeston, 1987 in Ogunsemi & Fasoranbaku, 2000). Raftery (1993) and Skitmore (2002) then suggested that, there should be an advisory mechanism to prepare the mind of the client on the likely future cost changes, since the future cannot be so certain at the time the bill is completed. In addition, management techniques should be laid at the onset capable of responding adequately to cost growth challenges so as to achieve cost objectives. Kern and Formoso (n.d) then suggested the need for a more proactive cost management method that can deal more readily with the dynamic, uncertain and complex construction environment.

2.2.5.3 Improving the accuracy of estimates

Research works have been carried out and reported on how to improving accuracy in construction projects estimates. A qualitative estimate must be completeand items within the estimate accurate**.** Completeness of the estimaterefers to the estimate that is whole in its entirety or has no part missing (Johnson & Mansfield, 2001). According to Stewart (1995), the cost estimating process is divided into twelve basic steps that represent the principal jobs the cost estimator must perform to produce a complete cost estimate, namely:

i. Develop the work element structure.
ii. Schedule the work elements.
iii. Retrieve and organise historical data.
iv. Develop and use cost estimating relationship.
v. Develop and use production learning curves.
vi. Identify skill categories, skill levels and labor rates.
vii. Develop labor-hour and material estimates.
viii. Develop overhead and administrative costs.
ix. Apply inflation and escalation (cost growth) factors.
x. Price or compute the estimated cost.
xi. Analyse; adjust and support the estimate.
xii. Published and present the estimate so that it can be utilised effectively.

Johnson and Mansfield (2001) preferred to pose seven questions to ensure a complete estimate. Estimators are advised to answer the questions after every exercise to ensure completeness of estimates.The questions are as follows:

a. Has the estimator determined who is responsible for which items, and is everything included that should be? Are the works and materials described by the specifications and drawings all covered?

b. Have all items that are shown been taken off the drawings?
c. Are the labor productivity rates in the estimates based on sound historic information, and has a thorough analysis of the work, the job and the conditions been done?
d. Have there been a sufficient number of sub-contract and vendor quotations to provide coverage and analysis? Is everything covered and are all exclusions incorporated into the estimate if they are part of the project?
e. Is the company using a system and a set of standards to put the estimate together? Does the system allow for crosschecking of items and mathematics? Can one estimator read and understand the other estimator's work?
f. Does the estimate include all the end-of-bid factors, and does it provide adequate mark up (profit and main office overheads)? Has the risk of the project been thoroughly analysed and the costs reflected in the work items and the profit of the project?
g. Does the estimate reflects the methods and techniques that will be used, the accountable conditions, the cost that will be incurred, and the job site management that will be used during the project?

Accuracy of estimates refers to the level of exactness or precision, and whether the items are correct or free from error. The level of accuracy of an estimate depends on a set of questions and guidelines also, according toJohnson and Mansfield (2001) in which, if answered will offer an accurate estimation of items.

A. Before the estimate started, has the company's data base of cost been updated to reflect any increases in price?
B. Is the estimator using the most recent labor costs from accounting? (Have there been any new labor contracts)?
C. Are the costs and productivity rates being used reflective of the marketplace?

D. How accurate are the quantities?
E. Is the estimator pricing and analysing the installation of the right type of permanent materials, those that the specification calls for?
F. Is the estimator analysing subcontractor's quotes with due care?
G. Are the phone quotations taken from subcontractors accurate and complete as to what the subcontractor is proposing?
H. To minimise mathematical errors, do estimators go back-checking from the drawings immediately when doubting the added up quantities?
I. At the completion of the estimate, check every item again?
J. The estimator has someone else that rechecks extensions carryovers and additions?
K. All sheets are read and reread?
L. Checked that the bond costs have been updated and are current?
M. Main office overheads recalculated on quarterly bases?
N. Permit costs reflect the actual costs that will be paid for permit?

However, any process that involves the synthesis of information, thoughts, or material into a complete product like the cost estimating process requires tools that must be available. The four principal tools for cost estimating process were identified by Stewart (1995) as information, methods, a plan for the estimate itself and skills.

2.2.6 The effect of change in construction projects

2.2.6.1 Concept of change in construction projects

Change occurs in the process of procurement of construction projects. The nature of the changes and the way and time the change occurs deserve serious scrutiny. Legal precedents, reported by Ssegawa *et al.* (2002) involving Pepper vs. Bourland in 1792; Myers vs. Sarl in 1860; Rusell vs. Sada Banderia in 1862 and Galanger vs. Hursch in

1899, illustrate that variations (or change) date back to a long time. Lock (2001) and Gray & Larson (2008) believe that change is a frequent occurrences in construction, and that it is difficult to run a construction project from inception to completion without at least one change occurring. Hao (2008a) puts it that change is inevitable and is a common denominator in all construction projects, though the size, scope, and complexity may vary significantly from case to case. While their occurrence is no longer an inconceivable issue, according to Ssegawa *et al.* (2002), it is the effect and subsequent management that continues to challenge stakeholders of projects to this day.

While accepting that change is inevitable in every subject including building construction and is a fact-of life, change should add value to the system in question or else it should be resisted. Where change proves detrimental to a system it becomes a point of great concern, which is the case in construction projects. Change has degraded value and caused serious unwanted situations such as overruns, rework, productivity degradation, claims and disputes, poor working relationship and quality degradation in construction projects. Copping with and controlling change presents very great challenge to most construction project managers (Arain & Low, 2005; Hao, 2008b; Gray & Larson, 2008; Ma & Zuo, 2010).

Change (US) or variation (UK) was defined as deviation or noticeable departure from the controlled estimate, specification or schedule (Harrison, 1992; Gray & Larson, 2008). This definition of change limits change to estimate, schedule and specification only. Assume the client decides to change the location or orientation of the project, or the contractor changes the kind of equipment to use, these can neither be estimate, specification nor schedule? Yet such kinds of changes do affect cost in projects. The understanding of change concepts must be comprehensive to be able to optimally

manage associated construction challenges. Change as depicted in Figure 2.13 affects two main components in production, namely the process and the product.

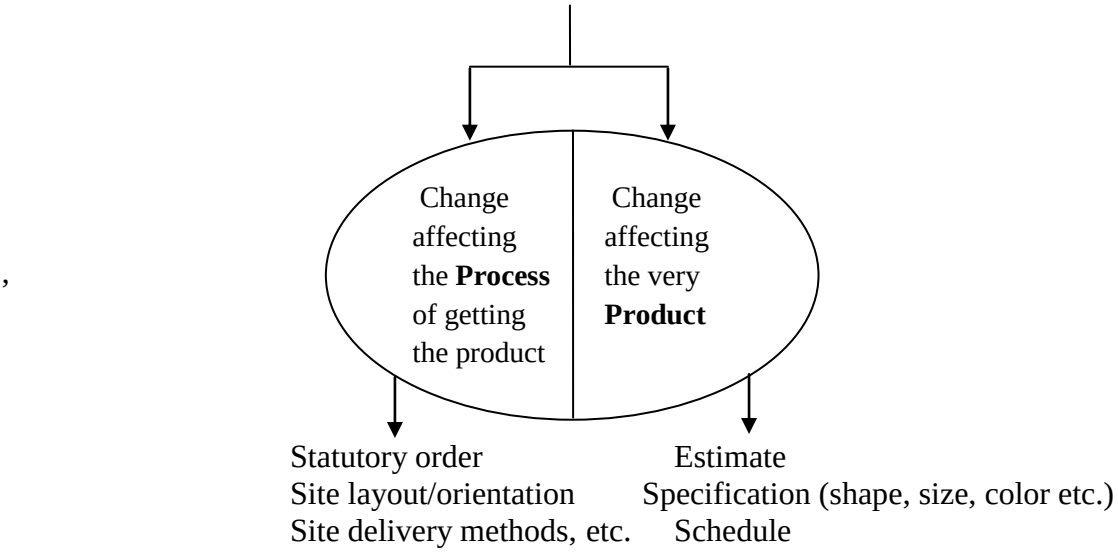


Figure 2.13: Scope of change (Source: Adapted from Arain & Low, 2005; Hao, 2008b; Gray & Larson, 2008; Ma & Zuo, 2010).

In other words, change is directed to either affect the actual product or the process of acquiring the product. This should be made explicit in any definition of change to enhance proper understanding of the concept. Poor understanding of this concept can lead to suboptimal management theory that brings about poor planning and misdirection in management priorities. Turner, (1984) in Ssagama, (2002) puts the two components differently as- changes to the work itself and changes to the means of getting the work done. Change that occurs during planning activities, before estimates, specifications and schedule are concluded was not explicit in this case. Change in the choice of kind of technology, in site location, orientation or planning arrangements; or change in the composition of the construction team members are all important influence on the final construction outcome.

Harrison (1992) explained how change affects the design and the process sequence. The design and process sequence refer to the whole construction cycle time which now includes the process as well as the product and covers the pre and the post-construction sequences. Change can happen anywhere (both in the process and product assembly sequences), in the project organization and any time (pre or post construction) during the project life cycle (EJCDC, 1996, clause 10.01; Harrison & Lock (2004). Ssagawa, *et al*. (2002) attempted to list as many change actions as possible by defining change as either additions, omissions or substitutions; and do include changes in quality, character, form, kind, position, dimension, line, level, specified sequence or method of timing of construction; changes which cause limitations or restrictions to site access, working space or hours; removal from sites of any material or goods that are not in the contracts; opening up for inspection of any work covered up; and the replacement of any person employed in connection with the contract. The list cannot said to be complete because there are so many changes affecting different myriad of activities in construction projects.

2.2.6.2 Types of change

When change is properly understood especially its nature and how it occurs, proper plan for its control can easily be made. In efforts to understand it better, change has been classified differently by different scholars using different bases. For example, Motawa *et al.* (2007) cited in Hao *et al.* (2008b) gave three main bases for the classification of change which relate to time, need and effect. The bases of the classifications are as Table 2.6.

Table 2.6: Change classification

1.	Time	Anticipated or Emergent, Proactive or Reactive, or Pre-Fixity or Post-Fixity
2.	Need	Elective or Required, Discretionary or Nondiscretionary, Preferential or Regulatory
3.	Effect	Beneficial, Neutral or Disruptive

(Source: Hao *et al.*, 2008b)

This classification draws the attention of stakeholders to a fundamental paradox in change and reveals that change can either be beneficial to the procurement system or non-beneficial. Managers of change should be able to identify value-adding change and accept them in construction, while those that are non-value adding should be rejected. However, Hao *et al*. (2008a) believe that the construction industry is project-based, as such, the best classification of change should relate to the typical stages/phases in a construction project. The scholar identified three project-based stages in a project cycle and stakeholders responsible for change at each stage in Table 2.7.

The classification accepts that change occurs in the three phases of the project lifecycle (specification, planning and construction). However, planning stage in traditional procurement consists of several steps known as Plan of Work (Seeley 1996). Detailed plan of work should reveal further the kind of change common in each stage which will offer better understanding and form good bases for change management procedure.

Table 2.7 Stages, sources and impacts of construction changes

Stage or phases	Stakeholder	Types of changes	Impacts	Actions
Specification	Owner/Client/ User or architect	Changes to requirements including specification, scope of projects, design brief, etc.	Changes in design and construction processes	Carefully provide detailed Specification documents before bidding.
Design	Design/enginee -ring Consultant	Incomplete/inconsistent drawings; design error/defect; design change; omissions of site conditions and buildability; changes in codes and regulations	Rework of design and drawing; rework in construction; change orders	Better control of design versions, drawings; site investigation; consider buildability in design
Construction	Contractor/ subcontractors	As-built not conform with as-design; quality defect; unanticipated site conditions; value engineering; materials or equipment not available; inclement weather	Rework; change orders; changes in design	Quality control; site operational control; coordinated documents and drawings; daily logs

(Source: Hao *et al.*, 2008)

The Engineering and Physical Sciences Research Council (EPRSC, 2004) also classified change under three main categories based on:

Severity: these are gradual or incremental change and refer to a change that happens slowly over a prolonged period and its intensity is low. Gradual changes often occur during the design development stage, where many decisions are fine-tuned and refined progressively.Radical change- refers to a sudden and dramatic change with marked effect.

Occurrence: such as, anticipated change- which are planned in advance and occur as intended and emergent change which arises spontaneously and are not originally anticipated or intended.

Necessity: like elective change- where one may choose whether or not to implement andrequired change- where there is no option but to make the change.Hao, *et al.* (2008b) recognised three kinds of change terminologies, namely change order (CO), construction change directives (CCD) and rework. In the detailed explanations, rework which was recognised as an arm of change presents different kinds of challenges from other arms (CO and CCD). Fisk (2000) defined a CO as a written agreement to modify or alter the work in the contract documents set forth at the time of opening bids. Fisk believes it is the only legal means available to change the contract provisions. This comes in form of (Hao *et al.,* 2008b):

a. Scope changes from the owner,
b. Design / technological changes from the architect,
c. Cost and/or time changes caused by supplier problems,
d. Design errors, material and operational failures.
e. Unsatisfactory site conditions.

When change is accepted due to error it leads to rework. Rework is re-doing a process or activity that was incorrectly implemented, and can be caused by quality defects, variance, negligence, and poor design and/or on-site management (Hao *et al.,* 2008b). According to Hao *et al*. (2008b), rework is a non-value adding activity (waste) and should be avoided as much as possible in construction projects. Hao *et al.* (2008b) believes that decisions on rework are generally difficult because of its impact in projects. In most cases, instead of rework the faulty items are retained and reworks become change orders by minor adjustments in either the designs, construction processes or the use of alternative materials as long as the baseline requirements are satisfied by the new alternative.

2.2.6.3 Decisions and change in construction projects

Many decisions are taken at each step in construction procurement process. The complex multi-tasking nature and the risks and uncertainties involved in construction projects further make change not only a frequent occurrences but a tasking exercise (Ahmed, 1992).

Seeley (1996) identified ten steps in the traditional construction assembly process. Ashworth (2010) grouped the sequence into three main stages and evolved eleven sub-stages, while Cooper *et al*. (2005) similarly identified five main stages and thirteen sub-stages. For each stage or sub stage, decisions are taken and those decisions can change. Many decisions made are often based on incomplete information, assumptions and personal experience of the construction professionals which can change (Hao *et al*., 2008b). Cooper *et al.* (2005) described the RIBA plan or work as representing a logical sequence of events that if followed should ensure sound and timely decisions made during the course of a project and should reduce the frequency of change in projects. Yet "construction projects experience incessant changes even when decisions are taken in strict terms with the RIBA guide, and the changes have affected projects success negatively" (Arain & Low, 2005; Ma *et al*., 2010). Key decisions taken that can change, according to Hao *et al*., 2008b) relates to:

i. Key dates that actions are intended to be carried and completed.
ii. The kinds of actions to be taken and where to act.
iii. Kind of resources to involve and
iv. The quality of the resources to be used to achieve the common goal.

Ashworth (2010) and Cooper *et al*. (2005) gave the stages and the sub-stages where decisions are taken in a project. Seeley (1996) believes that major decisions are taken at varied stages under the traditional procurement method (Table 2.8). Project success is enhanced when stakeholders know what decision to take and when to take them. Delayed decisions affect projects performance as well. While the reasons for delayed or changed decisions could be for good, the negative effects on projects have often been great and believed to add up to about 50% of the actual cost (Harrison, 1992).

2.2.6.4 Causes of change in construction projects

Causes of changes in construction projects are classified into five main groups namely, project related, owner (client) related, design related, contractor related and external factors (Hao *et al.*, 2008a; Ma *et al.*, 2010).

Owners (client) related: According to Hao, *et al.* (2008a), most of the changes in this section relate to increase in the scope of the work and for better quality targets. The nature of client'schanges therefore does affect the original program due to changes in his conditions. For example, when his economic circumstances change it may become physically possible and economically feasible to adjust the program to meet the new condition. In Florida, Ahmed *et al.* (1992)identified major changes induced by clients as- changes in:

a. The drawings, designs or specifications
b. Method, manner or sequence of contractor's work
c. Customer or owner furnished facilities, equipment, materials, services or site
d. Directing acceleration or deceleration in the performance of the work
e. Modifying the contract schedule or the contract milestones

Table 2.8: Major decisions during project procurement

	Stages	Sub-stages (phases)	Major decisions taken	Decisions makers		
				Client	consultants	Builders
1	Pre-design	Inception	Decision to build or not to build	✓		
			Type of project to build	✓		
			Appointment of consultants	✓		
			Briefing of consultants	✓		
			Location of project site	✓		
		Feasibility	Scope of Project	✓		
			Cost limit	✓	✓	
			Sources of resources to engage	✓		
			The form project will proceed	✓	✓	✓
			Technology to involve		✓	✓
2	Design	Outline proposal	General lay-out		✓	
			Obtaining statutory approvals		✓	
		Sketch design	Project configuration		✓	
			Quality definition	✓	✓	
			Outline specification	✓	✓	
			Detailed specifications		✓	
		Detail design	Presentation of final design		✓	
			Approval of final design	✓		
			Construction method		✓	✓
3	Preparing to build	Production information	Establishing quantity of work		✓	
			Nomination of domestic sub-contractors and suppliers	✓	✓	
		Bills of quantities	Establishing tender figure		✓	
			Completion of bill of quantities		✓	
			Printing of bills of quantities		✓	
		Tender action	Compile tender documents		✓	
			Short list of qualified bidders		✓	
			Invitation to tender		✓	
			Date for the return of offer		✓	
			Decision to bid			✓
			Adjudication			✓
			The return of bid			✓
			Bid analysis		✓	
			Identification of successful bidder	✓	✓	
			Signing of contract	✓		
			Handing over of site	✓	✓	
4	Construction	Project planning	Plan or program of work			✓
			Site visit and inspection			✓
			Road linkage to the site		✓	✓
			Mobilization to site			✓
			Appointment of domestic sub-contractor			✓
		Installation	Mark out			✓
			Setting out			✓
			Production			✓
		Commissioning	Handing over of finished work		✓	✓
5	Post construction	Feed back	✘		✘	✘

(Source: Adapted from Ahmed, 1992; Seeley, 1996; Cooper *et al.*, 2005; Ashworth, 2010**)**

Design related: this is mainly architect induced change, in most cases recommended in response to inadequate brief or unforeseen situations, directed mainly to improve the project quality. Furthermore, if errors are discovered in the contract documents, corrections are inevitable.

Contractors (construction related): usually unanticipated situations are discovered during implementation that would make it imprudent or impossible to follow the contract documents. Diverse conditions like unavailability of materials, equipment and labor, un-buildability of the design etc. are just a few of the factors that can cause design changes. Contractors often make suggestions for changing the contract requirements and sometimes, offer recommendations.

Other sources (natural causes) of change are: unanticipated soil conditions, damage by weather conditions such as wind and rain, natural disasters such as earthquake, labor and material shortages, and fire and explosion. The construction contract according to Hao, *et al.* (2008a) "allocates most of these risks between the owner and the contractor and some are covered by insurance". The owners, contractor, design related and natural causes of changes were grouped by the EPSRC (2004) into two broad categories depicting whether they are initiated externally or externally as follows:

a. External causes:the external causes are as follows:

i. Economic issues
ii. Environmental issues
iii. Technological issues
iv. Regulatory issues

b. Internal causes:internal causes are further divided into organizational level and project level as follows:

Organisational level-

i. Organisational culture
ii. Ineffective decision-making

Project level-

i. Design Improvements
ii. Inadequate skills and knowledge amongst the team
iii. Inclement weather
iv. Late change of client brief
v. Designer change of mind
vi. Design errors
vii. Inadequate knowledge of the site conditions
viii. Revised design parameters
ix. Minor field-originated changes
x. Contract disputes
xi. Ambiguity in project goal, scope, and resources

Any one or a combination of the above factors may result in changes to the design/construction of a building (EPSRC, 2004). This classification of causes of change by ESPRC (2004) reminds managers that change management should be cognizance of those arising within the organization which might easily be identified and contained through a strong change reduction mechanism while watching out for

any external effect which might occur outside the organization and might be less anticipatory in nature.

Harrison (1992) and Fisk (2000) put the reasons why change often occurs in construction projects as a result of errors and omissions, an afterthought in order to add certain features, to update latest developments in technology, for safety of legal requirements, need to improve the rate of return, need for simple luxuries or upgrade of some features. Ssagawa *et al.* (2002) identified seven kinds of changes having significant occurrences in building construction projects in Botwana as:

i. Additions
ii. Omissions
iii. Substitutions
iv. Removal from sites of any material or goods that are not in the contracts
v. Opening up for inspection of any work covered up
vi. Changes which cause limitations or restrictions to site access, working space or hours
vii. The replacement of any person employed in connection with the contract

The study conducted a test of common occurrence and discovered that omissions and additions were the most common occurrences. The client often gives financial reasons to omit items, while the designer frequently adds to the design. The contractor's request for change is mostly associated to the geological/geotechnical conditions. The findings therefore, call for proper financial budgeting to reduce the incidence of change and the designer to be meticulous. While it is more difficult to anticipate the geotechnical conditions, emphasis on feasibility study and proper geological surveys will reduce the occurrence of change.

2.2.6.5 Impact of change in construction projects

According to Nelson (2011), "change is normally defined as any event that results in modification of the original scope, execution time, cost, and/or quality of work". The scholar further identified five general types of changes, namely:

a. Change in scope;
b. Differing site conditions;
c. Delays;
d. Suspensions; and
e. Acceleration.

Regards the costs of performing changed work; Nelson (2011) believes that it consists of both those costs directly related to the accomplishment of the changed work; and those costs arising from the interaction between the changed work and unchanged work.

The importance of evaluating the impact of changes to a construction project, according to Hao *et al*. (2008b) is to assist the change decision making process. Some changes bring in "benefits" to the construction process and to the stakeholders especially the owner, while others result in "negative" impacts causing time and cost overruns.

On the negative impact, Nelson (2011) stated that project changes, disruptions, cumulative impacts, and factors affecting labour productivity have strong interrelationships. They play a vital role in establishing liability, causation, and resultant loss in lost productivity claim. In general, upper-stream changes (post contract period) have larger negative impacts compared to lower-stream changes (pre-contract period). However, apart from changed decisions, decisions can be delayed in

construction projects. When a decision is expected but fails to be taken at the right time, it becomes decision delayed. Associated actions related to it must wait until the decision is taken. Table 2.9 identifies major decisions in construction projects and the stages and change is mostly occurs.

Table 2.9 Major decisions and the period change occurs

	Major decisions	**Period decisions could be change**	
		Pre-contract	Post- contract
Inception	Decision to build or not to build	✓	×
	User type to build	✓	×
	Scope of Project	✓	✓
	Cost limit	✓	✓
	Appointment of consultants	✓	✓
	Location of project site	✓	×
	Project form	✓	✓
	The tender	✓	✓
Planning	General layout	✓	×
	Statutory approval		
	Project configuration	✓	×
	Quality of work	✓	✓
	Construction method	×	✓
	Outline specification	✓	×
	Detailed specifications	✓	✓
	Presentation of final design	✓	×
	Approval of final design	✓	×
	Printing of final drawings	✓	×
	Completion of bill of quantities	✓	×
	Quantity of work	✓	✓
	Cost of the project	✓	✓
	Short list of qualified bidders	✓	×
	Invitation to tender	✓	×
	Date for the return of offer	✓	×
	Successful bidder	✓	✓
	Signing of contract		×
	Builder (Contractor)	×	✓
	Handing over of site	✓	×
Construction & handing over	Plan or program of work	×	✓
	Mobilization to site	×	✓
	Mark out	×	✓
	Setting out	×	✓
	Engagement of resource or installations	×	✓
	Road linkage to the site	×	✓
	Handing over of finished work	×	✓

(**Source**: Adapted from Harrison, 1992; Fisk, 2000; Hao *et al*., 2008b)

The positive impact of most delayed or changed decisions aim at incorporating new ideas to the end product that will offer better ends satisfaction. Furthermore, instances do present a case of new technology or component that can be incorporated into the production process to achieve ease of installation of some components, better quality, cheaper and faster production process. Such cases add value to the production process. Managers must watch out for such opportunities in any production process.

The negative impact of change in construction projects is most when the order for a change is late as compared to when it is early and timely. When an item of work in the job sequence has already been executed before the change is ordered, the control system becomes more complex and the negative impact exerts more on projects.

A change order directed to vary a window component which has already been installed according to specification will affect the cost, time and process. The cost will not only involve the installation of a new window, but will now include removal of the existing one and some remedial works to accommodate the new one.The value of the former component might not also be recovered in the contract and constitutes a waste that builds up on the final cost of the project. Staff will have to be redeployed to carry out an item already completed and may take longer time to complete compared to the original time taken to do the original planned work. Change had been identified according to Hao *et al.* (2008b) as the major cause of project delay, cost overruns, defects, or even project failure. Unserious handling of changes causes serious ethical problems and disputes in the industry.

The negative impact of delayed decision depends on the stage of work within the procurement process, which has been divided into the pre-construction and the post

construction stages. Delayed decision at the pre-construction stage has no direct financial penalty to the client except that it cumulates to extend the planning period. The extension of planning period adds to the total procurement cycle-time with some resultant cost implications. Delayed decisions at the post-construction stage have more direct cost and time implications compared to that of the pre-construction stage. At the post contract stage, the builder has been involved and is entitled to claims where loss of time and money are incurred as a result.

Once a decision taken is changed in construction projects there is, most often, an accompanying negative effect. Like delayed decisions, change occurs at the pre-construction as well as the construction stage (Figure 2.14).

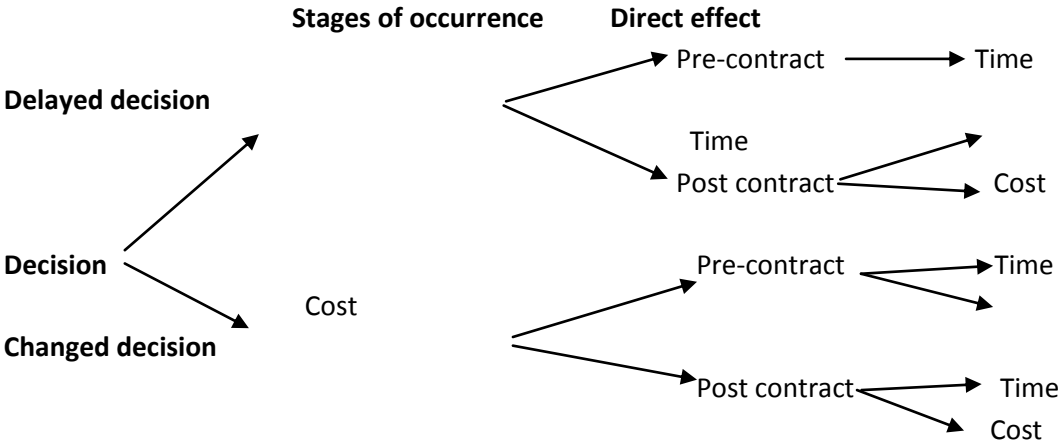


Figure 2.14 Effects of delayed and changed decisions on cost and time (Source: Adapted from Harrison, 1992; DG XVI, 1997)

The effect at the pre-construction stage is less when compared to the effect at the construction stage. According to the Directorate of European Commission, when change occurs at the construction stage, it affects the time and cost directly (DG XVI, 1997). Harrison (1992) gave the reasons changed decisions affect time and cost negatively as:

a. The whole process of that decision would have to be redone to blend the new with the entire existing process
b. All items interrelated to it must also be changed or modified
c. Materials and equipment may have to be scrapped and redesigned
d. Material purchasing activities and its installation process most often are done in a rush to cover for time delayed.

When change occurs in construction projects, the detrimental effects statedby Harrison (1992)are:

i. Increase in cost of the work
ii. Delay in the workflow process
iii. Reduction in morale and productivity of labor
iv. Worsening of relationships among those involved
v. Disruption of design and construction work organization structure and flow process
vi. Breakdown in the control system
vii. Bulkier documentation due to additional communications.

2.2.6.6 Change control systems

Change management is a critical problem faced by the construction industry. The effort of managing change has imposed a huge burden on project management. Change management should be taken a serious business in any construction project because construction changes are harder to control. The difficulty is because of the fragmented nature of the industry and low investment and limited adoption of IT technologies. Yet there is very limited research work addressing the change management issues

specifically within the construction project management context (Hao*et al.*, 2008b). An effective construction change management system will have the following requirements (Hao *et al.*, 2008b):

i. Consolidating all aspects of change information, including causes, symptoms, sources, impacts, actions, and processes of changes and their linkages
ii. Evaluating all elements affected by a change, across all design and construction phases
iii. Automating workflow processes for change review, approval and implementation
iv. Coordinating changes into operational systems of different parties
v. Coordinating changes into a shared project management system
vi. Coordinating people's activities (notification, reminding, monitoring, etc.)
vii. Coordinating the distribution and management of documents and drawings in latest versions
viii. Day-to-day process and cost recording
ix. Dispute resolution procedure
x. Change traceability and post-change analysis

Lock (2001) and Gray and Larson (2008) suggested that a well-defined change review and control process be set early in projects planning cycle. Ahmed *et al*. (1992) suggested how the effect of change by client can be reduced as:

a. Issue formal (change order) schedule extensions in time
b. Avoid ordering early or inappropriate completion
c. Respond to claims by the contractor in time

Harrison and Lock (2005) recommended a change management process to pass through an evaluation committee (usually top management) who ascertain the desirability. Proper documentation of all change orders was emphasised. To deal with change more expeditiously and effectively, the authors recommended that a change administrator be appointed to:

i. Receive each change request from originator
ii. Properly document the change request
iii. Communicate to the change committee without delay
iv. Keep the originator of the change request informed of progress and decision
v. Follow up to ensure that all the approved changes are implemented, integrated and documented

Hao *et al.* (2008a) used the concept of change in manufacturing which typically deals with any changes or inconsistencies between product designs, engineering and manufacturing life-cycles and suggested how best to manage that of construction. The scholars observed that engineering change management (ECM) is focused on the co-ordinance of product life-cycle model (PLM) and the enterprise management model. This change is not contractual in nature and the impact of engineering changes stays generally within an organisation and is well controlled via the vast adoption of integrated IT systems. Construction changes, on the other hand, are harder to control because of the fragmented nature of the industry as well as a result of low investment and limited adoption of IT technologies. Levy (2006) and Huang *et al*. (2007) both cited in Hao *et al.* (2008a) cautioned on the need to be more diligent in handling construction change.

2.3 Proffered Solutions to Cost Management Challenges

Cost management involves all activities employed to keep cost within budget. Seeley (1996) and Ashworth (2010) described the process as cost control and divided it broadly into pre-contract cost control and post contract cost control. The design evolution and how cost is controlled have been described by Seeley (1996). The design process is where specifications are refined, vague needs and wishes transformed into requirements and into cost; and several steps resulting to detailed designs solutions (Koskela, 1992; Seeley, 1996).Ashworth (2010) also described in detail how various post contract cost control is practiced.

Processes consume resources and process flaws cause delay with cost consequences (Koskela, 1992, Abdelhamid & Salem, 2005; Abdullah *et al.*, 2009). Therefore, to achieve cost objective in construction projects, not only direct payments for goods and services that should be controlled, but processes or activities lined up must be as well (Bertelsen, 2004). The money value of goods and services are influenced by market conditions, and mainly by forces of supply and demand (Stewart, 1995; Moyo, 2010). Therefore price fluctuation is common occurrences (Seeley, 2010).

The nature of construction projects has influenced a variety of unique management efforts towards achieving successful project objectives vis-à-vis cost objectives. Diverse constraints in construction projects often impact on cost sooner or later. Management of these constraints, challenges or impediments brings about success in meeting project goals. According to Cooper *et al*. (2005), most effort in the past in handling construction problems centered on management techniques. Technological advancement in terms of IT, industrialisation, new materials, components, plant and equipment continue to influence the way management is practiced. This section of the

thesis discusses a wide range of management techniques along cost efficacy in construction in five broad areas. The techniques may either relate more to the pre-contract, post contract, or to both stages. These are:

a. Process management
b. Management of procurement options
c. Operational and technical management techniques
d. Strategic initiatives
e. Quantitative techniques

2.3.1 Process management

Koskela (1992) believes that most problems in construction projects emanate from lack of understanding the concept of production, thus, causing wrong or suboptimal responses to challenges. A new theory of production was conceptualised for better understanding of the concept. Having understood production processes, constructors must strive to improve their management activities to achieve affordable and qualitative products at the right time. Researchers like Marchensan and Formoso (2003), Bertelsen (2004), Abdelhamid and Salem (2005) and Lessing (2006) became interested and worked on process improvement and recommended a number of best practices. It was first observed that to rely solely on the construction sector for improvement or innovation will continue to be fruitless exercise because construction process is so stagnant in terms of developments and innovations. Construction must therefore benchmark to improve its processes (Koskela, 1992; Cooper *et al*., 2005). Koskela (1992) then sought to improve construction process through benchmarking from the manufacturing sector.

Borrowing from manufacturing, a detailed explanation of production process was offered through just-in-time, lean construction, improved response to customer demand, lowest total cost and supply chain management (SCM), the SCM being a process oriented integrated approach to procuring, producing, and delivering products and services to customers, covering the management of material, information and financial flows (Alhager, 2002).

Waste reduction is another aspect that has attracted significant research attention. Construction projects have been found to generate so much waste that need to be curtailed. Waste in this case does not refer to the material waste alone, but includes waste in processes during assembly; i.e. activities that don't add value to the assembly process, and lean construction was found to achieve improvements in this regard especially in construction cost objectives (Bertelsen, 2004, Abdelhamid & Salem, 2005). Non value adding activities such as, idle time and accidents is a process waste. According to Lessing (2006), it is a common findings that less than 5% of all activities in processes actually add value, while about 35% are necessary but do not add value and the rest, 60% constitute waste. Koskela (1992) agreed that the non-value adding activities dominate most processes and the share of this should be a target for reduction in production to achieve project objectives. This implies that there is often a huge potential for improvement by the elimination of waste in construction processes.Waste then became a target of elimination in construction processes as means of cost efficacy. Waste was properly identified by Koskela (1992), Bertelsen (2004) and Abdelhamid & Salem (2005) as summarised in Table 2.10.

Table 2.10 Waste in construction that should be eliminated

	Waste	Form of waste	Example
1	Over-production	Producing over the customer requirements, producing unnecessary materials/products	Producing more pipe spools than required
2	Inventory	holding or purchasing unnecessary raw supplies, work-in-progress inventory, finishing goods	Stockpiling too much dry wall in area well before it is needed and in the way of other trades, finished goods not consumed for too long.
3	Transportation	multiple handling, delay in material handling, unnecessary handling	Locating materials too far from the point of installation.
4	Waiting	time delays, idle time	Crew B waiting for an activity to be completed as promised by crew A.
5	Motion	actions of people or equipment that do not add value to the product	Double and triple handling of material when planning could have reduced it to one move.
6	Over Processing	unnecessary processing steps or work elements	Rubbing a concrete foundation wall to well when it will be backfilled or covered.
7	Correction	producing a part that is scrapped or requires rework/procedures	Punchlist items or items of work that are deficient and do not meet requirements which require rework.
8	Not utilising human resources	not following-up/implementing ideas and suggestions	Not considering someone's idea to improve a work task particularly if that person performs that work
9	"Make do", not listening and not speaking	Refusing to disclose vital information that can help improve the process/repeating orders not carried out	Not disclosing information on new technology, market condition, internal problems that deserve attention, taking things for granted
10	Variability	Marked differences between what was produced and what is the need	Excess quality or specification like lengths, space, or height produced less or in excess of what is actually needed
11	Accidents	Collapse, jamming, drops due to care free attitudes that cause injuries or death	Collapse of trench, ladder, drop from height, jamming of cranes with electric lines
12	Starting daily work late	Arriving late to work place or delays to laborers	Road obstructions, weather challenge, lack of materials or working tools at time needed
13	Proliferation	Disappearance of movable items from site	Loss of materials due to theft by laborers or some external person
14	Productivity	Poor output per worker	Late coming, poor work attitude for lack of proper supervision
15	Dispute	Disagreement over certain issues	Fighting on site between laborers, client, consultants and contractor disagreement

(**Adapted** from Koskela, 1992; Bertelsen, 2004 and Abdelhamid & Salem, 2005)

Abdelhamid and Salem (2005) rather accorded greater importance to variability as a factor associated with waste that distorts work flow in construction. Bertelsen (2004) argued that variability constitutes waste from a flow or value perspective in a complex and dynamic system.The converging believe of the scholars (Koskela, 1992; Bertelsen, 2004 and Abdelhamid & Salem, 2005) is that if variability in construction project reported in Table 2.11 are eliminated or properly controlled, cost objectives will be more readily achieved.

Table 2.11: Sources of variability and control methods

	Sources of variability	**Methods of control**
1	Late delivery of material and equipment	Timely order for material and equipment
2	Design errors	Careful planning and control of design process
3	Change orders	Careful planning and control of design process
4	Equipment breakdowns	Planned maintenance and routine inspection
5	Tool malfunction	Planned maintenance and routine inspection
6	Improper crew utilisation	Flexible capacity of trades
7	Labor strikes	Motivation and information flow
8	Poor designed production systems	Proper planning
9	Accidents	Safety rule
10	Physical demands of work	Plan buffers
11	Poor site layout/organisation	Proper planning
12	Poor communication	Right and timely message or instructions

(**Source**: Abdelhamid and Salem, 2005)

To be able to deal with the waste (non-value adding activities) in construction, their sources must be understood. Koskela (1992) traced the sources of waste to three main ways. First, by design in hierarchical organisations, that is, every time a task is divided into two subtasks and executed by different specialists, the values of inspecting, moving and waiting increase. In this way, traditional organisational design contributes to an expansion of non-value-adding activities. In the traditional procurement system, design evolution undergoes seven main stages of brief, feasibility, outline proposal, sketch designs, detail designs, production information and tender actions. The tasks are shared between the client and the consultants who later engage the builder to construct.

Apart, the teams of consultants share different tasks also. The share of non-value adding activities therefore increases naturally. Second, there exists ignorance in the administrative sphere of production e.g. many processes have not been designed in an orderly fashion, but instead just evolved in an ad hocfashion to their present form. The volume of non-value-adding activities is therefore not measured, so there is no drive to curb them. Third, in the nature of production, work-in-process has to be moved from one conversion to the next, defects emerge and accidents happen.

Several ways to improve construction process were recommended like improve transparency, standardisation of parts, and systematic consideration of customer requirements, reduced cycle time and reduced number of steps. Koskela (1992); Bertelsen (2004) and Abdelhamid & Salem (2005) put the case in five areas as follows:

a. The longer a product stays within the cycle time the more likely waste occurs which could include, decay, accidents, proliferation, inflation, change order and depreciation. These factors add no value to the process and should be targeted for elimination. Koskela (1992) reported Hoppe *et al*. (1990), Stalk & Hout (1990) and Plossl (1991) who gave a practical way of cycle time reduction as:
    i. eliminating work-in-progress
    ii. reducing batch sizes
    iii. changing plant layout so that moving distances are minimised
    iv. keeping things moving; smoothing and synchronising the flows
    v. reducing variability
    vi. changing activities from sequential order to parallel order
    vii. isolating the main value-adding sequence from support work
    viii. in general, solving the control problems and constraints that prevent speedy flows

These recommendations can be seen contained in the organisation function of the assembly process.

b. Complex systems are more costly and inherently less reliable than simple systems. The human ability to deal with complexity is bounded and easily exceeded. Systems should therefore be simplified. Practical approaches to the simplification of complex systems include:

    i. shortening the flows by consolidating activities
    ii. reducing the part count of products through design changes or prefabrication
    iii. standardising parts, materials, tools, etc.
    iv. decoupling linkages
    v. minimising the amount of control information needed

c. Lack of process transparency presents three main challenges in construction including increases in the propensity to err, reduces the visibility of errors and diminishes motivation for improvement. When the main flow of operations from start to finish becomes visible and comprehensible to all employees, a teamwork scenario easily develops. In a transparent process, errors will easily be noticed and raised by participants who might have unique experience in certain associated areas.

d. The effort to reduce waste and to increase value is an internal, incremental, and iterative activity that can and must be carried out continuously. Different ways of achieving this are:

    i. Measuring and monitoring improvement

ii. Setting stretch targets (e.g. for inventory elimination or cycle time reduction), by means of which problems are unearthed and their solutions are stimulated.

iii. Giving responsibility for improvement to all employees; a steady improvement from every organisational unit should be demanded and rewarded.

iv. Using standard procedures as hypotheses of best practice, to be constantly challenged by better ways.

v. Linking improvement to control: improvement should be aimed at the current control constraints and problems of the process. The goal is to eliminate the root of problems rather than to cope with their effects.

Value is generated through fulfilling customer requirements and not as an inherent merit of conversion. In many processes, customers are never identified nor their requirements clarified. The dominant control principle has been to minimise costs in each stage; this has not allowed for optimisation of cross-functional flow in the organisation. The practical approach to this principle for better project objectives in the new philosophy is to carry out a systematic flow design, where customers are defined for each stage, and their requirements properly analysed. Activities will then be streamlined to satisfy relevant demand of the production process. This will bring about better satisfaction with less effort.Bertelsen (2004) recommended that during project implementation, pre-construction seminars for all project participants is essential in order to stress the need and agree on strategies to reduce the share of non-value adding activities in projects. However, this reduction should be done while considering if more non value-adding activities would not be created in other parts of the process.

2.3.2 Managing procurement options

Poor performance in the construction sector has been attributed to the barriers that exist between employers, designers and contractors (Morledge *et al.*, 2006). The UK construction environmentas an example is reputed for general poor performance in terms of its ability to deliver projects on time and within budget. The dissatisfyingclients then searched for value for money focusing their attention on the procurement process(NAO, 2001; Morledge *et al.*, 2006; Ashworth, 2010). Bennet and Grice (1990) have since identified the choice of the most appropriate procurement strategy as major determining factor to projects success (Morledge *et al*., 2006). The Latham report recommended strongly for a move towards collaborative methods of procurement (Latham, 1994).

This recommendation was made because reviews agreed that a significant contributory factor to poor cost and time performance in construction projects was the adversarial relationship that often exists between builders, consultants and clients in one hand, and builders, sub-contractors and suppliers in the other (NOA, 2001). It is believed that this initiative of looking into procurement will offer a significant improvement in cost and time overruns in construction projects. Steps to achieve the objectives were succinctly summarised by the Office of Government Commerce (OGC) and reported by NAO (2001). New forms of contract based on the outcome of the initiatives known as The Integrated Team Work and Partnering were developedin line with the recommendations (NAO, 2001).

The integrated project team (IPT) identified as a pragmatic way of working together consists of bringing all supply chains together to work in a team spirit and find ways of delivering the project to the required quality, within budget and within the timeframe.

A supply chain represents all parties responsible for delivering a specific product or service. The IPT is therefore made up of client's project team and the supply team of consultants, constructors and suppliers. The selection criteria is based on the qualification and experience, and the ability of individuals to work together as part of an integrated project team (IPT) starting from the earliest possible stage(NAO, 2001).

Partnering is simply the IPT developed to its full status, where the expectation of each member is open and there exists mutual benefit from the agreed outcome.According to Ashworth (2010), partnering is a working environment established where work is based upon the mutual objectives of team spirit, trust and sharing in risks and rewards.At the highest IPT level, team working moves into partnering. In partnering all parties have a shared goal of completing the project in a cost-effective and timely way that is mutually beneficial. The mutual benefit acts as an incentive to members to strive to achieve the set goals of partnering.

Key principles of partnering were further detailed which revealed its time and cost management functions/strategy through motivation and creation of confidence and trust in the supply chain towards better productivity. NAO (2001) reported six key principles to include:

i. Early involvement of key members of the project team
ii. Selection of builder by value, no emphasis on lowest price
iii. Common process such as shared information
iv. Commitment to measurement of performance as basis for continuous improvement
v. Long term relationship in the supply chain
vi. Modern commercial agreement based on target cost or target price with shared pain/gain incentivisation.

Williams (1998) reported how partnering arrangement improved construction delivery in the US by studying sixteen partnered projects and twenty-eight non-partnered projects based on their similarities.

> "Results of the study indicate a strong relationship between partnering and cost growth and schedule growth reduction for the sample projects. The average cost growth for the partnered projects was about 6% less than the cost growth for the non-partnered projects. It was felt that this was a direct result of reduction in change order costs, fewer claims, and more value engineering. Likewise, the average schedule growth for the partnered projects was about 6.5% less than the schedule growth for the non-partnered projects. Costs for implementing the partnering process were estimated to be less than 1% of the project cost".

Despite the report, partnering is "by no means the final solution…by no means the hoped-for panacea" (Ashworth, 2010).After the supply chain has been established, success depends solely on trust among members. The indices to assess steadiness in the trust or commitment is lacking. No mechanism to measure the dynamic nature of individual attitudes to work process or to indicate the effect of market forces acting on cost.

It has been found that the level of commitment of individuals to a project is affected by the level of interest he has on the project as well as the level of satisfying the interest in the developmental life of a project. The changing environment, organisational learning systems, changing values, and specific experiences which affect this interest and expectationswithin certain periods are among other factors (Chinyio & Vogwell, 2007; CRC for Construction Innovation, 2009). Monitoring and controlling the level of commitment of team members becomes inevitable in which partnering lacks the mechanism to achieve.

2.3.3 **Operational and technical techniques** (OTT)

So much progress has been recorded in the operational and technical techniques (OTT) in construction project management. This technique constitutesactivities like planning, monitoring and control tools, organisational methods, project success factors and product improvement methods, Life Cycle Analysis and cost control mechanisms (Cook & Williams, 2004; Bariga, 2005).

This work discussed monitoring and control management solutions and centered onEarned Value and Knowledge Management aspects which is directly linked andimpactmore on proactive cost management. Earned Value concept is a cost and time monitoring and control technique while knowledge management deals with knowledge/information acquisition and dissipation. Both aspects are relevant in the evaluation and feedback processes of continuous process improvement.

Six essential features in a control system that cover the whole procurement cycle time were listed by Lockyer and Gordon (1996), while Arrow (2008) reported seven tenets of proactive approach to project risk management.Both instances revealedthat actions plans, monitoring the plans, proper communication of information and prediction of likely adverse events before the events occur arenecessary proactive management practices. Attempts to achieve these values have been reported through Earned Value and Knowledge Management concepts.

2.3.3.1 The earned value concepts

Earned value (EV) has been used in the US, Australia, Canada and Sweden to manage major systems acquisitions. Questions on the popularity of earned value technique has been asked in a study and found that it is still a new concept for the fact that it has not

been widely known and applied in many countries (Wilkens, 1999; Vargas, 2002). This cost and time management technique enables managers to use current performance to predict the likely success of a project in progress. Earned Value Analysis (EVA) which is the mathematical aspect of Earned Value Management (EVM) uses the current data of performance of work done to portray the likely outcome of the project cost and time schedules arising from the knowledge of three key values, namely-Planned value, Actual cost and Earned value (Lukas, 2008; NASA, 2010; Haughey, 2011).

Harrison and Lock (2004) discussed the importance of earned value in projects monitoring and control. The authors started by observing the tenets of variance analysis (VA) method in which many projects are still being controlled with, and also exposed the inherent weaknesses as follows:

i. It is purely historic without sufficient predictive ability
ii. Performance is not clearly and simply indicated
iii. Insensitive enough to identifying problems at an early stage
iv. It does not effectively use all the data available
v. When used with 'percentage complete' assessments it tends to be highly subjective and unreliable
vi. It does not indicate trends
vii. It does not integrate schedule and cost.

This brought about the development of new monitoring techniques including the EV which has been accepted as the most comprehensive trend analysis technique. The EV concept therefore seeks to containthe weaknesses of VA (with a proactive tendency) to enhance project cost and time performanceby integrating cost and schedule on a structured personalised basis (Harrison & Lock, 2004;Haughey, 2011). Two ways EV is applied in construction projects was described by Haughey (2011).

a. **Performance analysis:** This is a methodology used to measure project progress and performance. It integrates cost and schedules on a structured and personalised basis.

b. **Forecasting analysis:** thefinal project cost or part of it can be done as project progresses through some forms of calculations. Nagrecha (2002) gave a number of factors that can be calculated to assist in the management of ingoing projects. These factors include-the total program budget, the schedule and the cost of performance; and can also show an estimated cost of the project at its completion.

Earned Value Management might be a good tool for project cost control, but will demand serious mathematical computations at each stage of application. Not being an easy exercise, it might need some form of training for a worker to implement it, apart from being difficult for untrained stakeholders to understand its concept. Understanding main terminologies was recommended as important in EV practice (Haughey, 2011). An illustrative explanation with terminologies is shown in Appendix IV.

2.3.3.2 Managing knowledge in construction projects

Knowledge management (KM): Theconstructionprojects environment is full of events. As construction projects progress, many events occur from inception to handing over. These events which create experiences may be positive in nature, as in a successful test, or negative, as in a mishap or failure (Marlin, 2008). Each of these does come along with many lessons to overtly or covertly, consciously or unconsciously learn from them. These experiences become valuable in processes; either used for the ongoing process improvement or reserved for other future jobs. However, the

construction industry is noted as being poor at learning from events and has led to chronic knowledge loss as compared to other industries (KLICON, 1999). The project-based, fragmented and unstable nature of the industry, the ad-hoc nature of its supply chain which is also often disbanded to reassemble together or members found in new teams in new jobs are all contributory to loss of knowledge. Knowledge management (KM) has therefore developed and promoted as means of harnessing and utilising intellectual capital resources to address the challenges of knowledge loss in construction, and by this, cause innovation, improve business performance and offer better client satisfaction (Senaratne & Sexton, 2008).

The first priority in the field of KM is to understand the concept through proper definition and yet, scholars believe that KM is still difficult to define precisely, owing to the lack of general consensus on a single unified meaning of the concept (Egbu, 2004). There are various definitions portraying various concepts of knowledge management. As an example:

> "… it is the processes by which an organisation formally creates, gathers and organises, analyses, shares and applies its knowledge in terms of resources, documents, experience and people's skills" (Egbu, 2004).
>
> It is an " effective learning processes associated with exploration, exploitation and sharing of human knowledge (tacit and explicit) that use appropriate technology and cultural environments to enhance an organisation's intellectual capital and performance" (Jashapara, 2004).
>
> "…knowledge management is the process through which organisations generate value from their intellectual capital and knowledge-based assets. Usually, the value is obtained by finding what employees, partners and customers know and sharing information with employees, departments and even with other companies, in order to find best practices" (Jelenic, 2011).
>
> "… a set of processes to capture, preserve and disseminate the knowledge of key individuals or groups in the organisation to assure the availability of that knowledge later when the individual has retired or the groups have dispersed it is a process which enables organisations to learn, create, develop and apply necessary knowledge" (Bhatt, 2001).

> "… is the deliberate and systematic coordination of an organisation's people, technology, processes, and organisational structure in order to add value through reuse and innovation. This coordination is achieved through creating, sharing, and applying knowledge as well as through feeding the valuable lessons learned and best practices into corporate memory in order to foster continued organisational learning" (Dalkir, 2005).

One common emphasis in the definitions is the need to capture knowledge for sharing and reuse. However, two fundamental distinctions in the taxonomy that specify various kinds of knowledge have also been identified as 'tacit' and 'explicit' knowledge. Describing tacit knowledge, King (2009) stated that tacit knowledge inhabits the minds of people and is either impossible, or difficult, to articulate. Most knowledge is initially tacit in nature; it is laboriously developed over a long period of time through trial and error, and it is underutilised because 'the organisation does not know what it knows' (Dalkir, 2005; King, 2009). According to King (2009), some knowledge is embedded in business processes, activities, and relationships that have been created over time through the implementation of a continuing series of improvements and constitute tacit knowledge. In contrast, explicit knowledge exists in the form of words, sentences, documents, organised data, and computer programs and in other explicit forms. King (2009) therefore, puts forward that if the 'difficult-to-articulate' concept of tacit knowledge is accepted, a fundamental problem of KM is to explicate tacit knowledge and then to make it available for use by others.

More argument was put forth by Raisanen & Gunnarson (2007), in efforts to explain the concept of KM better. According to Raisanen & Gunnarson (2007), while formal structures do serve as viable repositories for the accumulation and transfer of explicit knowledge, they cannot capture the enacted, context-specific practices of a workplace, nor can they ensure that the experiences acquired from one project may be used as a basis for judgments in future projects. The scholars continued that formal repositories

are only valuable for novices, who are struggling to learn the organisational routines, and the formal ways are less effective in the capture and sharing of new knowledge in the making and lessons learned among practitioners. Naturally, knowledge can be acquired informally even in an organised setting. Dialogue, such as feedback and storytelling across disciplinary borders in cross disciplinary construction project teams created mutual understanding and enhanced the sharing of tacit knowledge. For example, telling the story of a systems development is equally suggesting to the listener how the lessons learnt can be used to enhance other systems, subsystems or processes (Raisanen & Gunnarson, 2007). Considering all the definitions and arguments, KM concept should be summarised and understood under the following:

a. It is a process in which both implicit and explicit knowledge can be acquired either consciously or unconsciously, formally or informally.
b. People involved in a production system acquire knowledge as a team and as individuals, and the knowledge which may be different and unique to each member should be utilised in the process or in future processes.
c. Appropriate technology is important and should be employed in the formal knowledge management process of capturing, processing, storing and communicating/transfer of the knowledge.
d. The knowledge acquired should be available even when an individual or the team disperses.

Lessons learnt: Lessons Learned is an important aspect of Knowledge management. The term "lessons learned practices" refers to the activities, people, and products that support the collection, verification, storage, sharing, dissemination and reuse of verified lessons in organisations (Billows, 2011). The Construction Industry Institute (2008)

defines “lessons learned” as knowledge gained from experience, successful or otherwise, for the purpose of improving future performance.

Many organisations in the construction industry recognise the importance of lessons learned practices that play essential roles in knowledge management system. Yet the lessons learned processes are ineffective in most organisations and who suffer from the same mistakes over and over again from one project to another. The same issues that cause projects to fail also prevent the people involved from learning from the failure. These lessons are also often lost when the project ends and the parties move on to new projects, which make most mistakes to be repeated so often in construction projects (Fong & Yip, 2006; Billows, 2011).

> “Lessons learned may be identified at any point. Learning can come from successes where we did something creative or imaginative and we would like to see it repeated on future projects -- and learning can come from our failures where something failed to meet our expectations and we would like to improve and not make the same mistake again. It would be nice to say most of the learning comes from our successes, but the reality is that most of the learning comes from our failures” (Marlin, 2008).

Failures therefore increase the share of the flow sub-process in production and constitute waste. Lessons must therefore be acquired, stored, processed and used. According to Billows (2011), living lessons learned process gives the organisation and its management the opportunity for continuous improvement. If documented and disseminated properly, lessons learned provide a powerful method of sharing ideas for improving work processes, operation, quality, safety and cost effectiveness. It helps improve management decision making, and worker performance through every phase of a project. Seningen (2005) identified some events centered on mistakes and problems that typically occur for attention to be paid during construction processes,

which could be gathered as part of lessons-learned documentation. While not exhaustive, these are:

i. Vendor management

ii. Equipment delivery

i. Project approval

ii. Budget approval

iii. Communication (lateral and vertical)

iv. Testing

v. Technical support

vi. Training

Ahmad *et al*. (2007) described various services KM provides in the management of construction projects in Table 2.12. The knowledge services in the table essentially include knowledge capturing, storage, processing and sharing. Another dimension the table introduced is the search for relevant knowledge. If the construction industry is noted as being poor at learning from events and has led to chronic knowledge loss compared to other industries (KLICON, 1999), then the searched for knowledge will ameliorate the situation.

Koskela (1992) believes thatcontinuous process improvement management method is an important tool in production processes. Improvement can only be possible with adequate inflow of relevant information from within and outside the system and sub-systems. The kind of information should include not only challenges and successes within the system but breakthroughs elsewhere that can help improve performance in the system. The concept of lessons learnt in knowledge management therefore constitutes an important tool for acquiring relevant information. Since information is

essential in proactive management it becomes imperative to set up a mechanism to track down lessons and store them for onward transmission.

Table 2.12: Descriptions of services provided by KM system

.

	Service	Description	
1.	Document Management	The purpose of this service is to facilitate saving and recording the information of documents and reports of projects in digital forms.	Capture & Storage
2.	Video, Photo and Drawing Management	The purpose of this service is to facilitate saving videos, photos and drawings, and also to facilitate attaching them to digital records to simplify understanding of contents	Capture & Storage
3.	Knowledge Recording and Storing	The purpose of this service is to provide knowledge workers and other users the ability to record and save new knowledge of problem solving and innovations in digital format.	Capture & Storage
4.	Knowledge Publishing and Subscribing	This service provides the ability for the KM team to publish the knowledge that will be shared by the users, and provide the ability to subscribe new users and determine their authority level.	Sharing
5.	Knowledge Classification	This service provides the ability for the KM team/knowledge workers to categorise knowledge to facilitate future retrieve of knowledge.	Processing
6.	Training and Support	The purpose of this service is to provide e-learning to all participants in the construction projects. It also provides help and support to all users of the KM system.	Sharing
7.	Knowledge Editing and Approving	This service provides the ability for the KM team to review and modify the contents of knowledge packages and then approve them to be available for other users.	Processing
8.	Knowledge Referring	This service provides the ability for the KM team/knowledge workers to refer and connect the knowledge package to the related experts.	Sharing & Using
9.	E-Meeting and Messaging	The purpose of this service is to facilitate the contact of people through video conferencing and e-mails. It also provides the ability to record and save the contents in the KM system.	Capturing

10.	Knowledge Searching	The purpose of this service is to provide the ability for users to search for knowledge by using one or a combination of keywords, expert name, domain, activity name or project name etc.	Searching
11.	Yellow Pages and Contact Details	This service provides the contact information of experts and other employees with information about their professions and experiences.	Searching
12.	Knowledge Maps	This service provides another way for knowledge searching and also provides an overview of available and missing knowledge in the KM system	Searching

(**Source**: Adapted from Ahmad *et al*., 2007)

Legacy achieved and process information management: This principle developed in the 1990s deals with issues of knowledge management. It states that information technology (IT) solution should be in place to deal with how information or project knowledge can be reused in other projects, how the knowledge can be captured and what technology can be used to realise it. This is a 'live' communication link that facilitates better coordination in a project-based environment and offers the chances to learn from past projects' successes or failures to be applied on the future (Cooper *et al.*, 2005).According to Cooper *et al.* (2005), the process monitoring management involves knowledge-capture i.e. proper project documentation based on process framework, knowledge development functionalities i.e. online analytical processing to identify information pattern, potential areas of conflict, optimised construction program and possible crash detection; knowledge sharing functionalities like e-mail and document sharing; knowledge utilisation functionalities e.g. web based interface and document retrieval.

2.3.4 Strategic Initiatives

Cooper*et al*. (2005) explained that strategic initiative in construction delivery covers research works in diverse fields of knowledge some of which are industrialisation; computer integrated construction, robotised and automated construction practice as well as total quality management.

2.3.4.1 Industrialisation of production as management solutions

Industrialisation is not a new construction method in construction history. Record shows that industrialisation existed in Malaysia and Sweden since the early 60s (Lessing, 2006; Rahman & Omar, 2006). However, industrialisation remains a developing art in construction till today; and when it relates to the developing countries the level of the underdevelopment becomes even more severe. Rahman and Omar (2006) listed three key reasons developing countries are faced with the crippling art. The list includes the lack of technical expertise, poverty and dearth of technological knowhow.

Lessing (2006) reported a Danish study that viewed industrialisation in light of the structuring of processes and methods in order to achieve higher quality, fewer defects and fewer non-value adding activities. Key important areas managers should note were listed as:

a. Products and processes are explicitly documented
b. Suitable and proper production system
c. Knowledge about the product and the process
d. Repetition and strict methods
e. Skilled and trained work force
f. Knowledge management for continuous improvements
g. Controlled output of product and process

h. Repeatable technology

i. Market orientation

j. Quality throughout the process

k. Product development integrated with process development

Various definitions of the concept have been attempted. The Indiana administrative Code defined “Industrialised building system (IBS)" as any part of a building or other structure that is in whole or in substantial part fabricated in an off-site manufacturing facility for installation or assembly at the building site. Begum *et al*. (2010) reported the Malaysian IBS Roadmap 2003-2010, who defined IBS as a construction process that utilises techniques, products, components or building systems which involve prefabricated components and on-site installation. This method would involve the assembly of precast elements such as floor slabs, in-filled walls, bathrooms and staircases elsewhere for incorporation into the main units;it includes the assembly of columns and beams which reduce the amount of site labour involved in building operations and increase the productivity of the industry. Rahman and Omar (2006) simply defined IBS as a construction system that is built using pre-fabricated components. Lessing (2006) argued that it takes more than prefabrication alone to establish a strong industrialised concept; rather it is regarded as a complex concept involving several interacting sub-areas which may have reached different levels of development.

Two main features of IBS can be identified from the definitions as, the manufacturing of the components being systematically done using machines, formworks and other forms of mechanical equipment; and the components manufactured elsewhere and

delivered to construction sites for assembly or erection. Industrialised construction according to Koskela (1992) simplifies site processes and provides benefits of repetition which offer greater advantage to time, quality and cost of projects compared to non-industrialised projects. It is therefore, important to identify the parts that should be prefabricated at the onset of a project so as to plan adequately to accommodate them in the process flow. According to Rahman and Omar (2006), the Malaysia Construction Industry Development Board (CIDB) identifiedfive categories of the IBS system similar to Begum *et al*. (2010) as:

i. Pre-cast Concrete Framing, Panel and Box Systems like the pre-cast columns, beams, slabs, 3-D components (balconies, staircases, toilets, lift chambers) and permanent concrete formwork
ii. Steel Formwork Systems such as the tunnel forms, Expanded Polystyrene (EPS) forms, beams and columns molding forms and permanent steel formworks (metal decks)
iii. Steel Framing Systems such as the steel beams and columns, portal frames and roof trusses
iv. Prefabricated Timber Framing Systems like the timber frames and roof trusses
v. Block Work Systems-interlocking Concrete Masonry Units (CMU) and light weight concrete blocks

When industrialisation becomes fully developed and properly employed in production processes, many sub-processes can run simultaneously during production. It therefore becomes evident that time of production will greatly reduce. Apart from offering a better working environment for operatives, it will enhance productivity, better process and quality control.

Analogy from industrialised and conventional production systems: Begum *et al*.(2010) compared the industrialised production processes with the conventional system in a study in effort to find out the time and cost effect. Begum *et al*.(2010) studied "Waste Generation and Recycling" in the conventional way of construction and in the industrialised building systems in Malaysia. Two project sites were chosen as case study, one being the conventional and the other the IBS. Apart from two to three years of monitoring the projects in conjunction with the developer, contractor, subcontractor, project manager, quantity surveyor and site supervisor, which also covered the entire contract periods, information and data were also collated through interviews (using questionnaire). Wastes generated from each site were quantified in tones and compared, and the extent of recycling the wastes computed and also compared. The study identified materials most subjected to waste in construction sites. The total waste generated was also found to be very much higher in the conventional way of construction as compared to the prefabricated/IBS project. This study revealed that the rates of reused and recycled waste materials are relatively higher in projects that adopt prefabrication/IBS (94% of total waste generated at the IBS site is reused and recycled compared to only 73% at the conventional project site). The conclusion affirms that a huge amount of material wastage can be reduced by the adoption of prefabrication. This study is in line with the lean construction strategy which seeks to eliminate both process and material waste as key controlling mechanism to construction project success. Begum *et al.* (2010) therefore believe that the control of waste in processes and those in materials during construction procurement can easily be achieved if the prefabrication/IBS is used. Some of the advantages of prefabrication Begum *et al.* (2010) mentioned include cost and time reduction in construction projects.

Begum *et al.* (2010) warned managers not to take industrialisation processes for granted because the art is not without challenges, some of which have dampened the maximum benefits in construction process. It was made explicit for managers to note that:

a. Since there is usually a site and factory operations, the total process of construction tends to become more complex and vulnerable due to using two production locations (factory and site) and increased co-ordination needs. It contributes to expanding non value-adding activities because every time a task sub-divides the value of the flow process increases(Koskela, 1992).
b. Industrialised construction requires considerably better controlled processes than on-site construction. For example, requirements for dimensional precision as well as co-operation within the design and planning processes become more important in industrialised construction. Thus, it seems to be a plausible hypothesis that poorly controlled design, prefabrication, and site processes have often consumed the theoretical benefits to be gained from industrialisation (Begum *et al*., 2010).
c. High capital base is demanded to implement industrialised concept and there ispoor knowledge and exposure to the design, manufacture and the construction technology in the IBS. Most operatives are familiar with the conventional construction approach and are unwilling to shift to IBS that is more mechanised-base in nature (Rahman & Omar, 2006).

However, computer has played great role in the development of IBS and is most likely to accelerate its development. Rahman and Omar (2006) acknowledged the roles computer is playing in IBS as, more accurate design solutions that ensure buildability, simulation of erection and construction procedures and proper planning with the use of

computer software. Furthermore, feasibility studies on different building systems and alternatives are performed without incurring much cost. Problems during construction can also be observed, documented and better predicted. Any rectifications to the component designed can easily be done before the manufacturing process. Computer tools therefore contribute to a well-planned and systematic IBS system and are recommended by Rahman and Omar (2006).

2.3.4.2 Modeling production as management solutions

Works modeling: The three dimensional modeling has existed since in the 80's but the concept is just getting momentum(Carbosho, 2009). About 75% of building costs are fixed at the schematic design phase, changes should therefore be made and problems resolved during the design, rather than in the field during construction (Carbosho, 2009). The scholar relied on this concept and sought to lower cost while maintaining quality by creating a virtual image with the innovative Building Information Modeling (BIM). BIM recognises the multi professional input nature of consultants during designs development in construction projects and seeks to bring all members of the project team to work together to resolve discrepancies in the design phase rather than in the field. The virtual modeling was also critical about the exact specifications for equipment. With the results, services systems can be pre-fabricated off-site and installed at the most optimum time. Sanyido (2008) cited in Carbosho (2009) stated that the Three-dimensional Modeling is suitable for complex projects because it does not only increase accuracy but allows the designs of other disciplines taken to make sure nothing clashes in terms of equipment installation or systems logistics.

A case of the construction of Camino Medical Center for Sutter Health in Northern California where the BIM was used from start to finish was presented by Carbosho (2009). The mechanical systems were pre-fabricated off-site based on design specifications outlined in the model and installed before the walls were erected. It was found that the number of laborers needed reduced. For example, 30% fewer sheet metal workers and 55% fewer pipe fitters than originally estimated resulted. Furthermore, using the pre-fabricated mechanical, electrical, and plumbing systems resulted in minimal Requests for Information (RFIs), less conflicting designs, shorter time for rework and generally high cost savings in labor.

Carbosho (2009).believes the need for BIM came out of the growing complexity of buildings that makes it imperative for all stakeholders in the construction industry to streamline every aspect of project delivery from the design phase to completion. The BIM is an improvement over the more traditional computer aided drafting and it (Carbosho, 2009):

a. Enables precise documentation, faster decision-making, improved communication between parties, and optimisation of resources, more efficient workflow, increased productivity, and decreased errors. It communicates necessary design changes between the architect, construction manager, mechanical, electrical and plumbing engineers, subcontractors, and other project team members.
b. Is capable of showing extremely specific information relevant to the entire life cycle of a particular building from conception through construction and actual operation.

c. The BIM drawings can feature spatial relationships, the properties of building components, the scope of work, all included systems, interoperability of the equipment, and the most suitable installation sequence.

d. Being able to visualise each component of the building, and using a conflict-detection system makes BIM a powerful tool for reducing project errors significantly. Each team member, including specialty contractors and subcontractors, can analyse their work in relationship to that of other trades in order to avoid conflicts (Carbosho, 2009).

Process modeling: Cooper *et al*. (2005) discussed process modeling using the approach inherent in manufacturing to improve construction process. Process modeling is essentially to enhance team coordination and communication. For simple situations, flow charts and Gantt charts are often used but more complex scenarios of real-world phenomena, in which construction projects fall within, technologies like the integrated definition language (IDEF) and analytical reductionism/process decomposition are common and better used (Cooper *et al*., 2005). The IDEF family consists of a series of techniques developed to identify the need for better analysis and communication techniques for people involved in improving manufacturing productivity. This functional modeling is an engineering technique for performing and managing-needs analysis, benefit analysis, requirement definition, functional analysis, system design, maintenance and baselines for continuous improvement and also provide a blueprint of functions and their interfaces that must be captured and understood in order to make systems engineering decisions that are logical, integral and achievable (Cooper *et al*., 2005). This modeling concept brought about the benchmarking by Cooper *et al*. (2005) of two concepts into construction art namely, the continuous process improvement (CPI) and the process re-engineering concepts.

The general idea about CPIis that, when a process has been defined or designed, it becomes important to continue to improve that process. The CPI is defined as incremental change process focused on performing existing tasks more effectively. The aim is to optimise and continuously improve the on-going processes that are in operation within the organisation.

In contrast to CPI**,** process reengineering is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance, such as cost, quality, and service and speed. Breakthroughs can cause a quantum leaps in performance requirement, where the old should be completely replaced by the new (Cooper *et al*., 2005).

In managing construction projects, there is a choice between the process improvement strategy and the process reengineering approach. The choice depends on the circumstances and or opportunity offered. Where there is a breakthrough that demands the entire overhaul of the process, the opportunity should be fully utilised; otherwise the emerging realities and lessons learnt from the process implementation should be fully utilised for gradual improvement of the production of construction goods and services. Managers have the responsibility to be watchful or to set up a team to capture useful lessons and at the same time watch for any breakthrough that will be of interest to the ongoing process. When and how to use the information obtained should be totally analysed.

2.3.4.3 Computerised construction process as management solutions

Computer integration: Brown *et al*. (1996) argued that downward cost pressures, more specialised building trades and the increasing technical complexity of projects created the demand for the integration of construction project information. More efforts are

therefore being made on daily base to integrate computers or information technology (IT) into construction despite the unique construction characteristics.

Cooper *et al.*(2005) saw the latest technology developments in construction in two major areas. Firstly, the web-based project extranet enables members of the project team to communicate with each other and share project information via the internet in a controlled and secured manner. All participants therefore work with most current information with a reduced expensive cost of sending and printing project documents. Secondly, the building information model (BIM) is a digital data model of building design information which may contain information about the building construction, management, operations and maintenance. It is a single information model constructed with intelligent "objects" which represent building elements like walls, roofs, doors and windows. Whenever there is a change e.g. in the elevation, the corresponding plan, sections and schedules will be updated automatically. Brown *et al*. (1996) listed areas that computers have affected construction. Cooper *et al*. (2005) rather listed six critical dimensions of IT involvement in construction as:

i. simulation (example, "what if", project simulation, economic appraisal)
ii. integration (example, integrated data bases)
iii. communication (example, electronic data interchange, interact)
iv. intelligence (example, artificial intelligence, KBS, neural networks, case base reasoning).
v. visualisation (example, VR, 3D)
vi. IT supports (example, CAD, Project planning, cost control).

Therefore, one basic idea in the pursuit of computer integrated construction (CIC) is to facilitate effective communication of data, knowledge and design solutions between project participants. The integration of information in the construction process is

believed will also bring about faster and more accurate information flow which should optimise the process performance and lead to eventual customer satisfaction.

Brown *et al*. (16) described how information integration in construction have reached in diverse ways like communication between different software applications, integration through geometrical information like the CAD, knowledge-based interfaces linking multiple applications and multiple databases, and integration through central project databases holding all the information relating to a project according to a common conceptual model.

Brown *et al*. (1996) observed rightly that a typical large scale construction project involves hundreds of participants, thousands of decisions and huge volumes of data therefore deserves a means of centralising such large amounts of data in a single database to reduce technical difficulties. Three key areas of information integration gave the researcher greater concern:

a. **Rights and responsibilities:** As construction projects progress, actors' rights and responsibilities with respect to specific construction project objects do change. Such rights can be captured through the use of a role. As an actor performs different roles through the life of a project, so their rights over project information change. Defining roles in this way is essential for effective management of concurrent multi-actor engineering and needs to be tightly integrated with support for versioning.
b. **Notification:** Notification was defined as the process by which amendments made to objects are notified to the various roles concerned with that object. A notification mechanism is therefore essential for keeping actors aware of project changes and also supports the automation of other information management

processes such as approval. Quick notification can save many problems in construction activities.

c. **Versioning support and the representation of intent:** construction projects frequently involve multiple actors making changes and working simultaneously. Therefore a structured environment should be provided in which both the intent behind construction project decisions and changes are recorded and stored for reference so as to provide the client with a complete project history, and facilitate backtracking. Standardising version numbers reduces ambiguity when examining previous versions of objects.

Along this backdrop, Brown *et al*. (1996) developed software that sought to achieve information and data integration in construction. The software was founded on object-oriented information management model and distributed object technology; and the researchers demonstrated the technical, economic and sociological benefits that would be gained by adopting information integration approach in construction.

2.3.4.4 Robotised construction process as management solution

In the assembling tasks, robots are being developed to automate production.Williams II *et al.* (2004) presented a novel autonomous system concept for automated construction of houses and other buildings via deposition of concrete and similar materials. The researchers observed weaknesses in the characteristics of the conventional construction cranes mostly used in construction sites which need improvement. These weaknesses were identified as:

a. non-rigid support;
b. low payload-to-weight ratio (including counterweight);
c. low resistance to wind;

d. inaccurate control of loads;
e. only used to lift and coarsely position loads;
f. limited remote, autonomous capabilities;
g. workers are in a hazardous area; and
h. at any given location only one degree of freedom is controlled by the crane (i.e., the length of the lift cable between the boom and object); with these characteristics, the researchers believe that human workers are required with tag lines to maintain the load's remaining five degrees of freedom. This is inefficient, and it is dangerous to humans.

Williams II *et al*. (2004) then developed the RoboCrane which is an inverted Stewart Platform wherein a moving platform is controlled in six degrees of freedom via six active cables and winches. The system combines conventional rigid crane members with RoboCrane-type cable suspension and actuation concepts to provide a rigid, lightweight, long-reach, overhead platform. The overall system can be used as:

i. mobility system (self-contained cable-suspended crane),
ii. material deposition system (slip-form tool),
iii. metrology system, and
iv. material supply system

The crane is economical, self-contained, and a movable-base construction crane for tele-operated and/or autonomous construction applications.Estimates put the proposed automated approach to require just over one-third the time of conventional methods. The automated system has the additional benefit of little to no human supervision required after setup(Williams II *et al*., 2004). Technologies that can improve performance exist that managers must take advantage to improve construction production processes.

2.3.5 Quantitative Techniques

Quantitative management technique is mainly a forecasting method that uses historical data comprising past and present data to predict future values (Levine *et al.*, 2008). Statistical information and empirical data are analysed and information interpreted and used as bases for actions.Researchers have proposed and applied quantitative methods as panacea to many real life problems of the construction production process (Hamaker, 1995;Ozigbo, 2000). In construction, data are often gathered from previous projects of similar characters, analysis done and inferences made and used to predict or forecast behavior of some variables in the proposed task. Results from statistical analyses give the direction that management should concentrate efforts to be successful in production.

Quoting Stevenson (1999), Ubani and Unouju (2013) defined a forecast as a statement about the future, and Ozigbo (2004) simply putsit as, it is a prediction of what will happen in the future. Thisprediction can either be an optimistic or a pessimistic projection of the future, the outcome of which can either be more or less correct also. While many authors refer to forecast and prediction to be the same, Howard (1975) referred to forecast as an estimate of a future result based purely on a projection of a past series of results, while prediction is a forecast modified to allow for any changes in the relevant factors which is known, or some experience suggested will take place. For the purpose of this work, the two terms will be used interchangeably to mean a projection into future events.

Proactive cost management is all about projecting into the future cost trend of an article or facility and taking contingency measures against negative effects. The projection is either for a short term (less than 2years), medium term (2-5years) or long term purposes [5-10years] (Oswald, 2001).

Because of the importance attached to forecasting in human endeavors, many forecasting techniques have been introduced to meet some specific demands. These models are best suited for different circumstances (Stevenson, 1999). The choice of the method depends on the kind of data available, what item to forecast and the complexity of the situation to forecast. When it relates to construction, some methods have been used more frequently to address construction needs. Some of them are the variance analysis, earned value analysis, cost indices, the causal – or linear regression methods and the time series methods. Some of the methods are discussed below:

2.3.5.1 Cost predictions using casual methods

Ashuri and Lu (2010) believe that the causal and time series methods are more popular in construction. The casual method according to Levine *et al*. (2008) has many variables like regression, econometric modeling, and leading indicator analysis and diffusion indexes.These are essentially used to study relationships between variables. Knowing the relationship between variables then enables the prediction of the unknown from the known.In other form, linear regression models are typically used to explore the relationships between predictors and predicted variables. Srivastava *et al*. (1989) puts it that regression is used to estimate the value of one variable based on known values of the other, or to predict the values of the one variable given the values of other variables.

By implication, there is the need to have an existing variable (predictor) to be able to obtain the values of the one in question (predicted). The predicted therefore depends entirely on the characteristics of the independent variable. The causal methods thereforeassume that the variable to predict is determined by the independent explanatory variables (Ashuri & Lu, 2010). Noting that relationships are easily and

more accurately established if there are stronger similarities between the predictor and the predicted, yet construction projects mostly vary. As posited by Koskela (1992), every development is unique even if the same designs are implemented. With this stance, it is evident that regression will hardly offer reliable prediction of future cost behavior of construction projects. Hamaker (1995) clearly puts it further that the premise "is that cost can be estimated based on predictive variables that are only analogous, and not wholly causative, to final cost, "it does not (often) rely on detailed information nearly as much, but instead attempts to relate cost to only the cost drivers or cost descriptive variables of a project".

Furthermore, regression only provides a point prediction of the dependent variable. It cannot be used to obtain cost information on a project intermittently. This further poses a challenge to construction cost prediction using regression. Considering that the construction period of most projects is long, taking several years, and the fact that the cost is generally non-static, often influenced by several variables that derive the cost to change from time to time, point estimating will serve very little function in management. This instigates the recommendation by Raftery, (1993) that there is the need for predictions to be given in range or at intermittent levels. This is in efforts to contain time variable that cause cost to grow.

2.3.5.2 Cost predictions using time series methods

Ashuri and Lu (2010) defined time series as an ordered sequence of values of a variable at equally spaced time intervals. While Srivastava*et al.* (1989) put it that it consists of a set of chronological observations of a statistical series recorded at successive points in time or over successive periods of time. To properly understand the concept, Srivastava*et al.*(1989) defined some related terms like the time series method, time

series analysis and time series forecasting. The time series method, according to Ashuri and Lu (2010), is a method that seeks to determine future trends based on past values and corresponding errors. According to Srivastava*et al.* (1989), "previous performances must be studied to be able to generate or forecast future activities" affecting the very subject. For example, series of sales volume of weekly, monthly, quarterly or yearly or any other chosen interval can be used in time series to predict the future sales of that commodity. In this case, it is not as if sales of orange can be used to predict that of mango, rather that sales record of orange itself. Time series analysis rather makes use of methods to understand the underlying context of the data points and to make systematic forecasts based on that. Srivastava*et al*. (1989) added that it is used to determine the pattern in data collected over a period of time. Time Series forecasting uses a time series model to predict future data points based on known past data points. It means future data points can be generated at interval to show a future behavioral relationship between time and the data points. With this the user of the prediction can obtain a better understanding of the future compared to casual models.

Several weaknessesof the time series method have been documented. Some of them are that it treats the underlying trend of the series as a "black box" and makes no attempt in trying to discover the factors contributing to the trend;it is only suitable for short-term forecasting and large forecast errors may arise if discontinuities occur within the projected time period and that there is dare need for a previous mass data at regular interval to be able to project the future data points at same intervals (Pindyck and Rubinfeld, 1998; Goh and Teo, 2000; Wong, 2006, both cited in Fan *et al*., 2007). If construction projects are more variable in nature, cost data could also be variable (Seley 1996; Ashwoth, 2010); therefore it will be difficult to use one to obtain a reliable cost data for another facility. Agreeing with this Wyskida (2005) opined in different

perspectives that, “the methods by which records of past projects have been maintained are, in many instances, difficult to comprehend”. Where data is obtained from different organisations, the researcher is “further confronted with unique challenges concerning comparability of the collected data” (Wyskida, 2005). In time series, for an expert to predict the cost of any proposed development, e.g. a hotel, it will demand cost data of similar hotel development over a long period to be able to predict the cost of the future development. To find such cost data of similar development over a long period in construction is a difficult task. These arguments place time series in a tight corner in the search for reliability.

2.3.5.3 Cost indices

Cost index is mostly used to bring up a tender figure for a previous project to the current prices so that it can be used for comparison purposes with a similar project as part of cost planning. Seeley (1996) summarised four main uses of cost indices as to:

i. Assesses the differences in levels of tenders at varying dates
ii. Compare building cost where tenders are obtained at different dates
iii. Adjust analyses of the past costs of building to current prices
iv. Assess future trends in prices levels.

The common denominator in both uses is the time differentia which is expected to have influenced changes in prices. However, the main difficulties associated to cost indices noted by Seeley (1996) include difficulty in deciding which index to use in a particular situation, sample size having considerable influence on the reliability and quality of the assessment and the advice given. Also the problem of inconsistence of indices from

different organisations and the erratic occasions of price movements all have great influence on the quality of the assessment and advise given.

2.4. Summary of the literature review

Literature explored various publications that relate to management and cost growth. Essentially was the appraisal of the extent diverse researchers have reached in attempted to address the problem of cost growth in construction projects. Many areas that researchers have addressed as reviewed in this work touched on theories, the sources and causes of cost growth. Others addressed the classification, the impact of the factors, stakeholders' management, including, but not limited to responsibilities or ways to mitigate cost growth. Despite numerous commendable efforts, this research established that the intellectual domain generally agreed that so much is still desired in keeping building projects cost within budget. It is still a major challenge in construction business and needs to be addressed, because the desired success level is still hoped for. Major among challenges that are persistent are improper understanding of the concept of production, construction characteristics, procurement methods, planning processes and economic factors among other factors. Apart from the slow progression in the adaption of information and communication technology (ICT) in the sector, these challenges continue to impede progress in the cost management practice. These therefore, shed light on the root causes of the lack of progress in cost control art in the building construction production. Among the proffered solutions appraised from previous research works and from other varying publications are the need for proper understanding if the concept of production in construction business, proper planning and forecasting of future events, adoption of new technologies, industrialization of the production process, proper management of both stakeholders and the process flows. Whether these recommendations are being properly implemented is another subject

outside the scope of this research. However, a wide critique that dampens management efforts related to this was articulated. Generally, reiterating is that, the level of success desired is yet to attain because building projects are still found to underperform the desired level of success in cost and time objectives.

The conventional theory of production and the traditional management art that are still the dominant theories applied in building construction production were isolated in the sector and recommended for re-engineering. Coupled with the unique characteristics of construction projects they continue to impede and clog the wheel of cost management progress. While the conventional production theory, also referred to as traditionalproduction concept has been redefined, the traditional management art only received wide descriptions as not only responding late to management challenges, but that the response is often sub-optimal. Furthermore, that the management art also facilitates the multiplication of the non-value adding sub processes and, yet, prone to conflict. It therefore calls for new management theories and practices that will respond timely and adequately to the persistent array of impediments in the sector. Proactive cost management was identified as a feasible way to achieving this desire in building construction projects. This recommendation has not yet received the kind of research attention it requires.

This research therefore, exploited the understanding of the root causes of cost growth, their degrees of impact, characteristics, frequency of occurrence and the proffered solutions as recommended by researchers to develop a management model that offers a proactive tendency. Four proactive management sub-systems were first developed to meet the needs of unique management challenges and then harmonised into a single system called the Proactive Cost Management Model (PCMM) that can be used in mitigating cost growth in building construction projects in Nigeria. Fundamentally, cost

challenges were found to occur directly as well as indirectly, each exerting significant upward pressure on prices of materials and labor. The model addressed both cases as will be seen in the coming chapters. The succeeding chapter first described in detail how the objectives in this work were achieved.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Research Design

The generic problem of this study is the lack of proactive approach in cost management of building projects which has brought about less than satisfactory results in the product delivery processes. The basic philosophy that drives this thesis therefore is that the development of a strong predictive tool that offers a proactive way of cost management will ensure greater success in the management of construction projects**.**

3.1.1 Theoretical framework

In the general project management, the organisation can be thought of as a system compose of, but not limited to subsystems such as finance, site operations/implementation, planning, monitoring & control, communication, procurement and the purchasing subsystems. When it relates to construction projects, the organisation interrelationship can be more complex. According to Stevensons (2007) quoted by Ubani and Unonuju (2013), a system viewpoint is almost always beneficial in decision making. System approach was defined by Kerzner (2004) as a logical and disciplined process of problem solving. Ubani and Unonuju (2013) then

summed up that the system approach forces review of interrelationship of various subsystems; and a dynamic process that integrates all activities into a meaningful total system, systematically assembles and matches the parts of the system into a unified whole, and seek an optimal solution or strategy in solving a problem.

This research explored and considered system approach to mitigating the perennial problem of failed cost objectives in building projects. A proactive system comprising of relevant subsystems developed herein, will not only preempt flaws, but will serve warning signals to the entire project procurement process if properly employed by managers. Two main subsystems for flaws identification and cost prediction in form of a mathematical model (that predicts cost growth) will serve advanced warnings to stakeholders on incoming management challenges. Flaws in processes/activities as well as cost of processes or direct payments for labour, materials and services were therefore modeled to give a predictive tendency for a proactive cost management need. The steps in its evolution are shown in Figure 3.1.

3.1.2Data need for the research and their sources

Numerous data were required to be able to address the research questions vis-à-vis the aim and objectives of thisthesis.

i. To achieve the first and second objectives, identified impediments against the attainment of cost objectives in construction projects and their proffered solutions were appraised.

ii. The third and fourth objectives of the research were achieved by obtaining a set of standard designs of a prototype residential building project. This was needed in conjunction with:

iii. Prices of building materials and labour spreading over a long period to give the history of changes in prices also known as historical cost data (HCD). The essence of which is to analyse the trend in price changes and model the cost changes affecting building projects. The HCD was therefore obtained and varying estimates of the cost of the specified design obtained from fist principle as the historical cost of the entire building.

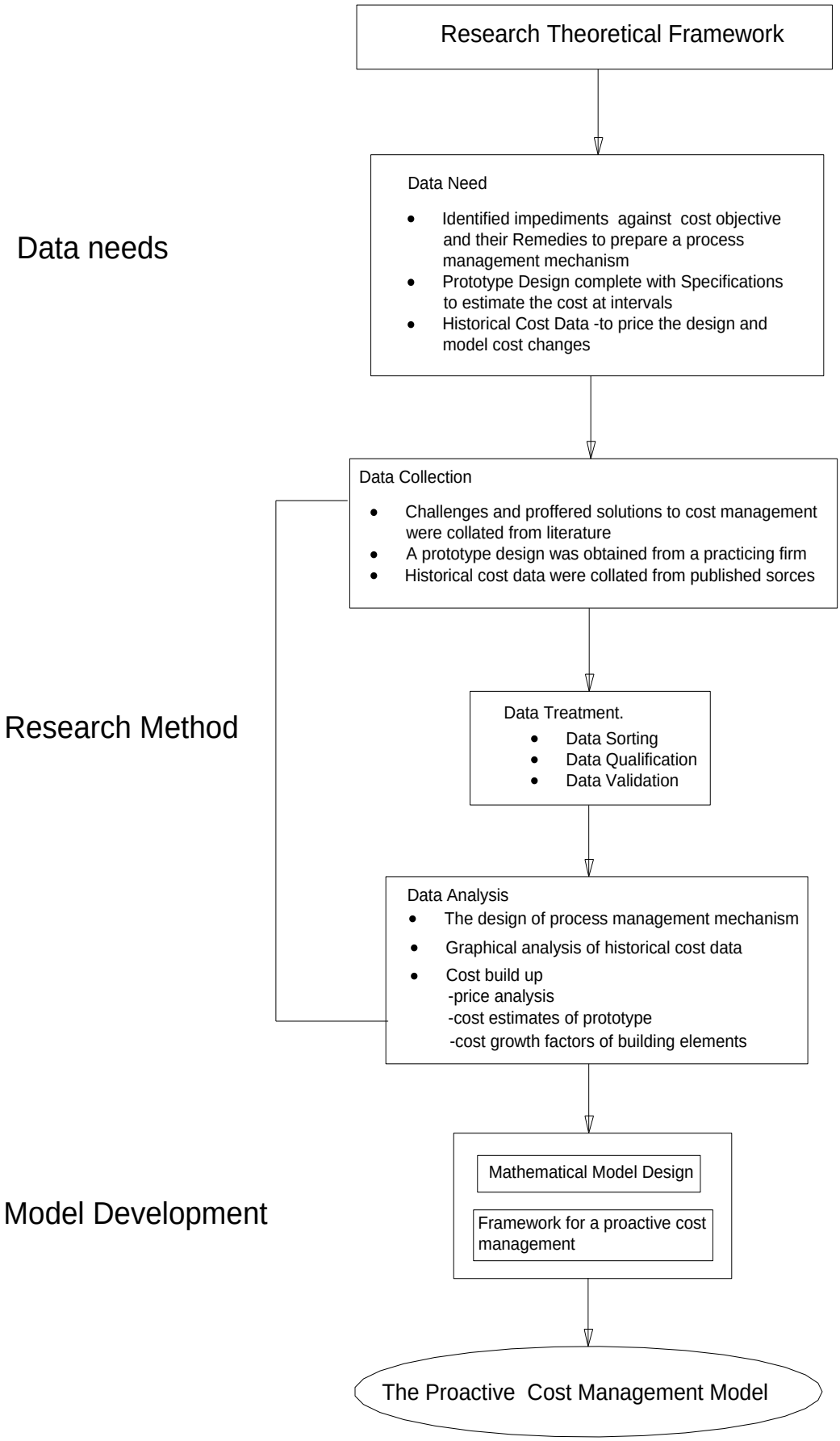


Figure 3.1: Steps followed in the research work

3.2 Research Methods

3.2.1 Data collection

Important numerous challenges to the procurement process of building projects have been documented (Olusegun & Michael, 2011; Khan, 2008; Oswald, 2001). These challenges either cause direct cost escalation or impede process flow that results to eitherdelay or other forms of cost growth leading to failure in achieving cost objective in building projects. Eighty-four such challenges also referred to as impediments were identified, ranked and classified in this work. The proffered solutions to the impediments which were recommendationsby other researchers on how to mitigate their negative effects on projects serve as best practices against the varying impediments, which were also collated herein and organised into a format to achieve the research objectives.

Adesign of a standard buildingprototype was obtained from a consultancy firm in Kaduna. The structure is a Four-Bedroom, Two-storey residential building that was implemented. The choice of a two-storey residential building was informed by the need to avoid a complexproject that could be less frequent in real life situation. Yet, the chosen design, while not too complex, is not also too trivial and naïve as in the case of a bungalow. The two-storey building chosen offered all the elements necessary in a building construction for modeling, including upper floors, staircase and frames that areoften absent in bungalows.

Empirical data is necessary in the modeling of cost changes. Historical Cost Data (HCD) obtained from reliable published sources served this purpose. After consulting diverse sources, the Nigerian Institute of Quantity Surveyors' (NIQS) quarterly magazine publications was found to possess reliable data, extending over ten

years,(between 1998 and 2007), which is a statistical long period required for this research.

The NIQS magazine publishes quarterly cost information of numerous building materials and labour by conducting constant market survey. The prices of items which were used in analysing the specified building design used in this work were sorted out based on the quarterly report. Series of reports were obtained between 1998 and 2007. Each itemconsidered therefore, has 40 data points over a ten year period (see Appendix VA-B) and spread at equal interval (i.e. quarterly) which serves the history of the cost of those materials or the HCD of the items considered. The basic characteristics of the HCD are that they are collated serially and at the same time interval. The period covered is long, that is ten years, and all the materials involved at the beginning of this work were used in every stage of the research that they are needed till the end of the period.

3.2.2 Treatment of empirical data

The HCD from the field must be tested to determine their validity as statistical samples and fit for statistical analysis (Wyskida, 1995). Two main problems that call for testing are often encountered in these kinds of data. According to Wyskida (1995) the first relates to whether the observed differences between samples signify that the populations sampled are themselves really different. Samples from different populations must possess the same probability distribution form to be valid data. According to Wyskida, (1995), the differences in data points reveal the sources of statistical samples. If the difference is large, the samples are probably from different populations, as such the samples are considered invalid, otherwise consider valid. The second problem is whether the cost data so collated are from some specified population. If the cost data is from different project/programme sources, a legitimate question on

whether the cost data differ among the projects/programmes then arises. Wyskida(1995) recommended two ways to validate data in relation to the above questions. Theseare namely, the treatment of outliers and the test of normality.

3.2.2.1 The treatment of outliers

Outliers do occur due to gross error in data entry, or may be from different population other than the population from which the rest of the data come. This is not to be thrown out without statistical justification. The tests of outliers justify keeping or rejecting one or two data points collected. Wyskida (1995) opined that often times, data collected from historical records find one or two data points falling far away from the range the rest lie. Garson (2012) stated that such outliers do radically alter the outcome of analysis and are violations of normality of data. The statistical theory often asks whether the data point in question comes from the same population as the rest data or was an error made in recording or typing the data. The null and alternate hypotheses presented to answer the above question are as follows:

H_0: $x_{(1)}$ and $x_{(2)}$ belong to S for points on the left (two smallest points in the data)
H_1: $x_{(1)}$ and $x_{(2)}$ do not belong to S.

Where S is the set of sample points from the population, and

H_0: $x_{(n)}$ and $x_{(n-1)}$ belong to S for points on the right (two largest points in the data)
H_1: $x_{(n)}$ and $x_{(n-1)}$ do not belong to S
Let the level of significance α= 0.05

H_0 is rejected when $Z_{cal} > Z_{crit.}$,where $Z_{crit.}$is taken from readily available tables for the rejection of outliers. Z_{cal} is computed from a formula, S stands for sample population, X stands for data point and n is the number of data points.

Motulsky (2002) recommends the use of Grubb's method of assessing outliers for the fact that the Grubb's method does include the outlier data point itself in the

calculations. The first step is to quantify how far the outlier is from the others? Calculate the ratio Z_{cal} as the difference between the outlier and the mean divided by the Standard Deviation (SD). If Z_{cal} is large i.e. greater than the critical value Z_{crit} read from a table in Appendix VI, then the value is far from the others. The null hypothesis is then rejected; otherwise accept the null hypothesis as belonging to the sampled population. Note that the mean and SD is calculated from all values, including the outlier.

$$\text{Calculated (Z)}, \quad Zcal = \frac{\text{mean}-\text{value}}{\text{Std Dev.}} \qquad \text{----------1}$$

Grubb tabulated the critical values for Z given in Appendix VI. The critical value increases with sample size, as expected. The value of Z (Z_{cal}) is calculated from the formula (1) and then compared with the critical value of Z (Z_{crit}) read from Appendix VI. Then accept or reject the hypothesis H_0 as the case may be.

Once an outlier is identified, further treatment of the outlier depends upon the source. If the source was an error of entry, the value of the data point may be excluded from analyses. Or rather, the outlier is kept but a robust analysis technique that does not assume that data are sampled from Gaussian populations is used for analysis. However, where it is a case of true non-normal distribution with extreme values, the data may be transformed to pull in the outlier values; alternatively, the extreme cases are analysed differently (Garson, 2012; Motulsky, 2002). Each data sample in this section like the historical cost of cement, blocks, iron bars, paint, etc., collated over ten years were tested separately to find out if an outlier exists in that particular material sampled.

3.2.2.2Test of normality

Normality of data is an underlying assumption in parametric statistics. A test to find out if the data collated is normally distributed therefore becomes necessary. Where it is found otherwise, the data is transformed to a normal form before utilising it for parametric statistical inferences. The hypothesis states as follows:

H_0: The sampled population is normally distributed

H_1: The sampled population is not normally distributed

The test procedure for normality, for a sample population less than 50, the Kolmogorov–Smirnov goodness-of-fit test(K-S Test) is used. The K-S Test is based on a statistic that measures the deviation of the observed *cumulative histogram* from the hypothesised cumulative distribution function. According to Soong (2004), given a set of sample values $x1, x2, \ldots, xn$ observed from a population X, a cumulative histogram can be constructed by (a) arranging the sample values in increasing order of magnitude, denoted here by $x(1), x(2), \ldots, x(n)$, (b) determining the *observed* distribution function of X at $x(1), x(2), \ldots$, denoted by $F0(x_1)\ F0(x_2)\ldots$ from relations $F0(x_i) = (i/n)$ and (c) connecting the values of $F0[x\ (i)]$ by straight-line segments. Soong (2004) gave the test statistic to be used in this case as:

$$\underset{i-1}{\overset{n}{D_2}} = max\{|\ F^0\ [x_{(i)}] - F_x\ [x_{(i)}]|\}$$

$$\underset{i-1}{\overset{n}{=}}\ max\{|i/n\ - F_x\ [x_{(i)}]|\}$$

Where $X(i)$ is the ith-order statistic of the sample. Statistic $D2$ thus measures the maximum of absolute values of the n differences between observed probability distribution function (PDF) and hypothesised PDF evaluated for the observed samples. In the case where parameters in the hypothesised distribution must be estimated, the

values for *FX* [*X*(*i*)] are obtained by using estimated parameter values. The step-by-step procedure for executing the K–S test outlined by Soong (2004) is as follows:

Step 1: rearrange sample values $x_1, x_2, \ldots, x_n$ in increasing order of magnitude and label them $x(1), x(2), \ldots, x(n)$.

Step 2: determine observed distribution function $F0(x)$ at each $x(i)$ by using $F0[x(i)]$ i/n.

Step 3: determine the theoretical distribution function $FX(x)$ at each $x(i)$ by using the hypothesised distribution. Parameters of the distribution are estimated from the data if necessary.

Step 4: form the differences $F^0(x(i)) - F_x(x_i)$, for $i=1,2,3\ldots n$

Step 5: calculate $d_2 = \max\{/ F^0[x_{(i)}] - F_x[x_{(i)}]/\}$ (n, $i-1$)

The determination of this maximum value requires enumeration of n quantities. This labour can be somewhat reduced by plotting $F^0(x)$ and FX(x) as functions of x and noting the location of the maximum by inspection.

Step 6: choose a value of α and determine from table the value of $c_{n,\alpha}$

Step 7: reject hypothesis H_0 if $d2 > c_{n,\alpha}$. Otherwise, accept H_0.

3.2.3 Data analysis

The three sets of data, namely: impediments and proffered solutions to cost objectives, standard prototype designs and specifications, and empirical cost data were analysed using varying tools and methods.

3.2.3.1 Tools used for data analysis

Various mathematical tools were employed to analysethe kinds of data collated in this work. The tools employed in this work include calculation of mean values using relative importance index, test of outliers, normality test, and analysis of variance, geometric mean, bar chart and line graphs. The tools were applied at the corresponding sections based on the need to achieve the goals so specified at the relevant section**.**

3.2.3.2 Analysis of identified impediments

Sambasivan and Soon (2007) identified causes of delay and classified them according to client, contractor, consultants, materials, contract, labour and external causes. In a similar manner, this work identified impediments challenging cost management and grouped them according to client, contractor, consultants and general induced factors. A set of questionnaires which Sambasivan and Soon (2007) administered to respondents generated values in which they used and computed the mean frequency of occurrences of each factor and the mean level of impact each factor exerts on projects. The impact assessment method in which Sambasivan and Soon (2007) used to compute an index to measure the relative importance of some factors was also employed in the relevant section in this work. The relative importance index (RII) offered Sambasivan and Soon (2007) the tool to compute the mean frequency of occurrence of each factor questioned and the mean level of impact each factor exerts on projects using a scale of 1 to 10. Sambasivan and Soon (2007) gave the value of RII as:

$$\text{RII} = \frac{\text{n1W1} + \text{n2W2} + \text{n3W3} + \cdots + \text{n10W10}}{A*N}$$

Where W is the weighting given to each factor by the respondents ranging from 1 to 10 in this case, n is the number of respondents that weigh in each W, A is the highest weight (i.e. 10 in this case) and N is the total number of respondents that weigh each factor.

Aina and Wahab (2011) used the same method to obtain the Relative Causes Index (RCI) of a set of values which indicated the degree each factor cause on buildability problem at construction sites. The RCI for each cause of buildability problem was computed from the analysis of the rating indicated by the respondents. The likert's scale weighting was used from 1 to 5; where 5 was used for very high causes, 4 for high causes, 3 for average causes, 2 for below average causes and 1 for not a cause. Therefore, the nearer the RCI to 5, the higher is the degree of causes of buildability problem on construction sites. This work however, measures the relative importance of impact, or rather the degree of impact each impeding variable exerts on project success using a scale of 1-10. This gives the respondents a wider flexibility in the rating of the 84 number of factors identified. The work then categorised findings into three main groups using a widely accepted rating scales of 0 to 39% as fail, 40-49% as pass, and 50% and above as credit. In accordance to the results generated from the analysis, the classification in this work adapts values as high or very high (0.50 and above), moderate (0.40-0.49) and (0.00-0.39) to mean low or no impact at all. The list of the factors was then classified into factors that have high, moderate and low impact on projects in separate tables based on the outcome of the analysis.

These classified factors were subsequently organised in a format that enables a continuous performance appraisal of stakeholders' commitment to mitigating the negative impact of the identified factors on projects.This serves as a mechanism for lessons to be learned during construction production. It therefore enables stakeholders

to capture, store and process lessons during contract implementation. The mechanism is a score card containing the list of the identified factors separated into four sections according to their sources. Thesections include general factors, client's factors, consultants' factors and contractor's factors. Each team member participating in the project process appraises the factors listed in each section with a wide scale of 0 to 10, and also administers the same score card on other relevant participants and then computes a mean value for each factor, and for the factors of the entire group representinghis own and other team members' level of commitmentto the project (also called Culpability Factor). The appraisal which starts from inception will therefore point out items from each section that are most likely to impact negatively on the cost of the project at a particular time, and also points to the stakeholder culpable. Items with high score in the card indicate low culpability; which also means that the item is most likely not to cause serious negative impact on the cost. Any item scored low,means high culpability. That is, the item in question is most likely to exert serious negative impact on the ongoing process. It can also be interpreted that the stakeholder concerned with that section in the classification is poorly preparedagainst its negative impact; such as inadequate planning, delay in payments or delay in approvals etc. The attention of the affected persons is drawn to such items for a deserving attention or proper precaution. The overall mean value of the entire groups can also be computed to show how the supply chain is committed to the project success as a team. The appraisal is also expected to be done periodically starting from the beginning to the end of the project. Values from continuous assessment are stored in a format to depict the trend of culpability and to also reveal the items most affected along with their sources.

This continuous performance appraisal therefore serves as a deliberate lessons learning process in the ongoing activities. Analysis of the results captured and stored can be

processed and fed back into the system for continuous process improvement or kept for future use. The source of failing project can easily be identified since the items consistently scored low points to the source.At the site solutions meetings, issues relevant to the lessons are raised for contingency plans.

3.2.3.3Analysis of standard designs and specifications of a prototype building

The bill of quantities of astandard design of a prototype residential building was prepared using the elemental format. An element of a building was defined as that part of the building that performs a particular function that no other part does, and it does not matter the kind of material used in its construction, its location in the building or the method used in its construction (Mbamali, 2003, Gandu & Haddary, 2007). It is also the most popular form for application in cost analysis of buildings (Morton & Jagger, 1995 cited in Mbamali, 2003). Therefore the bill of quantities based on elemental format classifies works based on the functions each part performs in a building.

This work adopts the Royal Institute of Chartered Surveyors' (RICS) elemental format in the bill preparation for an additional reason that it tried to harmonise other formats. The US Department of Commerce (1999) reported the RICS classification of buildings into six main elements with sub elements as presented in Table 3.1.

Table 3.1: The Royal Institution of Chartered Surveyors (RICS-UK) Elemental Format

Element nr.

1.0 SUBSTRUCTURE

2.0 SUPERSTRUCTURE
- 2.1 Frame
- 2.2 Upper floors
- 2.3 Roof
- 2.4 Stairs
- 2.5 External walls
- 2.6 Windows and exterior doors
- 2.7 Interior walls & interior partitions
- 2.8 Interior doors

3.0 INTERNAL FINISHES
- 3.1 Wall finishes
- 3.2 Floor finishes
- 3.3 3.3 Ceiling finishes

4.0 FITTINGS AND FURNITURE
- 4.1 Fittings and furnishings

5.0 SERVICES
- 5.1 Sanitary appliances
- 5.2 Services equipment
- 5.3 Disposal installations
- 5.4 Water installations
- 5.5 Heat source
- 5.6 Space heating & air treatment
- 5.7 Ventilation systems
- 5.8 Electrical installation
- 5.9 Gas installation
- 5.10 Life & conveyor installation
- 5.11 Protective installations
- 5.12 Communication installations
- 5.13 Special installations
- 5.14 Builders work in connection with services
- 5.15 Builders profit & attendance on services

6.0 EXTERNAL WORKS
- 6.1 Site works
- 6.2 Drainage
- 6.3 External services
- 6.4 Minor building work

(**Source**: US Department of commerce, 1999)

The following elements were adaptedfor the sake of this work, having derived from the RICS format and presented in Table 3.2. However, while sorting the cost data, some elements lacked reliable historical cost to allow analysis. Therefore some elements in Table 3.2 were not included in further analysis for lack of reliable cost data.

Table 3.2: Elements adapted for the research

Elemental number	Elemental name
1.	Substructure
2.	Frames
3.	Staircase
4.	Upper floors
5.	Roof
6.	External walls
7.	Interior walls & partitions
8.	Windows
9.	Doors
10.	Services
11.	Fittings and fixtures
12.	Wall finishes
13.	Floor finishes
14.	Ceiling finishes
15.	External works

3.2.3.4 Analysis of empirical data

The HCD was analysed in two ways, namely, the mathematical methods and the graphical methods.

a. **Mathematical analysis***:* In this section, the HCD was first analysed to generate an array of:

   i. Composite unit rates (CUR) using the quantity surveying price analysis principles. The CUR was also applied on the BOQ of the prototype design to generate other cost information as follows:

   ii. Historical elemental cost of the prototype design.

iii. Historical total cost of the prototype design.

iv. Elemental cost change Factors for each element of the prototype design.

v. Mathematical model.

i. **Composition of unit rates:** The history of CUR was first generated from the HCD. The unit rates for each item were generated 40 times to cover the research period. The CUR consists of the cost of material, labour, profits and overheads. Computations followed after the quantity surveyor's price analysis technique. The CUR also followed the pattern of the HCD in the nature of spread over the research period.

The CUR was used to answer the first research question on whether cost changes are significant as raised in the first chapter of this work. This is a major question that justified the need for the empirical research analysis and the final derivation of a mathematical model. Testing the significance of cost changes in the CUR was done for short, medium and long periods. A hypothesis was postulated and analysis of variance (ANOVA) single factor used to test the three cases. The null hypotheses for the three cases are as follows.

1. **H_0**: Cost change is insignificant in the Nigerian construction market within a
   a. short period.

   H_0: Cost change is insignificant in the Nigerian construction market within a medium period.

   H_0: Cost change is insignificant in the Nigerian construction market within a long period.

2. The alternate hypotheses are as follows:

   H_1: Cost change is significant in the Nigerian construction market within a short period.

   H_1: Cost change is significant in the Nigerian construction market within a medium period.

   H_1: Cost change is significant in the Nigerian construction market within a long period

3. A five (5) percent level of significance was chosen
4. The computed values of F were compared with the critical values.
5. When the computed value is more than the critical value, then reject the null hypothesis.

ii. **Historical elemental cost (HEC) of the typical design:** The CUR computed on quarterly bases in the ten years of the research period was used to price the elemental BOQ for the standard design of a building. It enabled the generation of the historical cost information of each element in a typical residential building over the research period, which was used for further analysis. Each element therefore was estimated four times per year; therefore, having a total of 40 estimated cost.

iii. **Historical total cost of the prototype design:** Additions of all the corresponding costs of elements brought about 40 historical total cost of the building. The historical total cost was used to find how seasons of the year affect the cost of carrying out construction assembly. Descriptive statistics was used and it revealed the period in which cost of building construction projects often become higher.

iv. **The elemental cost change factor:** The HEC of the standard design was used to generate the cost growth factor affecting each element which is also known as the rate of cost growth and denoted as "r". The rate of cost growth in this case is the proportion in which an estimated cost increased in a year.

Using the cost of each element, the geometric mean was used to compute the growth rate for each. According to Srivatava *et al*. (1989), the geometric mean is a more suitable measure of central tendency than arithmetic mean if the data relates to ratios or represents rates of change. The essence in this section is to compute a reliable rate of change in the cost of every element over the research timeframe.

The geometric mean is simply the nth root of the product of numbers to be averaged, and denoted by letter G. For example:

Items/Year	**1**	**2**	**3….**	**n**
Item 1	a_1	a_2	a_3…	a_n
Item 2	b_1	b_2	b_3…	b_n
Item 3	c_1	c_2	c_3…	c_n
Item 4	d_1	d_2	d_3…	d_n

Where a,b,c and d are numeral values:

Geometric mean, $G_1 = (a_1 \times a_2 \times a_3 \times \ldots \times a_n)^{1/n}$

$G_2 = (b_1 \times b_2 \times b_3 \times \ldots \times b_n)^{1/n}$

$G_3 = (c_1 \times c_2 \times c_3 \times \ldots \times c_n)^{1/n}$

$G_4 = (d_1 \times d_2 \times d_3 \times \ldots \times d_n)^{1/n}$

To normalise the data out as a percentage or ratio:

$$\text{Ratio } r_1 = \frac{G_1}{G_1+G_2+G_3+G_4}$$

$$r_2 = \frac{G_2}{G_1+G_2+G_3+G_4}$$

$$r_3 = \frac{G_3}{G_1+G_2+G_3+G_4}$$

$$r_4 = \frac{G_4}{G_1+G_2+G_3+G_4}$$

Results are presented in a format as in Table 3.3.

Table 3.3 Yearly elemental cost growth ratio

Nr.	Element x	Yearly Cost growth ratio r
1	X_1	r_1
2	X_2	r_2
3	X_3	r_3
.	**.**	**.**
.	**.**	**.**
.	**.**	**.**
n	X_n	r_n

b. **Graphical analysis***:* The HCD obtained was first plotted in a bar graph in this section. The essence is to categorise cost growth of samples according to their level of responses to market forces. The general behavioral trend to market conditions of each group categorised was further revealed when depicted in a line graph. The growth trends among the items were compared. The following pieces of information were sought in all the charts:

   i. The pattern of cost growth response to cost dynamics in the HCD over the research period

   ii. The level of yearly changes in the prices of items in the HCD over the research period

   iii. The sensitivity of the HCD to market conditions

   iv. How the changes in an item in the HCD relates to others.

3.3 Model Development

3.3.2 Process monitoring mechanism

In order to manage processes, it was necessary to identify major impediments and proffered solutions from literature. The most frequent and impacting impediments were identified and organised into a score card to form the bases for continuous query into process implementation performance index. Results are documented and organised in a way to enable lessons learnt to be properly documented for reuse. This will enable the prediction of the chances of occurrence of the factors. Proffered solutions are also organised into modules that guide the implementation of projects in a proactive manner.

3.3.2 Mathematical model development

The mathematical model was derived using the principle of incremental rate as follows:

Let an element in a building be identified as = X

Let the cost of an element X be = χ

If, for a period p, the cost has increased by a value = $\delta\chi$

Then, the total cost of an element at point P is c_p = $\chi + \delta\chi$..... *(1)*

To express the cost of the same element at constant interval or periods p, where p=1, 2, 3…p, to denote first, second, third etc. periods respectively.

First period, $c_1 = \chi + \delta\chi$

Second period, $c_2 = \chi + \delta\chi + \delta\chi = \chi + 2\delta\chi$

Third period, $c_3 = \chi + \delta\chi + \delta\chi + \delta\chi = \chi + 3\delta\chi$

.
.
.

P^{th}period, $c_p = \chi + p\delta\chi$ …….*(2)*

provided that $\delta\chi$ is constant.

The increment $\delta\chi$ can be expressed as a percentage of χ or in form of a ratio r.

If $\delta\chi$ is expressed in ratio such that $\delta\chi = \chi$ x r, where r is the incremental rateof χ, per annum.

Then, from eqn. 2, $c_p = \chi + (p \times \chi \times r)$

$= \chi + p\,\chi\, r$

$c_p = \chi\,(1+p\,r)$ …….*(3)*

c_p is therefore the cost of a particular element at a particular point p.

For the cost of various elements at that particular point p, element nr.1=, $c_{p1,}$element nr.2=c_{p2},element nr.3= $c_{p3,}$element nr. n = c_{pn}, which can also be represented by $C_{1,}$ $C_{2,}$ C_3 …C_n respectively.

However, the total cost of a building (T_p) at any point is the sum of the cost of all the elements at that point. The total cost of a building at a fixed point T_p is therefore:

$$T_p = C_1 + C_2 + C_3 + \cdots + C_n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Substituting c_p(eqn. 3) into eqn. 4, for a fixed point:

$$T_p = x_1(1 + pr_1) + x_2(1 + pr_2) + x_3(1 + pr_3) + \cdots + x_n(1 + pr_n) \ldots\ldots (5)$$

In this work, equation 5 is desired to compute the cost on quarterly bases. In equation 5, r is a yearly rate of change.The average quarterly rate of change is therefore r divided by 4.

$$T_p = x_1\left(1 + p\frac{r_1}{4}\right) + x_2\left(1 + p\frac{r_2}{4}\right) + x_3\left(1 + p\frac{r_3}{4}\right) + \cdots + x_n\left(1 + p\frac{r_n}{4}\right) \ldots\ldots (6)$$

$$T_p = \sum_{i=1}^{n} x_i\left(1 + p\frac{r_i}{4}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Equation 7 is the short form of equation 6,$\mathbf{T_p}$ is the total cost of a project at a particular point. By summation of the cost of all the elements (χ), Tpis obtained.

n is the elemental number identifier; **r** is the yearly incremental rateorthe cost growth factorof an element per year.

χ represents the estimated cost of an element X in a building project. It is the value of an element in the tender sum. The value of an element can be obtained from a proposed project by following the quantity surveying estimating procedure. The summation of the values of all the elements form the total cost of the building "T" carried to tender.

P is the period the estimate is sought. In this case the rate of cost growth has been expressed quarterly, therefore, the quarterly value is counted as 1, 2, 3, 4, -------k to represent 1^{st}, 2^{nd}, 3^{rd}, 4^{th} to k^{th} quarter respectively. If the cost of a project is to be projected in 3years time from today, thenk^{th} quarter is given by 3 (yrs) x 4(quarter) = 12, which means p = 12 in the equation.

3.3.2.1 Validating and testing the reliability of the mathematical model

Mathematical models such as the one derived herein should be tested so as to be sure that it serves the purpose for which it is intended. Two processes were carried out on a similar mathematical model derived by El Sawalhi (2012).

a. **Validity test:** According to El Sawalhi (2012), structure validity concerns the degree to which the variables, as measured by the research reflect the hypothesised construct. After building the model and making all rules to subject its application, the scholar ran the mathematical model he developed to generate output for cost. Many changes on the input data were done and the model gave more outputs. According to the scholar, the first test of validity was achieved since it is capable of generating values (i.e. cost estimates in this case).

b. **Reliability test:** The second process was the test of reliability of models according to the model run. According to El Sawalhi (2012), the reliability of an instrument is the degree of consistency which measures the attribute it is supposed to be measuring. The results from the model were then compared with real projects cost. The outcome gave a result near the real project cost and the model was adjudged reliable for estimating the values of future projects.

This work therefore adopts similar stepsin testing the mathematical model derived. The mathematical model was used to generate a set of values. Time variable was altered severally and varying outcome generated in form of cost of a particular project. At different milestone, different values were obtained to show that cost changes over time. The model was also able to generate values for each element and the sum of all the elements was obtained for each quarter to give the total cost on quarterly bases. The model is capable, therefore, to generate relevant values at different time frame; thus relating time to the cost of the items being researched, which is the hypothesis construct of this section of work. The model is therefore viable.

However, how reliable are the values generated is a major question in any research of this nature. It must be proved that the values generated by the model will serve the purpose of which it is intended. On this backdrop, the researcher tested the reliability of the model in line with the test carried out by El Sawalhi (2012). First, the values generated by the model were compared with the actual values of a quantified design obtained from first principle. Estimated cost schedule of a standard building design was obtained from first principle using the historical unit rates computed in the research. Values were then compared, using relevant statistical tools, with the computed cost

obtained by employing the mathematical model developed. To obtain the values from the model, the first estimated cost of the design at the beginning of the research was used as the value of **χ, and**r initially determined were both inserted into the model. The values of P were then altered on quarterly bases to correspond with the time values of **χ.** The two set of values were compared statistically using ANOVA and linear correlation. The same process was repeated but using different building design, but of similar nature. The design was priced by a quantity surveying firm in 2010. The researcher priced the same design in 2015 using unit rates from the same firm and obtained the elemental values. The elemental values in 2010 and 2015 of the same design were compared to know the reliability of the mathematical model developed using the same statistical tools.

3.3.3 Application of the mathematical model

The mathematical model developed and found reliable can be used to generate the cost of buildings at different milestones. When the elemental cost estimate is prepared, the model can be used to forecast future cost changes. Consider a project with two years contract period, there are eight quarterly values of the proposed project that can be generated using the mathematical model as shown in Chart 3.1. If relevant variables are substituted, the result in each cell gives the cost of an element at that corresponding period. Summation of the values in each column gives the total cost of the project including growth values at that milestone. The values clearly depict the incremental rate of the project over time.

Contractors are often requested to draw a proposed programme of work on how a project will run from start to completion. Chart 3.2 shows a proposed programme of work for a project having two years completion period. Based on this programme, a

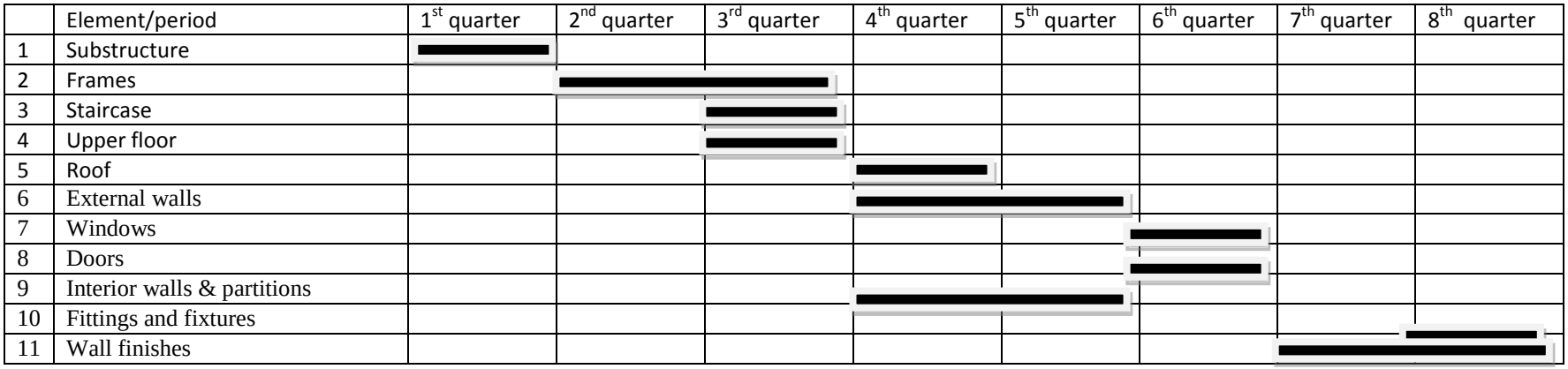
cash flow of the project can be drawn. The value at each quarter consists of the combination of the actual estimated cost with the growth value. In construction assembly, elements are scheduled to complete one after another in accordance to the programme of work. The cost of each element in the sequential assembly order of completion in the programme is shown in Chart 3.3. The values are computed at the end of the scheduled time in the programme. Therefore, the amount of money likely to be committed from start to end of each element is proactively shown. For example, the substructure is scheduled to end by the first quarter and the total cost at that point is presented by the mathematical expression which can generate the total commitment at that point if the variables were put in. However, at the end of the third quarter, three elements (frames, staircase and upper floors) are scheduled to complete. The results present cost implication of the project at various pointsto the team members. The values computed at each milestone covering the contract period serve as cash flow schedule to the parties in contract. Furthermore, this information offers a more realistic base for the computation of contingency allowance by the client at the planning stage. In fixed price non-fluctuating contracts, good bases for adding mark up now becomes possible.

	Element/period	1st quarter	2nd quarter	3rd quarter	4th quarter	5th quarter	6th quarter	7th quarter	8th quarter
1	Substructure	$x_1\left(1+\frac{r_1}{4}\right)$	$x_1\left(1+2\frac{r_1}{4}\right)$	$x_1\left(1+3\frac{r_1}{4}\right)$	$x_1\left(1+4\frac{r_1}{4}\right)$	$x_1\left(1+5\frac{r_1}{4}\right)$	$x_1\left(1+6\frac{r_1}{4}\right)$	$x_1\left(1+7\frac{r_1}{4}\right)$	$x_1\left(1+8\frac{r_1}{4}\right)$
2	Frames	$x_2\left(1+\frac{r_2}{4}\right)$	$x_2\left(1+2\frac{r_2}{4}\right)$	$x_2\left(1+3\frac{r_2}{4}\right)$	$x_2\left(1+4\frac{r_2}{4}\right)$	$x_2\left(1+5\frac{r_2}{4}\right)$	$x_2\left(1+6\frac{r_2}{4}\right)$	$x_2\left(1+7\frac{r_2}{4}\right)$	$x_2\left(1+8\frac{r_2}{4}\right)$
3	Staircase	$x_3\left(1+\frac{r_3}{4}\right)$	$x_3\left(1+2\frac{r_3}{4}\right)$	$x_3\left(1+3\frac{r_3}{4}\right)$	$x_3\left(1+4\frac{r_3}{4}\right)$	$x_3\left(1+5\frac{r_3}{4}\right)$	$x_3\left(1+6\frac{r_3}{4}\right)$	$x_3\left(1+7\frac{r_3}{4}\right)$	$x_3\left(1+8\frac{r_3}{4}\right)$
4	Upper floor	$x_4\left(1+\frac{r_4}{4}\right)$	$x_4\left(1+2\frac{r_4}{4}\right)$	$x_4\left(1+3\frac{r_4}{4}\right)$	$x_4\left(1+4\frac{r_4}{4}\right)$	$x_4\left(1+5\frac{r_4}{4}\right)$	$x_4\left(1+6\frac{r_4}{4}\right)$	$x_4\left(1+7\frac{r_4}{4}\right)$	$x_4\left(1+8\frac{r_4}{4}\right)$
5	Roof	$x_5\left(1+\frac{r_5}{4}\right)$	$x_5\left(1+2\frac{r_5}{4}\right)$	$x_5\left(1+3\frac{r_5}{4}\right)$	$x_5\left(1+4\frac{r_5}{4}\right)$	$x_5\left(1+5\frac{r_5}{4}\right)$	$x_5\left(1+6\frac{r_5}{4}\right)$	$x_5\left(1+7\frac{r_5}{4}\right)$	$x_5\left(1+8\frac{r_5}{4}\right)$
6	External walls	$x_6\left(1+\frac{r_6}{4}\right)$	$x_6\left(1+2\frac{r_6}{4}\right)$	$x_6\left(1+3\frac{r_6}{4}\right)$	$x_6\left(1+4\frac{r_6}{4}\right)$	$x_6\left(1+5\frac{r_6}{4}\right)$	$x_6\left(1+6\frac{r_6}{4}\right)$	$x_6\left(1+7\frac{r_6}{4}\right)$	$x_6\left(1+8\frac{r_6}{4}\right)$
7	Windows	$x_7\left(1+\frac{r_7}{4}\right)$	$x_7\left(1+2\frac{r_7}{4}\right)$	$x_7\left(1+3\frac{r_7}{4}\right)$	$x_7\left(1+4\frac{r_7}{4}\right)$	$x_7\left(1+5\frac{r_7}{4}\right)$	$x_7\left(1+6\frac{r_7}{4}\right)$	$x_7\left(1+7\frac{r_7}{4}\right)$	$x_7\left(1+8\frac{r_7}{4}\right)$
8	Doors	$x_8\left(1+\frac{r_8}{4}\right)$	$x_8\left(1+2\frac{r_8}{4}\right)$	$x_8\left(1+3\frac{r_8}{4}\right)$	$x_8\left(1+4\frac{r_8}{4}\right)$	$x_8\left(1+5\frac{r_8}{4}\right)$	$x_8\left(1+6\frac{r_8}{4}\right)$	$x_8\left(1+7\frac{r_8}{4}\right)$	$x_8\left(1+8\frac{r_8}{4}\right)$
9	Interior walls & partitions	$x_9\left(1+\frac{r_9}{4}\right)$	$x_9\left(1+2\frac{r_9}{4}\right)$	$x_9\left(1+3\frac{r_9}{4}\right)$	$x_9\left(1+4\frac{r_9}{4}\right)$	$x_9\left(1+5\frac{r_9}{4}\right)$	$x_9\left(1+6\frac{r_9}{4}\right)$	$x_9\left(1+7\frac{r_9}{4}\right)$	$x_9\left(1+8\frac{r_9}{4}\right)$
10	Fittings and fixtures	$x_{10}\left(1+\frac{r_{10}}{4}\right)$	$x_{10}\left(1+2\frac{r_{10}}{4}\right)$	$x_{10}\left(1+3\frac{r_{10}}{4}\right)$	$x_{10}\left(1+4\frac{r_{10}}{4}\right)$	$x_{10}\left(1+5\frac{r_{10}}{4}\right)$	$x_{10}\left(1+6\frac{r_{10}}{4}\right)$	$x_{10}\left(1+7\frac{r_{10}}{4}\right)$	$x_{10}\left(1+8\frac{r_{10}}{4}\right)$
11	Wall finishes	$x_{11}\left(1+\frac{r_{11}}{4}\right)$	$x_{11}\left(1+2\frac{r_{11}}{4}\right)$	$x_{11}\left(1+3\frac{r_{11}}{4}\right)$	$x_{11}\left(1+4\frac{r_{11}}{4}\right)$	$x_{11}\left(1+5\frac{r_{11}}{4}\right)$	$x_{11}\left(1+6\frac{r_{11}}{4}\right)$	$x_{11}\left(1+7\frac{r_{11}}{4}\right)$	$x_{11}\left(1+8\frac{r_{11}}{4}\right)$

12	Floor finishes	$x_{13}\left(1+\frac{r_{13}}{4}\right)$	$x_{13}\left(1+2\frac{r_{13}}{4}\right)$	$x_{13}\left(1+3\frac{r_{13}}{4}\right)$	$x_{13}\left(1+4\frac{r_{13}}{4}\right)$	$x_{13}\left(1+5\frac{r_{13}}{4}\right)$	$x_{13}\left(1+6\frac{r_{13}}{4}\right)$	$x_{13}\left(1+7\frac{r_{13}}{4}\right)$	$x_{13}\left(1+8\frac{r_{13}}{4}\right)$
13	Ceiling finishes	$x_{13}\left(1+\frac{r_{13}}{4}\right)$	$x_{13}\left(1+2\frac{r_{13}}{4}\right)$	$x_{13}\left(1+3\frac{r_{13}}{4}\right)$	$x_{13}\left(1+4\frac{r_{13}}{4}\right)$	$x_{13}\left(1+5\frac{r_{13}}{4}\right)$	$x_{13}\left(1+6\frac{r_{13}}{4}\right)$	$x_{13}\left(1+7\frac{r_{13}}{4}\right)$	$x_{13}\left(1+8\frac{r_{13}}{4}\right)$

Total cost of the building

Chart 3.1: Incremental Rate in Cost of project



12	Floor finishes						[redacted]	
13	Ceiling finishes							[redacted]

Chart 3.2: Proposed Programme of Work

	Element/period	1st quarter	2nd quarter	3rd quarter	4th quarter	5th quarter	6th quarter	7th quarter	8th quarter
1	Substructure	$x_1\left(1+\frac{r_1}{4}\right)$							
2	Frames			$x_2\left(1+3\frac{r_2}{4}\right)$					
3	Staircase			$x_3\left(1+3\frac{r_3}{4}\right)$					
4	Upper floor			$x_4\left(1+3\frac{r_4}{4}\right)$					

5	Roof	$x_5\left(1+4\frac{r_5}{4}\right)$										
6	External walls		$x_6\left(1+5\frac{r_6}{4}\right)$									
7	Windows			$x_7\left(1+6\frac{r_7}{4}\right)$								
8	Doors			$x_8\left(1+6\frac{r_8}{4}\right)$								
9	Interior walls & partitions		$x_9\left(1+5\frac{r_9}{4}\right)$									
10	Fittings and fixtures									$x_{10}\left(1+8\frac{r_{10}}{4}\right)$		
11	Wall finishes									$x_{11}\left(1+8\frac{r_{11}}{4}\right)$		
12	Floor finishes								$x_{13}\left(1+7\frac{r_{13}}{4}\right)$			
13	Ceiling finishes									$x_{13}\left(1+8\frac{r_{13}}{4}\right)$		
	Total cost of the building											

Chart 3.3: Cash Flow of Each Element at the End of the Completion Schedule

3.3.4 Framework for proactive cost management

Results and findings from this research that were organised in four forms were used as bases to develop a framework for proactive cost management. The forms in which the results were organised into were, the Graphical Models, Lessons Learnt Mechanism, Best Practice Modules and Predictive Mathematical Model. The framework covers the entire procurement stages, from inception to the handing over.

CHAPTER 4: DATA PRESENTATION, ANALYSIS AND DISCUSSIONS

4.1 Data Presentation

4.1.1Challenges and remedies to construction project cost delivery

From available secondary data dealing with projects cost management, this thesis identified challenges and their proffered remedies to cost management. The study then employed the relative importance index (RII) technique to appraise and categorise the list of important factors via a questionnaire shown in Appendix VII. The important factors are classified according to their sources as general, client, contractor and consultants induced factors.

4.1.1.1 Project cost management impediments

Classified factors that impede projects cost objectives were further categorised into different groups based on impact ranking conducted in this work. While the frequency of occurrences of each factor was ranked, the factors were categorised based on the degree of impact they exert on projects and reported as either high impact with values 0.50 and above, moderate (mod) with values between 0.40 and 0.49 or low impact with values between 0 and 0.39 in the assessment.

Table 4.1 presents the quality of respondents that returned their responses to the five questions asked in section A of the questionnaire. The questions sought to know where the respondent works and his profession; the highest qualification, the year of experience, number of projects involved and the spread of the projects locations they have been involved.

Table 4.1 Profile of respondents on classified factors impeding cost objective

Questions/Profession of respondents	Arch.	QS	Engr.	Bldr.	Total	%
1 Type of organisation						
Contracting	1	1	1	0	3	*20.00*
Consulting	2	6	0	0	8	*53.34*
Client	0	1	0	1	2	*13.33*
Contracting and consulting	0	2	0	0	2	*13.33*
Total number of respondents	***3***	***10***	***1***	***1***	***15***	***100.00***
2 Type of degree of respondent						
Doctorate degree	0	1	0	0	**1**	***6.67***
Masters degree	1	5	0	0	**6**	***40.00***
BSc. degree	1	3	1	1	**6**	***40.00***
HND	1	1	0	0	**2**	***13.33***
OND						***0.00***
3 Years of experience of the respondent						
0-2years	1	0	0	0	1	*6.67*
3-5years	0	1	0	0	1	*6.67*
6-10years	0	2	1	0	3	*20.00*
11years and above	2	7	0	1	10	*66.66*
4 **Number of building projects handled**						
0-10 projects	1	0	0	0	1	*6.67*
11-20 projects	0	4	1	0	5	*33.33*
21 and above	2	6	0	1	9	*60.00*
5 **Location of projects handled**						
Northern Nigeria	3	10	1	1	15	*100.00*
Southern Nigeria	1	5	1	1	8	*53.34*
Eastern Nigeria	2	4	1	1	8	*53.34*
Western Nigeria	1	4	1	1	7	*46.67*
% of professions of respondents	***20.00***	***66.66***	***6.67***	***6.67***	***100.00***	

In Table 4.2, different sets of cost factors affecting projects' success level emerged. Deriving from the wide literature search, the factors are presented as impediments to success in order to achieve first objective in this research. The results of theanalysis of the responses on the identified factors using the RII indicated the frequency of the occurrence of each factor as well asthedegree of negative impact it exerts on building projects, which were reported.

A number of cost significant factors were extracted from the analysis (of Table 4.2) and presented under Tables 4.3, 4.4 and 4.5. The identified factors either impact at a high, moderate or low level. The frequencies of occurrence of the factors were also rated.

Table 4.2Classification of impediments to project cost objective

		RII		RII	Impact	Degree
	General impediments	**Freq.**	**ranking**	**Impact**	**ranking**	**of impact**
1.	Complex project	0.57	6	0.53	6	High
2.	Inadequate budget for the work	0.35	16	0.51	7	High
3.	Statutory authorities' interruptions	0.45	14	0.29	19	Low
4.	Poor risk allocation among parties to the contract	0.57	6	0.45	12	Mod
5.	Bad general access to site	0.53	8	0.37	15	Low
6.	Effect of inclement weather	0.64	3	0.48	10	Mod
7.	Non-availability of locally sourced materials	0.60	5	0.44	13	Mod
8.	Non-availability of local labour	0.52	9	0.46	11	Mod
9.	Non-availability of water for the work	0.49	10	0.45	12	Mod
10.	Non-availability of electricity for the work	0.46	12	0.69	2	High
11.	Poor attitudes of benefiting/neighboring communities	0.57	6	0.58	5	High
12.	Poor team spirit among stakeholders	0.42	15	0.30	18	Low
13.	Poor information flow among stakeholders	0.46	13	0.60	4	High
14.	Inflation or economic instability	0.47	12	0.49	9	Mod
15.	Political instability and government policies	0.48	11	0.68	3	High
16.	Corruption factor in the project process	0.48	11	0.71	1	High
17.	Negative socio-cultural effect on the project	0.19	18	0.34	17	Low
18.	Wrong choice of procurement option	0.63	4	0.51	7	High
19.	Wrong choice of the type of contract	0.54	7	0.50	8	High
20.	Poor adoption of emerging technologies	0.65	2	0.38	14	Low
21.	Dispute among team members	0.42	15	0.45	12	Mod
22.	Low frequency of site meetings	0.45	13	0.35	16	Low
	Client's success drivers					
23.	Low level of importance attached to the project by the client	0.46	6	0.55	5	High
24.	Poor client's commitment to project success	0.42	9	0.50	7	High
25.	Poor client's commitment to management success	0.48	5	0.47	8	Mod
26.	Instability in client's cash flow	0.38	10	0.60	4	High
27.	Poor client's credit worthiness	0.35	11	0.87	1	High
28.	Poor planning by the client	0.49	4	0.71	2	High
29.	Delay in approval of change request	0.52	2	0.35	11	Low
30.	Delay in response to interim payments	0.45	7	0.67	3	High
31.	Inadequacy of client's brief	0.52	2	0.51	6	High
32.	Frequent change initiated by the client	0.49	4	0.47	8	Mod
33.	Incomplete design team appointed	0.45	7	0.44	9	Mod
34.	Lack of full time project management engagement	0.55	1	0.38	10	Low
35.	Poor client's attitudes to dispute resolution	0.51	3	0.50	7	High
36.	Constant interference of work progress by the client	0.43	8	0.60	4	High
	Contractors success drivers					
37.	Poor organisational setting of the constructing firm	0.62	9	0.52	6	High
38.	Incompetent personnel in the constructing firm	0.62	9	0.52	6	High
39.	inadequacy of relevant personnel for the work	0.42	20	0.53	5	High
40.	Inadequacy of relevant equipment	0.55	11	0.40	12	Mod

41.	Poor planning by the contractor	0.51	13	0.43	10	Mod
42.	Poor experience of the contractor on similar jobs	0.62	9	0.55	4	High
43.	Poor site layout and site organisational pattern	0.66	7	0.40	12	Mod
44.	Poor contractor's general attitude to the work	0.43	19	0.40	10	Mode
45.	Poor attitudes and general responses to site instructions	0.87	3	0.52	6	High
46.	Delay caused by sub-contractors/suppliers	0.83	4	0.43	10	Mod
47.	Poor cooperation among sub-contractors/suppliers	0.95	2	0.47	8	Mod
48.	Lack of clear identification of customers and their needs	0.55	11	0.62	1	High
49.	Poor process management mechanism in place	0.53	12	0.47	8	Mod
50.	Low level of industrialisation in the production process	0.45	18	0.35	14	Low
51.	Poor attitudes of contractor's personnel to instructions	0.49	14	0.42	11	Mod
52.	Inadequate measure to reduce the share of flow process	0.73	6	0.31	16	Mod
53.	Poor attitudes and poor productivity of labourers engaged	0.96	1	0.52	6	High
54.	Poor attitudes to the contractor to dispute resolution	0.51	13	0.60	2	High
55.	Large amount and frequency of rework due to error	0.51	13	0.55	4	High
56.	Poor work break down structure	0.46	17	0.43	10	Mod
57.	Poor transportation arrangement to and from site	0.58	10	0.36	13	Low
58.	Poor communication arrangement between site and head office	0.62	9	0.52	6	High
59.	Unclear instructions to workers	0.65	18	0.32	19	Low
60.	Long distance between head office and site	0.38	21	0.29	18	Low
61.	Poor staff motivation scheme	0.48	15	0.48	7	Mod
62.	Threats to Job stability of workers	0.49	14	0.58	3	High
63.	Absenteeism from work due to drugs, alcohol, health	0.51	13	0.43	10	Mod
64.	Poor health and safety measures	0.43	19	0.40	12	Mod
65.	Delay in payment of staff emoluments	0.45	18	0.45	9	Mod
66.	Delay in payments to sub-contractors/suppliers	0.82	5	0.48	7	Mod
67.	Ad-hoc nature of employment of workers	0.73	6	0.47	8	Mod
	Consultants success drivers					
68.	Poor qualification of consulting team in handling the job	0.49	12	0.78	1	High
69.	Poor experience of the consultants in the kind of job	0.37	15	0.57	5	High
70.	Poor commitment of consultants to the job	0.30	16	0.57	5	High
71.	Incompetent staff in the consulting team	0.65	5	0.48	8	Mod
72.	Inadequate consulting personnel for the job	0.54	9	0.45	10	Mod
73.	Delay in designs and other documents delivery	0.56	8	0.62	2	High
74.	Delay in response to calls for interim valuations	0.91	1	0.62	2	High
75.	Delay in contractors' request for approvals of stage of work	0.84	2	0.60	3	High
76.	Inadequate site condition and geotechnical survey information	0.81	3	0.40	12	Mod
77.	incomplete and unclear architect's designs	0.70	4	0.43	11	Mod
78.	Incomplete and unclear engineering design	0.64	6	0.62	2	High
79.	Incomplete and unclear bill of quantities	0.52	10	0.53	6	High
80.	Discrepancies in contract documents	0.43	14	0.47	9	Mod
81.	High change frequency initiated by consultants	0.57	7	0.43	11	Mod
82.	Poor coordination and in-cohesion in consulting team	0.50	11	0.49	7	Mod
83.	Poor attitudes of consultants to dispute resolution	0.57	7	0.57	5	High
84.	Constant architect's instructions on site	0.47	13	0.59	4	High

Table 4.3Classified impediments with high impact on project cost

	Mean General success drivers	Freq.	Freq. ranking	Mean Impact	Impact ranking	Degree of impact
1.	Complex project	0.57	6	0.53	7	High
2.	Inadequate budget for the work	0.35	16	0.51	8	High
10.	Non-availability of electricity for the work	0.46	12	0.69	2	High
11.	Poor attitudes of benefiting/neighboring communities	0.57	6	0.58	6	High
13.	Poor information flow among stakeholders	0.46	13	0.60	5	High
15.	Political instability and government policies	0.48	11	0.68	3	High
16.	Corruption factor in the project process	0.48	11	0.71	1	High
18.	Wrong choice of procurement option	0.63	4	0.51	8	High
19.	Wrong choice of the type of contract	0.54	7	0.50	9	High
	Client's success drivers					
23.	Low level of importance attached to the project by the client	0.46	6	0.55	5	High
24.	Poor client's commitment to project success	0.42	9	0.50	7	High
26.	Instability in client's cash flow	0.38	10	0.60	4	High
27.	Poor client's credit worthiness	0.35	11	0.87	1	High
28.	Poor planning by the client	0.49	4	0.71	2	High
30.	Delay in response to interim payments	0.45	7	0.67	3	High
31.	Inadequacy of client's brief	0.52	2	0.51	6	High
36.	Constant interference of work progress by the client	0.43	8	0.60	4	High
35.	Poor client's attitudes to dispute resolution	0.51	3	0.50	7	High
	Contractors success drivers					
37.	Poor organisational setting of the constructing firm	0.62	9	0.52	6	High
38.	Incompetent personnel in the constructing firm	0.62	9	0.52	6	High
39.	inadequacy of relevant personnel for the work	0.42	20	0.53	5	High
42.	Poor experience of the contractor on similar jobs	0.62	9	0.55	4	High
45.	Poor attitudes and general responses to site instructions	0.87	3	0.52	6	High
48.	Lack of clear identification of customers and their needs	0.55	11	0.62	1	High
53.	Poor attitudes and poor productivity of labourers engaged	0.96	1	0.52	6	High
54.	Poor attitudes to the contractor to dispute resolution	0.51	13	0.60	2	High
55.	Large amount and frequency of rework due to error	0.51	13	0.55	4	High
58.	Poor communication arrangement between site and head office	0.62	9	0.52	5	High
62.	Threats to Job stability of workers	0.49	14	0.58	3	High
	Consultants success drivers					
68.	Poor qualification of consulting team in handling the job	0.49	12	0.78	1	High
69.	Poor experience of the consultants in the kind of job	0.37	15	0.57	5	High
70.	Poor commitment of consultants to the job	0.30	16	0.57	5	High
73.	Delay in designs and other documents delivery	0.56	8	0.62	2	High
74.	Delay in response to calls for interim valuations	0.91	1	0.62	2	High
75.	Delay in contractors' request for approvals of stage of work	0.84	2	0.60	3	High
78.	Incomplete and unclear engineering design	0.64	6	0.62	2	High
79.	Incomplete and unclear bill of quantities	0.52	10	0.53	6	High
83.	Poor attitudes of consultants to dispute resolution	0.57	7	0.57	5	High
84.	Constant architect's instructions on site	0.47	13	0.59	4	High

Table 4.4Classified impediments with moderate impact on project cost

	General Factors affecting success	Mean Freq.	Freq. ranking	Mean Impact	Impact ranking	Degree of impact
1.	Poor risk allocation among parties to the contract	0.57	6	0.45	4	Mod
2.	Effect of inclement weather	0.64	3	0.48	2	Mod
3.	Non-availability of locally sourced materials	0.60	5	0.44	5	Mod
4.	Non-availability of local labour	0.52	9	0.46	3	Mod
5.	Non-availability of water for the work	0.49	10	0.45	4	Mod
6.	Inflation or economic instability	0.47	12	0.49	1	Mod
7.	Dispute among team members	0.42	15	0.45	4	Mod
	Client's success drivers					
8.	Poor client's commitment to management success	0.48	5	0.47	1	Mod
9.	Frequent change initiated by the client	0.49	4	0.47	1	Mod
10.	Incomplete design team appointed	0.45	7	0.44	2	Mod
	Contractors success drivers					
11.	Inadequacy of relevant equipment	0.55	11	0.40	6	Mod
12.	Poor planning by the contractor	0.51	13	0.43	4	Mod
13.	Poor site layout and site organisational pattern	0.66	7	0.40	6	Mod
14.	Poor contractor's general attitude to the work	0.43	19	0.40	6	Mod
15.	Delay caused by sub-contractors/suppliers	0.83	4	0.43	4	Mod
16.	Poor cooperation among sub-contractors/suppliers	0.95	2	0.47	2	Mod
17.	Poor process management mechanism in place	0.53	12	0.47	2	Mod
18.	Poor attitudes of contractor's personnel to instructions	0.49	14	0.42	5	Mod
19.	Poor work break down structure	0.46	17	0.43	4	Mod
20.	Poor transportation arrangement to and from site	0.58	10	0.36	7	Mod
21.	Poor staff motivation scheme	0.48	15	0.48	1	Mod
22.	Absenteeism from work due to drugs, alcohol, health	0.51	13	0.43	4	Mod
23.	Poor health and safety measures	0.43	19	0.40	6	Mod
24.	Delay in payment of staff emoluments	0.45	18	0.45	3	Mod
25.	Delay in payments to sub-contractors/suppliers	0.82	5	0.48	1	Mod
26.	Ad-hoc nature of employment of workers	0.73	6	0.47	2	Mod
	Consultants success drivers					
27.	Incompetent staff in the consulting team	0.65	5	0.48	2	Mod
28.	Inadequate consulting personnel for the job	0.54	9	0.45	4	Mod
29.	Inadequate site condition and geotechnical survey information	0.81	3	0.40	6	Mod
30.	incomplete and unclear architect's designs	0.70	4	0.43	5	Mod
31.	Discrepancies in contract documents	0.43	14	0.47	3	Mod
32.	High change frequency initiated by consultants	0.57	7	0.43	5	Mod
33.	Poor coordination and in-cohesion in consulting team	0.50	11	0.49	1	Mod

Table 4.5Classification of impediments with low impact on project cost

	General Factors affecting success	Mean Freq.	Freq. ranking	Mean Impact	Impact ranking	Degree of impact
1.	Statutory authorities' interruptions	0.45	14	0.29	6	Low
2.	Bad general access to site	0.53	8	0.37	2	Low
3.	Poor team spirit among stakeholders	0.42	15	0.30	5	Low
4.	Negative socio-cultural effect on the project	0.19	18	0.34	4	Low
5.	Poor adoption of emerging technologies	0.65	2	0.38	1	Low
6.	Low frequency of site meetings	0.45	13	0.35	3	Low
	Client's factors affecting success					
7.	Delay in approval of change request	0.52	2	0.35	2	Low
8.	Lack of full time project management engagement	0.55	1	0.38	1	Low
	Contractors factors affecting success					
9.	Low level of industrialisation in the production process	0.45	18	0.35	2	Low
10.	Poor transportation arrangement to and from site	0.58	10	0.36	1	Low
11.	Unclear instructions to workers	0.65	18	0.32	3	Low
12.	Long distance between head office and site	0.38	21	0.29	4	Low

Serious concern must be placed on factors exerting high impact on projects because by implication, once they occur their impact is usually high.

4.1.1.2 Proffered remedies to cost management impediments

Literature is awash with proffered remedies to identified factors that constitute impediments to successful cost management of building projects. In order to achieve the second objective, these remedies were collated and reorganised into specific modules. The modules constitute best practices recommended by researchers. Each module contains a set of activities that, if carefully carried out during construction assembly would contribute immensely to the desired goal of proactive cost management of any building project. The modules are meant to be applied in the three construction stages, namely; inception, planning and construction stages. The modules have also identified the stakeholder mainly responsible in carrying out the activities under each. The stage/ stages each module is best applicable is/are also shown. Derived from recommended best practices in literature, thirteen modules organised are shown in Module 4.1.

Module 4.1: Cost Management Best Practice

Module 1:
Activity: **Supply chain management**
Responsibility: **Client**
Stage: **Inception stage**
Actions:

a. Carefully select and bring in the supply chain that will deliver design services, supply services, manufacturing and assembling of products.
b. Use as criteria, qualification, experience, and ability to work as part of an integrated project team to select a team.
c. Establish the integrated project team (client and supply chain) under partnering principles

Module 2:
Activity: **Process design management**
Responsibility: **Consultants**
Stage: **Planning and implementation stages**
Actions:

Design:

a. Understand the end the final user and his needs properly
b. Write the specifications correctly and clearly
c. Design within the best acceptable error limit

Management:

a. Decompose the whole process into a work breakdown structure (WBS)
b. Identify the internal and external customers with their peculiar needs
c. Group similar tasks together to reduce the number of steps
d. Determine a standard procedure for cluster activities
e. Determine the shortest and also compress the cycle time for each cluster
f. Identify the flow and conversion sub-processes in each task
g. Set up a flow sub-process suppression and a strategy for waste elimination
h. Set up a continuous process improvement mechanism
i. Set up a learning mechanism to capture and use internal and external lessons
j. Decide on the best transparent process

Module 3:
Activity: **Communication and information System**
Responsibility: **Client, Consultants and Contractor**
Stage: **Planning and implementation stages**
Action:

a. Set up a strong communication system using modern technology where possible
b. Evaluate each communication to be sent or received to be sure it will add value
c. Ensure every communication sent is clear
d. Shorten the communication bureaucratic channel as much as possible

e. Document properly all communications received
f. Respond to all request or instructions received as appropriately and as promptly as possible
g. Raise observations on communicate inconsistencies or variability with the affected persons
h. Information that will add value should not be hoarded, and constructive criticism should be made and received without prejudice.

Module 4:
Activity: **Cost Estimating**
Responsibility: **Consultants**
Stage: **Planning stage**
Action:

i. Prepare an estimate in elemental bill formatfor the proposed project
j. Ensure a complete Cost estimate
k. Ensure accurate Cost estimate
l. Forecast the risk in the estimate failing
m. Advice on cost behavior of the project

Module 5:
Activity: **Contract Placement**
Responsibility: **Clients and Consultants**
Stage: **Planning stage**
Action:

a. Study the builders' capabilities for the proposed project at feasibility
b. Prequalify, shortlist and notify all prospective bidders at outline proposal stage
c. Issue scheme design and detailed design to all bidders as they are produced
d. Prequalify and Invite bidders to bid, and place a contract early

Module 6:
Activity: **Cost advice**
Responsibility: **Consultants**
Stage: **Planning stage**
Action:

a. The estimate forms the basis for the award of the contract
b. Determine the construction period for the project
c. Use the mathematical model to forecast cost growth at diverse milestone.
d. Plot the results in a line graph to view the growth trend in the project cost.
e. Advice on contingency plans to reduce the effect of cost growth on the project.

Module 7:

Activity: **Cost Monitoring and Control**
Responsibility: **Contractor**
Stage: **Implementation stage**
Action:

a. Undertake performance analysis
b. Compare actual expenditure at each stage with the projected cost changes
c. Identify areas of high cost challenges
d. Collate all information for the next stage of the work
e. Respond adequately and promptly to requests or instructions

Module 8:

Activity: **Process monitoring mechanism**
Responsibility: **Client, Consultants and Contractor**
Stage: **Inception, Planning and Implementation stages**
Action:

The challenges to cost management categorised in the Lessons Learnt Mechanism are continuously monitored during the procurement process. Each team member computes the level of optimism on the project success starting from the inception. Essentially, the assessor is either pessimistic that those factors in the chart will impact negatively on the project or optimistic that they will not. It can also be interpreted that the assessor is optimistic that proper plans are in place to contain the factors, or pessimistic that plans are not on ground. Therefore the higher the assessment values the more optimistic or confidence that the project will succeed, and vice-versa. The value is also called the Culpability Factor (CF) for that particular section duly assessed. High values mean high level of commitment to the success of the project, otherwise. More interactions bring about better understanding of individuals and the process entirely. Future assessments therefore reflect the lessons learntthrough interactions, documentations and experiences.

Module 9:

Activity: **Lessons learnt process**
Responsibility: **Client, Consultants and Contractor**
Stage: **Inception, Planning and Implementation stages**
Action:

a. Compute the culpability factor (CF) for every team member
b. Plot the values computed for each section in a line graph
c. Identify weaknesses of each member from the assessment
d. Present the weaknesses at site meetings for discussions and collective decisions
e. Repeat the process before each site meeting

Module 10:

Activity: **Continuous process improvement**
Responsibility: **Client, consultants and Contractor**
Stage: **Planning and implementation stages**
Action:

a. Collate all lessons learnt within the process and benchmark.
b. Store the lessons in a structured format for easy processing and retrieval
c. Evaluate relevant all lessons and feed back into the process to improve performance
d. Document results and study the trend in the improvement process

Module 11:

Activity: **Change management process**
Responsibility: **Consultants and Contractor**
Stage: **Planning and implementation stages**
Action:

a. Set up a well-defined change review and control process early in the project life
b. Evaluate every change initiated to find out how beneficial
c. Resist change until it is necessary
d. Communicate change accepted early and clearly
e. Ensure the order is carried out when and as due

Module 12:

Activity: **Stakeholders' management**
Responsibility: **Client and Consultants**
Stage: **Planning and Implementation stages**
Action:

a. Identify stakeholders important to the project
b. Classify the stakeholders according to the powers they can exert on the project noting the critical and less critical ones.
c. List the interests and priority of each stakeholder
d. Assure each class of the desire to satisfy their interest
e. Decide on the best strategy to satisfy the interest of each group

Module 13:

Activity: **Strategic initiative**
Responsibility: **Contractor**
Stage: **Planning and Implementation stages**
Action:

a. Decide on which parts to industrialise
b. Ensure a strong information and communication flow system
c. Use available information and communication technologies for the job
d. Decide on and employ relevant plant and equipment for optimum performance
e. Engage qualified and experienced personnel

4.1.2 Quantified standard design

The un-priced elemental bill of quantities for the standard prototype design is shown in Appendix VIII. The bill was priced severally with an intention to obtaining a historical total cost of the standard design, which revealed the quantum value of cost growth of each element over time; and also the pattern of growth in each element that are usually assembled sequentially during construction.

4.1.3 Empirical cost data

The Historical Cost Data (HCD) obtained over a long period from the field consisting of quarterly report of market survey of prices of building items is shown in Appendix V. The data analysed graphically and mathematically answered the research questions posed at the beginning of the work. The graphical analysis enabled the categorisation of building materials into two groups based on their degree of responses to market forces; and the cost change relationships compared among the varying items. Mathematical analysis generated several cost information like composite unit rates. The rates which were applied on the prototype standard building design offered further cost information such as the historical total cost (HTC) and the cost growth factors of the various elements in the prototype design. Pieces of information put together formed key variables in the mathematical model developed. Subsequently, a frame work for proactive cost management of buildings was also developed.

4.2 Analysis of Data

4.2.1 Analysis of classified impediments

Identified challenges impeding cost objectives in project implementation are organised into a lessons learnt mechanism for monitoring the level of their impact on the success of cost management (see Figure 4.1). This is a score card for constant subjective rating of the impact of each factor on the project during the assembly process which should be based on the assessor's previous and present lessons learnt or experiences and in the knowledge of the ongoing process.

Figure 4.1 Lessons learnt mechanism

	General impediments tocost management success	**Pessimistic◄ ►Optimistic**										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean**
2	Complex project											
3	Inadequate budget for the work											
4	Statutory authorities' interruptions											
5	Poor risk allocation among parties to the contract											
6	Bad general access to site											
7	Effect of inclement weather											
8	Non availability of locally sourced materials											
9	Non availability of local labour											
10	Non availability of water for the work											
11	Non availability of electricity for the work											
12	Poor attitudes of benefiting and neighboring communities											
13	Poor team spirit among stakeholders											
14	Poor information flow among stakeholders											
15	Inflationary or economic instability											
16	Political instability and government policies											
17	Corruption factor in the project process											
18	Negative socio-cultural effect on the project											
19	Wrong choice of procurement option											
20	Wrong choice of type of contract											
22	Poor adoption of emerging technologies											
23	Disputesamong team members											
24	Low frequency of site meetings											
	Number of items, N=24	**Mean =**										

	Client's impediments to cost management success	Pessimistic ← Optimistic										
		1	2	3	4	5	6	7	8	9	10	Mean
1	Low level of importance attached to the project by the client											
2	Poor client's commitment to project success											
3	Poor client's commitment to management success											
4	Instability in client's cash flow											
5	Poor client's credit worthiness											
6	Poor planning by the client											
7	Delay in the approval of change request											
8	Delay in response to interim payments											
9	Inadequacy of client's brief											
10	Frequent change initiated by the client											
11	Incomplete design team appointed											
12	Lack of full time project management engagement											
13	Poor client's attitudes to dispute resolution											
14	Constant interference on the work progress by the client											
	Number of items, N=14	**Mean =**										

	Consultants impediments to cost management success	Pessimistic ← Optimistic										
		1	2	3	4	5	6	7	8	9	10	Mean
1	Poor qualification of consulting team handling the job											
2	Poor experience of the consulting team in the kind of job											
3	Poor commitment of consultants to the job											
4	Incompetent staff in the consulting team											
5	Inadequacy of consulting personnel for the job											
6	Delay in designs and other documents delivery											
7	Delay in response to demand for interim valuations											
8	Delay in contractors' request for approvals of stage of work											
9	Inadequate site condition and geotechnical survey information											
10	Incomplete and unclear designs											
11	Incomplete and unclear bill of quantities											
12	Discrepancies in contract documents											
13	High change frequency initiated by consultants											
14	Poor coordination and in-cohesion in consulting team											
15	Poor attitudes of consultants to dispute resolution											
16	Constant architect's instructions											
	Number of items, N=15	**Mean =**										

	Contractors impediments to cost management success	Pessimistic ← → Optimistic										
		1	2	3	4	5	6	7	8	9	10	Mean
1	Poor organisational setting by the constructing firm											
2	Incompetent personnel in the constructing team											
3	Inadequacy of relevant personnel for the work											
4	Inadequacy of relevant equipment											
5	Poor planning by the contractor											
6	Poor experience of the contractor on similar job											
7	Poor site layout and site organisational pattern											
8	Poor contractor's general attitude to the work											
9	Poor attitudes and general responses to site instructions											
10	Delays caused by sub-contractors/suppliers											
11	Poor cooperation among sub-contractors/suppliers											
12	Lack of clear identification of customers and their needs											
13	Poor process management mechanism in place											
14	Low level of industrialisation in the production process											
15	Poor attitudes of contractor's personnel to instructions											
16	Inadequate measures to reduce the share of flow process											
17	Poor attitudes and poor productivity of labourers engaged											
18	Poor attitudes to dispute resolution by the contractor											
19	Large amount and frequency of rework due to error											
20	Poor work break down structure											
21	Poor transportation arrangement to site											
22	Poor communication arrangement between site and head office											
23	Unclear instructions to workers											
24	Long distance between head office and site											
25	Poor staff motivation scheme											
26	Threats to Job stability of workers											
27	Absenteeism from work due to drugs, alcohol, health											
28	Poor health and safety measures											
29	Delay in staff emolument											
30	Delay in payments to sub-contractors and suppliers											
31	Ad-hoc nature of employment of workers											
	Number of items, N=26	**Mean =**										

Optimistic, are values that tend towards ten in the card and mean that the assessor is optimistic that the negative impact of the factors in the card will not be high, or that adequate measure put in place against their impact. Pessimistic is therefore, the opposite which conveys opposing meanings to optimistic and as it tends towards zero. The card can be used to compute the mean values of each item, each section and the entire items in the card which gives the culpability of an item, the stakeholder and the entire team respectively. They can be computed as follows:

1. Mean value of each factor (M) = $\frac{T}{S \times 10}$

   Note: $T = N1 \times 1 + N2 \times 2 + N3 \times 3 + \cdots + N10 \times 10$

   $S = N1+N2+N3+---+N10$ (i.e. total number of people that weigh that particular factor).

2. Culpability factor of a stakeholder (C) is the pooled mean of all the factors in a section of the card.

$$C = \frac{S1 \times M1+S2 \times M2+S3 \times M3+---+Sf \times Mf}{S1+S2+S3+---+Sf}$$

Note: f = the number of factors in each section of the card, (e.g. client or contractor sections etc.).

3. Culpability of the entire team (CT) is the pooled mean of all the sections in the card.

$$CT = \frac{C1 \times f1+C2 \times f2+C3 \times f3+C4 \times f4}{f1 + f2 + f3 + f4}$$

Note: f = the number of factors usedin computing the value of C.

4.2.2 Analysis of cost data

Historical cost data (HCD) was subjected to graphical and statistical analysis and results presented as follows.

4.2.2.1 Graphical analysis of HCD

a. Quantum value of cost growth: the extent of cost growth was obtained by subtracting the first data point (FDP) of each item, i.e. the first price of each item obtained in 1998 from the corresponding last value or last data point (LDP) i.e. the last price of the item in 2007 in the HCD. The ratio between the value obtained and the FDP for each item were plotted in a bar chart to show the extent prices of materials have grown over the years and shown in Figure 4.2. The chart therefore reveals the extent of cost growth for each item caused by market forces within the 10 year period under this research.

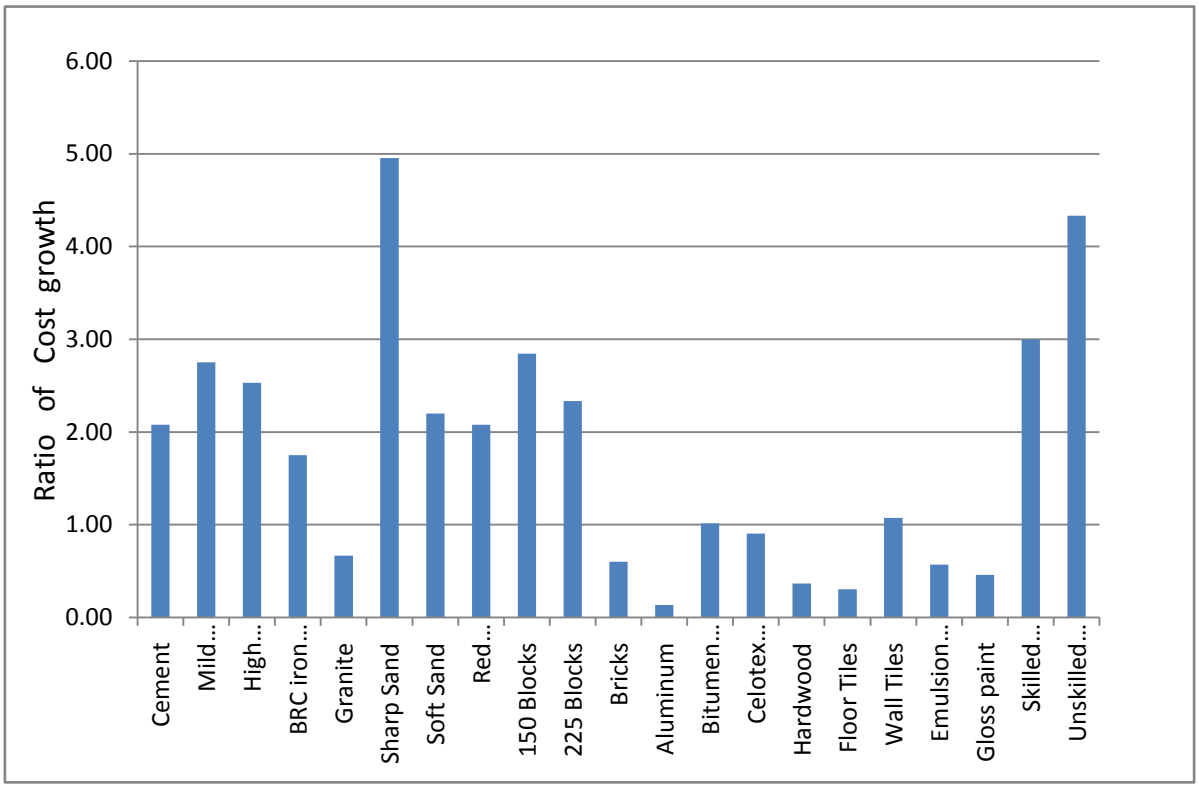


Figure 4.2: Extent of cost growth in construction items

Two main groups of items were revealed on inspecting the bar chart. The cost of the first group herein referred to as the fast cost growth items (FCG) have values of growth in the chart above 2.0. The second group is the slow cost growth items (SCG) having values of 2.0 or below. The list of items under each group is reported in Table 4.6.

Table 4.6: Classification of items based on extent of cost growth

	Fast cost growth items	Slow cost growth items
1	Cement	Granite
2	Mild steel bar	Bricks
3	High yield steel bar	Aluminum
4	BRC Mesh	Bitumen felt
5	Sharp sand	Celotex ceiling
6	Soft Sand	Hard wood
7	Red laterite	Ceramic floor tiles
8	150 blocks	Ceramic wall tiles
9	225 blocks	Emulsion paint
10	Skilled labour	Gloss paint
11	Unskilled labour	-

b. Analysis of classified building items: items in each group were analysed graphically. The set of items in each group were plotted together in a line graph to reveal and compare the trend in responses to cost changes affecting the group under market condition. The first analysis is that, the highest values each item attained each year were depicted on the graph. In Figure 4.3 the highest values each year were divided by the FDP to obtain an array of ratios and the values plotted. Therefore, the figure shows a line graph that depicts the trend in the growth ratio of the highest values over the FDP in the FCG group of items, while Figure 4.4 in like manner depicts the trend in the SCG group of items.

Similar to the highest values, the lowest yearly values each item attained were analysed and the ratios plotted in Figures 4.5 and 4.6 for the FCG and the SCG group respectively. The pattern of responses of various items in each graph was revealed and can easily be compared.

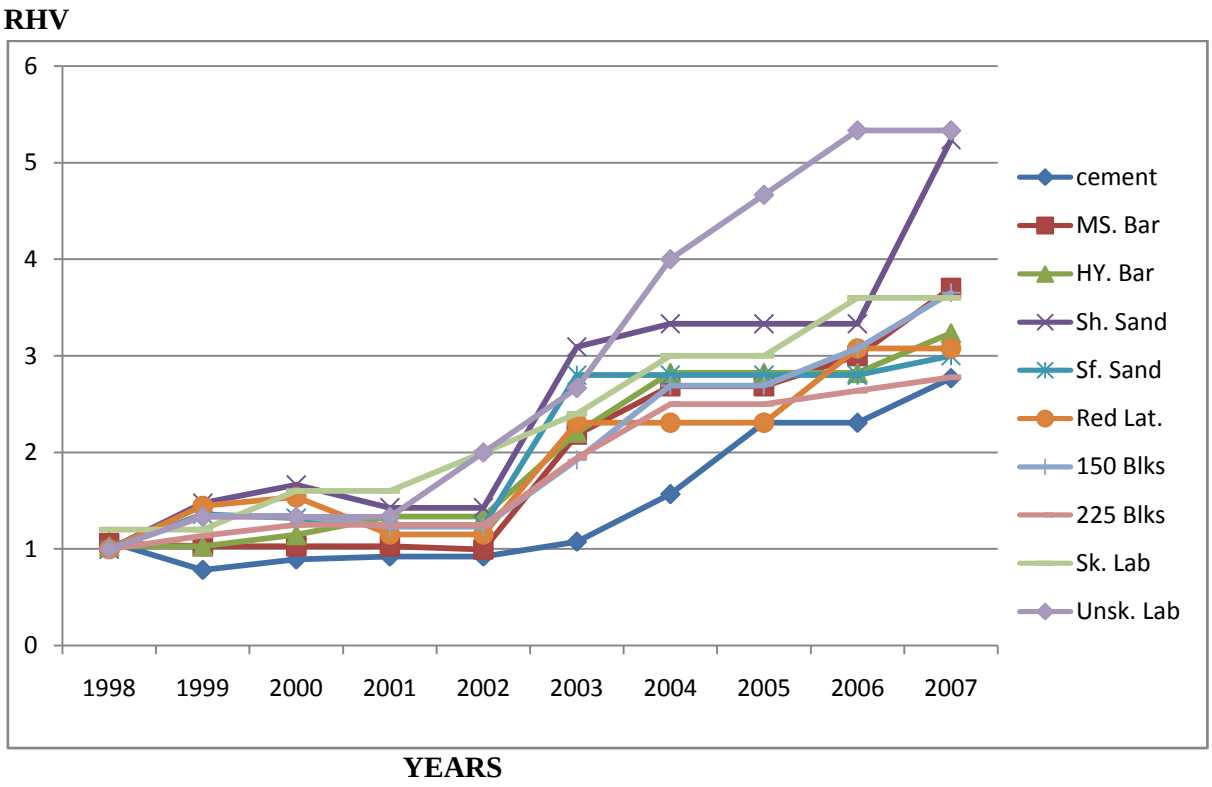


Figure 4.3: Trend in highest values in fast cost growth items

Note: RHV- ratio of highest values

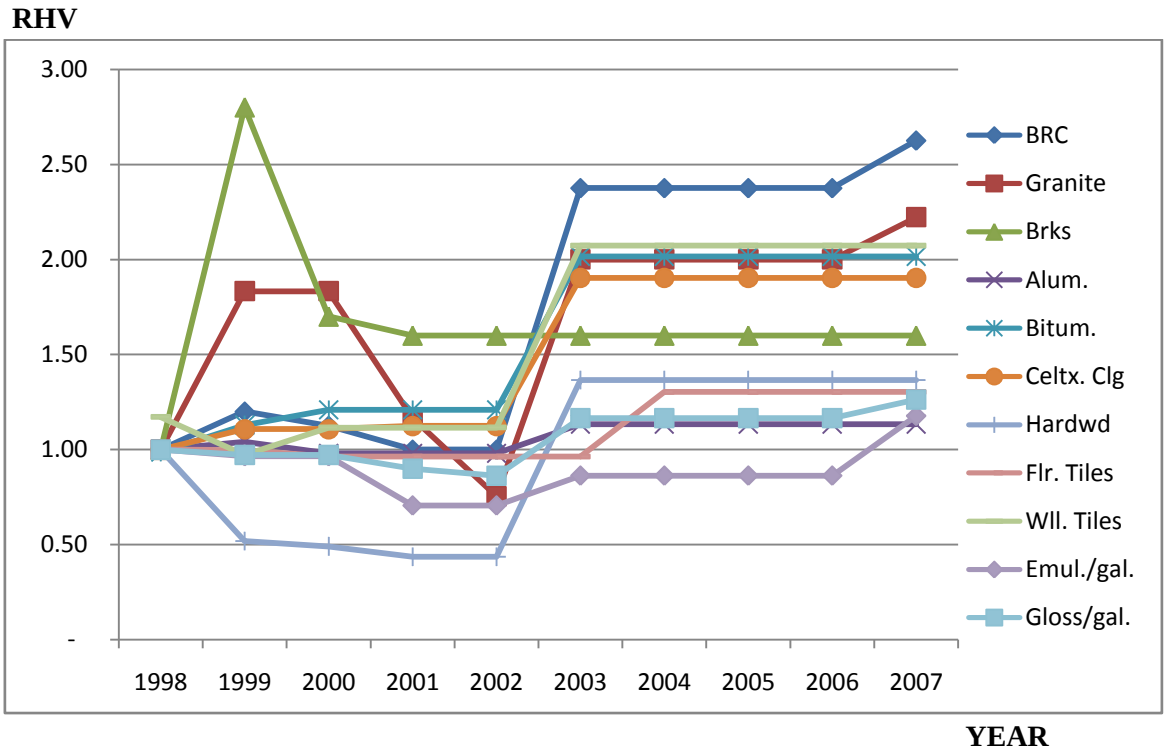


Figure 4.4: Trend in highest values in slow cost growth items

Note: RHV- ratio of highest values

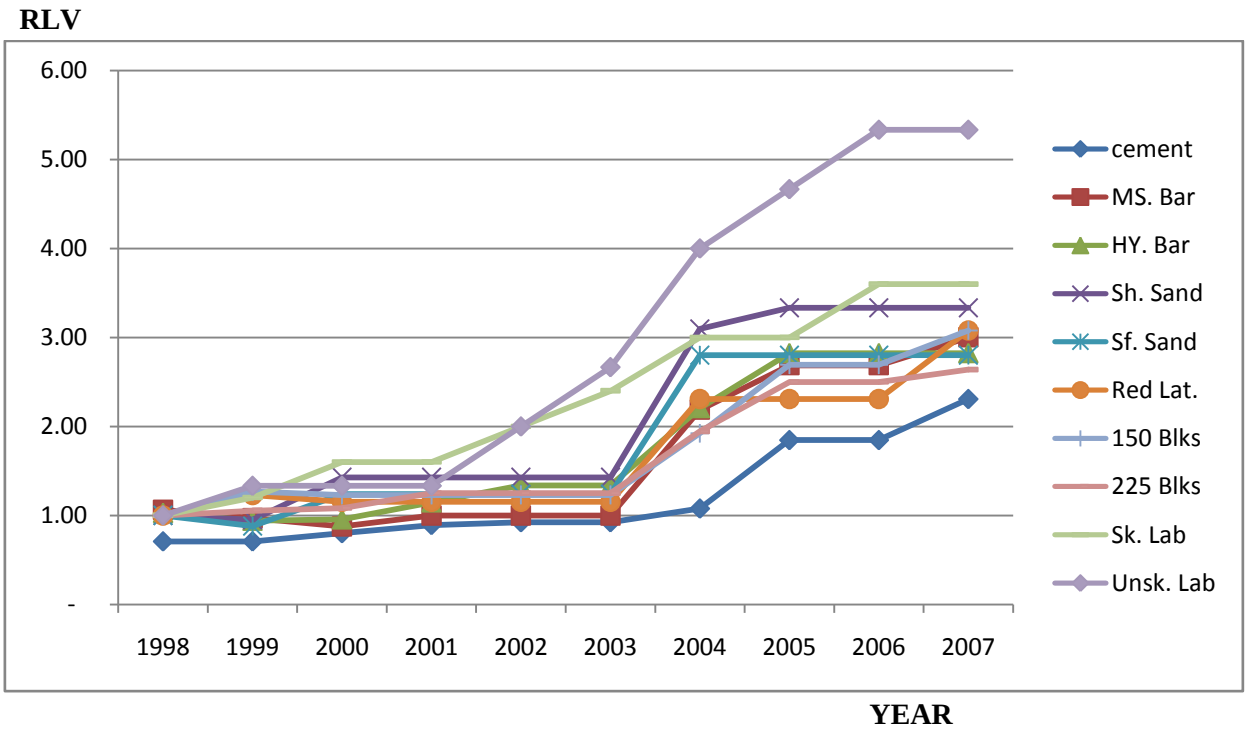


Figure 4.5: Trend in lowest values in the fast group

Note: RLV- ratio of lowest values

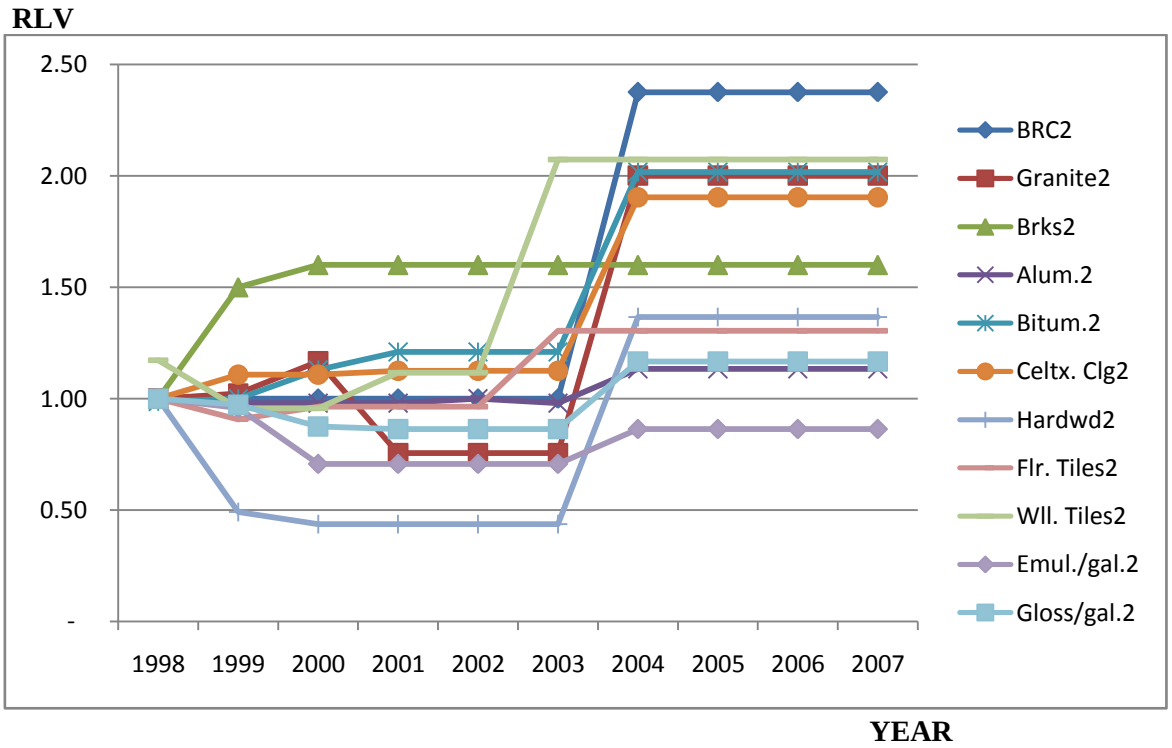


Figure 4.6: Trend in lowest values in the slow group

Note: RLV- ratio of lowest values

The study also sought to know and to compare the yearly degree of changes that occurred in various items within the research period. This is to reveal if the market forces that cause cost to change acted on items uniformly or differently over the years. In other words, if the reactions to market forces by items were similar or not. The highest values each item attained yearly were identified and divided by its corresponding value at the beginning of the year to obtain a ratio of the highest change in the affected year. Ten values for each item were therefore obtained covering the research period and plotted in a line graph. All the items within the first group were plotted in the same graph; likewise those in the second group. Figures 4.7 and 4.8 show the graphs for the FCG and the SCG respectively. It can be seen that the two figures looked similar. The way market prices fluctuate up and down follow the same pattern for all construction materials of course.

SR

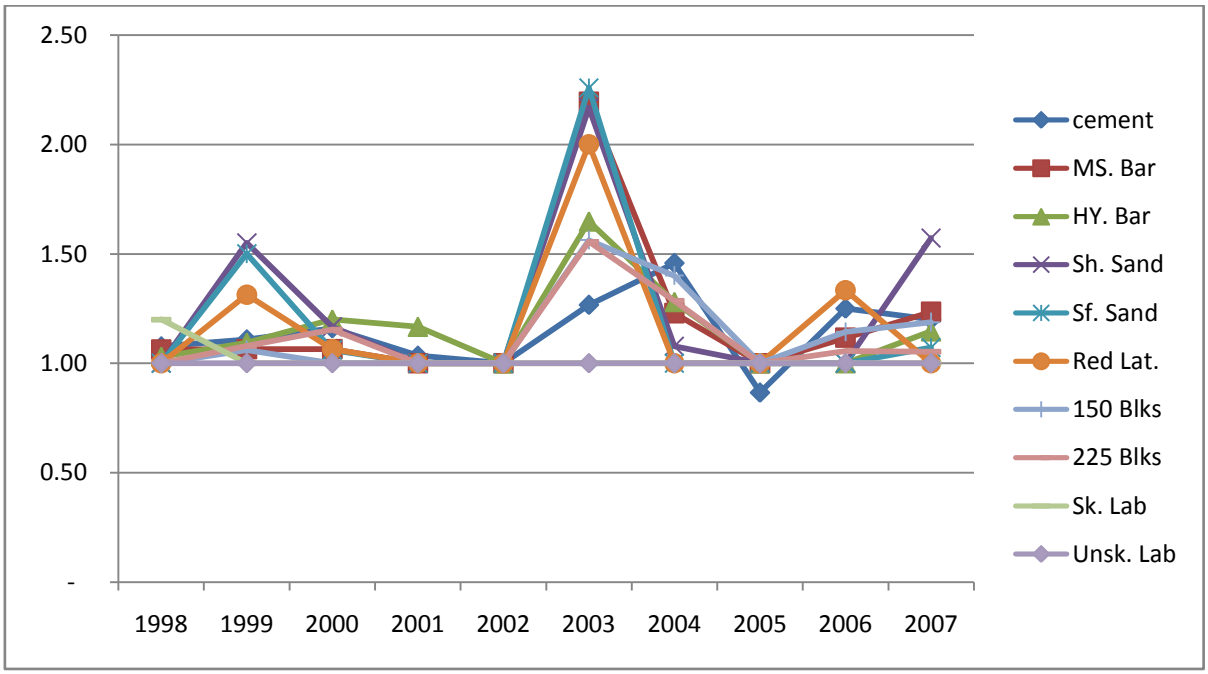


Figure 4.7 Yearly seasonal growths for fast group

Note: SR- seasonal ratio

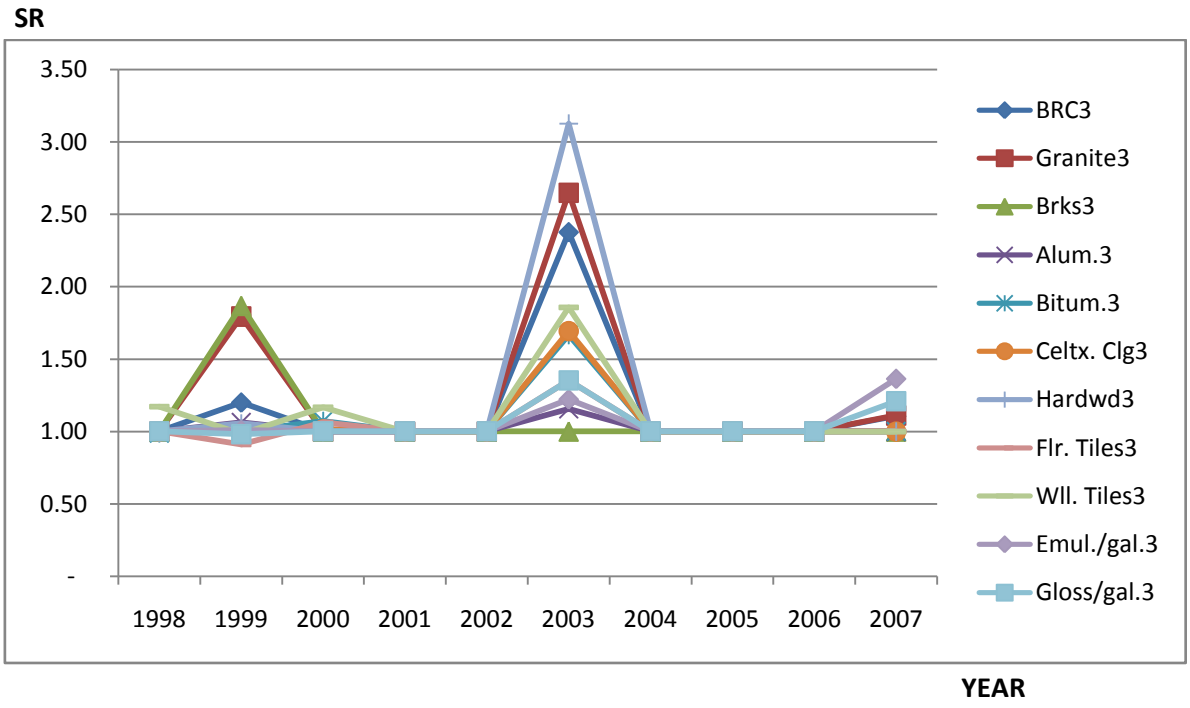


Figure 4.8: Yearly seasonal growths for slow group

Note: SR- seasonal ratio

4.2.2.2 Statistical analysis of HCD

c. Validation of historical cost data: tests were first conductedto establish if the data from the field should be accepted as valid for research purposes. Two tests were conducted, first was the test for outliers (see Table 4.7) and second the test for normality of data (Table 4.8). In Table 4.7, each sample was tested separately at the upper and the lower ends, Z_1 and Z_2 respectively.

The computed Z values were less than the Grubb's critical values (read in Appendix VII) except bricks. It means there are no outliers in all the samples except bricks. The outlier in bricks which is the smallest data point at the lower level was identified in the sample and excluded in subsequent analysis.

Table 4.7: Test for outliers on the historical cost data

Sampled populations	Mean	Std Dev	Z1	Z2	Grubb's critical value	Comments
Cement	877	399.6614	1.043383	2.309455	3.04	no outlier
Mild Steel Bar	58020	30156.73	0.995466	2.005523	3.04	no outlier
High Yield Bar	63312.5	28429.33	1.101415	1.64223	3.04	no outlier
BRC Reinforcement	13205	5543.393	0.938956	1.406179	3.04	no outlier
Granite	13882.5	4804.159	1.474244	1.273376	3.04	no outlier
Sharp Sand	4790	2321.008	1.202064	2.675562	3.04	no outlier
Soft Sand	4832.5	2054.936	1.281062	1.298094	3.04	no outlier
Red Laterite	2394	986.5683	1.108894	1.627865	3.04	no outlier
150 Blocks	49.8	22.35059	1.064849	2.022318	3.04	no outlier
225 Blocks	63.15	24.78683	1.09534	1.486676	3.04	no outlier
Bricks	80.25	16.71595	1.809649	3.57443	3.04	**outlier**
Aluminum	1723.2	118.9663	1.035587	1.065848	3.04	no outlier
Bitumen Felt	19003	5558.898	1.216608	1.078811	3.04	no outlier
Celotex. Ceiling	4219	1177.785	1.128389	1.087634	3.04	no outlier
Hard wood	168.55	80.03876	1.106339	1.017632	3.04	no outlier
Floor Tiles	982.7	154.6812	1.181139	1.08158	3.04	no outlier
Wall Tiles	950.65	321.945	1.089161	1.085123	3.04	no outlier
Emulsion Paint	547.075	72.88185	1.33195	2.784301	3.04	no outlier
Gloss Paint	1070.05	150.0249	1.213465	2.532579	3.04	no outlier
Skilled Labour	1155	455.7046	1.437335	1.415391	3.04	no outlier
Unskilled Labour	435	254.246	1.120962	1.435618	3.04	no outlier

The second test meantto find out if the sets of data are normally distributed. The Kolmogorov-Smirnov normality test was carried out in three levels from a more stringent level of significance of 0.01 to a more liberal level of 0.1 (see Table 4.8). All the cases indicated a normally distributed data at the three levels of 1%, 5% and 10% degrees of freedom (i.e.α = 0.01, 0.05 & 0.1) since none of the computed values is greater than any of the critical values. The hypothesis is accepted that the data is normally distributed.

These two tests therefore (test of outlier and test of normality) established that the data from the field is valid and can be used for further statistical analysis using parametric statistics.

Table 4.8: Test for normality

Sampled Population=40			**Critical Values, α**		
	Computed Value	**Critical Value at 0.01**	**Critical Value at 0.05**	**Critical Value at 0.1**	**Comments**
Cement	0.921102	0.959685735	0.971483994	0.976703837	accept H0
Mild Steel Bars	0.891059	0.959685735	0.971483994	0.976703837	accept H0
High Yield Bar	0.897368	0.959685735	0.971483994	0.976703837	accept H0
BRC Reinforcement	0.849214	0.959685735	0.971483994	0.976703837	accept H0
Granite	0.903109	0.959685735	0.971483994	0.976703837	accept H0
harp Sand	0.899098	0.959685735	0.971483994	0.976703837	accept H0
Soft Sand	0.870731	0.959685735	0.971483994	0.976703837	accept H0
Red Laterite	0.923413	0.959685735	0.971483994	0.976703837	accept H0
150mm Blocks	0.912386	0.959685735	0.971483994	0.976703837	accept H0
225mm Blocks	0.901358	0.959685735	0.971483994	0.976703837	accept H0
Bricks	0.714484	0.959685735	0.971483994	0.976703837	accept H0
Aluminum Sheet	0.858283	0.959685735	0.971483994	0.976703837	accept H0
Bitumen	0.867261	0.959685735	0.971483994	0.976703837	accept H0
Celotex Ceiling	0.843295	0.959685735	0.971483994	0.976703837	accept H0
Hard Wood	0.863795	0.959685735	0.971483994	0.976703837	accept H0
Floor Tiles	0.861438	0.959685735	0.971483994	0.976703837	accept H0
Wall Tiles	0.853035	0.959685735	0.971483994	0.976703837	accept H0
Emulsion	0.933302	0.959685735	0.971483994	0.976703837	accept H0
Gloss	0.926637	0.959685735	0.971483994	0.976703837	accept H0
Skilled Labour	0.955964	0.959685735	0.971483994	0.976703837	accept H0
Unskilled Labour	0.922421	0.959685735	0.971483994	0.976703837	accept H0

d. Computing the historical composite unit rates (HCUR): The HCD in Appendix V was subjected to price analysis so as to obtain a Historical Composite Unit Rates (HCUR) over the period of the research, which was reported in Table 4.9A-D. To know whether cost growth was significant during the research period, the HCUR was subjected to variance analyses. The ANOVA results in Tables 4.10A, B and C, show the same variance analysis tests for short (2yrs), medium (5years) and long periods (10years)in that order.

Item/Year	Top soil excavation (m2)	Trench excavation (m3)	Pit excavation (m3)	Remove exctd material (m3)	Backfill (m3)	Level & compact (m2)	Laterite filling (m3)	Plain in situ concrete (m3)	Reinfrcd in situ concrete (m3)	Mild Steel Reinfmt. (Kg)	High Yield Steel Reinforcement (Kg)	BRC Mesh Reinfrmt (m2)	Formwork (m2)	230mm Blocks Filled Solid (m2)	230mm Hollow blocks (m2)	150mm Hollow blocks (m2)
1998	15.82	82.03	103.13	58.59	35.16	11.72	505.84	6,891.02	8,255.42	18,976.99	34,055.17	154.85	1,316.21	1,637.28	648.70	197.87
	15.82	82.03	103.13	58.59	35.16	11.72	505.84	7,193.83	8,673.95	19,878.67	35,705.42	156.36	1,441.21	1,710.12	675.01	218.88
	15.82	82.03	103.13	58.59	35.16	11.72	505.84	7,193.83	8,673.95	19,878.67	35,705.42	156.36	1,441.21	1,710.12	675.01	218.88
	15.82	82.03	103.13	58.59	35.16	11.72	505.84	5,865.02	6,789.71	15,862.35	28,329.72	154.85	1,316.21	1,458.45	619.97	179.19
1999	21.09	109.38	137.50	78.13	46.88	15.63	625.57	6,025.26	6,948.32	16,275.58	29,049.41	156.99	1,130.81	1,522.32	668.41	208.07
	21.09	109.38	137.50	78.13	46.88	15.63	808.86	8,613.18	9,541.58	22,752.03	40,386.54	186.07	1,148.37	1,949.99	717.47	216.93
	21.09	109.38	137.50	78.13	46.88	15.63	808.86	8,613.18	9,541.58	22,752.03	40,386.54	186.07	1,148.37	1,949.99	717.47	216.93
	21.09	109.38	137.50	78.13	46.88	15.63	728.21	8,544.41	9,450.37	22,552.08	40,022.59	175.16	1,130.81	1,914.24	691.78	218.21
2000	21.09	109.38	137.50	78.13	46.88	15.63	728.21	8,610.04	9,516.00	22,716.14	40,309.70	178.19	1,380.81	1,965.81	729.28	250.40
	21.09	109.38	137.50	78.13	46.88	15.63	772.20	8,791.86	9,740.59	23,224.15	41,225.45	178.19	1,380.81	1,998.19	735.06	254.16
	21.09	109.38	137.50	78.13	46.88	15.63	588.92	7,270.39	8,445.85	19,703.89	35,206.70	160.02	1,345.69	1,852.79	812.26	254.33
	21.09	109.38	137.50	78.13	46.88	15.63	588.92	7,270.39	8,445.85	19,703.89	35,206.70	160.02	1,345.69	1,852.79	812.26	254.33
2001	21.09	109.38	137.50	78.13	46.88	15.63	588.92	7,270.39	8,445.85	19,703.89	35,206.70	160.02	1,345.69	1,852.79	812.26	254.33
	21.09	109.38	137.50	78.13	46.88	15.63	588.92	7,270.39	8,445.85	19,703.89	35,206.70	160.02	1,345.69	1,852.79	812.26	254.33
	21.09	109.38	137.50	78.13	46.88	15.63	588.92	7,270.39	8,445.85	19,703.89	35,206.70	160.02	1,345.69	1,852.79	812.26	254.33
	21.09	109.38	137.50	78.13	46.88	15.63	588.92	6,285.87	7,559.64	17,365.48	31,175.93	160.02	1,345.69	1,711.77	815.28	256.29
2002	31.64	164.06	206.25	117.19	70.31	23.44	608.45	6,517.78	7,792.51	17,975.75	32,239.62	164.30	1,628.08	1,780.41	866.01	296.39
	31.64	164.06	206.25	117.19	70.31	23.44	608.45	6,517.78	7,792.51	17,975.75	32,239.62	164.30	1,628.08	1,780.41	866.01	296.39
	31.64	164.06	206.25	117.19	70.31	23.44	608.45	6,517.78	7,792.51	17,975.75	32,239.62	164.30	1,628.08	1,780.41	866.01	296.39
	31.64	164.06	206.25	117.19	70.31	23.44	608.45	6,517.78	7,792.51	17,975.75	32,239.62	164.30	1,628.08	1,780.41	866.01	296.39
2003	42.19	218.75	275.00	156.25	93.75	31.25	627.98	6,749.69	8,025.38	18,586.03	33,303.32	168.58	1,910.46	1,849.04	916.74	336.49
	42.19	218.75	275.00	156.25	93.75	31.25	627.98	7,613.69	9,259.66	21,208.88	38,124.75	168.58	1,910.46	1,999.64	940.93	352.22
	42.19	218.75	275.00	156.25	93.75	31.25	1,177.83	11,113.51	12,438.54	29,557.25	52,533.80	368.50	2,507.44	2,817.19	1,246.47	382.48
	42.19	218.75	275.00	156.25	93.75	31.25	1,177.83	11,113.51	12,438.54	29,557.25	52,533.80	368.50	2,507.44	2,817.19	1,246.47	382.48

Table 4.9A: Historical composite unit rates (HCUR)

Item / Year	Top soil excavation (m2)	Trench excavation (m3)	Pit excavation (m3)	Remove exctd material (m3)	Backfill (m3)	Level & compact (m2)	Laterite filling (m3)	Plain in situ concrete (m3)	Reinfrcd in situ concrete (m3)	Mild Steel Reinfmt. (Kg)	High Yield Steel Reinforcement (Kg)	BRC Mesh Reinfrmt (m2)	Formwork (m2)	230mm Blocks Filled Solid (m2)	230mm Hollow blocks (m2)	150mm Hollow blocks (m2)
2004	63.28	328.13	412.50	234.38	140.63	46.88	1,216.89	11,544.53	12,871.46	30,695.77	54,517.63	375.55	2,947.20	2,928.68	1,329.18	446.59
	63.28	328.13	412.50	234.38	140.63	46.88	1,216.89	13,346.35	15,410.34	36,121.64	64,473.56	375.55	2,947.20	3,479.68	1,616.57	506.08
	63.28	328.13	412.50	234.38	140.63	46.88	1,216.89	13,346.35	15,410.34	36,121.64	64,473.56	375.55	2,947.20	3,479.68	1,616.57	506.08
	63.28	328.13	412.50	234.38	140.63	46.88	1,216.89	13,346.35	15,410.34	36,121.64	64,473.56	375.55	2,947.20	3,479.68	1,616.57	506.08
2005	73.83	382.81	481.25	273.44	164.06	54.69	1,236.43	16,104.64	19,280.44	44,436.42	79,714.43	376.80	2,979.58	3,948.54	1,702.37	561.17
	73.83	382.81	481.25	273.44	164.06	54.69	1,236.43	15,024.64	17,737.58	41,157.85	73,687.65	376.80	2,979.58	3,760.29	1,672.13	541.51
	73.83	382.81	481.25	273.44	164.06	54.69	1,236.43	15,024.64	17,737.58	41,157.85	73,687.65	376.80	2,979.58	3,760.29	1,672.13	541.51
	73.83	382.81	481.25	273.44	164.06	54.69	1,236.43	14,484.64	16,966.15	39,518.56	70,674.26	376.80	2,979.58	3,666.17	1,657.01	531.68
2006	84.38	437.50	550.00	312.50	187.50	62.50	1,255.96	14,749.36	17,231.83	40,210.87	71,881.50	382.59	3,386.96	3,760.59	1,726.49	587.88
	84.38	437.50	550.00	312.50	187.50	62.50	1,622.53	15,559.36	18,388.98	42,669.80	76,401.59	382.59	3,386.96	3,960.83	1,808.24	615.74
	84.38	437.50	550.00	312.50	187.50	62.50	1,622.53	15,559.36	18,388.98	42,669.80	76,401.59	382.59	3,386.96	3,960.83	1,808.24	615.74
	84.38	437.50	550.00	312.50	187.50	62.50	1,622.53	16,369.36	19,546.12	45,128.73	80,921.68	382.59	3,386.96	4,102.01	1,830.92	630.49
2007	84.38	437.50	550.00	312.50	187.50	62.50	1,622.53	16,369.36	19,546.12	45,128.73	80,921.68	382.59	3,386.96	4,102.01	1,830.92	630.49
	84.38	437.50	550.00	312.50	187.50	62.50	1,622.53	16,369.36	19,546.12	45,128.73	80,921.68	382.59	3,386.96	4,102.01	1,830.92	630.49
	84.38	437.50	550.00	312.50	187.50	62.50	1,622.53	17,769.91	21,265.69	49,028.88	87,946.34	418.94	3,386.96	4,394.17	1,918.17	668.50
	84.38	437.50	550.00	312.50	187.50	62.50	1,622.53	19,170.47	22,985.26	52,929.04	94,971.00	418.94	3,386.96	4,638.29	1,957.39	693.99
2008	84.38	437.50	550.00	312.50	187.50	62.50	1,622.53	19,061.17	23,398.58	53,309.07	95,962.69	440.15	3,636.96	4,939.02	2,269.64	757.77

Table 4.9B: Historical composite unit rates (cont'd)

Item / Year	12mm Rendering (m2)	Emulsion painting (m2)	Glosspainting (m2)	0.55 Aluminum Sheets (m2)	50 x 150mm Hardwood (m)	50 x 100mm Hardwood (m)	50 x 75mm Hardwood (m)	50 x 50mm Hardwood (m)	25 x 300mm Fascia board (m)	12 x 38mm Batten (m)	Celotex ceiling (m2)	50mm Screeded bed (m2)	Unglazed ceramic floor tiles (m2)	Glazed ceramic wall tiles (m2)
1998	64.75	82.02	126.09	1,863.08	205.46	136.98	102.73	68.49	205.46	12.49	1,389.52	269.45	1,215.52	570.95
	69.18	89.64	140.51	1,867.25	205.46	136.98	102.73	68.49	205.46	12.49	1,401.24	287.92	1,224.42	581.42
	69.18	89.64	140.51	1,867.25	205.46	136.98	102.73	68.49	205.46	12.49	1,401.24	287.92	1,224.42	581.42
	48.34	82.02	126.09	1,863.08	205.46	136.98	102.73	68.49	205.46	12.49	1,389.52	201.05	1,215.52	657.58
1999	47.56	87.78	140.03	1,833.33	101.50	67.67	50.75	33.83	101.50	6.17	1,544.17	202.05	1,226.25	573.02
	55.66	88.13	138.98	1,833.33	107.10	71.40	53.55	35.70	107.10	6.51	1,544.17	234.49	1,121.25	565.00
	55.66	88.13	138.98	1,833.33	107.10	71.40	53.55	35.70	107.10	6.51	1,544.17	234.49	1,121.25	565.00
	54.48	88.13	138.98	1,945.83	101.50	67.67	50.75	33.83	101.50	6.17	1,544.17	229.58	1,121.25	565.00
2000	54.69	103.38	167.81	1,954.17	101.50	67.67	50.75	33.83	101.50	6.17	1,567.60	230.51	1,139.06	585.94
	57.05	103.38	167.81	1,954.17	101.50	67.67	50.75	33.83	101.50	6.17	1,567.60	244.28	1,139.06	585.94
	60.98	92.01	162.56	1,841.67	90.30	60.20	45.15	30.10	90.30	5.49	1,590.62	259.31	1,204.69	666.15
	60.98	92.01	162.56	1,841.67	90.30	60.20	45.15	30.10	90.30	5.49	1,590.62	259.31	1,204.69	666.15
2001	60.98	92.01	162.56	1,841.67	90.30	60.20	45.15	30.10	90.30	5.49	1,590.62	259.31	1,204.69	666.15
	60.98	92.01	162.56	1,841.67	90.30	60.20	45.15	30.10	90.30	5.49	1,590.62	259.31	1,204.69	666.15
	60.98	92.01	162.56	1,841.67	90.30	60.20	45.15	30.10	90.30	5.49	1,590.62	259.31	1,204.69	666.15
	62.70	92.01	161.93	1,841.67	90.30	60.20	45.15	30.10	90.30	5.49	1,590.62	266.51	1,204.69	666.15
2002	63.04	107.26	190.76	1,854.17	90.67	60.44	45.33	30.22	90.67	5.51	1,614.52	271.15	1,231.41	697.55
	63.04	107.26	190.76	1,854.17	90.67	60.44	45.33	30.22	90.67	5.51	1,614.52	271.15	1,231.41	697.55
	63.04	107.26	190.76	1,854.17	90.67	60.44	45.33	30.22	90.67	5.51	1,614.52	271.15	1,231.41	697.55
	63.04	107.26	190.76	1,854.17	90.67	60.44	45.33	30.22	90.67	5.51	1,614.52	271.15	1,231.41	697.55
2003	63.38	122.51	219.59	1,866.67	91.03	60.68	45.51	30.34	91.03	5.53	1,638.43	275.78	1,258.13	728.96
	77.21	129.40	219.59	1,866.67	91.03	60.68	45.51	30.34	91.03	5.53	1,638.43	333.38	1,258.13	728.96
	84.31	129.40	235.97	2,147.92	281.39	187.59	140.70	93.80	281.39	17.11	2,674.08	357.71	1,651.88	1,210.21
	84.31	129.40	235.97	2,147.92	281.39	187.59	140.70	93.80	281.39	17.11	2,674.08	357.71	1,651.88	1,210.21

Table 4.9C: Historical composite unit rates (cont'd)

Item / Year	12mm Rendering (m2)	Emulsion painting (m2)	Glosspainting (m2)	0.55 Aluminum Sheets (m2)	50 x 150mm Hardwood (m)	50 x 100mm Hardwood (m)	50 x 75mm Hardwood (m)	50 x 50mm Hardwood (m)	25 x 300mm Fascia board (m)	12 x 38mm Batten (m)	Celotex ceiling (m2)	50mm Screeded bed (m2)	Unglazed ceramic floor tiles (m2)	Glazed ceramic wall tiles (m2)
2004	84.88	152.27	279.21	2,168.75	282.11	188.07	141.06	94.04	282.11	17.15	2,710.17	366.51	1,696.41	1,262.55
	112.53	152.27	279.21	2,168.75	282.11	188.07	141.06	94.04	282.11	17.15	2,710.17	488.28	1,696.41	1,262.55
	112.53	152.27	279.21	2,168.75	282.11	188.07	141.06	94.04	282.11	17.15	2,710.17	488.28	1,696.41	1,262.55
	112.53	152.27	279.21	2,168.75	282.11	188.07	141.06	94.04	282.11	17.15	2,710.17	488.28	1,696.41	1,262.55
2005	154.13	152.27	279.21	2,172.92	282.47	188.31	141.24	94.16	282.47	17.17	2,710.64	664.77	1,705.31	1,273.02
	136.85	152.27	279.21	2,172.92	282.47	188.31	141.24	94.16	282.47	17.17	2,710.64	592.77	1,705.31	1,273.02
	136.85	152.27	279.21	2,172.92	282.47	188.31	141.24	94.16	282.47	17.17	2,710.64	592.77	1,705.31	1,273.02
	128.21	152.27	279.21	2,172.92	282.47	188.31	141.24	94.16	282.47	17.17	2,710.64	556.77	1,705.31	1,273.02
2006	128.66	175.15	322.45	2,189.58	282.83	188.56	141.42	94.28	282.83	17.20	2,746.26	561.88	1,740.94	1,314.90
	141.62	175.15	322.45	2,189.58	282.83	188.56	141.42	94.28	282.83	17.20	2,746.26	615.88	1,740.94	1,314.90
	141.62	175.15	322.45	2,189.58	282.83	188.56	141.42	94.28	282.83	17.20	2,746.26	615.88	1,740.94	1,314.90
	154.58	175.15	322.45	2,189.58	282.83	188.56	141.42	94.28	282.83	17.20	2,746.26	669.88	1,740.94	1,314.90
2007	154.58	175.15	322.45	2,189.58	282.83	188.56	141.42	94.28	282.83	17.20	2,746.26	669.88	1,740.94	1,314.90
	154.58	175.15	322.45	2,189.58	282.83	188.56	141.42	94.28	282.83	17.20	2,746.26	669.88	1,740.94	1,314.90
	169.11	178.59	327.70	2,189.58	282.83	188.56	141.42	94.28	282.83	17.20	2,746.26	737.00	1,740.94	1,314.90
	182.07	188.93	335.58	2,189.58	282.83	188.56	141.42	94.28	282.83	17.20	2,746.26	830.37	1,740.94	1,314.90
2008	201.13	221.41	367.03	2,197.92	282.83	188.56	141.42	94.28	282.83	17.20	2,769.70	922.99	1,758.75	1,335.83

Table 4.9D: Historical composite unit rates (cont'd)

Table 4.10A: ANOVA table single factor for two years

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	807770216	28	28848936	284.0107	3.1493E-130	1.541161
Within Groups	17674388	174	101576.9			
Total	825444604	202				

Table 4.10B: ANOVA single factor for five years

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.6E+09	28	2E+08	224.7691	0	1.489328
Within Groups	7.73E+08	870	889056.4			
Total	6.37E+09	898				

Table 4.10C: ANOVA single factor for ten years

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.02E+10	28	3.64E+08	217.6929	0	1.486329
Within Groups	1.89E+09	1131	1670101			
Total	1.21E+10	1159				

In both cases, the computed values of F are greater than the critical values of F(F_{crit}). Both cases therefore indicate that the null hypothesis is rejected and concluded that there is significant change in the cost of materials and labour in the Nigerian construction market over short, medium and long periods. It means that market forces acting on prices of building materials impact significant changes in cost even at short periods.

e. Costing of quantified standard design: The HCUR reported in Table 4.9A-D was used to price the BOQ in Appendix VIII which gives the Historical Elemental Cost (HEC) of the standard prototype design. The elemental cost of the same building was generated over the research period as reported in Table 4.11A-B. Addition of corresponding elements for each year gives the total cost each year called Historical Total Cost (HTC) of the standard design, and is shown at the last row in Table 11A-B.

Elements	1998				1999			
Element Nr.1 Substructure	928,761.88	971,481.46	971,481.46	833,233.73	857,553.45	1,117,213.55	1,117,213.55	1,095,979.10
Element Nr.2 Frames	891,248.54	958,032.72	958,032.72	885,303.16	829,683.67	909,392.94	909,392.94	879,415.72
Element Nr.3 Staircase	132,862.63	142,096.76	142,096.76	127,115.93	120,662.15	140,942.95	140,942.95	137,625.98
Element Nr.4 Upper Floors	698,646.18	749,546.03	749,546.03	669,273.07	627,867.78	723,970.34	723,970.34	708,582.64
Element Nr.5 Roofing	965,672.49	976,358.10	976,358.10	961,555.26	844,686.41	865,361.51	865,361.51	896,599.66
Element Nr.6 External Walls	325,647.91	338,855.53	338,855.53	311,226.46	335,542.95	360,171.32	360,171.32	347,275.85
Element Nr.7 Internal Walls & Partitions	92,764.25	96,526.58	96,526.58	88,656.14	95,582.95	102,598.60	102,598.60	98,925.19
Element Nr.8 Fittings And Fixtures	42,357.12	45,123.08	45,123.08	39,384.65	37,786.68	46,257.27	46,257.27	45,461.23
Element Nr.9 Floors Finishes	650,997.36	654,949.95	662,596.01	622,679.76	627,859.68	594,689.06	640,476.74	592,655.35
Element Nr.10 Walls Finishes	339,658.04	362,629.14	362,629.14	321,983.70	319,494.88	333,518.74	333,518.74	331,409.54
Element Nr.11 Ceiling Finishes	474,874.35	482,204.64	482,204.64	471,476.24	473,849.06	477,770.69	477,770.69	475,439.07
Total Cost of the Building	**5,543,490.75**	**5,777,803.97**	**5,785,450.04**	**5,331,888.10**	**5,170,569.65**	**5,671,886.96**	**5,717,674.64**	**5,609,369.32**

2000				2001			2002				
1,127,093.01	1,145,473.91	1,012,852.12	1,012,852.12	1,012,852.12	1,012,852.12	1,012,852.12	929,000.22	990,626.11	990,626.11	990,626.11	990,626.11
968,680.27	956,197.02	981,533.21	981,533.21	981,533.21	981,533.21	981,533.21	993,546.25	1,096,772.38	1,096,772.38	1,096,772.38	1,096,772.38
149,275.69	149,040.35	143,450.70	143,450.70	143,450.70	143,450.70	143,450.70	139,771.83	153,900.07	153,900.07	153,900.07	153,900.07
779,588.43	779,677.36	746,349.86	746,349.86	746,349.86	746,349.86	746,349.86	727,138.33	811,813.95	811,813.95	811,813.95	811,813.95
913,245.34	913,141.67	857,962.66	857,962.66	857,962.66	857,962.66	857,962.66	854,847.28	875,760.42	875,760.42	875,760.42	875,760.42
366,100.85	369,002.36	407,752.29	407,752.29	407,752.29	407,752.29	407,752.29	409,270.34	434,737.21	434,737.21	434,737.21	434,737.21
104,287.69	105,114.22	116,152.54	116,152.54	116,152.54	116,152.54	116,152.54	116,584.98	123,839.48	123,839.48	123,839.48	123,839.48
48,749.43	49,049.47	45,092.25	45,092.25	45,092.25	45,092.25	45,092.25	42,639.86	46,808.53	46,808.53	46,808.53	46,808.53
600,948.66	606,646.00	641,996.24	641,996.24	641,996.24	641,996.24	641,996.24	644,977.04	658,753.45	658,753.45	658,753.45	658,753.45
361,894.51	366,112.90	363,621.03	363,621.03	363,621.03	363,621.03	363,621.03	366,712.47	398,842.85	398,842.85	398,842.85	398,842.85
488,311.17	488,799.25	485,994.12	485,994.12	485,994.12	485,994.12	485,994.12	486,351.81	499,502.39	499,502.39	499,502.39	499,502.39
5,908,175.05	**5,928,254.52**	**5,802,757.02**	**5,802,757.02**	**5,802,757.02**	**5,802,757.02**	**5,802,757.02**	**5,710,840.40**	**6,091,356.85**	**6,091,356.85**	**6,091,356.85**	**6,091,356.85**

Table 11A: Historical elemental cost schedule of a standard design

Elements	2003				2004			
Element Nr.1 Substructure	1,052,252.00	1,134,473.06	1,642,881.44	1,642,881.44	1,750,576.26	1,982,538.90	1,982,538.90	1,982,538.90
Element Nr.2 Frames	1,199,998.52	1,220,314.88	1,788,908.85	1,788,908.85	1,950,728.84	2,190,533.07	2,190,533.07	2,190,533.07
Element Nr.3 Staircase	168,028.31	174,358.31	250,901.12	250,901.12	273,332.75	304,545.44	304,545.44	304,545.44
Element Nr.4 Upper Floors	896,489.58	927,862.90	1,306,965.86	1,306,965.86	1,440,814.22	1,577,657.54	1,577,657.54	1,577,657.54
Element Nr.5 Roofing	896,673.57	900,993.57	1,246,171.28	1,246,171.28	1,279,674.73	1,301,174.56	1,301,174.56	1,301,174.56
Element Nr.6 External Walls	460,204.07	472,348.46	625,725.44	625,725.44	667,246.68	811,516.41	811,516.41	811,516.41
Element Nr.7 Internal Walls & Partitions	131,093.99	134,553.45	178,244.50	178,244.50	190,072.26	231,169.02	231,169.02	231,169.02
Element Nr.8 Fittings And Fixtures	50,977.21	53,775.32	76,344.05	76,344.05	83,037.30	92,033.98	92,033.98	92,033.98
Element Nr.9 Floors Finishes	672,529.86	696,376.26	881,195.86	881,195.86	904,602.03	955,011.36	955,011.36	955,011.36
Element Nr.10 Walls Finishes	430,973.22	468,032.31	545,702.21	545,702.21	594,720.48	644,183.58	644,183.58	644,183.58
Element Nr.11 Ceiling Finishes	512,652.98	518,663.56	850,021.74	850,021.74	869,886.86	875,609.99	875,609.99	875,609.99
Total Cost of the Building	**6,471,873.30**	**6,701,752.07**	**9,393,062.35**	**9,393,062.35**	**10,004,692.40**	**10,965,973.85**	**10,965,973.85**	**10,965,973.85**

2005			**2006**				**2007**				
2,258,432.40	2,156,190.10	2,156,190.10	2,105,068.95	2,182,251.80	2,297,029.38	2,297,029.38	2,373,711.11	2,373,711.11	2,373,711.11	2,532,951.55	2,674,139.30
2,260,689.21	2,237,274.81	2,237,274.81	2,225,567.61	2,373,426.02	2,445,314.51	2,445,314.51	2,462,875.31	2,462,875.31	2,462,875.31	2,603,592.42	2,721,084.71
325,335.93	317,705.94	317,705.94	313,890.95	333,844.05	344,572.47	344,572.47	350,294.96	350,294.96	350,294.96	370,306.46	388,239.66
1,680,867.50	1,643,559.12	1,643,559.12	1,624,904.92	1,745,083.44	1,793,297.58	1,793,297.58	1,821,278.86	1,821,278.86	1,821,278.86	1,910,156.77	1,991,107.63
1,318,402.03	1,313,002.03	1,313,002.03	1,624,904.92	1,745,083.44	1,346,963.89	1,346,963.89	1,351,013.89	1,351,013.89	1,351,013.89	1,910,156.77	1,991,107.63
854,591.43	839,410.95	839,410.95	831,820.71	866,700.08	907,734.81	907,734.81	919,120.17	919,120.17	919,120.17	962,921.84	982,607.98
243,439.39	239,115.07	239,115.07	236,952.91	246,888.67	258,577.84	258,577.84	261,821.08	261,821.08	261,821.08	274,298.45	279,906.26
101,103.09	97,691.16	97,691.16	95,985.19	101,797.96	105,253.17	105,253.17	107,812.12	107,812.12	107,812.12	114,029.99	119,897.44
1,032,033.66	1,002,225.66	1,002,225.66	987,321.66	1,005,244.73	1,027,600.73	1,027,600.73	1,049,956.73	1,049,956.73	1,049,956.73	1,077,745.80	1,116,401.02
720,023.64	689,109.20	689,109.20	673,651.98	721,024.84	744,210.67	744,210.67	767,396.50	767,396.50	767,396.50	799,563.46	841,240.59
884,473.18	880,896.22	880,896.22	879,107.74	898,694.37	901,377.09	901,377.09	904,059.81	904,059.81	904,059.81	908,643.03	916,049.27
11,679,391.48	**11,416,180.27**	**11,416,180.27**	**11,599,177.56**	**12,220,039.41**	**12,171,932.14**	**12,171,932.14**	**12,369,340.55**	**12,369,340.55**	**12,369,340.55**	**13,464,366.54**	**14,021,781.47**

Table 4.11B: Historical elemental cost schedule of a standard design (continued)

4.2.2.3 Mathematical model derivation

The result of the mathematical equation derived in chapter 3 and its short form are as follows:

$$T_p = x_1\left(1 + p\frac{r_1}{4}\right) + x_2\left(1 + p\frac{r_2}{4}\right) + x_3\left(1 + p\frac{r_3}{4}\right) + \cdots + x_n\left(1 + p\frac{r_n}{4}\right) \qquad -eqn.1$$

$$T_p = \sum_{i=1}^{n}\left(1 + p\frac{r_i}{4}\right)x_i \qquad --------eqn.2$$

While the variable x_i can be obtained from a complete set of designs, by estimating the elemental cost of a proposed project using the first principle, the HEC in Table 4.11 was used to derive the proportional values of change r (or yearly incremental rate of change, IRC) for each element. The result is reported in Table 4.12. The rate of change in the elements was also ranked in the table and the element most responding to market forces ranked in incremental order from 1 to 11.

Table 4.12: Yearly incremental rate of change of elements

ELEMENTS ELEMENT	IDENTITY	IRC (YEARLY r)	RANK
1. SUBSTRUCTURE	X_1	0.1540	4
2. FRAMES	X_2	0.1580	3
3. UPPER FLOORS	X_3	0.1180	5
4. ROOF	X_4	0.1100	6
5. STAIRCASE	X_5	0.0236	11
6. EXTERNAL WALLS	X_6	0.3260	1
7. INTERNAL WALLS & PARTITIONS	X_7	0.1720	2
8. WALLS FINISHES	X_8	0.0525	10
9. FLOORS FINISHES	X_9	0.0810	7
10. CEILING FINISHES	X_{10}	0.0670	9
11. FITTINGS & FIXTURES	X_{11}	0.0710	8

However, the data collated and used in this research was on quarterly bases. It is therefore justified to present the model in a form that it can generate and expressed cost growth on quarterly bases. In the real construction practice also, implementers may wish to express quarterly cost implications of tasks in the short term schedules of work. Since the value of r is a yearly rate, and the statistical tool used has considered and smoothen the yearly irregular trends in cost changes (Srivastava *et al.*, 2008), r divided by 4 gives an equal quarterly rate of cost growth. This is also in line with the basic assumption when deriving the model that provided the average cost growth is equal. The value of r is therefore divided by 4 in equation 1 and 2 above. Substituting the values of r from Table 4.12 into equation 1 then becomes:

$$T_p = \left(1 + p\frac{0.154}{4}\right)x_1 + \left(1 + p\frac{0.158}{4}\right)x_2 + \left(1 + p\frac{0.118}{4}\right)x_3 + \left(1 + p\frac{0.110}{4}\right)x_4 + \left(1 + p\frac{0.024}{4}\right)x_5 + \left(1 + p\frac{0.326}{4}\right)x_6 + \left(1 + p\frac{0.172}{4}\right)x_7 + \left(1 + p\frac{0.053}{4}\right)x_8 + \left(1 + p\frac{0.081}{4}\right)x_9 + \left(1 + p\frac{0.067}{4}\right)x_{10} + \left(1 + p\frac{0.071}{4}\right)x_{11} \quad -------eqn3$$

T_p– total cost of the project at a point **P**- the period (or quarter) **1, 2, 3, 4, -----k,** representing **1st, 2nd, 3rd to kth** quarters respectively, and k depending on the contract period. For any new project, x_n represents the estimated cost of element number X_n.

4.2.2.4 Testing the mathematical model

The HTC of the building extracted from Table 4.11 is shown on the first column in Table 4.13. With the first estimate from the table valued 5543490.752, varied values of variable p were inserted into the mathematical model (equation 3), and 39 quarterly costs of the building referred to as computed cost were generated (see Table 4.13). The estimated cost are therefore values obtained from first principle for the standard building design used in this research and the computed cost represent values of the

same design. The computed cost was compared with the estimated cost in two ways. First, to find out if the two samples are different statistically and second, to establish the kind of linear relationship between the two sets of values.

a. Test of variance of estimated and computed cost: Analysis of variance was used in the first test and the result shown in Table 4.14. The hypothesis is as follows:

H_0: there is no significant difference between the estimated cost and the computed cost in Table 4.12

H_1: there is significant difference between the estimated cost and the computed cost in Table 4.12

Where *F* calculated is above Fcritical (F_{crit}), reject H_0 and accept H_1.

Table 4.13: Estimated and computed cost

Year	Estimated cost	Computed cost	Year	Estimated cost	Computed cost
1998	5543490.752	5543490.752	2003	6471873.305	9195802.264
	5777803.975	5726106.328		6701752.075	9378417.840
	5785450.037	5908721.903		9393062.355	9561033.415
	5331888.104	6091337.479		9393062.355	9743648.991
1999	5170569.647	6273953.055	2004	10004692.40	9926264.567
	5671886.964	6456568.630		10965973.85	10108880.14
	5717674.642	6639184.206		10965973.85	10291495.72
	5609369.325	6821799.781		10965973.85	10474111.29
2000	5908175.046	7004415.357	2005	11679391.48	10656726.87
	5928254.521	7187030.933		11416180.27	10839342.44
	5802757.02	7369646.508		11416180.27	11021958.02
	5802757.02	7552262.084		11284574.67	11204573.60
2001	5802757.02	7734877.659	2006	11814493.98	11387189.17
	5802757.02	7917493.235		12171932.14	11569804.75
	5802757.02	8100108.811		12171932.14	11752420.32
	5710840.399	8282724.386		12369340.55	11935035.90
2002	6091356.852	8465339.962	2007	12369340.55	12117651.47
	6091356.852	8647955.537		12369340.55	12300267.05
	6091356.852	8830571.113		12919278.21	12482882.63
	6091356.852	9013186.689		13408343.32	12663689.30

The value of F is less than $F_{crit.}$ in the ANOVA of Table 4.14. Then accept the null hypothesis H_0 and conclude that there is no significant difference between the estimated and the computed cost in Table 4.13.

Table 4.14: Test of variance between estimated and the computed cost

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	40	3.36E+08	8394683	8.71271E+12
Column 2	40	3.64E+08	9104449	4.55729E+12

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.01E+13	1	1.01E+13	1.518518719	0.221545	3.963472
Within Groups	5.18E+14	78	6.63E+12			
Total	5.28E+14	79				

b. **Test of linear correlation**: A linear correlation coefficient was computed in the second test and shown in Table 4.15 which indicates a high positive correlation between the estimated and the computed costs.

Table4.15: Linear correlation coefficient

	Column 1	*Column 2*
Column 1	1	
Column 2	0.929571	1

Since the test used the same values generated from the research, it is important to use different and most recent data or variables to find out if the model still gives reliable results. Table 4.16 contains a set of values for another building. The new building is

similar in description to the one used in this work. The estimated values which are more recent were obtained from first principle, one in 2010 and the other in 2015, column 3 and 4 respectively. Using previous growth factors of r, the cost of each element in 2010 was used as the χ variables and put into the mathematical model and their costs forecasted in 2015. The forecasts were compared with the actual estimates in 2015.

Table 4.16: Elemental cost information of a new building design

ELEMENT	COST GROWTH FACTOR (r)	ESTIMATE (2010)	ESTIMATE (2015)	COMPUTED COST (2015)
SUBSTRUCTURE	0.154	2,988,145.00	4,562,842.00	4,828,842.32
FRAMES	0.158	1,405,480.00	142,990.00	2,293,743.36
UPPER FLOORS	0.118	1,379,360.00	1,837,722.00	2,030,417.92
STAIRCASE	0.0236	308,468.00	1,266,870.00	337,587.38
ROOF	0.11	-	-	-
INTERNAL WALLS AND PARTITIONS	0.172	96,250.00	181,500.00	162,470.00
EXTERNAL WALL	0.326	1,320,000.00	2,310,000.00	3,041,280.00
FITTINGS AND FIXTURES	0.071	-	-	-
WALL FINISHES	0.0525	1,601,577.00	2,746,632.00	1,937,908.17
FLOOR FINISHES	0.081	122,070.00	1,649,200.00	161,620.68
CEILING FINISHES	0.067	453,100.00	708,980.00	574,530.80
TOTAL			**15,406,736.00**	**15,368,400.63**

Similar method of comparison using ANOVA and correlation were done as in the case of the former building design and reported in Table 4.17 and 4.18 respectively. Table 4.17 ANOVA denotes F with a value of 3.67525E-05 which is less than the value of $F_{crit}$of 4.493998. Since the value of F is less than $F_{crit.}$ in the ANOVA of Table 4.17. Then accept the null hypothesis H_0 and conclude that there is no significant difference between the estimated and the computed cost of Table 4.16. There is therefore no significant difference between the estimated cost and the computed cost of all the elements of the new building compared in 2015. Table 4.18 shows a correlation coefficient of 0.75202826 which is a strong correlation case. It means the estimate and the computed values of the elements tested have a strong correlation.

Table 4.17: Variance test for a new building design

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	9	15406736	1711859.556	1.94794E+12
Column 2	9	15368400.63	1707600.07	2.49499E+12

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	81644480.8	1	81644480.8	3.67525E-05	0.995238	4.493998
Within Groups	3.55435E+13	16	2.22147E+12			
Total	3.55435E+13	17				

Table 4.18: Correlation test for the new design

	Column 1	*Column 2*
Column 1	1	
Column 2	0.75202826	1

The validity of the mathematical model is in its ability to generate values when relevant variables are put into it. However the question is how reliable are the values generated. This therefore brings about the need to test its reliability which was done by comparing the values generated from the model with actual estimates obtained from first principle. While the ANOVA test proves that there is no significant difference between actual estimates and the computed values in both cases, the correlation values of 0.929571 and 0.75202826 in the two test cases show strong positive relationship between the actual estimates and the computed values. It means the values generated by the mathematical model resemble the actual estimates, which attest to the reliability of the mathematical model.

4.2.2.5 Limitations of the mathematical model

However the limitations of this mathematical model are as follows:

1. Elements like doors, windows, services and external works were not included in the research for reasons earlier mentioned. This model cannot therefore be applied on them.
2. The values generated from the mathematical model take care of direct cost growth induced by the market environment. Internally cost induced factors like force measure and actions or inaction of stakeholders that link to process flaws will have to be assessed separately.
3. The elemental format or bill preparation is the basis of applying this mathematical model. Other bill formats like the work sections, trades, etc. cannot be applied in this mathematical model.
4. It is also recommended that within ten years, a growth rates (values of r) should be computed and compared to affirm its prevalence.

4.2.2.6Testing the seasonal effect on the HTC of the building

The study also sought to know about how cost is affected due to changes in seasons. The HTC of the standard design was subjected to descriptive statistical analysis to know which period of the year construction cost is often higher. The HTC arranged according to the four periods of the year is shown in Table 4.19 and its descriptive statistics presented in Table 4.20.

Table 4.19: Quarterly cost of the standard design

Years	1st quarter	2nd quarter	3rd quarter	4th quarter
1998	5543490.752	5777803.975	5785450.037	5331888.104
1999	5170569.647	5671886.964	5717674.642	5609369.325
2000	5908175.046	5928254.521	5802757.02	5802757.02
2001	5802757.02	5802757.02	5802757.02	5710840.399
2002	6091356.852	6091356.852	6091356.852	6091356.852
2003	6471873.305	6701752.075	9393062.355	9393062.355
2004	10004692.4	10965973.85	10965973.85	10965973.85
2005	11679391.48	11416180.27	11416180.27	11284574.67
2006	11814493.98	12171932.14	12171932.14	12369340.55
2007	12369340.55	12369340.55	12919278.21	13408343.32

Table 420: Descriptive statistics of historical total cost

	1st Quarter	*2nd quarter*	*3rd quarter*	*4th quarter*
Mean	8085614.1	8289723.822	8606642	8596751
Standard Error	944849.951	948277.2806	964618.5	1015717
Median	6281615.08	6396554.464	7742210	7742210
Mode	#N/A	#N/A	5802757	#N/A
Standard Deviation	2987877.89	2998716.06	3050391	3211978
Sample Variance	8.9274E+12	8.9923E+12	9.3E+12	1.03E+13
Kurtosis	-1.8838374	-2.080566194	-2.07606	-1.9081
Skewness	0.56434997	0.510780646	0.267955	0.315503
Range	7198770.9	6697453.586	7201604	8076455
Minimum	5170569.65	5671886.964	5717675	5331888
Maximum	12369340.6	12369340.55	12919278	13408343
Sum	80856141	82897238.22	86066422	85967506
Count	10	10	10	10
Largest(1)	12369340.6	12369340.55	12919278	13408343
Smallest(1)	5170569.65	5671886.964	5717675	5331888
Confidence Level (95.0%)	2137399.08	2145152.238	2182119	2297711

4.3 Discussions on the Results

4.3.1 Results of classified factors

Table 4.1 depicts high quality respondents that responded to the questionnaireregarding the frequency and degree of impact of the challenges that impede cost management. Respondents having HND, BSc, Masters or PhD. degrees were qualified as architects, quantity surveyors, engineers and builders and are working in client, contracting or consulting firms. About 67% of the respondents have at least 11 years of work experience, 60% have handled at least 21 projects and the projects spread all over the regions of the country.

The classified factors in Table 4.2 were separated into Tables 4.3, 4.4 and 4.5 based on their degree of impact on cost objectives. The rating in Table 4.3 indicates that the items exert high negative impact on projects once they occur or the high impact can be due to high frequency of occurrence. For example, respondents' experiences in item 27, indicated low frequency of occurrence in the item- poor client's credit worthiness (0.35). Yet, where poor client's credit worthiness was encountered, it exerted high impact on cost (0.87). Item 30 indicates that clients moderately delay interim payments (0.45) but have caused high impact (0.67),while item 17 indicates both low frequency (0.19) of occurrence of socio cultural effect on projects and low negative impact (0.34)on cost. Furthermore, despite high frequency of occurrence of item 57 (0.58), i.e. poor transportation arrangement to and from site, it exerted low impact on projects (0.36).

Tables 4.4 and 4.5 similarly exert moderate and low impacts respectively. The factors in Table 4.3 therefore deserve serious attention by managers during project

implementation. This is because the items are more of high impact once they occur on projects as compared to those in Tables 4.4 and 4.5. Items in Table 4.4 similarly impact and affect projects more than those in Table 4.5. However, both tables,4.3, 4.4, 4.5, should be issues of concern when implementing projects because persistency in occurrence of factors evenin Tables 4.4 and 4.5 can lead to high negative impact on cost. The tables are therefore to serve on matters of priority.

In section 4.2.1.2, twelve modules were organised to present best practices that a building project supply chain should diligently follow to achieve a proactive cost management. Most of the modules can be applied in all project phases, yet some are more suitable at a particular stage.

Figure 4.1 is a model for knowledge management. It helps managers in the learningand capturingof lessons for feed back into the ongoing process for a continuous process improvement activity. These classified impediments that were found to occur in construction projects production process are organised into a scorecard. Each member in the supply chain ofa project cycle is expected to subjectively score the items in the card using a scale of 1 to 10 and based on his experiences acquired within or outside the system; hisknowledge of the ongoing system starting from the inception of the project to the end. The scores are then used to compute a culpability factor (CF) for each item, for each stakeholder and for the entire supply chain. The CF is the mean rating of the assessment at a time. Higher values of CF indicate better commitment to the success of the project. It also indicates that the assessor is optimistic that adequate measures are in place against negative impacts of the factors on the procurement process; or rather, the factors will not impact significantly, vice versa.

Factors rated low and identified then become the subject for discussions at site meetings for possible contingency measures. The score card therefore enables constant tracking down of the process flaws likely to weigh down the smooth product assembly by their impact. Values from periodic assessment for each section can be plotted in a line graph to compare how each section fares and to depict the trend of successful implementation.

This is a knowledge management mechanism to deliberately capture and store relevant lessons in the project. It prompts stakeholders to consciously observe and track down lessons in an ongoing project. Records of values computed enable a proactive view of the production trend vis-à-vis impediments impacting on the production process from time to time. Information can then be used to feed back into the management modules for a continuous process improvement.

4.3.2 Results of Graphical Analysis

In Figures 4.3and 4.4, the values on the line graph that fall below unity are those that the highest cost fluctuation (or cost growth) was lower than the base value (FDP). Values above 1 indicate that the extent of cost growth was above the base value, likewise if the value lies on 1, it means that there was no change in cost at all. Similarly in Figure 4.4, the lowest market price fluctuation for each item was valued as either above, below or the same as the FDP.Figure 4.3 and 4.4 therefore depict how items in the first and second group attained their yearly highest price fluctuations due to market forces respectively.

The pattern in Figure 4.3 show that prices of all items in the fast cost grown graph were relatively stable between 1998 and 2002 and then began to rise progressively; except cement which had a drop in prices at the beginning and also maintained a relative stable

condition up to 2003 before it began to rise, but still its growth ratio remained below other items. In the slow cost grown graph (Figure 4.4) three items (bricks, granite and hardwood) resisted the pattern of cost changes shared by other items in the group between 1998 and 2002. Hardwood first had a dropin prices before it began to increase. There is therefore no consistent pattern of growth hardwood within the period of the study. However, towards the end of the period hardwood depicted similar growth pattern to the other members of the group. It means all items in the group responded in a similar manner towards the end if the period. Emulsion paint, gloss paint, aluminium, and bitumen indicated the lowest cost growth ratio in the period of the entire study in the second group.

In a general note, it can be concluded that the pattern of responsesto market forces for all items in Figure 4.3 are similar except cement that maintained a longer resistance to price fluctuation and the prices were more stable compared to other members of the group. Figure 4.4 also exhibited a distinctive patternaffecting all members of the groupexcept that the degree of change in some materials was low. There were deflections at each point in all the lines in Figure 4.3. It shows that the group was more sensitive and responds to market forces more readily than the items in Figure 4.4 where some points between 2003 and 2007 lie on a straight line. The same pattern was also depicted in Figures 4.5 and 4.6 to reaffirm the conclusions.

Figure 4.5 and Figure 4.6, show similar pictures to Figures 4.3 and 4.4 using the lowest market price fluctuations in the items for each group. Similar conclusions can also be made as discussed for Figures 4.3 and 4.4. In Figure 4.5, the line graph representing cement is also at a lower level compared to other lines. This interprets that the difference between its lowest market value compared to its base price was relatively smaller than similar prices of all other members in the group. It further confirms its

relative market price stability. Items in each group (FCG and SCG) maintained distinctive cost change pattern (or fluctuations) under market conditions and the pattern generallised to members of each group. Construction managers should therefore note that price change in one item is a reflection that similar changes may occur among other members in the group. If it is established that there is significant change in the market price of one item at any period in the developmental life of a project, it should be an indication that other members in the group might likely change in the same pattern. However, cement should less likely be a priority when making contingency measures against the negative effect of cost changes caused by market

In Figures 4.7 and 4.8, the prices of each item at the beginning of each year were kept constant and observations made on how the highest values attained within the year. This was aimed at comparing on yearly bases the forces acting on building materials. The question is whether prices are steady within the year or some seasons do experience higher cost fluctuations when compared to other seasons. Values within each year were therefore compared with the value at the beginning of the year. The ratio of most items in Figures 4.7 and 4.8 are above 1 and the graph never showed any regular pattern. This indicates that most items are likely not to fall below the prices at the beginning of the year and there is no fixed extent of change expected in cost of items within a year. Therefore,the magnitude of change differs and depends on the item. However, in Figure 4.7, the values of both skilled and unskilled labourfallinto straight lines. It means there was no change in cost within the year, interpreted as the cost of skilled and unskilled labour obtained at the beginning of the year is most likely to remain the same throughout the seasons till the end of the year. Since most items indicated positive change in their prices, managers should expect an increase in prices in one of the seasons within the year.

Table 4.17 identified the third quarter of the year as the season whereby cost is most likely to grow i.e. the months of July, August and September. The table shows that the mean cost of the project was higher during the third quarter with value of N8606642.The first two Skewness cases also leaned to the right and the second two leaned to the left to show that the cost concentration pulls towards the center and more to the third quarter which is the rainy season in Nigeria. Note also that there is a major change in cost behavior between the second and the third quarter, the difference between the mean 8289723.822 and 8606642 exceeding that of any pair within the year.

Generally, the mean increased from the first to the last quarter, except the interruption which might likely be due to inclement weather conditions during the third quarter. Despite the interruptions, the maximum cost of the project of N13408343 was found at the last quarter which indicates the effect of time. This confirms a direct cost time relationship-the cost increasing with time. In planning it is important to note that this period deserves special attention during the assembling sequence and in inventory management. The results also reveal that seasons of the year also affect the cost of construction projects with the rainy season (July-September) most likely to be more severe.

4.3.3 Results of statistical analysis

The conclusion in Tables 4.10 (a-c) answers one major research question that market forces in the Nigerian construction environment do cause significant cost changes in the prices of building materials and labour over short, medium and long periods. The results are the analyses of Table 4.9 (HCUR) which was also derived from the report of the market survey. Values in Tables 4.13 are also increasing with time similar to Table

4.9 to suggest a reflection of the nature of changes in Table 4.9 since the table was also used to generate the values in Table 4.13. These pieces of information therefore, buttress further the need for the development of a proactive cost management model.

Table 4.12 shows the ranking of the yearly incremental rate of change of elementsin a building; the incremental rate here was also referred to as cost growth factors. These are the factors in which the cost of a building element increase in a year due to market pressures relative to the initial cost. External Walls, Internal Walls & Partitions, Frame and Substructure indicate higher rates of cost growth of 0.32, 0.1720, 0.1580 and 0.1540 respectively.

The mathematical model in equation 2 in chapter 4.0 is a forecasting model if the variables **x, p** and **r** are substituted. Variable **x** can always be generated via a set of designs and specifications of a proposed project. The values of r have been established through mass data analyses. By inserting p (which) is the forecasting period the total cost of the proposed facility can easily be obtained.

Being a forecasting mathematical model, it is important to test the reliability of values that the model can generate over a periods. The HTC in Table 4.13 column 1(called estimated cost) gives the actual cost history of a building over ten years. The HTC was obtained through actual costing of the BOQ using the HCUR. The second column is the projections of the total cost of the same building at intervals using the mathematical model corresponding to the periods estimates were obtained. The cost of each element x_1 x_2 x_3 ---- x_n obtainedfromthe first estimate i.e. the BOQ was inserted in the mathematical model. With r (rate of cost growth) the period p was varied severally. The total cost of the project corresponding to the estimates obtained at varying p values is shown in column 2. The samples in the two columns were compared. The first

comparison was meant to finding out if the two samples (estimated cost and the computed cost) are statistically different or the same, while the second test which computed the linear correlation coefficient is to establish the kind of relationship between the two samples.

Table 4.14 (ANOVA) enabled this research to conclude that the two columns are the same while Table 4.15 indicates a strong positive correlation between the estimated and the computed costs. It means when the estimated cost increases, the computed cost also increases. The computed cost is therefore a true representative of the estimated cost. This is also accepted that r is the true reflection of the incremental cost changes affecting various elements in a building. The two tests therefore signify that the mathematical model is reliable and can be used to project the true incremental values of an estimated cost of a project.

Equation 1 represents a mathematical model that benefits the client and the contractor alike. With this mathematical model, an estimated cost can be modeled at different time interval. It means at any future time the cost of the project can be obtained unlike regression which is a point estimate. The interval can serve as milestones for cost checks and comparisons. Apart from being easy to understand and compute, there is no need for mass data to forecast as in time series. Unlike other models, the cost of delay in completing a task can be assessed and the cost of individual elements in a building can be modeled separately. This can take care of cost implication in the choice of which element comes first and which one comes last in the assembly sequence.

The model can therefore be used to generate vital cost information to feed back the proactive project planning, monitoring and control in the following ways:

1. Contingency sums have often been added in projects based on percentages without clear analytical bases. This model solves the problem and is a base to compute a more reliable contingency over the contract period. By substituting the variables in the equation, a more reliable contingency sum can be generated based on empirical data analysis specific to the Nigerian construction market cost dynamics.
2. The model can enable cost advice to be given in range of values. After the contract is signed, the client and contractor can use the elemental cost information in the bill to generate the pattern of cost growth at intervals to serve as warning signs to cost managers for possible contingency measures.
3. The cost consultant can use the mathematical model to compute likely cost changes after an estimate has been computed elementally. This can be used as vital information to advice the client on the cash flow demand based on the pattern of cost growth on estimates over the construction period. Therefore, given a new project with elemental estimate at current prices, the cost at the end of the contract period or any other period so desired can be generated by inserting only the corresponding values of each element and the period desired.
4. During assembly, the likely cost growth in individual elements can be projected based on the spot it is expected to be executed on the program of work. Each element can be treated separately and the cost effect compared which will help in prioritising the assembly process.
5. Where there is time overruns, the cost effect can easily be computed.
6. In a fixed price contract where the client shifts most of the risks to the contractor by expunging fluctuation clauses from contract conditions, the mark up can be more reliably established using the model.

However, this mathematical model represents the most unpredictable situation like the market conditions which cause inflations. It does not take care of changes due to a more situations like architect instructions and variations which can easily be controlled. These aspects can easily be take care by a percentage added to the more unpredictable market condition that has been modeled.

4.3.4 The framework for proactive cost management

The framework presents the flow relationships of events in the entire production process. The framework is shown in Figure 4.9 in form of a flow chart, which divides the whole procurement process into three stages, namely- inception, planning and the production stages. Each stage has some modules containing sets of activities necessary to achieve proactive cost management. At the end of each stage, lessons are learnt and fed back into the next stage for a continuous process improvement. The framework essentially depicts the points where lessons are learnt and what to do, if satisfied with the lessons or not. The details for best practices in each activity within various stages in the flow chart are found in Module 4.1. The first stage (inception) involves the setting of supply chain to design the process under partnering and alliance principles. The second involves planning and designs of the project and then construction. Then, query to ascertain if satisfied with supply chain. Correct whatever doubt and then monitor the process by assessing the level of confidence in the team by computing the CF value. Discuss challenges inherent and find solutions at site meetings, and the lessons learnt are fed back into the next stage.

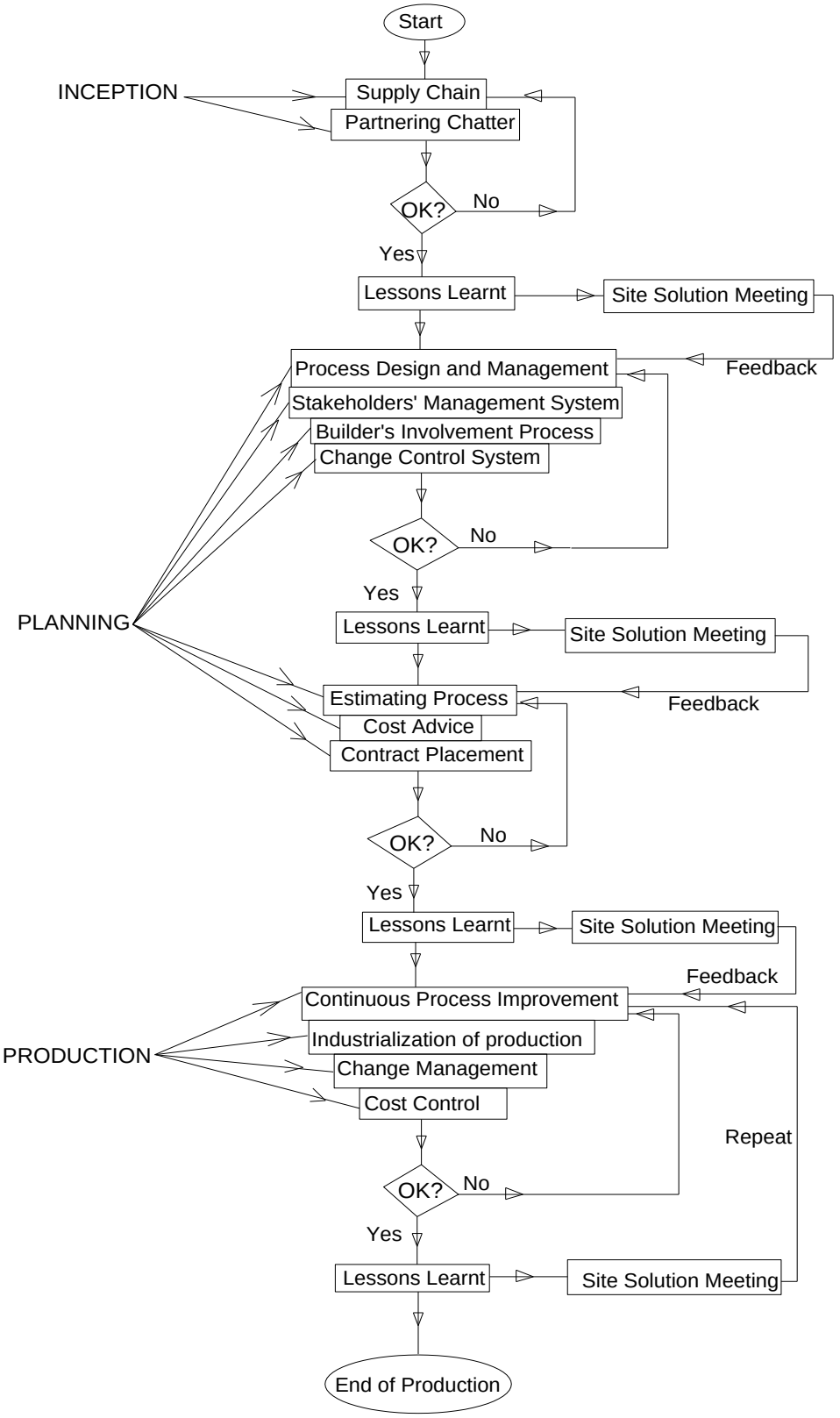


Figure 4.9: Proactive cost management framework

4.3.5The proactive cost management model

Four sub management systems were developed in this work in the quest to achieve the development of a proactive cost management model. The sub-systems namely-

1. Graphical trends models
2. Lessons learnt mechanism
3. Process best practice modules and
4. Mathematical model

These sub-systems are developed for the management of inventory, knowledge, process flow and inflationarytend respectively. These subsystems are incorporated into the Proactive Cost management Model (PCMM). The subsystems complement each other in the entire management process. For a better understanding of the PCMM, the key variables derived from the research and keyed into its development are captured in Table 4.18. The table shows the variables affecting the stages of procurement process called the proactive cost management variables (PCMV). Figure 4.10 then shows a PCMM developed.

The PCMM consists of four columns. Stages in the first column depict the flow process of a building project from start to finish. The second column which shows the major activities identifies major actions that are required to be taken by stakeholders in a proactive manner, the details of which are in the modules. The modules identify the stakeholder responsible in a set of activities. The details of the activities presented in a step by step manner also identify the stage most applicable in a procurement process. Tolls developed to aid the management process are shown in the last column of the model structure.

Table 4.21: The proactive cost management variables(PCMV)

Procurement Stages	**Major Activities**	**Relevant Module**	**Relevant Tools (Model)**
Inception	Supply chain setting Partnering Chatter Adequate Brief Cost Advise Lessons Learnt	Module 1, 8, 9, & 10	Process Best Practice Lessons Learnt Mechanism
Planning 1	Process Design & Management Cost Advise Stakeholders Management System Change Control System Builder Involvement Process Lessons Learnt	Modules 1, 2, 3, 4 & 10	Process Best Practice Lessons Learnt Mechanism
Planning 2	Process Management Change Management Cost Estimation Contract Placement Lessons Learnt	Modules 2, 4, 10, 11. 12 &13	Mathematical Model Process Best Practice Lessons Learnt Mechanism
Production (implementation)	Work Breakdown Continuous Process Improvement Idustrialisation Application of modern technology Cost advise Change Management Stakeholders Management Cost Monitoring and Control Strong Information and Communication Process Lessons Learnt	Modules 2, 3, Modules 6-13	Mathematical Model Process Best Practice Lessons Learnt Mechanism Graphical models

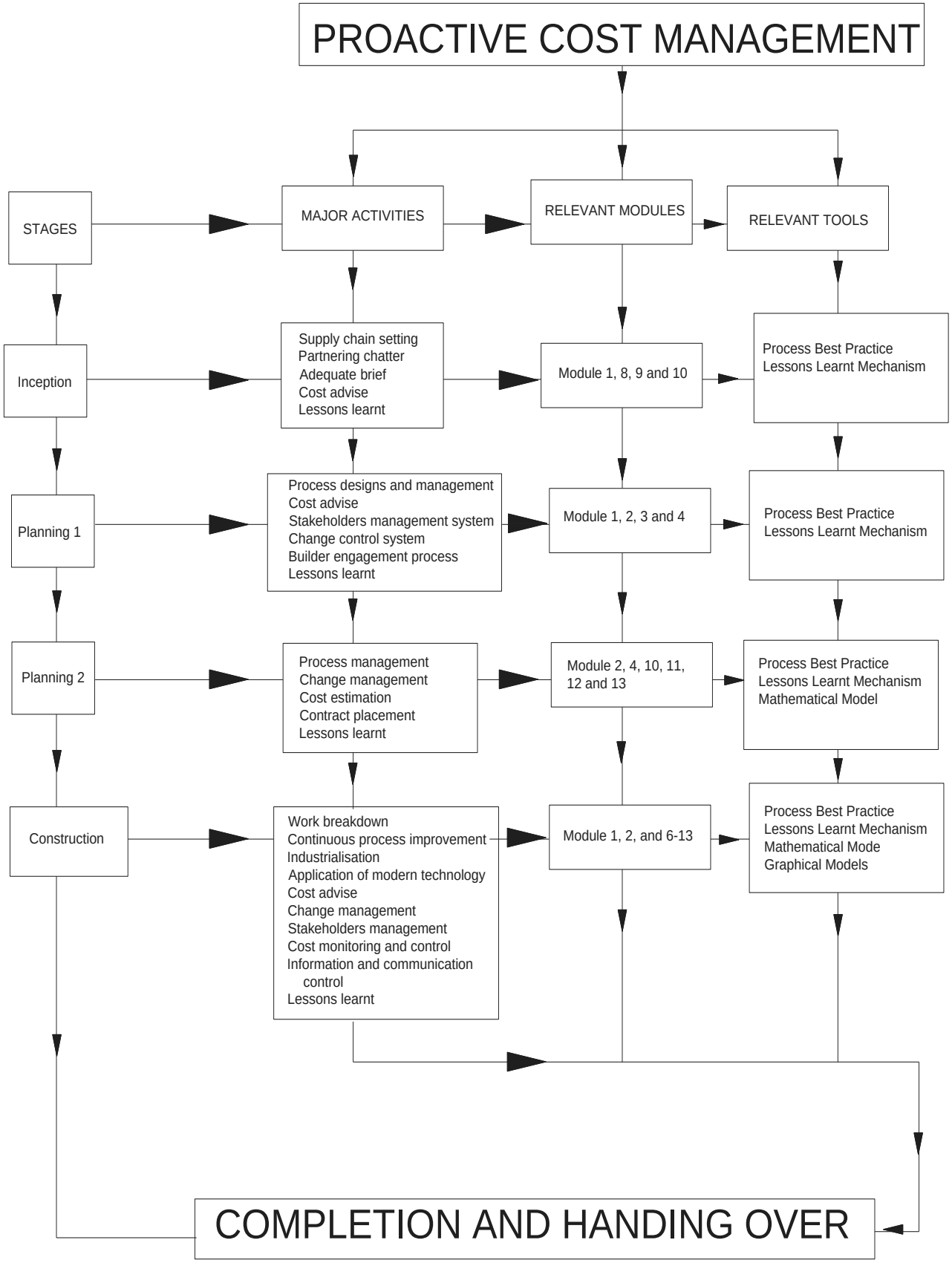


Figure 4.10: The Proactive Cost Management Model (PAMM)

Three main stages of the implementation process were identified as inception, planning and construction in the PCMM.For each stage, the set of main activities that are expected to be carried out were listed. Four subsystems namely: The modules, the forecasting model, the graphs and Lessons Learnt Mechanism are all referred to as tools in the PCMM which are shown in the far right part of the model. Combination of these activities in an organised manner as depicted in Figure 4.10 will give the desired proactive cost management of building projects and finally facilitate the achievement ofthe requisite cost efficacy. Large financial savings will result in the construction sector which is often loaded with a large part of the financial budget in the economy of every nation.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This research was set to develop a proactive cost management model that will meet the desire of building construction projects procurement in Nigeria. Emanating from the incessant cost and time overruns in construction projects procurement, calls were made to reconsider the conventional management model which often fail in responding optimally to management flaws. Chapter one set out the background of the entire work by introducing the research philosophy and stating more succinctlythe missing link in the body of knowledge that desires research attention. Precisely, the traditional management concept common in construction procurement responds poorly to the kinds of challenges plaguing it. Responses to flaws are often late sand suboptimal which leads to cost and time overruns, also known as cost growth. Proactive management approach was identified as panacea to the persistent cost and time overruns in the procurement of building projects. Despite incessant calls for the development of proactive management models to either replace or complement the traditional model, the subject has not however, received adequate attention required from researchers.This gave rise to the main issue in this research which is the lack of proactive tendency in the widely favoured traditional way of managing building construction projects. This work therefore developed a proactive cost management model that will respond optimally to building cost challenges of building construction projects. Chapter two then explored literature and articulated the challenges more explicitly as well as appraised the extent of efforts in mitigating those challenges. This brought about clear understanding of the entire subject and how the model can best be developed to meet the need.

Various factors impeding the achievement of successful building cost and time objectives and an array of proffered solutions were identified in this work. This form the basis of developing various components of the proactive cost management model (PCMM) envisaged. The third chapter described vividly how the objectives of this work were achieved. The fourth chapter analysed mass historical cost data (HCD) and made several discoveries.

5.1 Summary of findings

The entire exploration came up with the following major findings:

1. The achievement of cost and time objectives in the procurement of building construction projects in Nigeria like many parts of the world are yet to be satisfactory. Cost of buildings in Nigeria still exhibits significant upward change within short periods.
2. Materials and labour in construction markets do change in prices due to market forces. Changes are often positive and the items can be classified into two main groups according to the degree of sensitivity to the forces of change.
3. Each of the two groups of material and labour classified often respond to market forces in a unique pattern, and all items within a group share similar pattern. Knowledge of any change in an item suggests similar change affecting each item in the entire group.
4. The changes in individual prices of materials and labour are most likely to reflect in the total cost of procuring a building facility.
5. Cement, aluminium, bricks, emulsion and gloss paints often resist changes in prices and are more stable compared to other building materials.

6. The third quarter of the year (July, August and September) do experience higher cost growth than others in Nigeria, suggesting bigger challenges to the assembly process within this period of the year.
7. The cost of various elements in a building grows at different rates. Three elements ranked highest in the cost growth ratio were- External Walls, Internal Walls & Partitions and Frames,having 0.32, 0.1720 and 0.1580 valuesrespectively. Staircase was ranked the lowest having 0.0236 factor of growth.
8. The unique construction projects characteristics deserve a proactive cost management system to respond timely and optimally to flaws. Yet, management is still largely reactive, as such, often fails to offer the required success level in cost and time management.

5.2 Conclusions

Conclusions arising from these research findings are as follows:

1. There exist array of factors that obstruct successful procurement of building construction projects. Several of these obstructions have been well researched upon and solutions proffered to improve projects procurement.
2. One aspect of the recommendations that has received less than deserved attention is the proactive way of managing cost, believed will offer the deserved scientific cost management of building construction projects.
3. Findings in this research therefore, formed the background of developing a proactive cost management model (PCMM), such that, if applied will improve the success level of attaining cost objectives in building procurement. Lessons

can now be consciously and progressively learned on impediments against smooth process flow when implementing building projects. Impediments can now easily be captured, documented, processed, communicated and reused in an ongoing process and in future jobs.

4. Prices of building materials and labour inputs, vis-à-vis total cost of building projects exhibit significant growth within a short period in Nigeria making proactive cost management imperative.
5. Graphical models depicting trends in material and labour price escalations as presented in this work offers clear understanding of the manner each item responds to market pressure. Materials that deserve attention in inventory management were identified and can easily be proactively managed. Furthermore, the mathematical model derived offers a predictive ability on how cost will change before and during contract implementation. The uniqueness of the mathematical model is in its ability to easily predict cost changes in each element of a building at different time intervals.
6. Deriving from the set of objectives achieved, the PCMM was then developed. The overall declared management process operates under a recommended process framework that guides the entire implementation of the proactive model.
7. The PCMM therefore, if properly applied, will overcome the varying impediments that often prevent successful cost objective during procurement of building projects. The model complements the traditional method of project management by offering a proactive tendency that is most desired for the building construction management practice.

5.3 Recommendations

The cost of building construction projects should be managed in a proactive wayso as to achieve cost efficacy, a model of which now exists to aid management. The following are prerequisite to successful proactive cost management:

1. Construction managers should be cautious in inventory keeping and consumption, and should be weary of materials more sensitive to market pressure as identified in this work. Items that indicated higher sensitivity to market pressure should be given priority in inventory keeping and consumption. Cement, aluminium, bitumen and emulsion paints were found to deserve less priority for being more stable in price changes compared to other materials.
2. During the assembly process of a building project, elements with higher cost growth factors should be targeted for early completion since delay can result to greater impact of market forces on the cost of that element which will later translate into cost overrun of the entire project.
3. The mathematical model developed herein should be used to enhance pretender estimates by generating a more reliable contingency sums. This is possible because the model predicts cost changes based on the analysis of market trends in Nigeria. Inflation is more difficult to predict but has been modeled in this work using mass historical cost data over a long period which offer reliable empirical basis for forecasting. Furthermore, the mathematical modelshould be used to project the cost ofa project at different milestones in the assembly process. The values generated should form bases to advise clients on how to provide contingenciesfor cost management. The valuesshould also form the

bases for monitoring and control of expenditure during contract implementation.

4. Continuous process improvement duringbuildingprocurement should involve constant monitoring and control of different sub-processes using the PCMM. The proactive cost management model offers a strong information/communication derive for managers, who should not only look within, but outside their organisations foropportunities that can improve performance. The scorecard recommended for knowledge management in this work should be usedconsciously and systematically in capturing, storing and processing of lessons learnt forfeedback into the ongoing process.
5. Each stakeholder should be involved when implementing the PCMM in a project. The lessons from all stakeholders should be kept in a central pool and made accessible to every participant when needed for the benefit of the ongoing process, and should also be readily available for future jobs even after the disbandment of the supply chain.
6. Waste contributes significantly to failed cost objectives and must be a subject of consideration by all stakeholders. A special team vested with the responsibility for waste, change, stakeholders and knowledge management should be a key demand by clients. Setting up the team early in the life of a project will benefit the entire constructor team members.
7. The constructor should identify at an early stage the sections of the work to be industrialised and set up a harmonious programme to achieve it in line with other sections of the work. This should be part of client'scriteria in the selection of competent contractor especially where time in a project is of essence.

5.4 Areas for Further Research

This work has essentially set up a new philosophy of proactive cost management for building projects. However, further research effortsare needed to cover the limitations mentionedat the beginning of this thesis and to add other necessary aspects that were outside its scope.

1. The limitations in the data sources made this work to leave out the doors, windows, services and external works elements. A scientific way to assess these elements should be designed so as to give a complete package of the proactive model.

2. Another period should be chosen to compute the cost growth factors in Nigeria so as to compare the level of consistency with the results obtained in this work. This will help in establishing a more permanent growth trend in construction projects in Nigeria.

3. The use of computers which offer effective and efficient work output has become a norm in management. It is recommended that a computer programme be developed to aid better application of the model and to make the implementation of the philosophy herein easier.

4. Since the third quarter of the year was identified as the period construction contract implementation is more challenging, an in-depth study to identify and quantify those challenges is necessary to offer better understanding of the scenario to stakeholders for better planning process.

REFERENCES

Abanda, F. H., Tah, J. H. M., Pettang, C. & Manjia, M. B. (2011).An ontology-driven building construction labor cost estimation in Cameroon.*Journal of Information Technology in Construction (ITCON)*, 16, 617-634.Retrieved from http://www.itcon.org/2011/35, on 22 April, 2013.

Abbasnejad, B.& Nejati, M. (2013). Strategic risk management in projects: An applied Modelto Control Risk of projects (Eds. Hajdu, M. & Skibniewski, M. J.). *Proceedings of the Creative Construction Conference, Budapest, Hungary*. Diamond Congress Ltd. July 6-9. Retrieved from www.diamond-congress.hu, on 17 September, 2014.

Abdelhamid, T., & Salem, S. (2005). Lean Construction: A new paradigm for managing construction projects. *International workshop on Innovations in Materials and Design of Civil Infrastructure*, held in Cairo, Egypt, December.

Abdullah, M. R., Rahman, I. A. & Azis, A. A. A. (2009).*Causes of delay in MARA management procurement construction projects*.Faculty of Civil and Environmental Engineering Universiti Tun Hussein Onn Malaysia.

Adesiyan, A. (2014). Efficient project management of infrastructure in emerging economies. Seminar presented at a 2 –Day International Workshop - *Towards Sustained Growth of Emerging Economies in Africa- The Infrastructural Imperatives*, held at Leisure Spring Hotel, Ring Road, Osogbo, Osun State, Nigeria, 14th-15th, March.

Afolarin, A. O. (2013). Factors affecting quality in the delivery of public housing projects in Lagos state, Nigeria, 3 (3). *International Journal of Engineering and Technology*, March.

Ahmad, H. S., An, M. & Gaterell, M. (2007). Development of KM model to simplify Knowledge management implementation in construction projects.In*:* Boyd, D. (Ed), *Procs 23rd Annual ARCOM Conference*, 3-5 September 2007, Belfast, UK, Association of Researchers in ConstructionManagement, 515-524.

Ahmad, N., Osman-Schlegel, N.Y. & Elkadi, H. (2012).A Review of the cost estimation issues in the tender preparation process in construction industry. *ThirdInternational Conference on Construction in Developing Countries (**ICCIDC–III**)..Advancing Civil, Architectural and Construction Engineering & Management*, July 4-6, Bangkok, Thailand.

Ahmed, S. M., Azhar, S., Castillo, M. & Kappagantula, P. (2002).*Construction delays in Florida: AN empirical study*. Final report submitted to the planning consultant, state of Florida, Department of Community Affairs, USA. Retrieved from url:www.fiu.edu/~ahmeds, on 10 May 2009.

Aina, O.O. & Wahab, A.B. (2011).An assessment of buildability problems in the Nigerian construction industry.*Global Journal of Research Engineering.* March, Global Journals Inc., 11, 42-52.

Alarcon, L. F., & Ashley, D. B. (1992). Project performance modeling: A methodology for evaluating project execution strategies. Construction Industry Institute, Austin, Tx.

Alhager, J. (2002). Supply Chain Management: A Just-In-Time perspective. *Journal of Production Planning & Control.*Taylor& Francis Ltd. Retrieved from http://www.tandf.co.uk/journals, on 20 August, 2012.

Anderson, S., Molenaar, K. & Schexnayder, C. (2007). Guidance for cost estimation and management for highway projects during planning, programming, and preconstruction. NCHRP Report 574,Sponsored by the *National Cooperative Highway Research Program, Transportation Research Board Business Office*, Washington, DC.

Anigbogu, A.I., Achuenu, E., Anigbogu, N. A. & Kuroshi, P. A. (2007). Assessment of consultant's pre-tender cost and duration estimates of building projects in Nigeria. *Construction Focus. Journal of Construction Management and Engineering*,1 (1) 23-36.

Arain, F.M. & Low, S.P. (2005). The potential effects of variation orders on Institutional building projects. *Facilities*, 23 (11), 496–510.

Arditi, D., Akan, G.T., & Gurdamar, S. (1985). Reasons for delays in public projects in Turkey. *Journal of Construction Management and Economics.* 3, 171-181.

Aretoulis, N. G., Angelides, D. C., Kalfakakou, P. G., Fotiadis, S. G. & Anastasiadis, I. K. (2006).A Prototype System for the Prediction of Final Cost in Construction Projects.*Operational Research*.an international journal, 6 (3), 323-332.

Arrow, J. (2008). Knowledge-based proactive project risk management.*AACE International Transactions.*

Ashuri, B. & Lu, J. (2010). Is it Possible to Forecast the Construction Cost Index in the USA? Findings in built and rural environment, a *FibreSeries Publication*, RICS funded research work, Georgia Institute of Technology, USA, April.

Ashworth, A. (2010). *Cost Studies of Buildings*. New York: Addison Wesley Longman Limited, 244-245.

Assaf, S. A. &Al-Hejji, S. (2006). Causes of delay in large construction projects. *International Journal of Project Management.* 24 (2006), 349–357. Retrieved from www.sciencedirect.com, on 2 August 2010.

Azi, T. A. (2008). An evaluation of performance measurement criteria in construction projects in Nigeria (A case of Abuja and Plateau State). PhD. Seminar Proposal, Department of Building, ABU Zaria.

Baccarini, D. (2006). The maturing concept of estimating project cost contingency: A review. Retrieved from http://Citeseerx.Ist.Psu.Edu/Viewdoc/Download?Doi on 8April 2013.

Bal, M., Bryde D., Fearon, D. & Ochieng, E. (2013). Stakeholder engagement: Achieving sustainability in the construction sector. *Sustainability.* doi:10.3390/su5020695.

Bala, K. (2000). The Professionals' perception of successful project management parameters. Unpublished PhD. Thesis submitted to Department of Building, A.B.U Zaria.

Barriga, E. M., Jeong, J. G., Hastak, M. & Syal, M. (2005). Material control system for the manufactured housing industry. *Journal of Management and Engineering.* April.

Bayraktar, M., Hastak, M., Gokhale, S., & Safi, B. (2011). Decision tool for selecting the optimal techniques for cost and schedule reduction in capital projects. *Journal of Construction Engineering and Management*, 137(9), 645–655. doi: 10.1061/(ASCE).

Begum, R. A., Satari, S. K. & Pereira, J. J. (2010).Waste generation and recycling: comparison ofconventional and industrialized building systems. *American Journal of Environmental Sciences.*

Bertelsen, S. (2004). Lean Construction: Where are we and how to proceed? *Lean Construction Journal*.Retrieved from www.leanconstructionjournal.org.

Bhatt, G. (2001). Knowledge management in organizations: examining the interaction between technologies, techniques, and people. *Journal of Knowledge Management*, 5 (1), 68-75.

Billows, D. (2011). Post Project Review. Lessons never learned. Project management training and certification.*The Hampton Group*, South Ivanhoe St. Denver Colorado.Available at, www.4PM.com, on 17 July, 2012.

Bourne, L. (2010). Why is stakeholder management so difficult.*Stakeholder Management Pty Ltd*. Retrieved http://www.mosaicprojects.com.au/PDF_Papers/P123_Why_is_Stakeholder_Management_so_difficult.pdf on 28 August 2014..

Brook, M. (1998). *Estimating and tendering for construction works*. Butter Worth-Heinemann Publishers, Great Britain.

Brown, A., Rezgui, Y., Cooper, G., Yip, J. & Brandon, P. (1996). Promoting computer integrated construction through the use ofdistribution technology. *ITcon,* 1, University of Salford.

Bustani, S. A., Izam, Y. D. & Achuenu, E. (2000). Investigating the activities of indigenous contractors in the Nigerian construction industry. *Nigerian Journal of Construction Technology and Management,* 3 (1), 91-103.

Carbasho, T. (2009). Building information modeling drives lean construction management.3-D model facilitates installation of pre-fabricated mechanical systems.*Tradeline IncJournal*, USA. Retrieved from http://www.tradelineinc.com/reports/, on 18 October, 2011.

Chan, A. P. C. (n.d). *Framework for measuring success of construction projects. School of Construction Management and Property*, Queensland University of Technology, Brisbane, Australia.

`Chinyio, E. (2009). Mapping stakeholders.*Construction stakeholder management*. Review of Chapter 7 of a book authored by Lynda Bourne and Patrick Weaver published by Blackwell Publishing Company, London. Available at www.stakeholder-management.com.

Chinyio, E. & Vogwell, D. (2007).*Towards effective leadership in construction stakeholder management*.School of Engineering and the Built Environment, University of Wolverhampton, Wulfruna Street,WolverhamptonWV1 1SB, UK.

Construction Industry Institute [CII] (2012). Best practices guide: Improving project performance. *Implementation Resource, 166-3.*The University of Texas at Austin.

Chattered Institute of Building [CIOB] (1997).*Code of Estimating Practice* (6th edition). The Chartered Institution of Building, London, Longman.

Clement, J. P. & Gido, J. (2009).*Effective project management (*4th edition) South-West Cengage Learning, Canada.

Cooke, B. & Williams, P. (2004).*Construction planning programming and control*. Blackwell Publishing Ltd., UK

Hanid, M., Koskela, L., & Siriwardena, M. (2010).The construction, building and real estate research.*Conference of the Royal Institution of Chartered Surveyors*, Dauphine Université, Paris, 2-3 September, Retrieved from www.rics.org/cobra.

Cooper, R., Aouad, G., Lee, A., Wu, S., Fleming, A. & Kagioglou, M. (2005). *Process management in design and construction*. Blackwell Publishing Ltd., Oxford, UK.

Construction Excellence (2004). Procurement: Innovation, Best Practice and Productivity. Retrieved from www.constructingexcellence.org.uk.

Construction Industry Institute [CII] (2008). Effective management practices and Technologies for lesson learned programs. *Construction Industry Institute*. The University of Texas at Austin, USA.

CRC for Construction Innovation (2009).Multi-outcome construction policies: Literature Review on Stakeholder Theory. *The Cooperative Research Centre (CRC) for Construction Innovation,* Brisbane, Australia.Retrieved from www.construction-innovation.info, on 29 December 2014.

Creedy, G. D. (2006).Risk factor leading to cost overrun in the delivery of highway construction projects.PhD thesis, Queensland University of Technology.

Dalkir, K. (2005). *Knowledge management in theory and practice*. Elsevier Butterworth–Heinemann, Burlington, USA.

Damnjanovic, I., Anderson, A., Wimsat, A., Reinschmidt, K., & Pandit, P. (2009). Evaluation of ways and procedures to reduce construction cost and increase competition.Texas Department of Transportation and the Federal Highway Administration, Texas Transportation Institute, US.

Dayton, K. J. P. E., MacDonald, D. B. & Hammond, P. (2006). Construction cost escalation: The Washington State story. Report by the AASHTO Subcommittee on Construction Washington State DOT Headquarters Construction Office.

DG XVI (1997). Understanding and monitoring the cost-determining factors of infrastructure projects. A user's guide prepared by the Directorate of European Commission.

DVPM (2013).Construction management as a viable procurement option in comparison to traditional 'single-point' contracting.Retrieved from www.dvpm.co.zo, on 17 July 2014.

Egbu, C. O. (2004). The role of knowledge management and innovation in improving construction competitiveness.*Building Technology and Management Journal.*

EJCDC (2006).Standard form of agreement between owner and contractor on the basis of a stipulated price.*Construction Management.* No.1910-8-A-1 (1996 edition), Anderson W. (ed.). John Willey & sons, USA.

El Sawalhi, N. I. (2012). Modeling the parametric construction project cost estimate using Fuzzy Logic. *International Journal of Emerging Technology and Advanced Engineering,* 2, (4), 631-636. Retrieved from www.ijetae.com.

Encarta Dictionaries (2009). Microsoft Encarta English Dictionary, soft copy.

Engineering and Physical Sciences Research Council [EPSRC] (2004).Managing change in construction projects.A funded research work in the UK under the Engineering and Physical Sciences Research Council (EPSRC) System Integration, UK.

Fan, R. Y. C; Thomas Ng, S; Wong, J. M. W (2007).Forecasting the Hong Kong construction demand – A pilot study.*Department of civil engineering, the University of Hong Kong, Pokfulam Road, Hong Kong.*

Federal Facilities Council [FFC] (2007). Reducing construction costs: Uses of best dispute resolution practices by project owners.*Technical Report No. 149, National Research Council.*The National Academy Press, Washington DC, United States of America.Available at http://www.nap.edu/catalog/11846.html.on 12 December, 2009.Field, B. & Ofori, G. (1988).Construction and economic development-a case study.*Third World Planning Review*.

Fisk, E. R. (2000). *Construction project administration*. New Jersey, Prentice Hall.

Flyvbjerg, B. (2005). Policy and planning for large infrastructure projects: problems, causes, cures. A World Bank policy research paper, December.Retrieved from http://books.google.com.ng/books?id, on 16 October 2014.

Flyvbjerg, B., Holm, M. S., & Buhl. S. (2002) "Underestimating costs in public works projects: error or lie?"*Journal of American Planning Association*, 68 (3), 279-295.

Flybjerg, B., Holm, M. K. S. & Buhl, S. L. (2003). How common and how large are cost overruns in transportation infrastructure projects? *Transport Reviews*, 23 (1), 71-88.

Flybjerg, B., Holm, M. K. S. & Buhl, S. L. (2004).What causes cost overrun in transport infrastructure projects? *Taylor and Francis Group,Transport Reviews*, January, 24 (1) 3–18.

Flyvbjerg, B., Garbuio, M. and Lovallo, D. (2009).Delusion and deception in large infrastructure projects: Two models for explaining and preventing executive disaster. *California Management Review*, 51 (2), 170-193. DOI: 10.1225/CMR423.

Fong, P. S. W & Yip, J. C. H. (2006). An investigative study of the application of lesson learned system in construction project. *Journal for Education in the Built Environment*, 1 (2), 27-38.

Fryer, B. (1990). *The practice of construction management*. BSP Professional Books, Oxford, 1-2.

Fleming, G. (2007). *Construction project management handbook.*Prepared for Federal Transit Administration (FTA), Office of Research, Demonstration and Innovation U.S. Department of Transportation Washington, DC 20590.

Fleming, G. (2009). *Construction project management handbook.*Prepared for Federal Transit Administration (FTA) Office of Research, Demonstration and Innovation U.S. Department of Transportation Washington, DC 20590, Report Number FTA-CA-26-7077-2009.1.

.
Forgues, D., Schmitz, D., & Tahrani, S. (2013). Upbrella and Bim: Rethinking the construction process in residential construction. *Creative Construction Conference*, Budapest, Hungary, 6 – 9 July.

Fouracre, P. R., Allport, R. J., Thomson, J. M. (1990). *The performance and impact of rail mass transit in developing countries.* Transport and road research laboratory, Research Report 278, Department of Transport. Crowthorne, Berkshire.Gallagher, J. P. (2008). Material price escalation: Managing the risks. *Construction eNewsletter*.

Gambo, M. J & Ashen, M. J. (2012). Application of economic indicators in predicting construction cost escalation for residential buildings in Nigeria. *International Journal of Economic Development Research and Investment*, 3 (1).

Gandu, Y. J. & Haddarry, Y. M. (2007). *Understanding steps in quantity surveying procedure*. Shanshan Limited Publishers, Kaduna, Nigeria.

Gandu Y. J., Okoli O. G., & Rotimi O. B. (2007). The reliability of client's estimate during contractor selection. *Construction Focus. A Journal of Construction Management and Engineering*, January, 1 (1), 75-80.

Gandu, Y. J; Ali, A. A. & Gangas, P. C. (2010).Bidding model for sustainable projects using the traditional procurement method.*Information Manager Journal of Library and Information Science Department*, 9 (2), 54-60.

Garson, D. G. (2012).Testing statistical assumptions.*Statistical publishing associates*, USA. Retrieved from www.statisticalassociates.com, on 8 January, 2013.

Giwa, S. L. (1988a). Appraisal and prediction of final contract sums of building projects in Nigeria. Unpublished PhD. Thesis submitted to Department of Building, Ahmadu Bello University (A.B.U),Zaria.

Giwa, S. L (1988b). Analysis of abandoned projects in Nigeria. Paper presented at the NIQS yearly seminar, Lagos, Nigeria, 26 May.

Gray, C. F. & Larson, E. W. (2008).*Project management: The managerial process*. McGraw Hill, New York.

Gündüz, M., Nielsen, Y., & Özdemir, M. (2013). Quantification of delay factors using the relative importance index method for construction projects in Turkey. *Journal of Management Engineering*, 29 (2), 133–139.

Halpin, D. W. & Woodhead, R. W. (1998). *Construction management*. John Wiley & Sons Inc., United States of America, 13.

Hamaker, J. (1995). Parametric estimating. *Cost Estimating Manual*. (Eds. Stewart, R., Wyskida, R. M. & Johannes, J. D.). John Wiley &Sons, Inc. New York.

Hanscomb.means (2004). Report. International construction intelligence. Retrieved from www.icoste.org.

Hao, Q., Shen, W. & Neelamkavil, J.(2008a). Managing change in construction. Institute for Research in Construction, Canada, National Research Council.

Hao, Q., Shen, W., Neelamkavil, J. & Thomas, R. (2008b). Change management in construction projects. *International conference on information technology in construction.*Santiago, Chile, July.

Haris, F. & McCaffer, R. (2001). *Modern construction management* (5th edition), London, BSP Professional Books.

Harrison, F. L. (1992): *Advanced project management: A structured approach*. Gower Publishing House Limited, England.

Harrison, F. & Lock, D. (2005). *Advanced project management: A structural approach*. 4th edition, Gower Publishers Ltd. England.

Haughey, D. (2011). Retrieved from www.projectsmart.co.uk, on 21January 2012.

Hoegl, M., Weinkauf, K. & Gemuenden, H. G. (2004). Inter-team coordination, project commitment and teamwork in R&D Projects: A longitudinal study. *Organizational Science Journal*.Jan-Feb.

Howard, K. (1975). *Quantitative analysis for planning decisions.* Macdonald and Evans Ltd. London.

Hugill, D.& Ross, A. (2008). *Financial management in construction contracts*. John Wiley & Sons. Inc, New York, 282.

Idoro, G. I. (2011). The influence of project documents on the outcome of construction projects procured by traditional contract in Nigeria. J*ournal of Construction in Developing Countries.*

Ikegwuru, D. O. U. (2006). A system approach to a proactive cost control of building. PhD. Thesis Progress Seminar, Department of Building, ABU, Zaria.

Jashapara, A. (2004). *Knowledge management*: *An integrated approach*. Prentice Hall Publishers, London.

Jelenic, D. (2011).The importance of knowledge management inorganizations – with emphasis on the balancedscorecard learning and growth perspective. Management, *Knowledge and Learning.International conference*.Faculty of Economics, University of Nis, Republic of Serbia.

Johnson, H. & Mansfield, G. L. (2001).*Bidding and estimating procedures for construction.* Prentice-Hall, Inc., New Jersey.

Johnson, S. (2010). Proactive verses reactive project management. Retrieved from http://blogs.attask.com/blog/a-better-way-to-get-work-done/proactive-vs reactive-project-management, on14 January 2010.

Kagioglou, M., Cooper, R., Aouad, G. &Sexton, M. (2000). Rethinking construction: The generic design and construction process protocol. *Engineering, Construction and Architectural Management, 7 (2), 141–153.*

Karthodoros, G. (2012). Material planning in construction projects. Retrieved from http://www.academia.edu/2351159/Material_planning_in_construction_projects, on 12 September 2013.

Kasim, N. (2011). ICT implementation for materials management in construction projects: Case studies. *KICEM Journal of Construction Engineering and Project Management*.. Retrieved from www.jcepm.org,on30 August 2012.

Kern, A. P. & Formoso, T. C. (n.d). Guidelines for improving cost management in fast, complex and uncertain construction projects. Building Innovation Research Unit (NORTIE), Federal University of Rio Grande do Sul, Porti Alegre-RS.

Kerzner, H. (2004). *Project management; a system approach to planning, scheduling and controlling,* 2nd edition, CBS Publishers and Distributors.

Khan, R. A. (2008). Role of construction sector in economic growth: Empirical evidence from Pakistan economy. A paper presented at the First *International Conference on Construction in Developing Countries*(ICCIDC–I) Titled, "Advancing and Integrating Construction Education, Research & Practice"4-5 August, Karachi,, Pakistan.

King, W.R. (2009). Knowledge management and organizational learning.*Annals of Information Systems 4*.DOI 10.1007/978-1-4419-0011-1_1.

KLICON, (1999).The Role of information technology in knowledge management within the construction industry.Project report of knowledge learning in construction group, Centre for Research in the Management of project, University of Manchester, Institute of Science and Technology, UK.

Koskela, L. (1992). Application of the new production philosophy to construction. Center for Integrated Facility Engineering (CIFE) Technical Report. Stanford University.

KPMG (2012).**Budgeting, estimating, and contingency management for construction projects.**Major *Projects Advisory, Project Leadership Series*. KPMG Global Energy Institute.www.kpmgglobalenergyinstitute.com **.**

Lahdenperä, P. (2009). *Project alliance:The competitive single target-cost approach*. Julkaisija-Utgivare Publisher, Finland. Available in http://www.vtt.fi/publications/ index.jsp

Laryea, S. A. (2010. Challenges and oppurtunitiesfacing contractors in Ghana. In: West Africa Built Environment Research (WABER) Conference, 27-28 July, Accra Ghana.

Latham, M. (1994).Constructing the team. A report sponsored by the UK Government on the construction industry. The Stationery Office, Department of the Environment, London.

Le Masurier, J., Wilkinson, S. & Shestakova, Y. (2006).An analysis of the alliance procurement method for reconstruction following an earthquake.Proceedings of the 8th U.S. National Conference on Earthquake Engineering. April 18-22, San Francisco, California, USA.

Lessing, J. (2006). Industrialised house-building.Concept and processes.Research project at the division of design methodology, Department of Construction Sciences, Lund University, Lund Institute of Technology, Sweden.

Levine, D. M., Stephan, D. F., Krehbriel, T. C. & Berenson, M. L. (2008).*Statistics managers using Microsoft Exce*l.Pearson education inc., Pearson Prentice Hall, Upper Saddle River, New Jersey, USA.

Levy, S. (2006). *Design-build project delivery*: *Managing the building process from proposal Through.* Mcgraw-Hill, New York.

Lock, D. (2001). *The Essentials of Project Management*.Gower Publishing Company U.S.A.

Lockyer, K & Gordon, J. (1996).*Project management and project network techniques*. Prentice Hall Inc. U.K.

Lukas, J. A. (2008). Earned Value Analysis –Why it doesn't Work.*AACE International Transactions.*Retrieved from http://www.icoste.org/LukasPaper.pdf, on 22 January 2011.

Ma, T., Olifent, A. & Zuo, J. (2010). Towards the minimization of variations in design and build projects. Retrieved from http://www.msd.unimelb.edu.au/events/conferences/aubea2010/conference-papers/pdf/A030-Ma-Olifent-Zuo.pdf.

Malkat, M. & Byung-Gyoo, K. (2012). An investigation of the stakeholders of construction projects in Dubai and adjacent regions.Retrieved from www.ipedr.com/vol45/016-ICMTS2012-M00008.pdf. accessed on 28/8, on 14 March 2014.

Marchesan, P.R.C.& Formoso, C.T. (2003). Cost management and production control for construction companies. Accessed from internet on 10 August, 2009.

Marlin, M. (2008). Implementing an effective lessons learned process in a global project environment. Originally published as a part of UTD 2nd Annual Project Management Symposium Proceedings –Dallas, Texas.

Mbachu, J. I. C. (1995). Prediction of the construction duration of institutional building projects in Nigeria. *Nigerian Journal of Construction Technology and Management*, 1(1); 88-92.

Mbamali, I. (2003). The impact of accumulated deferred maintenance on selected building of two federal universities in the north-west zone of Nigeria. *Journal of Environmental Science.* University of Jos, Nigeria, 77-83.

Merrow, E. W., Philps, K. E. & Myers, C. W. (1981). Understanding cost growth and performance shortfalls in pioneer process plants, U. S. Prepared for the U. S. Department of Energy; The Rand Corporation.

Mogbo, T. C. (1992). Time and cost relationship of housing construction in northern Nigeria. Unpublished PhD. Thesis, Department of Building, A.B.U, Zaria.

Molenaar, K. R. (2005). Programmatic cost risk analysis for highway megaprojects. *Journal of construction engineering and management*, 131 (3).

Moris, S. (1990). Cost and time overruns in public sector projects. *Economic and Political weekly*, 47, m154-m168, Nov.

Morledge, R., Smith, A., & Kashiwagi, T. D. (2006). *Building procurement*. Blackwell Publishing Ltd. UK.

Motulsky, H. (2002).Detecting outliers.Retrieved from http://www.graphpad.com/articles/outlier.htm,**on 17July 2012.**

Moyo, A. (2010).The effects of hyperinflation on the Zimbabwean construction industry.Unpublished M.Sc. thesis. Faculty of Engineering, the Built Environment and Information Technology, Nelson Mandela Metropolitan University, Zimbabwe.

Munroe, C. (n.d). Construction cost estimating, a transcript of the closed circuit video broadcast by the AMSNA and presented by the Los Angeles Chapter of the American Society of Professional Estimators. Simi Valley, USA.

Muriro, A. & Wood, G. (2010).A comparative analysis of procurement methods used on competitively tendered office projects in the UK. A publication of The Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors, UK (September).

Nagrecha, S. (2002).An introduction to Earned Value Analysis.Retrieved from http://www.pmiglc.org/COMM/Articles/0410_nagrecha_eva-3.pdf, on 22 January 2011.

NASA (National Aeronautics and Space Administration, 2010).Retrieved from http//evm.nasa.gov, on 22 January, 2011.

NAO (2001). Modernizing Procurement. A report sponsored by the UK Government on construction industry. The stationery Office, UK.

NCHRP (2006).Best-value procurement methods for highway construction projects. Research sponsored by the American Association of State Highway and Transportation Officials in cooperation with the Federal Highway Administration, (eds. Scott, S.III., Molenaar, K. R., Gransberg, D. D. & Smith, N. C.), Washington DC. Retrieve from www.TRB.org., on 15 March, 2008.

Nelson, D. (2011).The analysis and valuation of disruption. Hill international, inc. Asia. Retrieved on 21 May, 2015 from https://www.hillintl.com/PDFs/The%20Analysis%20and%20Valuation%20of%20Disruption%20-%20Derek%20Nelson.pdf

Ng. Thomas, S., Palaneeswaran, E., & Kumaraswamy, M. M. (2002).A dynamic e-Reporting system for contractor's performance appraisal. Advances in Engineering Software 33 (2002), 339–349. Retrieved from www.elsevier.com/locate/advengsoft, on 30 June, 2008.

Nguyeh, L. D., Ogunlana, S. O. &Lan D. T. X. (2004). A study on project success factors in large construction projects in Vietnam. *Engineering construction and architectural management*, 11 (6), 404-413.

Nicholas, J. M & Steyn, H. (2008). *Project management for business, engineering and Technology. Principles and Practice*. Oxford, Butterworth- Heinemann.

Odeyinka, H. A. & Iyagba, R. I (2000). Risk management in construction to avoid cost overrun. *Journal of the Nigerian Institute of Quantity Surveyors*, 31, April/June, 14-21.

Office of Government Commerce [OGC] (2003).Achieving excellence in construction. Procurement guide 07. Whole-life costing and cost management.Published by the UK Office of Government Commerce (OGC).Retrieved from www.ogc.gov.uk, on 17 June 2009.

Oglesby, C. H., Parker, H.W. & Howel, G. A. (1989). *Productivity Improvement in Construction.* Mcgraw-Hill, New York.

Ogunsemi, D. R. & Fasoranbaku A. O. (2000). Developing a cost model for residential flats in Akure. *Journal of the Nigerian Institute of Quantity Surveyors*, 31, April/June, 26-28.

O'Haren, D. M. (2004)."Material price escalation and availability."*International Risk Management Institute, Inc*.

Olusegun, A. E. & Michael, A. O. (2011).Abandonment of construction projects in Nigeria: Causes and effects. *Journal of Emerging Trends in Economics and*

Management Sciences (JETEMS). Scholarlink Research Institute Journals, available at jetems.scholarlinkresearch.org.

Omotoso, K. (2012). Technology and human development. The 24th Convocation Lecture delivered at the Federal University of Technology, Akure (Quoting the report on abandoned projects by the Projects Audit Commission set up by President Goodluck Jonathan in 2011).

Oswald, P. F. (2001). *Construction cost analysis and estimating*. Prentice Hall Inc., Upper Saddle River, New Jersey.

Oyediran, O. S. (2006). Modeling inflation dynamics in the construction sector of a developingeconomy.*Construction Economics I,* Munich, Germany.Retrieved from www.fig.net/pub/fig2006/papers/ts28/ts28 06_oyediran_0613, on 8 October 2013.

Oyegoke, A. S. (2006). Managing client's expectations in project delivery: a comparative study of delivery systems. *Quantity surveying in the 21st century agenda for the future.* The 22nd Biennial conference of the Nigerian Institute of Quantity Surveyors, 22-25th November, Calabar, Nigeria.

Ozigbo, N. L. (2000). *Quantitative analysis for management decisions.* Precision Publishers limited, Enugu, Nigeria.

Ozigbo, N. L. (2004). *Operations management principles and cases*. Precision Publishers Limited, Enugu, Nigeria.

Patel, V. K. & Vyas C. M. (2011).Construction materials management on project sites. National conference on recent trends in engineering & technology, held at New Vallabh Vidhyanagar, Gujarat, India.

Park, M. (2002). Dynamic change management for fast-tracking construction projects. Department of Building, School of Design & Environment, National University of Singapore.

Queensland Government (2008).Relational procurement options - alliance and early contractor involvement contracts. Procurement guidance series, Version 0.95.

Raftery, J. (1993). Construction perspective from economics and psychology. Inaugural lecture, University of Greenwich, School of Land Construction and Construction Management, 16 December.

Rahman, A. B & Omar, W. (2006). Issues and challenges in the implementation of industrialised building systems in Malaysia. Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference (APSEC 2006)Malaysia, September.

Raisanen, C. & Gunnarson, S. (2007). Learning to know and knowing to learn: Discursive practice as knowledge enabler. *Building Economics and Management*.Chalmers University of Technology, Sven Hultins gt 8, Gothenburg, SE-412 96, Sweden.

Rashid, R. A., Taib, I. M., Ahmad, W. B. W., Nasid, Md. A., Ali, W. N. W. & Zainordin, Z. M. (2006). Effect of procurement systems on the performance of construction projects. Department of Quantity Surveying Faculty of Built Environment, Universiti Teknologi Malaysia.

Ren, Z., Atout, M., & Jones, J. (2008). Root causes of construction projects delays in Dubai. The 24th annual Association of Researchers in Construction Management (ARCOM) Conference, UK, September.

Rezakhani, P. (2012). Classifying key risk factors in construction projects.Buletinul Institutului Politehnic Din Iaşi.Publicat De Universitatea Tehnică „Gheorghe Asachi" din IaşiTomul LVIII (LXII), Fasc. 2, 2012 Secția. Construcții. Arhitectură, Kyungpook National University, Korea.

Royal Institute of Chartered Surveyors [RICS] (2009). International Cost Elements Enquiry, 2009 Report. Building Cost Information Service (BCIS) of the Royal Institute Of Chartered Surveyors, October.

Royal Institute of Chartered Surveyors [RICS] (2010). Is it Possible to forecast the construction cost index in the US? A *Fibreseries Publication*, the Royal Institute of Chartered Surveyors, April.

Sambasivan, M. & Soon, Y. W. (2007). Causes and effects of delays in Malaysian construction industry.*International Journal of Project Management*.retrieved from www.sciencedirect.com, on 8 October, 2010.

Seeley, I.H. (1996).*Building Economics*, 4th Edition, Macmillan, London.

Senaratne, S. & Sexton, M. (2008). Managing construction project change: A knowledge management perspective. *Construction Management and Economics*, October–December.

Seningen, S. (2005). Learnthevalue of lessons-learned. Retrieved from www.projectperfect.com.au on 19 May, 2009.

Shane, J. S., Molenaar, K. R., Anderson, S. & Schexnayder, C. (2009). Construction project cost escalation factors. *Journal of the Publisher*: American Society of Civil Engineers (ASCE).

Sheffer, D. A. (2011). Innovation in Modular Industries: Implementing Energy-Efficient Innovations in Us Buildings. A PhD. dissertation Submitted to the Department Of Civil and Environmental Engineering and the Committee on Graduate Studies, Stanford University. Retrieved from http://Purl.Stanford.Edu/Rq526jy0504, on9 February, 2012.

Singh, R. (2009). Delays and cost overruns in infrastructure projects: an enquiry into extents, causes and remedies. Centre for Development Economics, Department of Economics, Delhi School of Economics. Retrieved from http://www.econdse.org/faculty/ram/ram.htm, 25 October, 2011.

Skitmore, M. & Pachell, B. (1992). Developments in contract price forecasting and bidding techniques. *Quantity Surveying, New Direction. (*Ed. Bradon, S. P.). London, Blackwell Science Ltd.

Smith, N.J. (1999). *Managing Risk in Construction Projects*. Blackwell Science Ltd. London.

Soong, T. T. (2004). *Fundamentals of probability and statistics for engineers*.John Wiley & Sons Ltd, New York, USA.

Srivastava, U. K., Shenoy, G. V. & Sharma, S. C. (1989).*Quantitative techniques for managerial decisions.* New Age International Publishers Limited, New Delhi.

Ssegawa, J.K., Mfolwe, K.M., Makuke, B. & Kutua, B. (2009).Construction variations: A scourge or a necessity? Retrieved from http://buildnet.csir.co.za/cdcproc/docs/3rd/ssegawa_jk_mfolwe_km.pdf., on 5 December, 2010.

Stewart, R. D. (2005). Fundamentals of cost estimating. In *Cost Estimating reference Manuals.* (Eds. Stewart, R. D., Wyskida, R. M.& Johannes, J. D.). John Wiley and Sons, Inc. New York.

Sun, M. & Meng, X.H. (2009). Taxonomy for change causes and effects in construction projects, *International Journal of Project Management*, 27 (6), 560-572.

Szoke, K. (1977). Building economics. A Technical Sessions of the Seventh Triennial Congress of the International Council for Research Studies and Documentation (CIB), Edinburgh, September.

The Public Procurement Act (2007).*Procurement procedures manual for public procurement in Nigeria*.Bureau of Public Procurement, Federal Republic of Nigeria.

TramStore21 (2012).Building sustainable and efficient tram depots for cities in the 21st century:Communication & StakeholderManagement. A Report sponsored by the European Regional Development through INTERREGE IV B.

Trost, S. M. & Oberlander, G. D. (2003). "Predicting accuracy of early cost estimates using factor analysis and multivariate regression". *Journal of Construction Engineering and Management*. 129 (2), 198-204.

Tueninzen, J. (2007). Proactive building cost management: Managing is anticipating. Author's e-mail: j.teunizen@brinkgroep.nl, on 22 September, 2009.

Tumi, S. A., Omran, A., Pakir, A. H. K. (2009). Causes of delay in construction industry in Libya. The International Conference on Economics and Administration, Faculty of Administration and Business, University of Bucharest, Romania, Icea – Faa Bucharest, 14-15th November.

Ubani, E. C. & Ononuju, C. N. (2013). A Study of failure and abandonment of public sector- driven civil engineering projects in Nigeria: An empirical review. *American Journal of Scientific and Industrial Research*, 75-82. http://www.scihub.org/AJSIR, doi:10.5251/ajsir.2013.4.1.75.82

UKCG, (2009). Construction in the UK economy: The Benefits of investment. Astudy commissioned by the UK Contractors Group UKCG), October.

US Department of Commerce (1999). UNIFORMAT II Elemental classification for building specification, cost estimating and cost analysis, NISTIR 6389, (Charette P. R. & Marshall, H. E.). National Institute of Standards and Technology.

Valle, J. A. & Soares, C. A. P. (2005).The use of earned value analysis (EVA) in the cost management of construction Projects.IBEC – Brazilian Cost Engineering Institute, Brazil.

Vargas, R.V. (2002). Earned value analysis in the control of projects: Success or failure? Retrieved from http://www.ricardovargas.com.br, 17 September, 2011.

Veronika, A., Riantini, L. S. & Trigunarsyah, B. (2006). Corrective action for project cost variance in construction material management. The tenth east Asia-Pacific conference on structural engineering and construction, 3-5 August, Bangkok, Thailand.

Walker, D., Shelley, A. & Bourne, L. (2008).Influence, stakeholder mapping and visualization.*Construction Management and Economics*.Retrieved from http://journalsonline.tandf.co.uk/.on 15 October, 2010.

Warren, M. (1993). *Economics for the built environment*. Butterworth-Heinemann Ltd. Great Britain.

Wilkens, T. T. (1999). Earned value, clear and simple.Los Angeles County Metropolitan Transportation Authority, USA.

Williams II, R. L., Albus, J. S. & Bostelman, R. V. (2004). Self-contained automated construction deposition system. *Automation in Construction* (an International Research Journal).Retrieved from http://www.ent.ohiou.edu/~bobw, on 19 August, 2008.

Williams, T. (2002). "Predicting completed project cost using bidding data". *Journal of Construction Management and Economics*, 20 (3), 225-35.

Williams, T. P., Miles, J. C. & Moore, C. J. (1999). Predicted cost escalations in competitively bid of highway projects. Proceedings of the Institution of Civil Engineers Transport, USA.

Willoughby, K. A. (2005). Process improvement in project expediting: there must be a better way: *International Journal of Project Management,* 23, 231–236.

Wong, P. S. P. & Cheung, S. O. (2005). Structural equation model of trust and partnering success. *Journal of Management in Engineering*.

Wright, N. J. (1997). Time and budget: The twin imperative of a project sponsor. *International Journal of Project Management*, 15(3), 181-186.

Wyskida, R. M. (2005). Statistical techniques in cost estimating. In *Cost Estimating Manuals.* (Eds. Stewart, R. D; Wyskida, R. M & Johannes, J. D.). John Wiley and Sons, Inc. New York.

Yang, J., Shen, G. Q., Ho, M., Drew, D. S., & Chan, A. P. C. (2009).Exploring critical success factors for stakeholder management in construction projects.*Journal of Civil Engineering and Management*. Doi: 10.3846/1392-3730.2009.15.337 348.

Yusof, A. Md., Ismail, S. & Chin, L. S. (2011).Procurement method as conflict and dispute reduction mechanism for construction industry in Malaysia. A paper presented at the 2nd International Conference on Construction and Project Management (IPEDR vol.15, IACSIT Press), Singapore.

Zou P. X. W. & Seo Y. (2006). Effective applications of e-commerce technologies in construction supply chain: current practice and future improvement, 11, 127-147. *Journal of Information Technology in Construction(ITcon).*

Zou, P. X. W., Zhang, G., & Wang, J. (2004).Identifying Key Risks in Construction Projects: Life Cycle and Stakeholder Perspectives.*Journal of Information Technology in Construction(ITcon).*

APPENDIX I: TYPES OF PROGRAMS IN THE PROJECT LIFECYCLE

No.	Planning Stages	Types of Program	Planning Organ	Function
1	Design	Project Master Schedule	Client/Project Manager	This program is usually produced by the client at the start of the project. It consists of a broad framework for the project that covers: Key dates for the start and end of the project. Key dates for design, tender and construction. Overall program and phasing schedule. Design and tendering schedule. Key dates for start and completion of tasks. Stage or phased handover dates. Since the client is the financier of the project, the key dates in an overall master program enable him prepare cash flow program, and make releases so as to enable smooth production process. Delay in the releases of finances can cause time extension and subsequent cost escalation, therefore the key dates serve as constant reminder on the need for him to act accordingly.
2	Tender	Pretender Program	Tendering Contractors	Often produced by the contractor to form part of the tender information. It gives an idea on how the project will proceed if the contract is awarded. This pretender program gives the contractor a broad view of the whole project execution plan. The need for resources, kind of resources and time needed also become clearer.
3	Pre-contract	Master Program	Main Contractor	After signing the contract, the builder produces a master program of the work progress and submits to the client. This is a management tool required by the builder for the coordination and control of the many integrated tasks to be carried out during the project execution". The main feature of the program covers planned sequence of progress including major phases or sections of work. It indicates key dates to achieve set tasks. Clause 3.5.1.2 of the JCT 98 provides that the contractor without charge is to provide the employer with two copies of the master program for the execution of the work. The client uses the copy to monitor builder's progress.

		Target Program	Main Contractor	The target program often compresses the master program into a shorter period, thereby saving on time-related costs and releasing resources sooner for the next contract. The program targets a completion date earlier than set in the master program. This is an optimistic program if achieved can deliver the project in advanced of the planned completion period. However, a realistic target should be set.
		Sub-contractor's Program		Often accommodated in the main contractor's master program with a given duration. Each of this is effectively a sub project with its own list of activities and events. Activities within this period are controlled by the main contractor to achieve the general target date. Delays by subcontractors can affect the overall program.
		Procurement Program		Bar lines are usually produced to represent the procurement periods for each major component supplier or subcontractor. Each bar line is flagged with three milestone symbols relating to a sequence of information requirements placing order and the commencement of site operation (Cooke and Williams 2004).
4	Contract	Stage Program	Main Contractor and Sub-Contractor	**Stage program**: the contractor's master program is frequently developed as the project progresses in order to show a finer level of detail. An activity in the master program e.g. substructure can be broken down into sub-activities and their dependency shown for proper management.
		Short Term Program	Main Contractor and Sub-Contractor	Many contractors prepare short term programs at contract stage on a monthly or weekly basis. This short term program is used to reflect progress, problems and changes. It offers better means of controlling day-today operations to the contractor on site and act as a useful method of communication. Other objectives are to keep the master program under constant review in the short term, highlight information requirements to meet stages' planned completion dates, assessment of key material requirements and to inform senior management of site progress.
5		As-Built Program	Main Contractor and Sub-Contractor	The actual work sequence with dates of how the work was actually achieved mainly to be kept for reference purposes.

(Source: Adapted from Cooke and Williams, 2004)

	causes /countries	Pakistan	Florida US	Malaysia	H/Kong	H/Kong	Indonesia	Thailang	Jordan	S/Arabia	S/Arabia	Ghana	Libya	Nigeria	Nigeria	Nigeria
	year of research work	2008	2002	2006	1997	1998	1997	1999	2000	1994	2006	2003	2009	1994	1997	2011
1	poor estimating	*					*				*			*		*
2	poor planning and schedule	*		*			*						*		*	*
3	resource shortages			*			*			*		*	*	*	*	
4	unforseen site condition				*				*							
5	slow decision making		*		*					*			*		*	
6	poor management and supervision	*		*	*							*		*	*	
7	client innitiated changes		*		*										*	
8	design changes by consultants		*				*			*						
9	faulty designs									*			*			*
10	incomplete and unclear documents		*					*								
11	delayed drawings								*							
12	delayed shop drawings		*							*						
13	work variation	*			*											*
14	inflation/fluctuations	*					*					*		*		*
15	strikes														*	
16	complexity						*									
17	poor labor productivity						*			*		*				
18	bias of different industry groups					*										
19	delayed payment by client		*	*						*		*	*	*	*	*
20	construction error		*	*												
21	sub-contractor problems		*	*				*		*						
22	defficiencies between contractor and consultants							*								
23	weather problems		*						*						*	*
24	economic conditions								*		*					
25	poor cost control	*														*
26	increase in quantities								*							
27	inexperienced /unqualified staff		*	*							*					*
28	financial difficulty of contractor														*	*
29	bad decisions in regulating company's policy										*					
30	inadequate funding															*
31	code related (statutory approvals)		*													
32	user changes								*							
33	political factor/govt. policies	*														*
34	death of client															*
35	dispute														*	
36	communication problems			*									*			
37	inspection		*													

APPENDIX II: CAUSES OF DELAY IN CONSTRUCTION PROJECTS

APPENDIX: III: ALLIANCE PROCUREMENT PROCESS AND SUCCESSFACTORS

Steps	Factors	Reasons
Attitude and commitment	**Project's advantage**. Alliance team members must (have the possibility to) follow the "best of the project" principle in all project-related decision making.	To be secured as bedrock for selection of team
	Unprejudiced decision making. The actors must be ready to test and adopt new technology and new solutions to promote excellent results.	
	Commitment of parties. The owner and service providers must commit themselves to the project including upper management and alliance management group members.	
	Confidence building. The actors are to purposefully promote the building of active collaborative relationships and creation of mutual trust.	
	Atmosphere of openness. The relationships between alliance partners are to be based on openness and confidentiality in all operations and exchange of information.	
Selection and organizing	**Selection of execution team**. Effort must be put into the selection of the alliance team in order to maximize the competence and performance of the team for attaining set goals.	Client's actions and criteria for selection
	Quality as basis of selection. In implementer selection competence criteria, generally quality factors must be emphasized over price.	
	Earlier experience from collaboration. Actors with clear proof of successful cooperation in earlier projects should primarily be selected as alliance partners.	
	Qualities of personnel. Persons selected for the organization should be team players as well as unprejudiced and creative thinkers.	
Integration and cooperation	**Participation of facilitator**. An impartial expert focusing on the development of cooperation and observation of alliance principles is to be engaged at a sufficiently early stage.	Organization and clear responsibility
	Joint alliance office. The alliance organization should be a united team whose formation and activities are supported, for instance, by common space arrangements.	
	Unity of organization. The alliance team must display unity and operate under the name and logo of the alliance abandoning member organization's logos.	
	Continuity of participation. Actors representing different competencies are to stay involved for the length of the project to be able to meet the goals in the best possible way.	
	Informing owners. Owners are to be kept informed about all project issues so they can make decisions that support project implementation and promote its goals.	
Goals and monitoring	**Setting of goals**. The actors are to set such sufficiently challenging goals for the alliance that they cannot have precise information on how they can be attained.	Organization and clear responsibility
	Phasing of management by objectives. The project is to be phased to serve the monitoring of realization and setting and updating of new demanding objectives.	
	Key profit areas. The team must ensure that project-specific profit areas and indicators that guide and motivate the teams to reach set goals are defined.	
	Impact of goals. The parties. common interpretation of goals, and the guiding influence of goals must be ensured through risk sharing and incentive arrangements	
	Awareness of goals. It must be ensured that people at all levels of the project organization are fully aware of the goal and special objectives of the project.	
Costs and payments	**Accuracy of budgeting**. The owner must prepare the budget carefully before the project is launched since it guides thinking and sets expectations for the target cost	Client responsibility during project progress
	Definition of target cost. The owner must be involved in the definition of the	

	target cost to avoid it being interpreted as a tender or an opening of discussion	
	Evaluation of target cost. The owner should make use of benchmarking of costs so that a low implementation costs is not sought at the expense of quality and life-cycle goals.	
	Workability of the incentive system. The actors must agree to a payment mechanism that is reasonably symmetric (profit/loss) and fair to all parties	
Project management and decisions	**Joint management system**. The alliance partners are to have a single joint project management system for dissemination of information and facilitating management.	Management strategy
	Evaluation of design. External expert evaluation of design is a proven method of ensuring the realization of the value-for-money goal.	
	Workability of quality assurance. External quality assurance as well as monitoring and evaluation of performance indicators are indispensable in ensuring good governance.	
	Evaluation of performance. The alliance must conduct continuous performance measurement/ benchmarking to allow identifying success areas and targets of improvement.	
	Purposefulness of the owner. The owner must show leadership in order to ensure that proposals intended as design changes generate added value without weakening quality.	
Workshops and seminars	**Design workshops**. Service providers wishing to join the alliance must conduct workshops for building a team and creating team spirit already before the owner's workshops.	Development and information flow
	Selection-phase workshops. The owner must conduct exhaustive workshops with all tenderers in order to create a functioning basis for good cooperation.	
	Value-management workshops. The actors must conduct joint value-management and problem-solving workshops in order to attain the intended economic efficiency.	
	Personnel seminars. The project is to hold repeated alliance seminars for site personnel in order to include them in the cooperation procedure.	

(Source: adapted from Lahdenpera 2009)

APPENDIX IV: FACTORS CAUSING COST GROWTH OF PROJECTS

Source	Factor	Descriptions
Internal	Bias	Bias is a systematic tendency to be overly optimistic about key project parameters. It is often viewed as the purposeful underestimation of project costs to ensure that a project remains in the construction program.
	Delivery/Procurement Approach	When risk is shifted to a party that is unable to control it, project cost will likely increase. The decision regarding which project delivery approach (e.g., design-bid-build, design-build, or build-operate-transfer) and procurement methodology (e.g., low bid, best value, or qualifications-based selection) affects the transfer of project risks. In addition to the question of risk allocation, lack of experience with a delivery method or procurement approach can also lead to underestimation of project costs.
	Project Schedule Changes	Project schedule changes can be viewed in terms of the time value of money. There are two primary components to the issue namely, the inflation rate and the timing of the expenditures. Particularly extensions, caused by budget constraints, timing of fund allocations, environmental impacts, or design challenges can result in unanticipated increases in project overhead and/or inflation. Most often estimators frequently do not know what expenditure timing adjustments will be made by management or caused by external circumstances.
	Engineering and Construction Complexities	Caused by the project's location or purpose and can make early design work very challenging and lead to internal coordination errors between project components. Internal coordination errors can include conflicts or problems between the various disciplines involved in the planning and design of a project. Constructability problems that need to be addressed may also be encountered as the project develops. If these issues are not addressed, cost increases are likely to occur.
	Scope Changes	Such changes may include additions to or deletions from the project scope.
	Scope Creep	Is the tendency for the accumulation of many minor scope changes to increase project cost. While individual scope changes have only minimal cost effects, the accumulation of these minor changes, which are often not essential to the intended function of the facility, can result in a significant cost increase over time. Projects seem too often grow naturally as the project progresses from inception through development to construction. These changes can often be attributed on projects to the changing needs or environmental compliance in the area being served.
	Poor Estimation	**Relates to** underestimation, which subsequently translates into increases in project cost as errors and omissions are exposed. Estimation documentation must be in a form that can be understood, checked, verified, and corrected. The foundation of a good estimate is the formats, procedures, and processes used to arrive at the cost. Poor estimation includes general errors and omissions relating to plan details and project quantities as well as general inadequacies and poor performance in planning and estimation procedures and techniques. Errors can be made not only in the volume of material and services needed for project completion but also in the costs of acquiring such resources.
	Inconsistent Application of Contingencies	Causes confusion as to exactly what is included in the line items of an estimate and what is covered by contingency amounts. Contingency funds are typically meant to cover a variety of *possible* events and problems that are not specifically identified or to account for a lack of

		project definition during the preparation of planning estimates. Misuse and failure to define what costs contingency amounts cover can lead to estimation problems. In many cases, it is assumed that contingency amounts can be used to cover added scope, and planners seem to forget that the purpose of the contingency amount in the estimate is lack of design definition. Agencies run into problems when the contingency amounts are applied inappropriately. During project execution, contingency funds are often inappropriately used to cover project overruns, instead of being applied to and available for their intended purpose.
	Faulty Execution	This factor can include the inability of the state highway agency's representatives to make timely decisions or actions, to provide information relative to the project, and to appreciate design and construction difficulties caused by coordination of connecting work or work responsibilities.
	Ambiguous Contract Provisions	**Ambiguous contract provisions** dilute responsibility and cause misunderstanding between the state highway agency and other contractual parties, including design consultants and/or project constructors. Providing too little information in the project documents can lead to cost overruns during the execution of the contract. When the core assumptions underlying estimation are confused by ambiguous contract provisions, forecast accuracy cannot be achieved.
	Contract Document Conflicts	**Contract document conflicts** lead to errors and confusion when preparing an estimate and cause change orders and rework during project construction.
External	Local Concerns and Requirements	It typically results in mitigation efforts to minimize project effects and negotiated scope changes or additions. There are actions often required to alleviate perceived negative impacts of construction on the local societal environment, as well as on the natural environment. Local government concerns and requirements can affect the project costs during any project development phase, especially as legislatures seek to add or impose specific scope to a project. Similar to the effects during the planning phase, mitigation actions imposed by the local government, neighborhoods, and businesses as well as local and national environmental groups during the construction of a project can extend the project duration, thereby affecting inflation allowances, and can add direct cost. By not anticipating these changes, projects can be plagued by cost increases.
	Effects of Inflation	**Inflation** adds cost to a project. The time value of money can adversely affect projects when (1) the project estimates are not communicated in year-of-construction costs; (2) the project completion is delayed, and, therefore, the cost is subject to inflation over a longer duration than anticipated; and/or (3) the rate of inflation is greater than anticipated in the estimate. The industry has varying views regarding how inflation should be accounted for in the project estimates and in budgets by funding sources.
	Scope Changes	If scope changes are not controlled it can lead to underestimation of project cost escalation, similar to internal scope changes.
	Scope Creep	Scope creep from external causes is similar to scope creep from internal causes; however, the external category is usually the accumulation of minor scope changes from external participants.
	Market Conditions	Changes in the macro-environment can affect the costs of a project, particularly large projects. The size of the project affects competition for a project and the number of bids that a client receives for the work.

		Inaccurate assessment of the market conditions can lead to incorrect project cost estimation. Changing market conditions during the development of a project can reduce the number of bidders, affect the available labor force, or result in increased commodity prices, all of which can disrupt the project schedule and budget.
	Unforeseen Events	**Unforeseen events** are unanticipated occurrences that are not controllable by stakeholders, such as floods, hurricanes, tornadoes, or other weather-related incidents. Typically, these events are called "acts of god." These acts can bring construction to a standstill and have been known to destroy work, thereby creating the need for extensive rework or repair. Events controlled by third parties that are also unforeseen include terrorism, strikes, and sudden changes in financial or commodity markets. These actions can have devastating impacts on projects and project cost.
	Unforeseen Conditions	**Unforeseen conditions** are notorious for causing project cost overruns. Unknown soil conditions can effect excavation, compaction, and structure foundations. Contaminated soils may be present, thereby resulting in the need for special mitigation work. Utilities are often present that are not described or are described incorrectly on existing drawings. There are a multitude of problems that are simply unknown during the early project phases and that can increase project cost when they become apparent during construction.

Adapted from Anderson et al .2007)

APPENDIX VA: EARNED VALUE MANAGEMENT PROCESS

Earned Value Management Terms:

Term	Description	Interpretation
PV (BCWS)	Planned Value	What is the estimated value of the work planned to be done?
EV (BCWP)	Earned Value	What is the estimated value of the work actually accomplished?
AC (ACWP)	Actual Cost	What is the actual cost incurred?
BAC	Budget at Completion	How much did you BUDGET for the TOTAL JOB?
EAC	Estimate at Completion	What do we currently expect the TOTAL project to cost?
ETC	Estimate to Complete	From this point on, how much MORE do we expect it to cost to finish the job?
VAC	Variance at Completion	How much over or under budget do we expect to be?

APPENDIX VB: EARNED VALUE MANAGEMENT FORMULA AND INTERPRETATION:

Name	Formula	Interpretation
Cost Variance (CV)	EV – AC	NEGATIVE is over budget, POSITIVE is under budget
Schedule Variance (SV)	EV – PV	NEGATIVE is behind schedule, POSITIVE is ahead of schedule
Cost Performance Index (CPI)	EV / AC	I am [only] getting _____ cents out of every $1.
Schedule Performance Index (SPI)	EV / PV	I am [only] progressing at ___% of the rate originally planned.
Estimate At Completion (EAC)	BAC / CPI	As of now how much do we expect the total project to cost $_____. • Used if no variances from the BAC have occurred
Note: There are many ways to calculate EAC.	AC + ETC	• Actual plus a new estimate for remaining work. Used when original estimate was fundamentally flawed.
	AC + BAC – EV	• Actual to date plus remaining budget. Used when current variances are atypical.
	AC + (BAC – EV) / CPI	• Actual to date plus remaining budget modified by performance. When current variances are typical.
Estimate To Complete (ETC)	EAC – AC	How much more will the project cost?
Variance At Completion (VAC)	BAC – EAC	How much over budget will we be at the end of the project?

APPENDIX VC: ILLUSTRATIVE EXPLANATIONS OF EARNED VALUE

In the following four periods, we expect to complete $100 of work:

	1	2	3	4	Total
Work Scheduled ($) [Planned Value (PV)]	25	25	25	25	100

As time progresses, we can see what was actually spent in each period:

	1	2	3	4	Total
Work Scheduled ($) [Planned Value (PV)]	25	25	25	25	100
Actual Cost ($) [Actual Cost (AC)]	22	20	25	25	92
Variance	3	5	0	0	8 i.e. 8%

From an accounting sense, it appears that this project is experiencing an underrun of $8. It was expected to cost $100, and has actually cost $92. What is missing from this equation is the value of how much work actually was completed or "performed".

	1	2	3	4	Total
Work Scheduled ($) [Planned Value (PV)]	25	25	25	25	100
Accomplished Value ($) [Earned Value (EV)]	20	20	20	20	80
Actual Cost ($) [Actual Cost (AC)]	22	20	25	25	92
Schedule Variance (SV) [SV = EV – PV]	-5	-5	-5	-5	-20 i.e. 20%
Cost Variance (CV) [CV = EV – AC]	-2	0	-5	-5	-12 i.e. 15%

We now have a clearer picture of the actual status of the work. We currently have a schedule variance of -$20. We were scheduled to complete $100 of work, and have only completed $80. In addition, the work that was completed ($80) has cost more than we had planned ($92), creating a cost variance of -$12. The actual cost variance is not 8% as calculated by the traditional approach but it is 15% which is more accurate as it also considers the work accomplished.

(Adapted from Nagrecha, 2002)

Material Year	Cement	Mild Steel Rft. Bar	High Yield Rft. Bar	BRC	Granite	Sh. Sand	Sf. Sand	Red Laterite	150 Blocks	225 Blocks	Bricks	Alum.	Bitumen.	Celotex. Ceiling	Hard wood	Floor Tiles	Wall. Tiles	Emulsion paint	Gloss paint	Skilled Labor	Unskilled Labor
1998		32000	34000	8000	9000	2100	2500	1300	26	36	50	1632	12400	2890	183	882	627	637	1029	500	150
	700	34000	35000	8000	9000	2100	2500	1300	26	36	50	1632	12240	2890	183	882	627	637	1029	600	150
	700	34000	35000	8000	9000	2100	2500	1300	26	36	50	1632	12240	2890	183	882	627	637	1029	600	150
	460	34000	35000	8000	9000	2100	2500	1300	26	36	50	1632	12240	2890	183	882	735	637	1029	500	150
1999	460	31000	32000	8000	9200	2000	2200	1600	33	38	75	1600	14000	3200	90	880	610	610	1020	600	200
	510	33000	35000	9600	16500	3100	3400	2100	33	41	140	1600	12500	3200	95	800	600	615	1000	600	200
	510	33000	35000	9600	16500	3100	3400	2100	33	41	140	1600	12500	3200	95	800	600	615	1000	600	200
	500	31000	32500	9000	16500	3000	3300	1880	35	39	85	1700	14000	3200	90	800	600	615	1000	600	200
2000	500	31000	32500	9000	16500	3000	3300	1880	35	39	85	1700	14000	3200	90	800	600	615	1000	800	200
	520	28000	32500	9000	16500	3500	3500	2000	35	39	85	1700	14000	3200	90	800	600	615	1000	800	200
	580	33000	39000	8000	10500	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	900	800	200
	580	33000	39000	8000	10500	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	900	800	200
2001	580	33000	39000	8000	10500	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	900	800	200
	580	33000	39000	8000	10500	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	900	800	200
	580	33000	39000	8000	10500	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	900	800	200
	600	31900	45500	8000	6800	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	888	800	200
2002	600	31900	45500	8000	6800	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	888	1000	300
	600	31900	45500	8000	6800	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	888	1000	300
	600	31900	45500	8000	6800	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	888	1000	300
	600	31900	45500	8000	6800	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	888	1000	300
2003	600	31900	45500	8000	6800	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	450	888	1200	400
	760	31900	45500	8000	6800	3000	3100	1500	32	45	80	1600	15000	3250	80	850	700	550	888	1200	400
	700	70000	75000	19000	18000	6500	7000	3000	50	70	80	1850	25000	5500	250	1150	1300	550	1200	1200	400
	700	70000	75000	19000	18000	6500	7000	3000	50	70	80	1850	25000	5500	250	1150	1300	550	1200	1200	400

APPENDIXVIA: HISTORICAL COST DATA (HCD)

Material / Year	Cement	Mild Steel Rft. Bar	High Yield Rft. Bar	BRC	Granite	Sh. Sand	Sf. Sand	Red Laterite	150 Blocks	225 Blocks	Bricks	Alum.	Bitumen	Celotex Ceiling	Hardwood	Floor Tiles	Wall. Tiles	Emulsion paint	Gloss paint	Skilled Labor	Unskilled Labor
2004	700	70000	75000	19000	18000	6500	7000	3000	50	70	80	1850	25000	5500	250	1150	1300	550	1200	1500	600
	1020	86000	96000	19000	18000	7000	7000	3000	70	90	80	1850	25000	5500	250	1150	1300	550	1200	1500	600
	1020	86000	96000	19000	18000	7000	7000	3000	70	90	80	1850	25000	5500	250	1150	1300	550	1200	1500	600
	1020	86000	96000	19000	18000	7000	7000	3000	70	90	80	1850	25000	5500	250	1150	1300	550	1200	1500	600
2005	1500	86000	96000	19000	18000	7000	7000	3000	70	90	80	1850	25000	5500	250	1150	1300	550	1200	1500	700
	1300	86000	96000	19000	18000	7000	7000	3000	70	90	80	1850	25000	5500	250	1150	1300	550	1200	1500	700
	1300	86000	96000	19000	18000	7000	7000	3000	70	90	80	1850	25000	5500	250	1150	1300	550	1200	1500	700
	1200	86000	96000	19000	18000	7000	7000	3000	70	90	80	1850	25000	5500	250	1150	1300	550	1200	1500	700
2006	1200	86000	96000	19000	18000	7000	7000	3000	70	90	80	1850	25000	5500	250	1150	1300	550	1200	1800	800
	1350	96000	96000	19000	18000	7000	7000	4000	80	95	80	1850	25000	5500	250	1150	1300	550	1200	1800	800
	1350	96000	96000	19000	18000	7000	7000	4000	80	95	80	1850	25000	5500	250	1150	1300	550	1200	1800	800
	1500	96000	96000	19000	18000	7000	7000	4000	80	95	80	1850	25000	5500	250	1150	1300	550	1200	1800	800
2007	1500	96000	96000	19000	18000	7000	7000	4000	80	95	80	1850	25000	5500	250	1150	1300	550	1200	1800	800
	1500	96000	96000	19000	18000	7000	7000	4000	80	95	80	1850	25000	5500	250	1150	1300	550	1200	1800	800
	1650	115000	97500	21000	19500	8000	7500	4000	95	100	80	1850	25000	5500	250	1150	1300	600	1300	1800	800
	1800	118500	110000	21000	20000	11000	7500	4000	95	100	80	1850	25000	5500	250	1150	1300	750	1450	1800	800
2008	2000	120000	120000	22000	15000	13000	8000	4000	100	120	80	1850	25000	5500	250	1150	1300	1000	1500	2000	800

APPENDIX VIB: HISTORICAL COST DATA (HCD) (CONT'D)

APPENDIX VII: CRITICAL VALUES OF Z FOR VARIOUS SAMPLE SIZES OF N

N	Critical Z	N	Critical Z
3	1.15	27	2.86
4	1.48	28	2.88
5	1.71	29	2.89
6	1.89	30	2.91
7	2.02	31	2.92
8	2.13	32	2.94
9	2.21	33	2.95
10	2.29	34	2.97
11	2.34	35	2.98
12	2.41	36	2.99
13	2.46	37	3.00
14	2.51	38	3.01
15	2.55	39	3.03
16	2.59	40	3.04
17	2.62	50	3.13
18	2.65	60	3.20
19	2.68	70	3.26
20	2.71	80	3.31
21	2.73	90	3.35
22	2.76	100	3.38
23	2.78	110	3.42
24	2.80	120	3.44
25	2.82	130	3.47
26	2.84	140	3.49

Source: Motulsky, (2002)

APPENDIX VIII: QUESTIONNAIRE

*Developing a proactive cost management model for building construction projects in Nigeria*A PhD degree research questionnaire, Dept. of Building, ABU Zaria, by Gandu Yusuf Joe.

Dear Sir,

The following factors do impede cost objectives in building project procurement. From your experience, kindly rate the frequency of occurrence and the extent of negative impact for each factor (0-means low, 5- means high impact).

A. Personal information

1. Your profession Architect ◇ Q/Surveyor ◇ Engineer ◇ Builder ◇
2. Type of degree OND ◇ HND ◇ BSc ◇ MSc ◇ PhD ◇ ◇
3. Years of experience 0-2yrs ◇ 5yrs 6-10yrs ◇ 10yrs and above ◇
4. Type of organization working, Contracting ◇ Consulting ◇ Client ◇
5. Number of building projects handled 0-10 ◇ 11-20 ◇ 21-and above ◇
6. Tick locations of your projects, North ◇ East ◇ West ◇ Whole country ◇

	General factors affecting cost	Frequency					Negative impact				
		1	2	3	4	5	1	2	3	4	5
1.	Complex project										
2.	Inadequate budget for the work										
3.	Statutory authorities' interruptions										
4.	Poor risk allocation among parties to the contract										
5.	Bad general access to site										
6.	Effect of inclement weather										
7.	Non-availability of locally sourced materials										
8.	Non-availability of local labor										
9.	Non-availability of water for the work										
10.	Non-availability of electricity for the work										
11.	Poor attitudes of benefiting/neighboring communities										
12.	Poor team spirit among stakeholders										
13.	Poor information flow among stakeholders										
14.	Inflation or economic instability										
15.	Political instability and government policies										
16.	Corruption factor in the project process										
17.	Negative socio-cultural effect on the project										
18.	Wrong choice of procurement option										
19.	Wrong choice of the type of contract										
20.	Poor adoption of emerging technologies										
21.	Dispute among team members										
22.	Low frequency of site meetings										

	Client's factors affecting success	**Frequency**					**Negative impact**				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
1.	Low level of importance attached to the project by the client										
2.	Poor client's commitment to project success										
3.	Poor client's commitment to management success										
4.	Instability in client's cash flow										
5.	Poor client's credit worthiness										
6.	Poor planning by the client										
7.	Delay in approval of change request										
8.	Delay in response to interim payments										
9.	Inadequacy of client's brief										
10.	Frequent change initiated by the client										
11.	Incomplete design team appointed										
12.	Lack of full time project management engagement										
13.	Poor client's attitudes to dispute resolution										
14.	Constant interference of work progress by the client										

	Consultants factors affecting success	Frequency					Negative impact				
		1	2	3	4	5	1	2	3	4	5
1.	Poor qualification of consulting team in handling the job										
2.	Poor experience of the consultants in the kind of job										
3.	Poor commitment of consultants to the job										
4.	Incompetent staff in the consulting team										
5.	Inadequate consulting personnel for the job										
6.	Delay in designs and other documents delivery										
7.	Delay in response to calls for interim valuations										
8.	Delay in contractors' request for approvals of stage of work										
9.	Inadequate site condition and geotechnical survey information										
10.	incomplete and unclear architect's designs										
11.	Incomplete and unclear engineering design										
12.	Incomplete and unclear bill of quantities										
13.	Discrepancies in contract documents										
14.	High change frequency initiated by consultants										
15.	Poor coordination and in-cohesion in consulting team										
16.	Poor attitudes of consultants to dispute resolution										
17.	Constant architect's instructions on site										

	Contractors factors affecting success	Frequency					Negative impact				
		1	2	3	4	5	1	2	3	4	5
1.	Poor organizational setting of the constructing firm										
2.	Incompetent personnel in the constructing firm										
3.	inadequacy of relevant personnel for the work										
4.	Inadequacy of relevant equipment										
5.	Poor planning by the contractor										
6.	Poor experience of the contractor on similar jobs										
7.	Poor site layout and site organizational pattern										
8.	Poor contractor's general attitude to the work										
9.	Poor attitudes and general responses to site instructions										
10.	Delay caused by sub-contractors/suppliers										
11.	Poor cooperation among sub-contractors/suppliers										
12.	Lack of clear identification of customers and their needs										
13.	Poor process management mechanism in place										
14.	Low level of industrialization in the production process										
15.	Poor attitudes of contractor's personnel to instructions										
16.	Inadequate measure to reduce the share of flow process										
17.	Poor attitudes and poor productivity of laborers engaged										
18.	Poor attitudes to the contractor to dispute resolution										
19.	Large amount and frequency of rework due to error										
20.	Poor work break down structure										
21.	Poor transportation arrangement to and from site										
22.	Poor communication arrangement between site and head office										
23.	Unclear instructions to workers										
24.	Long distance between head office and site										
25.	Poor staff motivation scheme										
26.	Threats to Job stability of workers										
27.	Absenteeism from work due to drugs, alcohol, health										
28.	Poor health and safety measures										
29.	Delay in payment of staff emoluments										
30.	Delay in payments to sub-contractors/suppliers										
31.	Ad-hoc nature of employment of workers										

APPENDIX IX: ELEMENTAL BILL OF QUANTITIES FOR A FIVE BEDROOM TWO STOREY BUILDING

ELEMENT Nr.1 SUBSTRUCTURE

	Site Preparation		
A	Clear site ffree from bushes and shrubs and remove excavated materials from site.	532	M2
B	Excavate to remove vegetative top soil average depth 150mm.	342	M2
C	Excavate trenches to receive concrete in foundation starting from stripped level maximum depth not exceeding 2000mm	54	M3
E	Ditto columns pits not exceeding 2000m	44	M3
F	Remove from site surplus excavated materials	47	M3
G	Backfill around foundations and compacted in layers	51	M3
H	Level and compact bottom of excavation to recieve concrete	108	M2
J	"Dieldrex '20" or other antitermite solution spread to the faces of excavation in foundation	385	M2
K	450mm thick laterite filling compacted in layers	61	M3
	Concretework		
	Plain in-situ concrete (1:3:6-40mm aggregate) developing crushing strength of 21N/mm2 at 28 days in:		
L	Foundation	16	M3
	Reinforced in-situ concrete (1:2:4-19mm aggregate) developing crushing strength of 21N/mm2 in 28days in:		
M	Bed, 150mm thick	31	M3
N	Columns and column bases	16	M3
	Reinforcement		
	Round hot rolled high tensile deformed steel bar reinforcement to BS4449 and including all hooks, cutting, bending, concrete cubes, tying wire etc in:		
O	16mm diameter	618	kg
P	8mm diameter mild steel	97	kg
Q	BRC Square mesh reinforcement to BS 4483 ref 143 weighing 2.22kg sg.m lapped 200mm at all joint (measured nett)	207	M2
	Formwork		
	sawn formwork to:		
R	Edges of bed, 150mm high	97	M
S	Columns and column bases	40	M2
	Blockwork		
	Sandcrete hollow block with cavities filled solid plain in-situ concrete (1:4:8-10mm aggregate) in:		
T	230mm walls	176	M2
U	Damp proof membrane of polythene material	207	M2
	12mm thick cement and sand (1:4) rendering finished fair and smooth on block walls		
V	Plinth	62	M2
	Prepare prime and apply two undercoats and one finishing coat emulsion paint on:		
W	Rendered plinth	62	M2

SUBSTRUCTURE CARRIED TO SUMMARY

ELEMENT Nr.2 FRAMES

Concrete

Reinforce in-situ concrete (mix 1:2:4-20mm aggregate) developing crushing strenght of 21N/mm2 at 28 days in formwork well vibrated in:

A	Columns	10	M3
B	Beams	7	M3
C	Arch beam	1	M3

Reinforcement

Round hot rolled high tensile deformed steel bar reinforcement to BS4449 and including all hooks, cutting, bending, concrete cubes, tying wire etc in:

Beams, columns, arch beam

D	16mm diameter bar	2434	Kg
E	12mm diameter bar	2771	Kg
F	10mm diameter bar	867	Kg
G	8mm diameter bar	1202	Kg

Formwork

Sawn formwork to:

H	Sides of columns	176	M2
J	Sides and soffit of beams	52	M2
K	Sides and soffit of Arch beam	1	M2

12mm thick cement and sand (1:4) rendering finished fair and smooth on block walls

A	Sides of columns	176	M2
B	Sides and soffit of beams	53	M2
C	Sides and soffit of arch beam	1	M2

Prepare prime and apply two undercoats and one finishing coat of emulsion paint on:

D	Sides of columns	176	M2
E	Sides and soffit of beams	53	M2
F	Sides and soffit of arch beam	1	M2

FRAMES CARRIED TO SUMMARY

ELEMENT Nr.3 STAIRCASE

Concrete

Reinforce in-situ concrete (mix 1:2:4-20mm aggregate) developing crushing strenght of 21N/mm2 at 28 days in formwork well vibrated in:

A	Suspended landing slab, 150mm thick	3	M2
B	Slanting stair slab	2	M3
C	Steps	1	M3
D	Toe 1000 x 300 x 300mm thick	1	Nr
E	Isolated columns	2	M3
F	Attached beam ditto	1	M3

Reinforcement

Round hot rolled high tensile deformed steel bar reinforcement to BS4449 and including all hooks, cutting, bending, concrete cubes, tying wire etc in:

G	12mm Diameter bar	516.25	Kg
H	10mm Diameter bar	92	Kg
I	6mm Diameter bar	62	Kg

Formwork

Sawn formwork to

J	Sides of Isolated columns	4	M2
K	Sides of attached beam 150mm wide	6	M
L	Soffit of landing slab	6	M2
M	Slanting soffit of stair slab	15	M2
N	150mm Risers	25	M
O	Slanting sides of stair slab 150mm wide	11	M
P	Sides of landing 150mm wide	10	M

Metal work

Galvanized Iron steel pipes including cutting, welding, bolting and fixing to concrete or block work (measured separately)

Q	25mm Diameter baluster	6	M
R	20mm diameter ditto	9	M
S	Ditto top and bottom rail	16	M

Steel flats

T	150 x 3mm Thick mild steel flat handrail including drilling holes to receive bolts and welded to steel pipes (Measured separately)	8	M

Finishes

12mm thick cement and sand (1:4) rendering finished fair and smooth on block walls

U	Sides of Isolated columns	4	M2
V	Sides of attached beam 150mm wide	6	M
W	Soffit of landing slab	6	M2
X	Slanting soffit of stair slab	15	M2
Y	150mm Risers	25	M
Z	Slanting sides of stair slab 150mm wide	11	M
AA	Sides of landing 150mm wide	10	M

Prepare prime and apply two undercoats and one finishing coat of texcote textured paint on:

AB	Sides of Isolated columns	4	M2
N	Sides of attached beam 150mm wide	6	M
AC	Soffit of landing slab	6	M2
AD	Slanting soffit of stair slab	15	M2
AE	150mm Risers	25	M
AF	Slanting sides of stair slab 150mm wide	11	M
AG	Sides of landing 150mm wide	10	M

STAIRCASE CARRIED TO SUMMARY

ELEMENT Nr.4 UPPER FLOORS

Concrete work

Reinforce in-situ concrete (mix 1:2:4-20mm aggregate) developing crushing strenght of 21N/mm2 at 28 days in formwork well vibrated in:

A	Suspended slab	31	M3

Reinforcement

Round hot rolled high tensile deformed steel bar reinforcement to BS4449 and including all hooks, cutting, bending, concrete cubes, tying wire etc in:

B	12mm diameter bar	2027	Kg
C	10mm diameter bar	682	Kg

Formwork

Sawnform work to:

D	Soffit of suspended slab	207	M2
E	Edges of suspended slab	97	M

Finishes

12mm thick cement and sand (1:4) rendering finished fair and smooth on block walls

F	Soffit of suspended slab	207	M2
G	Edges of suspended slab 150mm wide	97	M

Prepare prime and apply two undercoats and one finishing coat emulsion paint on:

H	Soffit of suspended slab	207	M2
J	Edges of suspended slab 150mm wide	97	M

UPPER FLOORS CARRIED TO SUMMARY

ELEMENT Nr. 5 ROOF

Concrete work

Reinforce in-situ concrete (mix 1:2:4-20mm aggregate) developing crushing strenght of 21N/mm2 at 28 days in formwork well vibrated in:

A	Head course	5	M3

Reinforcement

Round hot rolled high tensile deformed bar reinforcement to BS4449 and 4461 including all hooks bends distance blocks tying wire etc in:

B	12mm Diameter bar	348	Kg
C	8mm Diameter bar	104	Kg

Formwork

Sawn formwork to

D	Sides of head course	44	M2

Roofing

0.55mm gauge longspan coloured aluminium roofing sheet with accessories lapped and fixed in accordance with fixing details to hard wood purlins (measured separately)

E	Roof covering	295	M2
F	600mm Ridge capping	71	M
G	600mm Valley	17	M
H	75x75mm Eave angle	75	M

Woodwork

Treated seasoned sawn hardwood in:

J	50x150mm Hardwood rafters	285	M
K	50x150mm Hardwood tie beam	221	M
L	50x100mm Hardwood struts	323	M
M	50x75mm Hardwood purlins	307	M
N	25x300mm Wrought hardwood fascia board	72	M

Knot, prime and stop and paint one undercoat and two finishing coats of 'Berger' or other equal and approved gloss paint on the surfaces of

P	Surfaces of facia board	25	M2

ROOF CARRIED TO SUMMARY

ELEMENT Nr.6 EXTERNAL WALLS

Blockwork

Sandcrete hollow block work in cement and sand mortar (1:4) in :

A	225mm External wall	502	M2

EXTERNAL WALLS CARRIED TO SUMMARY

ELEMENT Nr.7 INTERNAL WALLS AND PERTITIONS

Blockwork

Sandcrete hollow block work in cement and sand mortar (1:4) in :

A	225mm Internal and partition wallS	143	M2

INTERNAL WALLS AND PERTITIONS CARRIED TO SUMMARY

ELEMENT Nr. 8 WINDOWS

Concretework

Reinforce in-situ concrete (mix 1:2:4-20mm aggregate) developing crushing strenght of 21N/mm2 at 28 days in formwork well vibrated in:

A	Lintel	3	M3

Reinforcement

Round hot rolled high tensile deformed bar reinforcement to BS4449 and 4461 including all hooks bends distance blocks tying wire etc in:

B	12mm Diameter bar	209	Kg
C	8mm Diameter bar	65	Kg

Formwork

Sawn formwork to

D	Sides and soffits of lintel	25	M2

Supply and fix factory glazed standard aluminum sliding windows fixed complete to block or concretework including pointing all round with waterproof sealant

E	Doubleleaf, double sliding size 1500 x 1200mm high	9	Nr
F	Ditto size 1500 x 900mm high	1	Nr
G	Ditto size 1200x1200mm high	17	Nr
H	Ditto size 1200 x 900mm high	1	Nr
J	Ditto size 900 x 900mm high	1	Nr
K	Ditto size 900 x 600mm high	5	Nr
L	Singleleaf size 600 x 600 mm high	1	Nr

Knot, prime and stop and paint one undercoat and two finishing coats of 'Berger' or other equal and approved gloss paint on the surfaces of

M	Metal surfaces not exceeding 230mm wide	55	M

WINDOWS CARRIED TO SUMMARY

ELEMENT Nr. 9 DOORS

Concrete work

Reinforce in-situ concrete (mix 1:2:4-20mm aggregate) developing crushing strenght of 21N/mm2 at 28 days in formwork well vibrated in:

A	Lintel	2	M3

Reinforcement

Round hot rolled high tensile deformed bar reinforcement to BS4449 and 4461 including all hooks bends distance blocks tying wire etc in

B	12mm Diameter bar	139.3333	Kg
C	8mm Diameter bar	43	Kg

Formwork

Sawn formwork to

D	sides and soffits of lintel	17	M2

Supply and fix solid core flush door complete with metal frame and ironmongery obtainable from an approved manufacturer.

E	Size 900x2100mm High	11	Nr
F	Size 750x2100mm High	7	Nr

Supply and fix standard aluminum swing door obtainable from an approved manufacturer

G	Double leaf,1200 x 2100mm High	2	Nr.
H	Single leaf size 900 x 2100mm High	4	Nr.

Knot, prime and stop and paint one undercoat and two finishing coats of gloss paint on

	General surface of metal work	58	m2
J	Metal surfaces not exceeding 230mm wide	36	M

DOORS CARRIED TO SUMMARY

ELEMENT Nr. 10 FITTINGS AND FIXTURES

Concrete work

Reinforce in-situ concrete (mix 1:2:4-20mm aggregate) developing crushing strenght of 21N/mm2 at 28 days in formwork well vibrated in:

A	Wardrobe and kitchen slab	3	M3

Reinforcement

Round hot rolled high tensile deformed steel bar reinforcement to BS4449 and including all hooks, cutting, bending, concrete cubes, tying wire etc in:

B	12mm diameter bar	120	Kg

Formwork

Sawnform work to:

C	Soffit of wardrobe and kitchen slab	8	M2
D	Edges of wardobe and kitchen slab	13	M

Finishes

12mm thick cement and sand (1:4) rendering finished fair and smooth on block walls

E	Soffit of wardrobe and kitchen slab	8	M2
F	Edges of wardobe and kitchen slab 150mm wide	13	M

Prepare prime and apply two undercoats and one finishing coat emulsion paint on:

G	Soffit of wardrobe and kitchen slab	8	M2
H	Edges of wardobe and kitchen slab 150mm wide	13	M

FITTINGS AND FIXTURES CARRIED TO SUMMARY

ELEMENT Nr. 11 FLOOR FINISHES

Cement and sand screed to general surfaces to receive further finishes

A	50mm Screeded bed	414	M2

Glazed ceramic floor tiles of approved colour bedded and jointed in cement and sand floated bed (measured separately) with and including pointing with matching cement mortar on:

B	Screeded bed (measured seperately)	414	M2
C	100mm Skirting	298	M

FLOORS FISHES CARRIED TO SUMMARY

ELEMENT Nr. 12 WALLS FINISHES

Internal work

12mm thick cement and sand (1:4) rendering finished fair and smooth

A	Walls	1315	M2
B	Reveals not exceeding 230mm wide	295	M
C	200mmx200mmx6mm thick white glazed ceramic wall tiles bedded and jointed in floated backing (m.s.) and pointed all round in white cement	135	M2

Prepare and apply Berger Texcote or other approved textured finish on:

D	Rendered walls	1315	M2
E	Reveals not exceeding 230mm wide	295	M

External work

12mm thick cement and sand (1:4) rendering finished fair and smooth

F	Walls	345	M2
G	Reveals not exceeding 230mm wide	266	M

Prepare and apply Berger Texcote or other approved textured finish on:

H	Rendered walls	345	M2
J	Reveals not exceeding 230mm wide	266	M

WALLS FINISHES CARRIED TO SUMMARY

ELEMENT Nr. 13 CEILING FINISHES

Internalwork

12mm thick cement and sand (1:4) rendering finished fair and smooth on:

A	Soffit of suspended slab	207	M2
B	2400x1200x8mm Celotex ceiling lining fixed to hardwood noggins (measured separately)	207	M2

Treated seasoned sawn hardwood in:

C	50x50mm Hardwood noggins	783	M
D	Batten	783	M

Prepare and apply three coats of emulsion paint on:

E	Ceiling soffit	207	M2
F	Suspended slab soffit	207	M2

Externalwork

G	2400x1200x8mm Celotex ceiling lining fixed to hardwood noggins (measured separately)	43	M2

Treated seasoned sawn hardwood in:

H	50x50mm Hardwood noggins	163	M

Prepare and apply three coats of Berger emulsion paint on:

K	Ceiling soffit	43	M2

CEILING FINISHES CARRIED TO SUMMARY