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A Qualitative –Quantitative Model of Cost Estimate for Construction Projects in Yemen

نموذج وصفي - كمي لتقدير تكلفة مشاريع التشييد في اليمن

A thesis submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy in Architecture Engineering.

by
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DEDICATION

Dedicated to my beloved wife, daughter, and son (Doa'a and Mohammed) for their everlasting support, patience, and encouragement to complete this PhD works.

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ABSTRACT

Success of construction projects depends on many factors; most important are cost, quality, and time. Concerning cost, the cost estimate can lead the construction firm to huge losses and the correction action cannot be taken. In Yemen, the basic problem that construction firms face is how to make accurate cost estimate for both preliminary and detailed estimates. There were two objectives to conduct this study, which were: to identify the knowledge of cost estimate in construction management, and to obtain mathematical (quantitative) and frameworks (qualitative) models to estimate accurately construction cost in Yemen. In order to achieve these objectives, five questions were asked. The methodology of this study was to use both qualitative and quantitative methods. As well, the adopted strategies were literature review, questionnaire survey, structured interview, and case study. Comprehensive literature review has been undertaken to gather the information about the knowledge of construction cost estimate and both preliminary and detailed estimates. Nineteen hypotheses have been proposed from the literature review and previous researches to construct the theoretical model for qualitative model (detailed). The quantitative model (preliminary) was also proposed depending on the literature review and previous researches; so both the first and second objectives were achieved and the first and second questions were answered. The field survey was conducted through a questionnaire, which was reliable and valid based on statistical methods. The data from field survey for 79 factors of scales and from cost form were used to test both qualitative and quantitative models of this study. Then, the second objective was confirmed and the third question was answered. The models development were done by the structured interview from the point of views of interviewees. Therefore, the fourth question for this study was answered. In addition, the case study was undertaken to practice both preliminary and detailed models. Consequently, the fifth question for this study was answered. One of the conclusions reveals that the quantitative model can measure the qualitative model's output perfectly. Further, one of recommendations is recommended that the firms should enhance the knowledge of cost estimate through several trainings for their estimators.

ABSTRACT IN ARABIC (مستخلص)

يعتمد نجاح مشاريع البناء على عوامل كثيرة، أهمها: التكلفة، والجودة، والوقت، وفيما يتعلق بالتكلفة، فإن تقدير التكلفة قد يؤدي بشركة التشييد الى خسائر مهولة، وحينها ستكون الإجراءات التصحيحية غير مجدية، وفي اليمن، المشكلة الأساسية التي تواجه شركات التشييد هي كيفية عمل تقدير دقيق لكلا التقديرين: المبدئي و التفصيلي. وكان هنالك هدفان لإجراء هذه الدراسة وهما: تحديد المعرفة في علم تقدير التكاليف في إدارة التشييد، و الحصول على النموذج الرياضي (الكمي) و النظري (الوصفي) لتقدير تكلفة التشييد بدقة في اليمن. ولتحقيق هذين الهدفين، اعتمدت الدراسة على خمسة أسئلة. استخدم في منهجية هذه الدراسة المنهجان: الوصفي والكمي، وكانت الإستراتيجيات المعتمدة في هذه المنهجية هي: مراجعة الأدبيات، الإستبانة، المقابلة الشخصية، و دراسة الحالة، حيث أدت أدبيات البحث إلى جمع المعلومات حول المعرفة في تقدير تكاليف التشييد، وكلا التقديرين: المبدئي والتفصيلي. كما أَقترحت 19 فرضيةً من أدبيات البحث والدراسات السابقة؛ لبناء النموذج النظري الوصفي (التفصيلي)، وبالإضافة تم اقتراحُ النموذج الكمي بناءً على أدبيات البحث والدراسات السابقة أيضاً؛ لذلك اتضح الهدف الأول والثاني للدراسة، وتمت الإجابة عن السؤالين: الأول والثاني. تم إجراء المسح الميداني عن طريق الإستبانة، التي تم اختبارها من حيث الواقعية والتثبتية وفقاً للاختبارات الإحصائية، وقد استخدمت بيانات المسح الميداني لـ 79 عاملاً، وأيضاً من واقع بيانات استمارة التكاليف؛ لإختبار كلا نموذجي الدراسة: الوصفي والكمي، وبالتالي تأكد تحقيق الهدف الثاني للدراسة، وتمت الإجابة عن السؤال الثالث. وقد أَجري تطوير نماذج الدراسة من خلال المقابلة المنظمة من وجهة آراء الذين تم مقابلتهم، و تمت الإجابة عن السؤال الرابع لهذه الدراسة. بالإضافة إلى ذلك، تم تنفيذ دراسة الحالة بغرض ممارسة و تطبيق كلا نموذجي الدراسة للتقدير المبدئي والتفصيلي، وبذلك تمت الإجابة عن السؤال الخامس في هذه الدراسة. كما أن أحد الإستنتاجات يظهر قدرة النموذج الكمي لقياس مخرجات النموذج الوصفي بفعالية، وعلاوة على ذلك، قامت الدراسة بجملة من التوصيات منها, يجب على الشركات تعزيز معرفة مقدري التكاليف لديها من خلال إعطائهم دورات تدريبية متعددة.

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List of Symbols

X	Inputs	
W	Weight	
Y	Activation of the processing element ………………	Eq. (3-1)
θ	Threshold value	
∂	Output value	
y_i	Final (true) output values	
$\hat{y}_i$	Output of network	
N	Total number of observations ………………………	Eq. (3-9)
MSE	Mean-square error	
n	Number of examples ……………………………….	Eq. (3-10)
x_i	Network output ……………………………………..	Eq. (3-10)
E(i)	Desired output ……………………………………...	Eq. (3-10)
P	Number of output PEs ……………………………...	Eq. (3-11)
N	Number of exemplars in the data set ………………	Eq. (3-11)
dy_{ij}	Denormalised network output for exemplar i at PE j	
dd_{ij}	Denormalised desired output for exemplar i at PE j	
y_{ij}	Network output for exemplar i at PE j	
d_{ij}	Desired output for exemplar i at PE j	
R	Correlation Coefficient	
$\bar{x}$	Mean value over all output of network	
$\bar{d}$	Mean value over all desired output	
N	The total number of observations …………………..	Eq. (3-14)
n	The number of the outputs in the sample …………..	Eq. (3-15)
σ	standard deviation	
n	Size of sample ……………………………………...	Eq. (5-1)
z	Standard variate at a given confidence level	
p	Sample proportion ………………………………….	Eq. (5-1)
e	Acceptable error	
N	Size of population ………………………………….	Eq. (5-1)
X_2	Construction cost classification	
X_3	Cost estimation methods and techniques	
X_4	Types of contracts and delivery systems	
X_5	Critical factors	
X_7	Safety considerations	
X_8	Cost index	
Y_1	Knowledge of Cost estimate ……………………	Eq. (6-1)
X_{10}	Base estimate	
X_{11}	Measurements	
X_{12}	Querying	
X_{13}	Pricing	
X_{14}	Management review	

X_{16}	Knowledge of cost estimate	
Y_2	Final detailed cost …………………………........	Eq. (6-2)
Y_3	Base estimate ……………………………………	Eq. (6-3)
Y_4	Measurements …………………………………..	Eq. (6-4)
Y_5	Pricing …………………………………………..	Eq. (6-5)
Y_6	Management review …………………………….	Eq. (6-6)
Y_7	Bid summary ……………………………………	Eq. (6-7)
GDP	Gross domestic product	
LDC	Least developed Countries	
UNDP	United Nations Development Programme	
UN	United nation	
HDR	Human Development Reports	
WDI	World Development Indicators	
RIBA	Royal Institute of British Architects	
AACE	Association for the Advancement of Cost Engineering	
CER	Cost Estimation Relationships	
OSHA	Occupational Safety and Health Administration	
ANN	Artificial Neural Network	
KCE	Knowledge of cost estimate	
NN	Neural network	
SIC	Standard Industrial Classification Manual	
MLP	Multi-Layer Perceptron	
GFF	General Feed Forward	
RMSE	Root mean square error	
MAE	Mean Absolute Error	
RA	Regression analysis	
SVM	Support vector machine techniques	
WBS	Work Breakdown Structure	
RBS	Resource breakdown structure	
UK	United Kingdom	

CHAPTER I: INTRODUCTION

1.1 Background

Many factors that affect the construction project success, such as time, quality, and cost which considering the most important variables that should be investigated. Thus, Cost estimating is the most important activities during various project stages. Cost estimating may be a challenge task when the limitation of availability of information and other factors are happened. In the construction industry, a company' s success can be directly related to its ability to estimate a project accurately and to control costs and complete the project within budget.

Thus, the role of the estimator is vital for organisation leading to the success of the organisation. The estimator is also responsible for forecasting the costs for construction in a way that is both clear and consistent. Lack of time and information, and complexity of the building project allocated for cost estimating often lead to a poor performance in estimate. An estimate depends on the experience of the estimator who may be the best and fastest method to produce quality cost estimate, also is gained the knowledge embedded in his head.

Furthermore, the cost estimate can be classified according to the function of estimate with regards to the various stages, design estimate, bid estimate, and control estimate. Design estimate can be used in feasibility stage, and can be called an order of magnitude estimate, conceptual estimate, or preliminary estimate. While, detailed estimate (bid estimate and controlled estimate) is used when the scope of the project has been defined. However, detailed estimate is always determined by the time and efforts, which align with the available resources. The final account almost is greater than preliminary estimate of preconstruction stage.

Therefore, many researches cover the early stage estimate (preliminary estimate) and a few researchers cover the detailed estimate at tender stage. At preliminary estimate, the focusing is on the modern techniques such as artificial neural network, multiple regression, and fuzzy.

Hunter studied the cost estimation in the preconstruction stage and developing framework focusing on the type of estimation and factors affecting the cost estimation. The multiple regression, decision tree, & neural network were used in his model. In addition, Kim et al stated that the cost estimation in the early stage wasn't accurate due to incomplete drawings. Consequently, three various techniques had been applied and compared to the accuracy of three estimating techniques, regression analysis, neural network (NN), and support vector machine techniques to perform the cost estimate by using a historical data. As well, Shehatto discussed the needs of estimation of high degree of accuracy and without the need for detailed information or drawings to satisfy the parties of the project (Clients, Donors, Consultant, and Contractors). The Artificial Neural Network (ANN) model was used as new approach in cost estimation as preliminary estimate.

Furthermore, Leng developed his model to satisfy the contractor requirements in tender stage has model which was aimed to detailed estimate to ensure high accurately estimate. As well, Washington State and Pratt were used a detailed estimate model for tender stage. It was supposed to get a highly accurate estimate.

1.2 Problem Statement

In Yemen, clients and contractors firms may get inaccurate estimation for their projects. Consequently, they face such problems as disputes, projects delay, and cost overruns with regards to cost estimate.

Moreover, Construction projects become more complex, size, and very huge demand. They have to be success according to the way of correct budget due to the right estimation by the estimators. The basic problem that facing the construction firms is how the firms can make accurate cost estimate for their construction projects for both early stage and tender stage to satisfy the involved parties.

1.3 Research Objectives

Based on the current situation of firms in Yemen, and the prediction’s experience in Yemeni’s construction field, this study targets to achieve the following objectives:

1. To identify the knowledge of cost estimate in construction management; in order to determine the variables that will be used in the models.
2. To obtain a mathematical (quantitative) and frameworks models (qualitative), which may be used to estimate the accurate construction cost in Yemen.

1.4 Research Questions

Based on the objectives of this study, brainstorming, contacting with key personnel in construction field in Yemen, the following questions have been suggested:

Q1: What is the knowledge of cost estimate in construction management?

Q2: What are the quantitative and qualitative models can be used to estimate the construction cost?

Q3: What are the effects of qualitative and quantitative models' implementation on construction projects in Yemen?

Q4: What development kind of models should be applied in order to guide the construction firms in Yemen?

Q5: How these models can be applied in practice?

1.5 Research Hypotheses

Many hypotheses have been proposed in order to construct the theoretical model to fit with the structure equation modelling and can be summarised as the following:

- H:Independent variables (social and economic system of Yemen, understanding of construction cost classification, construction cost estimation methods and techniques, understanding the types of contracts and delivery systems, understanding the critical factors, understanding the cost control process, understanding the safety considerations, and cost index) have a positive effect on knowledge of cost estimate.
- H: Independent variables (base estimate, correct way of measurements, bid summary, and knowledge of construction cost estimate) have a positive effect on final detailed cost.
- H: Measurements and query list have a positive effect on pricing process.
- H: Pricing process has a positive effect on management review's process.
- H: Management review's process has a positive effect on bid summary.
- H: knowledge of construction cost estimate has a positive effect on base estimate, measurements, and pricing.

Another one hypothesis was proposed to investigate the relationship between the preliminary estimate and final detailed cost as the following:

- H: Preliminary estimate has a significant correlation with the final detailed cost

1.6 Research Limits

This study investigated both preliminary and detailed estimate models, which may help to estimate the construction projects cost accurately in both early stage and tender stage in Yemen from end of 2014 to the end of 2017. Therefore, the population of study was the engineers of construction firms in Sana'a and Hodeida provinces in Yemen, and their responses were collected.

1.7 Research Scope

The major scope of this study is to develop mathematical and frameworks models which can be used for estimating the construction projects in Yemen for both preliminary estimate and detailed estimate. These models may help the firms to make their estimate accurately.

1.8 Research Methodology

The study started with identifying the problem statement, study the extensive literature review, data collection, analysis and discussion of results, develop the models, practice the models, and conclusions and recommendations. One important way to strengthen a research design is to use both qualitative and quantitative methods. Figure (1.1) shows a flowchart of the research methodology in order to achieve the objectives of the study. The adopted strategies in this research were the literature review, questionnaire, structured interview, and case study. Comprehensive literature review had been conducted to gather the information on both preliminary and detailed estimates. Questionnaire survey was designed based on literature review. In addition, the structured interview was done in order to develop the models. As well as the case study was performed producing the practicing for models in the field.

1.9 Structure of Thesis

Chapter **1** presents a brief description about the thesis. As well, chapter **2** presents a wide view of construction industry in developing countries and in Yemen especially. Project life cycle is discussed and the knowledge of construction estimates is covered. Eight hypotheses are proposed in order to construct the qualitative model of this study.

Chapter **3** focuses on the preliminary estimate techniques. One hypothesis is suggested concerning quantitative model, ANN model is debated and formulated.

Chapter **4** discusses the detailed estimated as well as eleven hypotheses are proposed to share into qualitative model construct. Therefore, the model of this study are constructed. In addition, the research methodology and the analysis technique literatures are debated.

Chapter **5** appears the research methodology of this study; the adopted strategies of this study which are literature review, questionnaire survey, structured interview, and case study. The subjects of how to develop the research questionnaire and structured interviews, how to design and develop the questionnaire survey and structured interviews, and how to perform the case study are discussed. Furthermore, the instrument evaluation is conducted with regards to reliability, and validity.

Chapter **6** presents the analysis of both qualitative and quantitative models and their interpretations for the results. Therefore, the models test are done according to statistical tests.

Chapter **7** provides the model developments in detail, as well as how to formulate the improvement plan, which is used in case study. Furthermore, this chapter reveals the case study firm's details and its potential weakness that is the base of formulate the improvement plan. Therefore, the improvement plan is applied into two stages for covering the eight weakness areas of firm and to practice both qualitative and quantitative models.

Chapter **8** presents the conclusion of this study, general recommendation, future research's recommendation, and the limitation of this study.

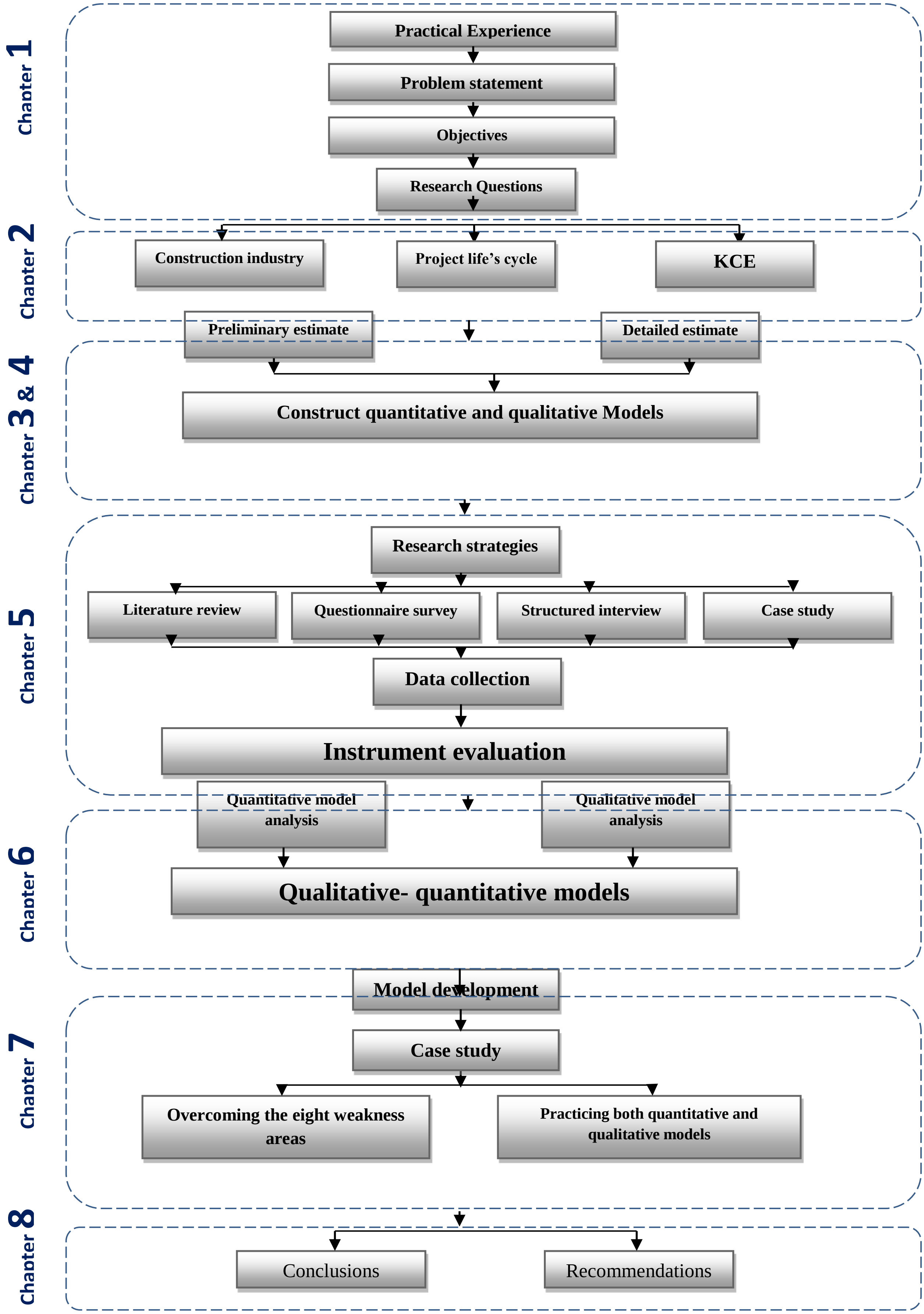


Figure 1.1 Flowchart of the research methodology, Author

CHAPTER II: KNOWLEDGE OF CONSTRUCTION COST ESTIMATE

2.1 Introduction

This chapter focuses on construction industry description as general and in Yemen in specific, which includes features of society, the economy, construction cost, and cost estimate practice. As well, explains the project's life cycle with regards the cost estimate. Furthermore, the literature review presents the knowledge of cost estimate. More accurately, it describes the type of cost estimate and the type of cost as well as the construction project's adopted cost. In addition, techniques of cost estimate covers the techniques that are mostly used in cost estimate.

Project delivery system and type of contract are discussed from estimate point of view, which is adopted in this study. In addition, the factors, which affect the construction estimate are clearly defined and mentioned. Sections (2.13) and (2.14) cover cost control and safety matters with regarding estimate respectively. As well, the cost index is described and explained. Finally, the summary describes this chapter shortly.

2.2 Construction Industry

The construction industry is one the largest industries in the global world, helping to build environment within which most other economic activities take place. Buildings and other construction products have influenced on social activity in modern society. Thus, the understanding of its nature is crucial at both macro and micro levels in the management of the industry and its constituent organisations (Hakami, 2012, Akintoye, 1991), Behm (2008) explained that the construction nature is a large, complex industry sector and dynamic, as well as playing important role in united state economy. Its workers and employees have the abilities to build our roads, houses, workplaces and repair, and maintain our nation's physical infrastructure. In addition, the construction industry employed 7% of the workforce in 2004, and in 2008 accounted for 23% of all work-related fatalities in the United States.

Popescu et al. (2003) mentioned that the division of construction by the Standard Industrial Classification Manual (SIC) in1987 was into three broad types: building construction, which belongs to general contractors or operative builders; heavy construction, which is done by general contractors and high specialty trade contractors; and construction done by special contractors such as electricians, plumbers, and painters.

Furthermore, Jackson (2010) argued that the construction industry is varied and vast, considering from homes to highways to hospitals, built political capitals, and great cities bustling. Construction is also big business, totalling more than $3.9 trillion annually worldwide, The industry employments are about million people who are directly (plumbers, carpenters, welders, and so on) and hundreds of thousands more indirectly. It assists the steel, lumber, carpet, furniture, paint, concrete, and paving industries, and so on. It expands trucking, manufacturing, shipping, and mining industries. Architects, engineers, draftspeople, building inspectors, code officials, and other professionals have familiarised in this industry.

Construction industry includes many business including constructed buildings, set-up and complete engineering projects, subdivide land for sale as potential building sites and site preparing. In addition, this industry exposure for alterations, additions, new developments or maintenance and repairs (An, 2004).

2.2.1 Construction industry in developing countries

Sultan (2005) explained the construction industry in developing countries might be viewed as a sector of the economy, which is responsible for the planning, design, construction, maintenance, and eventual demolition of buildings and works. It is essentially a service industry, obtaining its inputs from various sectors of the economy with which it is interrelated and interlinked in complex ways. The importance of construction to developing countries derives from its role in the generation of constructed physical facilities and employment, which, in turn, plays a critical and highly visible role in the process of development. In developing countries, the difficulties and challenges in the construction industries are present alongside a general situation of socio-economic stress, constant resources shortages, and a general inability to deal with the main issues. Hakami (2012) also specified that the development in the construction industry is increasing in size, technological complexity, interdependencies, and variations in demand from the client. The scope of construction industry is very wide, including residential construction, building construction of commercial, irrigation, roads, tunnels, transportation, facility building, and heavy engineering construction refer to infrastructure construction and industrial construction that need specialist expertise and contributes substantially to the economic growth of country.

2.2.2 Construction's GDP and the level of per capita national income

The relation between the construction and economic development has been found a positive effect between construction in GDP and the level of per capita national income. Turin (1967) mentioned that there is value–added between in GDP and per capita GDP regarding construction. In addition, Turin (1967) and Drewer (1980) subsidised that there is a relation between construction activity and economic development, consequently, the positive correlation between GDP per capita and construction output is indeed crucial matter. Lopes (1998) discussed that a long-term leads to decrease growth in GDP per capita according to construction volume. Consequently, when the GDP per capita increased in countries, the volume of construction increased also. On the other hand, the countries that the GDP per capita had decreased, the construction volume also decreased.

Some of researchers confirmed a relationship between GDP per capita and different measures of construction industry activity such as (Turin, 1967, Wells, 1985), as well as, Wells (1986) stated that the shared in construction GDP for national income per capita can be found if this relationship occurs in a country at a given point in time. Thus, the direct relationship between the construction sector and the economy development is more effective than development pattern downturn. Also, Tse and Ganesan IV (1997) revealed that the construction flow tends by the GDP not vice versa as well as an increase in income output affected by the expansion of construction activity.

Sultan and Kajewski (2003a) pointed out the construction contribution within 3-5% to GDP leads the construction industry grows faster than the economy as well as Han and Ofori (2001) have also confirmed this. Moreover, Hillebrandt (1984) subsidised that the purchasing reduction power might affect the construction industry from the output perspective, so if the output is down the investment is down.

On this side, An (2004) revealed that the construction industry yielded 4.4 per cent of the Gross Domestic Product (GDP) or $480 billion in 2003, as well as employing 28 per cent of workers who worked in goods-producing industries, including manufacturing, natural resources, and mining. In addition, 5.2% of the national workforce was employed by construction industry. Consequently, the construction industry is estimated to be among the economy's top 10 largest sources of employment growth through the following decades.

2.3 Yemen and construction industry

Yemen, which situated along the south eastern edge of the Arabian Peninsula, has an area of some 531,870 square kilometres and an increasing population of over 27447600 people. Sultan (2005) mentioned that the construction industry in Yemen has played key role in the economy which led to value-added in construction decreased from eight in 1975 and it employed 6.6% of the total workforce; construction activities in 1993 were raised and were down by 17% in 1994.

Moreover, Sultan and Alaghbari (2014) revealed that the construction industry in Yemen has many development constraints which is becoming challenging in Yemen, such as the inadequate implementation of appropriate building material and labour construction technologies. Consequently, it leads to consumes up to 90% of the initial expenditure in the overall process of a project. Further, construction activities have excessive waste and high costs, as well as the contribution was low in 2003 on which was 3.4% of value added in construction. In addition, construction industry in Yemen faces the shortage of adequately professional and skilled personnel in many sectors of construction projects.

Sultan and Kajewski (2003b) explained that the Yemeni construction industry's state which consisted of uniform style of the traditional Yemeni architecture, unique building tradition and townscape. In the past years, these building were successfully maintained by local skill labours. In addition, the rapid change from the traditional towards the modern style is controlling the mind of people. Of prime importance, SFD (2013) is a responsible about many types of development projects in Yemen. One of those projects is the culture heritage sector, which contributes to restore and save the country's rich to preserve both tangible and intangible assets, for instance, restoring project of the great mosques, paving streets of ancient cities, and strengthening and restoration the historic schools. It is important to mention that the approved projects since 1997-2013were 284 projects (20 in 2013) costing US 62570600 (US 5752300 in 2013) as well as the workforce was 275158 employees in 2013. In addition, Sultan and Kajewski (2003b) stated that the inadequacies in building materials, in design, and project management potential caused further hindrance.

Moreover, Crochet (2011) revealed that Yemen established a large primary road network given its level of GDP and population size as well as the Yemen network road was appeared better than any in most comparator countries, in addition, the annual allocation of funds of roads was insufficient and far below comparing to other countries as the same in Yemen.

Many difficulties faced the construction industry development in Yemen, which were administrative problems and red tape, the availability of materials, the availability of skilled labour, informal sector, the availability of specifications, inadequate supply of affordable land, lack of research and experimental projects, and lack of standardisation of local materials. As well, the more difficulties were inadequate supply of infrastructure, inappropriate law and legislation, poor utilization of local building technologies, inadequate of finance system, and poor utilization of local building materials (Sultan and kajewski, 2004).

Sultan and Kajewski (2003a) summarised the difficulties associated with the Yemen construction industry, which may be the unstable prices, high construction cost, inefficient planning, and weak contribution to the socio-economic development.

Industry characterises one of important of the national economy which contributes with the ratio of (10 - 15) % in GDP excluding oil industries; food industries are ranked the first and then construction industries which is in cement product, then tobacco and metals products (Embassy of the republic of Yemen, 2014).

2.3.1 Features of Yemeni's community

Sultan and Kajewski (2003b), Sultan (2005) and USAID (2014) explained the situation of Yemen as the poorest countries in the world with low standards of facilities and high growth rate of population. In addition, Yemen was ranked 154 of 182 countries in 2014 and 2015 on UNDP's Human Development Index as well as the GDP per capita was 3.8 and within the 44 LDC (Least developed Countries) in 2014. Before 1990, Yemen was divided into two political systems, Communist People's Democratic Republic of Yemen in the south, and the conservative, tribal Yemen Arab Republic. After uniting and form the Republic of Yemen, Sana'a in the north became its capital and Aden in the south as its economic centre. Yemen's GDP has been enhanced by remittances from Yemenis working in other countries and by aid of foreign, but after the Gulf crisis, remittances dropped substantially. Therefore, the need for the housing and other facilities projects remittances accordingly have dropped substantially.

Recently, USAID (2014) pointed out that the Yemen is a country in transition as a fragile state according to conflict-afflicted, impoverished, and in a critical post-revolutionary stage. More than half population have suffered chronic hunger, no access to safe water and sanitation, unemployment, and poverty regarding to political tension. The ownership and exploitation of resources are controlled by elite segments of society.

The important feature of society in Yemen is the tribes, which are culturally homogenous units not ethnically diverse. They are promoting the welfare of their members as well as have a conflict management mechanisms and systems. After political instability that Yemen skilled for the last periods of its history, tribes became functionally as states. Also, Yemenis have relied on tribal traditions to control conflict and launch justice, in addition, tribal law has effectively handled between tribes and extractive companies (Al-Dawsari, 2012).

Furthermore, that features of Yemeni communities have big influences on the construction projects by accept or reject those projects due to their mentalities and loyalties to tribe, which was clear from the author experience, for instance, small project was planned in 22 days; unfortunately, it was executed for 180 days making losses in time, money and the benefits.

However, the main problem was conflict between members of that tribal community which had led to these losses.

In addition, Ministry of oil and minerals (2010) stated that the social matters can affect the projects such as one case at Suth al-Zafim near Amran, the project's waste stone was prevented from depositing down slope into the valley (wadi) for their own reasons.

2.3.2 The Economy of Yemen

Engelke (2012) debated the economy of Yemen, in which; the events of 2011 were multifaceted and complex and economy growth was slow and service delivery was generally observed to be poor. On average of over the past decade, the economy was growing 4% a year; on the other hand, was unable to produce significant positive per capita growth as well as the Poverty raised from 35% in 2006 to 42% in 2011 and 54.4% in 2012. The private sector was affected by 2011 events, which estimated to losses range between $8-17 billion. In addition, the Public sector operations had severely disrupted with significant displacement of employees in more insecure governorates.

In the past 1990, the economic was started to deteriorate due to many causes which was mainly the Gulf Wars as well as the civil war in 1994 was also one of those causes to deteriorate the economy. With returning to the UN Human Development Reports (HDR) and the WB World Development Indicators (WDI) in the same period, there was no indication of any significant development. On the contrary, the construction activities were degeneration due to expulsion of over 1 million Yemenis by the gulf due to the war of 1991(Sultan and Kajewski, 2003a, Sultan and Kajewski, 2003b)

Recently, industry represents one of the key components of the national economy and contributes with the ratio of (10 – 15) % excluding oil industries. As for the contribution of these industries to the GDP, food industries are ranked the first and then construction industries the main ones are: cement, then tobacco products and metals with the exception of the oil industries (Embassy of the republic of Yemen, 2014).

2.3.3 Construction costs

A study conducted by Sultan and Kajewski (2003b) subsidised that the increase in rates of building construction costs was much faster than the inflation in 1990 regarding to input materials such as steel, brick, cement, and other materials of building which also led to increase the labour cost around 20% to 25% annually even when inflation was low. Also, Sultan (2005) mentioned that the effect of cost increase appeared in building quality and housing size which were also indications to the rapid increase in cost of construction.

Notwithstanding, the traditional construction in 1972 was more economical then in 1982 due to materials' expensive price and due to scarcity of skilled and semi-skilled labour to neighbouring countries.

Alaghbari et al. (2012) discussed that the factors that affecting the housing cost in Yemen; those factors were classified to factors related to land, factors related to materials used, factors related to finishing works, factors related to construction methods used, and external factors influencing cost of project construction. Therefore, the following ten factors were ranked respectively due to their effects on the cost; cost of project land, cement, steel for reinforced concretes, economic condition and incertitude cost of exchange, money, concrete frames used, relation between projects location, services, and transportation, materials available in local market, political condition, transportation and fuel cost, and Tools and equipment's available in local market.

2.3.4 Construction cost estimate

According to the author's experience in the field of construction, estimate method in Yemen uses the traditional methods for unit price as meter square, cubic meter as well as the analogous estimate is used within the similarities between the projects. In the formal construction projects, there are bill of quantity, which represents the costs of the project components, but in contrast, the estimation also by the traditional method, which accounts the determined unit cost ignoring other shared cost in the project and the systematic process.

Therefore, there was one hypothesis was proposed:

H1: The social and economic system of Yemen has a positive effect on knowledge of cost estimate.

2.4 Project's Life Cycle

Kerzner (2009) debated that the phases generally are found in certain industries are start-up, main phase, definition, and the termination phase as well as the computer programming industry uses the conceptual, planning, definition, and design and conversion phases.

It was mentioned that the Royal Institute of British Architects (RIBA) Plan of Work use a number of key work phases that are almost suited for projects within the built environment in order to organise the process of managing and designing building projects and administering building. The phases are: preparation, design, pre-construction, construction and use phase (Zulch, 2012).

Another concept was obtained by Burke and Barron (2014) who stated that the project's life cycle may be subdivided into four sequential phases, namely corporate strategy phases, project phases and operation phases, as well as the project phases consist of feasibility study, project definition, project execution, and project commissioning and handover. Furthermore, PMI (2008) stated that project's life cycle are the concept and initiation, design and development, construction and implementation, and commissioning and hand over phases.

The first phase, which is the conceptual phase, includes the preliminary evaluation of the idea. The second phase which is planning requires identifying the resources required and establishing realistic time, cost and performance, as well as preparing documentation to support the process (Kerzner, 2009). Also, Gido and Clements (2009) stated another division of project life's cycle which are the identification of a need, develop a proposed solution, perform the project, and terminate the project.

Bennett (2003) enhanced that the phases of the project are the pre-project, planning and design, contractor selection, project mobilisation, project operations, and project closeout and termination phases.

It is very clear; there are many different divisions for the project's life cycle, which is suited to the subject and topics of the study by the researchers. Consequently, in this research[1], the phases which can be adopted are two phases in order to estimate the cost of the project at the early stage (pre-project, concept and initiation or pre-bid) when there is no more enough information about the project, and in the tender stage when the estimate have to be more accurately than before.

2.5 Construction Project's Cost Estimate

There are many definitions of cost estimate from many researchers regarding with their field of study. Nevertheless, those definitions contribute in the same meaning with a little of variance.

Firstly, the terminology of cost was defined by Stewart (1991) as "the total amount of all the resources required to perform the activity". So, the price is the total amount paid for that activity. Mathematically, price equals the cost plus the desired profit (Price = Cost + Profit).

According to Shehatto (2013), there are two types of cost estimate can be used by researches. Firstly is construction cost which was defined by the Association for the Advancement of

[1] The author sometimes uses the term of "research" or "study" when it means this research or study of this PhD.

Cost Engineering (AACE) International (2007) as ‘‘the sum of all costs, direct and indirect, inherent in converting a design plan for material and equipment into a project ready for start-up, but not necessarily in production operation; the sum of field labour, supervision, administration, tools, field office expense, materials, equipment, taxes, and subcontracts’’. Secondly, the cost engineering which is “a field of engineering practice to be judgment and experienced by engineers in the application of scientific principles and techniques to solve problems of estimation, cost control, business planning, management science, and profitability analysis”.

The common type or terminology is cost estimate which is used by most of researchers in most of fields; Pratt (2011b) presented definition for the cost estimate in its essence; ‘‘is an assessment of the probable total cost of some future activity’’. Jackson (2010) also has defined that the estimate is “a summary and an educated guess which was based on the best information available of probable quantities and costs of materials, equipment, labour, and subcontracts to complete a project which also contain taxes, overhead, and profit. Consequently, they used to develop the project bid price”.

According to PMI (2008), the cost estimate is ‘‘to develop an approximation of the monetary resources needed to complete project activities’’. In addition, Marjuki (2006) mentioned that the (AACE) International has defined the cost estimation as to provide the basis for project management, business planning, budget preparation and cost and schedule control.

Dysert (2006) defined a cost estimate as, “the predictive process used to quantify cost, and price the resources required by the scope of an investment option, activity, or project”. Moreover, a definition was given by Smith and Mason (1997) which is “Cost estimation is a fundamental activity of many engineering and business decisions, and normally involve estimating the quantity of labours, materials, utilities, floor space, sales, overhead, time and other costs for sets series time of periods“.

Furthermore, Leng (2005) cited in his research two definitions for cost estimate; the first one is ‘‘an evaluation of all costs of the elements of a project or effort as defined by an agreed upon scope. It is an assessment based on facts and assumptions of the final cost of a project, program, or process’’. The second one was defined by A.A. Kwakye, (1994), which is “Estimating is a technical function undertaken to assess and predict the total cost of executing an item of work in a given time using all available project information and resources”.

From the last discussion, the construction cost estimate is adopted in this study as terminology and will be discussed wordiness.

2.6 Classification of Construction Costs

Construction cost is classified in most construction projects into direct cost and indirect costs, which the estimator has to distinguish all the types of those two classifications. According to Rad (2002), the direct costs are those costs which share directly in the project, such as buying, travel, and salaries or renting equipment which is used in the project. Consequently, the items that actually go into building facility are classified direct costs, which make up the bulk of any construction estimate.

The following items are considered as direct costs:

- Material
- Labour
- Equipment
- Subcontractors

Furthermore, the indirect costs are the expenses incurred in order to manage and deliver the materials, labour, equipment, and subcontracts employed on any given job. They are much more than expected according to the given project but some of the common items include the following but is not limited to:

- Supervision
- Job trailer expense
- building permits
- Temporary utilities
- Scaffolding
- freight charges
- sales tax
- Testing and inspections
- Job photographs
- Safety supplies
- Chemical toilets
- Security fencing and barricades
- Trash and debris removal
- Clean-up

- Bonds and insurance

On the other hand, Rad (2002) discussed the indirect costs which include the costs of infrastructure for human and physical resources, vacation, sick leave, training, portions of the salary of supervisory personnel, retirement benefits for the employees, as well as any resources that connected indirectly with the project. Other indirect costs can be portions of service's cost such as administrative support, computers, phone system, faxes, insurance, rent, taxes, and utilities.

All the above mentioned must take into consideration by the estimators in which to verify the cost accurate (Jackson, 2010).

According to Shehatto (2013) and Marjuki (2006), they stated that the construction costs can be classified into five types as the following: material cost, labour cost, equipment cost, overheads, and mark-up, see figure (2.1).

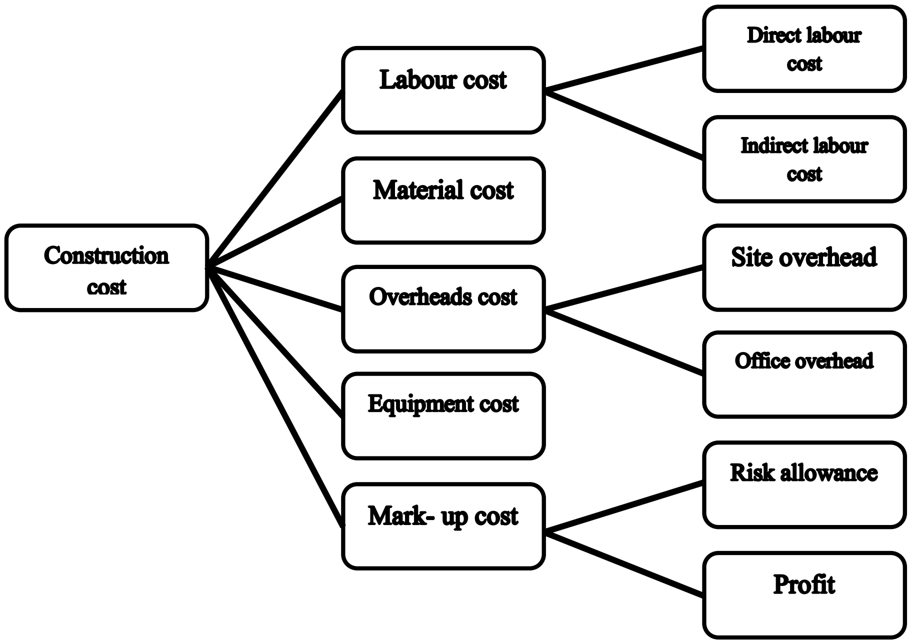


Figure 2.1 Construction cost classification, Shehato (2013).

2.6.1 Material cost

Cost of material includes the direct cost of the material items and any other cost related to the material as transportation, sales taxes and freight costs, delivery, storage, sales, and other taxes and losses. The price of tender sheet should be lump-sum amount including all cost related to the materials.

2.6.2 Labour cost

Shehatto (2013) stated that the labour cost is one of component in cost of project which often ranging from 30% to 50%, and can be as high as 60% of the overall project cost. It includes direct and indirect labour cost according to their relationship to the project. Also, Marjuki (2006) classified the cost into direct and indirect; the direct labour cost relates to the project such as engineers, carpenters, foremen, etc. the indirect labour cost don't related directly to the project such as payroll, taxes, insurance and employee fringe benefits such as health paid vacations and pension plans. Indirect labour cost normally accounts on a 35 to 50 per cent addition to the direct payroll costs.

2.6.3 Equipment costs

Generally, Shehatto (2013) explained the equipment cost can be classified into two types; the first one for specific equipment which is used for a specific construction operations and is removed it from the site by finished work; the second type is for general use equipment which is used by all the subcontractors on the site not for particular work. Marjuki (2006) has stated another description for the equipment cost, which divides into owning cost and operating cost as well as the equipment hourly cost should be determined. Moreover, the following factors should be considered and studied carefully to cost the equipment; number of hours per day, month and year, job conditions' severity, the way of maintenance, and the equipment's demand for selling.

2.6.4 Overheads

An overhead cost is the cost doesn't belong to the specific item of work and it is a significant item of expense. It accounts about 5% to 15% of the total project cost such as office activities (office rent, fuel, lights, telephone and stationery) and job overhead such as (superintendent, temporary buildings, offices, utilities, protection, clean-up, permits, survey, photographs, tools and equipment, insurance and benefits, sales taxes, surety bonds and warranties) (Shehatto, 2013, Marjuki, 2006). Rad (2002) also debated the overhead items that include the cost of preparing failure proposals, relation with general marketing and public, and entering the innovative ventures. Unfortunately, the profit will not be achieved when ignoring the overheads cost, then the project is unattractive.

2.6.5 Mark-up

According to Shehatto (2013) the mark-up's definition as ''as the amount added to the estimated direct cost and estimated job into overhead cost to recover the firm's main office allocated overhead (general overhead) and desired profit''.

In general, mark-up can be classified into two main categories as:

a. Risk allowance (Contingency)

Ritz (1994) explained the contingency allowance as the factor which adds to the estimate in order to cover the two important unknown presents of estimate; the error of inaccurate or incomplete design data, and the error of omission and commission in estimating, Ahuja (1994) also informed that the contingency is a specific provision which accounts on unforeseen element of cost.

b. Profit

A profit is a percentage that is added to the contract or to each items, this profit can be decided by the owner depending on the local market conditions, competition, and the contractor's need for new work (Shehatto, 2013, Marjuki, 2006).

Based on these empirical research findings, the following hypothesis was proposed:

H2: Understanding of construction cost classification has a positive effect on knowledge of cost estimate.

2.7 Types of Construction Cost Estimate

The construction estimates have different types varying according to numerous factors, which are but not limited to; estimate's purpose, quality and quantity of information availability, accuracy range desirable, techniques and methods of calculation, time chosen to yield the estimate, project stage, and perspective of the estimator (Humphreys, 2004, Westney, 1997).

The main common types of cost estimates were mostly taken by many researchers such as (Shehatto, 2013, Marjuki, 2006, Leng, 2005) namely; conceptual and preliminary estimate, engineering estimate, detailed estimate, and definitive estimate.

2.7.1 Conceptual and preliminary estimate

A top-down, order of magnitude, ballpark, feasibility, quickie, analogous, or preliminary estimates are also defined as Conceptual estimate. In this stage, it is the first serious effort made at trying to forecast the cost of the project with limited information on project scope without detailed design and engineering data usually. The accuracy range is expected to be ± 30% to 50%. It is also a pre-design estimate which usually done with limited or no design and engineering information. The information availability in these early stages is usually high-level information, such as number of building occupants, gross square footage area, or building enclosed volume. Importantly, the historical information is used to predict future cost of the new project (Leng, 2005).

Also Shehatto (2013) discussed the preliminary estimate which can be approximately based on the defined cost data to establish ground rules as well as to allow the owner to review design before details. Further, the accuracy range in this stage is also ± 30% to 50%. In addition, Jackson (2010) discussed the conceptual estimate which is often called ballpark estimates when the project is an idea or in concept stage, in order to advice the owner to accept the project economically and technically. Furthermore, the preliminary estimate considers a higher level of accuracy and may be used to create initial budgets as well as preliminary financing scenarios. Moreover, never be applied in a contract price because too many factors can impact the reliability of the numbers.

Consequently, the conceptual and preliminary estimate has been considered for pretender stage according to the accuracy of calculation. Thus, in this research, the preliminary estimate will be adopted for pretender stage; this term contains the conceptual and preliminary estimate, which is very important for the owner to accept the project from marketing point of view.

2.7.2 Engineers estimate

Engineers estimate was explained by Shehatto (2013) in which based on detailed design when all drawings are ready to guarantee design is within financial resources in order to support bids evaluating. The accuracy in this stage is ±15% to 30%[1].

2.7.3 Detailed estimate

Leng (2005) stated that after detail design work is complete and conceptual design has been approved, approximate estimates are generally supplemented by detailed estimates. There are also called a bottom-up, fair cost, bid estimate, or quantity take-off which can be tabulated of all quantities for a project. A fair-cost estimate is carried out by owner for bid evaluations, contract changes, legal claims, extra work, permits and government approvals. Then, a bid estimate is prepared by contractor in order to be submitted as the proposed cost to the owner for carrying out the construction work. Since the careful take-off can reduce or eliminate the unknowns of the amount of work, which would be performed, the margin of error is considerably reduced. Thus, the expected accuracy for a detailed estimate is within a range of ± 5% to 15%. Therefore, contingency requirements, which are for the cost of the work, consider the major variable in order to be left to the estimator’s judgment**.**

[1] The author sees that estimation can be considered a detailed estimation, in which the difference in accuracy is slight.

2.7.4 Definitive estimates

This type of estimation is also performed during the project's construction phase, or after the construction phase, or after the construction completion to evaluate the final actual cost. This estimate is extension and updating to the detailed estimates regarding the actual rather than projected construction (Leng, 2005).

Samphaongoen (2010) was also discussed the classification of the estimate types into three main types which are conceptual (±10-20%), semi-detailed (±5-10%), and detailed cost estimates (±2-4%).

In the first place, many researchers considered the estimation types into two types in which conceptual and preliminary estimate into conceptual (Preliminary) estimates, and integrating engineers; bid estimates into detailed estimates as (Clough, 1986, Shehatto, 2013), see table (2.1).

In this research, the preliminary and detailed cost estimates have been adopted in pre tender and in tender stages for cost estimate in Yemen.

Table 2.1 shows Preliminary and detailed estimates characteristic

	Conceptual Estimate	**Detailed Estimate**
When	At the beginning of the project in feasibility stage and no drawing and details are available.	The scope of work is clearly defined, and the detailed design is identified and a take-off of their quantities is possible.
Available of information	No details of design and limited information on project scope are available.	Detailed specifications, drawings, subcontractors are available.
Accuracy range	±30% to 50%	±5% to 15%
Purpose	Determine the approximate cost of a project before making a final decision to construct it.	Determine the reliable cost of a project and make a contract.
Requirements	Clear understanding of what an owner wants and a good "feel" for the probable costs.	Analysis of the method of construction to be used, quantities of work,

	Conceptual Estimate	Detailed Estimate
		production rate, and factors that affect each sub-item.

Source: Shehatoo (2013).

2.8 Techniques of Cost Estimate

Cost estimate techniques can be called into two techniques namely as:

2.8.1 Quantitative and qualitative technique

Qualitative approaches depend on expert judgment or heuristic rules, and quantitative approaches which are categorised into statistical models, analogous models, and generative-analytical models (Caputo and Pelagagge, 2008). Quantitative approach has been classified into three main techniques according to (Caputo and Pelagagge, 2008, Duran et al., 2009, Cavalieri et al., 2004) which are analogy-Based, parametric model, and Analytical model (Engineering approach).

2.8.1.1 Analogy-based techniques

Generally, this technique is used when there is significant similarity between the desired project and those projects limited to in historical database. These models mostly tend to be less complex, easier to use, and more inexact than parametric models. Normally, it is used for early estimates that are called order of magnitude, conceptual, or ballpark estimates. Many of the following deliverable indices as available can be used by project manager as values such as type, functions, requirements, design characteristics, capacity, size, location, cost constraints, and quality expectations (Rad, 2002).

In this technique, it is depending on analysis of the degree of similarity between the new project and another one in order to obtain a rough but reliable estimation of the future costs. The concept is to obtain the estimation from previous actual information, of course, there are still many problems exist in the application of this approach, such as:

- The difficulties are in the measure of the concept of degree of similarity.
- The difficulty of incorporating in this parameter is the effect of technological progress and of context factors.

2.8.1.2 Parametric models

In this model, the historical data are used as the basis of the model’s predictive features. As well, the output of parametric models includes duration of project major phases, the cost of major phases, total project cost, and resource requirements. In addition, it depends on one or more independent variables to calculate the dependent variable of cost. Consequently, these independent variables are quantitative indices lead to the performance such as desired floor space, project type, exterior material, frame material, ground conditions, and roof type. Nonetheless, the evaluated, validated, calibrated, and customised for accuracy and appropriateness should be considered (Rad, 2002).

Generally, the cost is stated as an analytical function by set of variables which are some features of the project (performances, type of materials used, etc.), in which can influence mainly the final cost of the project (known also as cost drivers). In addition, the analytical function can be named Cost Estimation Relationships (CER).

2.8.1.3 Analytical model

The detailed analysis and features of the project is the core of this estimation, which is calculated in a very analytical way; as the sum of its elementary components comprising by the resources' value which are used in each step of the project process (raw materials, labour, equipment, etc.). Therefore, when all the characteristics of the project process are well defined, the analytical model can be used only.

2.8.2 Preliminary and detailed techniques

Generally, the preliminary methods are less numeric than detailed methods. Especially, most of researchers look for perfect preliminary method with less prediction error. The preliminary can be divided into two sets qualitative preliminary methods and quantitative preliminary methods. Specifically, the qualitative methods can be opinion, conference, and comparison similarity or analogy, and the quantitative method can be as unit method, unit quantity, linear regression, artificial intelligent ...etc., figure (2.2) shows the level of the project and the proper estimation methods.

Clearly, a detailed estimate based on computed quantities after design work is complete and known by Bottom -up estimate. This computed quantities are then multiplied by unit costs, as well as the sum represents the estimated direct cost of the facility. Further, the addition of indirect costs, plant and equipment, office overhead, profit, escalation and contingency will then add to the total estimate project cost (Leng, 2005).

Consequently, the following hypothesis was supposed:

H3: Construction cost estimation methods and techniques have a positive effect on knowledge of cost estimate.

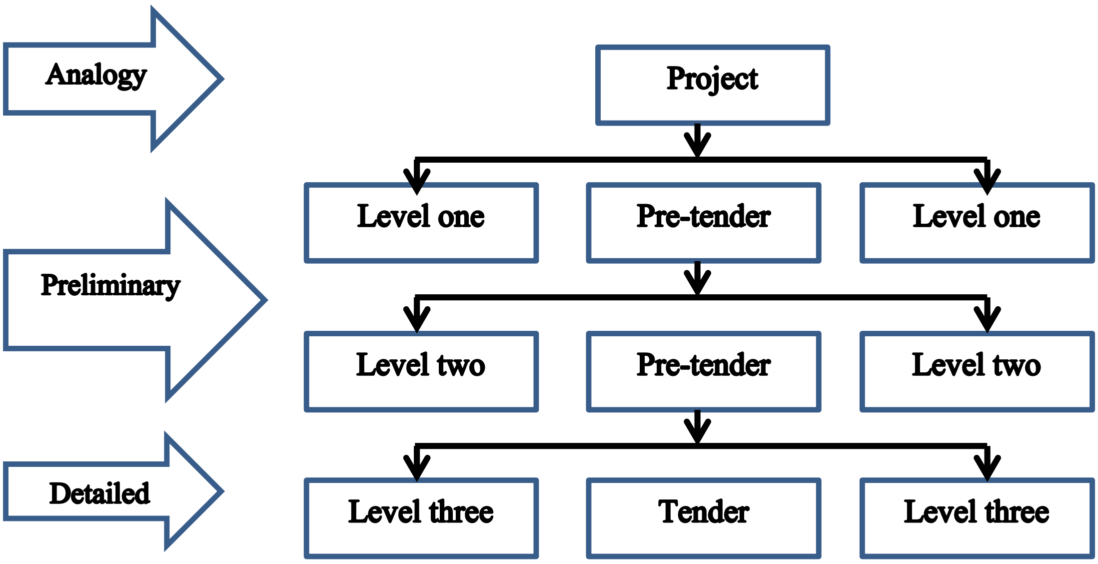


Figure 2.2 The project level and proper estimation, Author.

2.9 Estimator Characteristics

Jackson (2010) stated that the estimator as a key of project who knows the project very well than others, as well as the estimator thinks in terms of chunks of time and cost. The following skills and characteristics are common among estimators:

- Reads contract documents well
- Is knowledgeable about construction techniques
- Is familiar with typical job conditions
- Is familiar with construction products
- Has good visualization skills
- Follows instructions explicitly
- Is creative, yet practical
- Is detail-oriented and thorough
- Can meet deadlines and work under pressure
- Is familiar with purchasing
- Is familiar with computer applications
- Works well with numbers and statistics
- Is a perfectionist at the task level
- Has very good organization skills

Generally, the reputations of the firms depend on the estimating process. Consequently, the estimators must make judgment calls regarding techniques, pricing, and people.

2.10 Project Delivery Systems and Estimating

Different project delivery systems have been related to different types of estimates, preliminary, and detailed at various stages. Pratt (2011b) discussed from a wide knowledge of experience and science, in order to relate between the delivery system and estimate depending on how well the scope of work is defined at that particular stage. Design-bid-build delivery system is considered as traditional approach and is still used extensively. Although, the preliminary estimate methods are importantly adopted for reasons, the contractors and construction managers are hired before project design has been started in which without more enough information about the project.

2.10.1 Traditional (Design- Bid- Build) delivery

Accordance to the methods of delivery system (Design- Bid- Build), see figure (2.3), the projects have to be fully designed before work begins, in which bidden to the single contractor who is responsible for constructing the entire project on the terms of a lump- sum contract with the owner. The preliminarily estimate may help and manage the project cost within the budget of owner in which the design will be appropriate (Pratt, 2011b).

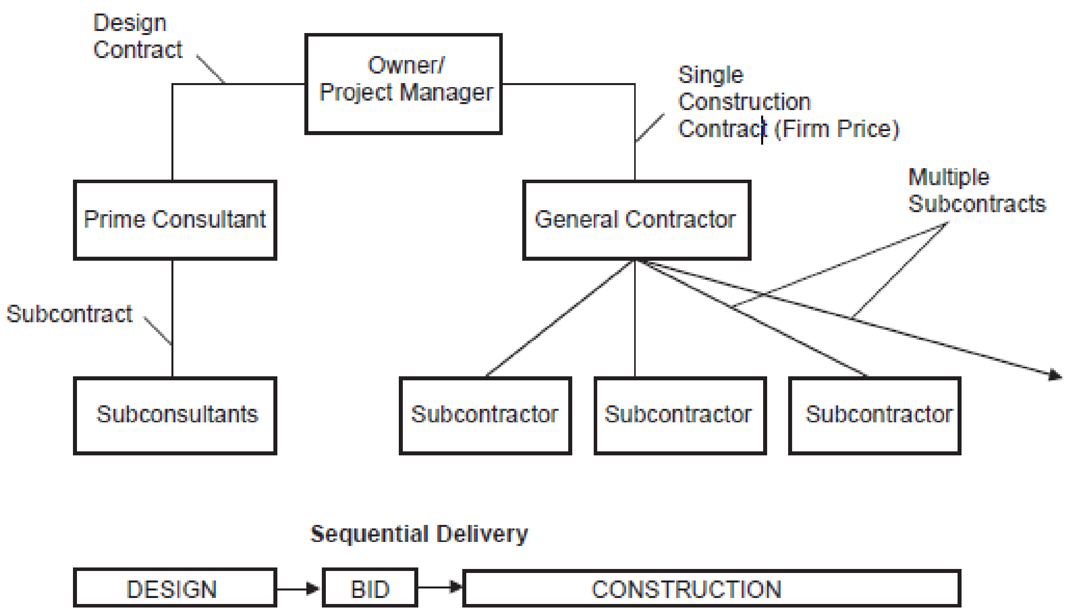


Figure 2.3 Design-Bid-Construction delivery system, Pratt (2011b).

2.10.2 Design- build delivery

In essence, this approach, the owner deals with a single firm, which are the responsible about both design and execution. It is known as turnkey and package forms that used in many type of projects, especially, the public private partnership, or P3 such as infrastructure projects. Furthermore, there may be some sketches were prepared by owner. Consequently, the contractors have confidents to satisfy the owner's needs together with a price for the project. Indeed, the preliminary estimate has to be adequate and accurate, see figure (2.4) (Pratt, 2011b).

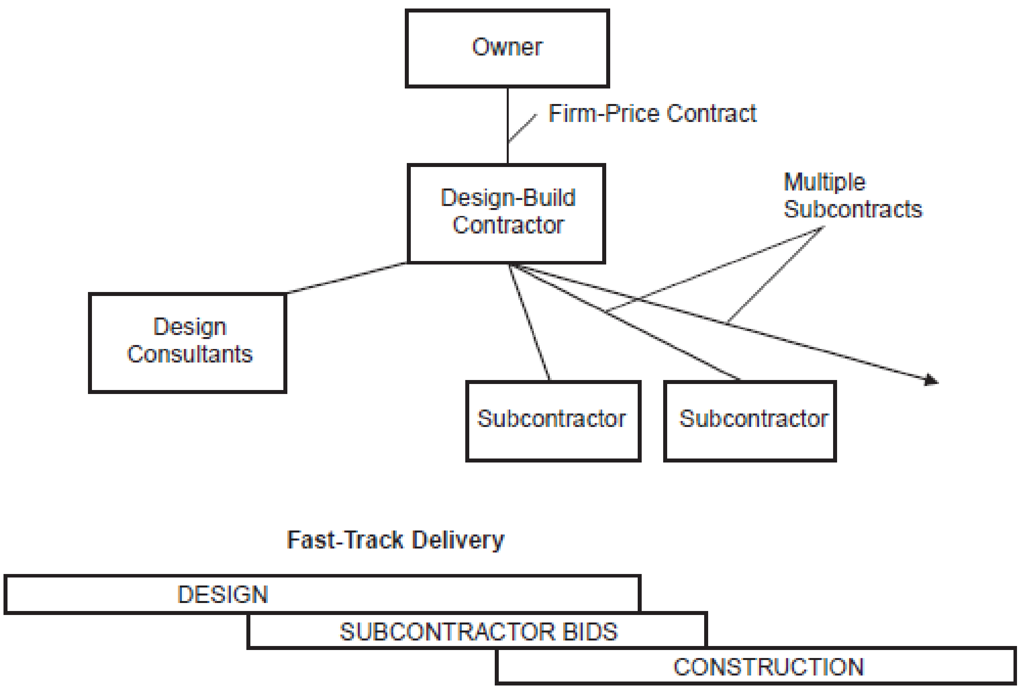


Figure 2.4 Design- Build Delivery System, Pratt (2011b).

2.10.3 Construction management delivery

Construction management organisation is the one alternative traditional system of project delivery in which to facilitate overlap between project stages using fast tracking technique, figure (2.5). Consequently, it is achieved by dividing the project into a number of phases when the design was begun for phase on and bids for this phase are then obtained. While the work on this first phase proceeds, the design continues for phase two and so on. In this type, the owner has to be carefully for its decision about the financial before long time depending on the preliminary estimate, which provide little information. It is importantly to develop an accurate estimate model as well as the cost progress may be reviewed and updated for all phases[1] (Pratt, 2011b).

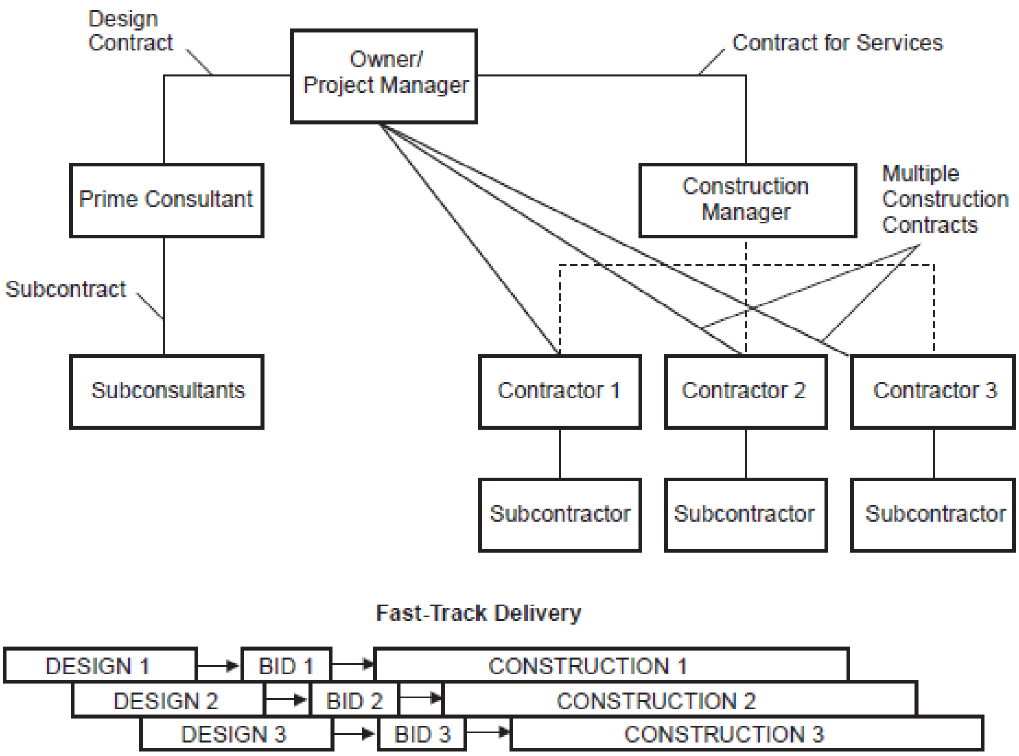


Figure 2.5 Construction Management delivery system, Source, Pratt (2011b).

2.11 Estimates for Different Types of Contracts

According to Pratt (2011b) there are three common types of contracts lump-sum contract, cost- plus contract, and unit-price contract. In the most construction projects, lump-sum contracts may be used, otherwise, owners may prefer a cost-plus alternative due to the scope of work's ambiguous to define or the time is not enough for documents of design to be finish at exactly time. Furthermore, detailed estimates may still be required with a cost-plus contract in which a guaranteed maximum price is involved.

2.11.1 Lump-sum contracts

In this type of the contract, the contractors estimate the projects by detail method to determine the sum of the bid without separating into items.

2.11.2 Cost- plus contracts

Cost–plus contract is generally used in case, the work get underway quickly or the total cost of construction uncertain when the work begins but also, the owner may not be able to

[1] In this type, the cost control must be perfectly done to ensure the derived cost parallel to the preliminary estimate cost within the budget.

avoid paying for mistakes or even inefficiencies. Furthermore, the difficulties of define the work which leads to use this type such as extensive renovations to old buildings. Consequently, there is little need for estimating with these types of contracts. In case, the contractors have to offer their price to perform the work for a guaranteed maximum price in which based on the allowances.

2.11.3 Unit- price contracts

The work breakdown structure is vital method, which is used in unit- price contracts as schedule. Pricing each items of schedule in which enters a unit price against each of the items and the total bid is determined from the aggregate of these prices multiplied by the estimated quantity of each item. The chosen bidder often obtained according to competitive prices in which the final quantity of work is difficult to predetermine. Therefore, the detailed estimate approach mainly is used, but the price has implicitly included an overhead and profit component.

From the experience of the author, the chosen bidder in Yemen is usually obtained for the lowest price ignoring his professional abilities, risk registers, quality manual, and technology advance. One important thing to refuse him or not, it is his financial ability. Thus, the most construction projects in Yemen are executed by local contractors suffering from inaccurate estimates in which lead to delays, inefficiencies, and overruns cost and time. Thus, an additional hypothesis was proposed as follows:

H4: Understanding the types of contracts and delivery systems has a positive effect on knowledge of cost estimate.

2.12 The Factors Affecting Construction Cost Estimate

Many various factors have been discussed by Jackson (2010) and Al-Shanti (2003) which may affect the cost estimate according to:

a. **Complexity of the Project:** complexity can greatly increase the cost of the project. These conditions may include rehabilitation and heavy loading. Furthermore, the project details impact productivity due to the complexity, for instance, the worker can build easily the first courses than higher-level courses of wall, which require more skills and time. Considering also, the shape of the facility, height of the facility, and unique materials or applications, which may change and adjust the estimate[1].

[1] Shape affects the price of all elements of the building, as well as heights, which require more equipment and tools, in which is required, the unique material increase the price. The estimator must involve for all circumstances.

b. **The Site Location:** sites may be difficult to access, either geographically or because the space is used during business hours, requiring that the project be scheduled for off hours. Jackson (2010) has believed that the location of the project impacts the ease of procurement and delivery of materials, labour, and equipment, and then it affects the overall pricing of the project as well as differs from city to city.

   In essence of Yemen's topography, there are sometimes types of topography which determine the land of the projects (mountains, deserts, valley, and coasts), indeed, must take into consideration estimate of the budget[1].

c. **Time of construction:** the most building construction are seasonal, in which, there are periods of the year when contractors are busy and also can barely keep up the demand, and then periods of the year when they are likely to be looking for work. In addition, there is always a period between when a project bids and when the construction actually starts as well as when a project starts and when it is anticipated to end. Consequently, the estimate process must be carefully taken into consideration the fluctuations in prices and availability of labour during this time, not to be ignored the influences of time on the processes of construction conditions.

Al-Shanti (2003) had also suggested another two factors from his point of view as following:

a. **Project Type:** the type of the project has an effect on estimating construction costs, regarding with the degree of specialisation of the work to be done as well as the cost of the materials.

b. **Material Costs:** The type and availability of a specific material can also impact the cost estimate.

Furthermore, Jackson (2010) has believed into some other factors from his experience as expert in estimate, which must be considered by estimators:

a. **Quality of the Work:** Quality clearly impacts project cost which can be set forth in the specifications which determine the cost is less or high.

b. **Market Conditions:** Market conditions always have an impact on the estimate. The willing of contractors to employee with little or no profit, which are determined by very selective and competitive of market.

c. **Management Factors:** Management factors are those considerations that include such things as knowing that a particular owner or architect is more

[1] The author has sometimes noticed that the some difficulties that facing the contractors in Yemen, access of the location of their project which they often use animals as transportation for materials, tools, and people.

difficult to deal with than other, i.e. management factors, in this paragraph considering from point of view of the prediction.

Another important factor which was discussed by Washington (2008) was:

d. **Geographic considerations:** These considerations can affect the selection of unit bid prices. Because of the project's location may be in an urban, suburban, or rural setting, so the project, which is in an urban, has to occur in more confined workspaces with greater volumes of traffic, and limited hours of operations, night time work, etc. Availability of local contractors, materials, equipment and personnel may be offset some factors. On the other hand, Projects located in rural may have affected the estimate of unit bid prices comparing to projects located in urban. Furthermore, construction operations may have some constraints such as restricted work areas, less traffic, and additional time to complete the work. On the other vision, the costs of materials, equipment and personnel may increase related to transportation, support, wage, per diem etc.

Moreover, Al-Hasan et al. (2006)[1] concluded that the main causes of inaccurate cost estimates are: Insufficient time for estimate development (rated the highest factor); followed by inadequate specification; incomplete drawings; quality of project management; lack of historical cost data; and then a lack of confidence in structured site feedback.

Some other factors considered by construction companies in cost estimating practice were grouped into seven factors; complexity, technological requirements, project information, project team requirement, contract requirement, project duration and, finally, market requirement. This study was conducted by questionnaire survey which were 24 factors listed and analysed to minimise and ranked them (Akintoye, 2000).

Enshassi et al. (2007) stated that the important factors, which were in the Gaza strip from contractors' perspective correlated to cost estimation of construction projects due to analyse fifty-one factors. The main factors are listed; location of the project, segmentation of Gaza strip and limitation of movements between areas, political situation and Gaza strip closure, financial status of the owner, increase of unit cost of construction materials, tender currency, experience of consultant engineer, number of competitors, clarity of information before execution and clarity of project drawings . While these factors appear to be relevant to many

[1] The research was done from mechanical and electrical contractors' point of view and focused also on the methods and technique of accurate estimates.

countries, three main factors (segmentation of the Gaza strip, limitation of movements between areas and political situation) are considered to be relevant to the Gaza strip.

A study conducted by Khalafallah (2002) about the factors affecting cost estimate of contingencies in which the important factors were the political and regulatory risks. These factors were shared between the contractor and the owner; changes in laws and regulations, wars and civil disorders, and problems with licenses and permits. Consequently, these factors may lead to financial risks, which can affect the estimation from perspective of the inflation, availability of foreign currency and exchange rate changes, and underestimation of direct costs.

According to Rad (2002), an allowance which is a lump-sum estimate that is assigned to certain project items, is a very important factor has affected the accuracy of estimate and mostly ignored by inexperienced estimators. Therefore, Page (1996) discussed the categories of allowances which affect the estimates and must be taken into consideration by estimators in order to minimise the percentage of inaccuracy.

a) **Quantity Allowance**

   The quantity allowance is an adjustment to the estimated construction activity take-off quantities in details and is considered as a part of the direct base cost.

b) **Escalation**

   The escalation is the percentage amount of cost, which is added to the estimated base cost regarding to procurement at a future date later than the estimate. It is also determined according to market conditions. Further, it is expected during the project, all escalation money will be expended.

c) **Contingencies**

   A percentage of amounts added to human calculation or judgment error in accumulation of estimate scope. Importantly, it isn't added any funds for scope changes. Another description said by Rad (2002) that was "the term contingency is used for the funds that are added to the estimate to compensate for those estimate inaccuracies caused by uncertainties in project details." In essence, it isn't to carry the cost of errors in design, implementation, omission, and miscalculation in estimating. The contingency magnitude of funds is 10 per cent to 50 per cent according to information available at the time of the estimate.

   Furthermore, PMI (2008) referred that the contingency reserve can be used as a term. It may mainly be a percentage of the estimated cost, a fixed number, or may be developed by using quantitative analysis methods.

d) Risk

In essence, risks, which can be either threats or opportunities and impact on both activity and overall project costs (PMI, 2008). The financial impact of risk events can determine a statistical monetary value for the risk in order to be into the project estimate (Rad, 2002).

Furthermore, the risk may be amount of money or per cent of base cost plus lower level additives (except fee) which is added to the base cost plus additives in order to cover the probabilities of threads for the base cost estimate plus additives is not ample for financing of the project. The risk percentage relies on the forecasting of the circumstances enveloping the project to cover costs that might occur (Page, 1996).

e) Fees

The amount of money expected of non-project overhead and profit to be covered by the contractor (Page, 1996). All last discussion factors would be called critical factors in this study.

Therefore, one hypothesis was proposed as following:

H5: Understanding the critical factors has a positive effect on knowledge of cost estimate.

2.13 Cost Control

A definition of cost control was given by Lock (2009) "is to ensure that no preventable wastage of money or unauthorised increase in expenditure is allowed to happen." Generally, the important principle of cost control is the element of cost, which relies on the nature of the costs. Therefore, the project manager has to be deal with variable cost and fixed cost. Variable cost, which is also called direct cost as well as fixed cost can be sometimes called indirect cost and overhead as in figure (2.6).

Jackson (2010) explained that the cost code, which is assigned to budget, is used to track all items of work contributing to the overall project costs by manager. That may include equipment, subcontracts, material, labour, and overhead. Consequently, these codes are used to compare the actual costs with the estimated costs throughout the construction process. Furthermore, Bennett (2003) debated that the cost control's outcomes are: (1) identification of any work items whose actual costs are exceeding their budgeted costs, and (2) estimating the total cost of the project at completion, based on the cost record so far and expectations of the cost to complete unfinished items. In addition, the earned value technique and analysis may lead to an indication that is according to the estimated cost and schedule standpoint of the project.

Based on these empirical research findings, the following hypothesis was proposed:

H6: Understanding the Cost control process has a positive effect on knowledge of cost estimate.

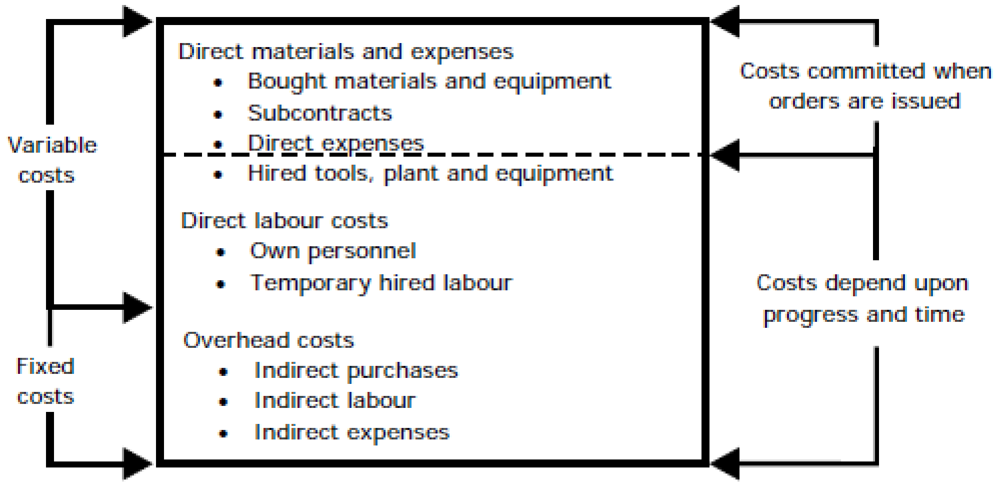


Figure 2.6 Elements of project's cost, Lock (2009).

2.14 Estimating and Construction Safety

The Occupational Safety and Health Administration (OSHA) safety standards are the law that the contractors should be complied the requirements of this legislation, or facing possible fines or even imprisonment. Consequently, most of contractors respect this law very seriously; then the estimate should be grantee the methods and materials that comply with its provisions, further, the price of estimate has relation with this requirements. The risk cost can be found in the direct cost of construction accidents, which are higher worker's compensation insurance and property insurance premiums as well as the hidden risk cost can be included in:

1. Tool and equipment repair and maintenance costs
2. Production interruptions and delay costs
3. Legal expenses
4. Expenditure on emergency supplies and equipment
5. Replacement equipment rentals

6. Investigative and administrative expenses
7. Cost of hiring and training replacement personnel
8. Overtime payments and other costs incurred trying to catch up
9. Decreased output of injured workers on return
10. Damage to company reputation and subsequent loss of business

This cost can affect the competitiveness of an organization, which trends to show their safety programs at their job sites, so this cost is accounted for in the general expenses section of an estimate. Because these costs can be substantial and may have a significant impact on the competitiveness of an organization, many construction companies have been encouraged to introduce vigorous safety programs at their job sites. Such project safety programs do, admittedly, have a cost, which is accounted for the general expenses section of an estimate (Pratt, 2011b). Furthermore, one hypothesis was proposed as following:

H7: Understanding the safety considerations has a positive effect on knowledge of cost estimate.

2.15 Cost Index

According to Humphreys (2004) explained that the typical problem face the engineer is estimating the current or future cost of equipment, plants, or buildings. The important one way for such estimate is to obtain costs of similar projects from an earlier or updating date to the present time. This variation is accordance to market conditions and the general state of inflation or deflation of a country's currency and from one area of the country to another area. Therefore, these differences in prices from time to another time and from place to another place can be measured by cost indexes. A definition of cost index was given by Humphreys (2004) is "the ratio of cost or price for a given commodity or service or set of commodities or services at a given time and place compared to the cost or price at a base or standard time and place." In essence, there are some cost indexes were published by many organisations in particular area of engineer interest such as building construction, for wage rates or for various industries and types of plants, and for various types of equipment, material, or commodities. Implicitly, cost indexes are based on present costs compared with cost history ignored the future escalation.

According to Popescu et al. (2003), the company's success can be obtained from the ability of accurate estimate for companies' budgets, the use of construction cost indexes provide valuable information to get the perfect success. Furthermore, there are several cost indexes, which are but are not limited to materials index, skilled labour index, and common labour index etc.

Based on the findings, one hypothesis was proposed:

H8: Cost index has a positive effect on knowledge of cost estimate.

In addition, the first objective was obtained and the first question was anwered.

2.16 Summary

This chapter explained the construction industry from wide of view concentrating on developing countries, Yemen construction industry, and Yemeni's economics. As well, Yemeni's community features was debated showing the ideology of the society and its tribal structure which formulate such mode of life. Economy of Yemen was also debated with many indices that referred to poverty of country. Furthermore, the construction cost and estimate practices in Yemen were represented the lack of materials and increase in rates of building construction costs as well as using traditional method of estimate which is unit price (meter square).

In addition, the project life's cycle was discussed from estimate point of view. The most important issue was the knowledge of cost estimate, which was classified into eight topics in order to enhance the estimators' knowledge. Classifications of cost and type of construction cost was defined and debated. Further, the techniques of cost estimate showed the most common techniques that used in construction cost estimate. From estimate point of view, the project delivery systems and types of contract were clearly put and related to estimate. There were factors could affect the process of estimate that were called critical factors were also discussed wordiness. Thereupon, the cost control discussion was undertaken. Alongside what mentioned last, the construction safety revealed its importance in estimate process and in hidden cost that could affect the projects estimate and success. The cost index was pointed out to the estimators with briefly discussion. Finally, the first objective of this study was achieved and the first question was also answered.

CHAPTER III: PRELIMINARY ESTIMATION METHOD

3.1 Introduction

This chapter presents a sight about the accuracy of the estimate as well as the process of estimate. It also focuses on preliminary estimate at early stage passing through the traditional and modern methods, which can be used. Traditional methods use common methods such as meter square, cubic meter, and unit method. As well, the modern technique, which is represented by many techniques such as analogical technique, parameter technique, and Artificial Neural Network (ANN) which is adopted in this study. ANN is the modern technique and can simulate the human brain. Biological of neural network, neural network architecture, neuron activation, neuron transformation, and network learning are debated from researchers' point of view. Furthermore, this chapter describes the training, cross-validation, and testing process as well as the performance of ANN and sensitivity analysis. Previous studies are discussed in the early stage to formulate the quantitative model of this study. After that, the quantitative models is debated and adopted in this study. Finally, the summary describes this chapter briefly.

3.2 Accuracy of Cost Estimate

To understand the method of cost estimate, the accuracy of estimate must be known. Therefore, many definitions were done by specialists in this field and many factors may affect this accuracy would be discussed.

Shehatto (2013) mentioned that the definition of accuracy according to Webster‟s College Dictionary (1999) as:

- The condition or quality of being true, correct, or exact; precision; exactness.

- The extent to which a given measurement agrees with the standard value for that measurement.

Dysert (2006) also defined the accuracy as ''the degree to which a measurement or calculation varies to its actual value; so estimate accuracy is an indication of the degree to which the final cost outcome of a project may vary from the single point value used as the estimated cost for the project''. Another definition was obtained by Rad (2002) as ''the expression of accuracy of the estimate is related to the expression of the probability that project's actual cost will match the prediction cost''. So, the accuracy of estimates rely on the availability information at the time of the estimate, in addition, the good practice of the estimators add value positively or negatively on estimate accuracy (Shehatto, 2013).

Liu and Zhu (2007) debated that the accuracy of early estimation has dependent on the historical cost data and level of professional expertise among other factors. Nonetheless, the assumption about the design details of a project must be taken, which may not eventuate as the design, planning, and construction evolve. Furthermore, Westney (1997) stated that the four trades-offs were the availability of information, time, available resources (people, equipment, and money), and estimating methodology or algorithm, determine the classic estimate as the following:

- The more accurate the estimate; the more information is required,
- The more information required; the more time is required to produce the estimate,
- Consequently, the more resources are required to develop the estimate,
- And, the more money it will cost to produce the estimate; the more money spent the more pressure to reduce resources, time, information, and accuracy.

3.3 Estimating Process

Project management Institute, PMI (2008) discussed and mentioned that the estimate process as process system (input, tools and techniques, and output), which implicitly, the following parameters must be taken into consideration by estimators that are Scope baseline, Project schedule, Human resource plan, Risk register, Enterprise environmental factors, and Organisational process assets. Consequently, the tools and techniques must be used to estimate the suppose final cost to determine the budget, these tools are, but are not limited to, expert judgment Analogous estimating, Parametric estimating, bottom-up estimating, and Three-point estimates. These tools can be used according to the type of cost estimate.

3.4 Preliminary Estimate and the Purpose

Early cost advice, which is the first step of the cost management process, is valuable in completing the concept of the project information. It will affect the cost implications of design decisions and answer the first question that is asked by the project client which is “How much will the project cost me” in which helps in decision-making. Then, the client can decide going on or not; i.e. it is important to convince the client rationally, thus, some researchers were used the preliminary estimate such as (Arab, 2011, Serpell, 2004, Shehatto, 2013, Arafa and Alqedra, 2011). Consequently, the cost estimation mission becomes desirable and crucial, especially during the preliminary (conceptual) stage, in which the project scope is not finalised and very limited information (Sonmez, 2004, Kirkham et al., 2015).

In addition, Aibinu and Pasco (2008) examined the accuracy of pre-tender building cost estimate which explored that it wasn’t improved over time and most of experts were not satisfied with the accuracy of estimates. Further, there were factors affected the accuracy of estimating process; the project information, client requirements, cost data and team experience (Liu and Zhu, 2007). Moreover, Jagger et al. (2002) stated that the clients determines the most important information which ensuring their project cost to be well; these factors are client needs and requirements, project parameters, size range, quality indicators, site information, and the type of procurement. Furthermore, Oberlender and Trost (2001) concluded that the people involved in estimate process, the way of estimate's preparation, the information of project, and the factors involving at the estimate were the main factors affecting the accuracy of cost estimates. According to Arab (2011), the many difficulties faced estimating at the preliminary (conceptual) stage. These included, but weren't limited to:

- Limited information available,
- Limited data and information resources,
- Some of the people who involved in this stage don't know what they need,
- The lack of experience and knowledge of estimators,
- The estimator needs help at this stage (company-wide co-operation),
- The time pressure driving an estimator to estimate quickly something they don't fully understand,
- Clear, complete and reliable specifications are difficult to formulate at this stage,
- Characteristics of project and project development might make estimating difficult, and
- The great number of factors that have an influence on the project or the components, which affect building cost. These factors are called cost drivers, such as project size, complexity, experience of development team.

From the last factors, which affect the accuracy of cost estimate, the cost estimate model is better solution either functionally or professionally. The cost model should give the client cost with confidence and provide the ability to analyse and test the factors of cost that represent the building. Regardless of insufficient data in the early stages, a preliminary estimate is necessary for making project decisions before project objectives are clarified, before project scope is defined, before requirements are fully spelled out, before the functions are clearly defined, and before the system architecture has been formulated. There are some techniques can be used by project managers for making preliminary project estimates include analogous, parametric, modular, ratio, and range estimating which depends on organisational policies, the project manager's experience, and the amount of information available at the time of the estimate (Rad, 2002).

Kim et al. (2004) mentioned that the cost estimate is a critical factor in the success of the project in order to make decision by the client according to the effective estimate in preliminary stage. Thus, the improved cost estimation techniques provide more effective control of time and costs in construction projects.

Antohie (2009) stated that the purpose of an estimate is to provide the costs required with highly prediction in order to fit the project in accordance with the contract plans and specification. Westney (1997) and Jitendra et al. (2011) concluded that the importance and purpose of estimate were:

- To assess the impact of changes and support re-planning,
- To classify and prioritize development projects with respect to an overall business plan,
- To form the basis for planning and control by defining the scope of work and its associated estimated cost,
- To determine what resources to commit to the project (hours, resources, tasks, and durations) that is needed for preparing a schedule,
- To provide an assessment of capital cost for a specified piece of project,
- To provide a stimulus to assess productivity and risks,
- To be easier to manage and control when resources are better matched to real needs,
- To provide the financial input required to prepare a cash flow curve,
- To help Customers expecting actual development costs to be in line with estimated costs, and
- Is a catalyst for discussion, idea generation, team participation, clarity and buy-in, it ties together much of the relevant project information within a simple document.

3.4.1 Traditional cost estimation methods and models

In traditional costing, there are two main estimates: a first sight estimate, which is considered for early stage, and a detailed estimate, which is considered to calculate costs precisely. In order to create these estimates, it is necessary to have an understanding of the project (Roy, 2003). Further, the most traditional methods of early estimate can be categorised into time referenced cost indices, cost capacity factors, component ratio, and parameter costs (Shehatto, 2013).

Some researchers discussed the traditional methods from first sight estimate point, which conducted to estimate the cost as single price rate methods such as the superficial area method, the cube method, the unit method, and the storey enclosure method as the typical methods. Some factors, which are determined by client are obtained by the estimator from the client to find an appropriate historic analysis in order to determine the cost such as location, size, client needs, and time to deliver a project. The financial advisor's mission is to audit the cost of specifications to be within the budget (Arab, 2011).

Fortune and Cox (2005) stated that the size of the building in square meters and a single price rate of cost estimate methods do not provide certainty in the final cost of the building. In addition, when these methods are applied, several considerations must be taken which are adjustments for time, location, specifications, building size, and number of storeys. The suggest model of cost estimate depends widely on the strength of the estimator and experience rather than developing a full understanding of the projects needs and requirements.

The traditional methods don't reflect the reality of the cost which is not considered the risk and circumstances of social and economics that affect the estimate. However, these models are used by contractors for preparing tenders and monitoring project execution, instead of evaluating and auditing a project success (Arab, 2011, Akintoye and Fitzgerald, 2000).

3.4.2 Modern cost estimation models

Recently, new approaches have presented in the last years depending on the concept of parametric models that based on computerised techniques such as artificial intelligence, which attempt to simulate human intelligence, for instance, Fuzzy logic, and Artificial Neural Network (ANN), etc., as well as it stills under research and development especially in construction sector.

3.4.2.1 Analogical cost estimation techniques

This technique is defined as the similarity of projects that have the same parameters, so the new projects have the similar costs. This is generally attained by the experience of estimators or historical databases of projects (Mittas et al., 2008, Roy, 2003), Holm (2011) also argued that the information from the similar cases, and reusing information from these cases in order to predict the new probability cost.

3.4.2.2 Fuzzy logic systems

Cheng et al. (2009) cited that the Zadeh (1965) proposed that the fuzzy logic a tool, which is used to define or describe uncertainty and imprecision. It simulates the human brain's orders to make decisions in the face of uncertainty or vagueness. As well, Cheng stated that the Fuzzy Logic is consists of inference engine, defuzzifier, rule base, and fuzzifier. Cheng et al. (2009) also mentioned that the fuzzy logic couldn't overcome such problems such as composition operator determination, and application specific fuzzy rule acquisition. Although, the parameters are determined by experience and knowledge of experts.

3.4.2.3 Parametric estimating models

Heemstra (1992) debated that these models are mostly used at preliminary (conceptual) phase rather than other phases in which are composed of a function with most important independent variables such as building type, location of the construction, construction year, number of floors, etc. The parameters and the type of algorithms values connect between the variables, which are rely on the database of previous historic completed projects. Algorithmic models and tools can be broadly categorised as empirical models and analytical models.

In essence, the data from the past projects, which are very important to evaluate the current project and derives the basic function for the current project by analysing the particular projects from the database. While analytical models uses formulae on global assumptions like the rate at which developer solve a problem and the number of available problems (Kaur et al., 2008).

According to Sonmez (2004) and Rush and Roy (2000) many techniques were categorised under this type of models.

a- Cost estimating relationship (CER)

Arab (2011) stated that this model is to find the relationship between the drivers of the project and the cost in the form of an algebraic equation, which might be either a simple or complex equation according to the number of drivers related to the cost figure.

Notwithstanding, Williams (2002) suggested that the regression model technique which is fitted to CER for predicting the project cost especially at the conceptual stage.

b- Linear and nonlinear regression model (parsimonious model)

These models based on CER equation in order to minimise the number of variables in which to obtain the strongest variables affecting the project cost (Sonmez, 2004).

c- Feature based costing:

This model is an equation similar to CER to find the relationship between project features and cost, so this model is used widely at design stage, because a broad understanding of the features is required (Rush and Roy, 2000).

3.4.2.4 Artificial neural network (ANN) model

Cook (2006) and Chen and Hartman (2000) used the technique of an artificial neural network methodology, it was described as “an information processing technology that simulates the human brain and nervous system,” Essentially, the ANN technique software simulation has been used to replicate basic learning by using training to identify complex non-linear relationships. The ANN methodology was selected to prove that the problems, which involved complex nonlinear relationships, can be better solved by neural networks than traditional methods.

3.5 The Artificial Neural Network (ANN)

In this research, the artificial neural network which is the most powerful modern technique for forecasting was adopted in preliminary estimate; it is also more accurate than the traditional methods.

3.5.1 Biological of neural network

This network simulates the biological human’s brains, which are comprised of large numbers of cells called neurons through the vertebrate nervous system, which composed of the peripheral nervous system and the central nervous system. The important part is the neuron, in which several thousands of neurons are called network. The neuron structure is composed of a cell body (the soma), the axon, and dendrites. The axon is a long thin structure extend to small structures called terminal buttons, in addition, the dendrites are representing the end hairs of the cell. The central part of neural is the soma, which contains the cell nucleus. The dendrites of the neuron are responsible to receive the information by synapses, which represent the small gaps between the dendrites for other neurons and the terminal buttons. So the information technique of passing from cell to another via synapse, see figure (3.1) (Kriesel, 2005).

Ashwood (2013) explained that the stimulus (input) is omitted from its network of dendrites and received by the neuron in which to process producing electrical impulses through the long thin axon. Therefore, the synapse function is to increase or decrease the connection strength as well as the inhibition in connected neuron may be caused. Furthermore, the learning way of brain happens through the effectiveness changing of the synapses.

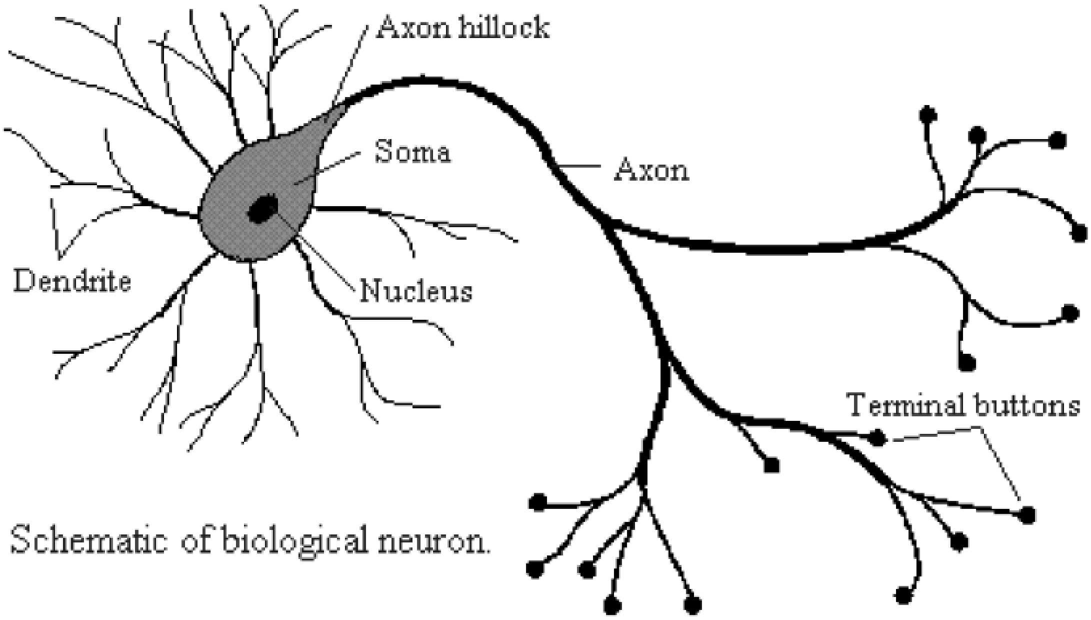


Figure 3.1 The network biological, Fraser (1998).

Generally, Haykin (2009) debated that the human nervous system consists of three stage model receptors, neural net, and effectors, figure (3.2). The neural net is represent the human brain, which is represented the human unit of the human nervous system and the input information is received by the brain from the receptors to process the information and making decision. Further, the receptor converts the stimulus into electrical impulses that transport information to the brain in order to process the input stimulus, which gives a message to effectors, which makes the system response.

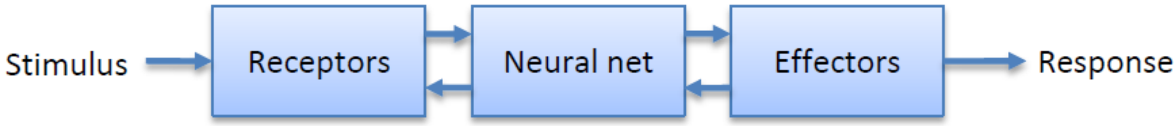


Figure 3.2 The human nervous system, Haykin (2009).

3.5.2 The artificial neuron

According to Ashwood (2013), the first artificial neuron was established by McCulloch and Pitts (1943). They used the binary inputs (inputs 0 or 1 which represented false/off and true/on) in their neuron model to create a binary threshold output. Thus, the neuron contains a single output, which is also binary figure (3.3).

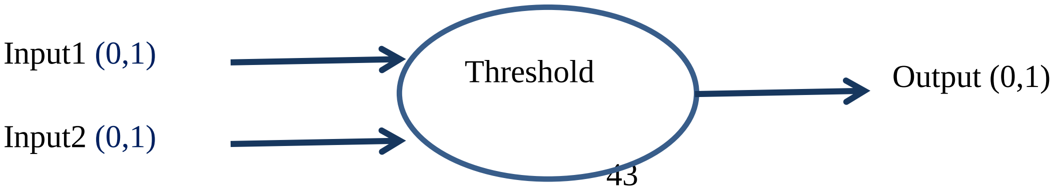


Figure 3.3 Perceptron model, McCulloch and Pitts (1943).

There are several constraints in this model:

1. Binary inputs providing binary outputs,
2. A fixed threshold.
3. Utilising identical input weights,
4. Inhibitory inputs had power of veto over excitatory inputs, and
5. Updating the neuron by simultaneously updating the excitatory inputs and setting the output to 1 if the sum meets the threshold level and there is no inhibitory input.

3.5.3 The artificial neural network

Mehrotra et al. (1997) confirmed that based on the first model was suggested, the process of development includes mathematics, statistics, and computer processing power helped to modify the model to be widely applied in subsequent work.

In this model, the structure of the neuron model, is similar to the early model and found in the most neural networks today, figure (3.4). Several key characteristics feature of the typical neuron are:

- A number of input signals (often including a bias input signal);
- A weight factor that is applied to each input signal;
- An activation and transformation function;
- An output signal; and,
- A learning algorithm.

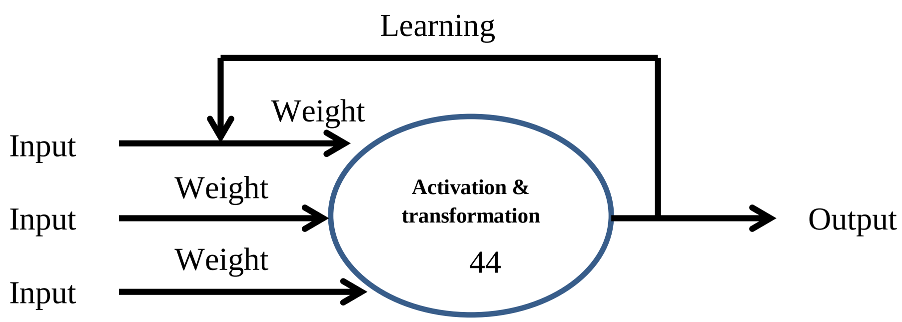


Figure 3.4 The typical neural processing, Ashwood (2013).

3.5.4 Neuron activation

Ashwood (2013) debated that the neuron activation is determined by calculation, which represent the strength of the input stimulus into the neuron. The vector X_1 to n and each input are the raw inputs, which are assigned randomly to calculated weighting W_1 to n. Then the activation of the processing element (*Y)* is specified by the sum of the product of each input (*X*) and its input weight (*W)* figure (3.5). The summation function for *n* inputs *i* into processing element *j* is given by:

$$Y=X_1W_1+X_2W_2+X_3W_3+\cdots+X_nW_n \qquad \text{Eq. (3-1)}$$

$$\mathrm{Y} = \sum_{j=0}^{n} Xi\mathrm{Wij} \qquad Eq.(3-2)$$

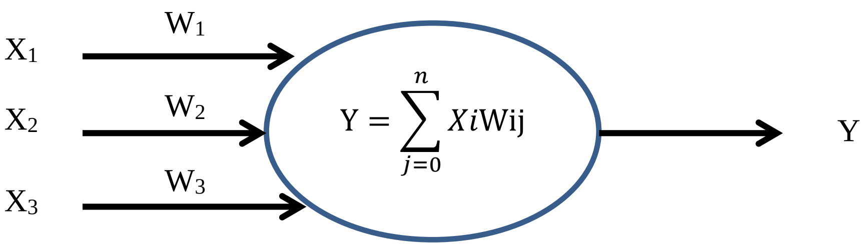


Figure 3.5 The neuron summing equation, Ashwood (2013).

3.5.5 Neuron transformation

Generally, the transformation function is applied after the neuron activation level in order to determine the output of the processing element. The purpose of the transformation function is to scale the output of the processing element into a useable form (generally between -1 and +1 or between 0 and +1) and can be considered a measure of neuron excitement (Ashwood, 2013).

3.5.5.1 Transformation functions

According to desired operation, there are several type of transformation functions due to the mathematical calculations underlying the back propagation algorithm, the transformation functions need to be bounded, differentiable functions (Patterson, 1998, Ashwood, 2013, Al-Shanti, 2003, Attal, 2010).

The most common functions are based on the independent variable in the model regarding to the expected output. Also, various forms of mathematical functions can be used as activation functions as the following:

a. **Threshold function**

The important purpose for using this type is generally in situations where the desired output is either 0 or 1. Therefore, it is useful in solving binary problems.

The Threshold function is given by the equation:

$$\partial\,(v) \;=\begin{cases}1\;if\;v \geq \theta\\0\;if\;v\;<\theta\end{cases} \qquad \text{Eq. (3-3)}$$

Where the (θ) is the threshold value and the (∂) is the output value.

b. Linear function

This function is obtained by the following equation

$$\boldsymbol{\varphi}\;(\mathbf{v})\;=\alpha v+\beta \qquad \text{Eq. (3-4)}$$

Where ∝ = 1 the weighted sum of the inputs is added to the bias (β)

The symmetrical linear function is given by the equation:

$$\varphi(v)=\begin{cases}\beta & v\geq 1\\ \propto & 0>v>1\\ 0 & v<0\end{cases} \qquad \text{Eq. (3-5)}$$

The linear function can be utilised as a symmetrical function using the following equation:

$$\varphi(v)=\begin{cases}\beta & v\geq \theta\\ \propto v+\beta & -\theta>v>\theta\\ -\beta & v<-\theta\end{cases} \qquad \text{Eq. (3-6)}$$

c. Sigmoid function

It is classified into two types of sigmoid functions. The first type, the hyperbolic tangent, is used to create output values between -1 and 1 as well as, the second type which is used to create the output values between 0 and 1is also called a logistic function. The hyperbolic tangent sigmoid function is given by the following equation:

$$\varphi(v) = \tanh(v) = \frac{e^{v} - e^{-v}}{e^{v} + e^{-v}} \qquad Eq. (3-7)$$

The logistic sigmoid function is given by the equation:

$$\varphi(v) = \frac{1}{1+e^{-v}} \qquad \text{Eq. (3-8)}$$

3.5.6 Neural networks architecture

Generally, the individual artificial neuron receives input stimulus and converts this input to output. Therefore, the ANN is a complex structure of highly interconnected processing elements, which has ability to learn from set of inputs stimuli. Nonetheless, it comprises a number of connected artificial neural processing elements. For each of the neural processing elements receives inputs from either raw data or output of other connected processing elements. In essence, the inputs are processed by the processing element to produce a signal output, which can be the final output or can be an input for other processing elements. Then the network structure uses the learning algorithm which will be used to train the network (Haykin, 2009). Ashwood (2013) and Haykin (2009) determined and classified that the artificial neural networks can be structured into several different ways (topologies) which are three fundamental classes of architecture

1. **Single-layer feed-forward networks-typically**, a neural network is structured into layers of processing neurons. In this type, the single layer feed-forward network has input stimulus, which is received into the output layers of neuron figure (3.6). Feed-forward networks do not contain feedback loops.

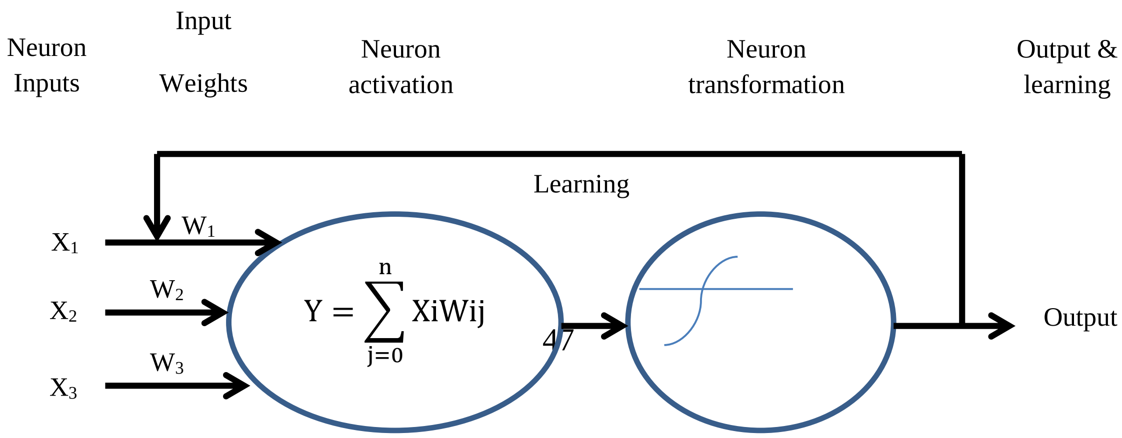


Figure 3.6 Single-layer feed-forward networks, Ashwood (2013).

2. **Multilayer feed-forward networks**- there are additional layers to the single layer feed forward network produces a multilayer feed-forward network. They contain neurons, which are between the input stimulus and the network output in order to model higher-order statistics.

   Precisely, the input layer feeds into the first hidden layers of neuron. This hidden layer is responsible about computations and to provide an output which transfer to the next hidden layer of neuron. This process continues until the output layer is the desired final output signal, figure (3.7).

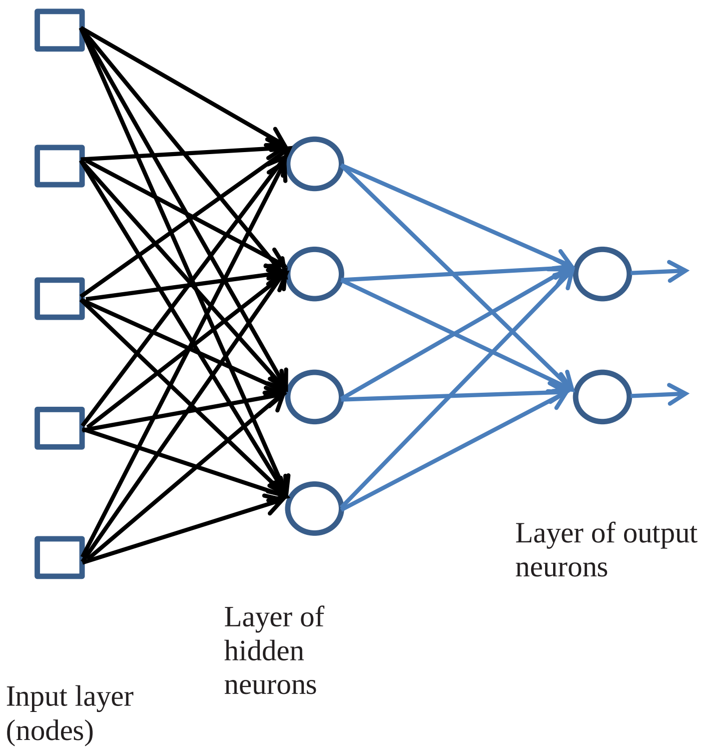


Figure 3.7 Multilayer feed-forward networks, Haykin (2009)

It is clear from the above figure; the ANN is the typical 3-layer fully connected feed-forward which each layer has three processing elements, in the input data, which is the first layer of network processes the input information and yields an output. Then, the output is used as input for each of the processing elements in the second layer. After that, each of the process elements (PEs) in the second layer processes the input information to yield the output, which is fed forward the third layer. Furthermore, the processing elements in the third layer use these inputs and compute the output as the final output of ANN. According to Pawar (2007), the multilayer feed-forward network has been classified into several types as Multi-Layer Preceptron (MLP), General Feed Forward (GFF), etc. The most common types are MLP and GFF networks; Weckman et al. (2010) debated that the MLP is the most popular type of network which uses currently, and in regression and classification problems which require a large amount of time, nodes, and epochs.

3. **Recurrent networks** – Recurrent networks vary from feed-forward networks in which including at least one feedback loop in order to deal with time varying or time-lagged patterns (Nygren, 2004).

3.5.7 Learning of network

Al-Najjar (2005) stated that the learning is a systematic for adjusting the weights to achieve a desired input/output relationship. Ashwood (2013) mentioned that Medsker & Liebowitz (1994) stated that the ANN should be trained or taught the correct answer of a problem. The process passes through saving the information and produces the new data in order to provide an output. In addition, Jitendra et al. (2011) stated that the learning process minimise the error between the desired output and the actual output in the network.

Consequently, there are some sequences of typical process, compute outputs; compare outputs with desired answers; and adjust the weights and repeat the process (Ashwood, 2013). Furthermore, different learning methods are used in ANNs that can be classified into the following categories:

1- Supervised learning – the obtained data (historical) is used to train the ANN what is the correct response (output) to the input. When the paradigm of supervised learning is adopted, the ANN will find a set of weights that minimise the error between the correct result and the computed result (Ashwood, 2013, Shehatto, 2013).
Generally, the network is contained with number of layers, the number of neurons per layer of the network and the type of activation function used, and the synaptic weights. Furthermore, supervised learning method has several learning algorithms as Back-propagation Learning rule, Gradient Descent Learning, and Delta Rule (Jitendra et al., 2011).

2- Unsupervised learning – the obtained data (historical) is not used to train the ANN. When the paradigm is adopted, the ANN owns response to the input must be determined. Thus, the network follows a self-supervised method and makes no use of external influences for synaptic weight modification (Jitendra et al., 2011, Ashwood, 2013).

3- Reinforcement learning, in this paradigm, the ANN determines its own response to the input (as the unsupervised learning), in order to rate this response as either good (rewarding) or bad (punishable) by comparing its response to the target response. In essence, the paradigm will be used, and then the weights are adjusted until an equilibrium state occurs. The classification of this learning is analogous to the way stimulus and response learning. Exactly, the network is informed if the output is a good fit or not (Ashwood, 2013).

3.5.8 Steps of building an artificial neural network

According to Alhutmany (2013), the ANN is built by many steps, which are collect data; pre-process the data; determine the structure of the network (number of hidden layers and nodes); create the network; initialise weights and biases; train network; validate network; and use network.

In which data collection can be collected from previous projects as well as data pre-processing handles with identifying the noisy data which should be eliminated and then normalising data which leads to convert all data values neural network to [0.1] or [-1.1] range in order to improve the performance of the system. Furthermore, the number of hidden layers and nodes in hidden layers can be determined according to some performance criteria such as mean squared error and/or regression.

3.5.8.1 Normalisation

Günaydin and Doğan (2004) argued that the data is implicitly normalised for confidentiality and for effective training of the model being developed, where the input data must be normalised between an upper and lower bound. Furthermore, Jayalakshmi and Santhakumaran (2011) informed that the normalization of training data is recognised to improve the performance of trained networks. Therefore, the training process for each data on the same scale would help increasing the training speed. There are various ways to normalise the data statistically such as min-max, median and sigmoid methods.[1]

3.5.8.2 Hidden layer selection

Number of hidden layers in neural network architecture is considered a very important to develop a network. Therefore, the more complex problem the more hidden layers is required as well as hidden layers nodes. Thus, the simple linearly problem isn't required any hidden layer. The adding hidden layer should be defined and taken into consideration in neural

[1] In this thesis the normalisation would done directly by NeuroSolution programme application.

network architecture's design. Many typical performance criteria are used as the root mean square error (RMSE) and the correlation factor (represented by R).

Generally, the root mean square error (RMSE) is a criterion, which is used to calculate the ability of network by researchers to yields accurate predictions as the following equation:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(y_i - \hat{y}_i)^2}{N}} \quad \text{Eq. (3-9)}$$

Where y_i is the final (true) output values, $\hat{y}_i$ is the output of network and N the total number of observations. Therefore, the lower value of RMSE leads to the more accurate prediction. Also, the correlation factor (R) is a statistical range from 0 to 1 which indicates to a perfect fit and 0 no fit (Dubuc et al., 1989). Alhutmany (2013) explained that the single layer with minimum nodes could be satisfied for the performance of the network with its current number of hidden layers and hidden layer nodes. If it isn't satisfied the nodes would be increased to satisfy the performance criteria in order to meet some determined set values.

3.5.9 Training of neural network

Before training, the data should be encoding, further, Kshirsagar and Rathod (2012) stated that the ANN deals only with numerical inputs. Therefore, the raw data can be transformed into numeric. Principe et al. (2010) explained that the data should be in numeric format or transformed to numeric format which is used many ways; some ways are better than others for neural network learning through training.

The training of a neural network is to adjust the neural network weights to bring the obtained output closer to the desired output, as well as the weights after training become more meaningful information than before training, when they are random and have no meaning.

In this process of changing the connection weights, suitable learning rule of the network must be referred and adopted (Doğan, 2005).

Firstly, the training process is to initialise the weight of parameters, which assigned randomly to the links between nodes. After that, the output of the neural network is compared to desired values. Consequently, error must be calculated by learning algorithm, in which the weights of each link are directly adjusted to minimise the network's mean square error. Then, the input values are run through the network with the adjusted weights in order to restart the process from the beginning, so the process is repeated for the predetermined number of epochs. Every one epoch represents one cycle of the training process. Doğan (2005) stated that when the satisfactory level of training is reached; the network holds the weights constant to use the trained network for making decisions, or to define associations in new input data sets, which are not used to train it. In essence, Ashwood (2013) and Weckman et al. (2010) argued that the network training process occurs until either of the following events occurs:

- A pre-defined, arbitrary error level has been achieved. Once this error level has been achieved, training terminates and simulation can occur.
- The maximum number of calculations (epochs) has been reached.
- The cross validation error started increasing, or
- Very large numbers of epochs without improvement in error are reached.

A study conducted by Günaydin and Doğan (2004) stated that there are several training algorithms which are chosen for training process, one of them which the powerful algorithm is "Back propagation" that belongs to the realm of supervised learning. Consequently, it is adopted in this study to learn multilayer network which concerns with feed forward network structure (Ashwood, 2013). Since, 1969[1], the Back propagation was invented to improve the performance of the neural network for a given set of input patterns by reducing the total error through changing the weights along its gradient (Jitendra et al., 2011).

The artificial neural network, which is created to utilise back propagation must have a minimum of three layers (input layer, output layer and at least one hidden layer). The information passes only in the forward direction and there is no feedback loops (in this type of process cannot be applied for recurrent network). Consequently, the back propagation algorithm changes the weights of neuron input to improve the accuracy of the network, in addition, the standard method of back propagation depends on the delta rule which is a gradient descent learning rule used for updating weights which are applied to network processing elements (neuron) (Ashwood, 2013).

The delta rule provides a method of calculating the gradient of the error function efficiently by using the chain rule of differentiation (Rao and Srinivas, 2003). The back propagation algorithm functions as follows:

1. Input weights are randomly applied to the network.
2. The network calculations occur and the network produces an output based upon the neuron inputs, the input weights, and the transformation functions.
3. The calculated output is then compared to the target output.
4. The error of the output is calculated using the selected error function.

[1] Ashwood (2011), argued that the back propagation algorithm was discovered by Werbos (1974).

5. The error is then back propagated through the network, thereby changing the input weights in each layer.
6. The process (steps 2 – 5) then repeats until the error reaches the desired level or the maximum number of epochs is reached.

The error can be expressed by the mean-square error (MSE), which is calculated by:

$$MSE = \frac{\sqrt{\sum_{i=1}^{n}(x_i - E(i))^2}}{n} \qquad Eq.(3-10)$$

Where:

- n is the number of examples to be evaluated in the training set,
- x_i is the network output (target) related to the example (i=1,2,…,n),
- and E(i) is the desired output.

3.5.10 Cross-validation of neural network

Edara (2003) stated that the method to compare the performance of neural network is to test the error by a separate validation / test data set. Generally, the available data is always divided into three parts before training, which are respectively training data, cross-validation data, and testing data. Consequently, the cross-validation data is used during the training only for monitoring but not to train the network in order to check the learning of the network in training process; and the testing data is used to validate the training network after finishing training process.

Basically, cross validation has its own data set checking the networks' ability to produce generalised output. Normally, networks have many training on a training set and comparing the errors of the network to the validation set. Then, the networks that performed best on the validation data set are selected (Dindar, 2004).

The learning of networks is continued as the error for the cross validation as well as training data set continue to decrease. When the error of the cross validation data set starts to increase, the training stops, and the weight values which verify the lowest error for cross validation data set are considered the best. The training set error values may still decrease once the cross validation error values start to rise. Consequently, the network is over-fitting and memorising the training data. If cross validation is not used, then a test data set is critical to prove that memorisation and over-fitting is not occurring figure (3.8) (Weckman et al., 2010, Dowler, 2008).

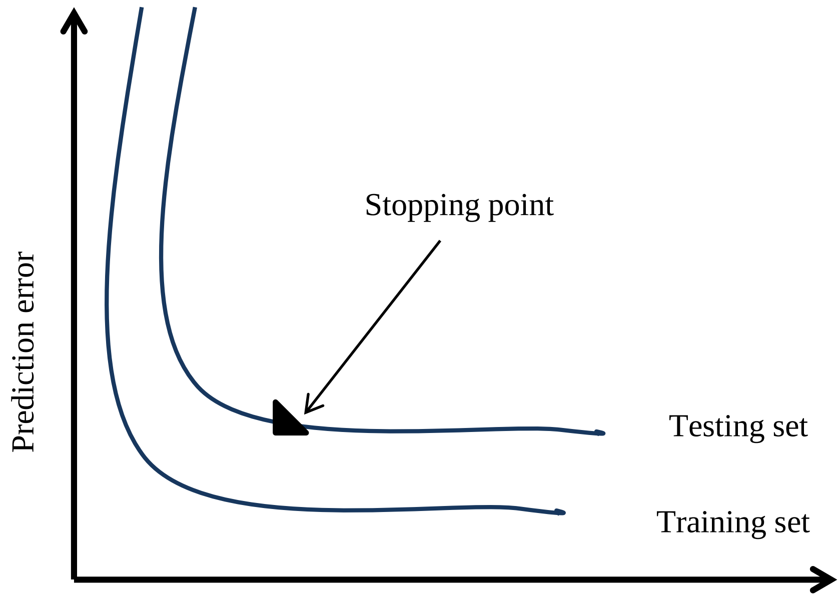


Figure 3.8 Typical error graph for NN using cross validation, Weckman et al., (2010).

3.5.11 Testing of neural network

Essentially, the testing process is the same as the training (ElSawy et al., 2011), testing set is used to confirmed that the network has been learned (Shehatto, 2013). Therefore, the data of test can be used after the training has been finished in order to use for validation and generalisation of the trained network. When the networks is capable to produce a precise output for the testing data, then it refers that the prediction of networks is correctly regarding to new data as well as the networks is validated. The availability of data controls the data amount, which is used in training and testing. Generally, the training data is 2/3rd of all data and the remaining is for testing. Although, the cross-validation data can be 1/10th of the training data (Edara, 2003).

3.5.12 Performance measures of ANN model

For determine the accuracy of estimate in testing phase, some calculation test should be performed such as:

- Mean Absolute Error (MAE)
- Mean Absolute Percentage Error
- Mean squared error
- Root mean squared error (RMSE)
- Correlation Coefficient (R)

a. Mean absolute error (MAE)

In order to quantify the difference between an estimated and the actual values, this test can be used. Also, Willmott and Matsuura (2005) pointed out the importance of the MAE which is simple, and can be obtained through summing the magnitudes (absolute values) of the errors in order to get the total error, after that dividing the total error by the number of exemplars in data set; the following formula should represent the MAE:

$$MAE = \frac{\sum_{i=0}^{p}\sum_{i=0}^{n}\left|dy_{ij} - dd_{ij}\right|}{NP} \qquad Eq.(3-11)$$

Where: P = number of output PEs.

N = number of exemplars in the data set.

dy_{ij}= denormalised network output for exemplar i at PE j.

dd_{ij}= denormalised desired output for exemplar i at PE j.

b. Mean absolute percentage error

According to Principe et al. (2010)[1], it can measure the network prediction performance as a percentage and can be defined as the following:

$$MAE\ (\%) = \frac{100}{NP}\sum_{j=0}^{p}\sum_{i=0}^{n}\frac{\left|dy_{ij} - dd_{ij}\right|}{dd_{ij}} \qquad Eq.(3-12)$$

Where: P = number of output PEs.

N = number of exemplars in the data set.

dy_{ij}= denormalised network output for exemplar i at PE j.

dd_{ij}= denormalised desired output for exemplar i at PE j.

c. Mean squared error

According to Principe et al. (2010), the Mean squared error is two times of average cost and can be represented by the following formula:

$$MSE = \frac{\sum_{i=0}^{p}\sum_{i=0}^{n}(d_{ij} - y_{ij})^2}{NP} \qquad Eq.(3-13)$$

Where:

P = number of output PEs.

N = number of exemplars in the data set.

y_{ij}= network output for exemplar i at PE j.

d_{ij}= desired output for exemplar i at PE j.

[1] In Principe et al (2010), it is called percentage error, contractory, shehatto (2013) is called it Mean Absolute Percentage Error which is considered in this study.

So, the Network performance can be measured as the sum of squared errors (Ashwood, 2013).

d. Root mean squared error (RMSE)

it is the network performance of using the square root of the mean squared error in order to provide errors as the output unit (Ashwood, 2013), Willmott and Matsuura (2005) revealed that the MAE is better than MSE or RMSE in which is a more natural measure of average error. The last equation Eq. (3-13) can take its root to achieve the RMSE, or another equation was obtained in section (3.5.8.2) Eq. (3-9).

e. Correlation coefficient (R)

The mean squared error doesn't give judgment how the network output fits the desired output. For the last reason, the correlation coefficient reflects whether the output and the desired output move in the same direction, then the correlation coefficient (R) can be defined as a correlate between the output of network (x) and the desired output (d) as the following formula (Principe et al., 2010, Shehatto, 2013):

$$R = \frac{\frac{\sum_i (x_i - \bar{x})(d_i - \bar{d})}{N}}{\sqrt{\frac{\sum_i (d_i - \bar{d})^2}{N}} \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{N}}} \qquad \text{Eq. (3-14)}$$

Where:

$\bar{x}$ = mean value over all output of network.

$\bar{d}$ = mean value over all desired output.

N = the total number of observations

So, the correlation coefficient is a range [-1,1]; the value of R = 1 indicating a perfect positive linear correlation and also means mean x and d vary by the same amount. Further, when the R = -1, it indicates that there is a negative correlation between x and d leads to vary in opposite ways increasing x decreasing d by the same amount and the same in contrast. Furthermore, when the value of R = 0 indicating there is no correlation between x and d. sometimes the correlation value can be considered as intermediate correlation or partial correlation such as R = 0.80 which means the fit of model is good.

3.5.13 Sensitivity analysis of ANN model

After the model of neural network has been considered, the sensitivity analysis performs on the best model in order to evaluate the effect of each input parameters to output variable; providing a feedback in which the input parameters which are most significant. This test provides information about how the inputs affect the output as well as helps to remove the less significant variable in order to reduce the size of the network and the complexity. It is also for extracting the causes and effect relationship between the input variables and the output variable (Günaydin and Doğan, 2004, Principe et al., 2010), Arafa and Alqedra (2011) stated that the small effect of the parameter on the output may be excluded to improve the learning process and to achieve a best output. Then, the concept of sensitivity analyses of the inputs depends on determining the standard deviation of each input when the inputs are fixed at their means by using the following formula:

$$\sigma = \sqrt{\frac{(x-\bar{x})^2}{(n-1)}} \qquad Eq. (3-15)$$

Where x: is the output value.

¯x: is the mean of the output values.

n: is the number of the outputs in the sample.

3.5.14 Artificial neural network and multiple regressions

The artificial neural network and multiple regression models are significantly different and can be used to predict the relationship between independent variables and dependent variable. In addition, the ANN is complex comparing to the multiple regression analysis and the ANN outperform the multiple regression when the inputs data include nonlinearities (Comrie, 1997).

Osborne and Waters (2002) debated that the multiple regression is a linear model makes a relationship between independent and dependent variables but also can include some noise data affecting the linearity. Then, the regression coefficient could be determined to minimise the error. Ordinary, least squared is used and is considered as the simplest and efficient method to minimise the sum of the squared error which is contained in each measurement. As well, the assumption of linearity is considered the base of accuracy for multiple regression model prediction. When the relationship isn't linear, the regression analysis will be under estimate the true relationship in order to turn carries two risks:

1. Increased probability of Type II error (failing to reject the null hypothesis when it is actually false) for each independent variable for which this assumption does not hold.

2. Increased probability of Type I error (incorrectly rejecting the null hypothesis) for other independent variables that share variance with that independent variable.

Furthermore, the multiple regression is a Gaussian technique of analysis that suppose the variables are normal distribution, so the model isn't strong to where the variables have fat tailed distributions which outlying data points leads to can distort relationships and significance tests.

Tabachnick and Fidell (2012) debated that the regression model is assumed to be homoscedasticity indicating that the variance of errors is constant for over the range of values of independent variable. A little effect on significant test refers to slight heteroscedasticity. Nonetheless, Osborne and Waters (2002) showed that higher levels of heteroscedasticity significantly increase the Type I error possibility[1]. Therefore, Ashwood (2013) stated that the limitation of multiple regression leads powerfully to use the ANNs. Otherwise, the ANNs can be formulated to be considered non-parametric, thus, no assumption about independent variables, the dependent variable or the error can be made. Of prime importance, theoretically, the ANNs may outperform multiple regression models to predict future cost.

Based on empirical findings, there was one hypothesis was proposed as following:

H9: Preliminary estimate has a significant correlation with the final detailed cost.

3.6 Previous Studies

In general, Günaydin and Doğan (2004) and Emsley et al. (2002) adopted NNs and regression techniques for estimating the early stage, but they used some parameters which were not defined in the early stage. For this reason, difficulties may face the accurate estimation to achieve the reality; some of these factors are the floor type of the building, stair types, wall-to-floor ratio, the foundation system, and Air conditioning. As well, Sonmez (2004) discussed the model using regression analysis and NNs techniques in which construction year, location, total area, number of floor and structured parking per cent were the cost attributes involved in this model. Another study was conducted by Chan and Park (2005), which used a principle regression to build a new cost estimation model. It included 57 factors some of which were not to be available at the conceptual stage, such as good bidding information, time given to owners/consultants to evaluate bids, bidding environment, subcontractors' experience and capability, and consultant's staffing level to attend to the contractor.

[1] Failing to reject the null hypothesis when it is actually false.

Moreover, Lowe et al. (2006) debated the model from regression model point view to estimate the cost at early stage relying on information such as mechanical installations, ceiling finishing, height, function, stories below ground, and piling, also some of them not available at the conceptual (preliminary) stage.

On the other hand, Cheng et al. (2009) estimated the house projects using the neural network model and depending on quantitative and qualitative 10 variables for their model such as, floors underground, floors aboveground, site area, total floor area, number of households, households in adjacent buildings (quantitative factors), soil condition, interior decoration, seismic zone, and electromechanical infrastructure (qualitative factors).

Also, Kim et al. (2008) choose his model for high way construction project according to CER algorithm. The factors which were debated as independent variables are location, project type (new, extension), contract type, construction period, total length of road, road width, total length of bridge, and total length of tunnel.

Nonetheless, Hunter (2014) studied the cost estimation in the preconstruction stage and developing framework focusing on the type of estimation and factors affecting the cost estimation. Two types of estimates were found top-down and bottom-up estimates, the difference in the estimate was dependent on the end user and the amount of data available. Three factors which were complexity, project type and construction cost were found to be the three factors that had a major influence on cost estimate. Multiple regression, decision tree, and neural networks' models were chosen to select the most appropriate model, which would reliably estimate the preconstruction costs. The neural network model, was adopted and applied with a top-down estimate, the final model providing estimates with error 1.4% over 13 projects.

Furthermore, Kim et al. (2013) stated that the cost estimation in the early stage wasn't accurate due to incomplete drawings. Consequently , three various techniques had been applied and compared to the accuracy of three estimating techniques (regression analysis (RA), neural network (NN), and support vector machine techniques by performing estimations of construction costs. Neural network model revealed more accurate estimation results than the regression analysis and support vector machine techniques models.

Shehatto (2013) debated the estimation of high degree of accuracy without the need for detailed information or drawings in order to fulfil the parties of the project. The Artificial Neural Network (ANN) model was used as new approach in cost estimation, with quantitative and qualitative techniques were utilised to define the variables for the building project costs. The ANN model considered eleven variables as independent input affected one dependent output variable "project cost". Furthermore, Neurosolution software was used to train the models. The average error of test dataset for the adapted model was largely acceptable (less than 6%).

3.7 Construct Models

In many researches of cost estimate field, they have focused on the early stage estimate to satisfy the client desires or the consultant decision as well as the contractors. To the best of the author's knowledge, there are not one research covering all estimates for all-important stages, which are in construction projects the conceptual or preliminary and the tender stages, which would be debated in the next chapter. The author has tried to verify all the requirements of these stages in order to achieve more accurately estimates.

In this research, there are numerous methods and levels of accuracy for preparing cost estimates for a construction project. In this chapter, the preliminary estimates is adopted for the early stage in order to satisfy the client desires about his/her project.

3.7.1 Quantitative estimate's model (preliminary)

Many researchers have investigated the early cost estimate for most types of construction projects (houses, commercial buildings, roads, etc.).

Hunter (2014) examined the cost estimation variables in the preconstruction stage and developing these variables for road project. Because these projects were roads, many variables did not belong to this research's objective. However, after he examined those 12 variables, only three independent variables were adopted as most important variables, which are complexity, project type, and construction cost.

The construction cost term is similar to project cost term in the meaning which was mentioned in Shehatto (2013) and other researchers as dependent variable. Thus, it is not a good decision to consider as independent variables at early stage. Three models (multiple regression, decision tree, & NN) were chosen to select the most appropriate model, which would reliably estimate the preconstruction costs. The NN model was adopted and applied with a top-down estimate, the final model provided estimates with a weighted error of 1.4% over 13 projects.

In addition, Shehatto (2013) discussed the needs of estimation for high degree of accuracy and without detailed information or drawings to satisfy the parties of the project (Clients, Donors, Consultant and Contractors). The Artificial Neural Network (ANN) model was used as new approach in cost estimation, were utilised to identify the significant parameters for the building project costs. The ANN model considered eleven significant parameters as independent input variables affected one dependent output variable "project cost". These variables were according to their significant area of typical floor, number of storeys, use of building, type of foundation, number of elevators, slab type (solid, ribbed…), type of external finishing, presence of HVAC and false ceiling, tiles type, type of electricity works, and type of mechanical works.

Furthermore, Kim et al. (2013) stated that the cost estimation in the early stage wasn't accurate due to incomplete drawings. Consequently, ten variables were adopted to be examined for school projects in UK in order to estimate the cost in the early stage. Those variables were year, budget, school levels, land acquisition, class number, building area, gross floor area, storey, basement floor, and floor height. Three various techniques had been applied and compared to the accuracy of three estimating techniques (regression analysis (RA), neural network (NN), and support vector machine techniques (SVM)) by performing estimations of construction costs. By using a historical data, it was found that NN model showed more accurate estimation results than the RA and SVM models.

Another study was conducted by Arab (2011) examined the variables which affect the school estimation cost in the early stage in UK. He determined two most important variables design and engineering requirements. Because of UK is not a developing country; the requirements of schools controlled by highly specifications through authority's agencies. Design and engineering requirements content may be interpreted as above mentioned variables (area of storey, number of floors, etc.). Multiple regression technique was used to analyse those variables.

On the other hand, Cheng et al. (2009) used the neural network model to estimate the house projects and relying on quantitative and qualitative 10 variables for their model which were floors underground, total floor area, floors aboveground, site area, number of households, households in adjacent buildings (quantitative factors), soil condition, seismic zone, interior decoration, and electromechanical infrastructure (qualitative factors).

Other variables, which were investigated and examines for early stage estimate by Doğan (2005) which were the total area of the building, the ratio of the typical floor area to the total area of the building, the ratio of the footprint area to the total area of the building, the number of floors, the type of overhang design, the foundation system, the type of floor structure, and the location of the core. In that research, the machine learning techniques was used for calculating the construction cost in the early stage of the project. The ANN model also used to enhance the model by experiments. Cost data belonging to the superstructure of low-rise residential buildings were used to test these models.

According to Arab (2011), some variable which were indicated in some researchers' models such as (Thalmann, 1998 and Lowe et al., 2006), those variable were not available at conceptual stage and didn't fit in the context of his research such as usable floor area, mechanical installations, ceiling finishing and year of construction as the input variables of their model.

In addition, Emsley et al. (2002) investigated that the failure of these cost models in expressing client needs and requirements which have difference between the early estimated cost and the cost estimated after the design was set out. Therefore, the design would express the others various client needs and requirements but does not fit and belong to the early cost figure. It is very important to determine the independent variables at early estimate that expresses client needs (the voice of client) rather than the design attributes (the voice of design).

Some models contain both the voice of client and the voice of design; but the voice of design can be determined by the voice of client, which is supported by the consultant (voice of design) such as, type of foundation, presence of HVAC, and type of electricity works. These variable may be determined by the experience of consultant that advice the client according to his experience in order to enhance the accuracy of estimate.

From the last discussion by Arab (2011), and Emsley et al (2002), there are three factors, which may be adopted in construct the model of this study as the following:

1- The variables must be at the early stages (preliminary) and fit to the context of this study.
2- The independent variables must be reflecting the client requirements (the voice of client rather than the voice of design).
3- The independents variables that reflect the both voices of client and design can be adopted.

Based on the above last discussion, the model would have been adopted in this research depends on the literature review of the last previous studies which controlled by the last three factors in order to achieve the most important independent variables.

The author is almost used all variables which are implicitly sharing between studies and are suitable for preliminary estimate in this research according to the following table (3.1). Sometimes, some variables are repeated by different text content. In this case, the author has chosen on of them. In addition, variables do not fit to the context of this study at the early stage is ignored and criticised as well as the variable which don’t satisfy the voice of client (client requirements).

The following variables, which are not adopted in this research don’t belong to the preliminary (conceptual) stage. They don’t represent the voice of the client but most of them represent the design attributes such as Year, budget, school levels, land acquisition, class number, number of households, households in adjacent buildings, seismic zone, the ratio of the typical floor area to the total area of the building, the ratio of the footprint area to the total area of the building, the type of overhang design, and the location of the core).

Seventeen variables were chosen as variables of model cost estimate at the early stage in Yemen. These variables are complexity, project type, area of floors, number of storeys, type of foundation, number of elevators, slab type, type of external finishing, interior decoration, type of HVAC system, tiles type, type of electricity works, type of mechanical works, basement floor, floor height, site area, and project location.

Table 3.1 shows Models of preliminary cost estimate at early stage.

Researcher	**Project type**	**Technique**	**Cost variables (drivers)** *
Hunter (2014)	roads	NN	- complexity - project type - *construction cost*
Shehatto (2013)	-Prayer place -Residential -School extension -Schools -Public building -Mosques	ANN	- Area of typical floor - Number of storeys - Use of building - Type of foundation - Number of elevators - Type of slab - Type of external finishing - Presence of HVAC and false ceiling - Type of tilling - Type of electricity works -Type of mechanical works
Kim et al (2013)	schools	- regression analysis - neural network (NN) - support vector machine	- *year* - *budget* - *school levels* - *land acquisition* - *class number* - building area - gross floor area storey - basement floor

			- floor height.
Arab (2011)	schools	Multiple Regression	- design requirements - engineering requirements
Cheng et al (2009)	Housing	NN	- floors underground - total floor area - floors aboveground - site area - *number of households* -*households in adjacent buildings* - soil condition - *seismic zone* - interior decoration - electromechanical infrastructure
Dogan (2005)	Buildings	machine learning	- the total area of the building - *the ratio of the typical floor area to the total area of the building* - *the ratio of the footprint area to the total area of the building* - the number of floors - *the type of overhang design* - the foundation system - the type of floor structure - the location of the core
Hakami (2015)	-Residential -schools	ANN	-Complexity - Project type - Area of floors - Storeys No. -Type of foundation - Number of elevators

			- Slab type - Type of external finishing - Interior decoration - Type of HVAC system - Tiles type - Type of electricity works -Type of mechanical works - Basement floor - Floor height. - Site area - Project location

Source: Author

*The italic words have chosen by the author to formulate this study model.

3.8 Summary

This chapter explained the term of accuracy from many points of view. The two techniques in preliminary estimate were debated which were the traditional and modern methods. It was clear, the most powerful technique was the modern techniques, which were discussed and investigated by many researchers. The artificial neural network (ANN) was adopted as a modern intelligence technique. As well, it was learned about its biological and structure such as neuron activation, transformation, its architecture, and the learning rules. Moreover, ANN appeared its ability to simulate the human brain in training, cross-validation, and testing process, which were learned and the performance of model became easy to handle as well as the sensitivity analysis.

In addition, the previous studies supported the theory of this study's model formulation. After that, the quantitative model was built for this study. Finally, the second objective of this study was partially achieved and the second question was also answered with regards the mathematical model.

CHAPTER IV: DETAILED ESTIMATION METHODS

4.1 Introduction

This chapter presents the importance of detailed estimate method and debates the process of estimate, which passes through many important steps. Firstly, decision to tender or not belongs to senior management as well as some factors affect the decision are mentioned. For more importance, base estimate refers to obtain and review the bid documents, which is debated through many additional processes, should be also studied and reviewed such as scope baseline, resource calendar, project schedule, human resource plan, risk register, enterprise environment factors, and organizational process assets. Measurements are also discussed as well as the site visit. Furthermore, pricing process, management review, and close bid appear more complement to the whole process of estimate in tender stage. Bottom–up method is debated as a tool of detailed cost estimate. Previous studies are mentioned in order to construct the theoretical model for this study. After that, the qualitative models are debated and adopted in this study. Furthermore, the operationalization of this study reveals how this study would be investigated. Methodology and analysis techniques are mentioned to define the literature of methodology and the analysis technique, which would be used later. Finally, the summary describes this chapter briefly.

4.2 Detailed Estimates

The detailed estimate method is considered to yield a price that is an accurate forecast of the actual costs of construction project rather than any of the other estimating methods considered. In the detailed estimate, the form of a quantity take-off is the accurate assessment of the work and can only be gained from the full design of the project. In addition, it consumes time rather than the preliminary estimate which is prepared by other quicker but less accurate (Pratt, 2011b).

Furthermore, Pratt (2011b) subsidised that the purpose of estimating according to:

1. Preparing construction cost estimates that will allow the contractor to gain profitable work by the competitive bidding process,
2. Maximising the accuracy of the estimating process by containing procedures for checking and verifying the precision of the work,
3. Maximising the productivity of the estimating department in terms of producing the highest volume of estimating product with the resources available,
4. Using the estimating department in an effective method that commits these resources to projects with the most likelihood of success, and
5. Fostering a company-wide cooperative approach to estimating and bidding that, in recognition of the value of good estimating, commits all company personnel to improving the quality of estimating.

Moreover, ElSawy et al. (2011) stated that the detailed cost estimate is a great importance in tendering phase as well as a key function for acquiring new contracts at right price in order to provide gateway for long survival in the business. Therefore an accurate estimate of the bid price for a construction project is important to secure the project contract and achieving a reasonable profit, where in practice, the available bid-estimation time is often insufficient (Akintoye and Fitzgerald, 2000).

4.2.1 Detail estimate process

According to Sha'at (1993), the beginning of cost estimate when the tender is decided by the contractor to bid and study the documents as well as cost estimating for project begins, practically, when the contractor decided to submit to the owner or her/his representative.
Nevertheless, after bid information is obtained, the decision to bid or not to bid on the project, it is not final (Pratt, 2011b). Consequently, the process of estimate has many steps to ensure the accurate estimation.

4.2.1.1 Decision to tender

The decision to tender for a particular contract is mainly the responsibility of senior management for both public and private projects after getting the information of the bidding, as well as the ability of company to obtain information about projects that are out for bid as part of the marketing effort (Pratt, 2011b, Shehatto, 2013) . In order to make decision to bid, there are many factors must be taken into consideration, but are not limited to, type of project, and size and (rough) estimate of contract value. As well, location of the project, quality of drawings and specifications, reputation of owners and designers, specialised work, anticipated construction problems, safety considerations, need for the work, and bonding capacity are also the factors of making decision (Pratt, 2011b).

4.2.1.2 Obtaining and review bid documents (Base estimate)

When the contractor has decided to bid, the documents of bedding must be obtained and reviewed, in which the contractor wishes to proceed or not.

Importantly, the reviewing for documents to verify the information necessary, in order to complete the bid report and also to highlight the data that the estimator will need to refer to later in the estimating process. Therefore, the team approach technique is a good manner to achieve accurate high- quality. The bid documents mainly includes, but aren't limited to, drawings, specification, form of the contract, etc.

Ideally, some others documents must be prepared by contractor team and submitted to estimators to help them in their calculation to ensure the accuracy of cost estimate as following:

a. Scope baseline

It is important, the level of scope detail varies depending on the project phase, project type, and project complexity which will influence costs and any change in scope has caused the cost overrun in which will be faced (O'Conchuir, 2011, Washington, 2008).

According to PMI (2008) and O'Conchuir (2011), Scope Baseline includes:

1- Scope Statement: it mainly contains the product description, acceptance criteria, key deliverables, project boundaries, assumptions, and constraints[1] about the project in which to define the project deliverables and the work needed to produce them. Washington (2008) stated also that the scope describes the project in words and includes underlying assumptions cautionary notes, and exclusions.

2- WBS (Work Breakdown Structure): is a deliverable-oriented hierarchical decomposition of the work to be executed, in order to fulfil the project objectives,

[1] Assumption must be briefly precise. Some of constraints are delivery dates, available skilled resources, and organisational policies.

and determine the very important required deliverables by descending levels of the WBS, which represent an increasingly detailed definition of the project work. Furthermore, the lowest level of WBS is called a work package, in an important; the basis is for estimating cost and durations as well as assigning project work. Rad (2002) defined the WBS, which is a uniform, consistent, and logical method for dividing the project into small, manageable components for purposes of planning, estimating, and monitoring.

3- WBS Dictionary: very useful documents provide more detailed descriptions and information about the components in the WBS and each work package. Information in the WBS dictionary includes (PMI, 2008, O'Conchuir, 2011), but is not limited to:

- Code of account identifier
- Description of work
- Responsible organisation
- List of schedule milestones,
- Associated schedule activities,
- Resources required,
- Cost estimates,
- Quality requirements,
- Acceptance criteria,
- Technical references, and
- Contract information.

b. Resource calendars

In essence, PMI (2008) and O'Conchuir (2011) described that the resource calendar is the availability of each significant human, material, and equipment resource which include information on which resource (such as people, equipment, and material) are available in planned activity period. Furthermore, this information considers also about attribute such as resource experience and/or skill level, as well as various geographical locations from. In addition, the time of each project team member can work including vacation time and commitments to other projects. Another technique must be taken into this calendar the resource breakdown structure which explained by Rad (2002) in which has its analogue in the well-known work breakdown structure (WBS). However, the project manager can also plan the project easily with greater assurance of the resource data reliability including the amount of resources at-hand and their estimated cost in order to capitalise on organisational memory with respect to project resources as in figure (4.1).

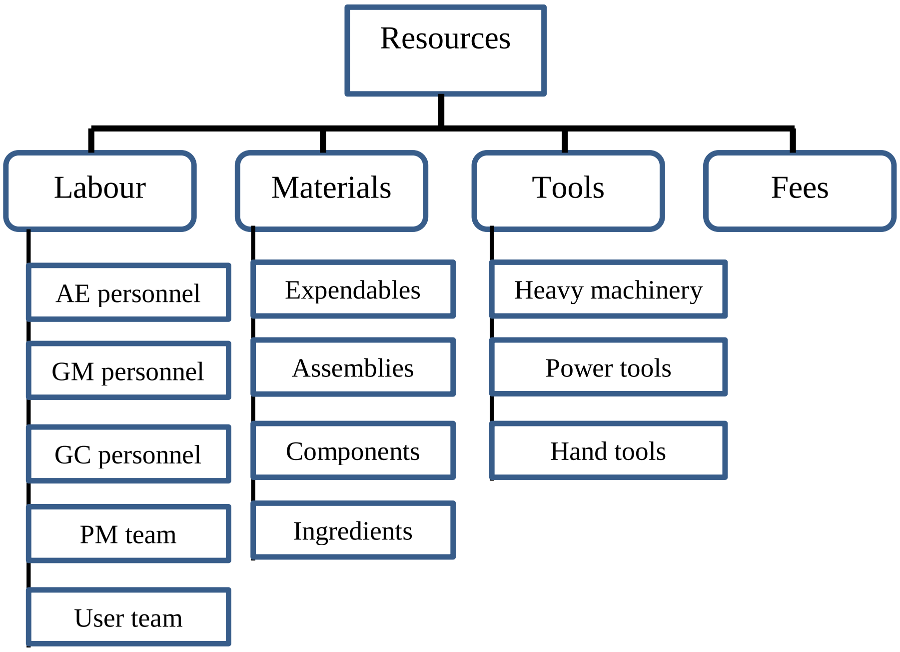


Figure 4.1 Project resources, Rad (2002).

c. **Project schedule**

O'Conchuir (2011) debated that the precise schedule has big influences on project cost, which is explicit in the next questions:

- How long will the team be active (and costing money)?
- Which skill levels will be used?
- How accurate is the schedule? Overruns will result in increased costs.
- What are the duration estimates for each activity and how accurate are they? If any tasks take longer than planned, then their costs will rise.
- What will the material costs be when the project is implemented?
- What happens if we do not get good prices for supplies?
- What cost should be added for interest and other fees?
- How stable are exchange rates?
- Do any costs have seasonal variations?

Furthermore, PMI (2008) mentioned that the schedule has a planned start and finish dates for each activity which must be included as well as resources (type and quantity) assignment. In addition, target dates for every activity should be defined (O'Conchuir, 2011).

d. **Human resource plan**

In order to accurate cost of the project, human resource plan[1] should be submitted, which provides guidance for human resources definition, staffing, and controlling.

The human resource plan should include, but not be limited to, the following: roles and responsibilities, project organisation charts, and staffing management plan.

e. Risk register

In essence, the risk register is used to mitigate the influences of risk on cost due to either threats or opportunities (PMI, 2008, O'Conchuir, 2011). Washington (2008) reported that the maximising the probability and consequences of positive risk events (opportunities) and minimising the probability and consequences of negative risk events (threats) to the project objectives should be defined.

f. Enterprise environmental factors

There are many enterprise environment factors, which affect the estimate cost process such as market conditions, employment statistics, global exchange rates, government or industry standards, and published commercial information (PMI, 2008, O'Conchuir, 2011, Washington, 2008).

g. Organizational process assets

It is a familiar as enterprise environment factors, in which, considered about internal factors that influence the estimate costs process include but are not limited to: cost estimating policies, cost estimating templates, historical information, and lessons learned (PMI, 2008, O'Conchuir, 2011).

4.2.1.3 Measuring the quantities

According to Pratt (2011b), A quantity take-off is a process of measuring the work of the project in which has to break down the design that is shown on the drawings and described in the specifications into predefined activities (work items). The take-off has been preferred to measure “net in place” for cost estimate not in “gross” for reasons:

1- Consistency: with the take-off which submit by the owner or consultant.

2- Objectivity: Measuring “net” quantities results in an objective appraisal of the design. Add-ons for waste factors, swell factors, compaction factors, and the other adjustments applied to quantities taken off are also all subjective assessments. However, this adds a complication to the pricing of the work items, which is already a difficult process.

[1] This plan also shows where the people will come and go to work, and what happen to them when the project is finished.

3- Unit Price Contracts: the Measurement of work done should familiar to a unit price contract, which is important to be calculated on a "net" quantity basis.

4.2.1.4 Site visit

After the bid documents have been reviewed, the good idea and specific questions has been obtained about the project by the estimator who can really get to know the nature of the job and may also be able to foresee possible construction problems that the project may face later. The environment investigation may be occurred regarding environment issues to consider the financial risk which can be added to the bid to cover this risk (Pratt, 2011b).

4.2.1.5 The query list

In the view of Pratt (2011b), after reviewing the drawings and the specification, some uncovered details will be shown. Thus, the query list must be prepared and submitted to designer to clarify those ambiguous matters.

4.2.1.6 Pricing the quantities

There are five pricing categories that need to be considered labour, equipment, materials, subcontractors, and job overheads. The pricing should cover the following components of construction projects, which are:

1. Pricing Construction Equipment
2. Pricing excavation and backfill
3. Pricing concrete work
4. Pricing masonry, carpentry, and finishes work
5. Pricing subcontractors' work
6. Pricing general expenses

The general expenses (jobs overhead) can be listed, but are not limited to,

1- Site Personnel
2- Safety and First Aid
3- Travel and Accommodation
4- Temporary Site Offices
5- Temporary Site Services
6- Hoardings and Temporary Enclosures
7- Temporary Heating
8- Site Access and Storage Space
9- Site Security
10- Site Equipment
11- Trucking

12- Dewatering
13- Site Clean-up
14- Miscellaneous Expenses
15- Labour Add-Ons
16- Bid Total Add-Ons

4.2.1.7 Management review

According to Pratt (2011b) and Washington (2008) mentioned that the management review is important process to ensure the best results of estimate passing with experts of estimating to enhance the comments of top management and to avoid many mistakes that could lead to losses for firm.

4.2.1.8 Closing the Bid

According to Pratt (2011b) this period the estimate prices are summarised, all the components of the bid and the bid documents are assembled and submitted to the place designated for the bid closing for summary sheets.

Based on the literature review, there were seven hypotheses were proposed as following:

H10: Base estimate has a positive effect on final detailed cost.

H11: Correct way of measurements has a positive effect on final detailed cost.

H12: Measurements has a positive effect on pricing process.

H13: Query list has a positive effect on pricing process.

H14: Pricing process has a positive effect on management review's process.

H15: Management review's process has a positive effect on bid summary.

H16: Bid summary has a positive effect on final detailed cost.

4.2.2 Bottom –up estimation method

Younossi et al. (2002) argued that the bottoms-up costing is also called as process based costing, relies on detailed engineering analysis and calculation.

Generally, bottom up cost estimate is a method to estimate cost depending on the overall cost of processes that produce the desired finished budget.

Traditionally, bottoms-up costing techniques account for overhead in materials and expenses, as well as expenses based on labour (Nachtmann and Needy, 2003), therefore, this model of bottom-up is very good, and every process is accounted for, as well as is a very powerful way to estimate cost. In addition, the design should be very detailed in order for the input data to be precise (Toth, 2006).

In addition, Rad (2002) stated that the bottom-up estimate is the most accurate and most reliable estimate for a project. Consequently, the elements of the work breakdown structure

(WBS) should be identified with a reasonable degree of reliability and the resource breakdown structure (RBS) should be also identified with the desired degree of certainty. Detailed estimate is referred to as the bottom-up estimate and it is derived from detailed information from WBS and RBS.

4.3 Previous Studies

Leng (2005) pointed out that the model, which was studied by Barrie and Paulson (1978) in estimating process, which is displayed graphically in Figure (4.2), to support the estimators in order to estimate the construction projects' cost accurately. Firstly, the decision of the top management to submit a bid if "not", then they will not continue. Furthermore, the estimators direct to gather the information about the specific project in order to measure the quantities (quantities, plant & equipment, waste allowances, and other factors). Consequently, the row cost will be then obtained and ready for make–up addition.

Also, Leng (2005) discussed another estimate model, which was belonged to Frank Harris and Ronald McCaffer (1995), and is displayed in figure (4.3). Their model consisted of decision to tender, programming the estimate, collecting & calculating of cost estimate, project study, preparing the estimate, site overheads, and estimators' report.

In addition, Leng (2005) conducted a study to develop his model according to the last two models in which is displayed in figure (4.4). Therefore, the model component was top managers' decision, gathering necessary information, review tender document, refer previous similar projects, prepare estimate, quantity take-off process to measure quantity, plant, allowances and labour, price databank, request for quotation from the subcontractors and suppliers, prepare row cost, add make-up per cent by top managers, prepare for bid submission, and the documentation.

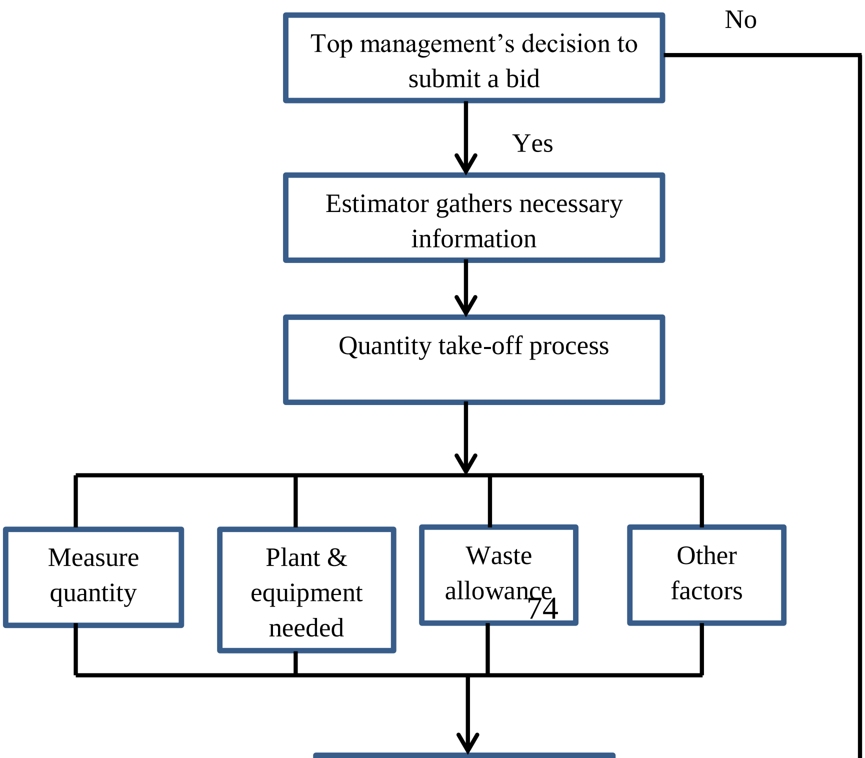


Figure 4.2 Detailed cost estimate model, Barrie and Paulson (1978).

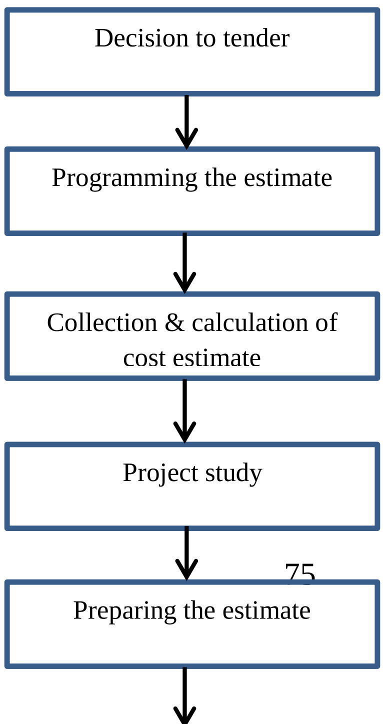
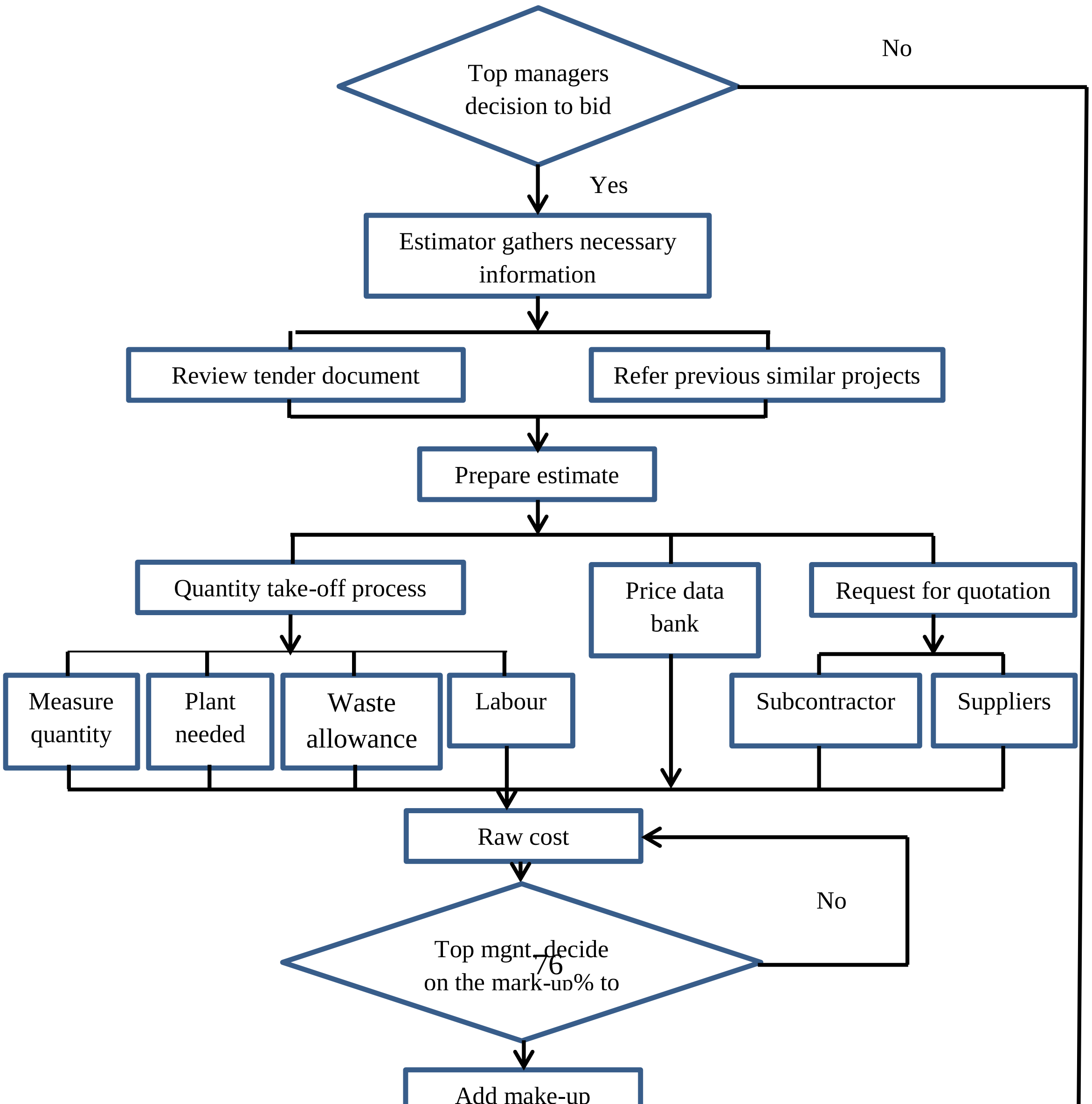


Figure 4.3 Detailed cost estimate model, Frank Harris and Ronald McCaffer (1995).



Washington State (2008) adopted another model for estimating the WSDOT project, which is displayed in figure (4.5), so their model was the following process: determine estimate basis, prepare base estimate, review base estimate, determine risks and set contingency, determine estimate communication approach, conduct independent review and obtain management endorsement, and the final estimate.

On the other hand, Pratt (2011) discussed his model which was consisted of the following, obtain bid information, decision to bid, obtain bid documents, review bid documents, notify subcontractors, take-off quantities, site investigation, price the work and general expenses, management review, price subcontractors, summarise and prepare bid, submit bid, and complete bid report, figure (4.6).

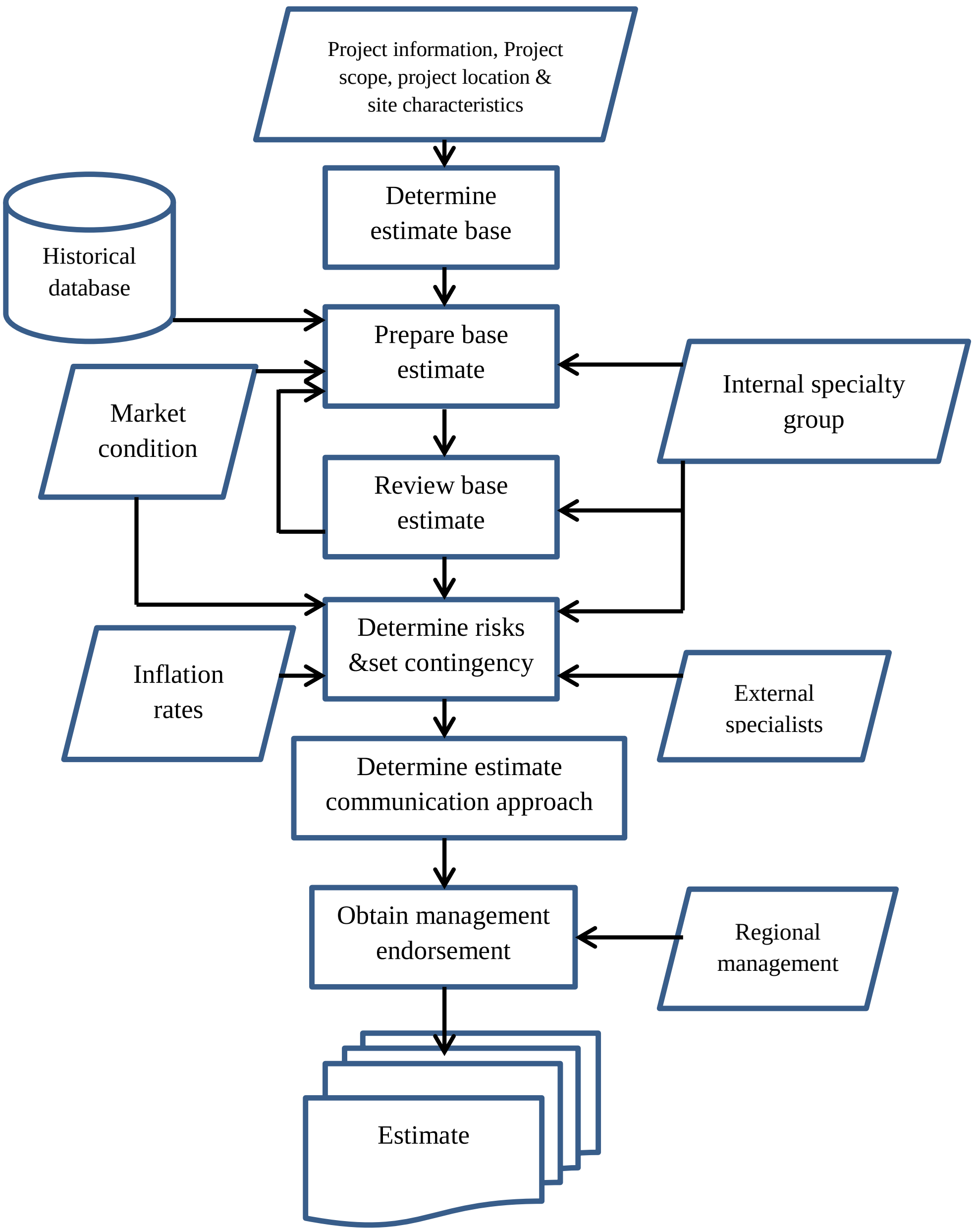
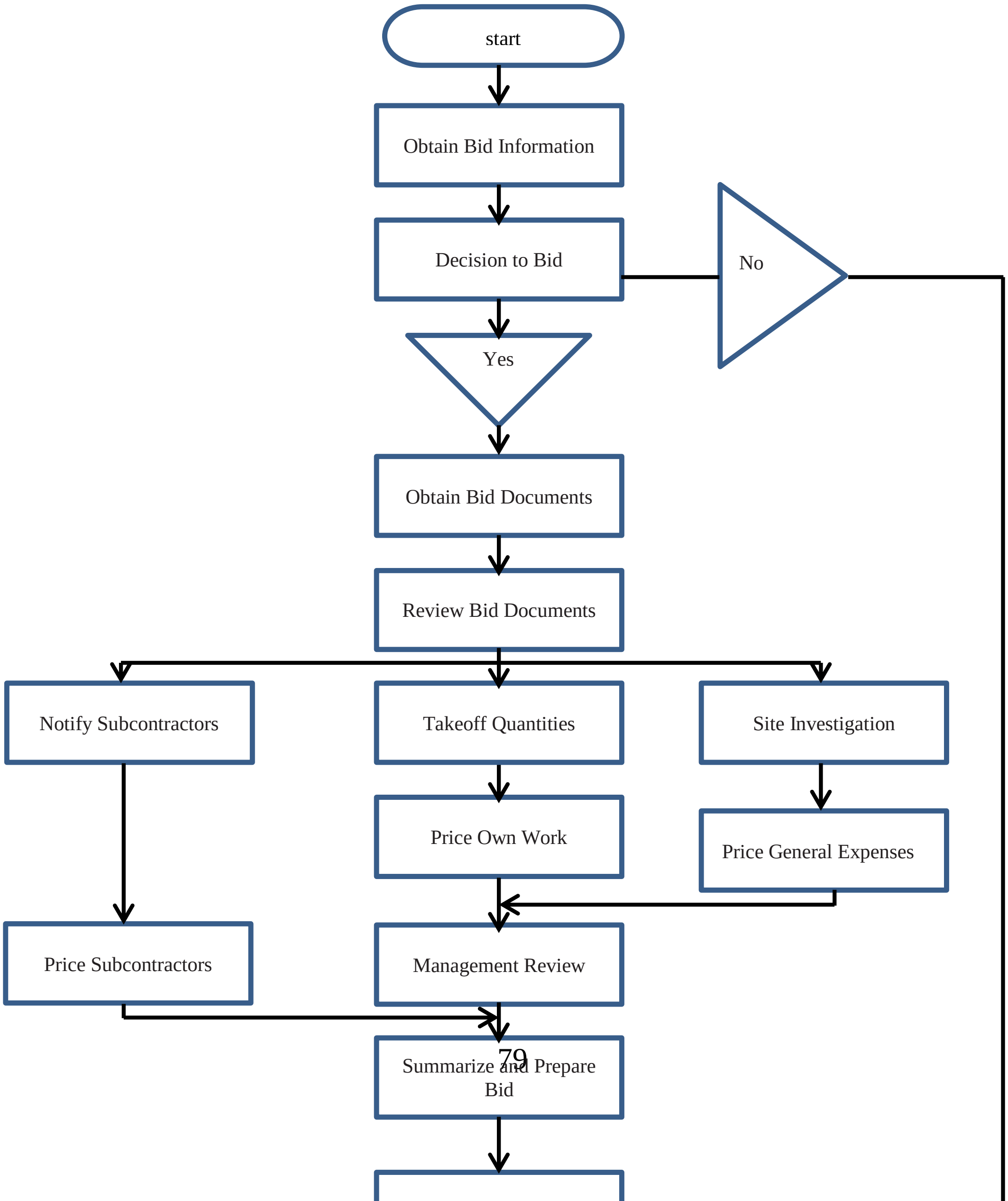


Figure 4.5 Detailed cost estimate model, WSDOT (2008).


start
Obtain Bid Information
Decision to Bid
No
Yes
Obtain Bid Documents
Review Bid Documents
Notify Subcontractors
Takeoff Quantities
Site Investigation
Price Own Work
Price General Expenses
Price Subcontractors
Management Review
Summarize and Prepare Bid

4.4 Construct Models

As it mention before in section (3.7) many researches focused on the early stage estimate to satisfy the client desires or the consultant decision; there is not one research covering all estimates for all-important stages, which are in construction projects the conceptual or preliminary and the tender stages. The preliminary estimate was discussed in the previous chapter; therefore, the detailed estimate would be discussed to unite the concept of this research to cover both early and tender stage's estimation.

The detailed cost estimate is adopted for the tender stage, which is to assist the contractors to estimate the cost of the project accurately to avoid cost overruns and delays. From the last discussion, the author has confident to satisfy the overall project's estimation from the conceptual stage until the tender stage in two models quantitative (preliminary estimate) for early stage and qualitative (detailed estimate) for the tender stage. This structure of research is considered the first attempt in construction management field to cover this range of stages as well as value added to the science of construction management and a compass for researchers to continue in the same way and idea. In addition, the two models may measure each other in different stages to reach the maximum validation.

4.4.1 Qualitative estimate's model (detailed)

Numerous studies have shown the process of detailed estimate as flow chart and model, as well as these studies were not enough in construction field. Thus, the final construction cost estimate is mostly suffering unreality estimate, which indicates that the projects may be stopped, delayed or terminated. This detailed estimate in tender stage is very important for contractors in order to offer bidding as success as they want. Therefore, the future disputes would be overcome from the beginning. Furthermore, some factors have been affected the estimate in this stage are not known by estimators. Therefore, many mistakes may be found through monitoring the cost when the corrective action is difficult and sometimes impossible. From the last discussion, the losses would be happened for all parties. Thus, successful firms prepare the estimation of their bids and finish their project according to the estimate.

For more specific, Pratt (2011) discussed his model from his point of view which was consisted of the following activities obtain bid information, decision to bid, obtain bid documents, review bid documents, notify subcontractors, take-off quantities, site investigation, price the works and general expenses, management review, price subcontractors, summarise and prepare bid, submit bid, and complete bid report, figure (4.6). This Pratt's model can be used by the skilled estimators. Thus, the knowledge, which can assist the estimators to be professional, is not available and the most important factors, which affect the estimate, are not shown. To achieve more accurate estimation, the construction cost estimate's knowledge have to be known to ensure the highly degree of accurate estimate by estimators. This addition of knowledge of construction cost is considered the first time in this study's model than others models of others researches. Thus, most researchers who investigated the cost estimate did not examine the effect of this knowledge on the process of estimate or even measured it.

Another model was developed by Washington (2008) for estimating the WSDOT projects is displayed in figure (4.5), so their model was the following process: determine estimate basis, prepare base estimate, review base estimate, determine risks and set contingency, determine estimate communication approach, conduct independent review and obtain management endorsement, and the final estimate.

From this model, it is clear there is different texts content than the last model, but they are still have the same meaning as those mentioned in Pratt's model such as determine estimate basis, prepare base estimate, and review base estimate which have the same meaning to obtaining bid documents and review bid documents. In this research, those terms were collected in one sentence (obtaining and review bid documents) as well as can be called "Base estimate". In addition, determine risks and set contingency, and inflation rates, they are two factors may affect the cost estimate as well as there are many factors may affect the cost estimate must be known and put them in front of estimators' eyes. About determine estimate communication approach, conduct independent review, and obtain management endorsement, all of them referred to management review, which was mentioned above. Therefore, the management review is adopted in this research model.

Leng (2005) conducted a study to develop his model according to Frank Harris and Ronald McCaffer (1995) and Barrie and Paulson (1978) models. Furthermore, he had added another activity in his model, which was called knowledge transfer. This transfer for knowledge had also three activities (identify the knowledge, capture the knowledge, store the knowledge) which displayed in figure (4.7). These activities are implicitly done in any work or activity managed by correct way such as documentation. Therefore, it is not important in detailed cost estimate than the reality of construction cost's knowledge, which must be known for everyone involved in estimation process.

Leng's model components were top managers' decision, gathering necessary information, review tender document, refer previous similar projects, prepare estimate, quantity take-off process to measure quantity, plant, allowances and labour, price databank, request for quotation from the subcontractors and suppliers, prepare row cost, add make-up per cent by top managers, prepare for bid submission, and the documentation. From the last brief, it is known these parameters have almost the same meaning, which is included in last two models.

Also, Leng (2005) wrote about another estimate model which was belonged to Frank Harris and Ronald McCaffer (1995), and is displayed in figure (4.3). That model had the same inputs of the last other models and was simple.

Furthermore, Leng (2005) mentioned that in (1978), Barrie and Paulson introduced their model of estimate process which is displayed graphically in Figure (4.2), to support the estimators to estimate the construction projects accurately. Firstly, the decision of the top management to submit a bid if "not", then they will not continue. Furthermore, the estimators direct to gather the information about the specific project in order to measure the quantities (quantities, plant & equipment, waste allowances, and other factors). Consequently, the row cost will be then obtained and ready for make–up addition. As we said before about Frank Harris and Ronald McCaffer (1995) model, there are no effective variables, which can be taken and this model was from the last decade.

The Model of this study relays on the structure of Pratt's model as reference model which was the newer one and included the basic variables which were examined by the others researchers; Washington State (2008), Leng (2005), Harris and Ronald McCaffer (1995), and Barrie and Paulson (1978). These basic variables, which were introduced in flow chart as estimate process, were developed in literature review. By the best of author's knowledge, there was no one examined the knowledge of cost estimate in separate model as well as the effect of this knowledge on the detailed cost estimate model.

The study's model would be formulated from two models; one model would examine the knowledge of construction cost estimate, and the second would examine the effect of this knowledge on some dependent variables, which may be also independent variables as well as would develop the basic concept of the main variables that showed in the last models.

Based on the last discussion and literature review, four new hypotheses were supposed to integrate with other hypotheses in the detailed estimate model (qualitative model) as following:

H17: knowledge of construction cost estimate has a positive effect on final detailed cost.
H18: knowledge of construction cost estimate has a positive effect on base estimate.

H19: knowledge of construction cost estimate has a positive effect on measurements.

H20: knowledge of construction cost estimate has a positive effect on pricing.

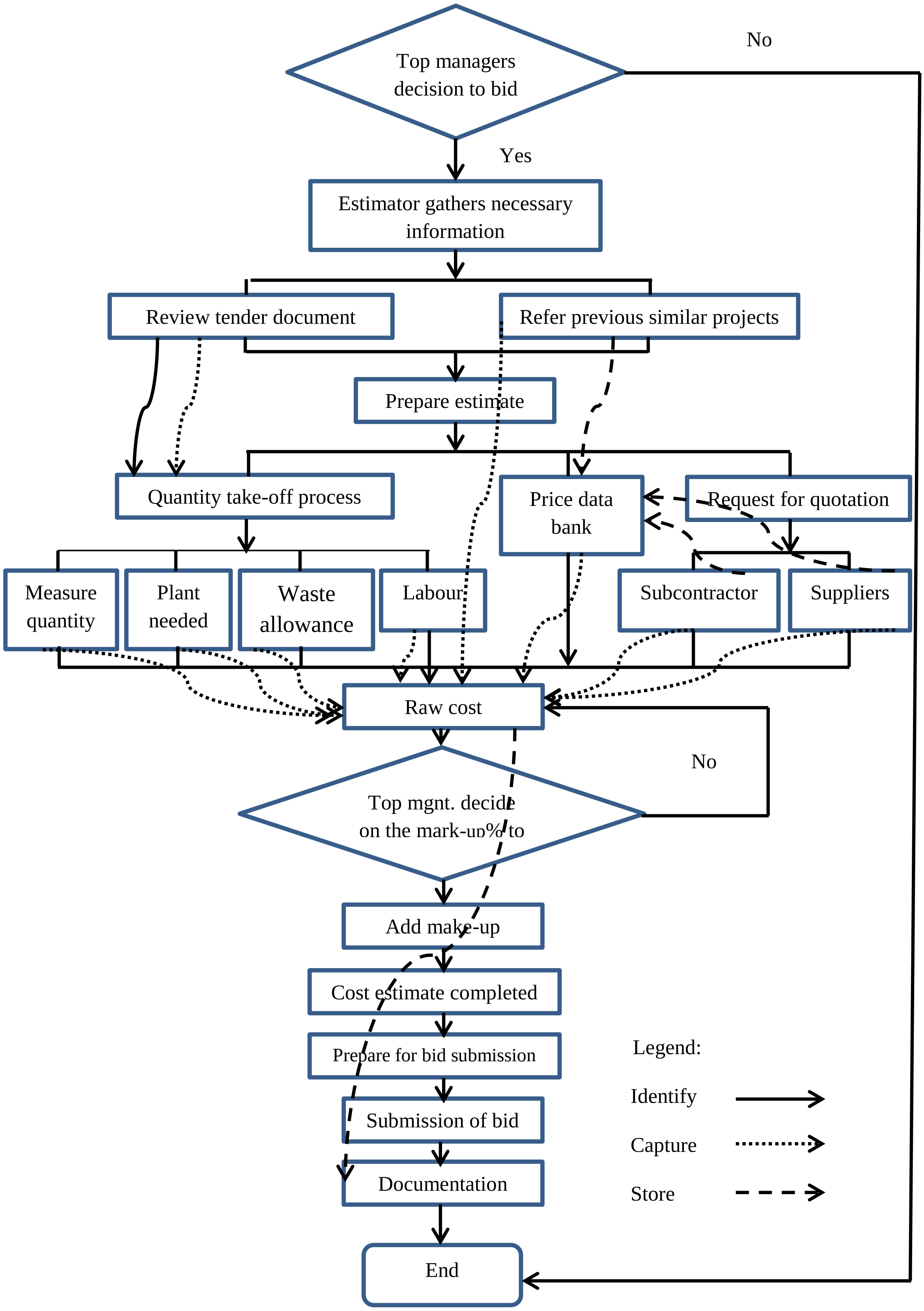


Figure 4.7 Knowledge transfer in cost estimating model, Leng (2005).

4.4.1.1 Knowledge of construction cost estimate's model formulation

Based on the literature review and first eight hypotheses, which were deduced and proposed from the literature and are mentioned below. A theoretical model of knowledge of cost estimate (KCE) was constructed by links between KCE, social and economic system, construction cost classification, cost estimation methods and techniques, types of contracts and delivery systems, critical factors, cost control process, safety considerations, and cost index. Therefore, the KCE is a dependent variable and the others eight variables are independent. The relationships between the independent variables and dependent variable (KCE) are studied. To the best of the author's knowledge, no researchers have empirically examined the relationships between the knowledge of construction cost estimate and the others eight variables, which constructed in this study. This model is displayed in figure (4.8). Based on the literature review, the following hypotheses constructed the Knowledge of cost estimate's model:

H1: The social and economic system of Yemen has a positive effect on knowledge of cost estimate.

H2: Understanding of construction cost classification has a positive effect on knowledge of cost estimate.

H3: Construction cost estimation methods and techniques have a positive effect on knowledge of cost estimate.

H4: Understanding the types of contracts and delivery systems has a positive effect on knowledge of cost estimate.

H5: Understanding the critical factors has a positive effect on knowledge of cost estimate.

H6: Understanding the Cost control process has a positive effect on knowledge of cost estimate.

H7: Understanding the safety considerations has a positive effect on knowledge of cost estimate.

H8: Cost index has a positive effect on knowledge of cost estimate.

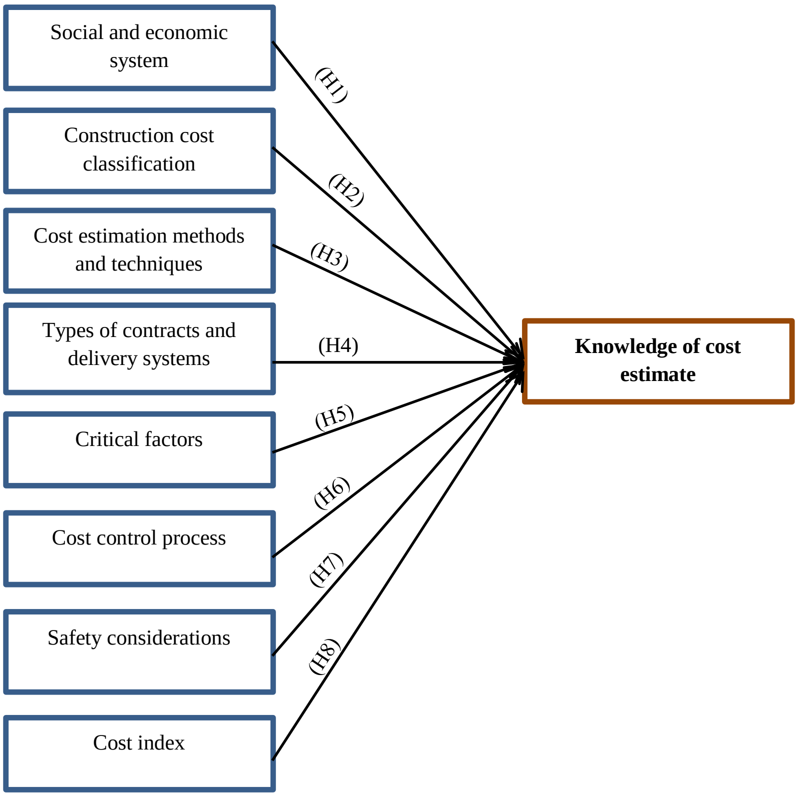


Figure 4.8 The theoretical model of Knowledge of cost estimate, Author.

4.4.1.2 Detailed estimation model formulation

Based on the KCE model, the literature review of detailed estimate process and the eleven hypotheses which were supposed from the literature and mentioned below, the detailed estimate's model which was mentioned by Pratt (2011b) which is almost satisfy the objective of this research; the detailed estimate model was constructed based on the Pratt's model. In addition, the KCE was formulated to examine the effect of the KCE as independent variable on some other important dependent variables (Base estimate, measurements, pricing, and the final detailed cost estimate) which affect the detailed estimate figure (4.9). As well, the basic variables' content were developed in the literature review by integrating most effect factors in one related common variable, for instance, base estimate variable concerned about collect documents and review them as well as contained effective factors such as scope baseline, resource calendar, project schedule, etc.). It can be seen, these variable were developed from many point of views of researches. Therefore, this study model is developed than any of other models.

Therefore, the variables, which are adopted in this study, are base estimate, measurements, querying, pricing, management review, bid summary, KCE, and final detailed cost. The final detailed cost is absolute dependent variable, and the other variables are independent variables, except base estimate, measurements, and pricing are also considered dependent variables, which are casually affected by other variable according to the proposed hypotheses, figure (4.9).

It should be noted that there might be some causal relationships between the detailed estimate process model and KCE eight constructs. Therefore, these relationships may be investigated and examined in another study. This model was formulated from the following hypotheses, which were assumed according to the theory of this study as the following:

H10: Base estimate has a positive effect on final detailed cost.
H11: Correct way of measurements has a positive effect on final detailed cost.
H12: Measurements has a positive effect on pricing process.
H13: Query list has a positive effect on pricing process.
H14: Pricing process has a positive effect on management review's process.
H15: Management review's process has a positive effect on bid summary.
H16: Bid summary has a positive effect on final detailed cost.
H17: knowledge of construction cost estimate has a positive effect on final detailed cost.
H18: knowledge of construction cost estimate has a positive effect on base estimate.

H19: knowledge of construction cost estimate has a positive effect on measurements.

H20: knowledge of construction cost estimate has a positive effect on pricing.

4.5 Study Operationalization (Procedures)

Generally, the test of these quantitative and qualitative models that hypothesised in this study depended on the operationalization these constructs from the literature review in order to investigate empirically. Therefore, set of factors (items) which were used to measure both quantitative and qualitative models' variables, which were KCE variables, preliminary estimate variables, and detailed estimate variables were adopted. Thus, factors (items) were educed from the literature review by the author by manner to be comprehensively for this study's theory and dominated the both quantitative and qualitative models variables, appendix (1) shows the factors, which are adopted in this study.

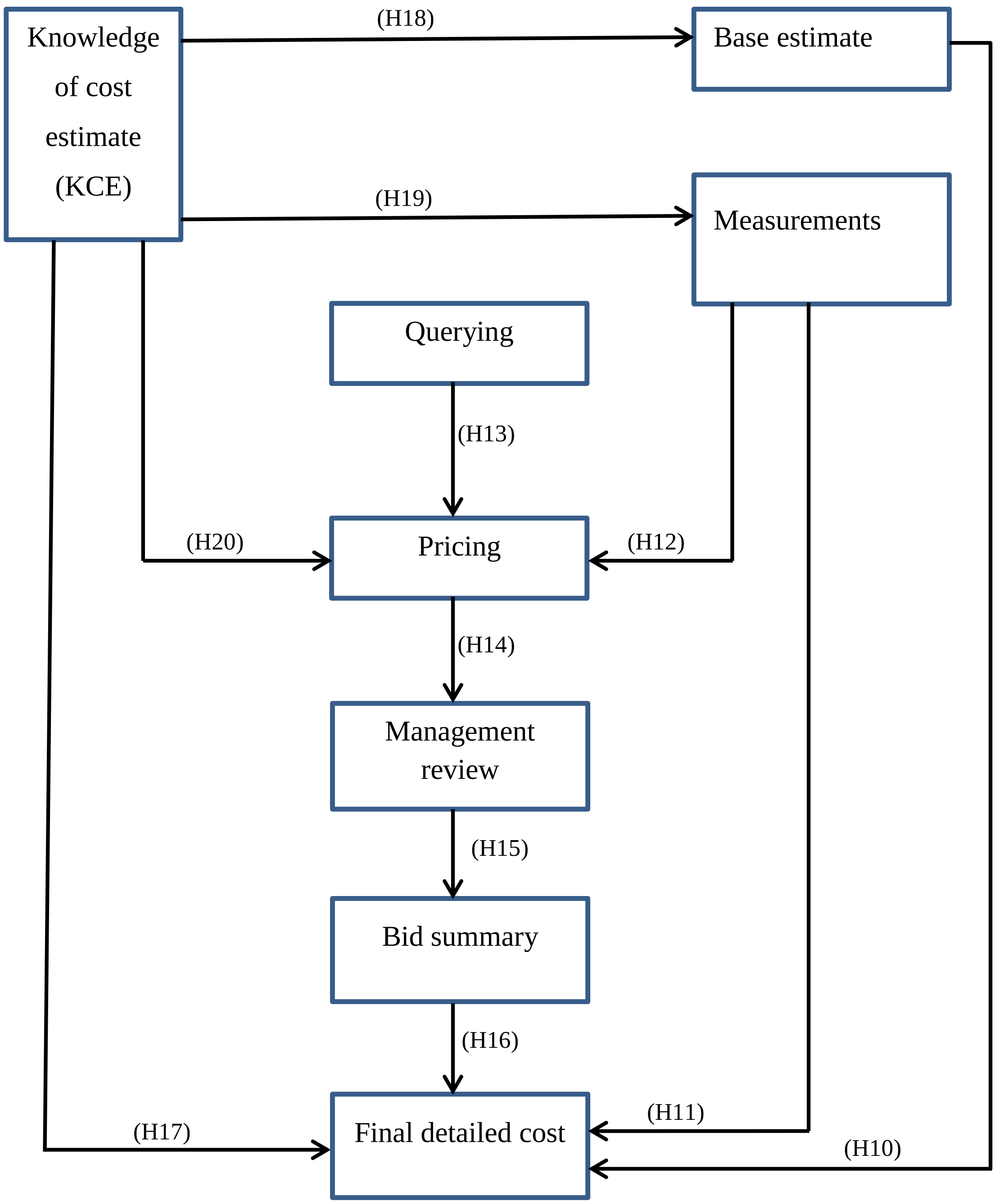


Figure 4.9 Theoretical model of detailed cost estimate, Author

4.6 Methodology and Analysis Technique

4.6.1 Introduction

This section is to give a large sight about the literature of the methodology, which would be used in the next chapter in order to be understood its methods and importance in research methodology. Furthermore, the analysis technique, which is structure equation modelling (SEM) which would be used for analysing the qualitative model, is also debated to make a good whole picture about this technique. SEM technique recently becomes more powerful than other prediction methods such as multiple regression technique and analysis of variance.

4.6.2 Research design

Flick (2007) defined a research design as a plan for collecting and analysing evidence that will make it possible for the investigator to answer questions posed to the target population. In more specific details, it is to connect the questions to data using tools and procedures in answering them. It is also the basic plan for a piece of empirical research including main ideas such as strategy, sample, the tools and procedures in order to collect and analyse the empirical data (Punch, 2000).

4.6.3 Research strategy

Naoum (2007) defined the research strategy is the way in which the research objectives can be questioned. Furthermore, Punch (2000) explained that the strategy is the centre of the design of a study which is its internal logic or rationale. In other words, the set of ideas in a study intends to proceed in order to answer its research questions.

There are two types of research strategies, which are qualitative research and quantitative research. In empirical research, these methods have their strengths and weaknesses. According to Naoum (2007), the Qualitative research is a subjective in nature in which to concentrate on the meaning, description, and experience. Cooper and Schindler (2014) and Patton (1990) stated that the qualitative research leads the selected issues to be studied and achieved in-depth understanding and details.

In other side, quantitative research method depends on the use of standardised instruments so; the experience and perspectives of people can fit a limited number of predetermined response categories according to numbers, which are assigned. Advantage of this method is a possibility of measuring the reactions of a great many people to a limited set of questions so; this presents succinctly and parsimoniously generalizable set of findings. The qualitative research method has also advantage which is to present a wealth of detailed information about a much smaller number of people and cases in order to lead to concentrate the understanding the studied situation of the cases but reduces the generalization (Patton, 1990).

In order to strength the research design, the both qualitative and quantitative research method may be used appropriately with any research paradigm (Denzin and Lincoln, 2007). A number of research strategies are used for conducting social sciences: Surveys, experiments, histories, case studies, and the analysis of any archival data. In this field, the strategies which is adopted depends on three conditions: The type of research questions, the control an investigator has over actual behavioural events, and the focus on contemporary (Zhang, 2001). For more emphasis, the most important condition for research strategies is to identify the type of research questions being asked (Yin, 2009). This research was based on five research questions, which were suggested, so that the research strategy covered a literature review, a questionnaire survey, structured interviews, and a case study. These strategies are explaining in the following subsections.

4.6.3.1 Literature review

Punch (2000) stated that a descriptive study is to collect, organise, and summarise information about the issues being studied. Furthermore, Naoum (2007) emphasis on the concentrating the meaning; this strategy is the best to answer the questions which have a descriptive nature.

4.6.3.2 Questionnaire

In Punch (2000) explanations, A theory verification study may be quantitative or qualitative or both; but have more often been quantitative. In other words, the theory verification is to test a theory or test hypotheses, which derived from the theory. It is a common in the social science research to emphasise the quantitative research when the study begins with a theory, conclude hypotheses from it, and proceeds to examine these hypotheses.

There are some advantages by using questionnaire, which are economy compared to other methods, a quick method of conducting a survey, and cover a wide range within a sample population (Linda and Eve, 2003, Naoum, 2007). Many researches in construction management have used a questionnaire surveys to collect the information such as (Al-e the shanti, 2003; Shehatto, 2013; and Hunter, 2014). They used the questionnaires to collect information about cost estimation in construction management and determine the important variables as well as to test their studies' hypotheses.

4.6.3.3 Structured interview

According to Kothari (2004), this method use a set of predetermined questions in order to ask questions in a form and order prescribed. In addition, Naoum (2007) informed that the structured interview has the same questions in their same order and with the same wording to all interviewees; the controlled on the questionnaire throughout the entire process can be easily by the interviewees. There are also some advantages from this strategy:

1- The answers can be more accurate.

2- The response rate is relatively high (approximately 60–70 per cent), especially if interviewees are contacted directly.
3- The answers can be explored with finding out 'Why' the particular answers are given.

4.6.3.4 Case study

Yin (2009) explained that the questions with "how" or "why" are the explanatory in their nature, and referred to the case study. Addition, Kothari (2004) stated the case study concentrates on the full analysis of a limited number of events and their interrelations in order to understand the factors, which account about that events.

Generally, the case study in the research design is the logical sequence to connect the empirical data with a study's initial research questions and, ultimately, to its conclusions. In addition, another way of thinking about a case design is as a "blueprint" of research which concentrating on issues of study, for instance, study questions and study objectives. Thus, the case study design before starts in, is to get a highly performance of desired results (Yin, 2009).

4.6.4 Research sample

Theory of sample is to estimate the properties of the population from those of the sample. The sample design achieves the purpose of statistical estimation, testing of hypotheses, and statistical inference. Two methods determine the size of sample; the first one is to determine the precision of estimation desired and then to specify the sample size; the second one is to use the Bayesian statistics to weigh the cost of the information. Thus, the second method is difficult to do in practice without using computerised program, so it would be neglected. In the first methods, there are also two techniques; the first technique uses mean to determine the sample and the second technique uses a percentage or proportion to determine the sample. Thus, the mean wasn't known in this research; and the percentages of successes or failure were known from the pilot study (Kothari, 2004). For this reason, the second technique was adopted in this study to determine the size of sample.

4.6.5 Instrument evaluation

In order to test the models, the instrument should be reliable and valid according to the statistical methods.

4.6.5.1 Reliability

Naoum (2007) defined the reliability as consistency of performance as well as dependability with low risk of errors. So, the researchers can either undertake the same methods themselves or produce the same results (Greener, 2008). In other words, reliability deals with the extent to which an experiment, test, or any measuring procedure which yields the same results in repeated trials (Carmines and Zeller, 1979). According to Drost (2011), the typical methods to measure the reliability are: test-retest reliability, alternative forms, split-halves, and internal consistency. Moreover, the limitations of the other methods are to overcome by the internal consistency method, for instance, requiring repeating the test or either splitting the items. Instead, it is only a single test administration, which provides a unique estimation of reliability.

The Internal consistency measures consistency within the instrument and questions which refers to how well a set of items measures a particular behaviour in the test. This method is based on the average intercorrelations among all the single items within a test (Drost, 2011). The internal consistency is measured by coefficient alpha which is considered the most popular of testing for internal consistency in the behavioural sciences (Bollen, 1989). According to Hair et al. (2014), the reliabilities shouldn't be the Cronbach's alpha below the 0.70 for widely used scales in general, except for exploratory research can't allow Cronbach's alpha below the 0.60 which is the same in this study (exploratory research).

4.6.5.2 Item analysis

According to Nunnally and Bernstein (1994), item analysis is a statistical test regarding to how subjects respond to each item as well as how each item relates to overall performance (scale), but content validity importantly rests on rational rather than empirical grounds. By other words, an item analysis should describe how each item relates to scale and thereby provide discrimination indices. Importantly, the correlations of item-score to scale-score, which are used to determine if the item belongs to the scale; or some other scale; or should be eliminated. So, the values of item to scale correlations should be good when those higher than **0.30**; those which are lower than **0.30** do not share enough variance with the other items in that scale (Ferketich, 1991). Although, the lower correlation's value indicates that the item doesn't share enough variance, but the content validity should be checked if necessary.

4.6.5.3 Validity

Validity is more of theoretical oriented issue as well as it is an indicator of how well instrument measures what it is intend to measure. Furthermore, there are several different types of validity, which are criterion-related validity, content validity, and construct validity. In general, criterion-related validity is used when the purpose to use an instrument to measure some form of behaviours that is external to measuring instrument itself, therefore, most of researchers don't use this type of validity due to their instruments' purpose

(Carmines and Zeller, 1979). Consequently, the content validity and the construct validity were adopted in this study.

4.6.5.3.1 Content validity

Bollen (1989) defined the content validity is “a qualitative type of validity where the domain of a concept is made clear and the analyst judges whether the measures fully represent the domain”. Also, Carmines and Zeller (1979) debated that the content validity depends on the extent to which an empirical measurements specify a specific domain of content. Furthermore, it cannot be measured numerically, but it is a subjective measure of how appropriate the items to various reviewers with some knowledge of the subject matter. The evaluation of content validity typically reflects an organised review of the survey’s contents in order to ensure that the instrument includes everything designed for it, and does not include anything not necessary. In addition, it isn’t a scientific measure for a survey instrument’s accuracy (Zhang, 2001).

4.6.5.4 Construct validity

According to Carmines and Zeller (1979), the construct validity is concerned with the extent to which a specific measure related to other measures consist with theoretically derived hypothesis concerning the concepts which can be measured. Strictly speaking, construct validity should measure the extent to which items of scale measure the same construct (Flynn et al., 1994), further, it is extent to which a set of measured items which actually represent the theoretical latent construct they are designed to measure. It can be also evaluated by the factor analysis, which states that the issue of analysing the interrelationships among a large number of items and then explaining these items in terms of their common underlying dimensions (factors[1]). In order to condensing the information contained in a number of original items into a smaller set of dimensions (factors) by losing minimal information. In specific, there are two factors analysis techniques, namely, exploratory factor analysis and confirmatory factor analysis. Most of researchers consider the exploratory is useful in searching for structure among a set of variables or as a data reduction method (Hair et al., 2014).

After all, this study adopted exploratory factor analysis, for reason, the instrument was used for the first time and it was exploratory in nature. In contrast, the confirmatory factor analysis is used when the instrument has used from before for another research.

[1] These factors don’t mean the factors (items) of study, but the underlying dimensions.

Hair et al. (2014) stated that the exploratory factor has also two techniques, namely, Principal component analysis and common factor analysis. Specifically, principal component analysis is proper in researches which researchers are primarily concerned about the minimum number of factors, which needed to account for the maximum portion of the variance denoted in the original set of items. Further, the common factor analysis is also proper when the primary objective should identify the latent dimensions or constructs denoted in the original items. Consequently, the purpose of conducting the factor analysis in which it can determine how and to what extent items are linked to their underlying factors; the Principal component analysis was adopted in this study (Byrne, 2010).

As mentioned by Hair et al. (2014), Principal component analysis can support to identify whether selected items group on one or more than one factor. So, the loading can be assessed as the following:

- Rang of factor loadings of ±0.30 to ±0.40 are considered to meet the minimal level for interpretation of structure.
- Factor loadings ±0.50 or greater are considered practically significant.
- Factor loadings exceeding 1.70 are considered indicative of well-defined structure and are the aim of any factor analysis.

In general, factor loading signifies the correlation between an original variable and its factor. In addition, the sample size is considered key parameter for determining the factor loading value in order to be considered significant. Furthermore, the most usually used method of defining whether items are loading on one factor is the latent root criterion. Therefore, the factors having only latent roots (eigenvalues) greater than 1 are measured significant; in contrast, all factors having eigenvalues less than 1 are measured insignificant and are disregarded.

4.6.6 Analysis technique (Structure Equation Modelling)

Hair et al. (2014) discussed that multiple regression; factor analysis; multivariate analysis of variance; discriminant analysis; and other techniques can provide powerful tools for addressing a wide range of managerial and theoretical questions. They also have their limitation for examining only a single relationship at a time as well as represent only a single relationship between the dependent and independent variables. In order to overcoming these issues, Structural equation modelling (SEM) can test a series of dependence relationships at the same time. Therefore, SEM can examine theories that contain multiple equations involving dependence relationships. Also, Ho (2014) defined SEM as "(SEM) is a multivariate technique that can best be described as a combination of both factor analysis and path analysis. It is a statistical technique that allows the analyst to examine a series of dependence relationships between exogenous and endogenous[1] variables simultaneously".

There are many names for SEM, which are covariance structure analysis, latent variable analysis, as well as names of software package, for instance, a LISREL or AMOS model. The most general form of SEM composed of two parts, first part is path of measurement model, and the second part is structural model. Path of measurement model aims to relate several observed variables (indicators) for a single independent or dependent latent variable (construct), which are obtained by factor analysis model (EFA or CFA[2]). Furthermore, structural model represents the proposed hypothesis between latent variables, in order to examine the direction (path) of the relationships of variables (exogenous and endogenous), which are as hypothesised and the strength of hypothesised links. Further, the variance of endogenous should be explained by R^2 for the equations of structure (Vieira, 2011, Byrne, 2010, Bollen, 1989, Hair et al., 2014, Ho, 2014).

The path analysis is one of component of SEM in order to relate simple bivariate correlations or covariance to parameters by equations for seeking the relationship in SEM, and also provides a means to determine direct, indirect, and total effects of one parameter on another (Bollen, 1989, Hair et al., 2014). Further, SEM has many causal process under study which consist of a series of structural (regressions) equations, so that the structures relations can be formulated the model which enables a clearer conceptualisation of the theory under study (Byrne, 2010). There are two involved variables independent (cause or exogenous) variables X_1, X_2, X_3,... X_n, and dependent (effect or endogenous) variables Y_1, Y_2, Y_3, …, Y_n.

4.6.6.1 Method of SEM estimate

There are many different methods for estimating the structure equation models solutions, some of them are the maximum likelihood (ML), the generalised least squares (GLS), and the generally weighted least squares (WLS), especially, are used in most SEM program.

According to Hair et al. (2014) stated that the maximum likelihood (ML) is more efficient and unbiased when the postulation of multivariate normality is met. Furthermore, it is a flexible approach in order to estimate parameter in which the "Most likely" parameter values to attain the best model fit. Therefore, the (ML) was adopted as method of SEM estimation in this study, in which the normality is met to produce the best estimation. According to Hair

[1] Endogenous means the dependent variable, as well as exogenous means the independent variables.
[2] EFA means exploratory factor analysis and CFA means confirmatory factor analysis.

et al. (2014) which was cited by Zhang (2001) that the skewness and kurtosis should not exceed the absolute value of 1 for the normality of the data of SEM estimate.

4.6.6.2 Hypotheses test

AMOS programme, which was adopted to analyse the SEM in this study, can estimate the regression estimates, standard error, critical value, precept, and the correlations. Further, the hypothesis can confirmed if the critical value is > ± 1.96 and considered significant for the estimated path coefficient (Arbuckle, 2014, Byrne, 2010).

4.6.6.3 Models fit

In the first place, the reality of the theoretical models testing has the priority is whether there is conflict with reality as observed in the sample; strictly speaking, how the models fit the data (Zhang, 2001). There are many indicators or techniques are used to test the fitting of model, most common, which can be used in this study to evaluate the global model-fit, which can be used to evaluate the global model-fit. Five common measures for judging goodness-of-fit are the Chi-square (χ^2), Normed Fit Index (NFI), Comparative Fit Index (CFI), the root mean square error of approximation (RMSEA), and Akaike's Information Criterion (AIC) (Hair et al., 2014, Byrne, 2010).

In SEM, the chi-square statistics is a likelihood ratio, which used to measure the overall fit of models in order to get a relatively small (χ^2) value and P-value > 0.05 to be accepted. In contrast, when the P-value less than 0.05, the hypothesised model is not entirely adequate (Hair et al., 2014), in addition, most of findings of good-fitting for hypothesised models, in which the χ^2 value estimates the degrees of freedom, it is proven to be unrealistic in most SEM empirical research (Byrne, 2010).

Normed Fit Index (NFI), it is a ratio of the difference in the χ^2 value and considering one of the original incremental fit indices[1], further, also, has a tendency to underestimate fit in small samples. Although, (NFI) takes the sample size into accounts and suggested the Comparative Fit Index (CFI). Its value is from 0 to 1 as well as the value > 0.90 considering representative of a well-fitting model (Hair et al., 2014, Byrne, 2010, Arbuckle, 2014).

Another important index, which is Comparative Fit Index (CFI) is also belonged to the incremental fit indices as well as considering the improvement for (NFI). Moreover, the same concept of values as NFI to judge the model fit is > 0.90 (Hair et al., 2014, Byrne, 2010, Arbuckle, 2014).

[1] Incremental fit indices differ from absolute fit indices in which to assess the model relative to some alternative baseline model assuming all the observed variables are uncorrelated in order to represent the improvement in fit.

The forth indicator is the root mean square error of approximation (RMSEA), which is important to represent how well a model fits a population. Also, it is one of the most widely indices that attempt to correct for the tendency of the χ^2 GOF test statistic in order to correct for both model complexity and sample size. Moreover, it takes the error of approximation in the population into account as well as it sensitive to the number of estimated parameters in the model. The value of measuring to assess the model fit are value < 0.05 indicates good fit; 0.05 < value < 0.08 indicates represent reasonable errors of approximation in the population (fair fit); 0.08 < value < 0.10 indicates mediocre fit; and value > 0.10 indicates poor fit (Hair et al., 2014, Byrne, 2010).

Furthermore, Akaike's Information Criterion (AIC) indicator takes into account statistical goodness of-fit and the number of estimated parameters, so it addresses the issue of parsimony in model fit assessment. It generally used in comparison of two or more models through smaller values which is representing a better fit of the hypothesized model (Byrne, 2010).

4.6.6.4 Model modification

The best model doesn't mean that the model is fit only, but also indicates the model has passed through several improvements when it fitted. Therefore, a possible actual model modification should be taken into account in order to improve the theoretical explanations or the goodness-of-fit of the model. As well as the misfit can be developed to be fit and best. Consequently, modification is a powerful tool in SEM to develop or modify the model in order to provide insights into its respecification. This modification must always be with theoretical support rather than just empirical justification (Hair et al., 2014, Byrne, 2010), so, the AMOS program provides a service of model modification in order to improve the model fit indicators and regression estimation (Byrne, 2010).

4.7 Summary

This chapter explained the detailed estimate technique. Firstly, the processes of estimate were debated wordiness leading to discover the most important variables in detailed estimate. Decision to tender was the beginning of choice for the senior management. As well, base estimate appeared its importance to formulate the foundation of estimate through obtaining and reviewing the bid documents. Additional documents should be attained in the base estimate due to their importance as scope baseline, risk register, etc. measurements were cooperated with the process of estimate as important variable in the detailed estimate as well as site visit, pricing, management reviews, and close the bid.

Secondly, bottom-up was the magic tool to perform the detailed estimate. The previous studies also supported the constructed model. The qualitative model was built for this study and constructed from two models. One about KCE, which integrated in the final model of detailed estimate affecting some independent variables according to the hypotheses. The operationalization of this study was debated and determined as procedures. Furthermore, section (4.6) discussed the methodology techniques, which would be used in next chapter based on the design of this research, the objectives, and the research's questions. In addition, the analysis technique of structure equation modelling took its part in discussion showing its importance, procedures, etc. Finally, the second objective of this study was achieved and the second question was also answered.

CHAPTER V: RESEARCH METHODOLOGY

5.1 Introduction

This chapter is considered the core of this study; it presents the research design, which contains the research strategy and research sample. In order to strength the research, both qualitative and quantitative strategies are adopted. Literature review, questionnaire, structured interview, and case study are the qualitative and quantitative research strategies. The sample of this study is determined according to statistical methods. After that, the data collection discusses how to collect data according to type of adopted strategy. In order to perform the tests for this study; the instrument of this study should be reliable and valid. Thus, the reliability test use test-retest reliability, alternative forms, split-halves, and internal consistency which is adopted in this study. In addition, item analysis uses the Pearson correlation test to perform the test. Furthermore, construct validation are debated wordiness and factor analysis and content validity are adopted in this study to check validity. Finally, the summary explains briefly this chapter.

5.2 Research Strategy

The qualitative and quantitative research strategy was adopted in this study to strength the study. Thus, this research was based on five research questions, which were suggested, so that the research strategy covered a literature review, a questionnaire survey, structured interviews, and a case study.

5.2.1 Literature review

The first and the second research questions "What is the knowledge of cost estimation in construction management?", "Q2: What are the quantitative and qualitative models can be used to estimate the construction cost?" are a descriptive in their nature. Consequently, to answer these two questions, the literature review was the best strategy to collect, organises, and summarise the information about the knowledge of cost estimate. The literature review debated the knowledge of cost estimate, methods, and techniques, which are used in construction field, in order to obtain deep understanding these methods and techniques as well as the terms that are mostly used in cost science. Further, the cost classifications were discussed to establish a ground base for understanding the cost estimate from engineers' point of view. Factors, which should affect the cost estimate, were mentioned from researchers' point of view. Furthermore, delivery systems and type of contract, cost control, safety consideration, and cost index were deeply debated from point of construction cost's science. Consequently, the first question was answered.

On the other hand, the most important methods and techniques to estimate the construction cost were discussed. Preliminary and detailed estimates are used in construction cost estimation in the conceptual stage and in the tender stage respectively. These two methods were discussed explicitly in the literature review in which to answer the second question. Then, the second question was answered.

5.2.2 Questionnaire survey

In this section, the third question "What are the effects of qualitative and quantitative models' implementation on construction projects in Yemen?" is to test the effects of qualitative and quantitative models' implementation on construction projects in Yemen. Furthermore, the existing theories, which were debated in the literature review, the two qualitative models, and the quantitative model, which were done. To answer the third question, the questionnaire was the best strategy.

In this study, the questionnaire survey was used to collect data on a wide large sample from construction firms about their projects' estimation to obtain the major effect of cost estimation technique implementation on construction projects in Yemen. In addition, the hypotheses, which were proposed, were also tested to verify these models.

5.2.3 Structured interviews

In order to answer the fourth question, "What development kind of models should be applied in order to guide the construction firms in Yemen?" The structured interview is the best strategy to answer it and make it practicable. Therefore, the current practices of cost estimate, success cost estimation experience, problems facing the Yemeni engineers, difficulties facing the Yemeni engineers in estimation process, and the effect of cost estimate on construction project in Yemen should be studied. This strategy gave a wide sight about the cost estimate implementation in Yemen and the situation as well as the information was obtained according to the areas identified for the research. The information which couldn't mostly obtain from the questionnaire survey; they was more dynamic and detailed information as well as these information explained the results, which were get from the questionnaire findings. Furthermore, these results from the structured interview helped the author to understand the whole situation of cost estimate in construction projects in Yemen.

5.2.4 Case study

The case study strategy was the best strategy to answer the fifth question "How these models can be applied in practice?" This strategy aimed to provide practical assistance to help the construction firms to implement the proper cost estimate in their projects. In addition, a case study added value for understanding the models in practice.

5.3 Research Sample

According to section (4.6.4), and because the population of study was known, the following equation was adopted in this study:

$$n = \frac{z^2 \times p \times q \times N}{e^2(N-1) + z^2 \times p \times q} \qquad Eq.(5-1)$$

Where:

n= size of sample;

z= standard variate at a given confidence level;

p= sample proportion;

q= 1-p;

e= acceptable error;

N= size of population.

Then, the parameters from the pilot study section (5.4.1.1) were:

The success of the desired study was = 0.85 (Approximately)

Then the failure is = 1- 0.85= 0.15

e= 0.05

z= from the table of z-test; and the confidence level was 0.95;

z= 1.96

According to the ministry of public works and highways, the population of study was 206 firms which registered in construction field in building sector as well as they belongs to grade from 1 to 4.

Therefore, the sample size was:

$$\frac{1.96^2 \times 0.85 \times 0.15 \times 206}{0.05^2(206-1) + 1.96^2 \times 0.85 \times 0.15} = 100$$

5.4 Data Collection Techniques

5.4.1 Questionnaire survey

Most of researchers have used the questionnaire survey to collect the data such as, Al-shanti (2003); Shehatto (2013); Hunter (2014); and Azzam (2015). Those questionnaires were designed according to their researches aims as well as they were different from each other in order to cover the topics of their researches. After the questionnaires were studied and examined, they didn't fully meet the requirements of this research. Thus, the new questionnaire had to develop regarding this research purpose. Based on the last discussion, the questionnaire design was depended on the theoretical constructs and the operationalization of the theoretical constructs. Furthermore, it was necessary to achieve the best measurement questions, which the respondents could answer them. According to Naoum (2007), this research questionnaire were based on the following issues :

1. Your questions/questionnaire should be short but comprehensive;
2. Avoid leading questions;
3. Avoid double questions;
4. Avoid presuming questions;
5. Avoid hypothetical questions;
6. The questions must not be ambiguous;
7. The questions should be logical in their sequence;
8. The questionnaire must be attractive in appearance.

It should be noted that the questionnaire aimed to study the knowledge of cost estimate gained by Yemeni engineers as well as the preliminary and detailed cost estimates and their effects on the construction projects in Yemen. In other words, the questionnaire covered these three areas which were 16 constructs (social and economic system, construction cost classification, cost estimation methods and techniques, types of contracts and delivery systems, critical factors, cost control process, safety considerations, cost index, preliminary estimate, base estimate, quantity measurement, querying, pricing, management review, bid summary and final detailed cost). All items of questionnaire were built up according to the factors (items) of these 16 constructs in chapter two, three, and four. Furthermore, Zhang (2001) examined the questions words according to another two questions to give sufficient attention when the measurement items were built up. Thus, the questionnaire of this research was also examined regarding those two questions were:

- Is the question wording stated in terms of a shared vocabulary?
- Is there biased wording?

5.4.1.1 Pilot study

Most of researchers advise to conduct a pilot study or pilot survey for testing the wording of the question, identifying ambiguous questions, and testing the technique. In the first, this research was in English language, thus the questionnaire was also prepared in English language version as the language of study. Moreover, the study was conducted in Yemen which its formal language is Arabic as well as most of local engineers are talking Arabic. Therefore, the questionnaire was translated into Arabic version. Thus, the author who has relevant with site and academic fields in Yemen did the translation. This translation might bias to the original design of the questionnaire. A number of cost estimate terms such as qualitative, analogy, and cost plus, might not be precisely translated into Arabic. To overcome this weakness in questionnaire design, the pilot study was the best method. After the Arabic version was done, the questionnaires were distributed to five experts into construction field in Yemen, and they have been asked whether:

1) The items were stated in a shared vocabulary;
2) The items were precise and unambiguous;
3) There were biased wordings;
4) The questions were logical in their sequence;
5) The questions were presuming, hypothetical, and leading questions;
6) They could answer these questions.

After all, their comments were returned with the questionnaires and some modifications were made according to the comments. In this stage the questionnaire almost ready for distributing to the respondents, but for more confidence, the questionnaires have been also distributed to small group of participants who involve in the construction cost estimate and academic fields in Yemen as well as they represented part of sample of study population. This method was formally pre-tested. At the same time, the author interviewed and asked them to give their feedbacks and comments about ease of comprehension, clarity of the specific items, possible change if necessary, and additional items if necessary, etc. the respondents gave their suggestions and feedbacks which were carefully evaluated by the author. Then, the Arabic version was more capable to be used for the large-scale survey.

Consequently, the author had more confidence about the questionnaire efficiency and the final Arabic version consisted of 52 items to measure the knowledge of cost estimates, which are the ground of this science for the engineers. Moreover, 22 items were used to measure the preliminary estimate as well as 20 items were also used to measure the detailed estimate. The final Arabic version was retranslated back into English. Appendix (2) lists the two English and Arabic instruments, which used in this research to collect the data.

5.4.1.2 Survey sample

According to the sections (4.6.4) and (5.3), the research sample was determined according to the technique that using a percentage or proportion to determine the sample. From the pilot study, which was early conducted and the results gave some indication to the author to demonstrate some of characteristics of the population sample, which was used to determine the sample size in section (5.3). Furthermore, the population of study of construction firms was more than 200 firms, which implemented the cost estimate methods by any way and most of them were in Sana'a. In particular, the investigated firms were from Sana'a and Hodeida provinces. These firms were large and medium sized construction firms as well as the sample size was 100 firms. These firms might reflect the whole situation of construction firms in Yemen.

Another key point, this research results might be generalised for all construction firms in Yemen. The sample firms were randomly selected to investigate the cost estimate models in Yemen. The questionnaires sent to the selected firms with their respective official document. This document namely was (cover letters) which drafted by the author and register, which described the aim of the questionnaire survey and its importance for construction firms in Yemen. The questionnaires were distributed to the respondents to their places by the author and his assistances. The questionnaires were returned with the respondents' answers. In addition, the response rate was 70%, which referred to the high response for such researches.

5.4.1.3 Obstacles of survey in Yemen

Firstly, the author would mention about what called "the revolutions of Arab spring" which made some differences in the ideologies of the parties in the political sector. These alterations have affected all sectors of economy, unfortunately, the crisis of Yemeni political hasn't solved. Moreover, the war was started after this study has begun; strictly, all facilities of the country couldn't run as well as the life was difficult. Secondly, the construction firms suspend their projects and activities for a long time, then, some of them have slightly started to work according to situation as well as they had stopped and sometimes continued. In the questionnaires survey, some firms were indefinitely closed, but their subordinates existed in the society and could found them according to the relation between the author and his friends who have worked in the academic or site field or both.

There were a number of additional issues regarding the questionnaires survey, the names of author and the college of Architectural and Planning at Sudan University of science and Technology were mentioned in the questionnaires in order to give motivation to answer for academic field only.

The situation of dealing with questionnaires were different from each other, some firms registered the questionnaires according to their system and gave the author appointment. Some other firms were closed due to force majeure of the war, thereupon, the author tried to contact their engineers by his friends' relationship as well as money and time lost in order to contact them was paid by author. Furthermore, some respondents gave their promise to fill the questionnaires, and the contacting with them was continuing many times, but according to their perceptions about the questionnaires' importance; there were no responses. In addition, the author contacted some respondents by telephone and got their admission to send the questionnaires by E-mail to fill, unfortunately, most of them didn't fill them. Consequently, the low response rate was belonged to the last reasons, which have mentioned above.

5.4.2 A Brief description of the surveyed firm

5.4.2.1 Respondents

In the table (5.1) shows that 35.7% were public sector firms, 48.6% were private sector firms and 15.7% were semi-private firms, which indicate that the variation of experiences could be obtained in preliminary estimate and in the detailed estimate due to their practices.

In addition, the experience years of respondents were from 5 to more than 30, and the average was 12.9 year with standard deviation was 7.73 year. The respondents highly had experiences which indicates that they could answer the questions of questionnaires with more accurate according to their experience in the field. Therefore, this gave the author highly confidence about the results of the study survey.

Table 5.1shows Firms types

Description	Frequency	Percentage (%)
Public sector	25	35.7
Private sector	34	48.6
Semi-private	11	15.7

Source: field survey

In the table (5-2), the educational level of respondents were 70% graduate, 25.7% post graduate, and 4.3% diploma which mean the most of respondents had a qualification of knowledge to answer the questionnaires perfectly.

Table 5.2 shows Respondents' Education Level

Description	Frequency	Percentage (%)
Graduate	31	70
Post - graduate	27	25.7
Diploma	12	4.3

Source: field survey

5.4.2.2 Respondent firms

In the table (5.3), shows the scope of works that were 44.3% consultant, 38.6% contractor, and 17.1% both (consultant and contractors). These gave wide sight, which highly covered the qualitative and quantitative models matters of this study. Furthermore, the table (5.4) shows the classification of firms according to their fixed assets that were; 27.1% the first grade; 64.3% the second grade; 4.3% the third grade; and 4.3% the fourth grade. This indicates that the degree of respondents' interest regarding the questionnaires.

Table 5.3 shows Work's scope of firms

Description	Frequency	Percentage (%)
consultants	31	44.3
contractors	27	38.6
Both	12	17.1

Source: field survey

Table 5.4 shows Grade firms' classifications

Grade	Frequency	Percentage (%)	Fixed assets ($)
1st	19	27.1	>500000

2nd	45	64.3	100000-500000
3rd	3	4.3	50000- 100000
4th	3	4.3	< 50000

Source: field survey

5.4.3 Structured interviews

The importance of the structured review is to cover the major points, which the questionnaires couldn't cover. Therefore, in order to design the perfect structured interview, the structured interview was mainly depended on the research objectives, research questions, the literature review, and the theoretical models. Before the structured interview process, the pre-tested was done by participants and academician experts. Some alterations were done to the questions according to their advices. Further, the structured interview was divided into four categories, which were general information, major cost estimate knowledge, preliminary cost estimate practices, and detailed estimate practices.

5.4.3.1 Sample of study

In order to choose the sample of structured interview, it was necessary to determine whom interviewees, their abilities, and range of benefits might be got from them. Thus, there were some criteria for choosing the interviewees as following:

- The interviewees should have experience more than 10 years and worked in the construction firms.
- The interviewees should be excited toward the research to obtain much information required for the research.
- At least, one interviewee should belong to business and cost accounts sciences in order to establish the terms and vocabularies according to cost accountant and management.

After that, the number of interviewees was determined according the required information against the cost, the time of conducting the interviews and the situation of war. Thus, the five interviewees were selected as sufficient for this study.

5.4.3.2 Process of structured interview

The structured interview was done in November 2015. It was hard time to conduct the interview because the rockets of the war were spreading throughout Sana'a and Hodeida provinces as well as no predicting time for bombing. Under those circumstances, the author tried hardly to contact the interviewees to finish this stage quickly. The questions were sent to them in advance to prepare the interview effectively and efficiently. During the interview, the interviewees were active and they gave the author the major points regarding the cost estimate knowledge, which should be obtained by the engineers. In addition, they presented the important issues in cost estimate from their experience. Furthermore, some interviewees supported their opinions by documents about their practices to the author. The time of the interview was within 2 to 4 hours as well as the author had some times to travel in which interviewee was living, in fact, in that time, the author was fighting the fate circumstances. Sometimes, several visits were required to satisfy all information required.

5.4.4 Case study

In this study, the question was "How these models can be applied in practice?", therefore, after the models were developed based on the literature review and knowledge of cost estimate, the questionnaires survey, and the structures interview in Yemen. The case study was done for providing a practical case to use these models in practice,. Explicitly, one construction firm was chosen to conduct the case study with limitation in permission to the author as well as some constraints formed the relation between the author and the top management of this firm.

In addition, the data about the firms was also limited, for reasons, the security situation was bad and there weren't confidence by the top management toward the author. Thus, the author's friends who were working in this firm had supported him to the top management on their responsibilities. However, the limitation and constraints weren't removed at once. Another issue was faced the author, the temporary closing of firm regarding the war, so the author tried to meet the relevant persons in other places to conduct the procedures of case study. This led the author to lose a lot of money to prepare the planned requirements to discuss and apply the improvement plan, which would verify the theoretical models in practice.

Firstly, there were a template, which designed to evaluate the strengths and weaknesses of the firm with regarding the cost estimate knowledge and the practices in preliminary and detailed estimate. The weak areas were used as improvement possibilities, so these possibilities would lead to an improvement plan, which could be formulated. Consequently, three questions should be answered through conducting this case study, which are as follows:

1- What are the strengths of the firm's cost estimate practices and knowledge?

This question is a descriptive in natural, which deals with the strength of the firm's current cost estimate implementation, compared to the practices in the models of this study. So the strength of the firms should be identified.

2- What are the weaknesses of the firm's cost estimate practices and knowledge?

This question is also a descriptive in natural, which deals with the weaknesses of the firm's current cost estimate implementation, compared to the practices in the models of this study. After the weaknesses were identified, these weaknesses could be used as opportunities to seek improvement actions and develop an improvement plan.

3- What the improvement plan can be used in order to improve the firm's cost estimate implementation?

The firm's current situation (knowledge, skills, resources, and employee) and the potential improvement possibilities would be formulated into improvement plan. Thus, the improvement possibilities should be carefully examined and analysed. There were some questions asking by the key personal of the firm as following:

What the fund could be paid by the firm related to the improvements possibilities? Which improvement possibilities could be effective? Which improvement possibilities could be implemented? As a matter of fact, the improvement plan was based on the identified improvement possibilities and according to the firm's resources without affecting loses of money.

5.4.4.1 Data collection

The data sources were mainly documents, archival records, interviews, and observations. Therefore, they offered a more comprehensive insight into the subject matter than the single data source. The interviews were done with the relevant persons of cost estimate in the firm's departments, which had strong relations with the cost estimate (Contracting sectors, department of technical and economic studies, design department, etc.).

5.4.4.2 Process of case study

The case study was done between December 2015 to May 2016. To conduct the case study, the recommendation letter from the post-graduated college's register, which was approved by the cultural consular in Embassy of Yemen in Sudan, was sent to the top management in order to take the permission to conduct this case study. As the discussion earlier, the top management had their fears from the author and his intention, whilst, the author's friends had supported him to raise the strong relation between the top management and author which led finally to success. The author had met with the most important persons who had been participating in the cost estimate process so that he took a brief about all departments, which practice the cost estimate process, for instance, number of employees, processes of estimate, hierarchy of firm, and policies of the firm.

To satisfy the requirements of this case study, the author asked the relevant departments to support him by the relevant documents about current processes of cost estimate. After that, plan of interview according to the template, which was designed to evaluate the current situation as well as to know their suggestion about the situation and the way of improvement. Therefore, the current strengths and weaknesses were identified, thus, the improvement plan was formulated based on the weaknesses regarding the cost estimate. For more accuracy, the improvement plan had passed through several stages in order to raise their knowledge, then, concentrating on the methods and techniques, which were proper to cost estimate processes. The full description of case study is presented in chapter seven.

5.4.5 Cost form survey

In order to construct the quantitative prediction's model by ANN, the historical projects' data should be collected. Many researchers hadn't referred to such form when they collected the historical projects' data, so in this study, this form was designed according to the obtained literature review in chapter three in order to make it easy to distribution and got them quickly.

5.4.5.1 Pilot study

The cost form was in English language version as the language of study. Moreover, the study was conducted in Yemen, thus the formal language is Arabic. Therefore, the cost form was translated into Arabic version. After the Arabic version was done, the cost forms were distributed to five experts[1] into construction field in Yemen, and they have been asked whether:

1) The terms were stated in a shared vocabulary;
2) The terms were precise and unambiguous;
3) There were biased wordings;
4) The project component were satisfy to the construction field;
5) The Skeleton types and material finishing which are used in Yemenis' construction field;
6) The terms of construction in this form were professionally.
7) They could fill these cost form.

The comments of experts were returned and some modifications were made according to the comments. Then the Arabic version was translated into English. The Arabic version was almost ready for distributing to collect the data about the parameters that affecting cost of building projects in Yemen from the implemented projects, see appendix (3). In the following table (5.5), the parameters of cost form were adopted in this study after expert's comments to develop the neural network model (Quantitative model).

Table 5.5 shows the parameters of cost form.

No.	parameters	Range
1	Project type	Administration, commercial, educational, residential, mosques, and health centre.
2	Projects' complex degree	Complex, normal
3	Site area	Less than 13000m^2
4	Project position	Mountain, coastal, desert,
5	Floor area	Less than 700m^2
6	Storeys No.	(1-4) storey

[1] The same persons in questionnaire's pilot study.

7	Floor height	From 3m to 4m
8	Type of foundation	Pad, strip, raft, piles
9	Slab type	Drop beams, hollow block, flat
10	No. of elevators	0,1,2
11	Interior decoration	Basic - Luxury
12	Type of external finishing	None, normal plaster, stones, aluminium cladding
13	Type of HVAC	None, window, split, central
14	Tiles type	Ceramic, terrazzo, Porcelain, granite
15	Type of electricity works	Basic - Luxury
16	Type of mechanical works	Basic - Luxury
17	Basement	Exist, not exist
18	The final cost	In Dollars ($)

Source: Author

5.4.5.2 Data collection

There were some basic conditions that controlled the distribution of cost form in order to overcome any defects in collected data, which were defined as:

- The implementations of the projects were from 2011 to 2015.
- The projects should be finished and in the use (Arafa and Alqedra, 2011).
- Unifying the prices of projects' currency (Shehatto, 2013).
- The maximum project No. in one category doesn't exceed 95% (Islam et al., 2009).

The data collected from 136 projects from the past four years 2011 to 2015; which were used in ANN model (Quantitative model). The data collected were classified into the following:

- **Project type**

  The following table (5.6) shows the types of projects, which collected from the survey.

Table 5.6 shows the types of projects.

Project type	No. of projects	Percentage (%)
Administration	8	5.8
Commercial	16	11.7
Educational	24	17.7
Residential	48	35.3
Mosques	0	0
Health centre	40	29.5
Total	136	100

Source: cost form survey

- **Projects' complex degree**

In table (5.7), the degree of complex is shown after collecting the data from the survey.

Table 5.7 shows the degree of complex.

Projects' complex degree	No. of projects	Percentage (%)
Complex	8	5.8
Normal	128	94.2
Total	136	100

Source: cost form survey

- **Site area**

After the data had collected, the area was classified into ranges in order to involve in ANN model (Quantitative model) as the following in table (5.8).

Table 5.8 shows the areas range.

Site area	**No. of projects**	**Percentage (%)**
200-300	32	23.5
301-400	24	17.6
401-850	24	17.6
851-1200	8	5.9
1201-1350	8	5.9
1351-1600	8	5.9
1601-2050	8	5.9
2051-2300	8	5.9
2301-2750	8	5.9
2751-11700	8	5.9
Total	136	100

Source: cost form survey

- **Project position**

In table (5.9), the collected data results are shown as the following:

Table 5.9 shows the projects' position.

Project position	**No. of projects**	**Percentage (%)**
Mountain	40	29.5
Coastal	96	70.5
Desert	0	0
Total	136	100

Source: cost form survey

- **Floor area**

The floor areas were classified into ranges in order to encode for ANN analysis to predict Quantitative model as the following table (5.10).

Table 5.10 shows the floor area.

Floor area	**No. of projects**	**Percentage (%)**
100-200	16	11.8
201-250	24	17.6
251-300	48	35.3
301-350	8	5.9
351-400	0	0
401-450	24	17.6
451-500	0	0
501-550	8	5.9
>550	8	5.9
Total	136	100

Source: cost form survey

- **Storeys No.**

The following table (5.11), Storeys No. are shown according to the survey:

Table 5.11 shows the storeys No.

Storeys No.	**No. of projects**	**Percentage (%)**
1	32	23.6
2	72	52.9
3	8	5.9
4	24	17.6
Total	136	100

Source: cost form survey

- **Floor height**

After the survey was done, the collected data is presented in the table (5.12).

Table 5.12 shows floor height.

Floor height	No. of projects	Percentage (%)
3.1	16	11.8
3.2	24	17.6
3.3	8	5.9
3.4	40	29.4
3.5	48	35.3
Total	136	100

Source: cost form survey

- **Type of foundation**

In the following table (5.13), the collected data is summarised as:

Table 5.13 shows type of foundation.

Type of foundation	No. of projects	Percentage (%)
Pad	136	100
Strip	0	0
Raft	0	0
Piles	0	0
Total	136	100

Source: cost form survey

- **Slab type**

The collected data is presented in the following table (5.14).

Table 5.14 shows slab type.

Slab type	**No. of projects**	**Percentage (%)**
Drop beams	96	70.5
Hollow block	24	17.7
Flat	16	11.8
Total	136	100

Source: cost form survey

- **No. of elevators**

The collected data showed that there wasn’t any elevator recorded.

- **Interior decoration**

In the following table (5.15), the data is presented as:

Table 5.15 shows the interior decoration.

Interior decoration	**No. of projects**	**Percentage (%)**
Luxury	0	0
Basic	136	100
Total	136	100

Source: cost form survey

- **Type of external finishing**

The data which was collected from the survey is presented in table (5.16) as following:

Table 5.16 shows the type of external finishing.

Type of external finishing	**No. of projects**	**Percentage (%)**
None	0	0
Normal plaster	48	35.3
Stones	88	64.7
Aluminium cladding	0	0
Total	136	100

Source: cost form survey

- **Type of air condition**

There were three types of AC as collected data, which is presented in table (5.17):

Table 5.17 shows the type of HVAC.

Type of HVAC	**No. of projects**	**Percentage (%)**
None	80	58.9
Window	32	23.5
Split	24	17.6
Central	0	0
Total	136	100

Source: cost form survey

- **Tiles type**

The data of survey is presented in the following table (5.18):

Table 5.18 shows the tiles type.

Tiles type	**No. of projects**	**Percentage (%)**
Ceramic	128	94.1
Terrazzo	0	0
Porcelain	0	0
Granite	8	5.9
Total	136	100

Source: cost form survey

- **Type of electricity works**

In table (5.19), the collected data is shown as the following:

Table 5.19 shows the type of electricity works.

Type of electricity works	**No. of projects**	**Percentage (%)**
Luxury	0	0
Basic	136	100
Total	136	100

Source: cost form survey

- **Type of mechanical works**

The data of survey is presented in the following table (5.20).

Table 5.20 shows the type of mechanical works.

Type of mechanical works	**No. of projects**	**Percentage (%)**
Luxury	0	0
Basic	136	100
Total	136	100

Source: cost form survey

- **Basement**

The collected data is presented in the following table (5.21).

Table 5.21 shows the basement.

Basement	**No. of projects**	**Percentage (%)**
Exist	0	0
Not exist	136	100
Total	136	100

Source: cost form survey

5.5 Instrument Evaluation

For specific, the questionnaire was developed to get the empirical data from construction firms in Yemen so that to test the quantitative model and a theoretical models which hypothesised in this study. This questionnaire designed to measure the cost estimate knowledge of Yemenis' engineer as well as to measure the both preliminarily and detailed estimate implementation in construction field in Yemen. The instrument had 16 scales (see appendix 2). In order to test the quantitative and qualitative models, the instrument should firstly be evaluated by the reliability and validity so that the hypothesis testing would conduct. The following sections provide the results of the reliability and validity testing.

5.5.1 Reliability

In the instrument of this study, there were 16 scales in order to measure the cost estimate knowledge, and preliminary and detailed estimate implementation in Yemen. In each Scale, there were items what were intended for measuring. The SPSS 19 IBM was used to calculate the reliability for the items of each scale. In table (5.22), the Cronbach's alpha was assigned for each scale which was more than (**0.60**) (see section 4.6.5.1). The scales' reliability coefficients ranged from **0.63** to **0.90**, which indicating that some scales were reliable than other. In addition, scales 7, 8, 14, 15, and 16 had only one question, therefore, they weren't necessary to conduct internal consistency reliability analysis, item analysis, and factor analysis for these five scales; they were supposed to be reliable and valid. Furthermore, the instrument, which was developed for this study and deleting some items, which didn't necessary according to reliability test; judged to be reliable.

Table 5.22 shows Reliability of instrument

Scale	No. of items	Cronbach's alpha	Deleted items
1	3	0.78	
2	2	0.68	Q.3
3	2	0.78	Q.2, Q.4, Q.5, Q.6
4	3	0.63	Q.2, Q.5, Q.6
5	30	0.80	
6	2	0.90	
7	1	reliable	
8	1	reliable	
9	21	0.80	Q.19
10	7	0.84	

11	3	0.71	Q.4
12	2	0.89	
13	4	0.69	
14	1	reliable	
15	1	reliable	
16	1	reliable	

Note: Q. means Question or item

Source: field study

5.5.2 Item analysis

The SPSS IBM 19 was used to perform the calculation for statistical correlation by Pearson test. In table (5.23), the correlation matrix for the 16 scales of cost estimate models and their items. In this table, some of items' correlations were less than **0.30**, which means that the item wasn't appropriately assigned to its scale as well as should be deleted. In addition, there is exception, if the content validity of the item is rational to be used, and then this item shouldn't delete. After the contents validity was checked for those were less than **0.30**, the following items weren't accepted according to their contents which had been understood in some other items, were: in scale five were item 1 (complexity of the project); item 12 (quality of project management); item 13 (lack of historical cost data); and item 17 (project team requirement). Further, in scale nine was item 22 (project location).

In contrast, others items, which were less than **0.30** and were bold and italic values, were accepted according to their content validity. For instance, in scale five, item No. 4 (Material costs), which is important variable should be known in cost estimate process, as well as item No.1 in scale nine (Traditional Cost Estimation) which also was important in the preliminary estimate. Consequently, it was concluded that all items were accepted according to item analysis were appropriately assigned to their scales.

Table 5.23 shows Item to scale correlation (Pearson correlation)

Item	scales										
	1	2	3	4	5	6	9	10	11	12	13
1	**0.86**	**0.89**	**0.86**	**0.76**	0.25	**0.95**	***0.25***	**0.73**	**0.68**	**0.94**	**0.79**
2	**0.88**	**0.86**	**…**	**…**	**0.51**	**0.95**	**0.37**	**0.76**	**0.82**	**0.96**	**0.69**
3	**0.75**	**...**	**0.95**	**0.78**	**0.30**		**0.50**	**0.68**	**0.89**		**0.66**
4			**…**	**0.75**	***0.22***		**0.63**	**0.82**			**0.78**

5			**…**	**…**	**0.51**		***0.27***	**0.72**			
6			**…**	**…**	**0.52**		**0.37**	**0.76**			
7					**0.50**		**0.55**	**0.67**			
8					**0.37**		**0.61**				
9					**0.56**		**0.61**				
10					**0.51**		**0.65**				
11					**0.54**		**0.61**				
12					-0.10		**0.62**				
13					-0.05		**0.62**				
14					**0.50**		**0.38**				
15					**0.60**		**0.62**				
16					**0.66**		**0.51**				
17					0.26		**0.54**				
18					**0.38**		***0.24***				
19					**0.50**		**...**				
20					**0.50**		***0.16***				
21					***0.16***		**0.50**				
22					**0.50**		0.20				
23					***0.14***						
24					**0.50**						
25					**0.53**						
26					**0.74**						
27					**0.38**						
28					**0.52**						
29					***0.24***						
30					**0.30**						

Note: the item number in this table is the same in the instrument as well as the bold number and italic indicating that it was accepted not deleted.

The symbol (**…**) indicates the item was deleted in reliability test.

Source: field study

5.5.3 Construct validity

In this study, the sample size was 70 and the factor loading should be **0.65**, which was used as the usual cut-off point according to (Hair et al, 2014). The factor analysis was performed by SPSS IBM 19 to test each scale separately. In the table (5.24), the results of exploratory factor analysis for 16 scales were listed according to No. of factors, Eigen-value, and percentage of variance, in which scales 1, 2, 3, 4, 6, 11, 12 and 13 were loading on factor 1. As well, scales No. 7, 8, 14, 15, and 16 had only one question indicating they were valid. Further, scales 5 (Critical factors), 9 (Preliminary estimate), and 10 (Base estimate) were loading on more than one factor, the rotated varimax, or quartimax were necessary to be examined. The Eigen-vales were greater than 1 according to the latent root criterion (eigenvalue), which is the most commonly used method of judging whether items are loading on one factor. Also, in principal component analysis, the factors have Eigen-values greater than one is considered significant, or less than one is considered insignificant and disregarded. The usual cut-off point in this study was **0.65** (see section 4.6.5.3) factor loading which used to judge in the rotated varimax or quartimax. Correspondingly, if any item is loaded on two factors, then the content validity should be checked in order to delete it or not.

Table (5.25) shows the rotated factor for scale 5 (Critical factors). In this table, the items 9, 10, 11, 16, and 18 established underlying latent factor[1] which is 1, it can be interpreted as (lack related to time, and specification), as well as the items 6, 7, 25, and 26 which were on factor 2, can be collected in interpretation of (Management risk). Further, items 2, 3, and 19 also constituted underlying latent factor which is 3, in which can be interpreted that of (Type of project and the duration), whilst, the underlying latent factors 4 belonged to items 23, 29, and 30. This underlying dimension can be interpreted as (Consultant advice regarding risk and fees). In addition, items 27, and 28 also formed that of (Handling materials) on latent factor 5, as well as the latent factor 6 belonged to items 4, and 21, in which to interpret that of (Client's financial status). The item 22 was on factor 7 in which to interpret what it designed to do. There were other items (5, 8, 14, 15, 20, 22, and 24) didn't constitute factors due to their low factor loading less than **0.65**.

Table 5.24 shows Results of exploratory factor analysis for 16 scales.

Scales	**Factor number**	**Eigen-value**	**% of variance**
1	1	2.08	69.38
2	1	1.52	75.95

[1] Underlying latent factor means factor, latent factor, underlying latent construct, or underlying dimension as well as they were used in this study,

3	1	1.69	84.81
4	1	1.75	58.59
5	8	5.58	21.49
		5.41	20.81
		3.20	12.31
		2.31	8.89
		1.57	6.04
		1.44	5.55
		1.29	4.97
		1.06	4.10
6	1	1.81	90.59
7	Only one question		
8	Only one question		
9	6	6.03	30.17
		4.79	23.94
		1.91	9.57
		1.71	8.58
		1.22	6.13
		1.07	5.37
10	2	3.48	54.97
		1.20	17.24
11	1	1.92	64.10

12	1	1.81	90.87
13	1	2.16	54.13
14	Only one question		
15	Only one question		
16	Only one question		

Source: field study

Table 5.25 shows Rotated factor for Critical factors (scale 5).

Rotated factor (Varimax)

Items	Component (factor loading)							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2	0.039	0.221	**0.938**	0.068	0.019	0.056	-0.012-	0.005
3	-0.200	-0.096	**0.650**	0.440	0.034	0.055	0.168	.000
4	0.389	-0.209	0.043	0.027	-0.172	**0.761**	-0.023	0.033
5	0.227	-0.048	0.547	0.599	-0.031	0.320	-0.227	-0.200
6	0.290	**0.771**	0.207	0.048	-0.099	-0.277	-.127	.290
7	0.034	**0.876**	0.317	0.030	0.024	-0.085	-0.201	0.113
8	0.155	0.061	0.451	0.499	0.104	-0.238	0.042	-0.529
9	**0.686**	0.416	-0.097	-0.167	-0.091	0.030	0.426	0.084
10	**0.695**	-0.126	0.331	-0.222	-0.096	-0.171	0.350	0.223
11	**0.795**	-0.056	0.029	0.075	0.237	-0.119	-0.008-	0.168
14	0.596	0.146	-0.248	-0.293-	0.149	0.190	-0.129-	0.206
15	0.349	0.441	0.473	0.043	-0.132-	-0.066-	0.327	0.025
16	**0.820**	0.357	0.086	-0.088-	-0.060-	0.171	0.219	-0.215
18	**0.807**	0.032	-0.115	-0.339-	0.149	0.034	-0.090	-0.035
19	-0.186	0.329	**0.697**	0.066	0.081	0.267	.301	-.048
20	0.477	-0.207	-0.177	.069	0.614	0.261	-0.111	0.183
21	-0.305	-0.022	0.294	0.083	-0.024-	**0.737**	0.283	0.053
22	0.192	-0.099	0.194	0.159	0.002	0.158	**0.867**	0.065
23	-0.196	0.284	-0.014	**0.796**	-0.213	.140	0.010	-0.092
24	0.239	0.256	.011	-0.031	.176	0.008	0.097	0.824

25	0.096	0.**922**	-0.041	0.131	0.212	0.004	0.053	0.022
26	-0.232	0.**656**	0.068	0.410	0.247	0.037	0.385	-0.112
27	0.083	0.373	-0.036	-0.053	**0.763**	-0.288	-0.094	0.085
28	0.088	0.055	0.124	-0.055	**0.921**	-0.024	0.087	-0.011
29	-0.248	-0.006	0.068	**0.650**	0.488	-0.331	0.018	0.265
30	-0.296	0.109	0.255	**0.845**	0.005	0.038	0.190	-0.027

Source: field study

In table (5.26) presents the rotated factor for scale 9 (Preliminary estimate). In this table, the items 13, 14, 15, 16, and 17 established a factor which is 1, it can be interpreted as (Building services and finishing), as well as the items 3, 4, and 5 which were on latent factor 2, can be collected in interpretation of (Modern estimate’s techniques). Further, items 9, and 10 also constituted a latent factor which is 3, in which can be interpreted that of (Mass of building), whilst, the latent factors 4 belonged to items 6, 7, and 8. This underlying dimension can be interpreted as (Substantive factors). In addition, items 18, and 20 also formed that of (Mechanical installation) on latent factor 5. Moreover, the latent factor 6 belonged to item 1, in which to interpret what it designed to do. There were also other items (2, 11, 12, and 21) didn’t constitute latent factors due to their low factor loading less than **0.65**.

Table 5.26 shows Rotated factor for Preliminary estimate (scale 9)

Rotated factor (Varimax)						
Items	Component (factor loading)					
	1	**2**	**3**	**4**	**5**	**6**
1	-0.111	0.031	0.138	0.259	-0.225	**0.858**
2	-0.109	0 .601	0.239	0.180	-0.499	-0.053-
3	0.002	**0.859**	-0.005	0.260	0-.105-	0.083
4	0.122	**0.781**	0.164	0.297	-0.232-	0.038
5	-0.226	**0.793**	-0.139	0.218	0.332	-0.037
6	-0.147	0.389	-0.154	**0.829**	0.072	0.042
7	-0.011	0.216	0.183	**0.912**	-0.154	0.148
8	-.078	0.397	0.312	**0.799**	-0.122	0.050
9	0.154	0.093	**0.940**	0.111	0.055	0.033
10	0.293	0.031	**0.806**	0.160	0.078	0.241
11	0.460	0.062	0.482	-0.044-	0.062	0.633
12	0.484	-0.030	0.565	-0.049-	0.206	0.438
13	**0.764**	-0.103	0.423	0.026	0.083	0.056
14	**0.690**	-0.384	0.374	0.084	-0.079	-0.315
15	**0.823**	0.035	0.241	0.022	-0.017	0.115
16	**0.933**	-0.090	-0.021	-0.086	0.090	0.062
17	**0.952**	-0.037	-0.023	-0.075	0.159	0.035
18	0.381	-0.126-	-0.026	0.043	**0.733**	-0.286-
20	-0.088-	-0.018-	0.316	-0.150-	**0.845**	0.025
21	0.635	0.193	0.238	-0.318-	-0.106-	-0.168-

Source: field study

Table (5.27) displays the rotated factor for scale 10 (Base estimate). The items 2, 3, 4, and 6 constituted the latent factor which is 1, it can be interpreted as (Project resources availability), as well as the items 1, 5, and 7 which were also on the latent factor 2, can be collected in interpretation of (Initial requirements and documents).

Table 5.27 shows Rotated factor for Base estimate (scale 10).

Rotated factor (Varimax)		
item	Component (factor loading)	
	1	**2**
1	0.196	**0.827**
2	**0.722**	0.307
3	**0.910**	0.050
4	**0.860**	0.312
5	0.291	**0.754**
6	**0.812**	0.282
7	0.153	**0.795**

Source: field study

On the positive side, there weren't any items had been loaded on two factors in the same time according to the varimax rotated test, and the content validity were also checked for all the items, which sharing the same underlying dimension (factor). Therefore, items weren't deleted and the instrument was valid.

5.6 Summary

Research design of this study discussed the strategy that adopted in this study; it was both quantitative and qualitative research methods in order to strength the research. Literature review, questionnaire, structured interview, and case study were represented the adopted strategies and each one of them were responsible about answering one of questions of study. After that, the process of conducting questionnaire, structured interview, and case study were discussed through pilot study, survey sample, and process of conducting the strategy.

Therefore, the whole strategies were understood and became the map for this study as well as becoming a guide for collecting the data.

Furthermore, the instrument of this study, which was tested for both reliability and validity, were 94 items. In reliable test, internal consistency was used; items, which had score less than 0.60, were deleted; 10 items were deleted in order to be reliable the instrument. Therefore, the instrument was reliable. Item analysis tested the correlation between the items and its scale by Pearson correlation's test. The items which had value less than 0.30 were deleted after checking their content; 5 items were deleted. It was reflected that accepted items were appropriately assigned to their scales.

Because this study was exploratory, the exploratory factor analysis and the Principal component analysis were adopted. After performing the test, there was no item had been loaded on two factors; therefore, the instrument was valid. Then, the instrument became 79 items. Thus, the instrument can be used to test the both quantitative and qualitative models.

CHAPTER VI: MODELS TESTING RESULTS

6.1 Introduction

In this chapter, the qualitative model introduces the process of analysis using structural equation modelling (SEM) technique, which is performed by the IBM SPSS AMOS 23 programme. The first qualitative model, KCE model is tested by the SEM and developed to be fit according to some covariance relationships which are supposed by AMOS and don't conflict with the theory of this study and reality. Hypotheses test, model fit indices, and model modification results are revealed. In addition, the results' interpretations are discussed from wide view of the author and structured interview. Furthermore, the qualitative model is also tested by the SEM by the IBM SPSS AMOS 23 programme. The results of test reveals the hypotheses tests, model fit indices, and model modifications. As well, the results' interpretations of model M4 are stated according to the author's point of view supporting by the structured interview and other research's findings. Of prime importance, the quantitative model is also discussed and used ANN technique. The ANN model formulation reveals the model constraints, data encoding, data set, model building, model results, and sensitivity analysis. Further, the hypothesis test is done by the SPSS programme, and the results of both ANN model test and the hypothesis test are discussed. Finally, the summary explains briefly this chapter.

6.2 Qualitative Model

In this study, the path of measurement model was done to construct the variables based on the factor analysis, which was analysed in chapter five in order to test the validity of the instrument as well as was used in the measurement model. Therefore, in this chapter, the only structural model would use to estimate and test the theoretical models. The IBM SPSS AMOS[1] 23 was used to test the SEM models. In this research, the qualitative models was composed of two models, the first one was to test the Knowledge of cost estimate (dependent variable) which consist of 8 constructs as independents variables. And the second one was to test the implementation of detailed estimate (dependent variable) combined with the first model (Knowledge of cost estimate) as independent as well as other six constructs were also belonged to the detailed estimate as independent variables.

6.3 Process of Analysis

The IBM SPSS AMOS 23 was used to analysis the qualitative models according to SEM, in which to determine the regression equations of the paths from independent variables to dependent variables. AMOS graphical, which also works directly from a path diagram is used within Microsoft Windows interface, therefore; it is easy to draw the model paths or relations between the variables by easy way. AMOS analyses the model as a series of regression equations and estimates all the structural coefficients directly. The path coefficients (regression estimate[2]) and intercept (α) were obtained by AMOS. Also, the data was got from SPSS file and treated as observed variable (both dependent and independent variables), which were actually latent variables. These data was assumed continuous.

6.4 Knowledge of Cost Estimates' Model

This hypothesised model consists of eight independent variables: Social and economic system (X_1), Construction cost classification (X_2), Cost estimation methods and techniques (X_3), Types of contracts and delivery systems (X_4), Critical factors (X_5), Cost control process (X_6), Safety considerations (X_7), Cost index (X_8), and the knowledge of cost estimate (KCE) is the dependent variable (Y_1). Therefore, the mean of each constructs were used in the

1 AMOS which is also known (Analysis of Moment Structures), is famous program in SEM in order to quickly specify, view, and modify the model graphically using simple drawing tools.

2 Regression estimate in AMOS refers to the regression coefficient β of independent variable.

analysis. In order to perform the analysis, the data normality should be checked, therefore, AMOS provides skewness and kurtosis values to check normality. In table (6.1), the skewness and kurtosis values don't exceed the value 1 which indicates that the variables have a relatively normal distribution and can be used to estimate the knowledge of cost estimate model. Figure (6.1) shows the theoretical model of knowledge of cost estimate and the parameters, which should be estimated to test the model.

Table 6.1 shows Summary of data normality of variables

Variable	Mean	Min	Max	Skew	C.R.	Kurtosis	C.R.
Social and economic system (X_1)	3.49	1.000	5.000	-.753	-2.572	-.704	-1.202
Construction cost classification (X_2)	3.57	2.000	4.500	-.801	-2.736	-.520	-.887
Cost estimation methods and techniques (X_3)	3.92	2.000	5.000	-.692	-2.365	-.845	-1.443
Types of contracts and delivery systems (X_4)	3.56	2.000	4.667	-.460	-1.572	-.594	-1.015
Critical factors (X_5)	3.69	2.923	4.846	.643	2.198	.285	.487
Cost control process (X_6)	3.46	1.500	5.000	-.157	-.535	-.066	-.113
Safety considerations (X_7)	2.37	1.000	5.000	.395	1.350	-.764	-1.305
Cost index (X_8)	2.51	1.000	4.000	-.104	-.355	-.735	-1.256
Knowledge of Cost estimate (Y_1)	4.05	2.868	4.851	-.517	-1.766	-.331	-.566

Source: data analysis by Author

In addition, table (6-2) shows the theoretical model parameters estimate and the hypothesis test, in which model consists of eight hypothesis that would be tested simultaneously. Model M1 that represents the original model, which has been assumed in the literature review study as well as every path also represent the hypothesis, which has hypothesised to formulate the model according to the theory of study. In order to test the hypotheses of theoretical model, the critical values (C.R.) were obtained from IBM SPSS AMOS 23 should be greater than ± 1.96 to be significant and confirmed. Only two hypotheses weren't confirmed H1 which was (The social and economic system of Yemen has a positive effect on Knowledge of cost estimate) and H6 which was (Understanding the Cost control process has a positive effect on Knowledge of cost estimate) in which their C.R. values were less the ± 1.96.

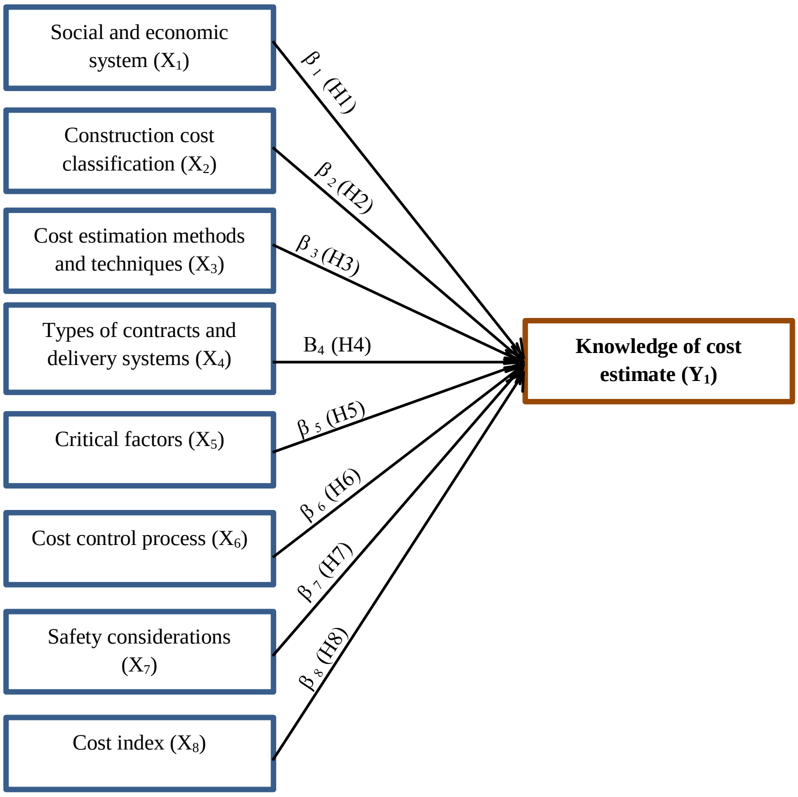


Figure 6.1 Theoretical model of Knowledge of cost estimate, Author.

Notes:

Hypotheses No. are in parentheses.

β_n is the regression estimate.

As well as, the model fit indices were Chi-square (χ^2) = 195.135, with 28 degrees of freedom and P-value was = 0.0001 which indicates that the model is bad fit; and the Normed Fit Index (NFI =0.263) which was less than the cut-off point 0.90 indicates the model is also poor fit. The value of Comparative Fit Index (CFI=0.269) also indicates poor model fit as the same NFI estimate. Furthermore, the root mean square error of approximation (RMSEA = 0.294) indicator had value greater than 0.10 which indicates that the model is poor fit. Consequently, the modification was done by AMOS in order to add another variable or relation between the observed variable to improve the model fitting. After the modification was performed, the model M2 was suggested by AMOS, so, the new values of the best model fit indicators and regression estimate value (β) were generated. Some constraints were supposed by AMOS to improve the model M1 to model M2, which were the two independent variables X_1 and X_6 should be deleted, and covariance relationship between some other variables should be undertaken in the model as in table (6.3).

In model M2, the Chi-square (χ^2) = 9.516, with 7 degrees of freedom and P-value was = 0.218 which indicates that the model is good fit. The Normed Fit Index (NFI =0.95) value which was greater than the cut-off point 0.90 indicating a better model fit. Further, the value of Comparative Fit Index (CFI=0.98) also indicates a better model fit as the same in NFI estimate. The value of the root mean square error of approximation (RMSEA = 0.072) was below the value of 0.08, which indicates a fair model fit. The final indicator Akaike's Information Criterion (AIC), which is used to compare two models which the model is better to fit data through comparing their two AIC values which is smaller than other should be better. In this study the model M1 had AIC value = 247.135, and the model M2 had value = 65.516, therefore, the model M2 had the smaller value which indicates it better to fit data.

In this study, the model M1 was used as a benchmarking model, and improved by AMOS to model M2 by deleting two parameters and adding some relations between variables which were led to improve the model fit as shown in the analysis and model fit indicators according to the theory of study. Therefore, the model M2 has a better model-fit compared with model M1 as shown in figure (6.2) and figure (6.3) respectively.

In table (6.4), the parameters of knowledge of cost estimate's model M2 was listed according to AMOS analysis, so the equation of predicting the model M2 is:

$$0.372X_2 - 0.195X_3 - 0.168X_4 + 0.691X_5 - 0.267X_7 + 0.123X_8 + 1.861 = Y_1 \qquad Eq.(6-1)$$

Table 6.2 shows Maximum likelihood estimates and Models fit indices for model M1 and M2

Model M1				Model M2			
Model's path	**Estimate (β)**	**C.R.**	**P**	**Model's path**	**Estimate (β)**	**C.R.**	**P**
KCE <--- X_1	.030	.920	.358	KCE <--- X_2	0.372	5.663	000
KCE <--- X_2	.325	7.078	000	KCE <--- X_3	-0.195	-3.643	000
KCE <--- X_3	-.186	-5.200	000	KCE <--- X_4	-0.168	-2.488	0.013
KCE <--- X_4	-.155	-3.133	.002	KCE <--- X_5	0.691	6.864	000
KCE <--- X_5	.639	7.553	000	KCE <--- X_7	-0.267	-6.744	000
KCE <--- X_6	.060	1.381	.167	KCE <--- X_8	0.123	2.148	0.032
KCE <--- X_7	-.257	-8.123	000				
KCE <--- X_8	.143	3.452	000				
Chi-square (χ^2)	195.135			9.516			
Degree of freedom	28			7			
P-values	0.0001			0.218			
NFI	0.263			0.95			
CFI	0.269			0.98			
RMSEA	0.294			0.072			
AIC	247.135			65.516			

Source: data analysis by Author

Table 6.3 shows Covariance relationships in Model M2

Variables	**Covariance relationships**	**Variables**
X_2	<-->	X_3
X_4	<-->	X_7
X_7	<-->	X_8
X_3	<-->	X_8
X_2	<-->	X_4
X_4	<-->	X_8
X_3	<-->	X_5
X_4	<-->	X_5

Source: data analysis by Author

Table 6.4 shows Knowledge of cost estimate's parameters

Independent variables (X_n)	**Regression estimates (β_n)**	**Intercept (α)**	**R^2**	**Dependent variable (Y_1)**
Construction cost classification (X_2)	0.372	1.861	0.59	Knowledge of cost estimate
Cost estimation methods and techniques (X_3)	-0.195			
Types of contracts and delivery systems (X_4)	-0.168			
Critical factors (X_5)	0.691			

Safety considerations (X_7)	-0.267			
Cost index (X_8)	0.123			

Source: data analysis by Author

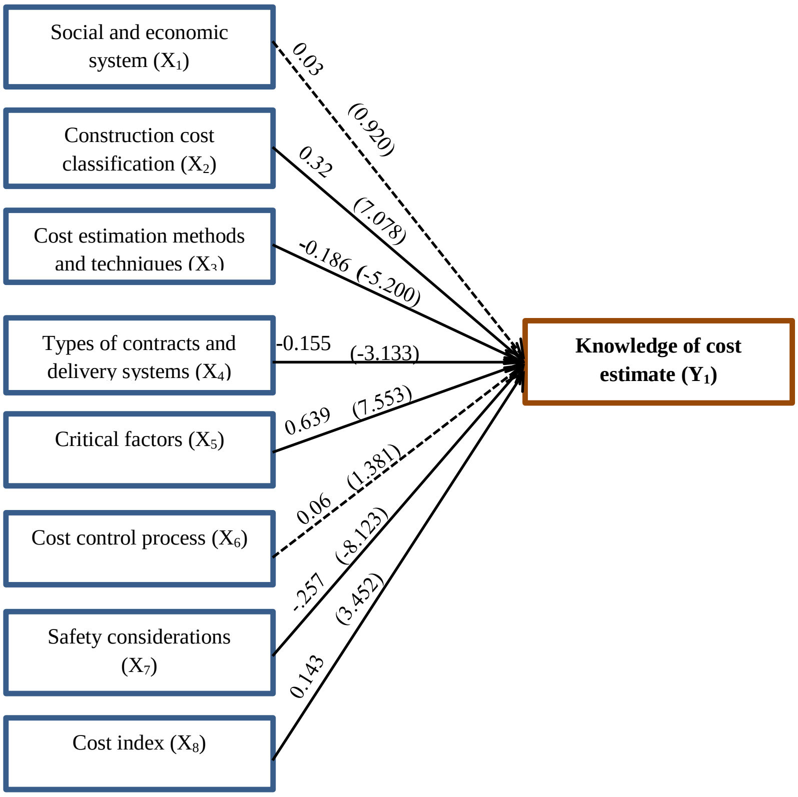


Figure 6.2 Testing the theoretical model of Knowledge of cost estimate (M1), Author

Notes:

Critical ratios (C.R.) are in parentheses.

A hypothesis was confirmed ⟶

A hypothesis wasn't confirmed --------->

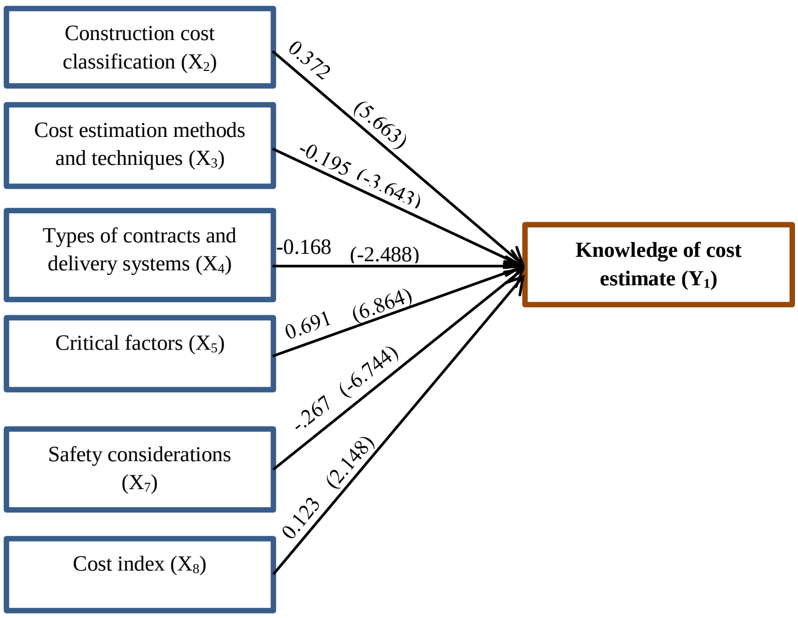


Figure 6.3 Testing the theoretical model of Knowledge of cost estimate (M2), Author.

6.5 Results' Interpretation

In appendix (4), the results of analysis the factors of scales were set for this section of KCE that contains eight scales as well as the result of KCE model test.

In scale one, **Social and economic system**, there were three questions that respondents were asked according to:

1. With respect to the question of ''GDP'', the respondents were asked ''GDP has strongly effects on our projects and construction industry'', from their answers, the analysis shows the mean was **3.70**, which is higher than the mean average (**3),** which indicates that the respondents may have a partially knowledge about the GDP and its relation to the economic.
2. With respect to the question of ''National income per Capita'', the respondents were asked ''our project performance is affected by National income per capita'', from their answers, the analysis shows the mean was **3.52**. The mean is slightly higher than the mean average (**3),** which concludes that the respondents may not deal with this terminology in their business life or in the firm. As well, the structured interviews had appeared not care about this concepts and its relation with the demand of projects or its effects on the performance.
3. With respect to the question of ''Tribal system'', the respondents were asked ''the project progress is affected by the tribal system'', from their answers, the analysis shows the mean was **3.25**. The mean is slightly higher than the mean average **(3)**, which refers that respondents thought that the tribal system affected the projects due to their suffering of delay or also to their believes and affiliations to the tribe. In addition, the Yemeni society is controlled by this system mostly; tribal culture has forced into society from decades.

From last discussion, the mean of scale ''social and economic system'' was **3.49**, which is slightly higher than the mean average **(3)**. As well, questionnaire survey had provided no significant statistical support for the hypothesis ''the social and economic system of Yemen has a positive effect on knowledge of cost estimate'' that wasn't confirmed which concludes that the most matters of economics and social with regards Yemeni engineers weren't taken into account. Especially, those two economic and social didn't interrupt directly with knowledge of cost estimate. Therefore, it didn't affect the process of estimate itself.

In scale two, **Construction cost classification**, there were two questions that respondents were asked according to:

1. With respect to the question of ''variable cost'', the respondents were asked ''we know all variable cost (direct cost) of construction'', from their answers, the analysis shows the mean was **3.36**, which is slightly higher than the mean average (**3),** which concludes that the respondents mightn't know this terminology correctly. As well, the structured interview confirmed that the respondents didn't know how to determine the direct cost or variable cost.
2. With respect to the question of ''fixed cost'', the respondents were asked ''we know all fixed cost (indirect cost) of construction'', from their answers, the analysis shows the mean was **3.78**, which is slightly higher than the mean average (**3).** It is concluded that the respondents need more knowledge in cost classification, which might affect the progress of estimate towards success or failure.

Of prime importance, the mean of scale ''Construction cost classification'' was **3.57**, which is slightly higher than the mean average **(3)**. Furthermore, the hypothesis ''understanding of construction cost classification has a positive effect on knowledge of cost estimate'' was confirmed which indicates that more understanding of cost classification more powerful of estimate ability.

In scale three, **Cost estimation methods and techniques**, there were two questions that respondents were asked according to:

1. With respect to the question of ''Conceptual and preliminary estimate'', the respondents were asked ''Conceptual and Preliminary estimate is used to estimate projects at the early stage'', from their answers, the analysis shows the mean was **4.14**, which is higher than the mean average (**3).** It is deduced that the respondents were familiar with preliminary estimate in their practices as well as the structured interviews referred to the traditional method that was used in this stage. The traditional method, exactly, unit price of squared meter is the most practically used in Yemen.
2. With respect to the question of ''Definitive estimate'', the respondents were asked ''in the end of the project, the definitive estimate is used'', from their answers, the analysis shows the mean was **3.71**, which is slightly higher than the mean average

(**3).** It means that the final real cost is defined after the project has finished comparing to the detailed estimation cost. Moreover, the respondents had a little attention about. Thus, more knowledge is more achievable.

After being finished discussion, the mean of scale ‘‘Cost estimation methods and techniques’’ was **3.92**, which is higher than the mean average **(3)**. Furthermore, the hypothesis ‘‘Construction cost estimation methods and techniques have a positive effect on knowledge of cost estimate’’ was confirmed which deduces that those methods and techniques lead definitely to enhance the estimate process and they considers one of the ground base of KCE. Furthermore, the respondents might have need updating their methods and techniques aligned with sophistication.

In scale four, **Types of contracts and delivery systems**, there were three questions that respondents were asked according to:

1. With respect to the question of ‘‘Design- Bid- Build’’, the respondents were asked ‘‘Projects are obtained by design-bid-build traditional delivery system’’, from their answers, the analysis shows the mean was **3.81**, which is higher than the mean average (**3),** which concludes that the respondents had a normal knowledge and practice with this type. Although, it is a common type in construction projects, but the terminology might be unknown perfectly.
2. With respect to the question of ‘‘Design- Build Delivery’’, the respondents were asked ‘‘We design our projects and execute them’’, from their answers, the analysis shows the mean was **3.36**, which is slightly higher than the mean average (**3).** It is concluded that the respondents didn’t understand or might have confused about this terminology despite of the structured interviews which had confirmed their knowledge for this type.
3. With respect to the question of ‘‘Lump-Sum Contracts’’, the respondents were asked ‘‘Lump-sum contract is used in our projects’’, from their answers, the analysis shows the mean was **3.53**, which is slightly higher than the mean average (**3).** It means that the respondents agreed about this type of contract; likewise, the other types might be used either.

Therefore, the mean of scale ‘‘Types of contracts and delivery systems’’ was **3.92**, which is greater than the mean average **(3)**. As well, the hypothesis ‘‘Understanding the types of contracts and delivery systems has a positive effect on knowledge of cost estimate’’ was confirmed that means to perform accurate estimate should know the types of delivery systems and types of contract in order to fulfil the requirements of every type. Moreover, this knowledge should be taken into account and should be understood perfectly.

Then scale five, which is **Critical factors**, there were twenty-six questions that respondents were asked according to:

1. With respect to the question of ‘‘Time of construction’’, the respondents were asked ‘‘we put in our mind the time of construction when estimate our projects’’, from their answers, the analysis shows the mean was **4.48,** which is greater than the mean average **(3)**. It is concluded that the respondents had aware about the construction time aligned with their estimation as a crucial factor.
2. With respect to the question of ‘‘Project type’’, the respondents were asked ‘‘Project type has important effect on estimate process’’, from their answers, the analysis shows the mean was **4.38**, which is greater than the mean average **(3)**. It means that the most respondents knew the importance of the project type with respect to the project estimate and what complicated matters that concerning with the type.
3. With respect to the question of ‘‘Material costs change’’, the respondents were asked ‘‘we suffer from material cost changes in and after estimating process’’, from their answers, the analysis shows the mean was **4.28**, which is greater than the mean average **(3)**. It refers to that material cost which was forced by the escalation affect the estimate process leading to many errors would appear in the estimation. Thus, the respondents took into account this factor seriously. Exactly, when, the tender currency was in Rials.
4. With respect to the question of ‘‘Quality of the work’’, the respondents were asked ‘‘the cost estimate is affected by quality of the work’’, from their answers, the analysis shows the mean was **4.47**, which is greater than the mean average **(3)**. It indicates that the respondents believed in their mind and hearts about this meaning. It is a rational logic in construction industry and in Yemeni construction field especially.
5. With respect to the question of ‘‘Market condition”, the respondents were asked ‘‘the market conditions is taken into consideration when estimate projects’’, from their answers, the analysis shows the mean was **4.00**, which is greater than the mean average **(3)**. It refers that the respondents involved in the market and their estimate had contained a well knowledge about the market.
6. With respect to the question of ‘‘Management factors”, the respondents were asked ‘‘Management factors are considered into our projects’ cost estimate’’, from their answers, the analysis shows the mean was **3.61**, which is greater than the mean average **(3)**. It is deduced that the respondents might not know what the management factors or

might not have management contact that reveal the management factors confirming that structured interviews.

7. With respect to the question of ‘‘Geographic considerations”, the respondents were asked ‘‘the geographical considerations have the priority when estimate projects’ cost’’, from their answers, the analysis shows the mean was **4.61**, which is greater than the mean average **(3)**, which deduces that the respondents focused on the geographic considerations which differs in Yemen (coast, mountains, deserts). It might negatively affect the estimate output.
8. With respect to the question of ‘‘Insufficient time for estimate development”, the respondents were asked ‘‘We don’t have enough time for estimating our projects’’, from their answers, the analysis shows the mean was **3.31**, which is slightly higher than the mean average **(3)**, which means that the respondents mightn’t have enough time for estimating their projects. It would lead to rapid the process of estimate resulting miscalculation and forgotten data; then, it would unfortunately be failure.
9. With respect to the question of ‘‘Inadequate specification”, the respondents were asked ‘‘We suffer from inadequate specification at the cost estimate process’’, from their answers, the analysis shows the mean was **3.08**, which is close to the mean average (**3),** which indicates that the respondents might face inadequate specification. Further, the most specifications were available according to the structured interviews declared.
10. With respect to the question of ‘‘Incomplete drawings”, the respondents were asked ‘‘We suffer from incomplete drawings at the cost estimate process’’, from their answers, the analysis shows the mean was **3.08**, which is close to the mean average (**3),** which means that the respondents might face inadequate drawings. As well, the most of projects don’t begin with complete drawings in Yemen.
11. With respect to the question of ‘‘lack of site feedback”, the respondents were asked ‘‘We don’t suffer from lack of site feedback’’, from their answers, the analysis shows the mean was **1.98**, which is less than the mean average (**3),** which indicates that the respondents mightn’t have the feedback from the site to improve their estimate. Feedback may help to develop the knowledge of cost estimate in future.
12. With respect to the question of ‘‘Technological requirements”, the respondents were asked ‘‘Technological requirements are very important factor in cost estimate process’’, from their answers, the analysis shows the mean was **3.91**, which is higher than the mean average (**3),** which indicates that the some respondents preferred the technology than the traditional. Thus, they tried to fulfil the requirements of technology in order to be innovators.

13. With respect to the question of ‘‘Project information”, the respondents were asked ‘‘we have sufficient project information at cost estimate process’’, from their answers, the analysis shows the mean was **2.80**, which is slightly less than the mean average (**3). It** indicates that the respondents might not understand the required information; another important issue that revealed due to structured interview was some projects had lack information; this could affect the process of estimate.
14. With respect to the question of ‘‘Contract requirements”, the respondents were asked ‘‘Contract requirements are available at cost estimate process’’, from their answers, the analysis shows the mean was **2.15**, which is less than the mean average (**3),** which concludes that the respondents had definitely lack of contract requirements; thus, they might have enough knowledge about it.
15. With respect to the question of ‘‘Project duration”, the respondents were asked ‘‘We take into consideration the project duration at cost estimate process’’, from their answers, the analysis shows the mean was **4.22**, which is greater than the mean average (**3),** which indicates that the respondents knew the importance of project duration to be key factor at estimate process.
16. With respect to the question of ‘‘Political situation”, the respondents were asked ‘‘We suffer from political situation in and after estimate’’, from their answers, the analysis shows the mean was **4.12**, which is greater than the mean average (**3),** which indicates that the respondents might understand carefully the impact of the political situation.
17. With respect to the question of ‘‘financial status of the owner”, the respondents were asked ‘‘our firm puts in its eyes the owner’s financial status at cost estimate process’’, from their answers, the analysis shows the mean was **3.77**, which is slightly higher than the mean average (**3).** It means that the respondents might focus on the client’s financial status to balance the estimation with the client capability.
18. With respect to the question of ‘‘Tender currency”, the respondents were asked ‘‘Tender’s currency is very important factors at cost estimate process’’, from their answers, the analysis shows the mean was **4.01**, which is greater than the mean average (**3),** which deduces that most the respondents preferred the currency should be determined to avoid ambiguous matters. Most of the projects in Yemen are in Dollar currency that decreases any potential inflation in prices.
19. With respect to the question of ‘‘Experience of consultant engineer”, the respondents were asked ‘‘We have a good feedback from the consultant in estimate process’’, from their answers, the analysis shows the mean was **3.95**, which is greater than the mean

average (**3),** which indicates that the respondents had faced many qualified consultants who might give them a good answers.

20. With respect to the question of ‘‘Number of competitors”, the respondents were asked ‘‘Competitors give us a promotion to improve our cost estimate’’, from their answers, the analysis shows the mean was **3.51**, which is slightly higher than the mean average (**3),** which refers that the respondents mightn’t active with the competition of the market. Somehow, the corruption may affect the selection of contractor in Yemen.
21. With respect to the question of ‘‘Evaluate political risks”, the respondents were asked ‘‘We suggest and evaluate the political risks at cost estimate process’’, from their answers, the analysis shows the mean was **3.38**, which is slightly higher than the mean average (**3),** which indicates that the respondents didn’t understand carefully how to evaluate the political risks.
22. With respect to the question of ‘‘Evaluate regulatory risks”, the respondents were asked ‘‘We suggest and evaluate the regulatory risks at cost estimate process’’, from their answers, the analysis shows the mean was **3.34**, which is slightly higher than the mean average (**3),** which indicates that the respondents mightn’t contact with regulatory matters that could affect the estimate. It might be delegated to the administration; thus, the estimators didn’t know it well.
23. With respect to the question of ‘‘Quantity Allowance”, the respondents were asked ‘‘Our firm adds the quantity allowances when measuring our project quantities’’, from their answers, the analysis shows the mean was **3.54**, which is slightly higher than the mean average **(3),** which indicates that the respondents mightn’t add this quantities. It was led them to losses according to the error of knowledge.
24. With respect to the question of ‘‘Escalation”, the respondents were asked ‘‘We take into consideration the escalation at estimate process’’, from their answers, the analysis shows the mean was **3.78**, which is slightly higher than the mean average (**3),** which means that the respondents might know about the escalation. In addition, the escalation didn’t affect the market of Yemen before the war in 2015.
25. With respect to the question of ‘‘Evaluate the risks”, the respondents were asked ‘‘We estimate and evaluate the potential risks at cost estimate process’’, from their answers, the analysis shows the mean was **3.74**, which is slightly higher than the mean average (**3),** which indicates that the respondents sometimes took the potential risk into account. However, it still they were beyond the ultimate knowledge and practice of risk evaluation.

26. With respect to the question of ‘‘Fees”, the respondents were asked ‘‘We take into consideration the formal fees at cost estimate process’’, from their answers, the analysis shows the mean was **4.08**, which is greater than the mean average (**3),** which refers that the respondents might determine all fees that required for specific project.

Furthermore, the scale mean of ‘‘Critical factors’’ was **3.69**, which is slightly higher than the mean average **(3)**. As well, the hypothesis ‘‘Understanding the critical factors has a positive effect on knowledge of cost estimate’’ was confirmed which refers that the more understanding the factors surrounding the estimate process, the more efficiency of estimate; those factors should be taken into account and studied properly.

In scale six, which is **Cost control process**, there were two questions that respondents were asked according to:

1. With respect to the question of ‘‘Cost control”, the respondents were asked ‘‘We know the process of cost control and monitoring’’, from their answers, the analysis shows the mean was **3.61**, which is slightly higher than the mean average (**3),** which refers that the respondents might know how to control the cost. More evidence, from the structured interviews, the process of control didn’t apply almost.
2. With respect to the question of ‘‘Earned value technique”, the respondents were asked ‘‘Earned Value technique is used to control and monitor the cost’’, from their answers, the analysis shows the mean was **3.31**, which is slightly higher than the mean average **(3)**, which means that the respondents didn’t know properly the technique of earned value. This technique might be uncommon in field of Yemeni’s engineers.

As it can be seen, the scale mean of ‘‘Cost control process’’ was **3.46**, which is slightly higher than the mean average **(3)**. As well, the hypothesis ‘‘Understanding the Cost control process has a positive effect on knowledge of cost estimate’’ wasn’t confirmed which concludes that this process doesn’t belong to the estimate process; thus, it can be seen it doesn’t matter the cost control to be taken into account in cost estimate. In addition, the structured interviews also insisted this process shouldn’t affect the cost estimate.

Scale seven, which is **Safety considerations**, there was one question that respondents were asked according to:

1. With respect to the question of ‘‘No safety consideration”, the respondents were asked ‘‘We don’t take into consideration the safety requirements when we estimate our projects’’, from their answers, the analysis shows the mean was **2.37**, which is

slightly less than the mean average **(3)**, which means that the respondents might had safety consideration. However, the most projects in Yemen didn't take safety into consideration. Therefore, the safety consideration should be activated in all projects.

In this scale, the scale mean of ''Safety considerations'' was **2.37**, which is slightly less than the mean average (3). As well, the hypothesis ''Understanding the safety considerations has a positive effect on knowledge of cost estimate'' was confirmed which concludes that the safety should take a place in knowledge of cost estimate; safety can indirectly affect the cost and making a horrible losses.

In scale eight, which is **Cost index**, there was one question, which respondents were asked according to:

1. With respect to the question of ''Cost index", the respondents were asked ''Our firm use the construction cost indexes in estimate process'', from their answers, the analysis shows the mean was **2.51**, which is slightly less than the mean average **(3)**, which indicates that the respondents mightn't know the cost index; cost index wasn't common in Yemen.

With referring to the scale mean of ''Cost index'', it was **2.51**, which is slightly less than the mean average **(3)**. As well, the hypothesis ''Cost index has a positive effect on knowledge of cost estimate'' was confirmed which concludes that the cost index can provide a good tool to estimate the projects. The five structured interviews have preferred that the cost index should be prepared by the firms' own method. Therefore, the cost index knowledge should be involved in knowledge of cost estimate. A study was conducted by Al-Shanti (2003) gave results that **92.5%** of respondents agreed using cost index (Database) of building materials, **72.5%** of respondents agreed using cost index (Database) of building labours, and **47.5%** of respondents agreed using cost index (Database) of plants. Al-shanti's finding supports finding of this study.

After the KCE model was tested and the hypotheses were examined; the final model of knowledge of cost estimate is considered the unique model in construction cost estimate. Many researchers have focused on the process of estimate whatever, in the preliminary estimate, or in detailed estimate. They haven't thought about the root of problem. Thus, this model is value added to the science of construction management as well as is considered independent variable in detailed cost estimate model that would be discussed later. With comparing to another study was conducted by Leng (2005) who focused on the knowledge's transfer in construction cost estimate; this transferring was through many steps (identify, capture, store, share and adapt). That research focuses on the process of transferring, not on the knowledge itself ignoring knowledge. In fact, the transferring automatically passes through observing, talking, teaching and so on; thus, the KCE model of this study is more effective than Leng's model; the KCE model concentrates on the variables of knowledge that should be gained.

6.6 Qualitative Cost Estimate's Model

This hypothesised model consists of seven independent variables which are: Base estimate (X_{10}), Measurements (X_{11}), Querying (X_{12}), Pricing (X_{13}), Management review (X_{14}), Bid summary (X_{15}), Knowledge of cost estimate (X_{16}), and Final detailed cost is the dependent variable (Y_2). In table (6.5), the normality test result was listed and the skewness and kurtosis values don't exceed the value 1 which indicates that the variables have approximately normal distribution to be used to estimate the parameters of theoretical model of qualitative cost estimate (M3).

Notwithstanding, some variables are independent or dependent, but also can be dependent or independent variables according to the relation of regressions (causal and effect) in the theoretical model, strictly, the knowledge of cost estimate was dependent variable (Y_1) in the model M2, but in the model M3 is independent variable (X_{16}). Furthermore, Base estimate, Quantity measurement, Pricing, Management review, and Bid summary can also be dependent variables Y_3, Y_4, Y_5, Y_6, and Y_7 respectively. Figure (6.4) shows the theoretical model of qualitative cost estimate and the parameters, which should be estimated to test the model M3.

The theoretical model of qualitative cost estimate (M3) represented 11 hypotheses, which would be tested simultaneously according to the theory of study. In table (6.6), the hypotheses of model M3 were significant and confirmed except three hypotheses which their C.R. less than ± 1.96. The unconfirmed hypotheses were H14 which is (Pricing process has a positive effect on management review's process), H16 which is (Bid summary has a positive effect on final detailed cost), and H17 which is (knowledge of construction cost estimate has a positive effect on final detailed cost) as shown in figure (6.5) for model M3.

Table 6.5 shows Summary of data normality of variables

Variable	Mean	Min	Max	Skew	C.R.	Kurtosis	C.R.
Base estimate (X_{10})	3.62	1.85	4.85	-.76	-2.62	.030	.052
Measurements (X_{11})	4.20	3.00	5.00	-.17	-.59	-.86	-1.48
Querying (X_{12})	4.38	3.00	5.00	-.84	-2.88	-.53	-.91
Pricing (X_{13})	3.82	2.00	5.00	-.41	-1.40	-.60	-1.03
Management review (X_{14})	4.10	3.00	5.00	-.15	-.53	-.81	-1.39
Bid summary (X_{15})	4.32	3.00	5.00	-.53	-1.83	-.81	-1.39
Knowledge of cost estimate (X_{16})	4.05	2.868	4.85	-.51	-1.76	-.33	-.56
Final detailed cost (Y_2)	3.45	2.00	5.00	.18	.62	-.88	-1.51

Source: data analysis by Author

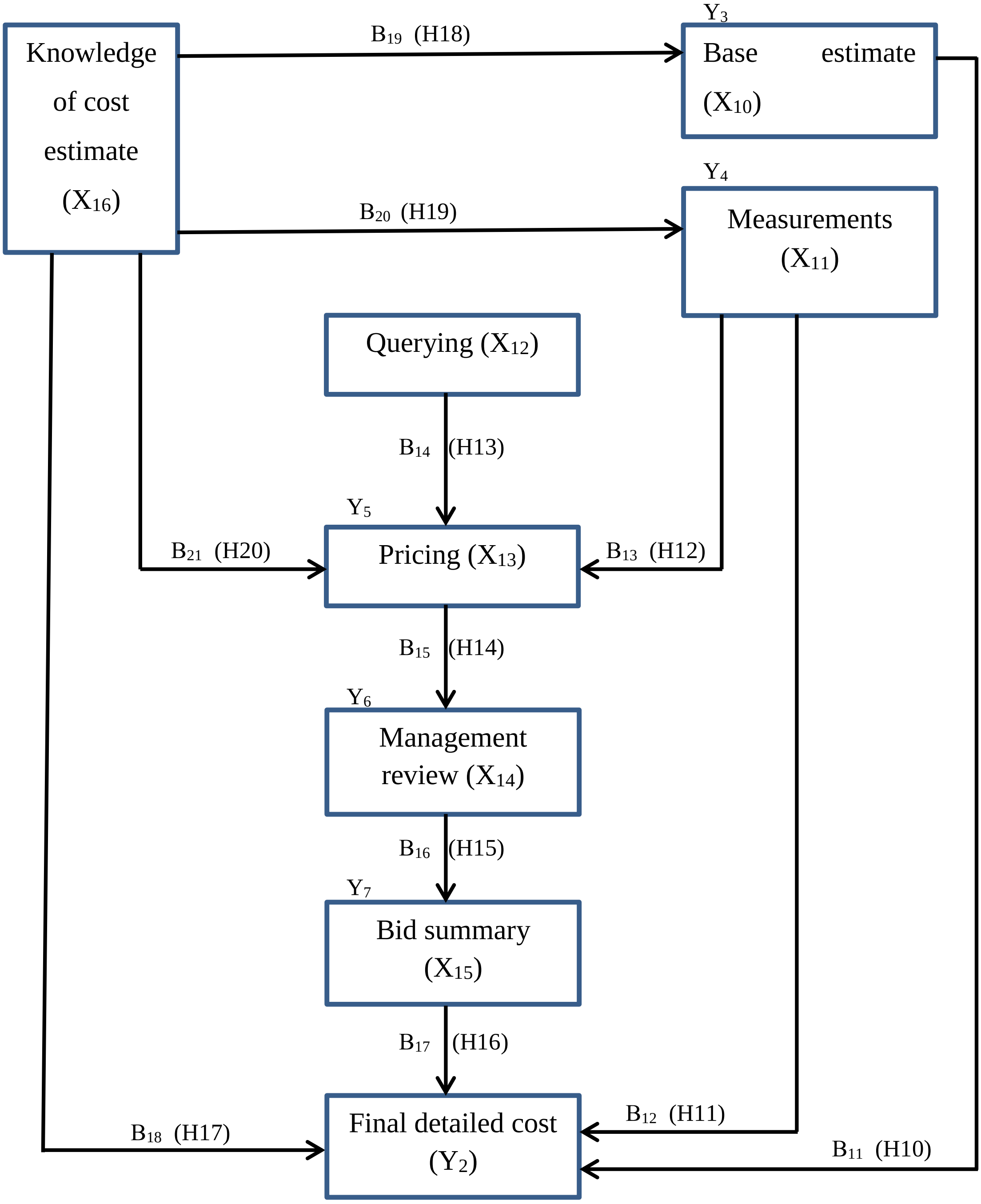


Figure 6.4 Theoretical model of Qualitative cost estimate, Author.

Notes:

Hypotheses No. are in parentheses.

β_n is the regression estimate.

Furthermore, the model fit indices for model M3 were Chi-square (χ^2) = 234.326, with 17 degrees of freedom and P-value was = 0.0001 which indicates that the model is bad fit; the Normed Fit Index (NFI =0.58) which is less than 0.90 indicating poor model fit. The value of Comparative Fit Index (CFI=0.59) also indicates poor model fit, as well as the root mean square error of approximation (RMSEA = 0.43) indicator has value greater than 0.10 which indicates the model is poor fit.

Consequently, the modification was required to improve the model M3 to model M4 by AMOS ability of improvement suggestions. Therefore, in the table (6-6), model M4 was improved from the model M3 by AMOS in order to make best model fit indicators and regression estimates value (β) which dependent on some suggestions as following:

- Adding a new path line (casual and effect) from KCE (X_{16}) to management review (X_{14}).
- Delete two paths from KCE (X_{16}) to final detailed cost (Y_2) and from bid summary (X_{15}) to final detailed cost (Y_2).
- Covariance relationship between some variables are shown in table (6.7).
- The hypothesis H14 that wasn't confirmed in model M3 was confirmed in model M4.

After review the four suggested constraints, which were supposed by AMOS regarding with the theory of study, they were accepted and not conflicted with the theory. The new model M4 is shown in figure (6.6) after improved from model M3, which was considered as benchmark model.

In the improved model M4, the Chi-square (χ^2) = 13.280, with 11 degrees of freedom and P-value was = 0.275 which indicates that the model is good fit. The Normed Fit Index (NFI =0.976) value which is greater than 0.90 indicating a better model fit. Also, the value of Comparative Fit Index (CFI=0.996) indicating a better model fit. The value of the root mean square error of approximation (RMSEA = 0.055) is slightly greater than 0.05, which indicates a good model fit. Furthermore, the final indicator Akaike's Information Criterion (AIC), the model M3 had AIC value = 288.326, and the model M4 had value = 79.280, therefore, the model M4 has the smaller value indicating better model fit for data.

Table 6.6 shows Maximum likelihood estimates and Models fit indices for model M3 and M4

Model M3				**Model M4**			
Model's path	**Estimate (β)**	**C.R.**	**P**	**Model's path**	**Estimate (β)**	**C.R.**	**P**
X_{11} <--- X_{16}	.925	11.161	***	X_{11} <--- X_{16}	.925	11.022	***
X_{13} <--- X_{12}	.307	3.938	***	X_{13} <--- X_{12}	.313	2.507	0.012
X_{13} <--- X_{16}	1.363	7.617	***	X_{13} <--- X_{16}	1.367	6.099	***
X_{13} <--- X_{11}	-.484	-3.117	.002	X_{13} <--- X_{11}	-.494	-3.236	0.001
X_{14} <--- X_{13}	.148	1.299	.194	X_{14} <--- X_{13}	-.627	-6.166	***
X_{10} <--- X16	1.276	13.875	***	X_{14} <--- X_{16}	1.458	7.318	***
X_{15} <--- X_{14}	.651	6.796	***	X_{10} <--- X_{16}	1.277	14.068	***
Y_2 <--- X_{16}	-.378	-1.146	.252	X_{15} <--- X_{14}	1.011	5.855	***
Y_2 <--- X_{10}	.495	2.712	.007	Y_2 <--- X_{10}	.352	3.025	0.000
Y_2 <--- X_{11}	.669	3.299	***	Y_2 <--- X_{11}	.563	3.771	0.000
Y_2 <--- X_{15}	.074	.717	.473				
Chi-square (χ^2)	234.326			13.280			
Degree of freedom	17			11			
P-values	0.0001			0.275			
NFI	0.58			0.976			
CFI	0.59			0.996			
RMSEA	0.43			0.055			
AIC	288.326			79.280			

***= P<0

Table 6.7 shows Covariance relationships in Model M4

Variables	Covariance relationships	Variables
X_{10}	<-->	X_{11}
X_{10}	<-->	X_{13}
X_{10}	<-->	X_{15}
X_{11}	<-->	X_{14}
X_{16}	<-->	X_{12}
X_{16}	<-->	X_{15}

Source: data analysis by Author

In table (6.8), the parameters of qualitative model M4 was listed according to AMOS analysis, so the equations of predicting for model M4 are:

Table 6.8 shows Qualitative cost estimate model's parameters

Independent variables (X_n)	Regression estimates (β_n)	Intercept (α)	R^2	Dependent variable Y_n
Base estimate (X_{10})	0.352	-0.187	0.45	Final detailed cost estimate (Y_2)
Measurements (X_{11})	0.563			
Knowledge of cost estimate (X_{16})	1.227	-1.588	0.74	Base estimate (Y_3)
Knowledge of cost estimate (X_{16})	0.925	0.457	0.64	Measurements (Y_4)
Measurements (X_{11})	-0.494	-1.007	0.69	Pricing (Y_5)
Querying (X_{12})	0.313			
Knowledge of cost estimate (X_{16})	1.367			
Pricing (X_{13})	-0.627	0.586	0.38	

Knowledge of cost estimate (X_{16})	1.458			Management review (Y_6)
Management review (X_{14})	1.011	0.184	0.20	Bid summary (Y_7)

Source: data analysis by Author

Therefore, the equations can be summarised as following:

$$0.352\,X_{10} + 0.563\,X_{11} - 0.187 = Y_2 \qquad EQ.(6-2)$$

$$1.227\,X_{16} - 1.588 = Y_3 \qquad Eq.(6-3)$$

$$0.925\,X_{16} + 0.457 = Y_4 \qquad Eq.(6-4)$$

$$-0.494\,X_{11} + 0.313\,X_{12} + 1.367\,X_{16} - 1.007 = Y_5 \qquad Eq.(6-5)$$

$$-0.627\,X_{13} + 1.458\,X_{16} + 0.586 = Y_6 \qquad Eq.(6-6)$$

$$1.011\,X_{14} + 0.184 = Y_7 \qquad Eq.(6-7)$$

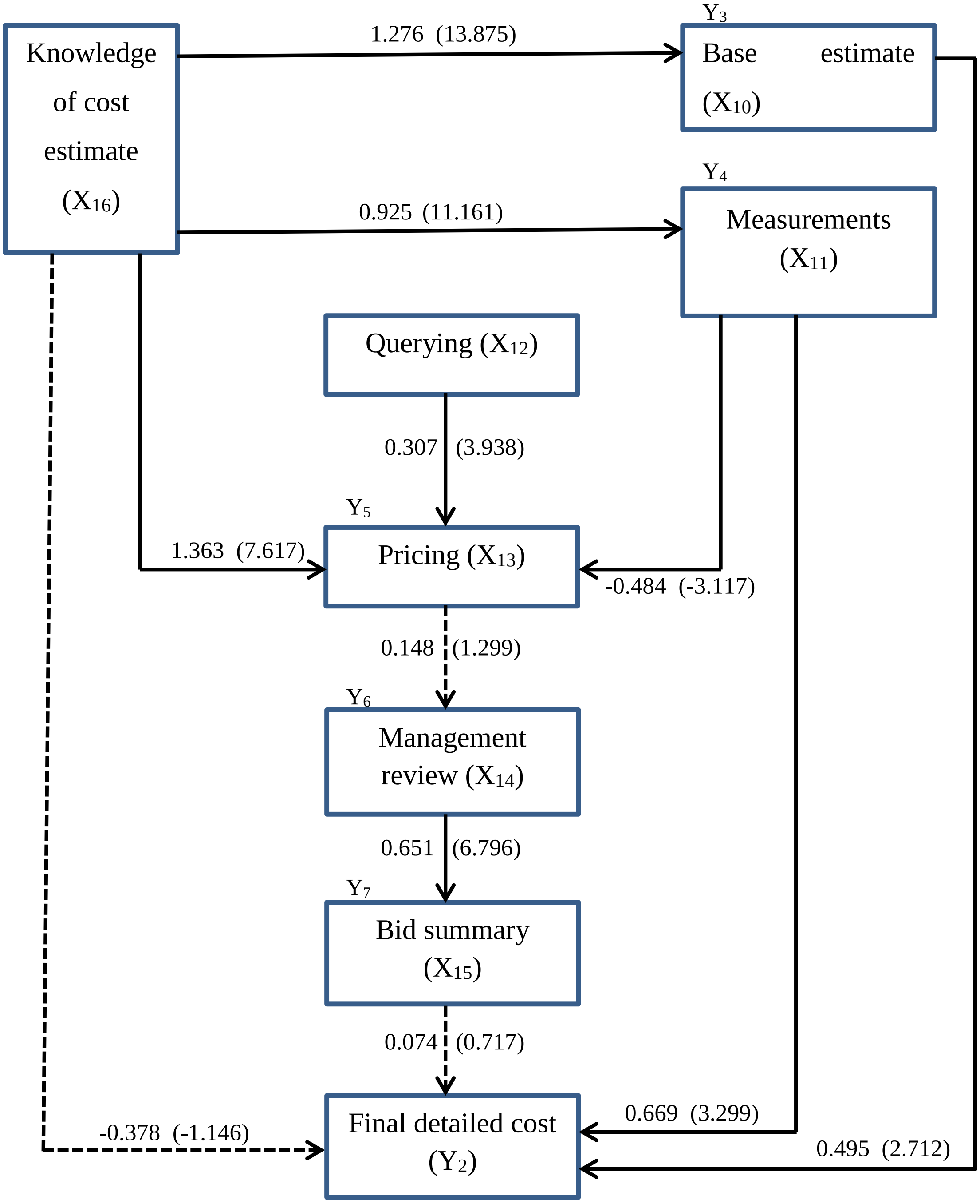


Figure 6.5 Testing the theoretical model of Qualitative cost estimate model (M3), Author.

Notes:

Critical ratios (C.R.) are in parentheses.

Hypothesis was confirmed →

Hypothesis wasn't confirmed - - - - →

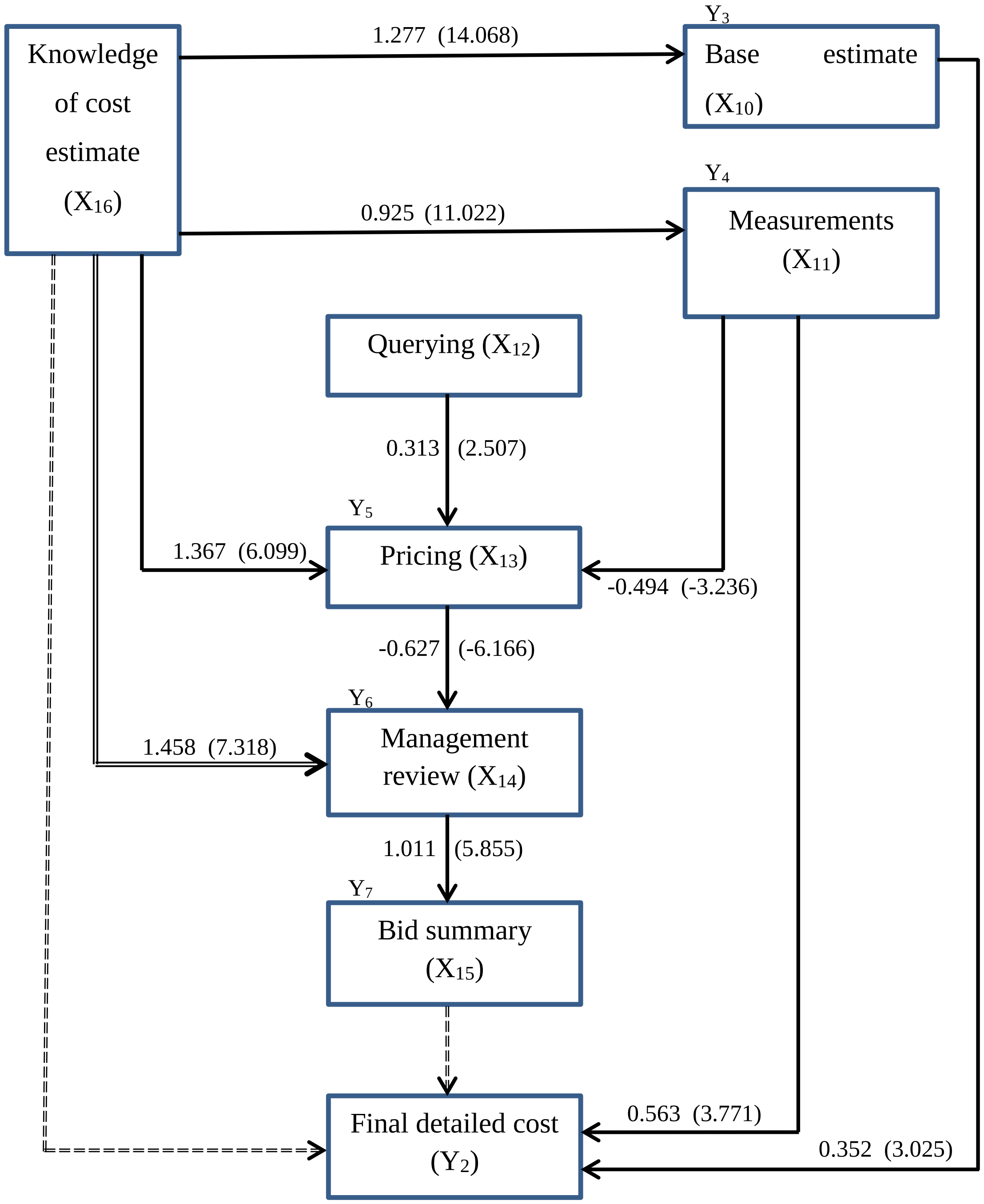


Figure 6.6 Testing the theoretical model of Qualitative cost estimate model (M4), Author.

Note:

Additional path by AMOS ⟹

Deleted path by AMOS ⇢

6.7 Results' Interpretation

In appendix (4), the results of analysis factors of scales were set for this section of detailed estimate (qualitative model) that contains seven scales (from base estimate scale to final detailed cost scale) as well as the test result of Qualitative cost estimate model.

In scale ten, **Base estimate**, there were seven questions that respondents were asked according to:

1. With respect to the question of ''Scope baseline", the respondents were asked ''We prepare scope baseline (scope statement, WBS, & dictionary of WBS)'', from their answers, the analysis shows the mean was **2.91**, which is slightly less than the mean average **(3)**, which indicates that the respondents mightn't know more about scope baseline. As well, it was noticed the five structured interviews didn't know well this terminology; especially, it belongs to project management study.
2. With respect to the question of ''Resource calendars", the respondents were asked ''Our firm prepares Resource calendars'', from their answers, the analysis shows the mean was **3.52**, which is slightly higher than the mean average **(3)**, which concludes that the respondents mightn't prepare their resource calendars perfectly.
3. With respect to the question of ''Project schedule", the respondents were asked ''We use Project schedule in cost estimate process'', from their answers, the analysis shows the mean was **4.07**, which is greater than the mean average **(3)**, which means that the respondents prepared the project schedule for every projects. Those schedules might lead them to estimate the cost accurately.
4. With respect to the question of ''Human resource plan", the respondents were asked ''we use human resource plan in cost estimate process'', from their answers, the analysis shows the mean was **3.72**, which is slightly higher than the mean average **(3)**. It indicates that the most respondents might have human resource plan than others; it might help them to estimate their projects based on real information.
5. With respect to the question of ''Risk register", the respondents were asked ''We study the risk register at cost estimate process'', from their answers, the analysis shows the mean was **3.74**, which is slightly higher than the mean average **(3)**, which refers that the respondents might have risk register. As well, the five structured interviews had confirmed the most firms didn't have risk register formally; the firms could develop a proper risk register.
6. With respect to the question of ''Enterprise environmental factors", the respondents were asked ''We study the Enterprise environmental factors at cost estimate

process'', from their answers, the analysis shows the mean was **4.00**, which is greater than the mean average **(3)**, which indicates that the respondents had knowledge about and could use enterprise environmental factors in their firms.

7. With respect to the question of ''Organizational process assets'', the respondents were asked ''we study the Organizational process assets (policies, templates, historical data, etc.) at cost estimate process'', from their answers, the analysis shows the mean was **3.37**, which is slightly higher than the mean average **(3)**. It means that the respondents didn't have various organisational process assets that could be used; organisational process assets also might be inactive in policies of top management.

From the above discussion, the mean of scale "Base estimate" was **3.62**, which is slightly higher than the mean average **(3)**. As well, the hypothesis "Base estimate has a positive effect on final detailed cost" was supported statistically by questionnaire survey data, which concludes that base estimate has direct effect on detailed estimate; it is a ground base for estimators. The good preparation of bases the good quality of estimate, further, the structured interviews supported the good preparation in this stage would be led to **75%** of success estimate. Furthermore, this finding was supported by the Leng's study results (Leng, 2005), that showed the base estimate (review documents) mean was **4.6**, which is greater than the mean of this study. This indicates the base estimate definitely affects the detailed cost estimate.

The next scale, which is the eleventh, **Measurements**, there were three questions that respondents were asked according to:

1. With respect to the question of ''Project items quantities'', the respondents were asked ''we measure all the items' quantities of construction project'', from their answers, the analysis shows the mean was **4.61**, which is greater than the mean average **(3)**, which means that the respondents measured the quantity of their projects. The measurement might be familiar for most of the respondents as well as it is a basic of calculation the quantities.
2. With respect to the question of "Jobsite Overhead", the respondents were asked ''we measure and determine the jobsite overheads'', from their answers, the analysis shows the mean was **4.14**, which is greater than the mean average **(3)**. It refers that the respondents took into account the job site overheads quantity and activities that might formulate a dangerous cost that couldn't be ignoring in the estimate. A finding of Al-shanti's study (Al-shanti, 2003), indicates that all respondents measured the

site overheads in their projects without any exception; this finding supports the importance of measuring the jobsite overheads.

3. With respect to the question of ‘‘Surety bonds, insurance, and taxes”, the respondents were asked ‘‘we determine the surety bonds, insurance, and taxes’’, from their answers, the analysis shows the mean was **3.87**, which is slightly higher than the mean average **(3)**. It means that the respondents mightn’t determine the surety bond, insurance, and the taxes; they might be delegated to the administration staff. This could lead to ambiguous in calculation that might make losses according to the gap between the two groups of estimators.

From the above discussion, the mean of scale “Measurements” was **4.20**, which is grater higher than the mean average **(3)**. As well, the two hypotheses “Correct way of measurements has a positive effect on final detailed cost” and “Measurements has a positive effect on pricing process” were confirmed statistically, which conclude the implement a correct way of measurements definitely affect the process of estimate with positively manner. More important advice by the structured interview, that the engineers should be able to measure various cases of projects to enhance their practices. In addition, the correct measures lead to the right pricing; many incorrect measure would reach the destination of failure due to mistake of pricing. This finding is also confirmed by the Leng’s results (Leng, 2005), which the mean was **4.65**; that indicates the measurements really is effective variable on detailed cost estimate.

In scale twelve, **Query**, there were two questions that respondents were asked according to:

1. With respect to the question of ‘‘Site Visit”, the respondents were asked ‘‘we visit and investigate the site (access, topography, services, etc.)’’, from their answers, the analysis shows the mean was **4.46**, which is greater than the mean average **(3)**. It means that the respondents visit the site to study and prepare the important ambiguous questions; this step might affect the estimation and avoiding such losses that shouldn’t happen. This finding is almost congruent with Leng’s finding results (Leng, 2005), which was **3.82**; it is more evidence for visit site importance for cost estimate. Another evidence is going with this study finding was the finding of study that was done by Al-Shanti (2003); **95%** of his respondents confirmed that the site visit was necessary for estimating process.
2. With respect to the question of ‘‘The query list”, the respondents were asked ‘‘we prepare the query list with ambiguous issues and submit to consultant’’, from their answers, the analysis shows the mean was **4.30**, which is greater than the mean

average **(3)**. It means that the respondents knew how to make such query list to introduce to the consultant after reviewing all documents and visit the site. Furthermore, the structure interviews supported the data of questionnaire.

Therefore, the mean of scale "Query" was **3.62**, which is slightly higher than the mean average **(3)**. As well, the hypothesis "Query list has a positive effect on pricing process" was supported statistically by questionnaire survey data, which indicates that query process support the detailed estimate and helps the estimators to avoid a huge losses in order to price correctly. It is important to know the heart of firm is the estimator. The good practices the good estimate; thus, the firm should train and qualify their estimators not ignoring their development. It is meant that the firm which afraid to lose a few money and time to qualify their estimators, it has to face a huge unexpected losses due to its unqualified estimators. Therefore, it will be late just crying.

The following scale, which is scale thirteen, **Pricing**, there were four questions that respondents were asked according to:

1. With respect to the question of ‘‘Pricing construction equipment", the respondents were asked ‘‘we price all construction equipment (own or rent)’’, from their answers, the analysis shows the mean was **3.91**, which is greater than the mean average **(3)**. It means that the construction equipment were mostly priced. The most equipment was owned to the large firms than the small firms, which depended on the rent. Further, this gave a good practice for who estimate the cost as well as it refers that the respondents might implement practices for pricing private and rent.
2. With respect to the question of ‘‘Pricing construction project items", the respondents were asked ‘‘we price all construction projects' items’’, from their answers, the analysis shows the mean was **4.42**, which is greater than the mean average **(3)**, which indicates that the respondents had enough practice in pricing the construction project items. It might be necessary to price the all component of items such as labours, materials, and equipment. Al-Shanti (2003) supported this finding with **92%** of his study respondents' opinion confirmed pricing the entire item's components of construction works.
3. With respect to the question of ‘‘Pricing subcontractors' work", the respondents were asked ‘‘we price all subcontractors' works’’, from their answers, the analysis shows the mean was **3.42**, which is slightly higher than the mean average **(3)**. It indicates that the respondents didn't have enough practice to price the subcontractors works; most of the projects weren't large and could be implemented by one contractor. Thus,

it might be a key reason for fewer practices of the respondents to pricing subcontractor's works. It was supported by the structured interviews for insufficient practices.

4. With respect to the question of ‘‘Pricing general expenses”, the respondents were asked ‘‘we determine price for all general expenses’’, from their answers, the analysis shows the mean was **3.54**, which is slightly higher than the mean average **(3)**. It means that the respondents didn't know how to determine the price of general expenses which might be determined by the administration staff; this process repeated and ignoring the key estimators who should be involved and familiar with such processes. Structured interviews referred that there were slightly difficulties to price the general expenses that were ambiguous for many engineers as well as they insisted on the importance of it. Further, Al-shanti's study reached that all respondents pricing the general expenses; it is the most important in reality to avoid ignoring it in order to success the project.

In like manner, the mean of scale “Pricing” was **3.82**, which is slightly higher than the mean average **(3)**. As well, the hypothesis “Pricing process has a positive effect on management review's process” was confirmed statistically, which indicates that the correct pricing should affect the estimate process towards success; thus, management review should be taken a position to ensure the success. The time losses during the reviewing could be fewer, if the price was correct. Therefore, the right starts (pricing) leads to the right ends (management review). This finding was get a high mean of pricing scale by the Leng's study (Leng, 2005), which was **4.8** that concerns about the process of pricing; his finding strongly supports the finding of this study in order to show the importance of pricing for detailed cost estimate.

In scale fourteen, **Management review**, there was one question that respondents were asked according to:

1. With respect to the question of ‘‘Management review”, the respondents were asked ‘‘Our top managers review the estimate process’’, from their answers, the analysis shows the mean was **4.10**, which is greater than the mean average **(3)**, which indicates that the reviewing process was done by the management staff who had experience in estimate projects. This could ensure avoiding errors even minimum of them that could happen.

In addition, the mean of scale “Management review” was **4.10**, which is greater than the mean average **(3)**. As well, the hypothesis “Management review's process has a positive effect on bid summary" was supported statistically with questionnaire data, which indicates that the respondents were aware about the management review that might lead to perfect bid summary, which may lead to successful bid. It can be said, the management review can tie the neck of bottle (check the estimate process) in order to close it (bid summary). As well, Leng's finding study confirmed the role of top management to decide the mark-up; which indicates the necessary of involving the top management to review the estimate process. Therefore, Leng's finding supports this study finding indirectly.

The following scale, which is scale fifteen, **Bid summary**, there was one question that respondents were asked according to:

1. With respect to the question of ''Bid summary", the respondents were asked ''We summarise the cost estimate process for bidding'', from their answers, the analysis shows the mean was **4.32**, which is greater than the mean average **(3)**, which refers that the bid summary was done by the respondents in their firms. This might help the firm to catch the dead time of bidding before close it; bid summary have to be prepared at least one day before closing to ensure bidding at time.

Nonetheless, the mean of scale "Bid summary" was **4.32**, which is greater than the mean average **(3)**; the hypothesis "Bid summary has a positive effect on final detailed cost" wasn't supported statistically with questionnaire data, which indicates that the bid summary represent a final result whatever the result of final detailed cost. This was supported by the structured interviews; therefore, it is logically to be not confirmed.

The final scale, which is scale sixteen, **Final detailed cost**, there was one question that respondents were asked according to:

1. With respect to the question of ''Final detailed cost", the respondents were asked ''There is no difference between the estimation and the final cost of our projects'', from their answers, the analysis shows the mean was **3.45**, which is slightly higher than the mean average **(3)**. It indicates that the estimate of their projects weren't perfectly equalled the final cost. It might be not much of projects' final cost consistent with their estimates.

In final scale, the mean of scale "Final detailed cost" was **4.45**, which is greater than the mean average **(3)** as well as this is absolute dependent variable. It is a destination of qualitative model; all the processes, efforts, knowledge, and experience fall into this destination in term of success or failure.

Furthermore, the KCE is also independent variable in qualitative model; it had four hypotheses that were proposed depending on the KCE variable. The following three hypotheses "knowledge of construction cost estimate has a positive effect on base estimate", "knowledge of construction cost estimate has a positive effect on measurements", and "knowledge of construction cost estimate has a positive effect on pricing" were confirmed. They indicate that the KCE is representing a core of the three variables (Base estimate, measurements, and pricing); it was also supported by the structured interviews. A true Knowledge formulates the three variables towards a perfect output. Thus, the bad knowledge definitely yields a bad output. Most of cost estimate models didn't mention the knowledge variable and ignoring the heart of estimators that might lead them to repeated failures. This model represents a value added to the science of construction management.

The fourth hypothesis "knowledge of construction cost estimate has a positive effect on final detailed cost" wasn't confirmed, which is concluded that the KCE doesn't affect the final detailed estimated; because, the final detailed cost is a juice of the last knowledge's fruits that have extracted from other independent variables.

Of prime importance, additional path from the KCE to the management review was suggested by the AMOS programme. This path indicates that the KCE has a positive effect on the management review; it was discussed before, the management review should be done by the experienced estimators. As well, the structured interviews were insisted that the experienced estimators should be the management review's staff. Thus, this path didn't conflict with the theory of study; and supported the theory of study as well as had made that the model was best fit to the data in this study statistically.

More important issue, most of contractors used a unit price within a specific range of project variables. This range sometimes does not fit specific project due many variable and risks; thus, qualitative model should be the contractors' guide to perform the estimation to fit the circumstances.

6.8 Quantitative Model (ANN) Formulation

The sophisticated application programmes have been spread due to the impressive technology in most sectors of life; in prediction process, there are many useful programmes, which are used in many fields such as economics, construction, industries, etc. There are many application programmes use ANN technique for forecasting such as MATLAB, SPSS, and NeuroSolution.

In this study, the NeuroSolution 6 was used to build the quantitative model (ANN), in like manner many researchers built their ANN model using NeuroSolution programme which gives a good performance and output such as (Shehatto, 2013; Edara, 2003; Gunaydın & Dogan, 2004; Bouabaz & Hamami, 2008; Dowler, 2008; Attal, 2010; Wang, et al., 2012). In specific, NeuroSolution 6 for Excel was used to build the ANN model; it is easier and flexible in use in both training and testing execution.

6.8.1 Constraints of model in ANN

According to use the historical data in ANN to estimate the cost, this dependency has defect, although the accuracy of ANN in estimation, this defect has some disadvantages, which are:

1- The inputs of variables are limited according to collected data.
2- Sufficient projects should be available for each variable.
3- Any new variable which doesn't belong to adopted model will not be handled (Shehatto, 2013).

From the last points and after applying on this study, the most variables in Yemeni's construction field belonged to ANN model except that didn't have enough frequency in collected data. The variables which had limitations in their inputs, for instance, the type of foundation was only pad type for all 136 collected projects; thus, this variable was excluded from the analysis and considering one of the model's parameters implicitly[1]. In addition, the variable (No. of elevators) didn't appear any collected data for 136 projects which led that this variable was excluded from the ANN model, see section (5.4.5.2).

Therefore, the limitations in ANN model can be summarised according to the inputs of the variable; when the input was only one for all the cases (136 projects), the variable should be exclude from the analysis but still in the ANN model implicitly. On the other hand, any inputs didn't appear in collected data; these inputs excluded from the variable's inputs choice and the variable still in ANN analysis, in which be shown clearly in the following table (6.9).

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[1] NeuroSolution 6 application always gives notifications when the inputs of variables only one input for all cases to indicate this variable can be excluded from the ANN model in which doesn't affect the process of ANN output.

Table 6.9 shows the variable constraints

variable	Excluded input	Implicitly in ANN model and excluded from analysing*	Remarks
Project type	Mosque	No	Only one input excluded
Project position	Desert	No	Only one input excluded
Type of foundation	Strip, raft, and pile	Yes	Only one recognised input for all projects
Interior decoration	Luxury	Yes	Only one recognised input for all projects
Type of external finishing	None, Aluminium cladding.	No	Only two inputs excluded
Type of HVAC	Central	No	Only one input excluded
Tiles type	Terrazzo, porcelain	no	Only two inputs excluded
Type of electricity works	Luxury	Yes	Only one recognised input for all projects
Type of mechanical works	Luxury	Yes	Only one recognised input for all projects
Basement	Exist	Yes	Only one recognised input for all projects

Source: cost form survey

*: This variable didn't analyse but belonged to ANN model implicitly.

6.8.2 Data encoding

The encoding was done according to the collected data and their constraints to perform the analysis of ANN by NeuroSolution 6. The table (6.10) shows the data encoding which was used in the ANN analysis. It must be remembered that there were also implicitly variables in ANN model according to above table (6.9).

Table 6.10 shows the data encoding

No.	Variable	Variable's inputs (encoding)	Code
1	Project type	Administration	1
		Commercial	2
		Educational	3
		Residential	4
		Health centre	5
2	Complex degree	Complex	1
		Normal	0
3	Site area	200-300m2	1
		301-400	2
		401-850	3
		851-1200	4
		1201-1350	5
		1351-1600	6
		1601-2050	7
		2051-2300	8
		2301-2750	9
		2751-11700	10
4	Project position	Mountain	1
		Costal	2
5	Floor area	100-200	1
		201-250	2
		251-300	3
		301-350-400	4
		401-500	5
		501-550	6
		>550	7
6	Storeys No.	From 1-4	1,2,3,4
7	Floor height	3m	1
		3.2m	2
		3.3m	3
		3.4m	4
		3.5m	5

No.	Variable	Variable’s inputs (encoding)	Code
8	Slab type	Drop beams	1
		hollow block	2
		Flat	3
9	Type of external finishing	Normal plaster	1
		Stones	2
10	Type of HVAC	None	1
		Window	2
		Split	3
11	Tiles type	Ceramic	1
		Granite	2

Source: data analysis by Author

6.8.3 Data set

In order to perform the analysis by NeuroSolution 6, the data should be set in groups according to the ANN technique requirements. Therefore, the data were divided into three sets namely; training set; cross-validation set; and test set. Generally speaking, the training set and cross-validation set are used to train the model through learning to modify the network weights in order to minimise the network error by monitoring this error by cross validation set at the training process. Moreover, separately, the test dataset is used after the finishing of training process; it is used to measure the generalisation of network as well as the network’s performance. The common ratios which are used to divided the data are 70% to train the network, 15% as cross-validation, and 15% to test the network. Consequently, this study was divided according to this common ratio; strictly speaking, the data were 136 projects, which were three sets as following:

- Training set was 96 exemplars representing 70%.
- Cross-validation set was 20 exemplars representing 15%.
- Test set was 20 exemplars representing 15%.

6.8.4 ANN model’s building

ANN model building should pass through clearly steps; after the data were prepared, the sequential steps were to create the initial network by choosing the type of network, number of hidden layers, transfer function, learning rule, and number of epochs. Thus, the multilayer perceptron (MLP) which was selected which consisted of inputs, hidden layer, sigmoid functions (transfer function), Back-propagation Learning rule and output, is the most common type used in cost estimate. To conduct the training phase, the normalisation of training data was recognised improving the training performance of network by NeuroSolution program.

6.8.5 ANN model training

In this study, the training was applied for 1000 epochs, which ran 10 times for each one of 1000 epochs. Therefore, the new weights were generated from first epoch and adjusting to minimise the percentage of error in other epochs. It is important, to avoid the overtraining, the cross-validation dataset was used in the training process to compute the error as the same time of the network training by the training dataset. The study's model was one hidden layer of (MLP) network type and one hidden node, which considers the simple architecture of ANN, in addition, the number of hidden process elements was growing up from 1 to 40 hidden nodes.

As can be seen in the table (6.11), the training was stooped in the 38 PEs at 3 runs when the minimum errors were achieved for both training and cross-validation datasets, in which were (**8.4×10^{-8}**) for training data and (**9×10^{-8}**) for cross-validation data in which they appear very smallest values.

Table 6.11 shows the training and cross-validation process

Best Networks	**Training**	**Cross Validation**
Hidden 1 PEs	38	38
Run #	3	3
Epoch #	1000	1000
Minimum MSE	8.42817×10^{-8}	9.00496×10^{-8}
Final MSE	8.42817×10^{-8}	9.00496×10^{-8}

Source: data analysis by Author

6.8.6 ANN model results

After ANN model training was run, the model also tested by test dataset to evaluate the performance of ANN model in order to check the training successful of ANN model. The data from twenty projects were used to comparing the actual costs with the estimated costs, which were obtained by ANN model. In table (6.12), the results of the testing process are shown clearly which refers to the best results with lowest values of errors.

Table 6.12 shows Results of testing process

Project No.	Actual cost ($)	estimated cost ($)	Absolute Error AE ($)	Absolute percentage error (%)	Squared error
1	400000	400634.31	634.316	0.15	402357.10
2	250000	249440.47	559.52	0.22	313071.26
3	250000	248918.22	1081.77	0.43	1170233.20
4	208744.12	208942.54	198.4217	0.09	39371.18
5	155579.24	155882.51	303.27	0.19	91973.04
6	261802.8	261795.50	7.30	0.002	53.29
7	117077.44	117158.20	80.76	0.06	6522.57
8	189822	189736.54	85.45	0.04	7302.00
9	167441.86	167382.90	58.95	0.03	3475.50
10	151325.85	151328.98	3.13	0.002	9.82
11	198919.56	195229.21	3690.34	1.85	13618624.76
12	204249.5	206367.85	2118.35	1.03	4487406.60
13	183125	182953.08	171.91	0.09	29555.42
14	429534.88	429660.27	125.39	0.02	15723.40
15	175595.73	178272.12	2676.39	1.52	7163077.47
16	5703400	5703451.68	51.68	0.0009	2671.13
17	334883.72	334586.76	296.95	0.08	88180.27
18	400000	400634.31	634.31	0.15	402357.10
19	250000	249440.47	559.52	0.22	313071.26
20	250000	248918.22	1081.77	0.43	1170233.20
Mean	**514075.08**		**720.97**	**0.14**	**1466263.48**

Source: data analysis by Author

In table (6.13), the Mean Absolute error (MAE) is (**720.79 $**) which refers that it is acceptable amount comparing to the total cost of projects. Although, it isn't a significant indicators; it can’t provide overview about the performance of the ANN model, where the MAE may small if the project’s cost is large; or it may be large if the project’s cost is small.

Therefore, the Mean Absolute Percentage Error (MAPE) was (**0.14%**) which is less than 1 per cent indicating that the efficient of the ANN model to predict the cost is accurately and effectively with smallest errors. Also, according to Shehatto (2013), it can be shown as accuracy performance (AP) as following:

AP= 100- MAPE

AP =100 - 0.14= **99.86%**; this value refers that the network’s accuracy is **99.86%**, so the ANN model is optimum for predicting the cost estimate in Yemen with highly accurate. Therefore, the use MAPE can provide overview about the performance of ANN model.

Furthermore, the difference between the output (estimated cost) and the desired output (actual cost) of the network is called error and can be measured in different ways. Thus, the most common measurement is mean squared error and the root mean squared error, which is the root square of mean squared error, which can provide with the true value of the errors’ mean. In this study, the RMSR was (**1210.89)** which is small comparing to the total project cost which indicating that the model is a perfect to predict the cost, therefore, RMSR points out the performance of ANN to predict the construction cost in Yemen with highly potential of accuracy.

Another evidence of fit model for estimate accurately cost in Yemen was RMSE/ Actual cost mean which was to test the performance of the neural network. In this research, the RMSE/ Actual cost mean was (**2.35×10^{-4}**) which is almost equal zero, indicating the smallest error comparing to the mean, so the ANN model is a perfect model.
As well, the two values of absolute minimum and maximum errors are mentioned in table (6.13); these two values indicate that the Min. value (**3.3**) is very smallest value and the Max. (**3690.34**) is also small value comparing to the total price of the project or the mean of actual cost which is (**514075.08**), interestingly, these values is reliable evidence about efficiency of the ANN model which can be widely used to estimate the construction projects cost in Yemen.
Nonetheless, the correlation coefficient is also considered another test of model performance. The R value was (**0.999**) which indicates there is a strong linear correlation between the actual cost and the estimated cost in the test phase.

Table 6.13 shows ANN performance results

Model’s Performance	F. cost
Mean Absolute Error (MAE)	720.97($)
Mean Absolute Percentage Error (MAPE)	0.14%
Mean squared error (MSE)	1466263.48 ($)
Root mean squared error (RMSE)	1210.89 ($)
RMSE/ Actual cost mean	$2.35\times10^{-4} \approx 0$
Min. Abs Error	3.13 ($)
Max. Abs Error	3690.34($)
R	0.999

Source: data analysis by Author

In figure (6.7), the actual cost and estimated cost were almost consistent in this ANN model, which is considered the best result of model can be got in ANN models and can be used to estimate cost in Yemen with highly potential of accuracy.

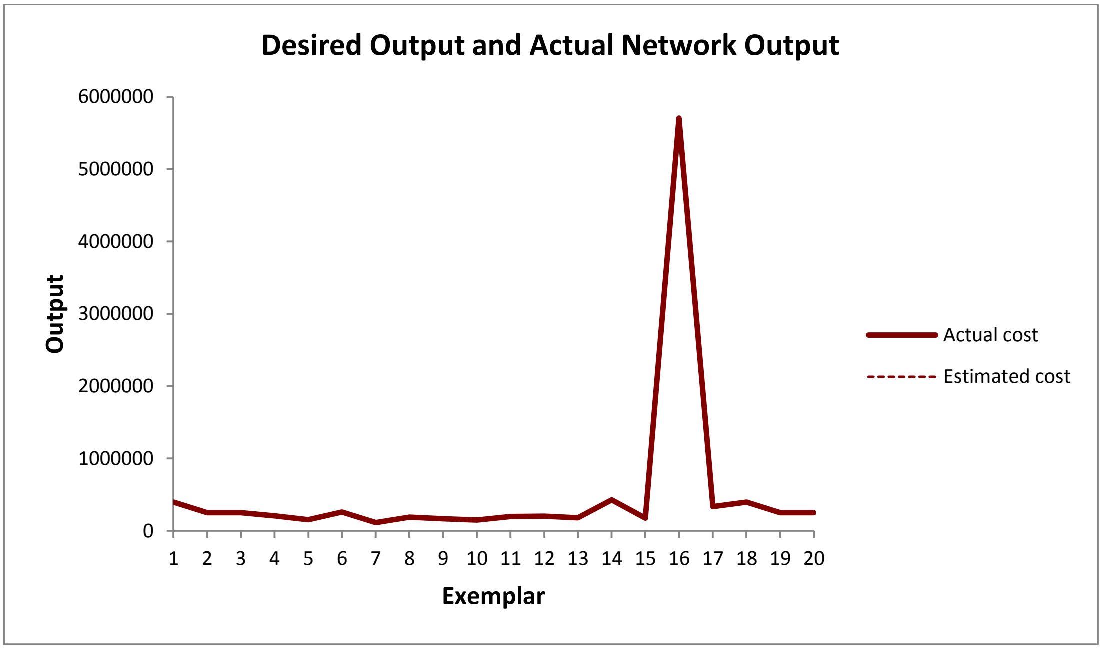


Figure 6.7 Desired output and actual network output, Author.

6.8.7 Sensitivity analysis

In table (6.14) and figure (6.8), the results of sensitivity analysis, which was reported by NeuroSolution 6 in order to measure the influences of each input in ANN model to its output in order to evaluate the important and significant variables which affect the ANN model. These values were represented the standard deviation (+/-) about the mean. It can be seen the input variable (tiles type = **154752.86**) was the largest value which indicates that there is a large significant influences on the cost estimated (output) as well as the input variable (complex degree = **104568.84**) was also a very significant influences on the output, which means any changes in those two parameters can affect the cost (output). In contrasts, the variables (HVAC & Project type) was the lowest values of impact on the cost which indicates that there are slightly significant influences on the output (estimated cost) if they might change. Other input variables had gradual moderate influences on the output as mentioned in the table (6.14).

Table 6.14 shows Results of sensitivity analysis about mean.

Sensitivity	**F. cost**
Tiles Type	154752.86
Complex degree	104568.84
Position	46591.92
Floors height	45964.03
slab type	43489.83
External finishing	36103.83
Site area	34666.41
Storeys No.	24640.64
Floor Area	24285.11
Project type	15797.79
HVAC	7443.78

Source: data analysis by Author

6.9 Hypothesis Test

The SPSS programme tested the ninth hypothesis; the Pearson correlation test was used, where a significant level was 0.05. The hypothesis was "Preliminary estimate has a significant correlation with the final detailed cost", after the test was done, the null hypothesis rejected; the significant level was 0.001 less than 0.05. Therefore, the hypothesis was accepted and there was significant correlation, see table (6.15).

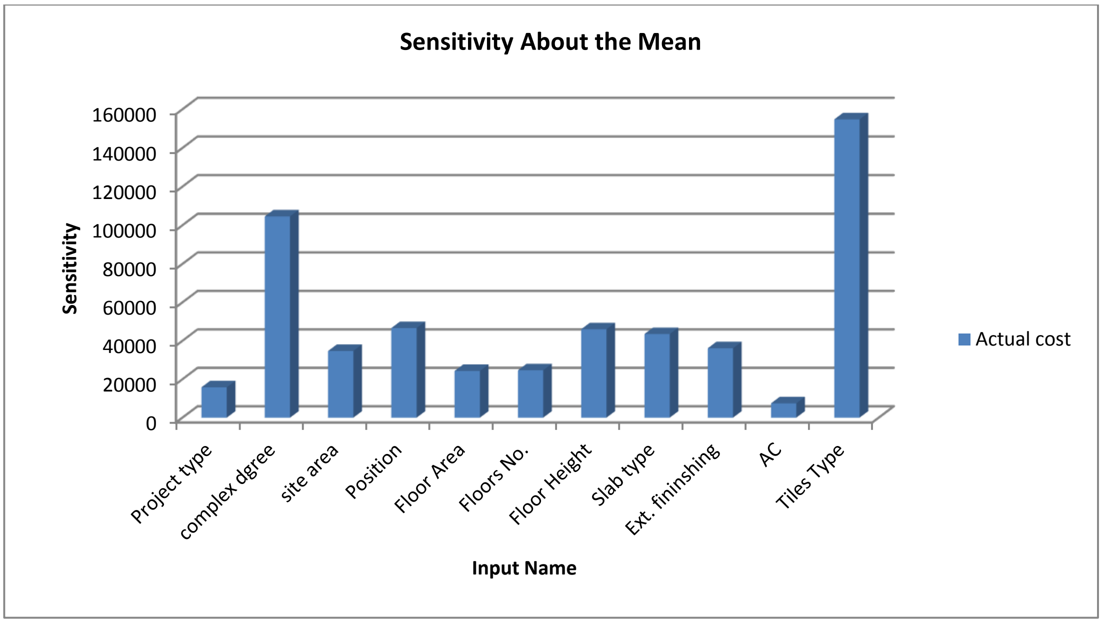


Figure 6.8 Sensitivity analysis about mean, Author.

Table 6.15 shows H_0 Pearson correlation test.

Hypothesis	Preliminary estimate	final detailed cost	**Pearson correlation**
Pearson correlation	1	0.39	**0.39**
Sig.(2-tailed)	0.001	0.001	

Source: data analysis by Author

6.10 Results' Interpretation

In appendix (4), the results of analysis factors of scales were set for this section of preliminary estimate (Quantitative model) that contains one scale as well as the test result of Quantitative cost estimate model.

In scale ten, **Preliminary estimate**, there were twenty questions that respondents were asked according to:

1. With respect to the question of ''Traditional Cost Estimation'', the respondents were asked ''we use the traditional estimate methods (square meter price-cube meter, etc.) to estimate cost at early stage'', from their answers, the analysis shows the mean was **4.34**, which is greater than the mean average **(3)**. It indicates that the traditional methods, especially, meter square unit was common in Yemeni's construction field.

The preliminary estimate was divided into three classifications according to the quality of project; i.e. every square meter had three prices according to the quality.

2. With respect to the question of ‘‘Analogical cost estimation techniques”, the respondents were asked ‘‘we use analogical cost estimate technique’’, from their answers, the analysis shows the mean was **3.13**, which is slightly higher than the mean average **(3)**. It deduces that the respondents sometimes used the analogical estimate that depends on the experience of expert and the similarity of projects.
3. With respect to the question of ‘‘Fuzzy logic systems”, the respondents were asked ‘‘We use Fuzzy logic systems’’, from their answers, the analysis shows the mean was **2.62**, which is slightly less than the mean average **(3)**, which indicates that respondents didn’t know the technique of fuzzy logic, which is considered from the intelligent techniques that are used in industries.
4. With respect to the question of ‘‘Parametric estimating models”, the respondents were asked ‘‘We use Parametric estimating models’’, from their answers, the analysis shows the mean was **2.90**, which is slightly less than the mean average **(3)**, which indicates that the respondents had many confusing about this terminology. As well, the structured interviews had the same confuse, after that, the parametric was explained to them by the author; then it was clear.
5. With respect to the question of ‘‘Artificial Neural Network”, the respondents were asked ‘‘We use Artificial Neural Network’’, from their answers, the analysis shows the mean was **2.33**, which is slightly less than the mean average **(3)**, which means that the respondents mightn’t heard about this technique; which is intelligent technique can be used for prediction. Thus, it might also be a new terminology in their construction knowledge.
6. With respect to the question of ‘‘Complexity”, the respondents were asked ‘‘At preliminary estimate, the complexity is very important factor’’, from their answers, the analysis shows the mean was **4.13**, which is greater than the mean average **(3)**, which refers that the respondents valued the importance of complexity in projects. It might affect the preliminary estimate when ignoring the complexity.
7. With respect to the question of ‘‘Project type”, the respondents were asked ‘‘At preliminary estimate, the project type is very important factor’’, from their answers, the analysis shows the mean was **4.14**, which is greater than the mean average **(3)**, which indicates that the respondents focused on the type of project as a factor could affect their preliminary estimate. This finding’s mean is higher than the Shehatto’s

finding mean (Shehatto, 2013), which was **3.70**; thus, this study provides more evidence about importance of project type in preliminary estimate.

8. With respect to the question of ‘‘Floor area”, the respondents were asked ‘‘At preliminary estimate, the floor area is very important factor’’, from their answers, the analysis shows the mean was **4.42**, which is greater than the mean average **(3)**, which indicates that the respondents also saw the floor area was the important key in preliminary estimate. As well, the finding is congruent with Shehatto’s finding mean (Shehatto, 2013), which was **4.50**; it gives more assurance for floor area variable to be involved into preliminary estimate model.
9. With respect to the question of ‘‘Storeys No.”, the respondents were asked ‘‘At preliminary estimate, the No. of storeys is very important factor’’, from their answers, the analysis shows the mean was **4.53**, which is greater than the mean average **(3)**, which indicates that the storeys No. was agreed by the respondents for its importance for preliminary estimate. As comparing to Shehatoo’s finding mean (Shehatto, 2013), which was **4.50**; finding of this study confirms what Shehatoo reached to.
10. With respect to the question of ‘‘Type of foundation”, the respondents were asked ‘‘At preliminary estimate, the type of foundation is very important factor’’, from their answers, the analysis shows the mean was **4.63**, which is greater than the mean average **(3)**, which concludes that the respondents also confirmed the importance of this factor.
11. With respect to the question of ‘‘Number of elevators”, the respondents were asked ‘‘At preliminary estimate, the No. of elevators is very important factor’’, from their answers, the analysis shows the mean was **4.20**, which is greater than the mean average **(3)**, which indicates that the No. of elevators could be used in preliminary estimate as important factor. This finding had mean of **3.60** in Shehatto’s study (Shehtto, 20.13), but, in this study was higher than Shehatto’s mean confirming the importance of this variable in preliminary estimate model. Although, this variable was eliminated from the main model of this study according to the collected projects that didn’t contained elevators; this doesn’t mean it is not necessary for preliminary estimate model.
12. With respect to the question of ‘‘Slab Type”, the respondents were asked ‘‘At preliminary estimate, the type of slabs is very important factor’’, from their answers, the analysis shows the mean was **4.27**, which is greater than the mean average **(3)**, which refers that the respondents decided that the slab type was important factor in

preliminary estimate. In addition, **3.50** was the mean of finding of Shehatto's study (Shehatto, 2013), which also refers to agree both studies about slab type variable in quantitative model.

13. With respect to the question of ''Type of external finishing", the respondents were asked ''At preliminary estimate, the type of external finishing is very important factor'', from their answers, the analysis shows the mean was **4.47**, which is greater than the mean average **(3)**. It indicates that the type of external finishing had summed most of respondents' opinion by its importance in preliminary estimate. For more evidence, the finding of study that was conducted by Shehatto (2013) with mean of **3.90** for external finishing (plastering); refers that the variable of external finishing could affect the preliminary estimate model.
14. With respect to the question of ''Interior decoration", the respondents were asked ''At preliminary estimate, the interior decoration is very important factor'', from their answers, the analysis shows the mean was **4.30**, which is greater than the mean average **(3)**, which indicates that the respondents agreed that this factor had importance in preliminary estimate.
15. With respect to the question of ''Type of HVAC system", the respondents were asked ''at preliminary estimate, the type of HVAC system is very important factor'', from their answers, the analysis shows the mean was **4.24**, which is greater than the mean average **(3)**. It means that the respondents did not refuse the importance of HVAC system in cost of preliminary estimate. This finding is supported by Shehatto's finding (Shehatto, 2013), which was mean of **3.80**, which is less than the finding of this study; thus, this study provides more assurance for importance of HVAC system variable.
16. With respect to the question of ''Tiles type", the respondents were asked ''At preliminary estimate, the type of tilling is very important factor'', from their answers, the analysis shows the mean was **3.97**, which is greater than the mean average **(3)**, which indicates that tiles type might strongly affect the cost of preliminary. Shehatto's study finding mean was **3.65**, which is almost congruent to this study finding giving more acceptable for this variable to belong in preliminary estimate model.
17. With respect to the question of ''Type of electricity works", the respondents were asked ''at preliminary estimate, the type of electricity works is very important factor'', from their answers, the analysis shows the mean was **4.06**, which is greater than the mean average **(3)**. It refers that type of electricity works had also been agreed

by the respondents in terms of its importance for preliminary estimate. The mean of this study is greater than the Shehatto's mean study (Shehatoo, 2013), which was **3.60.** It offers more certainty about the electricity works; this variable could affect the preliminary estimate. Although, all collected projects were basic type; so this variable was deleted from the analysis, but it was considered implicit in the model of this study.

18. With respect to the question of ''Type of mechanical works", the respondents were asked ''at preliminary estimate, the type of mechanical works is very important factor'', from their answers, the analysis shows the mean was **3.97**, which is greater than the mean average **(3)**. It indicates that the respondents might have knowledge about mechanical works and its importance in preliminary estimate as factor. As it can be seen to the comparison between this study finding and Shehatto's study mean finding (Shehatto, 2013), which was **3.65**, is slightly less than the mean of this study. It confirms the importance of the mechanical variables in preliminary estimate model. This variable was eliminated from the analysis of this study according to the same reasons for the electricity works and was implicit in the preliminary estimate model for this study.
19. With respect to the question of ''Floor height", the respondents were asked ''at preliminary estimate, the floor height is very important factor'', from their answers, the analysis shows the mean was **3.89**, which is slightly higher than the mean average **(3)**. It indicates that floor height was confirmed by the respondents in terms of its importance for the preliminary estimate model.
20. With respect to the question of "Site area", the respondents were asked ''At preliminary estimate, the site area is very important factor'', from their answers, the analysis shows the mean was **4.36**, which is greater than the mean average **(3)**, which concludes that the respondents didn't ignore the site area as important key in preliminary estimate.

From the above interpretation, the mean of scale "Preliminary estimate" was **3.76**, which is slightly higher than the mean average (**3**). As well, the hypothesis "Preliminary estimate has a significant correlation with the final detailed cost" was confirmed statistically by questionnaire survey data, which concludes that there was a significant correlation between the preliminary estimate and final detailed estimate. The preliminary estimate (quantitative model) can be used to evaluate the qualitative model too. For the efficiency of this study, the Mean Absolute Percentage Error (MAPE) was (**0.14%**) as well as the Shehatto's model MAPE was **6%,** in addition, the accuracy performance (AP) of this study model was **99.86%**

and Shehatto's model accuracy performance (AP) was **94%.** Furthermore, the correlation coefficient of this study was **0.999** and Shehatto's model was **0.995.** From the last comparisons, the model of this study has large values of test analysis than Shehatto's model, which indicates the model of this study is more powerful to estimate the preliminary cost.

In sensitivity analysis, the largest value was for tiles type, whereas, in Shehatto's model was the area of floor. This contrary might be according to the importing of tiles from out of Yemen. On the other hand, the lowest value was for HVAC system, whereas, in Shehatto's model was tiles type. This contrary might be the HVAC system in the collected projects were window type or none; whereas, the tile type in Shehatto's model might be caused according to use on type of tile. On the positive side, the correlation coefficient of regression model that was obtained by Arab (2011), which was **0.608** of his predicted cost model; it was smaller than the correlation of this study indicating the artificial neural network's model of this study is more efficiency than the regression model of Arab's study. More evidence was obtained by the Attal (2010), that his study shows that the Artificial neural network model is better than the regression model; the R of ANN was **0.98** and the R of regression model was **0.94**.

Of prime importance, this study enters a new method of estimate that uses the artificial intelligence "Artificial Neural Network" in Yemen. As well, the Quantitative model is used alone in construction cost estimate by the researchers. Instead of that, another value added in this research for the construction management science, is to combine the quantitative model for early stage with qualitative model for tender stage. Those models cover the requirements of clients, consultants, and contractors.

6.11 Summary

This chapter discussed the qualitative model analysis for both KCE and detailed cost estimate, using structure equation modelling technique, which was the best technique in modelling than the other techniques such as multiple regressions. In addition, two hypotheses weren't confirmed according to SEM and some covariance relationships was proposed by AMOS in order to improve the model M1 to model M2 with not confliction with the theory of study and reality. KCE model was improved its indices from model M1 to model M2, which had become good fit for data. After that, the results of analysis were discussed and interpreted from the author's point of view, which combined with the structural interviewee's opinions and results of previous studies. In addition, the quantitative model was also analysed by SEM technique passing through improvement from model M3 to model M4. In order to improve the model to model M4, two hypotheses weren't confirmed and the hypothesis H14 which wasn't confirmed in model M3 was confirmed in model M4, therefore, these confirmed and unconfirmed hypotheses in model M4 weren't conflicted with the theory of study, in contrast, they were more logic for the theory and reality. Further, additional path (causal and effect) was supposed by AMOS, which also wasn't conflicted with theory and reality as well as some covariance relationships were also supposed and didn't conflict with the theory of study and reality. After that, the quantitative model was more capable to fit the data. The results' interpretations were done according to findings of questionnaires and structural interviewee, which combined with results of previous studies.

The analysis of ANN model was done by Neurosolution programme 6; the constraints of model, data encoding, data set, and building the model were performed accurately. Then, the training was done showing the perfect results that referred that the model was trained perfectly and had ability to predict. In order to check the ability of the model for prediction, the test was done and the error of estimation was less than 1%, which concluded that the model could estimate the cost accurately. After that, the sensitivity analysis appeared the important variables, which could affect the output of model when they might change. One hypothesis was checked and confirmed as well as the interpretations of questionnaires results and model analyse were discussed. Finally, the second objective of this study was confirmed and the third question was answered.

CHAPTER VII: MODEL DEVLOPEMENT AND CASE STUDY

7.1 Introduction

This chapter represents the model development that focuses on the knowledge of cost estimate model's variables and the detailed cost estimate model's variables. These variables are discussed from wide view of knowledge supported with examples, researchers' opinion, and suggestions in order to establish a solid base knowledge for estimators. After that, the evaluation of firm's (case study) capability to estimate describes how to determine the weakness areas of firm by the evaluation tool, which is designed according to the practices and knowledge. As well, the improvement plan is discussed. Then, section (7.5) provides the case study importance and its procedures as well as the firm's description. The current situation of firm is debated; thus, the improvement plan is formulated with the relevant persons into two stages. Stage 1 and 2 of improvement plan explains what issues should be discussed and how to perform the quantitative model and qualitative model practically. Finally, the summary is described briefly this chapter.

7.2 Basics of Model Development

The situation of construction firms in Yemen regarding the cost estimate based on the experiences frequency, which is obtained from the field and from the historical data. Most inaccurate estimations were caused according to the lack of principle of cost estimate; i.e. the knowledge of cost estimate which have to be learned and practiced from the study stage extent to the practices in the field. In this study, the first qualitative model concerned about the knowledge of cost estimate (KCE) which contained the most terminology and techniques in the cost field. In addition, the (KCE) had added to the detailed model as a qualitative model as well as artificial neural network (ANN) was considered as the quantitative model. Nonetheless, the detailed estimate depends on the estimators himself to prepare the estimation as well as contains the most variables to estimate the project cost. Further, this model's variables have also the knowledge of preliminary estimate; i.e. how to estimate the projects by traditional methods such as square meter, cubic meter that are considered the basic calculation to measure some items of bill quantity in detailed estimate.

So, in this chapter, the focusing on qualitative model was to enhance the practices of the qualitative model. This model gives users a wide experience in cost estimate. Some advices and lessons, which were obtained from the structured interview, were seriously used to improve and develop the model, further, the literature review and the questionnaires findings were also considered in this development. In addition, the focus would be on the matters what should be explained by examples, discussion, or calculations in order to establish the ground base for estimate information. The development can be used to assist users to determine the strength and weakness in order to improve what area should be improved. Therefore, the detailed cost estimated model development consisted of the following:

- Knowledge of cost estimate,
- Base estimate
- Measurements
- The querying
- The pricing
- Management review
- Bid summary

7.2.1 Knowledge of cost estimate (KCE)

The KCE was discussed and detailed in chapter two; in addition, it was constructed from eight constructs, which were based on the hypotheses to formulate the KCE, but the social and economic system and cost control variables weren't confirmed in analysis, so they were eliminated. In addition, there were four hypotheses from the KCE affect four variables (base estimate, measurements, pricing, and management review) positively; which were confirmed.

In this chapter, the most practical matters should be taken in order to develop the ability of knowledge for estimators. Therefore, the other six constructs have a positive effect on KCE figure (7.1). This model was considered a ground base to improve the efficiency and effectively for engineers in cost estimate field.

According to the literature review and the structured review, some points should be discussed and focussed in order to improve the knowledge of cost estimate; these important matters would be explained in the following discussion.

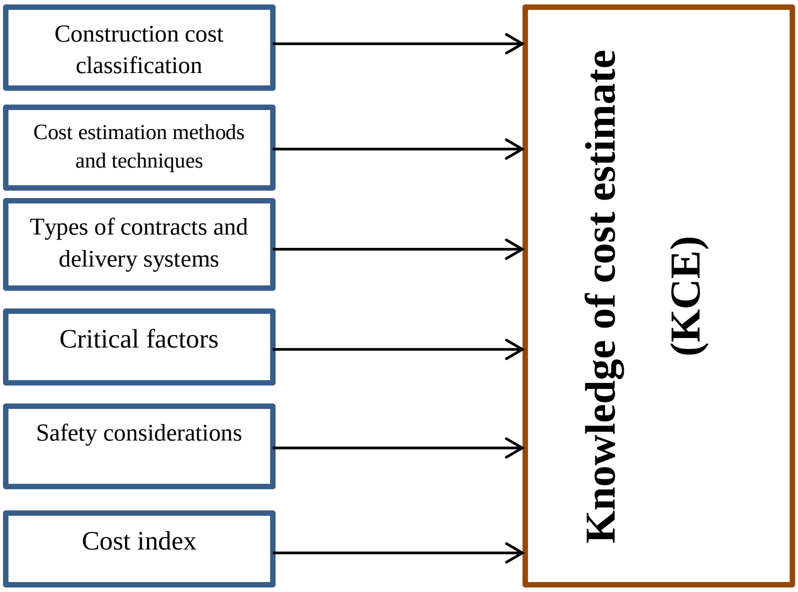


Figure 7.1 KCE model, Author

7.2.1.1 Construction cost classification

Ritz (1994) explained that the construction cost could be classified into direct and indirect cost. Direct cost is made up of labour, subcontractors, and materials which directly corporate to execute the project according to plan and specifications as well as defined in the scope of work. Thus, the direct cost forms the heart of detailed estimate. In the large project, this direct cost should be break down into sub-levels to match any site-specific works such as various buildings. In addition, Rad (2002) and Pratt (2011b) pointed out that the equipment cost[1] is a direct cost which directly inter in the execution of the project, so in this research the equipment cost is considered a direct cost. As well, the buying, travel, and salaries or renting equipment, which is used in the project are considered direct cost.

The indirect cost are a significant factor and also known overhead cost which are used for running the projects as well as considering the vital cost can affect the profit of the project when it is ignored. These indirect costs can be:

- Temporary site improvements;
- Field supervisory staff salaries, burdens, and fringes;
- Field office staff salaries, burdens, and fringes;
- Vacation;

[1] Ritz (1994) considers the equipment cost indirect cost, but the author agrees the other researcher who said that the equipment cost in construction projects is direct cost according to its relationship with project's execution.

- Sick leave;
- Training;
- Retirement benefits for the employees;
- Administrative support;
- Field office equipment and supplies;
- Site utility systems and bills;
- Site safety and security costs;
- Materials management and warehousing;
- Cost for small tools, supplies, and consumables;
- Staff relocation and living allowances;
- Communications lines and services;
- Building, utility, roads, etc. maintenance costs ;
- Scaffolding;
- Legal, bonds, and insurance fees;
- Labour and public relations costs;
- Laboratory, field testing, and inspection costs;
- Other miscellaneous field costs;
- Temporary heat, dewatering, and weather-related costs; and
- Government, OSHA, etc.

Furthermore, the type of work in construction field force the main contractor to delegate a specific works to subcontractors who commitment for the most indirect cost (Rad, 2002, Ritz, 1994).

7.2.1.2 Cost estimation methods and techniques

According to the purpose of this study, the five experts from the structured review have preferred to enhance the main subject of this study, which is cost estimate in preliminary stage and in tender stage, but the preliminary estimate was done by ANN technique depending on the NeuroSolution programme in which make it easy for the estimators. Therefore, in the preliminary estimate could only explain the traditional methods. Traditional methods are based on a cost per primary unit and can be used by the estimators such as for hospital the primary unit would be bed which is the No. of proposed beds multiplied by the bed's cost, school would be No. of pupils, and square meter or cubic meter of the building multiply by cost of meter.

Example:

If the area is 500 m^2, estimate the total cost of apartment if the unite price for luxury building is $500?

Solution:

We use the traditional method technique, which is unit price of m^2.

The luxury m^2 price= $ 500

Then the cost estimate is 500 m^2 × $ 500 = $ 250000.

The vital point is a detailed estimate technique which would be discussed wordiness; it can be called bottom-up estimate which can go from it, strictly speaking, the bottom-up technique is used to demonstrate the component of project into sub-levels in order to cost all the materials, activities, and labours or any other expenses.

7.2.1.3 Types of delivery systems and contracts

This was discussed in section (2.10), and other issues would be mentioned to provide a wide knowledge. The procurement method depends on the client expectations, then the contract form could be determine.

Client's needs

The needs of clients can belong to public or private sectors; the private sector includes commercials, socials, and professional organisation and the government department represent the public sector. Further, the experience of client can affect his/her expectations (Brook, 2008).

Important issues

The contracts were discussed in section (2.11) and for more knowledge; some important issues would be mentioned to be aware by the estimators.

The risk in lump-sum contract when the cost overruns occur for the material cost runs out the estimated cost, thus the contractor would pay extra cost. Therefore, the contractor should add contingency per cent to the tender. Some contractor adds a clause in their contract (escalation clause) to allow price increase than the original when the escalation occurs (Pratt, 2011a).

Bennett (2003) pointed out that the Design–Build Institute of America (1994) listed some benefits for lump-sum contract as the following; singular responsibility, quality, cost savings, time savings, potential for reduced administrative burden, early knowledge of firm costs, risk management, and balanced award criteria. In addition, Bennett (2003) stated also that the disadvantages are importance of the project brief, difficulty of establishing a price for the work, costly tendering, short tender periods, potential low quality, less control over subcontractor and consultant selection, and generally less control by the owner over both project definition and execution than design– tender–build projects.

Brook (2008) revealed some important points that should be taken by the package contractors in construction management delivery as the following:

1- The risk that is associated to the bill of quantity that should be prepared with all works needed to complete the package.
2- The need to complete elements of the design to the satisfaction of the architect;
3- Payment retentions may be kept for up to twelve months after the completion of the whole project;
4- Complex warranties for all contractors with design responsibilities.

Furthermore, Pratt (2011a) stated that the unit price contract appropriates when the uncertainty occurs about the works. As well, this type has two parts:

1- Prices per unit of measurement for the different types of work involved in the project, and
2- Measurement of the actual work completed.

The following example reveals the meaning of this issue;

If the excavations and backfilling 100 m^3 on the project; and the cost of 1m^3 excavation= \$15; the cost of 1m^3 backfilling =\$25

Then;

100 $m^3 \times \$15 = \$ 1500$ (for Excavations)

100 $m^3 \times \$ 25 = \$ 2500$ (for Backfilling)

Total = \$ 4000

7.2.1.4 Critical factors

In order to facility the factors, which affect directly or indirectly the cost estimate; the thirty factors were mentioned below, to be aware easily by the estimators as the following:

Degree of the complexity, site location, time of construction, project type, material cost, quality of the work, and management factors, which affect the process of estimate. As well, other factors were geographical consideration, insufficient time of estimate, inadequate specification, incomplete drawings, quality of project management, lack of historical cost data, technological requirements, project information, project team requirement, and contract requirement. Furthermore, these factors also were considered of 30 critical factors such as market requirement, political situation, financial status of the owner, escalation, tender currency, experience of consultant engineer, number of competitors, regulatory risks, inflation, availability of foreign currency and exchange rate changes, quantity Allowance, contingencies allowance, risk allowances, and fees.

7.2.1.5 Safety considerations

Gido and Clements (2009) mentioned that the contractor waiting to unfavourable accidents to happen, then the react would be taken leading to result in panic and costly responses. Furthermore, the most common approach to identify the accidents is a brainstorming that leads to the following questions (How many accidents should be identified?) as well as the historical information from past projects.

Bennett (2003) also stated that if the safety is ignored, then the project might be finished more quickly, and might be cost lower. However, unfortunately, construction industry has many hazards, which is considered higher than other industries. So, the knowledge of which accidents type are most frequently occur, helping the contractor to design the safety programme which also helps the estimator to estimate the cost of safety. The cost of accidents divided into direct and indirect cost. However, several ratios control the relationship between the indirect to direct cost such as 4:1 or 11:1 respectively. Therefore, direct cost is that reimbursed by workers' compensation or other insurance. However, the indirect cost is the other cost that affects the project budget due to injured worker, material, equipment's damage, the assistance from the other, and leading to low productivity. The most common construction site hazards are ladders, lifting equipment, openings, holes and platform edges, rigging, ropes and chains, scaffolding, trenches and other excavations, heavy equipment and trucks, machinery (woodworking, pipe fabrication, compaction), motor vehicles, hazardous substances (asbestos, carcinogens), littered workplace (debris, liquids, tools), electricity, fire (open flames, combustible liquids), welding and cutting, ice, snow and mud, and noise.

7.2.1.6 Cost index

Generally, cost index was discussed in section (2.15) as well as to enhance the knowledge for this technique, especially, it is not commonly used in Yemen; the examples should be discussed wordiness in order to cover all ambiguous matters that belong to the cost index. For more specific, the current or future cost of materials, plants, equipment, labours, or buildings is a problem to predict by the estimators; in addition, the prices vary from time to time according to the market condition and the general state of inflation; so, the cost index can help the estimators to estimate. Importantly, the cost index based on the present cost comparing to the cost history, in addition, it can't predict the future escalation which depends on the discretion of the individual estimator (Humphreys, 2004). Kirkham et al. (2015) pointed out that the cost index is "weapon of choice" which provides a sight into changes in the cost of an item or group of items from time to time in a determined point.

In sophisticated countries, there are many indices, which are published in many areas of industry, inversely; Yemen is considered a developing country, so there isn't any index that can be used to estimate the cost of building components. Otherwise, if we take a wide view on the index, it can be formulated by the firms itself as well as can be updated through the periods or every three to five years.

There are many limitation in used of index should be taken seriously as the following according to (Humphreys, 2004):

1- Accuracy limited; two indexes might produce two different answers.
2- Based on average values; thus, specific cases may be different from the average.
3- At best situation, accuracy might be limited by applying indexes over a 4 to 5 year period.
4- For time intervals more than 5 years, indexes are highly inaccurate and should be used for order-of-magnitude estimates only.
5- Due to rapid technology changes or other factors, the indices may be prepared periodically, but in such cases, index values before and after the date of the change may not be directly comparable.

Popescu et al. (2003) explained that the formula uses the ratio of two years indexes due to the following:

$$\text{Cost in Year A (Future Cost)} = \frac{\text{Index for Year A (Future)}}{\text{Index for Year B (Past)}} \times \text{Cost in Year B} \quad \text{Eq.}(7-1)$$

Tables (7.1) and (7.2) show example of used cost index and is supported by examples.

Table 7.1 shows Turner building cost index, 1976=100.

year	**Turner**	**Increased from the previous year (%)**
1980	273	0.0
1981	301	10.3
1982	325	8.0
1983	342	5.2
1984	360	5.3
1985	374	3.9
1986	384	2.7
1987	397	3.4
1988	412	3.8
1989	426	3.4
1990	441	3.5
1991	448	1.6
1992	450	0.4
1993	460	2.2
1994	467	1.5
1995	474	11.5
1996	505	6.5
1997	525	4.0
1998	549	4.6
1999	567	3.3
2000	592	4.4

Source: Turner

Table 7.2 shows Typical material price indexes, 1995 = 100.

	1994	1995	1996	1997	1998	1999	2000	2001
Sand and gravel	89	100	106	114	118	118	112	112
Cement	79	100	102	106	110	113	115	114
Common bricks	97	100	100	103	109	115	117	121
Hardwood	97	100	100	94	90	91	99	102
Softwood	94	100	93	96	90	88	87	86

Structural steel	98	100	99	100	101	102	103	104
Copper	82	100	100	116	111	72	79	80
Plastic	84	100	105	106	110	113	115	118
Sanitary ware	96	100	102	103	108	107	106	108
Insulation	95	100	106	108	106	106	105	105
Concrete tiles	99	100	100	103	114	125	129	130

Source: DTI Construction Annual, HMSO

For example:

We suppose the cost of building is $ 50 million in 1990, and could be estimated in market with index 1998, what the supposed cost is in 1998?

Solution:

By applying the EQ. (6-1), and from the table (6.1)

$$\text{Cost in Year A (Future Cost)} = \frac{\text{Index for Year A (Future)}}{\text{Index for Year B (Past)}} \times \text{Cost in Year B}$$

Where Index for 1998 (future) = 549;

Index for 1990 (past) = 441;

Cost in the past (1990) = $ 50 million;

Therefore, $\text{Cost in 1998} = \frac{549}{441} \times 50 = \$\ 62.24 \text{ million}$

Another example for determining the price of material from the table (7.2), If we suppose the cost of one bag cement in 1995= $ 10; what the supposed cost is in 2001?

The given information is:

Price of cement's bag in 1995= $10;

Index in 1995=100;

Index in 2001= 114;

Therefore, the cost of cement bag in 2001=

$$\text{Cost in 2001} = \frac{114}{100} \times 10 = \$\ 11.4$$

By the same token, Ashworth (2004) also stated that a building cost index can be one of the following:

1- The total construction costs of a building or a type of building;
2- An element (external walls) or trade (brickwork) within the building process; and
3- A single material, e.g. cement.

After discussion the last examples, it can be seen the structure of the indexes are very simple, in which the construction firms can construct a private index for itself which can be updated in the beginning of every year. It should also be checked the inflation when the estimate would be for the future index.

7.2.2 Base estimate

Of reviewing the result of the hypotheses, there were two hypotheses; one of them is "knowledge of construction cost estimate has a positive effect on base estimate" which was strongly confirmed in which the knowledge is the base of base estimate; thus, it should be mastered to apply it perfectly in the areas of estimate. Another one is "Base estimate has a positive effect on final detailed cost" which was also confirmed in which indicates the proper base estimate is definitely led to accurately detailed estimate.

After the contractor decided to bid, the study of documents; in which contains drawings, specification, form of the contract, scope baseline, resource calendars, project schedule, human resource plan, risk register, enterprise environment factors, and organisational process assets should be done.

7.2.2.1 Drawings

Del Pico (2012) stated that the completion drawings is called working drawings which are ready for bidding and also should be "set" and comply with all applicable building codes, including all information to prepare the estimate. As well, the set of working drawings should include architectural drawings, structural drawings in order to ensure structure will support impose loads, mechanical and electrical drawings to make the space habitable and functional, specialty drawings to show unique requirements for special part of space, and site drawings to ensure the relationship of structure to property. Furthermore, there are six formats of main drawings as the following:

- Plans
- Elevations
- Sections
- Details

- Schedules
- Diagrams

7.2.2.2 Specifications

It can be called “Specs” and it performs various functions, which are but not limited to:

1- Serving as the legal basis for the contract for construction,
2- Defining the quality or grade of materials to be used in the project,
3- Defining the acceptable workmanship or providing standards to judge workmanship,
4- Providing guidelines for resolving disputes between parties to the contract,
5- Providing a basis for accurately estimating cost, and
6- Complementing the graphic portion of the project

Further, project manual often refers to specs, which is a document attached to the drawings and contract in order to define how to bid, obligations of contract for the successful contractor, and the specification of the materials of the project. In addition, the sequence of the project manual can be as the following:

1. Invitation to bid (advertisement for bidders),
2. Instructions to bidders,
3. Bid (or proposal) forms,
4. Form of owner/contractor agreement,
5. Form of bid bond,
6. Forms of performance bonds,
7. General conditions of the contract,
8. Supplementary general conditions, and
9. Specifications (technical specifications).

Of prime importance, the construction specification institute (CSI) has a standard format which is called “MasterFormat” including 50 divisions (0 to 49) as well as each division is subdivided into specific area; for example, division 8 refers to openings (doors, windows, and skylights), while the subdivision 08 50 00 deals specifically with windows. Then, Subdivision 08 50 00 is divided as well as subdivision 08 51 00 deals with all types of metal windows. Furthermore, subdivision 08 51 00 is subdivided by type of metal window, with 08 51 13 dealing with aluminium windows; part of the first levels is shown in appendix (5) (Del Pico, 2012, Dagostino and Peterson, 2011).

7.2.2.3 Contract document

Dagostino and Peterson (2011) explained that the bid submission based on the contract documents, which helps the estimator to prepare the estimate accurately; thus, they should be known and familiar for the estimator. Furthermore, the contract documents are the owner-contractor agreement, the general conditions of the contract, the supplementary general conditions (Special condition), the working drawings, and specifications, including all addenda.

7.2.2.4 Scope baseline

Scope baseline includes the following as section (4.2.1.2) scope statement, WBS, and WBS dictionary.

Scope statement

In general, scope statement provides a description about business opportunity, a brief background of the project, the business objectives the project should get. According to the PMBOK Guide, the scope statement should contain the following:

1. Project objectives,
2. Product scope description,
3. Project deliverables,
4. Project requirements,
5. Project boundaries,
6. Product acceptance criteria,
7. Project constraints,
8. Project assumptions,
9. Initial project organisation,
10. Initial defined risks,
11. Schedule milestones,
12. Fund limitations,
13. Cost estimates,
14. Project configuration management requirements,
15. Project specifications, and
16. Approval requirements.

These last 16 criteria help the estimators to estimate the project cost accurately and fair judgement, the example of scope statement is shown in appendix (6) (Heldman, 2005, O'Conchuir, 2011).

Resource calendars

According to O'Conchuir (2011) and Heldman (2005) the resource calendar provides the availability of each resources (human, material, equipment) their skills, abilities, and quantity, for human the important dates should be mentioned such as weddings, absence for training, public holidays, courses, personal absence, pregnancy, summer holidays, military service, and festivals[1]. It should also provide the key people. The resource calendars also examine the capability, availability, and quantity of materials and equipment resources, which are supposed to affect the project.

In the planning stage, the detailed list of available resources even the resources from the outside should be provided by the project manager; thus, the initial resources are estimated correctly, the proportional cost of deliverables would be also estimated correctly. The technique of resource breakdown structure (RBS) helps to classify and catalogue the resources that are important for accomplishing the project's objectives. The RBS divides the resources into small units for planning, estimating, and managing, see figure (3.9). It contains the unit of measurement (M^2, M^3, and ML) and the cost of a single unit of the resources (e.g. $1000 for m^2). It can be seen the first level is composed of labours, tools and machinery, materials and installed equipment, and fees and licence. Importantly, the labour category often indicates to human resources that have to include skills grade, professional disciplines, and work functions. Tools and machinery are physical items that used to perform some activities by the project team and removed from the site such as (testing equipment, hand tools, and computers). In addition, installed equipment and materials are purchased for the project to be installed ultimately or embedded into the project such as furniture, tape drives, fibre-optic cables, monitoring equipment, pumps, ducts, and computers. Fees and licences which are represented those cost that required for the execution such as insurance policies, permit fees, bond agreements, license charges, and taxes. Also, the RBS can be tabulated and graphics, WBS and RBS can provide a good tools for manager to estimate accurately estimate; the WBS mapping onto RBS to assign the appropriate resource to the individual WBS elements, an example is mentioned in appendix (7) showing the WBS and RBS how to work together (Rad, 2002).

[1] Project manager who ignores these dates and constraints which would lead him to invite the troubles in the project.

Project schedule

Cost is impacted by the changes in duration and scope, so any changes in a schedule leads to changes in project expenditures and cost of the project (Rad, 2002), Del Pico (2012) mentioned that the schedule is used to estimate purposes in order to estimate the general requirements which are timeline due to occur the activities with their durations. The most common graphics for residential and commercial projects is the Bar graph, or Gantt chart. Otherwise, the complex project uses the Critical Path Method (CPM). As well, PMI (2008) informed that the project schedule can be presented graphically or in tabular form as Milestone charts, Bar charts, and Project schedule network diagrams (CPM), see figure (7.2).

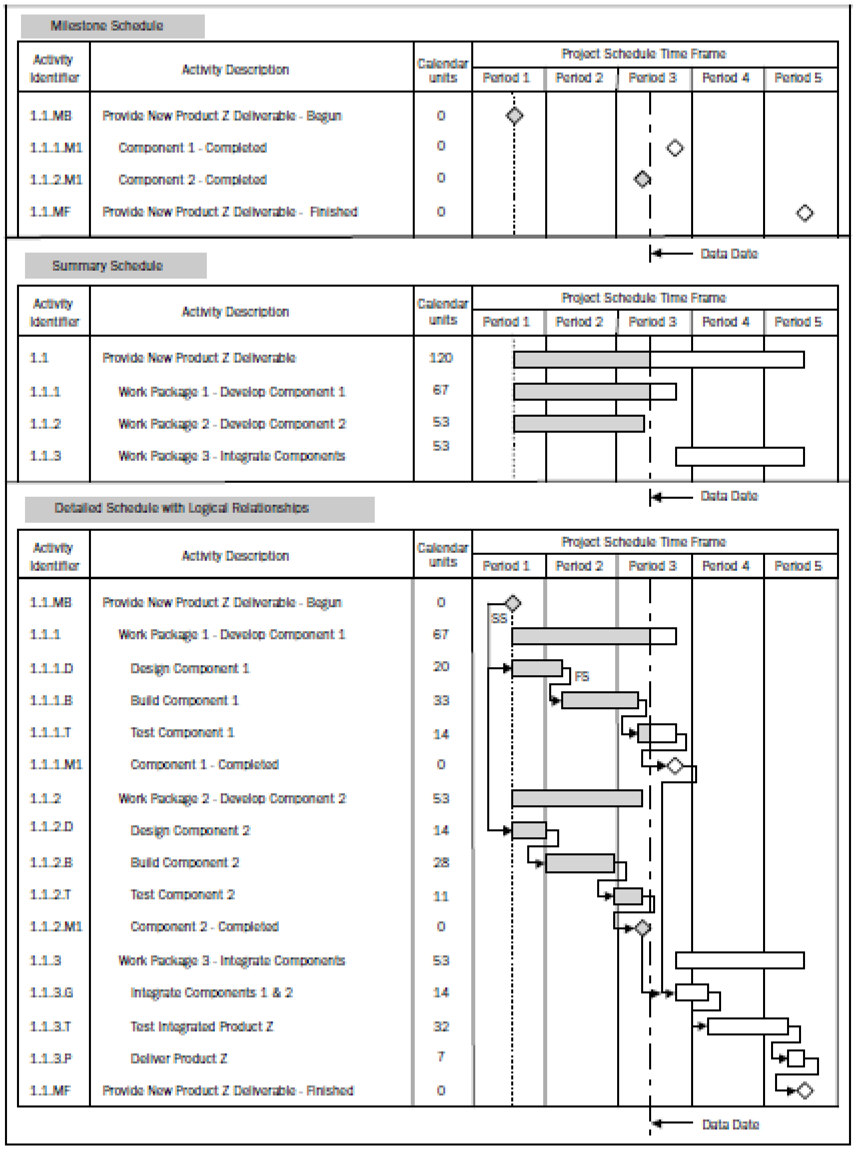


Figure 7.2 Project Schedule (Graphically), PMI (2008).

Human resource plan

Equally important, the human resource plan is considered a part of project management plan guiding the management about how the human resources are defined, staffed, managed, controlled, and released as well as include but not be limited to:

Roles and responsibilities that refer to the person who is accountable about execute a portion of project; thus, role, authority, responsibility, and competency should be clearly mentioned.

Project organisation charts is a graphical chart, which illustrates the project team hierarchy and their reporting relationships.

Staffing management plan provides when and how human resources will be met and concerning about how the staff acquisition (from inside the firm or out); resource calendar; staff release plan; training needs; recognition and rewards; compliance; and safety (PMI, 2008).

Risk register

O'Conchuir (2011) explained that the risk register could be database or spreadsheet. More explanation was given by PMI (2008), which revealed that the risk register contains list of identified risks, list of potential responses, relative ranking or priority list of project risks, risks grouped by categories, causes of risk or project areas requiring particular attention, list of risks requiring response in the near-term, list of risks for additional analysis and response, watchlists of low-priority risks, and trends in qualitative risk analysis results.

Enterprise environment factors

This terminology is not very popular for ordinary engineers who don't involve in construction project management, but recently is rapidly spread. O'Conchuir (2011) and PMI (2008) discussed wordiness the enterprise environment factors, which refers to everything about the firm either internal and external environmental factors that affect the project's success such as government and legislation; organisational culture, structure, and processes; infrastructure (e.g., existing facilities and capital equipment). In addition, the following factors are but not limited to existing human resources; personnel administration; company work authorisation systems; marketplace conditions; stakeholder risk tolerances; political climate; organisation's established communications channels; commercial databases; and project management information systems (e.g. scheduling software tool).

Organisational process assets

Organisational process assets are considered as an asset for the organisation or firm and can include but not limited to:

Formal and informal plans, policies, procedures, guidelines, organisation's knowledge bases, completed schedules, risk data, earned value data, standardised guidelines, work instructions. Further, proposal evaluation criteria, templates, organisation communication requirements, project closure guidelines or requirements, change control procedures, and risk control procedures can be also considered (O'Conchuir, 2011, PMI, 2008).

7.2.3 Measurements

A discussion was obtained about the hypotheses that are regards with the measurement in the previous chapter, which is "knowledge of construction cost estimate has a positive effect on measurements", "Correct way of measurements has a positive effect on final detailed cost", and "Measurements has a positive effect on pricing process". All of the hypotheses were confirmed which refer to the knowledge is very important part in the estimator personality in order to determine the measurements correctly and systemically; the second hypothesis gives a good idea when the measurements would be correct, then the final detailed cost result is positively affected by and in contrast is vice versa.

It is difficult to cover all matters regarding the measurements, so to solve this case the references were attached in the end of this study about estimate are recommended to be read by the estimators to enhance their knowledge and ability to estimate the construction projects avoiding the mistakes of estimate.

7.2.3.1 Quantities

Site work and excavation

This work has different from other work of construction because the bid information often furnishes a little detailed information about a specific requirements of site work, also regarding the foundation, the dimensions, and shape of the excavations required aren't disclosed. Thus, the site visit should be required to estimate the works of site proper. As well, the soil report can give value information about the site soil if the contractor can get it, which hasn't attached with bid documents. It should be taken attention for swell and compaction factors which are measured according to the excavation or filling; soil is extracted which leads to be less dense after excavation; so it will occupy more space than before; the difference between the volume of hole and the extracted soil is called swell factor see table (7.3). On the other hand, a similar adjustment method is used when the filling is required by the volume of the hole, but the compaction will dens the soil in which its volume would be increased the difference between the true volume of the hole and the surplus is called compaction factor table (7.4). Importantly, these two factors aren't used in the net quantity of the bill of quantity which would be bid to the client according to the bid document measurements; but can be used in pricing the items of bid. Furthermore, the potential of danger to workers regards the trenches and their sides should be taken into consideration of measurement (Pratt, 2011b, Pratt, 2011a).

Excavation support can't be ignored in estimate to adjust the side slopes in purpose to provide safety; the type of soil, water table's elevation, excavation depth, and existing structures. As well, cost and time of execution with a chosen type of support that are the factors of selection the excavation support system such as steel soldier piles and horizontal sheeting, sheet piling, and a reinforced concrete diaphragm wall which are measured by m^2 (Popescu et al., 2003). As well, Pratt (2011a) stated that the site works are depending on measuring the sidewalks, concrete paving, kerbs, and gutters for concrete work requirements as well as describing the asphalt paving in m^2. In addition, with regards the fence should be described stating the height and measuring in linear meter; also, gates should be described and enumerated. Furthermore, mulching, seeding, and sodding should be measured (in m^2) and described as well as plants, shrubs, trees, and site utilities should also be measured and described.

According to Popescu et al. (2003) the site works operations can also be encountered by the top of soil which might be different soils which affect the workability and handling of the soil according the type of soil. Table (7-5) shows the productivity adjustment factor regards the type of soil, for more details see the example about site works in appendix (8) section (a).

Table 7.3 shows Soil and Swell Factors

Material	**Swell factor**
Topsoil	1.25–1.35
Sandy loam	1.10–1.20
Sand and gravel	1.10–1.18
Clay	1.20–1.35
Blasted rock	1.40–1.60

Source: Popescu et al (2003).

Table 7.4 shows Soil Compaction Factors

Material	Compaction factor
Topsoil	0.70–0.75
Sand and gravel	0.75–0.80
Crushed stone	0.80–0.85

Source: Popescu et al (2003).

Table 7.5 shows Productivity Adjustment Factor for Different Soil Conditions

Type of material	Productivity adjustment
Moist loam/sandy clay	1.00
Sand/gravel	0.94
Hard clay	0.81
Rock—well blasted	0.61
Rock—poorly blasted	0.39

Source: Popescu et al (2003).

The following examples were mentioned strictly by Popescu et al. (2003).

Example (1) for Soil Swelling Computation

Given that the soil type on a site is determined to be primarily clay, and a 1000 m^3 bank measure[1] of excavation is to be performed, the number of loose cubic meters of soil to be hauled away by truck can be computed as follows.

Volume of Haul (loose measure) = In-Place Volume (bank measure) × Swell Factor.

Example: 1,000 m^3 ×1.30 = 1,300 m^3.

Therefore, if the capacity of the hauling unit is 12.6 m^3, the number of loads can be calculated as follows.

Number of Loads = Volume of Haul ÷ Haul Unit Capacity.

Example: 1,300 m^3 ÷ 12.6 m^3/load = 104 loads.

[1] Bank measure refers to the quantity which provide by the bill of quantity in bid documents.

Example (2) for Soil compaction Computation

Given that the in-place backfill volume is computed to be 600 m^3 and the gravel fill is specified, the volume of gravel to be brought to the site can be computed as follows .

Volume of Fill (loose measure) Required =

In-Place Volume (compacted) ÷ Compaction Factor.

Example: 600 m^3÷ 0.80 = 750 m^3.

Example (3) General Excavation Volume Computation

This example refers to Figures (7.3) to (7.5). Compute the volume for general excavation for the basement construction as shown in Figure (7.3).

The primary step in excavation take off is to determine the size of the excavation pit. In this example, side slopes are 1 to 1 and workspace allowance is 0.5 m from the footing edge. From Figure (7.4), the bottom length, top length, and average length of the excavation pit can be computed as follows.

Bottom Length =Wall to Wall Length of Basement+Footing Projection +Working Space Both Sides.

= 15 m +2(0.3 m + 0.5 m) = 16.6 m.

Top Length = Bottom Length+Horizontal Distance of Side Slope on Both Sides.

= 16.6 m + 2(6 m) = 28.6 m.

Average Length = (Top Length + Bottom Length) ÷ 2.

= (28.6 +16.6) ÷ 2 = 22.6 m.

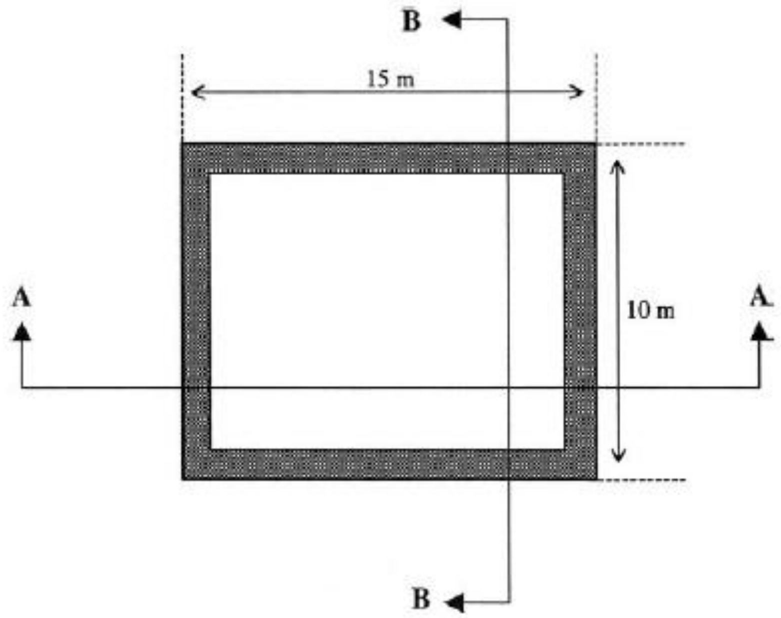


Figure 7.3 shows the plan of basement.

Referring to Figure (7.5), the same procedures are carried out to determine the bottom, top, and average widths of the excavation pit.

Bottom Width = 10 m + 2(0.3 m + 0.5 m) = 11.6 m.

Top Width = 11.6 m + 2(6 m) = 23.6 m.

Average Width = (23.6 + 11.6) ÷ 2 = 17.6 m.

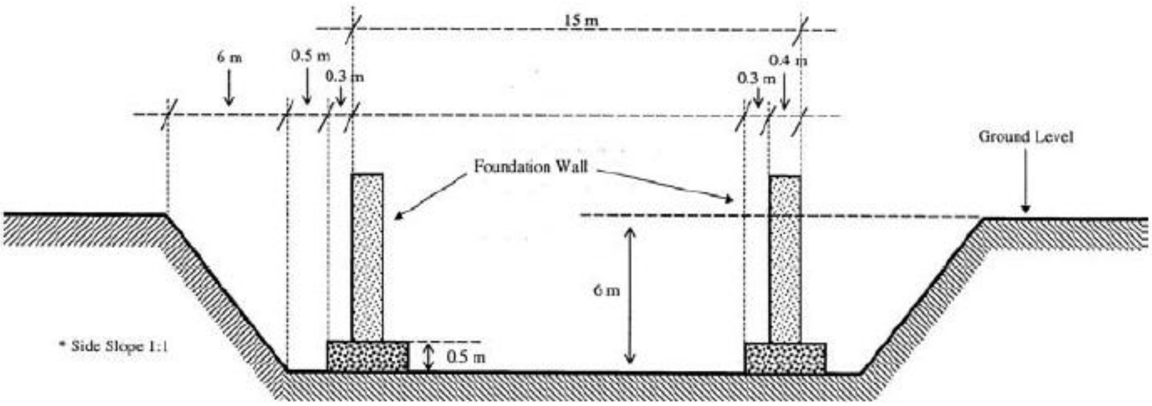


Figure 7.4 shows section A_A

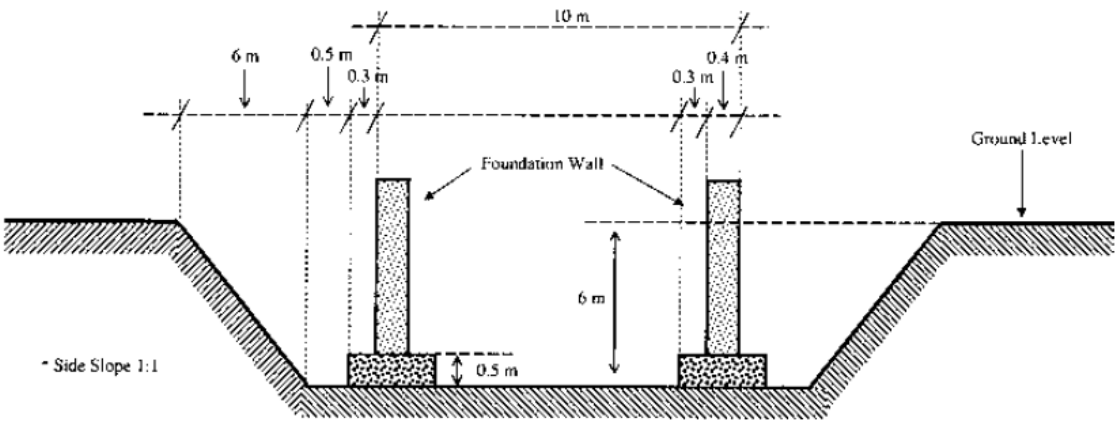


Figure 7.5 shows section B_B

The general excavation volume can thus be computed as follows:

Volume of General Excavation = Average Length × Average Width × Depth.

Example: 22.6 m × 17.6 m × 6 m = 2387 m^3.

Concrete

It is important to confirm that the total direct cost of concrete includes all cost of labour, equipment, materials, and subcontractor who required completing the work. In addition, the cost of labour, equipment, and material are separated to be understand, but in reality should be measured together.

Concrete can be measured in volume (m^3) = Length (m) × Width (m) ×Height (m), and to produce concrete, the aggregates and cement are the mixture of concrete; the aggregates consist of the fine aggregate (sand) and the coarse aggregate (gravel or crushed stone) which available in various size. Some important facts which are the cement is 1510Kg/m^3, and loose damp sand and dry sand is approximately 1690 and 1407 kg/m^3, respectively. As well, crushed stone is approximately 1525kg/m^3, and the water cement ratio ranges from 0.40 to 0.75 regards concrete strength, desired concrete material properties, and slump test, the table (7.6) shows the quantity of 1 m^3 mix and a given example is in appendix (8) section (b).

Table 7.6 shows Quantities of dry materials for 1 m3 of concrete.

Concrete mixture	Cement		Sand	Stone	Concrete mixture	Cement		Sand	Stone
	kg	m^3	m^3	m^3		kg	m^3	m^3	m^3
1:1:1	755	0.5	0.50	0.50	1:2:4	317	0.2	0.43	0.86
1:1:2	574	0.4	0.38	0.75	1:2.25:3	347	0.2	0.52	0.70
1:1:1.75	559	0.4	0.37	0.65	1:2.75:4	287	0.2	0.53	0.78
1:2:2	453	0.3	0.60	0.60	1:3:3	317	0.2	0.64	0.64
1:2:2.25	423	0.3	0.56	0.65	1:3:5	257	0.2	0.50	0.83
1:2:3	378	0.3	0.50	0.75	1:3:6	227	0.2	0.45	0.9

Source: Popescu et al. (2003).

Formwork system has different system can be used in cast-in-place concrete taks to serve several functions (Popescu et al., 2003), also can be mostly measured in square meter (m^2) and forms to walls and forms to columns should be measured separately as well as the bulkheads, edge forms, pilasters projecting from the walls, forms to slab edges, and construction joints from the wall form. The openning can be deducted if the area more than $10m^2$, and the items of formwork are less the 0.30 m can be measured in length meter such as grooves, chases, keyways, chamfers, and narrow strips of formwork. Some other works belongs to concrete works could be measured such as slabs, walls, columns, stairs, and sidewalks finishes as well as screeds, curing slabs, and vapor barrier which is lapped at edges; so the additional 10% to the area of vapor barrier. In addition, the welded wire mesh shall be measured in plan area with additional 10% because including overlaps. Waterstops, expansion joint (linear meter), and inserts in concrete such as anchor bolts (No.) can be described and measured. Nonshrinking grout which is used with anchor bolts and base plates mesuring in cubic meter as well as the reinforcement steel bars are measured in linear meter (Pratt, 2011b).

Masonry work

Masonry work components include masonry walls, masonry units, mortar, grout, and accessory materials. As mentioned, masonry units contain clay masonry, concrete masonry, clay tiles, ceramic veneer, glass masonry, adobe masonry units, and masonry stones. Mortar which is considered basic component of masonry is used to bed masonry units and combined them (Popescu et al., 2003). Mortar composites of water, cement, fine aggregates (such as sand), and lime. According to ASTM, there are four type of mortar as the following:

Type M: a high strength that is used as the primary in foundation masonry, retaining walls, walkways, sewers, and manholes.

Type S: a relative high strength that provide maximum bonding strength for masonry units.

Type N: medium strength that is used for above grade.

Type O: a low strength that is used for interior non-load applications.

Mortar mixes in the site by labour and machines according to the required work (Del Pico, 2012).

Concrete block is widely used in building, especially in Yemen, table (7.7) shows the type of concrete block and the No. of blocks per square meter with its volume of mortar which is used to build them. In Yemen, most common type is concrete masonry and stones.

Table 7.7 shows Sizes, Weights, and Quantities of Concrete Blocks per m^3 and Required Mortar [a]

Concrete blocks nominal size (mm) T × H × L	**Concrete blocks specified size (mm) T × H × L**	**Approximate weight (kg)**		**No. blocks/1 m^2 of wall (units)**	**Quantity of mortar/1 m^2 of wall (m^3)**
		Heavyweight units	**Lightweight units**		
100 × 130 × 300	90 × 120 × 290	5-6	4-5	25.83	0.024
150 × 130 × 300	250 × 120 × 290	8-9	5-6	25.83	0.026
200 × 130 × 300	190 × 120 × 290	10-11	6-7	25.83	0.027
100 × 200 × 300	90 × 190 × 290	8-9	5-6	16.15	0.018
150 × 200 × 300	140 × 190 × 290	12-13	8-9	16.15	0.020
200 × 200 × 300	190 × 190 × 290	15-16	10-11	16.15	0.021
250 × 200 × 300	240 × 190 × 290	19-20	12-13	16.15	0.023
300 × 200 × 300	290 × 190 × 290	22-23	13-14	16.15	0.024
100 × 100 × 400	90 × 90 × 390	5-6	4-5	24.22	0.027
150 × 100 × 400	140 × 90 × 390	8-9	5-6	24.22	0.029
200 × 100 × 400	190 × 90 × 390	10-11	7-8	24.22	0.030
100 × 200 × 400	90 × 190 × 390	10-11	7-8	12.11	0.015
150 × 200 × 400	140 × 190 × 390	16-17	11-12	12.11	0.015
200 × 200 × 400	190 × 190 × 390	20-21	13-14	12.11	0.020
250 × 200 × 400	240 × 190 × 390	26-27	16-17	12.11	0.021
300 × 200 × 400	290 × 190 × 390	29-30	18-19	12.11	0.024

[a] Wall thickness= 1 block

Source: Popescu et al, (2003).

Metals

Metals refers to aluminium, brass, bronze, and steel which is considered the most common on the market, as well as the structural steel is recently used in the multi-storey buildings, theaters, auditoriums, gymnasiums, and stadiums due to the steel flexibility and productivity in both shape and style. The structural steel can be purchased or fabricated and erected. The estimation can be done separately with each item such as columns, lintels, beams, and any other item required and the purchasing can be in tons. Therfore, the estimation for field depends on delivery of materials, weather conditions, equipment available, amount of riveting, bolting, and welding required, and size of the building. Effectively,the basic materials affect the cost of the project can be metal connectors and other miscellaneous items which are used to support other structural building components (Dagostino and Peterson, 2011, Popescu et al., 2003).

The Wide-flange (W or WF) beams, S-beams, I-beams, channels, H-columns, angles, and bearing plates are the most common shapes of steel, for example, W 460 × 52 that refers to wide-flange steel in which a nominal depth 460 mm and a nominal weight of 52 Kg/m, figure (7.6) shows the typical drawing of steel members.

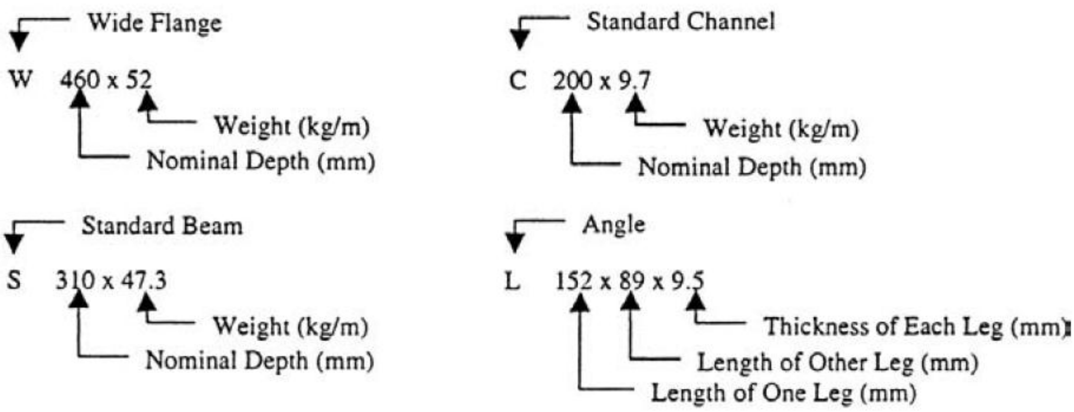


Figure 7.6 shows the typical drawing of steel members, Popescu et Al. (2003).

In order to estimate the metal framing, taking off the quantities from the plans and computing the weight of the steel members with shop drawing and details; the take-off passing floor by floor importantly. One is the most important to estimate knowing what the work is subcontracted.

Carpentry

The carpentry works including the framing and sheathing in the project; the last two purposes of carpentry works isn't common used in Yemen except a little work of carpentry structure inserting in structure of building. Generally, the large scale and small details drawings of rough carpentry as well as identifying the all items of carpentry in each details; determining where the item applied and belong with its length or area, so this sequence of method helping the estimators to estimate the carpentry works easily and faster than other (Popescu et al., 2003, Pratt, 2011b).

The main material in rough carpentry work is lumber, which is considered less than 5 in. in the smallest dimension or larger in its smallest dimension is a timber. The common measurement of the lumber is in inch (in), which should be known by the estimator carefully. The following table (7.8) shows the common lumber sizes by the nominal dimension as well as associated dressed or actual dimensions. There are some abbreviations used as S1S2E for (smooth surface, one side, two ends), and S4S for (smooth surface, four sides), as well as the production state whatever in dry (a moisture content less than 19%) or green (a moisture content more than 19%). Another crucial items are used in carpentary for subfloor, roof sheathing, and wall sheathing are Plywood and waferboard.

Table 7.8 shows Nominal and Dressed Sizes of Lumber

Nominal size (in.)	**Dry S4S- actual size (in.)**	**Green S4S- actual size (in.)**
2 × 4	11/2 × 3 1/2	1 9/16 × 3 9/16
2 × 6	11/2 × 5 1/2	1 9/16 × 5 5/8
2 × 8	11/2 × 7 1/4	1 9/16 × 7 1/2
2 × 10	1 1/2 × 9 1/4	1 9/16 × 9 1/2
2 × 12	1 1/2 × 11 1/4	1 9/16 × 11 1/2

Source: Popescu et al. (2003).

Generally, in rough carpentry the lumber is measured in piece, length in feet (meter), or board measure; theses measures rely on the dimension, dressing, grade, and species. In addition the wall board measures in square feet or square meters regarding type of material and thickness, and deduction isn't less than 40 square feet (≈3.6 m^2).

In framing, the measurement is calssified according to the type of frame as the following:

- Trusses, Truss Joists, and Truss Rafters (No.)
- Manufactured Beams, Joists, and Rafters (linear feet or meters)

- Sheathing (square feet or square meters)
- Copings, Cant Strips, and Fascia (linear feet or meters copings)
- Soffits (square feet or square meters)
- Sidings (square feet or square meters)
- Vapour Barriers and Air Barriers (square feet or square meters)
- Underlay and Subfloors (square feet or square meters)
- Blocking and Furring (board measure or linear meters)

For the finish carpentry, the measures can be calissified according to materials, size,and method of fixing; and other measurement belong to the finishing as the following:

- Trim (linear feet or meters)
- Shelving (linear feet or meters)
- Cabinets, counters, and cupboards (No.)
- Panelling (square feet or square meters)

In addition, the bathroom accessories are measured by number (Pratt, 2011b).

Doors and windows

Frame of window and curtain wall may be made of aluminium, steel, wood, bronze, plastic, or stainless steel. As well, doors that classified as the interior or exterior as well as the exterior can be used for the interior position. They made of wood, aluminium, steel, glass, stainless steel, bronze, copper, plastics, fiberglass, and hardboard, see table (7-9) that helps estimators to estimate doors and windows cost.

Table 7.9 shows Door and Window Checklist.

Doors and windows	
1	Sizes and number required
2	Frame and core types
3	Face veneer specified: wood/veneer doors
4	Pre-finished or job finished: the finish
5	Pre-hung or job hung: the installer
6	Special requirements: fire rating, sound control, and louvers
7	Frame, hardware, and accessories
7.1	Frame: types, sizes, styles, number required (glass required, preassembled)

7.2	Method of attachment of frame to surrounding construction
7.3	Finish required on frame: who will apply it
7.4	Hardware: types required and installer
7.5	Accessories: types required and time to install them

Source: Popescu et al. (2003).

Another important factors, the accessories which should be checked by the estimators that include hardware, screening, light control, saddles, weatherstripping, glass, transoms, grilles and louvers, sills, mullions, flashing, lintels and stools in order to determine the accessories that should be estimate. The estimate process include study the specification, drawings, and all the documents; take off the quantity for the windows and doors which counting by number of unit and the accessories required (Popescu et al., 2003, Dagostino and Peterson, 2011).

Finishes

Finishes are important key of estimate which is included in most component of the poject surrounding the users. *Lath and plaster work system* which means both gypsum and portland cement plasters that applied directly on the concrete and masonry surfaces might be two or three coats with diffirent of materials, and the metal reinforcement (lath) is used as a base, is also used when the plaster appling over sheathed or unsheathed wood framed construction with expanded and wire lath. The estimates can be done by the calculating the areas for walls and ceilings, but the deduction for windows and doors depending on the subcontractors; most of them don't deduct them and the other deduct 50% of the areas.

Example (4)

Calculate the area of plaster of a room (walls and cielling) 6×4×3 m, with two windows 1 × 1 m and one door 1.5 × 2 m?

Answer:

Walls (6 + 6 + 4 + 4) × 3 = 60 m^2.

Ceilings (6 × 4) = 24 m^2.

Total = 84 m^2.

Deduct 50% of door and window openings:

Windows 2 × 1 × 1 = 2 m^2 + door 1 × 1.5 × 2 = 3 m^2 = 5 m^2.

Quantity to be priced: 84 - 5 × 0.5 = 81.5 m^2.

In order to estimate the quantity of plaster the table (7.10) shows the the plaster mix which covering capicity of $1m^3$ in m^2 based on the thickness 20mm for metal lath; 10 mm on gypsum lath; and 15 mm on unit masonry.

Table 7.10 shows Plaster mix covering capacity of 1 m^3 in m^2.

Coat type	Metal lath	Unit masnory	Rough concrete
Scratch	55–65		
Brown	75–85	65–70	65–70
Finish	400	400	400

Source: Popescu et al. (2003).

Gypsum plasterboard system is referred to gypsum wallboard as drywall; it is used to finish walls and ceilings. Gypsum boards are manufactured in different sizes and thicknesses; composing of a gypsum core finished paper on the face side and on the backside with a strong liner paper. The whole areas, which should be covered with gypsum boards, should be identified and measured (walls and ceilings); openings such as doors, windows, and duct vents, which is less than four m^2, should be not deducted. The panel quantities are categorised due to type, size, and thickness of board required for each area in order to be summed with allowances. In addition, accessories for each type of board include nails, screws, staples, joint tape, and joint compound should be estimated. The waste factor should be obtained from 1% to 5% for materials which to be purchased (Dagostino and Peterson, 2011, Popescu et al., 2003).

Tiles are an important finishes in the project, include many types such as ceramic, marble, stone, and terrazzo. Tiles are measured in m^2; a special tile should be measured in linear meters such as trim, bullnose, surface bullnose, or base tile (skirting) as well as a waste factor should be taken into consideration from 5% to 10%.

Specificity, for marble and stone flooring (such as polished granite and sandstone) the measurement is executed according the table (7.11), and the waste factors for good quality stones is 3%; and 6% for bad quality stones.

Table 7.11 shows Marble and stone flooring quantity take off units.

Specification	Unit of measure
Horizontal surfaces square meter	Square meter
Base under 30 cm high linear meter	Linear meter
Base over 30 cm high	Square meter
Die or wainscot	Square meter
Stair treads	Square meter
Stair risers	Linear meter
Stone floor tile, regular size	Square meter
Stone floor tile, small size	Square meter
Circular base	Linear meter
Circular die or wainscot	Square meter

Source: Popescu et al. (2003).

Another important finishes is *acoustic treatment* that can be wall or ceiling, therfore, acoustic wall panel which composite of backmounted, standard and custom spline-mounted, and metal panels is consists of fabric or vinyl facing over mineral, glass, or wood fiberboard. Furthermore, for ceilling the suspension system components such as tees, hangers, and channels should be estimated; table (7.12) shows the accoustic materials unit and the table (7.13) shows acoustical materials waste factors.

Table 7.12 shows Accoustic materials unit.

No.	Materials	Unit
Acoustical tiles		M^2
1	Fiberglass	M^2
2	Mineral fibre, fine	M^2
3	Mineral fibre, rough	M^2
4	Luminous panels	M^2
5	Metal pan	M^2
Complete suspended acoustical ceilings		
1	Fiberglass	M^2
2	Mineral fibre	M^2
3	Luminous panels	M^2
4	Metal pan	M^2
5	Tile	M^2

No.	Materials	Unit
6	Channel carriers (add)	M^2
Acoustical wall treatment (wall panels)		
1	Standard	M^2
2	High quality	M^2
Acoustical baffles		
1	Sound-absorbing panels (hung)	M^2
2	Sound-absorbing panels (mount)	M^2

Source: Popescu et al. (2003).

Table 7.13 shows Acoustical materials waste factors.

No.	Materials	Waste factor estimated % material wasted
	Acoustical wall panels—for every 1000 m^2	5
	Ceiling tiles/panels—for every 1000 m^2	5
	Ceiling grid—for every 100 m	2.5
	Acoustical baffles—for every 1000 m^2	2.5

Source: Popescu et al. (2003).

Finshed wood flooring

Furthermore, *wood flooring* is also a type of finishes that can be made from the hard woods or soft woods; to measure the wood flooring the total area should be calculated and then quantify the quantity of materials. In addition the waste factor should be taken into consideratiom according to the following table (7.14). In Yemen, this type of flooring has rarely found; it is mentioned here for knowledge in ordet to be useful for estimators.

Table 7.14 shows Wood Flooring Installation Waste.

Measured size (mm)	**Finished size (mm)**	**No. Pcs. in bundle**	**Ass. for waste (%)**
25 _ 50	9.4 _ 37.5	24	38.33
25 _ 63	9.4 _ 50.0	24	30
25 _ 56	19.5 _ 37.5	12	55
25 _ 69	19.5 _ 50.0	12	42.5
25 _ 75	19.5 _ 56.3	12	38.33
25 _ 100	19.5 _ 81.3	8	29

Source: Popescu et al. (2003).

Paints which are considered one of finishes type are calissified based on the type of solvent which is solvent-based (oil or alkyd) or water-based (latex). Of prime importance, the accurate estimate depends on the following variables such as surface materials, surface shape, height, type of paint, method, location, waste factors, labour productivity, labour wages, burdens, equipment cost, overtime, weather, coverage ratios, materials prices, thickness of the coats, and so on. In appendix (8) section (c), figure (1) and (2) shows the material covering ratio for internal and external painting perspectively; as well as the following table (7.15) shows the waste factor based on the method of application.

Table 7.15 shows Painting waste factors based on method of application.

Method of application	Waste factor (%)
Brush	3–5
Roller	5–10
Airless spray	20–25
Conventional spray	25–35

Source: Popescu et al. (2003).

In addition, the following table (7.16) can help the estimators to determine the difficulty' factor of painting for different hieghts.

Table 7.16 shows Painting difficulty factors affecting productivity.

Height	Add to surface area (%)	Or multiply by
2.4 to 4 m	30	1.3
Over 4 to 5.2 m	60	1.6
Over 5.2 to 5.8 m	90	1.9
Over 5.8 to 6.4 m	120	2.1

Source: Popescu et al. (2003).

Wallpapers

As well, wallpapers are considered a finishes type commonly consist of vinyl and vinyl-coated for their own durability, ease of cleaning, water resistance, and ease of installation, as well as a variety of designs are available. In installation, there are some tools and materials required might be used to prepare the wallpaper such as adhesive, paint roller, and seam roller. Although, the waste does not seem that can be happening; there are some resources estimate the waste range from 10% to 20%, which can be interpreted that the geometry of the room controls the value of waste.

Mechanical works

Most of mechanical works which may transfer to one or more than one subcontractors are classified into two types plumbing and sewage system, and HVAC system; the function of plumbing (mechanical) are bringing water to the building, supplying and installing fixture, and taking the discharged water and waste to the out of the building. The materials, fixtures, and equipment that related to the plumbing are defined in the spec. Plumbing represents from the total job 3 to 12% relying on the type and number of fixtures required. In order to estimate plumbing the following steps should be taken into consideration studying plan and specification of plumbing, taking-of materials quantities, and determining cost for materials, labours, supplementary costs, and overhead.

The experience plays the key role in estimating the HVAC ranging from small project to large project in details considering equipment, materials, labour, and supplementary costs. For strictly speaking, the checklist should be taken into consideration by the estimators in order to check the plumbing works as follows:

Permits, excavation and backfill, water, gas, and sewage lines required pipes and fittings, cleanouts, valves, tanks, sleeves water closets, bath tubs, lavatories, drinking fountains, showers, tubs, service sinks, water heater, urinals, washers and dryers, dishwashers, and hook-up to equipment.

To check HVAC works the following points should be taken into consideration:

Boiler, stoker, oil tanks, gauges, fuel, piping, insulation, circulating pumps, piping accessories, radiators, fin tubes, enclosures, clocks, hangers, unit heaters, boiler, accessories, thermostats, wiring, chimney, ducts, diffusers, fans, valves, filters, humidifiers, dehumidifiers, insulation, baffles, central, units, coolant, fans, registers, filters, inlets, returns, fresh air, louvers, and thermostats (Popescu et al., 2003, Dagostino and Peterson, 2011).

Electrical works

Mostly, electrical works delegates to the subcontractors. Estimate electrical works needs extensively knowledge and experience in properties and behaviour of electricity, which divided into two types of work wiring and fixtures; wiring is the rough work to be concealed in a conduit as well as the cable is also considered a wiring work for the first step of project's establishement, and fixtures is a finish work. As possible preparing a take-off list for various electrical components that are service equipment (such as fuses, circuit breaker, etc.), distribution equipment (such as switchboard), branch work or branch circuit which includs raceway, and conductors, devices and loads (such as outlets, light switches, etc.) (Popescu et al., 2003, Dagostino and Peterson, 2011).

Checklist should be taken into consideration for following points that are conduit (sizes and lengths), wire (type, sizes, and lengths), outlets (floor, wall, overhead), switches (2-, 3-, and 4-way), breakers (size, number of each), outlets, power requirements, weatherproof, panel boards, control panels, fixtures (floor, wall, ceiling, etc.), mounting requirements, clocks, time clocks, bells (buzzers), alarm systems, TV outlets, heaters, and hook-up for various items from the other trades (motors, boilers, etc.) (Dagostino and Peterson, 2011).

Thermal and moisture protection

Materials of mosisture and thermal preotction have been sophisticated and widely used in construction projects; there are many materials which are but not limited to: Membrane waterproofing (m^2), integral methods which is considerably with admixture adding to the mix due to the manufacture's recommendations. As well metallic waterproofing method that is a combined of graded fine-iron aggregate and oxidizing agents; it is measured by the square area that should be covered by metallic waterproofing to determine how many gallons covering that area according to the manufacture's data; and damp proofing can be painting, or plastering in m^2.

Insulation method use many types of materials such as rolls or sheets, felt (or papers), as well as bituminous materials, asphalt shingles, wood shingles, slate, tiles, and flashing. The following cheklist should be taken into account, see appendix (8) section (d) (Dagostino and Peterson, 2011).

Job site overheads

Popescu et al. (2003) stated that the comprehensive checklist for general jobsite requirements that helps estimators to remember every cost item; exactly when the time pressure of finalising bid would attend. Further, many items that should be seriously taken by the estimators; where items would be the baseline of site budget; these items are:

1. Jobsite personnel wages and fringe benefits;
2. Jobsite personnel project-related travel expenses;
3. Outside contracted engineering support (surveying, materials testing, etc.);

4. General use equipment for the benefit of the general contractors and subcontractors (cranes, hoists);
5. Field buildings;
6. Site utilities for the job duration;
7. Horizontal structures (roads, parking, fences, and gates);
8. Temporary environmental controls requirements;
9. Winter and summer protection of completed works or works in progress;
10. Related camp facilities for remote jobs;
11. Jobsite production facilities (concrete batching plants, quarry, various shops);
12. Protective aids for workers (gloves, hard hats, etc.) during construction and final clean-up of the project; and Bonds, insurance, permits, and taxes required in the contract general conditions.

Also, Dagostino and Peterson (2011) informed that the checklist should be investigated and taken into consideration; the checklist might be the same checklist generating by Popescu et al. (2003), see appendix (8) section (e).

Amount of contingency which adds to the estimation as a sum of money or percentage due to forget any items to estimate; or to lack of estimator's experience to cover the fault of estimates; but rationally, it is used for price escalation.

General overheads and profit

The expenses of home office can be considered general overheads expenses, which is also a contractor fixed expenses. Anyway, the home office expenses ranges from the 2.5 to 10% annually (Popescu et al., 2003).

Furthermore, profit is the final destination of efforts to earn and execute the projects; it is clear mount money added to the total estimated cost of the project. Profit can be added to the project by many approaches such as percentage to each item, percentage to the total price, or according to adopted strategy of firm and their experience, see appendix (8) section (f) (Dagostino and Peterson, 2011).

7.2.4 The querying

From the last analysis, there was one hypothesis, which is "Query list has a positive effect on pricing process" was confirmed; also, a covariance relationship with KCE. Therefore, strong effect from the right way of defining the ambiguous matters lead to form the query list by knowledge affecting positively the process of pricing.

This process depends on site visit and reviewing the bid documents; site visit has overlapping with process of pricing; it is also the best way to get information about the site after reviewing the documents. The checklist could be used to check the site was attached in the appendix (8) section (g) (Popescu et al., 2003). After studying the documents and visiting the site; many ambiguous questions will be appeared and should be listed to the designer or consultant to answer. This process helps the estimator to judge and estimate the items and activities accurately (Pratt, 2011b).

7.2.5 The pricing

In pricing variables, there was one direct hypothesis and another three hypotheses that were discussed in the last sections, the direct hypothesis was ‘‘Pricing process has a positive effect on management review’s process’’; all hypotheses were confirmed. For material cost, mostly, the unit price of dollars or riyals per unit of measure of a quantified material as well as the material cost does not include the direct cost only, but all the costs related to the material (interest rate, escalation, holding cost, handling and storage costs, and shipping costs,) except labour and equipment. In addition, any tax of sales should applied and taken into account by the estimators (Popescu et al., 2003).

After the quantities are taken-off, the pricing method would be applied; strictly, there are two methods of pricing for equipment and labours, firstly, the using productivity rate to transform the take-off into labour-hours and equipment-hours after that applying the wage rates. Secondly, using unit price is to calculate the total price of labour and equipment according to the take-off quantities (Pratt, 2011b).

For equipment that is used for a specific item or task on the project. For example, for digging the trench by excavator, which is brought to the site for finishing this specific task and would be shipped back to its source. It is also important practically, the equipment can be renting for a while. If the equipment is possessed by the owner; there are some important factors should be added on the annual ownership costs of the equipment such as (insurance premiums, and storage costs, licenses fees, and annual taxes) (Pratt, 2011b). In addition, the operating cost should be determined and calculated from historical or manufacturing data in order to be aware by the estimators to achieve the tasks of the projects (Popescu et al., 2003). With referring to the section (7.2.3) in measurement example (3), after the quantity was calculated and was (**2387** m^3), supposed to use excavator with unit cost = \$1.83/m^3 (include labour and equipment cost), then, the total cost = excavation volume × unit cost

Total cost = 2387 × 1.83 = $ **4368**, for more examples for other tasks in construction projects, see appendix (8) section (h).

According to Pratt (2011b), most subcontractors submit a lump-sum price for the specific works; this reduce the risk of overruns to the subtrade who agrees to perform the work.

7.2.6 Management review

After the analysis was done, there was one hypothesis "Management review's process has a positive effect on bid summary" was confirmed as well as another relation was supposed by the AMOS programme that indicates that the KCE affect positively the management reviews' decision which also means the staff of management should be full knowledge in cost estimate.

In management review, there are two levels to review; firstly, the project management delegates to the expert estimators to review and reconcile all estimation's process writing the key important notes to be recheck by the estimators before the final management review would be done. In addition, this review may include but not be limited to:

- Reviewing the base estimate documents,
- Ensuring that the estimating methodologies are noted by individual item of work,
- Reviewing the overall estimate documentation and processes, and
- Conducting a detailed check of the estimate to include:
- Checking the development of unit rates and quantities of those items that drive the majority of the bottom-line cost.
- Making note of comments on unit rates and quantities,
- Checking for mathematical errors.

Secondly, the staff of management revised all estimate's process and documents to approve them to reflect management comments (Washington, 2008).

Pratt (2011b) stated that the advantage stage, which is a stage before summarising the bid at least 2 days before the closing, including:

1. The quantity take-off, the recaps, the general expenses and the summary sheet, except for the subcontractor prices, are completed.
2. Unit prices and alternative prices relating to the contractor's work are calculated.
3. Bid bonds, consent of surety forms, and any other documents required to accompany the bid are obtained and completed.

4. Bid forms are signed by company officers, witnessed, sealed, and completed as far as possible.
5. Duplicate copies of all bid documents are made for retention by the contractor.
6. An envelope to contain all bid documents is prepared.
7. All bid documents and their envelope are retained by the chief estimator until the closing day.
8. A plan is formulated for the delivery of the bid. The bid runner (the person who is to deliver the bid) is carefully briefed about his or her role and how he or she will complete the bid documents if this is required.
9. The office staff members are briefed regarding their roles on bid closing day.
10. All fax machines, computers, and telephones are checked to ensure they will be operational for closing day. Backup fax machines and computers are made available.

7.2.7 Bid summary

Popescu et al. (2003) revealed that this the final crucial process for putting bid together within a limited time at least 24 hours before bid closing. According to Pratt (2011b), bid summary should cover the estimate summary process, the description of items that including in bid process, the risk identifier and how handle it, distinguishing a unit-price bid from a lump-sum bid, and finalising the estimate. The summary sheets prefers from the contractor to be used. This can helps the estimators to determine the items that should be estimated at every stage of estimate process as well as to price all items. As it should be mentioned that the bid results should be tabulated, compiling the bid documents, storing bid documents, compiling and storing estimate file, and handling subcontractors see appendix (9).

7.3 Evaluation the Estimation's Capability of Firm

To evaluate the capability of case study's firm to estimate its projects perfectly, an evaluation tool was designed according to the practices of cost estimate and the earned knowledge of cost estimate. The model of cost estimate practices including 77 practices and knowledge that should be accomplished by the firms and their subordinates. This model helps the firm to find the areas of weakness and strength in its body with regards cost estimate. As well as, this model can provide easy way to improve the areas of weakness in the firm. A fact-based measurement leads the firm to learn how to improve such weakness areas of its current approach, see appendix (10) for an evaluation tool.

7.3.1 Improvement weakness areas

After using the evaluation tools, the weakness areas would be clear, and the firm can identify many improvement possibilities. The improvement plan would be difficult according to the situation of country and firm; and can't be implement all plans. The war, the firm's closing and poor demand from the clients might lead the firm to decrease its resources. For such circumstances that involve the firm, the improvement plan may handle the critical issues that affect the main process of estimate and this plan should be aligned with limited resources of firm and author as well as the constraints from the top management according to the deteriorate of economy of the country.

Many factors should be taken into account before improvement plan implementing (e.g., firm structure, level of educations, attitude of employee, traditional estimate methods, agreement of top management). After getting the scores of evaluation tool, the improvement plan can be formulated to cover the weakness areas. Then the improvement plan can be discussed with the key personnel of firm or the involved key persons in the improvement plan to ensure highly performance of effectiveness.

Once improvement plan has been accepted and agreed, it should be explained for relevant persons[1] to understand the underlying principles and ideas of the improvement plan as well as the sufficient resources should be available. Secondly, check system for improvement plan should be every time for ensuring two functions. Firstly, it should be monitored the progress to ensure the plan going on as the expected. Secondly, the necessary corrective action would be provided to return the plan to its correct way. The results of improvement plan may not be promptly and takes a long time. Therefore, the acceptance for developing and there is no "quick fixes" and "instant results" have to be expected with patience and tenacity. Nonetheless, the analysis of results should be done; if it isn't effective, the PDCA cycle (plan, do, check, action) could be applied to find other improvement plans.

7.4 Improvement plan

According to Zhang (2001), the methods towards the formulation improvement plan is divided into four categories as follows: impossible improvement possibilities, temporary barrier improvement possibilities, ineffective improvement possibilities, and feasible improvement possibilities figure (7.7). These possibilities have been affected by the surrounding environment such as (political, security, war, economic, social, etc.) as well as the situation in Yemen in this decade had much complicated things according to the war

[1] They are key persons who estimate, helps to estimate, or would be estimator later.

between parties of government. This situation had led the firm to stop most of its projects for a while or terminate them. In addition, these circumstances affected changing in the firm internally and externally. As well, possibilities might change if the situations change for better; but not all, because the ability of firm controls the range of change or possibilities.

Impossible improvement possibilities could be affected by the standing war between parties of government; the current situation has controlled the improvement such as bidding for big contract, avoiding delays in current projects, or continuing by steady steps in firm's progress. It was decided also by the five-structured interview there would be impossible difficulties to improve according to the current situation. Also, small firm has many impossible difficulties according to its size and policy which can't provide a training programme to improve its employees' skills or developing its techniques of estimate.

With regards to temporary barrier improvement possibilities that can be done in future after the obstacles would be removed from the face of firm. Gradually approach leads such firms to improve such as using programme in process of estimate, structure a private cost index, and training the estimators. These possibilities cannot be implemented immediately with the current situation of firm.

Ineffective improvement possibilities that cannot be achieved considering useless for firm under the current situation. The evaluation might have more subjects that don't need to be improved and cost firm money, for example, using a specific template that can be bought and used to estimate their projects. Even in the current situation, there was no demand for projects and the market was inactive; also if there was any projects it could be done manually or by the current template of firm.

Generally, feasible improvement possibilities can be executed under the current situation by the firm due to the evaluation results, which would determine the weakness parts of the estimation methods of firm. It might be faced many difficulties to implement the improvement and would take time; i.e. it cannot be implemented according to the critical feasible improvement possibilities as well as the priority should be taken into account for which is better for improvement.

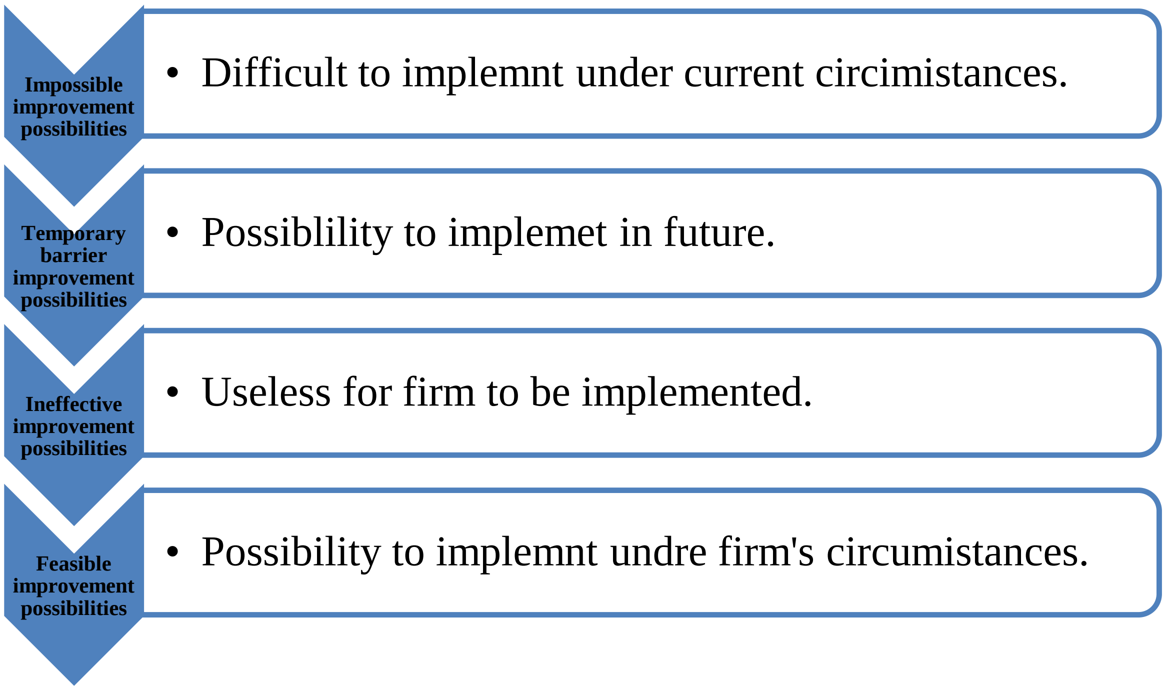
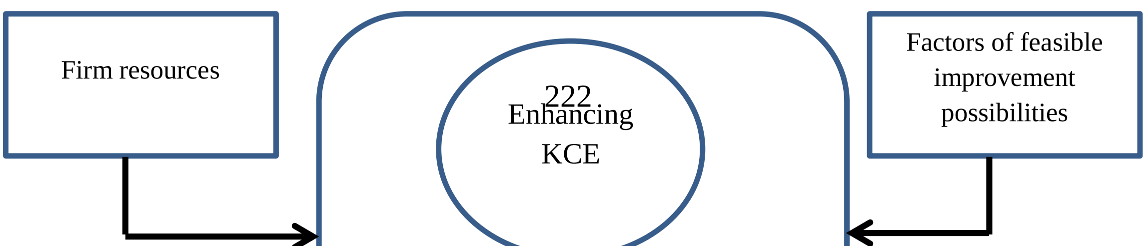


Figure 7.7 Improvement plan possibilities, Zhang (2001).

7.4.1 Formulation of improvement plan

The discussion with key personnel about the improvement plan was decided to be taken into account; three important objectives that were enhancing the knowledge of cost estimate, practicing the preliminary estimate, and supporting the detailed estimate. From the three objectives, there would be factors appeared from the evaluation tool to be feasible improvement possibilities as well as the resource of firm, acceptance the author by the top management, understanding the current situation of firm, time planning for executing the improvement plan, and the relevant persons with the improvement plan's execution. The last factors might affect the improvement plan progress positively or negatively figure (7.8).

Improvement plan is a systematic approach that helps firms to improve their potentiality of successes estimate accurately. Thus, the important factors of cost estimate knowledge and practices should be determined systemically by the evaluation tool to find out the targeted areas. Based on the feasible improvement areas that should be ranked according to their potential effects of the improvement should be also studied carefully.



As well, the firm resources is considering factor can affect the progress of improvement plan; if the resource would be available then the process may lead to success the plan. However, resources might be limited according to the current situation, agree top management to the study importance, and the income of firm is limited. Resources can be tangible (e.g., places, devices, copy machines, etc.) or intangible (template, programme, organisation structure, etc.).

Another important factor that formulate the improvement plan the acceptance from the top management for the author, especially, in war time, the safety and security issues represent the most important life's progress for the firms in Yemen. Because, not every firm need to be accounted on any side of conflict that leads the business of firm to be stopped or terminated. Therefore, the doubt about the author would be large; and to remove that doubt the efforts to bring the confidence for the top management would be the priority of author in that time.

Of prime importance, understanding the current situation of firm can logically help to formulate the improvement plan easily and accurately. The current situations include the educational level of its employee, financial capability, current opened projects, technological level, and the system of work. According to the available resources, the feasible improvement possibilities can be implemented within that resources or deleted what is out the resources possibility.

An improvement plan should be within time dimension, which involves such as time for preparation (e.g., training, coordination, revision the priority), date of start, observing, and checking the results, investigating and analysing results, and expected date of finish. Generally, rapid change could lead to negative results, therefore, gradually approach should be recommended when the time planning execution would be set.

In order to get highly success to perform the improvement plan, the relevant persons of firm should be involved in the process; i.e. the key persons who estimate, helps to estimate, or would be estimator later, all of them should be involved in implementing the improvement plan.

7.5 Case Study (field work)

7.5.1 Introduction

In order to give a real example for how to use the models of this study in practice, the case study is the best method to achieve this goal. Therefore, the gradually steps of executing the case study is debated. As well, the selected firm is chosen for its high ability in construction field as medium firm, which is considered the top one in Hodeida province as well as is described and the current situation of the firm is debated showing the weakness areas according to the evaluation tool. After that, the improvement plan takes its place to improve the weakness areas of the firm and to practice both model quantitative and qualitative.

7.5.2 Steps of case study procedures

Firstly, the evaluation results were obtained and studied carefully. Due to the war and high risk potential with regarding the war, the time was limited that forced the author to rapid the process of the case study applying, as well as the current situation, that had forced the firm to close several times. Further, its projects had been also stopped several times. As well, some feasible improvement possibilities would take long time that hadn't available according to the study and situations' time limit. The important issue was formulating appropriate improvement plan that would be offered to the top management to get their approval.

First step was introducing the concept of study and the case study approach to the top management. However, the top management were worried about accept the author's application; giving the author many reasons that had might be turned him to another firm such as the current situation of country, firm's activity-stopped, and firms' plan to decrease its resource. In fact, the real reason was the safety and security issues that had been felt by the author, to overcome this problem, the friends of author who work in the firm supporting the author on their responsibilities; so the acceptance was got. In addition, any resource increasing in order to perform this case study should be on author responsibility that was agreed by the author with the top management.

The second step was to determine the relevant persons who involving in this study conducting. The big challenge for the author was to convince targeted persons to be effective to achieve this study. Especially, the condition of top management; the process of firm and its output should be flowed normally as possible as normal. Therefore, some persons were afraid to join these activities; thus, the author had advised them about the personality benefits after this study finished; and they were exciting to involve. There were four persons who involved in this study directly; two persons from the sector of planning, design, and studies as well as two persons from the contracting sectors. In addition, all participants of other technical sectors can be involved indirectly.

The third step was to evaluate the KCE of the participants and their ability of using preliminary and detailed estimate. This evaluation was done by the evaluation tool, which could present the area of strength and weakness of firm. As well, the author was learned the process of estimate in firm by the relevant persons in order to understand the current situation of firm.

The fourth step was to formulate the improvement plan depending on the weakness areas in order to implement it. Of prime importance, many weakness areas were identified and further. Only feasible improvement possible was used to formulate the improvement plan. It also should be analysed and prioritised in terms of the degree of importance. Furthermore, the improvement plan was put to time schedule by the author and relevant persons together taking into account the main activities of firm that couldn't be interrupted by the improvement plan according to the order of the top management. This plan had to be accepted by the top management, otherwise, it would be ineffective.

7.5.3 Firm description

The case study was conducted in Hodeida province; the firm was semi-private established in 2005. Its activities field are in real state, town planning, construction building, and infrastructure. It was ranked in the intermediate firms in Yemen. It has to be mentioned that the top management assist to not mention a specific information of firm in this study such as (name of firm, No. of employees, fixed asset, financial capability, annual income, annual profit). The top management concerned about that information as top secret even author doesn't has the right to know them. This firm relies on itself to design and execute all the stages of the project; even producing every items in its workshop such (doors, windows, steel works, blocks, main boards, etc.). The hierarchy structure of firm shows the departments of firm in figure (7.9), as well, other sublevels don't appear in the figure according to narrow size of paper.

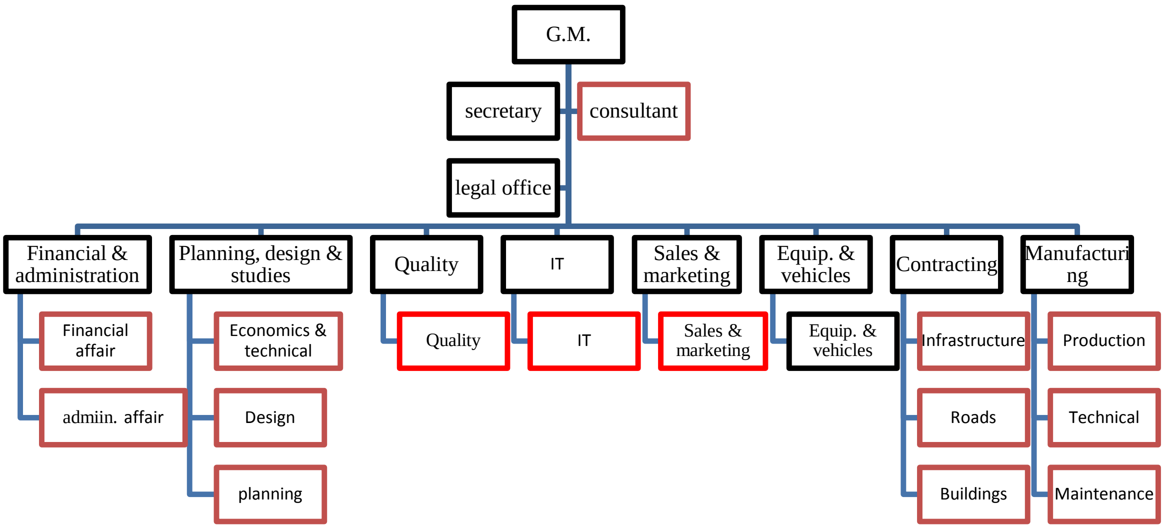


Figure 7.9 Organisational structure of the firm.

7.5.4 Evaluation the current situation of firm

The evaluation was done by the evaluation tools (see appendix 10) in order to determine the strength and weakness areas of firm. Thus, the evaluation tool was distributed to the relevant persons to answer; also, the interview with them was conducted. After that the results of evaluation was clear for both strength and weakness by the scores of tool. The weakness areas were adopted to be improved that didn't mean other areas shouldn't need improve, but, the weakness areas should receive more attention, see appendix (11) for the total results and see table (7.17) for the weakness areas that should be improved.

Table 7.17 shows Weakness areas of firm.

Model core	section	Areas	Factors	Mean	Areas Mean
Knowledge cost estimate	Cost estimation methods and techniques	Preliminary estimate	Understanding preliminary estimate	5	3.7
			Historical data	2	
			Analogy (similarity)	3	
			Multiple regression	2.5	
			Artificial neural network	6	
	Critical factors	Management and planning factors	Project duration	5	4.4
			Project management quality	5	
			Documentation	4.5	
			Project team requirement	3	
			Contract duration	6	
			Waste of materials	3	
		Risks and regulations	Risks, political, and other risks.	0.5	2.8
			Laws and regulations	5	
	Safety considerations	Cost and safety tools	Safety tools	2.5	3.8
			Safety and Health cost	5	
	Cost index	Cost index	Cost index	1	2
			Cost index usage	4.5	
			Foreign cost index	0.5	
Preliminary estimate	Preliminary estimate	Modern techniques	Multiple regression	3	3
			ANN	3	

Detailed estimate	Measurements	Measurements	Items of construction projects	3	4.4
			Jobsite Overhead	3	
			Surety Bonds, Insurance, and Taxes	3.5	
			General Overhead	4	
			Contingencies, and Profit	6.5	
			Bottom-up technique	6.5	
	Query	Review bid documents	Review bid documents	3.5	3.5

Source: case study analysis.

Based on the evaluation results[1], the weakness areas that scored less than 5; they were eight areas. As well, it doesn't mean other areas haven't need any improvement exactly what scored 5 or nearest to 5. Therefore, these weakness areas can be handling as possibilities for firm in order to improve its ability towards accurate cost estimate for its construction projects. These eight areas were identified on basis of unbiased, honest, and fact-based judgements as well as they were discussed with the relevant persons to formulate the improvement plan in order to align with the firm activities.

7.5.5 Improvement plan formulation

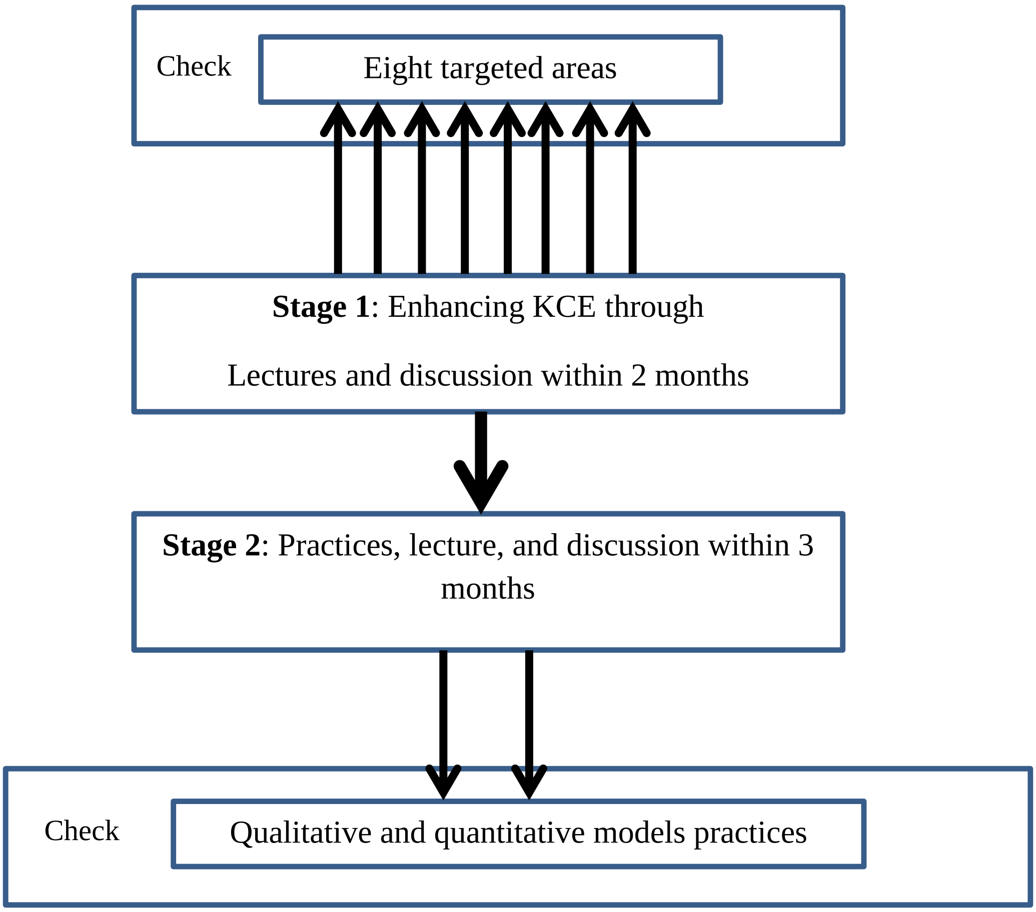
The eight weakness areas were distributed into KCE, preliminary estimate, and detailed estimate; otherwise, the main aim of this case study to identify the models of study to be applicable in practice. Therefore, there were two stages for formulate the improvement plan. Stage one, it had to overcome the weakness of the firm; this plan was done through lectures and discussion with the relevant persons with promptly evaluation for the persons. The proposed time for this stage was discussion with the relevant persons and evaluating to be two months.

Stage two, there were two models of this study qualitative model (detailed estimate model) and quantitative model (preliminary estimate model); these two models should be explained

[1] The scoring method of evaluation tool was from 0 to 10; so the 5 score means neutral.

and practiced. For the quantitative model, which was artificial neural network model; it could be performed by the NeuroSolution programme. Then, it would be compared with a final cost of another project that had been finished. For the qualitative model, there were a big problem was mentioned by the relevant persons and was not absent from the author; that was the projects of firm couldn't finish within 6 months as well as most of the project were stopped for unknown dead time[1].

In order to cover this problem, it was decided with relevant persons to understand the process of detailed estimate through examples for its components by lectures and discussion as well as to compare the final cost of finished project with the result of quantitative model. For most important, these two models can compare each other and used to check alternatively the results of estimate. The time plan was going to be three months, see figure (7.10). This improvement plan can be delegated to the others subordinates in the firm by the relevant persons in order to continue improvement; thus, the learned lessons and experience gained in this six month will be covered the all estimators or people interesting in estimating process of cost in the firm.



[1] This was to practice the detailed estimate for project and compared its final cost with the estimated cost; it would take a long time.

Figure 7.10 Case study's time plan, Author

7.5.5.1 Stage one of improvement plan

The first stage was to overcome the weakness of the estimators in the targeted areas that consist of eight areas. As well, the first objective of the case study was to enhance the knowledge of cost estimate; thus, this stage would verify this objective. The agreement between author and the relevant persons was to meet them at least one per week whatever in the firm or in out the firm.[1] The eight-targeted areas are explained as the following:

1. With respect to preliminary estimate, from the relevant persons' answers, the analysis shows that the mean was **3.7**, which is less than the mean average **(5)**, which refers that they might confuse a little about the preliminary estimate approach. Furthermore, with referring to the field study results that found the respondents' answers were more than average, which means most of them have knowledge about the preliminary estimate especially the traditional methods. Therefore, the modern techniques that made the weakness area; thus, the focusing was on the explained the modern techniques, which were historical data, analogous, multiple regression, and artificial neural network techniques. The learning process included on the definition of them, how to use, and examples for explanation.
2. With respect to management and planning factors, from the relevant persons' answers, the analysis shows that the mean was **4.4**, which is slightly less than the mean average **(5)**, which means that they might face difficulties to understand and implement the factors that belong to this area. Further, the field study result, which was almost the same result of the evaluation tool leading to ask the relevant persons about their knowledge for every factor. It was cleared the lack of knowledge was the key reason; thus, the author learned them about requirements of every factor (project duration, project management quality, documentation, project team requirement, contract requirement, and waste of materials) as well as how to achieve documentation and calculate the material waste. This generated a large confidence and exciting to continue of learning with freely style that means they didn't need to commit by tidy group, time attendance, hall, and quiet respect, it could be like focus group.
3. With respect to risks and regulations, from the relevant persons' answers, the analysis shows that the mean was **2.8**, which is less than the mean average **(5)**, which refers that they hadn't enough knowledge and experience of risk and regulation. As the

[1] There is Yemenis' habit that is chewing the Qat in the afternoon together; which has represented a chance to meet them and lecturing them freely..

respondents' of field study answers referred that they didn't commit the construction safety's regulation in site; because Yemen is developing country that doesn't care about the safety concerns, if there are accidents delegating to tribal judgment mostly. In addition, the regulation that organise the construction projects exist; the major problem in how to apply those regulations in the sites with monitoring and accounting from the formal agency. Thus, the effects of political and risks were discussed and the example of situation in Yemen due to the war and political matters was a large evidence for them to know the influences of these matters.

4. With respect to cost and safety tools, from the relevant persons' answers, the analysis shows that the mean was **3.8**, which is less than the mean average **(5)**, which refers that they didn't think about the relation between the safety and cost. Furthermore, with referring to the field study results that found the respondents' answers were less than the mean average, which means the cost that happens by ignoring the safety matters leads to many unexpected losses. Therefore, the author and the relevant persons debated the effects of ignoring the safety regarding to cost that led finally to understand the majority of hidden losses cost.
5. With respect to cost index, from the relevant persons' answers, the analysis shows that the mean was **2**, which is less than the mean average **(5)**. Moreover, with referring to the field study results that found the respondents' answers were less than the mean average, which means that they might not know about the cost index and how to use and how to construct. Consequently, the lessons and lectures about the cost index were done for relevant persons focusing on the model development explanation and examples. Of prime importance, the cost index technique isn't known in construction Yemeni's field; although, Yemen is a developing country, there was no important escalation in no war period even in events of eleventh of February in 2011. Therefore, the cost index will be most effective for the firm when the situation of country is stable.
6. With respect to modern techniques of preliminary estimate, from the relevant persons' answers, the analysis shows that the mean was **3**, which is less than the mean average **(5)**, Furthermore, with referring to the field study results that found the respondents' answers were less than the mean average. As well, it was discussed in the preliminary estimate; further, it would be focused on the artificial neural network wordiness due to usage in quantitative model for preliminary estimate. It is important that the neural network is used as a modern technique simulating the human brain. It was a new knowledge for relevant persons in construction management field. Uses

of ANN, its structure, methods of learning, method of test, and how to collect data for ANN were explained and discussed many times.

7. With respect to measurements, from the relevant persons' answers, the analysis shows that the mean was **4.4**, which is slightly less than the mean average **(5)**, which refers that they didn't know how to measure some items of construction projects. Nonetheless, with referring to the field study results that found the respondents' answers were more than average, which indicates most of respondents have knowledge about the measurements. As it was described in the models development section (7.2.3), the author had focused on the components of construction items' measurements through discussion and examples. This was led the relevant persons to develop their ability to measure and calculate the quantities effectively and efficiency due to their answers for a few problems of measurements.
8. With respect to review bid documents for making query list, from the relevant persons' answers the analysis shows that the mean was **3.5**, which is less than the mean average **(5)**, which refers that they might confuse a little about the review the bid documents in this position. Furthermore, with referring to the field study results that found the respondents' answers were more than average. Therefore, after reviewing the process of query in Yemen, it had clear to the author this process was not active in Yemen. Thus, the relevant persons have confused about it, but the discussion with the relevant persons had removed most of ambiguous matters related to the query list as well as they believed that the query list is important for estimators.

On the other hand, the author advised the relevant persons to read the literature review and the development models to enhance their knowledge about the cost estimate and the study's models. As well, some specific books were suggested to read and understand in order to develop their abilities in estimate to be beyond the local estimators. In this stage, the patience of relevant persons and their commitment to attend, discuss, and follow the instruction of the author; it has given the author push toward giving everything the author has possessed.

7.5.5.2 Stage two of improvement plan

Stage two was concerned about practice the two models (quantitative and qualitative); further, this stage has divided into two divisions; the first, which was the quantitative model that was ANN model and represented the preliminary estimate in order to be performed by the NeuroSolution programme. The Second, which was the qualitative model, represented the detailed estimate.

Firstly, the quantitative model was obtained for the preliminary estimate, so it was begun with it to practice. After the first division had finished, the relevant persons gained more knowledge about the ANN technique, and they were able to use computer's programme to perform their estimate easily and accurately. To put first step, the NeuroSolution programme was defined and explained its benefits for estimators and its importance for other forecasting field such as (marketing, concrete structure, business, etc.).

The cost form that was used to collect data about the finished projects in order to use in ANN model, was explained. Furthermore, the variables of ANN were also discussed and determined according to the model. In this moment, the relevant persons were able to collect the required data from any client in order to give him the preliminary estimate. Then, the programme was given to the relevant persons by the author and was set-up in their computers devices. Moreover, the following were learned by the relevant persons through the author:

- Constraints of model,
- Data encoding,
- Data set,
- ANN model building,
- ANN model training,
- Model test,
- Performance measures, and
- Sensitivity test.

The last points passed through several training and practices using the NeuroSolution programme. It was used the exemplars, which was collected from the social development fund as well as the targeted project was also obtained from the social development fund in order to forecast its final cost and comparing with its real final cost see table (7.18).

The results of analysis was perfect and predicted the cost estimate taking slightly time yielding accurate result. The relevant persons were impressed and happy to gain this technique.

Table 7.18 Shows the results of ANN model.

Project type	Real final cost ($)	Estimated cost ($)	Error percentage
Health centre	168525.83	169128.792	% 0.35

Source: case study

Of prime importance, the perfect results depend on the exemplars may be the same type as possible, as well as the large No. of exemplars lead to a perfect training. In addition, the exemplars should be represented stable market's period as possible as available.

Secondly, the qualitative model consists of two models; KCE model that one of detailed estimate model variable. The KCE was enhanced in the first stage as well as in the development model. In addition, the components of qualitative model to produce detailed estimate were discussed in the development model that was used to teach the relevant persons the model basics. This led to generate many questions by the relevant persons; those questions were answered and supported with examples and tutorials.

At the beginning, it was looked taking long time to prepare the base estimate; but when the relevant persons were familiar with the process and understanding the requirements that should be available at estimate period. Then, it was easy for them to prepare the most important documents with regards the specific project.

From the example, which was used to prepare the preliminary estimate, it was considered as a final detailed estimate as well as it was compared its real estimate with the output cost by ANN model. Moreover, the hypothesis H9, which was confirmed by the analysis test, it was also supported here. That means there is a relationship between the quantitative model and qualitative model; they can be used to compare each other's results.

7.6 Summary

In this chapter, the model development was debated according to KCE model variables and detailed cost estimate's variables. The information of knowledge that represented KCE model variables and detailed cost estimate's variables formulated a solid base with the models of this study to enhance the abilities of the estimators through knowledge and practices. This process was through several discussion for increasing the literatures of estimation's knowledge and a given examples for calculations, or providing with important statistical tables which can be used by estimators aligned with models. The evaluations of firm that would be the case study of this study were debated in order to how evaluate its weakness areas. The evaluation was done by the evaluation tool, which designed according to 77 factors representing the practices and knowledge of cost estimate.

After the weakness areas would be diagnosed and determined, the improvement plan would be formulated in order to overcome those weaknesses. Improvement plan was designed to achieve three objectives and affected by external factors such as understanding the current situation of firm in Yemen, firm resources, etc. Case study was done in order to produce a real example to apply the models of this study; therefore, the selected firm was in Hodeida province and was ranked as a medium firm. After the approval was got from the top management, the evaluation was done. The weakness eight-targeted areas were determined and the improvement plan was discussed with the relevant persons who would involve in case study process. It was decision; the improvement plan would be divided into two stages to achieve the objectives of improvement plan. First stage was done through discussion and lectures to enhance the weakness areas of knowledge, which was achieved in the end of the first stage. The second stage was to practice both models quantitative (ANN) and qualitative model (detailed estimate) through lectures, discussion, and practices. After the stage two was finished, the relevant persons had ability to use the ANN model to estimate their projects through collecting data, encoding, build the model, training, testing, and predicting as well as the ANN model appeared its capability to estimate the detailed estimate for finished project perfectly. The relevant persons also gained the ability to prepare the important documents for detailed estimate and uses model to estimate their projects systemically. Finally, the fourth question and the fifth question were answered.

CHAPTER VIII: CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

This chapter provides conclusions about the more effective factors and variables that affect the knowledge of cost estimate, preliminary estimate, and detailed estimate in Yemen according to the field survey as well as the effect of hypotheses, which appeared statistically in this study according to the respondents' answers. Furthermore, general recommendations suggest some solutions and suggestions to improve the weakness with regards the conclusions. As well, future research's recommendations suggest expanding the model to be more effectiveness and efficiency. Limitations of this study also debate the surrounding limitation in this study.

8.2 Conclusions

Several conclusions have been drawn from this study as the following:

1- The knowledge of cost estimate in construction science is defined; the first objective is achieved.
2- The quantitative model (ANN) and the qualitative model (detailed estimate) for early stage and tender stage are obtained; the second objective of this study is achieved.
3- The instrument of this study is reliable and valid; it can be used to measure the knowledge of cost estimate, preliminary estimate, and detailed estimate.
4- The variable ‘‘Construction cost classification’’ mean is 3.57, which is slightly higher than the mean average (**3**); thus, more knowledge is required to understand the cost classification.
5- According to the field study, the ‘‘Cost estimation methods and techniques’’ mean is 3.92, which is greater than the mean average (3); so these techniques and methods aren’t mastered.
6- The ‘‘Types of contracts and delivery systems’’ mean is 3.92, which is greater than the mean average (3); the knowledge of contracts types and delivery systems is more than average for Yemenis’ estimators.
7- Most important, the “critical factors” mean is 3.61, which is slightly higher than the mean average (**3**); the Yemenis’ estimators’ don’t understand these factors.
8- Because ‘‘Safety considerations’’ has mean 2.37, which is less than the mean average (3); knowledge and practice of safety considerations are bad in Yemeni’s construction field.
9- “Cost index” mean is 2.51, which is less the mean average (3); the knowledge is poor.
10- The level of knowledge of cost estimate between Yemenis’ engineers is average.
11- The KCE model is capable to evaluate and improve the knowledge of engineers with regard to cost estimate; the root of weakness can be diagnosed.
12- Base estimate process mean is 3.62, which is slightly higher than the mean average (3); it isn’t good enough to improve the estimate in Yemenis’ firm.
13- Query process has mean 3.62, which is slightly higher than the mean average (3); this process is poor practice in construction field in Yemen.

14- Pricing process mean is 3.82, which is slightly higher than the mean average (3); this process affects negatively the accuracy of estimate.

15- A detailed cost estimate (qualitative model) is capable to guide the estimators to estimate their projects accurately and systematically.

16- A case study reveals that the development model can support the knowledge of estimators as well as the practices of the qualitative model.

17- The social and economic system of Yemen has not a positive effect on knowledge of cost estimate according to the statistical test's result, which doesn't conflict with the theory of this study and reality.

18- Understanding the Cost control process has not a positive effect on knowledge of cost estimate according to the statistical test's result, which doesn't conflict with the theory of this study and reality.

19- Bid summary has not a positive effect on final detailed cost according to the statistical test's result, which doesn't conflict with the theory of this study and reality.

20- knowledge of construction cost estimate has not a positive effect on final detailed cost according to the statistical test's result, which doesn't conflict with the theory of this study and reality.

21- Understanding of construction cost classification has a positive effect on knowledge of cost estimate.

22- Construction cost estimation methods and techniques have a positive effect on knowledge of cost estimate.

23- Understanding the types of contracts and delivery systems has a positive effect on knowledge of cost estimate.

24- Understanding the critical factors has a positive effect on knowledge of cost estimate.

25- Understanding the safety considerations has a positive effect on knowledge of cost estimate.

26- Cost index has a positive effect on knowledge of cost estimate.

27- Base estimate has a positive effect on detailed cost estimation.

28- Correct way of measurements has a positive effect on final detailed cost.

29- Measurements have a positive effect on pricing process.

30- Query list has a positive effect on pricing process.

31- Pricing process has a positive effect on management review's process.

32- Management review's process has a positive effect on bid summary.

33- Knowledge of construction cost estimate has a positive effect on management review's process.

34- Knowledge of construction cost estimate has a positive effect on base estimate.
35- Knowledge of construction cost estimate has a positive effect on Measurements.
36- Knowledge of construction cost estimate has a positive effect on pricing.
37- The ANN model (quantitative model) has percentage error that doesn't exceeds 1; this model is more capable for estimating the preliminary estimate in Yemen.
38- Case study points out that the preliminary model can measure the detailed estimate output model with small error.

8.3 General Recommendations

Some recommendations are suggested by the author as following:

1- With respect to KCE model variables, it is recommended that the firms to enhance the knowledge of cost estimate through several trainings for their estimators.
2- With respect to base estimate, it is recommended that the firms to establish workshop to define the most important documents, and how to use them in estimate process.
3- With respect to query process, it is recommended that the firms to activate this process to be formal within the estimate process; query provides more clear insight to estimate confidently.
4- With respect to pricing process, it is recommended that the firms to use the chick list to price everything systematically; check list provides time and accurate steps for pricing exactly general expenses.
5- With respect to qualitative model, it is recommended that the firms to use this model to ensure a highly accurate estimate through following the model steps, using also the model's development to support the model in order to get the most perfection state of model.
6- With respect to quantitative model, it is recommended that the firms to use ANN model and any sophisticated programme to enhance their estimate performance.

8.4 Recommendations for Future Researches

Recommendations for future research include:

1- Expanding the models to cover factors that weren't discussed within model.
2- Examine the KCE variables' effect on the independent variables of detailed estimate separately.

8.5 Limitations of this Study

This research has completed with limitations in its study in Yemen. The data was gathered from 70 construction firms from both Hodeida and Sana'a provinces; thus, the most effective way to expand this study in other provinces of Yemen by other researchers. The period of collecting data and performing the case study was in the war period which was affected the process of this study surely. If the situation were good, the collect data would be from wide large samples.

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APPENDIX 1

The factors (items) of operationalisation of this study.

Variable	**Factors (items)**
Social and economic system	GDP
	national income per capita
	Tribal system
Construction cost classification	variable cost
	fixed cost
	Risk allowance (Contingency
Cost estimation methods and techniques	Conceptual and preliminary estimate
	Detailed estimate
	Definitive estimate
	Qualitative technique
	Quantitative technique
	Preliminary and detailed cost estimation methods
Types of contracts and delivery systems	Design- Bid- Build
	Construction management delivery
	Design- Build Delivery
	Lump-Sum Contracts
	Cost- Plus Contracts
	Unit- Price Contracts
Critical factors	Complexity of the project
	Time of construction
	Project type
	Material costs changes
	Quality of the work
	Market conditions
	Management factors
	Geographic considerations
	Insufficient time for estimate development
	inadequate specification
	incomplete drawings
	quality of project management;
	Lack of site feedback
	a lack of confidence in structured site feedback
	technological requirements
	project information
	project team requirement,
	contract requirements
	project duration

	political situation
	financial status of the owner
	tender currency
	experience of consultant engineer
	number of competitors
	evaluate political risks
	evaluate regulatory risks
	Quantity Allowance
	Escalation
	Evaluate the risks
	Fees
Cost control process	Cost control
	Earned value technique
Safety considerations	no safety consideration
Cost index	Cost index
Preliminary estimate	Traditional Cost Estimation
	Analogical cost estimation techniques
	Fuzzy logic systems
	Parametric estimating models
	Artificial Neural Network
	complexity
	project type
	Floor area
	Storeys No.
	Type of foundation
	Number of elevators
	Slab Type
	Type of external finishing
	interior decoration
	Type of HVAC system
	Tiles type
	Type of electricity works
	Type of mechanical works
	basement floor
	Floor height
	Site area
	project location
Base estimate	Scope baseline
	Resource calendars
	Project schedule
	Human resource plan
	Risk register
	Enterprise environmental factors
	Organizational process assets
Measurements	Project items quantities

	Jobsite Overhead
	Surety Bonds, Insurance, and Taxes
	General Overhead, Contingencies, and Profit)
Query	Site Visit
	The query list
Pricing	Pricing Construction Equipment
	Pricing construction project items
	Pricing subcontractors' work
	Pricing general expenses
Management review	Management Review
Bid summary	Bid summary
Final Detailed cost	Final detailed cost

APPENDIX 2

1- English questionnaire version

Sudan University of Science &Technology

College of Architecture and planning

"A Qualitative and quantitative models of cost estimate in Yemeni's construction projects"

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Ph.D. student

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Objectives: construction performance data questionnaire

Most of researchers consensus that the estimate is vital and crucial in construction project in matter of success and failure. The estimators may be the heart of the construction firms in which to improve the performance of the firms. The role of estimators should be supported by a wide knowledge about construction cost. From the last point, the knowledge has a lot of branches to be investigated in this study to support the Yemeni estimators to raise their professionally. In addition, the preliminary estimate which in this questionnaire targets the clients' desire when the project in the zero point and has not sufficient information. Another important issue has been investigated in this study, the detailed estimate in the tender stage in order to evaluate and improve it.

The data collected through this questioners, will be used only for the subject above PhD. The successful completion of the work will depend on your full co-operation and answering the questions below. We appreciate your help, giving us your valuable time, thank.

Part A: General Information:

I) Personal Data (optional)

Name of person filing the questionnaire: ………………………………...

Name of Company: …………………………...……….....

Position :………………………………………..

1) a) Type of firm (if exist):

Public sector	Private sector	Semi-private	Other specify

b) Scope of Work:

Consultants	Contractors	Both	Other specify

2) Experience of Company in Years:

Less than 5 years	5-10 years	11- 20	more than 21

3) Educational level of respondents:

Post graduated	Graduate	Deploma

4) Fixed assets of the company:

Less than $50,000	50,000-100,000 $	100,000-500,000 $	More than 500,000$	Other specify

<u>Part B:</u> An engineering's opinion of acquiring and having the construction cost knowledge in their firms.

Each question in this section refers to the knowledge of construction cost which has to be known professionally.
Please indicate your action to each concept by ticking one number (one box) on a 5-point scale, which range from 1 to –5.

Sample of the scale (to indicate agreement)

Strongly Agree	Agree	Uncertainty	Disagree or Undecided	Strongly Disagree
5	4 √	3	2	1

II) Subject Matters

Scale 1: Social and economic system

No	factors	Str. Agree				Str. Disagree
.1	GDP has strongly effects on our projects and construction industry.	5	4	3	2	1
.2	Our project performance is affected by National income per capita.	5	4	3	2	1
.3	The project progress is affected by the tribal system.	5	4	3	2	1

Scale 2: Construction cost classification

No	factors	Str. Agree				Str. Disagree
.1	We know all variable cost (direct cost) of construction.	5	4	3	2	1
.2	We know all fixed cost (indirect cost) of construction.	5	4	3	2	1
.3	We have a wide knowledge about risk allowances of construction projects.	5	4	3	2	1

Scale 3: Cost estimation methods and techniques

No	factors	Str. Agree				Str. Disagree
.1	Conceptual and Preliminary estimate is used to estimate projects at the early stage.	5	4	3	2	1
.2	At the tender stage, we use the detailed estimate.	5	4	3	2	1
.3	In the end of the project, the definitive estimate is used.	5	4	3	2	1
.4	We estimate our projects by qualitative technique which depending on the historical data and estimators' experience.	5	4	3	2	1
.5	Quantitative technique which is analogy (similarities between projects), parametric variables, or detailed approach is used to estimate our projects.	5	4	3	2	1
.6	We use the two types of preliminary and detailed estimate methods	5	4	3	2	1

Scale 4: Types of contracts and delivery systems

No	factors	Str. Agree				Str. Disagree
.1	Projects are obtained by design-bid-build traditional delivery system.	5	4	3	2	1
.2	Projects are obtained by Construction management delivery system.	5	4	3	2	1
.3	We design our projects and execute them.	5	4	3	2	1
.4	Lump-sum contract is used in our projects.	5	4	3	2	1
.5	Cost -plus contract is used in our projects.	5	4	3	2	1
.6	Unit- price contract is used in our projects.	5	4	3	2	1

Scale 5: Critical factors

No	factors	Str. Agree				Str. Disagree
.1	Complexity of the project is a fundamental factor of project's cost estimate.	5	4	3	2	1
.2	We put in our mind the time of construction when estimate our projects.	5	4	3	2	1
.3	Project type has important effect on estimate process.	5	4	3	2	1

.4	We suffer from material cost changes in and after estimating process.	5	4	3	2	1
.5	The cost estimate is affected by quality of the work.	5	4	3	2	1
.6	The market conditions is taken into consideration when estimate projects.	5	4	3	2	1
.7	Management factors are considered into our projects' cost estimate.	5	4	3	2	1
.8	The geographical considerations have the priority when estimate projects' cost.	5	4	3	2	1
.9	We don't have enough time for estimating our projects.	5	4	3	2	1
10	We suffer from inadequate specification at the cost estimate process	5	4	3	2	1
11	We suffer from incomplete drawings at the cost estimate process.	5	4	3	2	1
12	Our firm has high level quality of project management which controlling the estimate process very well.	5	4	3	2	1
13	Our firm doesn't have enough historical cost data from our past projects.	5	4	3	2	1
14	We don't suffer from lack of site feedback.	5	4	3	2	1
15	Technological requirements are very important factor in cost estimate process.	5	4	3	2	1
16	We have insufficient project information at cost estimate process.	5	4	3	2	1
17	All project team requirements aren't available at cost estimate process.	5	4	3	2	1
18	Contract requirements are available at cost estimate process.	5	4	3	2	1
19	We take into consideration the project duration at cost estimate process.	5	4	3	2	1
20	We suffer from political situation in and after estimate.	5	4	3	2	1
21	Our firm puts in its eyes the owner's financial status at cost estimate process.	5	4	3	2	1
22	Tender's currency is very important factors at cost estimate process.	5	4	3	2	1
23	We have a good feedback from the consultant in estimate process.	5	4	3	2	1
24	Competitors give us a promotion to improve our cost estimate.	5	4	3	2	1
25	We suggest and evaluate the political risks at cost estimate process.	5	4	3	2	1
26	We suggest and evaluate the regulatory risks at cost estimate process.	5	4	3	2	1
27	Our firm adds the quantity allowances when measuring our project quantities.	5	4	3	2	1
28	We take into consideration the escalation at estimate process.	5	4	3	2	1
29	We estimate and evaluate the potential risks at cost estimate process.	5	4	3	2	1

30	We take into consideration the formal fees at cost estimate process.	5	4	3	2	1

Scale 6: Cost control process

No	factors	Str. Agree				Str. Disagree
.1	We know the process of cost control and monitoring.	5	4	3	2	1
.2	Earned Value technique is used to control and monitor the cost.	5	4	3	2	1

Scale 7: Safety considerations

No	factors	Str. Agree				Str. Disagree
.1	We don't take into consideration the safety requirements when we estimate our projects.	5	4	3	2	1

Scale 8: Cost index

No	factors	Str. Agree				Str. Disagree
.1	Our firm use the construction cost indexes in estimate process.	5	4	3	2	1

<u>Part C:</u> Preliminary estimate at early stage

Scale 9: Preliminary estimate

No	factors	Str. Agree				Str. Disagree
.1	We use the traditional estimate methods (the square meter price-cube meter, etc.) to estimate cost at early stage.	5	4	3	2	1
.2	We use analogical cost estimate technique.	5	4	3	2	1
.3	We use Fuzzy logic systems.	5	4	3	2	1
.4	We use Parametric estimating models.	5	4	3	2	1
.5	We use Artificial Neural Network.	5	4	3	2	1
.6	At preliminary estimate, the complexity is very important factor.	5	4	3	2	1
.7	At preliminary estimate, the project type is very important factor.	5	4	3	2	1
.8	At preliminary estimate, the floor area is very important factor.	5	4	3	2	1
.9	At preliminary estimate, the No. of storeys is very important factor.	5	4	3	2	1
10	At preliminary estimate, the type of foundation is very important factor.	5	4	3	2	1
11	At preliminary estimate, the No. of elevators is very important factor.	5	4	3	2	1

12	At preliminary estimate, the type of slabs is very important factor.	5	4	3	2	1
13	At preliminary estimate, the type of external finishing is very important factor.	5	4	3	2	1
14	At preliminary estimate, the interior decoration is very important factor.	5	4	3	2	1
15	At preliminary estimate, the type of HVAC system is very important factor.	5	4	3	2	1
16	At preliminary estimate, the type of tilling is very important factor.	5	4	3	2	1
17	At preliminary estimate, the type of electricity works is very important factor.	5	4	3	2	1
18	At preliminary estimate, the type of mechanical works is very important factor.	5	4	3	2	1
19	At preliminary estimate, the basement floor is very important factor.	5	4	3	2	1
20	At preliminary estimate, the floor height is very important factor.	5	4	3	2	1
21	At preliminary estimate, the site area is very important factor.	5	4	3	2	1
22	At preliminary estimate, the project location is very important factor.	5	4	3	2	1

Part D: Detailed estimate at tender stage

Scale 10: Base estimate

No	factors	Str. Agree				Str. Disagree
.1	We prepare scope baseline (scope statement, WBS, & dictionary of WBS).	5	4	3	2	1
.2	Our firm prepares Resource calendars	5	4	3	2	1
.3	We use Project schedule in cost estimate process.	5	4	3	2	1
.4	We use human resource plan in cost estimate process.	5	4	3	2	1
.5	We study the risk register at cost estimate process.	5	4	3	2	1
.6	We study the Enterprise environmental factors at cost estimate process.	5	4	3	2	1
.7	We study the Organizational process assets (policies, templates, historical data, etc.) at cost estimate process.	5	4	3	2	1

Scale 11: Measurement

No	factors	Str. Agree				Str. Disagree
.1	We measure all the items' quantities of construction project.	5	4	3	2	1
.2	We measure and determine the jobsite overheads	5	4	3	2	1
.3	We determine the Surety Bonds, Insurance, and Taxes	5	4	3	2	1
.4	We determine the General Overhead, Contingencies, and Profit.	5	4	3	2	1

Scale 12: Query

No	factors	Str. Agree				Str. Disagree
.1	We visit and investigate the site (access, topography, services, etc.)	5	4	3	2	1
.2	We prepare the query list with ambiguous issues and submit to consultant.	5	4	3	2	1

Scale 13: Pricing

No	factors	Str. Agree				Str. Disagree
.1	We price all construction equipment (own or rent).	5	4	3	2	1
.2	We price all construction projects' items.	5	4	3	2	1
.3	We price all subcontractors' works.	5	4	3	2	1
.4	We determine price for all general expenses.	5	4	3	2	1

Scale 14: Management review

No	factors	Str. Agree				Str. Disagree
.1	Our top managers review the estimate process	5	4	3	2	1

Scale 15: Bid summary

No	factors	Str. Agree				Str. Disagree
.1	We summarise the cost estimate process for bidding.	5	4	3	2	1

Scale 16: Final detailed cost

No	factors	Str. Agree				Str. Disagree
.1	There is no difference between the estimation and the final cost of our projects.	5	4	3	2	1

Remark: Your answer will be treated confidentially, and will be used for academic purposes. Thank you for your corporation

Student: Waled Gaber M.

Supervisor: Dr. Awad Saad Hassn
Co-supervisor:Dr. Adil Abdalla M.

2- Arabic questionnaire version

جامعة السودان للعلوم والتكنولوجيا

كلية العمارة والتخطيط

قسم الهندسة المعمارية

النموذج الوصفي والكمي لتقدير تكلفة مشاريع التشييد في اليمن

وليد جابر محمد حكمي*

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الأهداف: استبيان عن المعلومات المتعلقة بتقدير التكاليف لمشاريع التشييد

أجمع الكثير من الباحثين على أن عملية التقدير عملية حيوية وحاسمة في مشاريع التشييد فيما يتعلق بمسألة نجاح وفشل المشروع. كما أن مقدري تكاليف المشاريع يعتبرون قلب شركات التشييد والذين لهم الأثر الأكبر في تحسين أداء شركاتهم. هذه الوظيفة المهمة يجب أن تدعم بمعرفة واسعة حول تكاليف التشييد. ومما سبق، فإن هذه المعرفة تحتوي على عدة فروع ستدرس وتحقق في هذه الدراسة لدعم ورفع كفاءة مقدري التكاليف اليمنيين. بالإضافة إلى أن التقدير المبدئي في هذه الاستبانة يهدف إلى تحقيق رغبة العميل عندما يكون المشروع في نقطة الصفر ولا توجد معلومات كافية عنه. علاوة على ذلك، فهناك قضية أخرى مهمة ستدرس وتحقق في هذه الدراسة وهي التقدير التفصيلي في مرحلة العطاء من أجل تقييمه وتحسينه.

وبالتالي، فإن البيانات التي ستجمع من هذه الاستبانة، ستستخدم لموضوع الدراسة أعلاه.

لذلك، النجاح في انجاز هذا العمل سيعتمد على كامل تعاونك واجابتك على جميع الأسئلة أدناه. نقدر لك مساعدتنا واعطائنا وقتك الثمين، وشكراً.

القسم الأول: المعلومات العامة

أ. المعلومات الشخصية (اختياري)

الاسم:..

اسم الشركة:...

الموقع الوظيفي:..

5) نوع الشركة (*إن وجدت*)

القطاع العام	القطاع الخاص	عام/خاص	أخرى

6) نطاق العمل

استشاري	مقاول	كلاهما	أخرى

7) الخبرة بالسنوات

أقل من 5سنوات	5-10 سنوات	10-20 سنوات	20 سنة أو اكثر

8) المستوى التعليمي

دراسات عليا	جامعي	دبلوم

9) أصول الشركة

أقل من 50000$	50000-100000$	100000-500000$	أكثر من 500000$	أخرى

القسم الثاني: رأي المهندس حول اكتساب وامتلاك المعرفة الضرورية في تكاليف التشييد.

كل سؤال في هذا القسم يشير إلى المعرفة الضرورية في تكاليف التشييد والتي يجب أن تكون معروفة. فنرجو اعطائنا رأيك من خلال وضع علامة √ في المربع المناسب بحسب الأهمية لـ 5 نقاط من 1الى 5 .

نموذج للمقياس (بحسب درجة الموافقة)

لا أوافق بشدة	لا أوافق	محايد	اوافق	أوافق بشدة
1	√ 2	3	4	5

ب. المواضيع الأساسية

المقياس 1: النظام الاجتماعي والاقتصادي

الرقم	العوامل	لا اوافق بشدة ← ... → أوافق بشدة
.1	الناتج القومي المحلي (GDP) يؤثر بشدة على مشاريعنا وصناعة التشييد	1 | 2 | 3 | 4 | 5
.2	يتأثر أداء مشاريعنا بالدخل القومي للفرد	1 | 2 | 3 | 4 | 5
.3	يتأثر سير المشروع سلبا بسبب النظام القبلي للمنطقة	1 | 2 | 3 | 4 | 5

المقياس 2: تصنيف تكاليف التشييد

الرقم	العوامل	لا اوافق بشدة				أوافق بشدة
.1	لدينا معرفة بكل أنواع التكاليف المتغيرة (Direct cost).	1	2	3	4	5
.2	لدينا معرفة بكل أنواع التكاليف الثابتة (Indirect cost).	1	2	3	4	5
.3	لدينا معرفة واسعة حول بدلات المخاطر لمشاريع التشييد.	1	2	3	4	5

المقياس 3: طرق وتقنيات تقدير التكاليف

الرقم	العوامل	لا اوافق بشدة				أوافق بشدة
.1	نستخدم التقدير المبدئي لتقدير التكاليف في المرحلة المبكرة للمشروع.	1	2	3	4	5
.2	نقدر تكاليف المشاريع بشكل تفصيلي في مرحلة العطاء.	1	2	3	4	5
.3	نقدر التكاليف النهائية للمشروع (Definitive estimate) عند انتهاءه.	1	2	3	4	5
.4	نقدر تكاليف مشاريعنا بالتقدير النوعي (Qualitative) معتمدين على خبرة المقدر والمعلومات المكتسبة من المشاريع السابقة.	1	2	3	4	5
.5	نقدر تكاليف مشاريعنا بالتقدير الكمي (Quantitative) معتمدين على درجة التشابه بين المشاريع (Analogy)، والمتغيرات الكمية (Parametric)، او التقدير المفصل (Detailed).	1	2	3	4	5
.6	نستخدم التقدير المبدئي للمرحلة المبكرة من المشروع والتقدير المفصل لمرحلة اعداد العطاء.	1	2	3	4	5

المقياس 4: أنواع العقود وأنظمة تسليم المشاريع

الرقم	العوامل	لا اوافق بشدة				أوافق بشدة
.1	نكسب عطاء المشروع كاملا لمرحلة البناء (Design-Bid-Build)	1	2	3	4	5
.2	نكسب العطاء لمرحلة معينة من المشروع (Construction management delivery).	1	2	3	4	5
.3	نقوم بالتصميم والتنفيذ لأغلب مشاريعنا (Design-Build Delivery).	1	2	3	4	5
.4	نتعاقد بعقود الثمن الكلي (Lump-Sum).	1	2	3	4	5
.5	نتعاقد بعقود التكلفة مع نسبة استرداد المصروفات (Cost-Plus).	1	2	3	4	5
.6	نتعاقد بعقود ثمن الوحدة (Unit-Price).	1	2	3	4	5

المقياس 5:العوامل الحرجة

الرقم	العوامل	لا اوافق بشدة				أوافق بشدة
.1	نضع في اعتبارنا عند تقدير تكلفة مشاريعنا درجة التعقيد للمشروع.	1	2	3	4	5
.2	نضع في اعتبارنا زمن التشييد عند تقدير تكلفة مشاريعنا.	1	2	3	4	5

الرقم	العوامل	لا اوافق بشدة ←		بشدة		أوافق →
.3	نوع المشروع يؤثر على عملية تقدير التكلفة.	1	2	3	4	5
.4	نعاني من تغيرات مفاجئة في اسعار المواد عند تقدير تكلفة مشاريعنا وبعدها.	1	2	3	4	5
.5	عامل الجودة له اعتبار مهم عند تقدير تكلفة مشاريعنا.	1	2	3	4	5
.6	الظروف السوقية تأخذ في الاعتبار عند تقدير تكاليف مشاريعنا.	1	2	3	4	5
.7	نهتم بالجوانب الادارية في عملية تقدير تكاليف مشاريعنا.	1	2	3	4	5
.8	موقع المشروع له اولوية عند حساب تكلفة مشاريعنا.	1	2	3	4	5
.9	نعاني من شُح الوقت عند تقدير تكلفة مشاريعنا.	1	2	3	4	5
10	نواجه عدم كفاية المواصفات عند تقدير تكلفة مشاريعنا.	1	2	3	4	5
11	نواجه عدم اكتمال الرسومات عند تقدير تكلفة مشاريعنا.	1	2	3	4	5
12	شركتنا لديها ادارة ذات كفاءة عالية تتحكم في تقدير تكلفة المشاريع.	1	2	3	4	5
13	نعاني من شُح معلومات المشاريع السابقة عند تقدير التكاليف.	1	2	3	4	5
14	لا نعاني من نقص التغذية الراجعة من الموقع.	1	2	3	4	5
15	المتطلبات التكنولوجية عامل مهم في عملية تقدير تكلفة المشاريع.	1	2	3	4	5
16	نعاني من قلة المعلومات المتوفرة عن المشروع عند تقدير التكلفة.	1	2	3	4	5
17	لا تتوفر لدينا كل متطلبات فريق المشروع عند تقدير التكاليف.	1	2	3	4	5
18	تتوفر لدينا كل متطلبات العقد عند تقدير التكاليف.	1	2	3	4	5
19	نضع في الاعتبار فترة انجاز المشروع عند تقدير التكاليف.	1	2	3	4	5
20	نعاني من الأوضاع السياسية عند وبعد تقدير التكاليف.	1	2	3	4	5
21	شركتنا تضع نصب عينيها الوضع المالي للعميل عند تقدير التكاليف.	1	2	3	4	5
22	نوع عملة العطاء عامل مهم عند تقدير التكاليف.	1	2	3	4	5
23	يجيب الاستشاري عن الكثير من تساؤلاتنا عند تقدير التكاليف.	1	2	3	4	5
24	نُحسِّن عملية تقدير تكاليف مشاريعنا كلما زاد عدد منافسونا.	1	2	3	4	5
25	نُخمن ونقيم المخاطر السياسية عند تقدير تكاليف المشاريع.	1	2	3	4	5
26	نُخمن ونقيم مخاطر الأنظمة والتشريعات عند تقدير تكاليف المشاريع.	1	2	3	4	5
27	نقوم بحساب الفاقد في الكميات عند تقدير التكاليف.	1	2	3	4	5
28	نضع في اعتبارنا تضخم الاسعار عند تقدير تكاليف المشروع.	1	2	3	4	5
29	عند تقدير تكاليف مشاريعنا لا نهمل جميع المخاطر المحتملة.	1	2	3	4	5

الرقم	العوامل	لا اوافق بشدة 1	2	3	4	أوافق بشدة 5
30	نأخذ في الاعتبار جميع أنواع الرسوم المفروضة عند تقدير التكاليف.	1	2	3	4	5

المقياس 6:عملية التحكم بالتكلفة

الرقم	العوامل	لا اوافق بشدة 1	2	3	4	أوافق بشدة 5
.1	لدينا معرفة كاملة بعملية مراقبة التكلفة والتحكم بها.	1	2	3	4	5
.2	نتحكم ونراقب التكلفة بتقنية القيمة المكتسبة (Earned Value).	1	2	3	4	5

المقياس 7: الاعتبارات الأمنية

الرقم	العوامل	لا اوافق بشدة 1	2	3	4	أوافق بشدة 5
.1	لا نأخذ في الاعتبار متطلبات الأمن والسلامة عند تقدير التكاليف.	1	2	3	4	5

المقياس 8: مؤشر التكلفة

الرقم	العوامل	لا اوافق بشدة 1	2	3	4	أوافق بشدة 5
.1	نستخدم مؤشرات التكلفة (Cost index) عند تقدير تكاليف المشاريع.	1	2	3	4	5

القسم الثالث: التقدير المبدئي للمشروع في المرحلة المبكرة

المقياس 9: التقدير المبدئي

الرقم	العوامل	لا اوافق بشدة 1	2	3	4	أوافق بشدة 5
.1	نستخدم الطرق التقليدية (سعر المتر المربع-المتر المكعب-الخ) لتقدير مشاريعنا في المرحلة المبكرة من حياة المشروع.	1	2	3	4	5
.2	نستخدم الطريقة التناظرية (Analogical) في تقدير تكلفة المشاريع.	1	2	3	4	5
.3	نستخدم تقنية المنطق المبهم (Fuzzy logic) عند تقدير التكاليف.	1	2	3	4	5
.4	نستخدم الموديلات البارا مترية (Parametric) عند تقدير التكاليف.	1	2	3	4	5
.5	نستخدم تقنية الشبكة العصبية الاصطناعية (Artificial Neural Network) عند تقدير التكاليف.	1	2	3	4	5
.6	عند تقدير التكاليف في المرحلة المبكرة لا نهمل درجة تعقيد المشروع.	1	2	3	4	5
.7	نوع المبنى عامل أساسي عند تقدير التكلفة في المرحلة المبكرة للمشروع.	1	2	3	4	5

الرقم	العوامل	لا اوافق بشدة ⟶		بشدة		أوافق ⟵
.8	مساحة الطابق عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.9	عدد الطوابق عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.10	نوع الاساس عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.11	عدد المصاعد عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.12	نوع البلاطة عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.13	نوع التشطيبات الخارجية عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.14	نوع الديكور عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.15	نوع نظام التكييف عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.16	نوع البلاط عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.17	نوع التجهيزات الكهربائية عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.18	نوع التجهيزات الميكانيكية عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.19	نأخذ في الاعتبار البدروم كعامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.20	ارتفاع الطابق عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.21	مساحة الموقع عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5
.22	موقع المشروع عامل أساسي عند تقدير تكلفة المشروع في المرحلة المبكرة.	1	2	3	4	5

القسم الرابع: **التقدير التفصيلي في مرحلة العطاء**

المقياس 10: خط الأساس

الرقم	العوامل	لا اوافق بشدة ⟶		بشدة		أوافق ⟵
.1	نقوم بإعداد وثائق خط اساس النطاق (Scope baseline) وكل ما يحتويه من البيان (statement)، هيكل تجزئة العمل (WBS)، قاموس هيكل تجزئة العمل.	1	2	3	4	5
.2	نقوم بإعداد هيكلة موارد المشروع.	1	2	3	4	5
.3	نستخدم الجدول الزمني للمشروع عند تقدير التكاليف.	1	2	3	4	5
.4	نستخدم خطة الموارد البشرية للمشروع عند تقدير التكاليف.	1	2	3	4	5
.5	ندرس سجل المخاطر عند تقدير التكاليف للمشروع.	1	2	3	4	5
.6	ندرس العوامل البيئية المؤثرة في المشروع عند تقدير التكاليف.	1	2	3	4	5

لا اوافق بشدة — أوافق بشدة

الرقم	العوامل	1	2	3	4	5
7.	ندرس أصول العملية التنظيمية من سياسات وقوالب ومعلومات تاريخية ودروس مستفادة عند تقدير التكاليف.	1	2	3	4	5

المقياس 11: قياس الكميات

لا اوافق بشدة — أوافق بشدة

الرقم	العوامل	1	2	3	4	5
1.	نقوم بحساب كميات جميع بنود اعمال مشروع التشييد.	1	2	3	4	5
2.	نقوم بتحديد النفقات العامة لأعمال الموقع.	1	2	3	4	5
3.	نقوم بتحديد كافة سندات الضمان والتأمينات والضرائب.	1	2	3	4	5
4.	نقوم بتحديد كافة النفقات العامة ونفقات الطوارئ والارباح.	1	2	3	4	5

المقياس 12: الاستعلام

لا اوافق بشدة — أوافق بشدة

الرقم	العوامل	1	2	3	4	5
1.	نقوم بزيارة الموقع ودراسته (طرق الوصول، الخدمات، الطبوغرافية، الخ).	1	2	3	4	5
2.	نقوم بإعداد قائمة بالمواضيع المبهمة لتقديمها للاستشاري بعد دراسة الوثائق وزيارة الموقع.	1	2	3	4	5

المقياس 13: التسعير

لا اوافق بشدة — أوافق بشدة

الرقم	العوامل	1	2	3	4	5
1.	نقوم بتسعير معدات التشييد الخاصة والمؤجرة.	1	2	3	4	5
2.	نقوم بتسعير جميع بنود اعمال مشروع التشييد.	1	2	3	4	5
3.	نقوم بتسعير أعمال مقاولي الباطن.	1	2	3	4	5
4.	نقوم بتسعير جميع الاعمال الغير رئيسية كنفقات عامة.	1	2	3	4	5

المقياس 14: المراجعة الإدارية

لا اوافق بشدة — أوافق بشدة

الرقم	العوامل	1	2	3	4	5
1.	تقوم الادارة بمراجعة عملية التقدير.		2	3	4	5

المقياس 15: خلاصة العطاء

لا اوافق بشدة — أوافق بشدة

الرقم	العوامل	1	2	3	4	5
1.	نقوم بعمل ملخص بكافة التكاليف لعملية العطاء.	1	2	3	4	5

المقياس 16: التكلفة التقديرية المفصلة

5	4	3	2	1	العوامل	الرقم
أوافق بشدة ←				لا اوافق بشدة →		
					تقديرات تكلفة مشاريعنا تطابق التكلفة النهائية للمشروعات.	1.

ملاحظة: معلوماتك سوف تعامل بسرية تامة, و تستخدم للأغراض الأكاديمية فقط.

"شكرا لتعاونكم"

APPENDIX 3

1- English version of cost form

Cost form to determine the implemented projects cost for the subject below PhD

A Qualitative –quantitative models of cost estimate in construction projects in Yemen

Waled Gaber M.

PhD. Student

Pleas, complete the gab with the proper information, and put √ in front of the right choice?

1. Project type: Administration commercial educational residential mosques health centre
2. Projects' complex degree: Complex normal
3. Site area: …………….m^2
4. Project position: Mountain coastal desert
5. Floor area: ………………..m^2
6. Storeys No.:
7. Floor height:
8. Type of foundation: Pad strip raft piles
9. Slab type: Drop beams hollow block flat
10. No. of elevators:
11. Interior decoration: Basic Luxury
12. Type of external finishing: None normal plaster stones aluminium cladding
13. Type of HVAC: None window split central
14. Tiles type: Ceramic terrazzo Porcelain granite
15. Type of electricity works: Basic Luxury
16. Type of mechanical works: Basic Luxury
17. Basement: Exist not exist
18. Year of finish:
19. The final cost:

Remark: Your information will be treated confidentially, and will be used for academic purposes. Thank you for your corporation

2- Arabic version of cost form

استمارة تحديد تكاليف المشاريع السابقة لموضوع الدكتوراه أدناه

النموذج الوصفي والكمي لتقدير تكلفة مشاريع التشييد في اليمن

وليد جابر محمد حكمي

طالب دكتوراه

أكمل الفراغ بالمعلومة المناسبة، وضع ايضا علامة √ أمام الاختيار المناسب؟

1. نوع المشروع: اداري تجاري تعليمي سكني مساجد صحي
2. درجة تعقيد المشروع: عادي معقد
3. مساحة الموقع: ....م^2.
4. موقع المشروع: منطقة جبلية ساحلية صحراوية
5. مساحة الطابق:........................ م^2.
6. عدد الطوابق:
7. ارتفاع الطابق:
8. نوع الأساس: منفصلة شريطية لبشة خوازيق
9. نوع البلاطة: بلاطة مع جسور بلاطة بلوكات مفرغة بلاطة مسطحة
10. عدد المصاعد:
11. نوع التصميم الداخلي: عادي فاخر
12. نوع التشطيب الخارجي: لا يوجد لياسة عادية حجارة الواح المونيوم
13. نوع التكييف: لايوجد وحدات شباك وحدات منفصلة مركزي
14. نوع البلاط: سيراميك ترازو بورساين جرانيت
15. نوع النظام الكهربائي: عادي فاخر
16. نوع الصرف الصحي: عادي فاخر
17. البدروم: يوجد لا يوجد

18.عام الانتهاء:

19.التكلفة الفعلية للمشروع:

ملاحظة: معلوماتك سوف تعامل بسرية تامة، و تستخدم للاغراض الأكاديمية فقط

"شكراً لتعاونكم"

APPENDIX 4

Analysis for mean of factors and scales.

Scale	Factors	Factor's Mean	Scale's Mean	Scale's average
Social and economic system	GDP	3.7	3.49	**3**
	national income per capita	3.52		**3**
	Tribal system	3.25		**3**
Construction cost classification	variable cost	3.36	3.57	**3**
	fixed cost	3.78		**3**
Cost estimation methods and techniques	Conceptual and preliminary estimate	4.14	3.92	**3**
	Definitive estimate	3.71		**3**
Types of contracts and delivery systems	Design- Bid- Build	3.81	3.56	**3**
	Design- Build Delivery	3.36		**3**
	Lump-Sum Contracts	3.53		**3**
Critical factors	Time of construction	4.48	3.69	**3**
	Project type	4.38		**3**
	Material costs changes	4.28		**3**
	Quality of the work	4.47		**3**
	Market conditions	4.00		**3**
	Management factors	3.61		**3**
	Geographic considerations	4.61		**3**
	Insufficient time for estimate development	3.31		**3**
	inadequate specification	3.08		**3**
	incomplete drawings	3.08		**3**
	Lack of site feedback	1.98		**3**
	technological requirements	3.91		**3**

	project information	2.8		**3**
	contract requirements	2.15		**3**
	project duration	4.22		**3**
	political situation	4.12		**3**
	financial status of the owner	3.77		**3**
	tender currency	4.01		**3**
	experience of consultant engineer	3.95		**3**
	number of competitors	3.51		**3**
	evaluate political risks	3.38		**3**
	evaluate regulatory risks	3.34		**3**
	Quantity Allowance	3.54		**3**
	Escalation	3.78		**3**
	Evaluate the risks	3.74		**3**
	Fees	4.08		**3**
Cost control process	Cost control	3.61	3.46	**3**
	Earned value technique	3.31		**3**
Safety considerations	no safety consideration	2.37	2.37	**3**
Cost index	Cost index	2.51	2.51	**3**
Preliminary estimate	Traditional Cost Estimation	4.34	3.76	**3**
	Analogical cost estimation techniques	3.13		**3**
	Fuzzy logic systems	2.62		**3**
	Parametric estimating models	2.9		**3**
	Artificial Neural Network	2.33		**3**
	complexity	4.13		**3**
	project type	4.14		**3**
	Floor area	4.42		**3**
	Storeys No.	4.53		**3**
	Type of foundation	4.63		**3**
	Number of elevators	4.2		**3**
	Slab Type	4.27		**3**
	Type of external finishing	4.47		**3**
	interior decoration	4.3		**3**
	Type of HVAC system	4.24		**3**
	Tiles type	3.97		**3**
	Type of electricity works	4.06		**3**

	Type of mechanical works	3.97		**3**
	Floor height	3.89		**3**
	Site area	4.36		**3**
Base estimate	Scope baseline	2.91	3.62	**3**
	Resource calendars	3.52		**3**
	Project schedule	4.07		**3**
	Human resource plan	3.72		**3**
	Risk register	3.74		**3**
	Enterprise environmental factors	4.00		**3**
	Organizational process assets	3.37		**3**
Measurements	Project items quantities	4.61	4.20	**3**
	Jobsite Overhead	4.14		**3**
	Surety Bonds, Insurance, and Taxes	3.87		**3**
Query	Site Visit	4.46	4.38	**3**
	The query list	4.30		**3**
Pricing	Pricing Construction Equipment	3.91	3.82	**3**
	Pricing construction project items	4.42		**3**
	Pricing subcontractors' work	3.42		**3**
	Pricing general expenses	3.54		**3**
Management review	Management Review	4.10	4.10	**3**
Bid summary	Bid summary	4.32	4.32	**3**
Final Detailed cost	Final detailed cost	3.45	3.45	**3**

APPENDIX 5

The Construction Specifications Institute and Construction Specifications Canada (2016, April)

MasterForm

00 00 00 Procurement and Contracting Requirements

00 01 01 Project Title Page

00 01 03 Project Directory

00 01 05 Certifications Page

00 01 07 Seals Page

00 01 10 Table of Contents

00 01 15 List of Drawing Sheets

00 01 20 List of Schedules

00 10 00 Solicitation

00 11 00 Advertisements and Invitations

00 11 13 Advertisement for Bids

00 11 15 Advertisement for Prequalification of Bidders

00 11 16 Invitation to Bid

00 11 19 Request for Proposal

00 11 53 Request for Qualifications

00 20 00 Instructions for Procurement

00 21 00 Instructions

00 21 13 Instructions to Bidders

00 21 16 Instructions to Proposers

00 22 00 Supplementary Instructions

00 22 13 Supplementary Instructions to Bidders

00 22 16 Supplementary Instructions to Proposers

00 23 00 Procurement Definitions

00 24 00 Procurement Scopes

00 24 13 Scopes of Bids

00 24 13.13 Scopes of Bids (Multiple Contracts)

00 24 13.16 Scopes of Bids (Multiple-Prime Contract)

00 24 16 Scopes of Proposals

00 24 16.13 Scopes of Proposals (Multiple Contracts)

00 24 16.16 Scopes of Proposals (Multiple-Prime Contract)

00 25 00 Procurement Meetings

00 25 13 Pre-Bid Meetings

00 25 16 Pre-Proposal Meetings

00 26 00 Procurement Substitution Procedures

00 30 00 Available Information

00 31 00 Available Project Information

00 31 13 Preliminary Schedules

00 31 13.13 Preliminary Project Schedule

00 31 13.16 Preliminary Construction Schedule

00 31 13.23 Preliminary Project Phases

00 31 13.26 Preliminary Project Sequencing

00 31 13.33 Preliminary Project Milestones

00 31 16 Project Budget Information

00 31 19 Existing Condition Information

00 31 19.13 Movement and Vibration Information

00 31 19.16 Acoustic Information

00 31 19.19 Traffic Information

00 31 19.23 Existing Structural Information

00 31 21 Survey Information

00 31 21.13 Site Survey Information

00 31 21.16 Measured Drawing Information

00 31 21.19 Photographic Information

00 31 24 Environmental Assessment Information

00 31 24.13 Soil Contamination Report

00 31 24.23 Environmental Impact Study Report

00 31 24.26 Environmental Impact Report Evaluation

00 31 24.29 Record of Environmental Impact Decision

00 31 24.33 Environmental Impact Mitigation Report

00 31 25 Existing Material Information

00 31 25.16 Existing Concrete Information

00 31 25.19 Existing Masonry Information

00 31 25.23 Existing Metals Information

00 31 25.26 Existing Wood, Plastics, and Composites Information

00 31 25.29 Existing Thermal and Moisture Protection Information

00 31 26 Existing Hazardous Material Information

00 31 26.23 Existing Asbestos Information

00 31 26.26 Existing Lead Information

00 31 26.29 Existing Polychlorinate Biphenyl Information

00 31 26.33 Existing Mold Information

00 31 26.36 Existing Hazardous Waste Drum Information

00 31 31 Geophysical Data

00 31 31.13 Seismic Investigations Information

00 31 31.16 Gravity Investigations Information

00 31 31.19 Magnetic Investigations Information

00 31 31.23 Electromagnetic Investigations Information

00 31 31.26 Electrical Resistivity Investigations Information

00 31 31.29 Magnetotelluric Investigations Information

00 31 32 Geotechnical Data

00 31 32.13 Subsurface Drilling and Sampling Information

00 31 32.16 Material Testing Information

00 31 32.19 Exploratory Excavation Information

00 31 32.23 Geotechnical Monitoring Information

00 31 43 Permit Application

00 31 46 Permits

APPENDIX 6

Example of scope statement

Scope Statement for The Northumbria Building Centre (sample)

The scope statement is an agreement among the project team, the project sponsor and key stakeholders. It represents a common understanding of the project for the purpose of facilitating communication among the stakeholders and for setting authorities and limits for the project manager and team. The scope statement includes relating the project to business objectives, and defining the boundaries of the project in multiple dimensions including approach, deliverables, milestones, and budget.

Scope Statement

01/12/11 Page 2 of 13

Scope Statement JSB Construction

Table of Contents

A. Executive Summary

This project is concerned with the design of the building to house Northumbria Building Centre Ltd.

Deliverables included:

- Client Brief
- Feasibility Report
- Energy Strategy Report
- BREEAM Pre-Assessment

 Outline Proposals (Drawings)

 Design Stage Submissions (Drawings)

 Energy Statement

Scope:

 Space Heating

 Mechanical Ventilation

 Air Conditioning

 Electrical Installation and Lighting

 Water Services and Drainage

Costs: The anticipated budget for the M&E and renewable components of the project is £1,100 000.00

Time: Expected possession date – June 2012. The Building will need to be finished and ready for its opening 18 months after possession. Completion date Christmas 2013.

B. Business Objectives

The Northumbria Building Centre will also support the Trust's core aims and objectives by providing a long needed centre in the north-east of England for the display of materials, products and equipment for the building, construction and building services industries. The Trustees also wish that the building be an example of good building practice and showcase the use of renewable energy and sustainable practices.

The Centre will be located on land provided by the University of Newcastle-upon-Tyne. It will incorporate a library for manufacturers' and suppliers' literature and will have a comprehensive information retrieval system based on the latest information technology techniques for the research and location of materials, products and equipment both from the UK and overseas.

The Centre will also provide facilities for promotional launches, special exhibitions and demonstrations and will also be able to host lectures, conferences and other events for local organisations and professional bodies.

There will also be an educational element to its activities which will provide programmes for schools and colleges.

The Centre must therefore provide accommodation for displays, storage and study of the exhibits and information and, of course, facilities for visitors.

The Centre should attract local residents, members of the building, construction and building services professions, educational groups and be a venue for courses, conferences and seminars. The business plan forecasts visitor levels in the first year to be about 10,000 annually, with about 1,300 a month during the summer rising to 30-50,000 annually after five years.

1. Business Need/Opportunity/Objectives

Over the last two years the Trust has experienced a reduced level of income, due primarily to poor performance of the investment portfolio and a reduction in charitable donations. To counteract this decline in income the Governors have decided to use money from the trust to create a wholly owned trading subsidiary, the Northumbria Building Centre Ltd: the trust will own 100% of the shares in NBC Ltd, and NBC Ltd will contribute to the Trust via the Gift Aid Scheme.

2. Product Description (Solution)

This project is concerned with the design of the building to house Northumbria Building Centre Ltd.

3. Deliverables

Deliverables included:

- Client Brief
- Feasibility Report
- Energy Strategy Report
- BREEAM Pre-Assessment
- Outline Proposals (Drawings)
- Design Stage Submissions (Drawings)
- Energy Statement

Exclusions:

- Implementation of the new service
- Implementation of the feasibility study recommendations
- Maintenance of the new system

C. Project Description

1. Scope

Includes:

- Space Heating
- Mechanical Ventilation
- Air Conditioning
- Electrical Installation and Lighting
- Water Services and Drainage

2. Completion Criteria

We will communicate our designs using Sketch Layout and Sketch Schematic drawings.

Where space is constrained, co-ordinate drawings (plan and section) will be produced to demonstrate that the systems will fit.

3. Risk Assessment

A full CDM Risk Assessment shall accompany the design package.

The health and safety at work act 1974 will apply.

The working at height regulations will apply.

The Construction (Design and Management) Regulations 2007 will apply.

Workplace health, safety and welfare. Workplace (Health, Safety and Welfare) Regulations 1992 will apply.

The project is notifiable and an F10 shall be prepared and issued by the Contactor who may employ a suitably qualified health and safety consultant.

4. Constraints

Costs: The anticipated budget for the M&E and renewable components of the project is £1,100 000.00

Time: Expected possession date – June 2012. The Building will need to be finished and ready for its opening 18 months after possession. Completion date Christmas 2013.

Space: An outline design has been produced by the architect to meet the Client's spatial requirements.

Occupancy: The normal and expected occupancy is as follows:

3 Office staff, 1 receptionist, 2 kitchen staff (1 part time for events), 2 workshop staff (1 part time for events) and 1 member of staff for the display area. The normal working hours for the staff being 9am to 5pm from Monday to Friday and 8am to 10am weekdays for the cleaner.

The canteen will have a seating capacity of 40 people while maximum occupancy will be 250 people at any one time.

Ventilation: A survey of the site has revealed that due to noise and air pollution it would not be practicable to use natural ventilation and therefore the building will have sealed, glazing units and air conditioning. However some form of natural ventilation may still be possible and shall be researched.

Legal: The Client is unaware of any restrictions or regulations in place by the local council on planning as far as renewable energy systems to new builds are concerned.

1. The structural design is final.
2. No arboriculture report has been made.
3. There is no soil report nor are there bore hole samples.
4. There are no special supply chains or manufacturers that the client wishes to adhere to.

5. The Client wishes both SBD and DDA guides/standards to be applied.

6. No less than 20% renewable technology is to be used in order to achieve a good BREEAM rating.

5. Roles and Project Stakeholders

Roles

The following role definitions are being applied to the resources assigned to this project:

Project Sponsor Provides executive team approval and sponsorship for the project. Has budget ownership for the project and is the major stakeholder and recipient for the project deliverables.

Project Owner Provides policy definition to the Project team. Resolves all policy issues with the appropriate policy owners in order to provide a clear, decisive definition. Makes final decisions and resolves conflicts or issues regarding project expectations across organizational and functional areas. The project owner and the project manager have a direct link for all communication. The project manager will work directly with the project owner on all policy clarification.

Project Manager Provides overall management to the project. Accountable for establishing a Project Charter, developing and managing the work plan, securing appropriate resources and delegating the work and insuring successful completion of the project. All project team members report to the project manager. Handles all project administrative duties, interfaces to project sponsors and owners and has overall accountability for the project.

Steering

Committee

Provide assistance in resolving issues that arise beyond the project manager's jurisdiction. Monitor project progress and provide necessary tools and support when milestones are in jeopardy.

Stakeholder Key provider of requirements and recipient of project deliverable and associated benefits. Deliverable will directly enhance the stakeholders' business processes and environment. Majority of stakeholders for this project will be agency heads, CIO's and project management representatives.

Team Member Working project team member who analyzes, designs and ultimately improves or replaces the business processes. This includes collaborating with teams to develop high level process designs and models, understanding best practices for business processes and partnering with team members to identify appropriate opportunities, challenging the old rules of the business and stimulating creating thinking, and identifying organizational impact areas.

Project Team

- Project manager
- Architect
- Structural Engineer
- Suppliers
- Utilities
- Contractors
- Local authorities
- Government agencies
- Consultants

Stakeholders

Negative stakeholders	Significant	Some	Little	None
Significant	Client Sponsor Project manager Project Team Project office Contractors Subcontractors Suppliers Consultants Management Site Personnel End Users			
Some	Disgruntled end user Pressure groups Competitors	Press (media) Families Accounts Dept HR dept Banks Politicians Residents' associations Local authorities Government agencies Technical departments Utilities Insurers Unions		
Little	Disgruntled employees			

D. Project Approach

Planned Approach

The project will follow a traditional path, with no phasing requirements. The main Contractor will undertake all works except for pre-approved sub-contractors and specialists.

E. Project Estimates

1. Estimated Schedule

Key Project milestones relative to project start are as follows:

Project Milestones Target Date

Project Start June 2012

Project Completion December 2013

2. Estimated Cost

Expense	Original Budget	Current Budget	Spent to Date	Est. to Complete	Current Forecast	Variance
Electrical						
Lighting	£102,000.00					
Small Power	£86,250.00					
Photovoltaics	£138,000.00					
Security	£57,500.00					
Emergency Lighting	£34,500.00					
Telecommunications	£46,000.00					
Mechanical						
Water services	£63,250.00					
Waste	£28,750.00					
Rainwater	£17,250.00					

3 Checkpoint/ Funding Schedule

□ The project will be reviewed on a monthly basis with progress meetings.

□ Monthly Interim Payments shall be produced by the Contractor and a Cost Report to be issued to the Client every month detailing any project savings.

F. Project Controls

1. Weekly Team Meetings

2. Monthly Status Reports

3. Risk Management

Ensure the project risks and associated mitigation actions are monitored and controlled in accordance with the Risk Management Plan

4. Issue Management

Project-related issues will be tracked, prioritized, assigned, resolved, and communicated in accordance with the Project Management Procedures:

Issue descriptions, owners, resolution and status will be maintained on the project Blog in a standard format. Issues will be addressed with the Project Owner and communicated in the project status report.

5. Change Management

The change control procedures to be followed will be consistent with Project Management Procedures and consist of the following processes:

A Blog will be established by the project team to track all changes associated with the project effort.

All Change Requests will be assessed to determine possible alternatives and costs. Change Requests will be reviewed and approved by the project owner.

The effects of approved Change Requests on the scope and schedule of the project will be reflected in updates to the project plan.

The Blog will be updated to reflect current status of Change Requests.

6. Communication Management

The following strategies have been established to promote effective communication within and about this project:

The project team will have weekly update/status meetings to review completed tasks and determine current work priorities. Minutes will be produced from all meetings. A project blog will be established on the Internet to provide access to the project documentation by geographically dispersed project members.

G. Authorizations

The Scope Statement will be approved by:

The Project Manager

The Project Owner

The Project Sponsor

Project Changes will be approved by:

The Project Owner

Project deliverables will be approved/accepted by:

The Project Owner

The Project Sponsor

The key Stakeholders

Specific task responsibilities of project resources will be defined in the Project/work Plan.

H. Scope Statement Approval Form/Signatures

Scope Statement Approval Form

Project Name:

Project Manager:

The purpose of this document is to provide a vehicle for documenting the initial planning efforts for the project. It is used to reach a satisfactory level of mutual agreement between the project manager and the project sponsors on the objectives and scope of the project before significant resources are committed and expenses incurred.

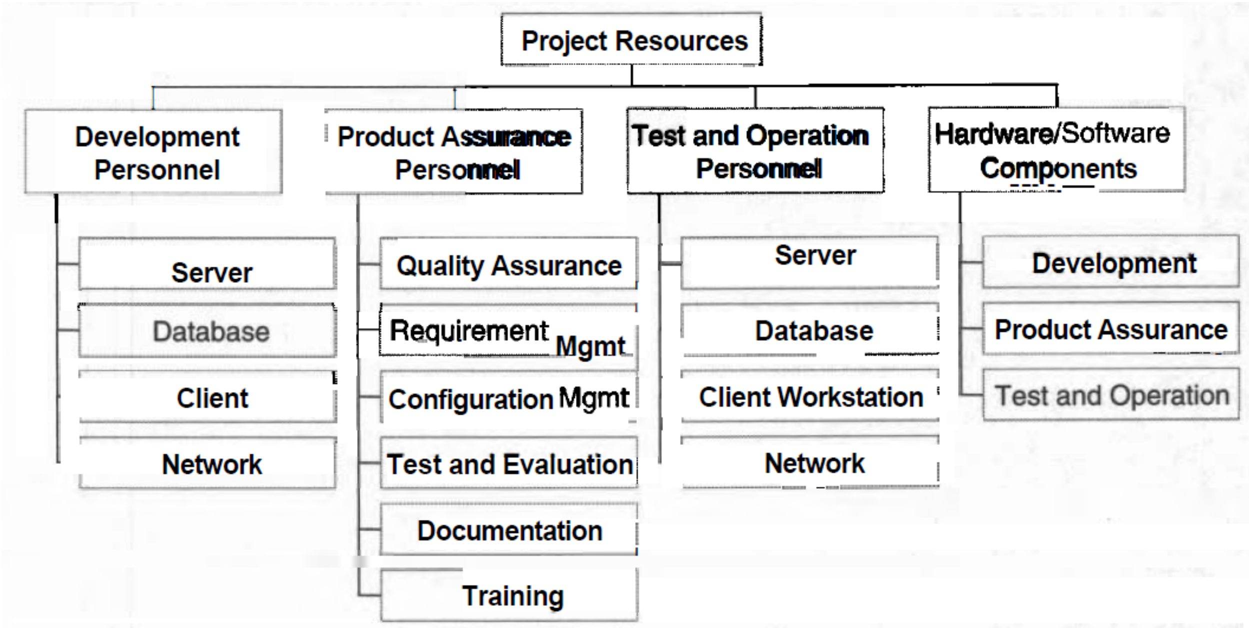
I have reviewed the information contained in this Scope Statement and agree.

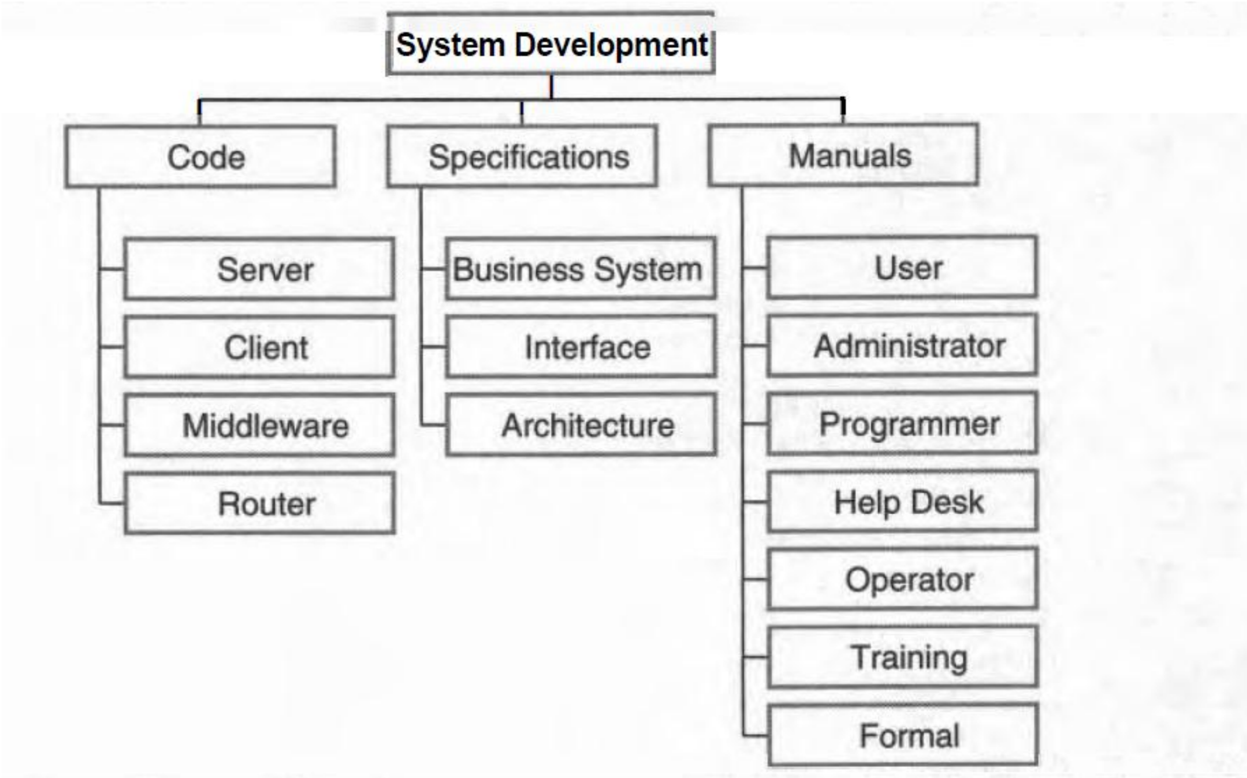
Name Signature Date

The signatures of the people above relay an understanding in the purpose and content of this document by those signing it. By signing this document you agree to this as the formal Project Scope Statement.

APPENDIX 7

Example for resource breakdown structure with WBS by rad (2002, Pp. 39-42).





WBS detailed

000 System								
	100 System Code							
		110 Server Code						
			111 Server Source Code					
			112 Server Object Code					
		120 Client Code						
			121 Client Source Code					
			122 Client Object Code					
		130 Middleware Code						
			131 Middleware Source Code					
			132 Middleware Object Code					
		140 Router Tables						
			141 Internal Routing Tables					
			142 External Routing Tables					
	200 System Specifications							
		210 Business System and Technical Design						
			211 System Requirements					
			212 System Boundary					
			213 Version Definition					
		220 Interface Design Definition						
			221 Data Interchange Requirements					
			222 Interfacing Protocols					
		230 Implementation Level Architecture						
			231 Server Architecture					

RSB sample

	Unit of Measure	Cost/Price (Dollars)
R100 Development Staff		
R110 Server Development Personnel		
R111 Systems Analyst	Staff Hour	$70
R112 Application Analyst	Staff Hour	$60
R113 Systems Programmer	Staff Hour	$50
R120 Database Development Personnel		
R121 Data Base Administrator	Staff Hour	$75
R122 Sr. Data Design Specialist	Staff Hour	$65
R123 Data Design Specialist	Staff Hour	$60
R130 Client Development Personnel		
R131 PC Systems Analyst	Staff Hour	$65
R132 PC Systems Programmer	Staff Hour	$55
R140 Network Development Personnel		
R141 Infrastructure Analyst	Staff Hour	$85
R142 Infrastructure Engineer	Staff Hour	$80
R143 Network Engineer	Staff Hour	$70
R200 Product Assurance Staff		
R210 Quality Assurance Personnel		
R211 Sr. QA Specialist	Staff Hour	$65
R212 QA Specialist	Staff Hour	$45
R220 Requirements Management Personnel		
R221 Requirements Manager	Staff Hour	$65
R222 Requirements Specialist	Staff Hour	$45
R230 Configuration Management Personne		

Element estimate

	Unit	Intensity	Duration (Days)	Total (Staff Hours)	Unit Cost	Extension
000 System						$2,426,760
100 System Code						$966,400
110 Server Code						$373,160
111 Server Source Code						$345,600
R121 Data Base Administrator	Staff Hour	1	100	800	$75	$60,000
R122 Sr. Data Design Specialist	Staff Hour	1	125	1000	$65	$65,000
R123 Data Design Specialist	Staff Hour	3	125	3000	$60	$180,000
R241 Test Manager	Staff Hour	1	10	80	$70	$5,600
R242 Sr. Test Engineer	Staff Hour	1	25	200	$65	$13,000
R243 Test Engineer	Staff Hour	1	50	400	$55	$22,000
112 Server Object Code						$27,560
R121 Data Base Administrator	Staff Hour	1	6	48	$75	$3,600
R122 Sr. Data Design Specialist	Staff Hour	1	12	96	$65	$6,240
R123 Data Design Specialist	Staff Hour	1	24	192	$60	$11,520
R231 Sr. CM Specialist	Staff Hour	1	5	40	$65	$2,600
R232 CM Specialist	Staff Hour	1	10	80	$45	$3,600
120 Client Code						$139,200
121 Client Source Code						$124,600
R131 PC Systems Analyst	Staff Hour	1	75	600	$65	$39,000
R132 PC Systems Programmer	Staff Hour	2	75	1200	$55	$66,000
R241 Test Manager	Staff Hour	1	5	40	$70	$2,800
R242 Sr. Test Engineer	Staff Hour	1	12	96	$65	$6,240
R243 Test Engineer	Staff Hour	1	24	192	$55	$10,560
122 Client Object Code						$14,600
R131 PC Systems Analyst	Staff Hour	1	6	48	$65	$3,120
R132 PC Systems Programmer	Staff Hour	1	12	96	$55	$5,280
R231 Sr. CM Specialist	Staff Hour	1	5	40	$65	$2,600
R232 CM Specialist	Staff Hour	1	10	80	$45	$3,600
130 Middleware Code						$294,040

Project resource and cost estimate – level one item

Level 1 Resource Requirements				
000 System				$2,414,360
100 System Code				$969,400
R111 Systems Analyst	Staff Hour	848	$70	$59,360
R112 Application Analyst	Staff Hour	1104	$60	$66,240
R113 Systems Programmer	Staff Hour	2136	$50	$106,800
R121 Data Base Administrator	Staff Hour	848	$75	$63,600
R122 Sr. Data Design Specialist	Staff Hour	1104	$65	$71,760
R123 Data Design Specialist	Staff Hour	3192	$60	$191,520
R131 PC Systems Analyst	Staff Hour	648	$65	$42,120
R132 PC Systems Programmer	Staff Hour	1296	$55	$71,280
R141 Infrastructure Analyst	Staff Hour	640	$85	$54,400
R142 Infrastructure Engineer	Staff Hour	640	$80	$51,200
R143 Network Engineer	Staff Hour	640	$70	$44,800
R231 Sr. CM Specialist	Staff Hour	160	$65	$10,400
R232 Configuration Managememnt Specialist	Staff Hour	200	$45	$9,000
R241 Test Manager	Staff Hour	216	$70	$15,120
R242 Sr. Test Engineer	Staff Hour	664	$65	$43,160
R243 Test Engineer	Staff Hour	1248	$55	$68,640
200 System Specifications				$775,000
R111 Systems Analyst	Staff Hour	2560	$70	$179,200
R112 Application Analyst	Staff Hour	1920	$60	$115,200
R121 Data Base Administrator	Staff Hour	320	$75	$24,000
R122 Sr. Data Design Specialist	Staff Hour	640	$65	$41,600
R123 Data Design Specialist	Staff Hour	640	$60	$38,400
R131 PC Systems Analyst	Staff Hour	320	$65	$20,800

Project resource and cost estimate – project level

Level 0 Resource Requirements				
000 System				**$2,414,360**
R111 Systems Analyst	Staff Hour	4888	$70	$342,160
R112 Application Analyst	Staff Hour	4224	$60	$253,440
R113 Systems Programmer	Staff Hour	2136	$50	$106,800
R121 Data Base Administrator	Staff Hour	1808	$75	$135,600
R122 Sr. Data Design Specialist	Staff Hour	2984	$65	$193,960
R123 Data Design Specialist	Staff Hour	4712	$60	$282,720
R131 PC Systems Analyst	Staff Hour	2448	$65	$159,120
R132 PC Systems Programmer	Staff Hour	1696	$55	$93,280
R141 Infrastructure Analyst	Staff Hour	1280	$85	$108,800
R142 Infrastructure Engineer	Staff Hour	1280	$80	$102,400
R143 Network Engineer	Staff Hour	1280	$70	$89,600
R221 Requirements Manager	Staff Hour	240	$65	$15,600
R222 Requirements Specialist	Staff Hour	320	$45	$14,400
R231 Sr. CM Specialist	Staff Hour	160	$65	$10,400
R231 Sr. Configuration Management Specialist	Staff Hour	200	$45	$9,000
R241 Test Manager	Staff Hour	216	$70	$15,120
R242 Sr. Test Engineer	Staff Hour	664	$65	$43,160
R243 Test Engineer	Staff Hour	1248	$55	$68,640
R251 Documentation Manager	Staff Hour	1088	$50	$54,400
R252 Sr. Documentation Specialist	Staff Hour	1848	$45	$83,160
R253 Documentation Specialist	Staff Hour	3640	$40	$145,600
R261 Sr. Training Specialist	Staff Hour	120	$45	$5,400

APPENDIX 8

Measurements

a- Example for Sitework measurements by Pratt (2011 a,P.p. 60-70)

Example of Sitework Takeoff (measurement with inch)

Figure 3-8a and Figure 3-8b show the takeoff for the sitework on the sample house project described on drawings shown in Figure 3-7.

Comments on the Sitework Takeoff Shown in Figure 3-8a and Figure (3-8b)

1. This particular site has no topsoil to be stripped, so the first calculation is for the depth of basement to be excavated.
2. The average ground level over the area of the house is calculated from the elevations at the four corners of the house.
3. The depth of the basement excavation will extend from the ground level over the area of the house down to the level of the underside (u/s) of the gravel below the basement slab. The elevation of the underside of the gravel is not provided on the drawings, so we have to determine it from the information given:

The elevation of top of the main floor	100'-0"
(this is indicated on the site plan)	
Less: top of foundation wall to top of sub-floor	(1'-9¾")
Less: top of footing to top of foundation wall	(7'-1¾")
Less: depth of gravel (-8")	
90'-4½"	

This is equal to 90.38 feet.

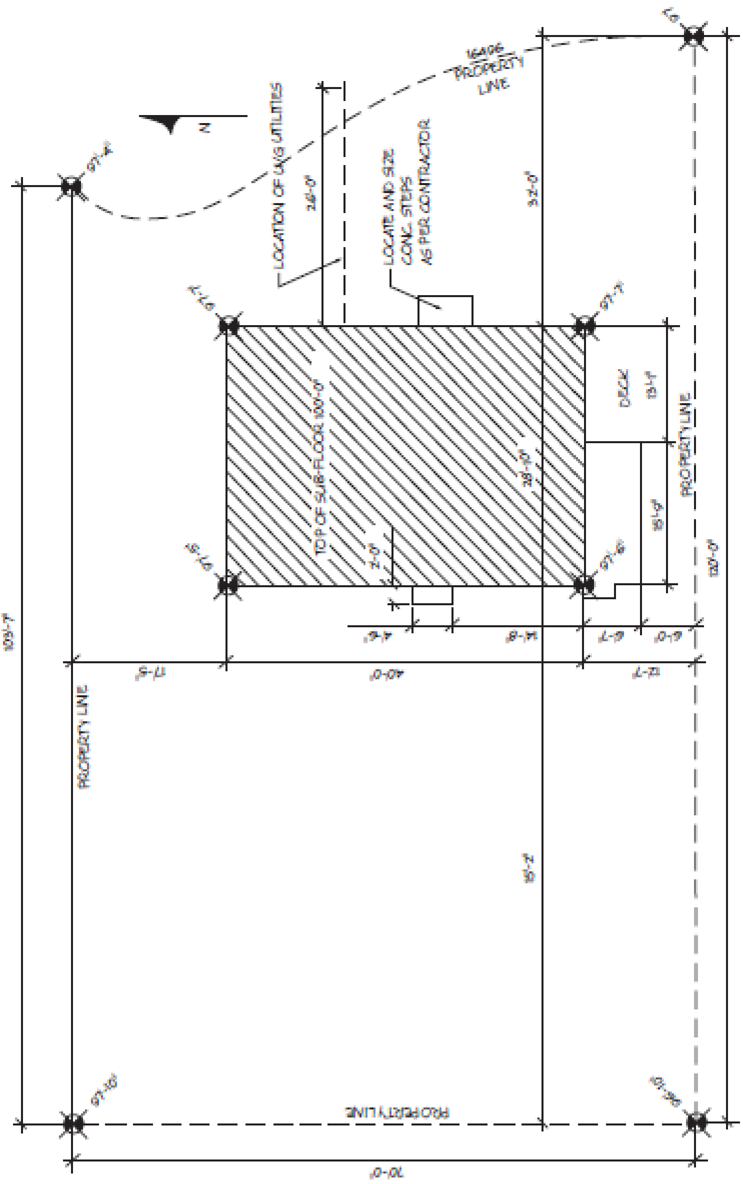

PROPERTY LINE
LOCATION OF U/G UTILITIES
LOCATE AND SIZE
CONC. STEPS
AS PER CONTRACTOR
DECK
TOP OF SUB-FLOOR 100'-0"
70'-0"
40'-0"
120'-0"

Figure (3-7)

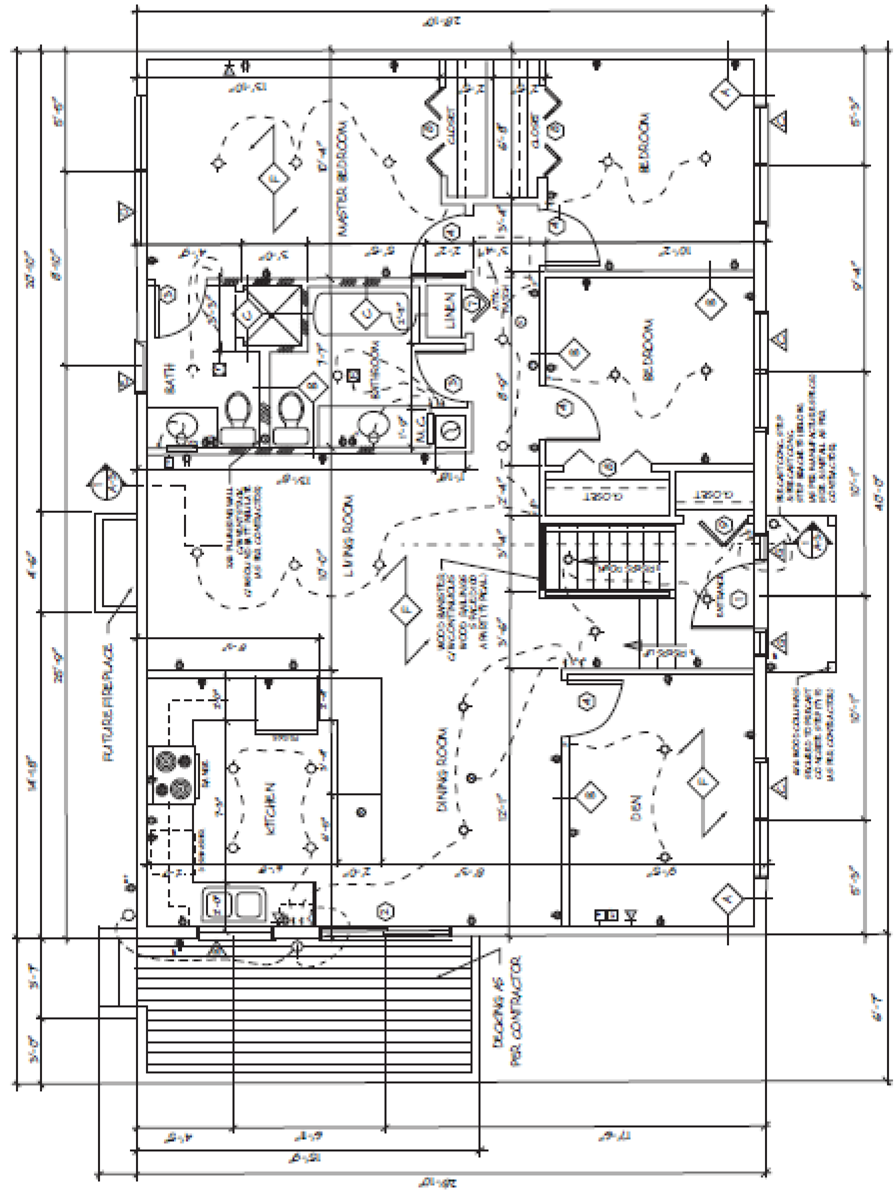


Figure (3-7) continued.

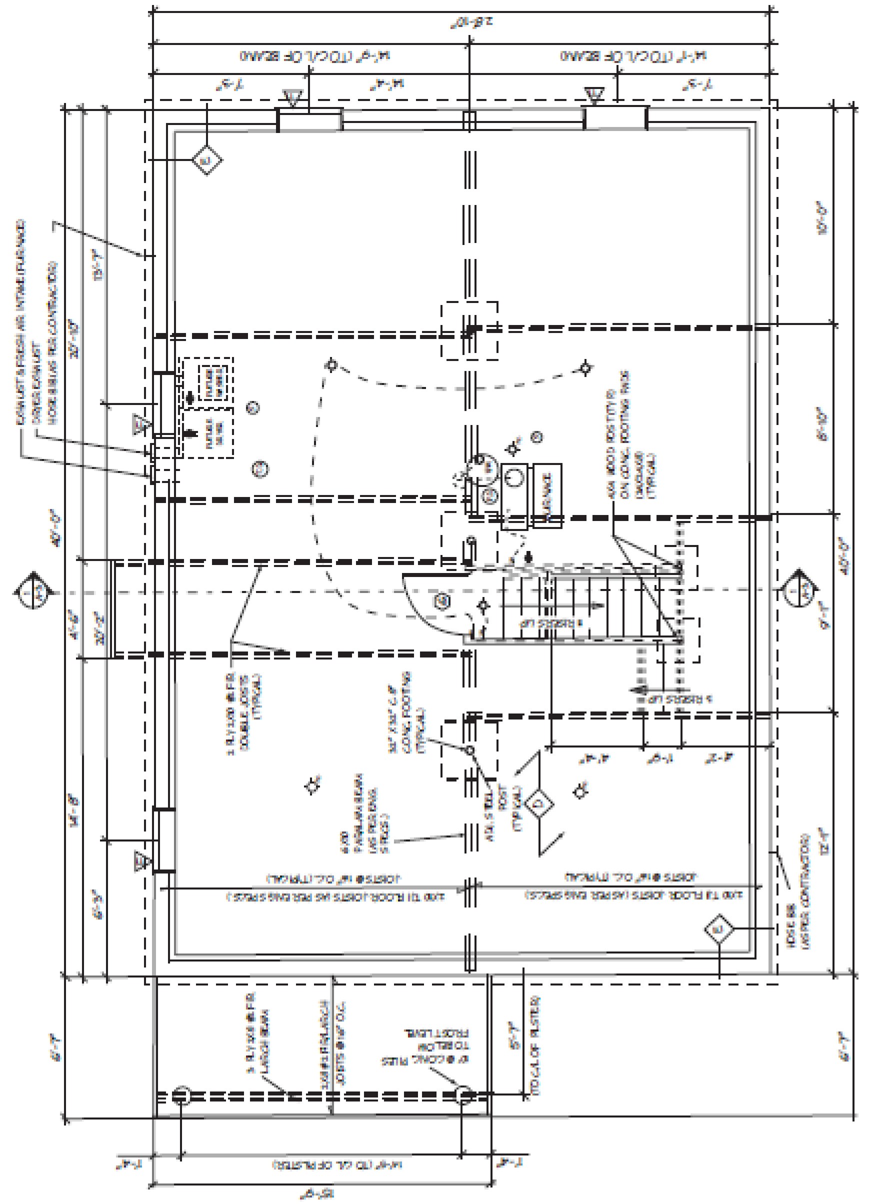


Figure (3-7) continued.

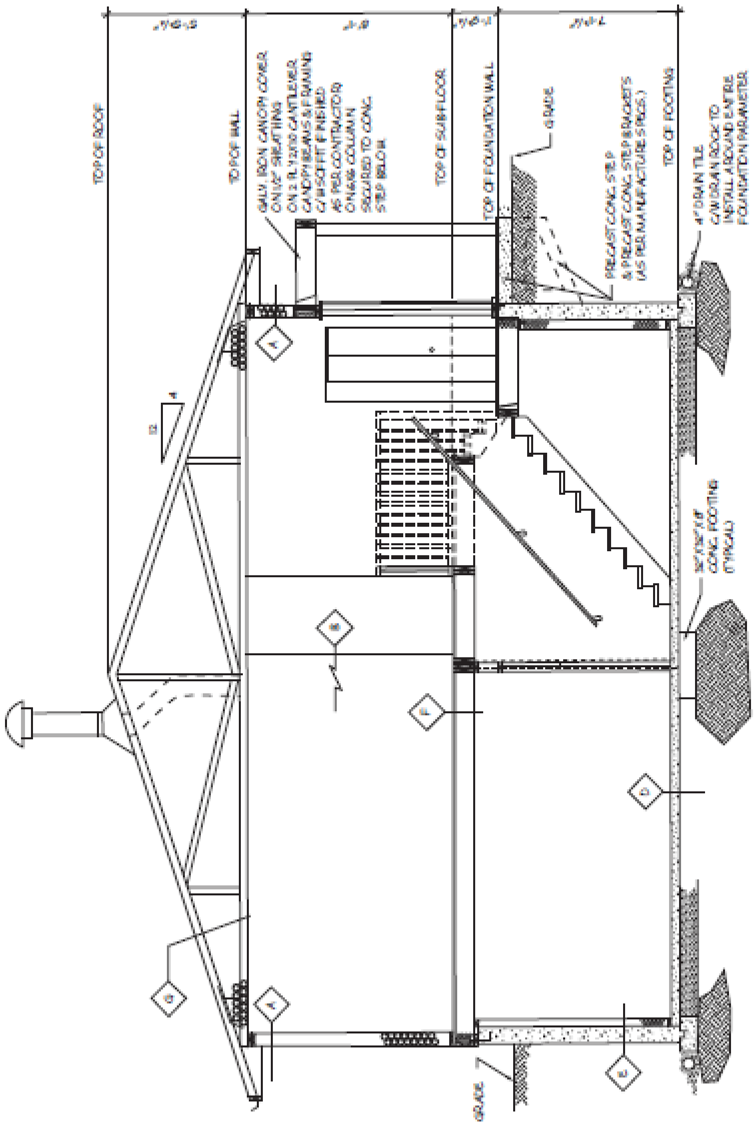


Figure (3-7) continued.

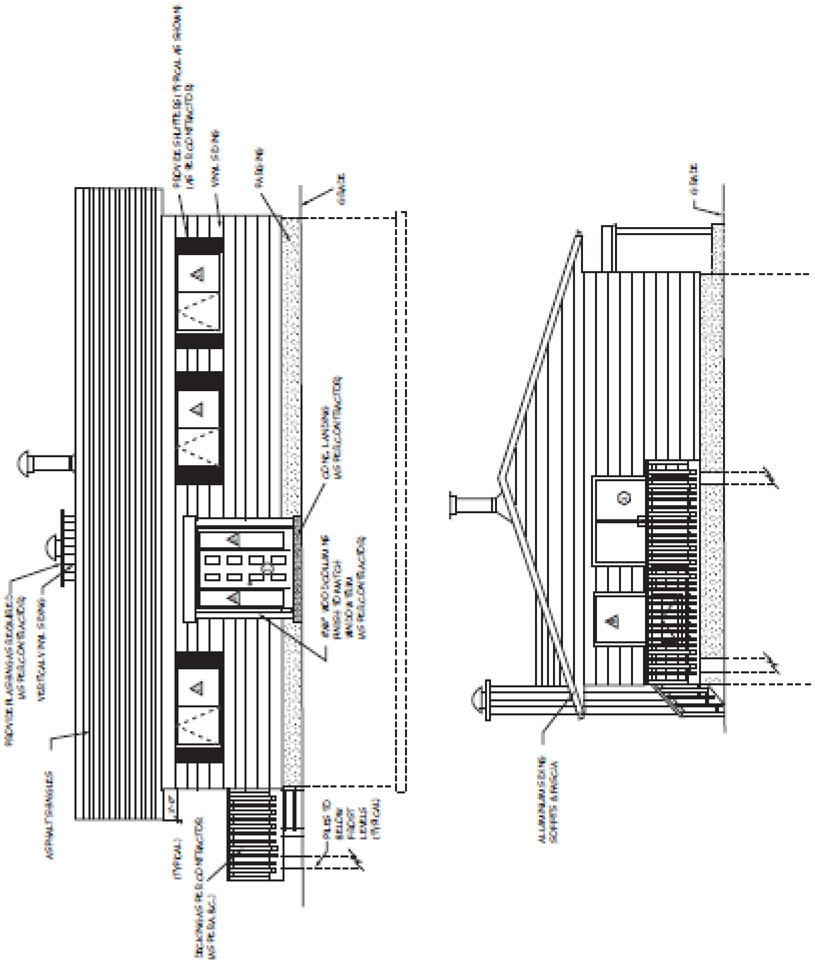


Figure (3-7) continued.

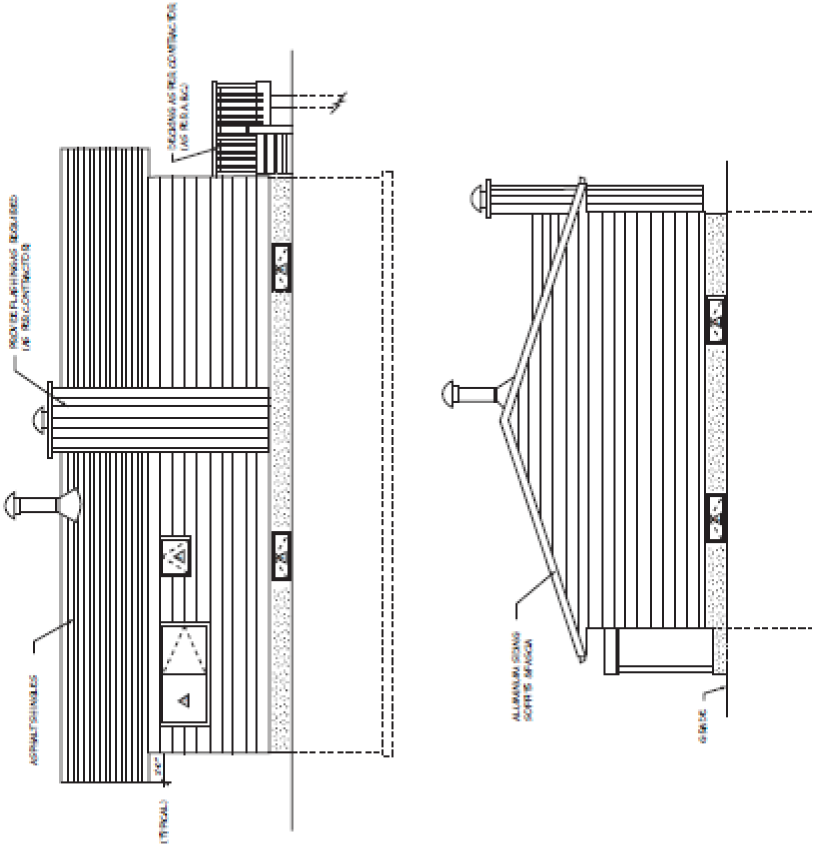


Figure (3-7) continued.

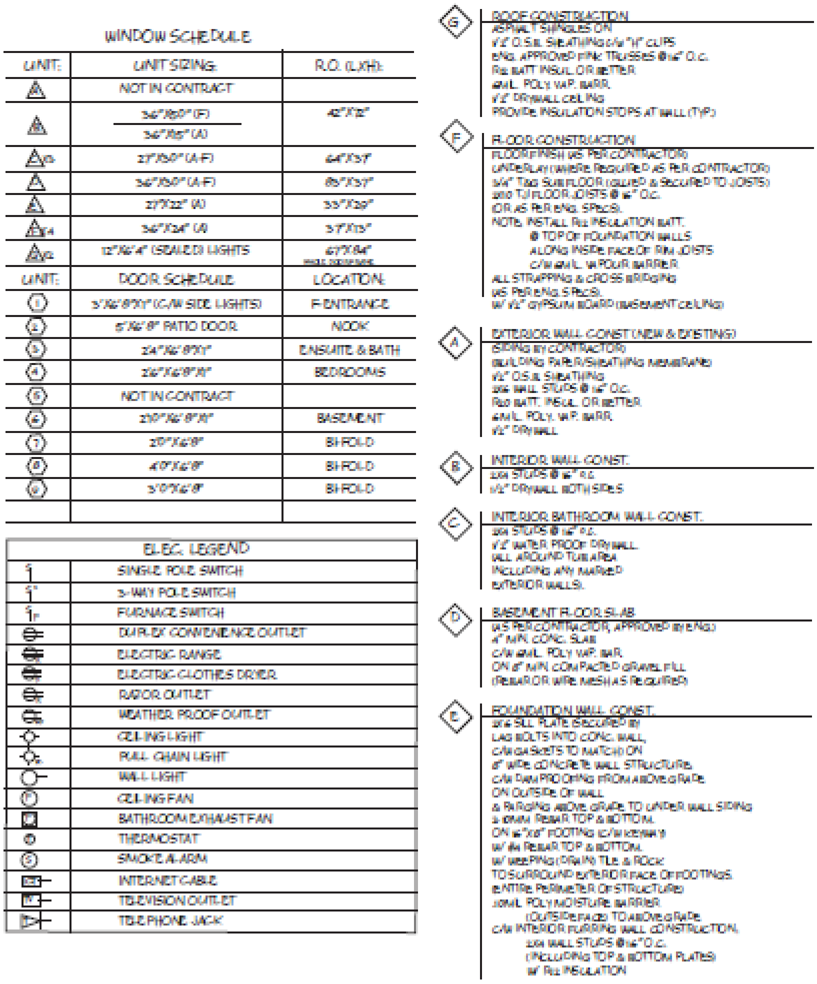


Figure (3-7) continued.

QUANTITY SHEET SHEET No. 1 of 2

JOB: House Example DATE: ______

ESTIMATOR: ABF EXTENDED: ______ EXT. CHKD: ______

DESCRIPTION	DIMENSIONS TIMES	Length	Width	Height			
Excavation and Backfill							
Elev of Ave Grade / Elev of U/S of Gravel							
97.42 Main Floor: 100.00							
97.58 Less							
97.58 1'-9 3/4"							
97.50 7'-1 3/4"							
Ave: 97.52 -8" (9'-7 1/2")							
90'-4 1/2"							
(90.38) ← = 90.38							
7.14 Depth of Excav.							
40.00 x 28.83							
W/S 2 x 2.0 4.00 4.00							
C/B 2 x 1/2 x 7.14 7.14 7.14							
51.14 39.97							
EXCAV BSMT		51.14	39.97	7.14	14,595		
					541	CY	
BACKFILL BSMT		as excav.			14,595		
DDT		40.00	28.83	7.14	(8,234)		
					6,361		
					236	CY	
4" Dia FOOTING DRAIN		145.66			146	LF	
2 x 40.00 80.00							
2 x 28.83 57.66							
137.66 Outside wall perimeter							
4 x 2 x 1.00 8.00							
145.66 Centerline of pipe							
DRAIN GRAVEL		145.66	2.00	2.00	583		
					22	CY	
DEDUCT BACKFILL BSMT			Ditto		(22)	CY	

Figure (3-8 a)

QUANTITY SHEET SHEET No. 2 of 2

JOB: House Example DATE:

ESTIMATOR: ABF EXTENDED: EXT. CHKD:

DESCRIPTION	DIMENSIONS TIMES	Length	Width	Height			
Utility Services Trench							
Ave Depth *Ave Width*							
5.00 *Bottom: 2.50*							
6.00 *Cutback: 5.50*							
Ave: *5.50* *8.00*							
EXCAV TRENCH		26.00	8.00	5.50	1,144		
					42	CY	
SAND BEDDING		26.00	3.00	0.50	39		
Ave Width					1	CY	
Bottom: 2.50							
Cutback: 0.50							
3.00							
BACKFILL TRENCH		as excav.			1,144		
DDT		sand			(39)		
					1,105		
					41	CY	

Figure (3-8 b)

4. Then the difference between the average ground level and the elevation of the bottom of the gravel gives the depth of the basement excavation:

97.52'

(90.38')

Depth of excavation: 7.14'

5. The length and width of the basement excavation is based on the size of the house, so we start with the dimensions of the house to the outside of the walls shown on the basement plan.
6. A 2'-0" wide workspace is allowed outside of the foundation walls, and an allowance is also made for cutting back the sides of the excavation. (See Figure 3-9)
7. The volume of backfill is equal to the volume of excavation less the space taken up by the building. (The space taken up by the footing projection is ignored here.) Note

that the abbreviation "DDT" indicates a deduction, and the amount of the deduction is placed in brackets.

8. A footing drain is located 1'-0" outside of the foundation wall, so the length of this drain is calculated from the outside perimeter of the house:

Plus the adjustment for corners:	137.66'
4 corners 3 2 3 1.0' at each corner gives:	8.00'
Centerline perimeter:	145.66'

9. The footing drain is required to be surrounded by drain gravel, so an area 2'-0" 3 2'-0" is allowed around the pipe.
10. The space taken up by drain gravel reduces the amount of basement backfill required, so an adjustment is made to account for this.
11. A Utilities Trench is a trench that is excavated to accommodate building utilities such as sewer, water, and electrical lines. Figure 3-10 gives details of what the estimator allows for when measuring this trench work.

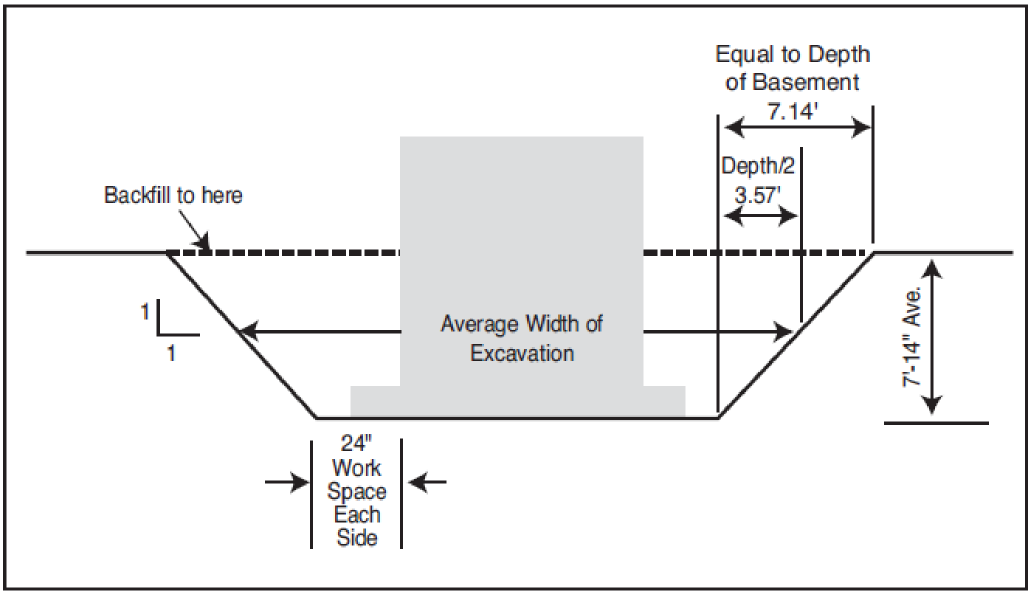


Figure 3-9

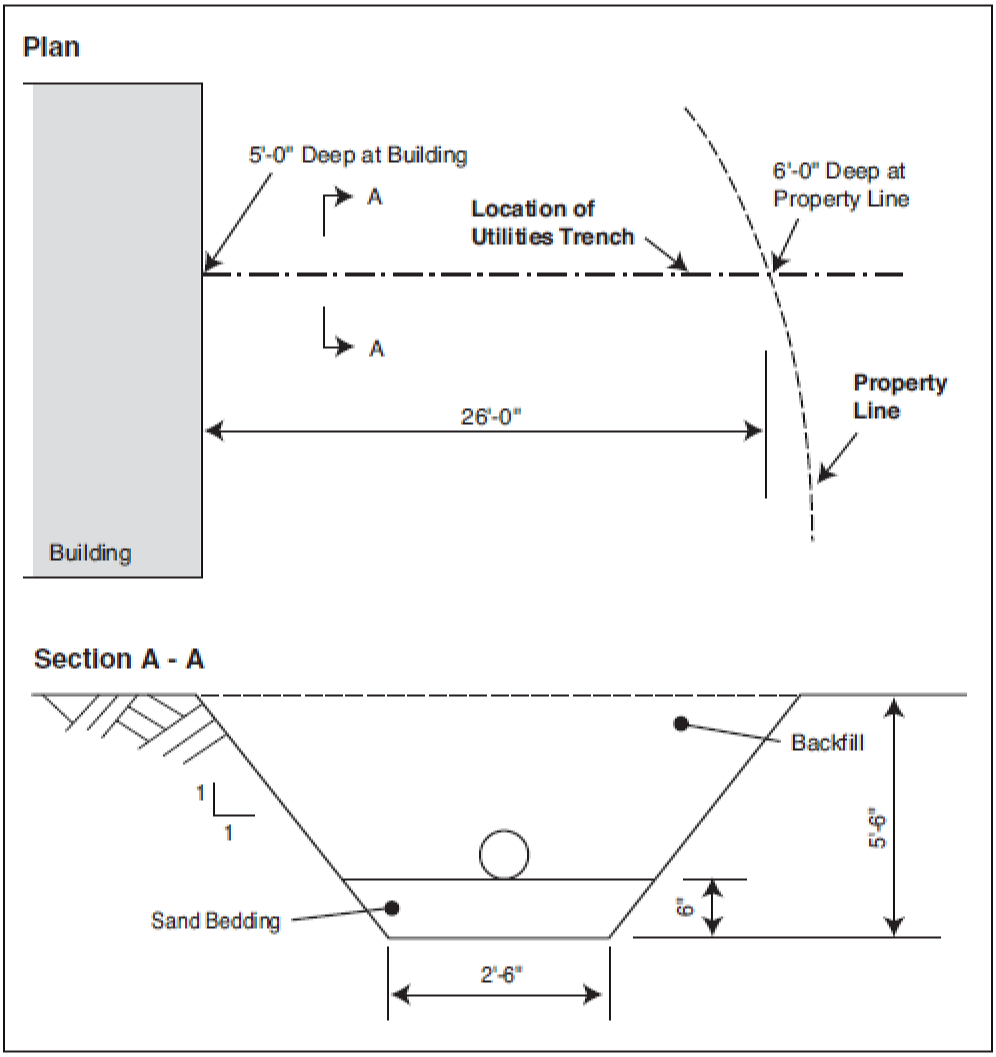


Figure 3-10

b- Example for Basic Concrete Materials (Popescu et al., 2003, Pp. 245)

According to the continuous footing and wall shown in Figure (8-2), the total cost of major concrete materials (including cement, sand, and crushed stone) will be determined (see Table 8.8). This project requires the use of Portland cement type I, washed sand for concrete, and 30 mm stone. The concrete mixture for the footing and wall is 1:2: 3. The water–cement ratio is 0.60. A concrete mixture of 1:3:6 is employed for the lean concrete.

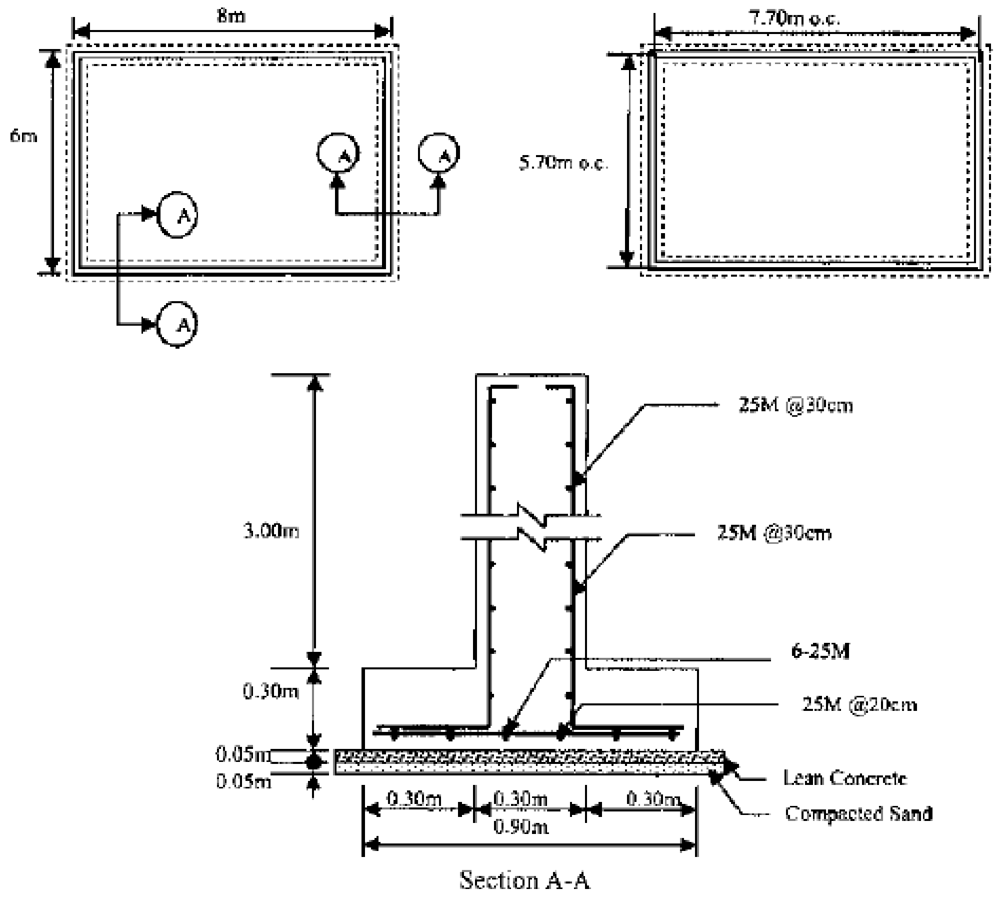


Figure 8.2

Table 8.8

Code 03060	Basic concrete materials	Unit	Mat.	Total	Total[a]
110-0950	Sand, washed, for concrete	M^3	15.55	15.55	17.1
110-1050	Stone, 20 to 40 mm	M^3	28	28	31
200-0240	Portland, type I, plain/air entrained, TL lots, 68 kg bags	Bag	7.3	7.3	8.05

[a] including operation & productivity

Source: Means (1999).

Table 8.7 Quantities of Dry Materials for 1 m^3 of Concrete.

Concrete mixture	Cement		Sand	Stone	Concrete mixture	Cement		Sand	Stone
	kg	m^3	m^3	m^3		kg	m^3	m^3	m^3
1:1:1	755	0.5	0.50	0.50	1:2:4	317	0.2	0.43	0.86
1:1:2	574	0.4	0.38	0.75	1:2.25:3	347	0.2	0.52	0.70
1:1:1.75	559	0.4	0.37	0.65	1:2.75:4	287	0.2	0.53	0.78
1:2:2	453	0.3	0.60	0.60	1:3:3	317	0.2	0.64	0.64
1:2:2.25	423	0.3	0.56	0.65	1:3:5	257	0.2	0.50	0.83
1:2:3	378	0.3	0.50	0.75	1:3:6	227	0.2	0.45	0.9

Source: Popescu et al. (2003).

Step 1. Perform the quantity take off for structural concrete, lean concrete, and sand. The total volume of the footing and wall is 31.5 m^3, the total volume of lean concrete is 1.6 m^3, and the total volume of the compacted sand is 2.1 m^3.

Step 2. Determine the quantity of the concrete materials required for 1 m^3 of concrete. This project requires the concrete mixture of 1:2:3 for footing and wall elements, and the concrete mixture of 1:3:6 for the lean concrete purpose. According to Table (8-7), a total quantity of 378 kg of cement, 0.50 m^3 of sand, and 0.75 m^3 of crushed stone is required for 1 m^3 of concrete for footing and wall elements. For the lean concrete, a total quantity of 227 kg of cement, 0.45 m^3 of sand, and 0.90 m^3 of crushed stone is required for 1 m^3 of concrete.

Step 3. Determine the total quantity of the concrete materials for the footing and the wall. This project requires dry concrete materials:

Cement = (31.5 × 378 kg) + (1.6 × 227 kg) = 12,270 kg = (12,270 kg) / (68 kg/bag) = 180 bags;

Sand = (31.5 × 0.50 m^3) + (1.6 × 0.45 m3) = 2.1 m^3 = 18.6 m^3;

Stone = (31.5 ×0.75 m^3) + (1.6 × 0.90 m3) =25.1 m^3.

Step 4. Consider a waste factor for each concrete material used, waste factors of 5, 20, and 20% are exercised for cement, sand, and stone, respectively.

Therefore, the total estimated quantity of concrete materials is:

Cement = 180 bags × 1.05 = 189 bags;

Sand =18.6 m^3 × 1.20 =23 m^3;

Stone =25.1 m^3 × 1.20 = 30 m^3.

Step 5. Using Table (8-8), the total cost of major concrete materials is calculated ; The total cost for the basic concrete materials is $2578.

c- Paints

Figure (1) about Interior Painting Production Rate (PR) and Material Coverage Ratio (CR)[a,b] Popescu et al. (2003,P.p556).

			Interior painting														
			Brush					Roller					Spray				
			PR (m^2/hr)			CR (m^2/l)		PR (m^2/hr)			CR (m^2/l)		PR (m^2/hr)			CR (m^2/l)	
Description of work	Paint	Coat	S	M	F	H	L	S	M	F	H	L	S	M	F	H	L
Ceilings, drywall	Oil base	First	13.9	16.3	18.6	8.0	8.6	25.5	32.5	37.2	6.7	7.4	65.0	74.3	83.6	6.7	7.4
		Second	18.6	20.9	23.2	9.2	9.8	32.5	37.2	39.5	8.0	8.6	74.3	83.6	92.9	8.0	8.6
		Third	20.9	23.2	25.5	9.8	10.4	39.5	41.8	44.1	8.6	9.2	83.6	92.9	102.2	8.6	9.2
Doors, wood	Enamel	Undercoat	7.0	9.3	13.9	7.4	9.6	7.0	9.3	13.9	7.4	9.6	27.9	31.0	34.8	11.0	12.5
		First finish	8.4	11.1	16.4	8.1	10.3	8.4	11.1	16.4	8.1	10.3	34.8	34.8	39.8	11.8	13.3
		Add coat	11.1	8.0	19.9	8.8	11.0	11.1	8.0	19.9	8.8	11.0	39.8	46.5	46.5	12.5	14.0
Floors, concrete	Oil base	First	8.4	13.0	18.6	6.7	7.4	12.5	22.3	27.9	7.9	9.1	74.3	83.6	92.9	4.3	4.9
		Second	11.6	17.2	29.7	9.2	9.8	18.1	25.5	31.6	11.0	12.3	83.6	92.9	102.2	6.7	7.4
Floors, wood	Oil base	Prime	25.5	27.9	30.2	11.0	12.3	37.2	39.5	44.1	10.4	11.7	—	—	—	—	—
		Second	27.9	30.2	32.5	12.3	13.5	39.5	41.8	46.5	11.7	12.9	—	—	—	—	—
Siding, smooth wood	Oil base	First	9.3	11.6	13.9	8.0	9.8	9.3	11.6	13.9	7.4	8.6	37.2	46.5	55.7	3.2	4.2
		Second	12.5	15.3	18.6	9.2	11.0	16.3	23.2	30.2	8.6	9.8	51.1	67.4	83.6	6.0	7.4
Wall, gypsum, drywall flat wall paint, smooth finish	Oil base	First	16.3	18.6	20.9	8.0	8.6	27.9	46.5	67.4	6.7	7.4	69.7	79.0	88.3	6.7	7.4
		Second	20.9	23.2	25.5	9.2	9.8	34.8	51.1	69.7	8.0	8.6	79.0	88.3	97.5	8.0	8.6
	Epoxy	First	16.3	18.6	20.9	—	—	27.9	46.5	67.4	—	—	69.7	79.0	88.3	—	—
		Second	20.9	23.2	25.5	9.2	10.4	34.8	51.1	69.7	8.6	9.8	79.0	88.3	97.5	—	—
Wall, gypsum, drywall flat wall paint, sand finish	Oil base	First	16.3	18.6	20.9	8.0	8.6	25.5	46.5	65.0	6.1	7.4	65.0	74.3	83.6	6.1	6.7
		Second	18.6	20.9	25.5	8.6	9.8	32.5	51.1	67.4	7.4	8.0	74.3	83.6	92.9	7.4	8.6
	Epoxy	First	16.3	18.6	20.9	6.1	6.7	25.5	46.5	65.0	—	—	65.0	74.3	83.6	—	—
		Second	18.6	20.9	25.5	8.0	9.2	32.5	51.1	67.4	7.4	8.6	74.3	83.6	92.9	—	—
Wall plaster, smooth finish	Oil base	First	13.9	16.3	18.6	8.6	9.8	24.2	41.8	59.5	8.0	9.2	46.5	55.7	69.7	8.6	10.4
		Second	16.3	18.6	20.9	9.2	10.4	27.9	41.8	62.7	8.6	9.8	51.1	65.0	79.0	9.2	11.0
	Epoxy	First	13.9	16.3	18.6	—	—	24.2	41.8	59.5	—	—	46.5	55.7	69.7	—	—
		Second	16.3	18.6	20.9	9.2	9.8	27.9	41.8	62.7	8.0	9.2	51.1	65.0	79.0	8.0	9.2
Wall plaster, medium texture	Oil base	First	11.6	13.9	16.3	7.4	8.0	20.9	41.8	60.4	6.1	6.7	44.1	53.4	67.4	8.0	9.8
		Second	13.9	15.3	17.2	8.6	9.8	23.2	44.1	62.7	7.4	8.6	48.8	62.7	76.6	8.6	10.4
	Epoxy	First	11.6	13.9	16.3	—	—	20.9	41.8	60.4	—	—	44.1	53.4	67.4	—	—
		Second	13.9	15.3	17.2	9.2	9.8	23.2	44.1	62.7	7.9	8.6	48.8	62.7	76.6	7.4	8.6

[a] For heights over 2.44 m (8 ft), use high time difficulty factors.
[b] S = slow, M = medium, F = fast, H = heavy, L = light.
Source: Gleason, *Estimating Painting Cost*, 1989.

Figure (1)

Figure (1) about exterior Painting Production Rate (PR) and Material Coverage Ratio (CR)[a,b] Popescu et al. (2003,P.p557).

			Exterior painting														
			Brush					Roller					Spray				
			PR (m²/hr)			CR (m²/l)		PR (m²/hr)			CR (m²/l)		PR (m²/hr)			CR (m²/l)	
Description of work	Paint	Coat	S	M	F	H	L	S	M	F	H	L	S	M	F	H	L
Beams from 4 × 6 in. to 8 × 14 in., one coat	Oil base	to 13 ft high	8.5	9.7	10.9	2.6	3.2	—	—	—	—	—	—	—	—	—	—
		to 17 ft high	5.8	6.5	7.2	2.6	3.2	—	—	—	—	—	—	—	—	—	—
		to 18 ft high	3.9	4.3	4.8	2.6	3.2	—	—	—	—	—	—	—	—	—	—
Doors, wood	Paint grade	Two coats	5.6	7.0	9.3	3.7	5.2	5.6	7.0	9.3	3.7	5.2	—	—	—	—	—
	Polyurethane	Two coats	4.0	4.6	5.6	2.9	3.7	—	—	—	—	—	—	—	—	—	—
	Varnish	Two coats	5.6	7.0	9.3	2.9	4.4	—	—	—	—	—	—	—	—	—	—
Floors, concrete	Oil base	First	8.4	13.0	18.6	6.7	7.4	12.5	22.3	27.9	7.9	9.1	74.3	83.6	92.9	4.3	4.9
		Second	11.6	17.2	29.7	9.2	9.8	18.1	25.5	31.6	11.0	12.3	83.6	92.9	102.2	6.7	7.4
		Third	13.9	20.0	31.6	12.3	13.5	19.5	26.9	36.2	12.3	13.5	92.9	102.2	111.5	8.0	8.6
Masonry brick	Oil base	First	18.6	20.9	23.2	9.2	8.6	30.2	32.5	34.8	6.1	8.0	60.4	69.7	79.0	5.5	6.7
		Second	23.2	25.5	27.9	8.0	9.8	34.8	37.2	39.5	6.7	8.6	69.7	79.0	83.6	6.7	7.4
	Water base	First	18.6	20.9	23.2	6.1	7.4	30.2	32.5	34.8	4.3	6.1	60.4	69.7	79.0	4.9	6.1
		Second	23.2	25.5	27.9	6.7	8.0	34.8	37.2	39.5	5.5	6.7	69.7	79.0	83.6	6.1	6.7
Masonry concrete	Oil base	First	10.2	12.1	13.9	2.7	3.2	22.8	27.9	32.5	2.1	2.7	55.7	65.0	74.3	1.6	2.5
		Add coat	17.2	19.5	21.4	3.9	4.9	25.5	30.2	39.0	3.8	4.5	65.0	74.3	83.6	3.1	3.9
	Epoxy	First	10.2	12.1	13.9	2.1	2.7	22.8	27.9	32.5	1.8	2.5	55.7	65.0	74.3	1.2	2.1
		Add coat	17.2	19.5	21.4	4.3	4.9	25.5	30.2	39.0	3.6	4.3	65.0	74.3	83.6	2.8	3.6
	Water base	First	10.2	12.1	13.9	1.8	2.5	22.8	27.9	32.5	1.6	2.2	55.7	65.0	74.3	1.3	2.5
		Add coat	17.2	19.5	21.4	3.8	4.4	25.5	30.2	39.0	3.1	3.9	65.0	74.3	83.6	2.7	3.8
Plaster and stucco	Water base	First	9.3	11.1	13.0	2.5	3.7	22.8	24.6	27.9	3.7	5.5	55.7	62.7	69.7	2.2	4.9
		Second	13.9	15.3	16.3	4.9	6.1	27.9	29.7	31.6	5.2	6.7	65.0	74.3	83.6	3.1	5.5
	Oil base	First	7.4	9.3	11.1	5.8	6.5	18.6	23.2	27.9	4.9	6.1	51.1	55.7	60.4	3.7	4.9
		Second	13.5	15.3	17.2	6.1	7.4	20.9	25.5	30.2	5.5	6.7	60.4	69.7	83.6	6.7	8.6
Roofing shingle of shake	Penetrating stain	First	9.3	14.4	19.5	3.4	3.9	19.5	23.7	28.3	4.4	4.9	55.7	65.0	74.3	3.4	4.9
		Second	13.9	18.1	22.3	4.5	5.0	23.2	27.9	32.5	6.7	7.2	65.0	74.3	83.6	5.9	7.4
Siding rough wood	Water base	First	9.3	12.5	15.8	5.5	6.1	13.9	20.9	25.5	5.2	5.8	37.2	46.5	55.7	5.9	6.9
		Second	12.5	15.8	18.6	6.7	7.4	18.6	25.5	32.5	6.4	7.0	41.8	51.1	60.4	7.1	8.1
		Third	13.9	17.2	20.0	8.6	9.2	24.2	31.1	38.1	8.0	8.6	51.1	60.4	69.7	9.6	10.6
Lightweight structural steel after erection	Oil base	First	6.8	7.2	7.5	11.0	12.3	—	—	—	—	—	37.5	39.8	41.7	3.3	3.7
	Industrial enamel	First	6.8	7.2	7.5	11.0	12.3	—	—	—	—	—	37.5	39.8	41.7	3.3	3.7
		Second	9.3	9.8	10.4	13.5	14.7	—	—	—	—	—	35.1	37.3	39.3	4.0	4.4
Medium to heavy-weight structural steel after erection	Oil base	First	8.8	9.3	9.9	11.0	12.3	—	—	—	—	—	45.1	47.9	50.8	3.3	3.7
	Industrial enamel	First	8.8	9.3	9.9	11.0	12.3	—	—	—	—	—	45.1	47.9	50.8	3.3	3.7
		Second	10.4	11.0	11.6	13.5	14.7	—	—	—	—	—	58.1	61.6	65.1	4.0	4.4
Siding smooth wood	Oil base	First	9.3	11.6	13.9	8.0	9.8	9.3	11.6	13.9	7.4	8.6	37.2	46.5	55.7	3.2	4.2
		Second	12.5	15.3	18.6	9.2	11.0	16.3	23.2	30.2	8.6	9.8	51.1	67.4	83.6	6.0	7.4
		Third	13.9	16.7	20.0	11.0	12.9	24.2	31.1	38.1	9.8	10.4	60.4	76.6	92.9	8.5	9.8

[a] For heights over 8 ft (2.44 m), use high time difficulty factors.
[b] S = slow, M = medium, F = fast, H = heavy, L = light. *Source*: Gleason, *Estimating Painting Cost*, 1989.

Figure (2)

d- Checklist of thermal and moisture protection works by (Dagostino and Peterson, 2011,P.p 185)

Paper	Flashing
Felt	Ridges
Composition (roll)	Valleys
Composition (built-up)	Fasteners
Tile (clay, metal, concrete)	Trim
Shingles (wood, asphalt, slate)	Battens
Metal (copper, aluminium, corrugated, steel)	Blocking (curbs)
Insulation	Cant strips
Base	**Waterproofing:**
Solder:	integral
paints	membrane
plaster	**Damp proofing:**
foundation walls	integral
slabs	parge
sump pits	vapor barriers
protective materials	bituminous materials
exterior	drains
interior	foundation walls
admixtures	slabs
drains	
pumps	

e- checklist of Job site overheads

Checklist which was stated by Dagostino and Peterson (2011) is:

- Job superintendent, Assistant superintendent,
- Engineers (Job engineers, Field engineers (surveyors), Expediter, Cost engineer, and Scheduling engineer),
- Timekeepers,
- Material clerks,
- Security personnel,

- Project meetings,
- Submittal coordination,
- Secretaries, Temporary fences,
- Temporary sheds, Storerooms,
- Storage and handling,
- Temporary enclosures,
- Ladders and stairs that used prior to permanent ones being installed,
- Temporary partitions that used to separate new construction from existing facilities,
- Temporary closures for doors and windows,
- First aid,
- Construction elevators,
- hoists, and cranes,
- Noise control,
- Dust control,
- Water control,
- Pest/rodent control,
- Temporary job office,
- Temporary office for architect/inspector,
- Telephone, Heat,
- Lights and power,
- Computers,
- Stationery,
- Project sign and associated signage,
- Building and maintaining barricades,
- Cost of maintaining signal lights,
- Temporary toilets,
- Water lines,
- Electric lines,
- Removal of rubbish (typically weekly),
- Cleaning for final acceptance,
- permits,
- Surveys,
- Photographs,
- Testing,
- Cash equivalents and allowances,

- Social security,
- Medicare,
- Federal unemployment taxes,
- State unemployment taxes,
- Workers’ compensation insurance,
- Benefits,
- Sales tax,
- Bid bond,
- Performance and payment bonds,
- Maintenance bonds,
- Permit bonds,
- Contractor’s public liability insurance,
- Pick-up truck(s),
- Flatbed truck(s), and
- Pumps.

f- General overhead expenses for home office by Popescu et al. (2003,P.p 270).

	Planned		
Home office expenses	Annual expenses	Percentage of total	Industry average (%)
Nonreimbursable salaries			
Exempt employees			
President			
Vice president			
Comptroller			
Estimating group			
Human resource personnel			
—			
—			
—			
—			60
—			
—			
Nonexempt employees			
Secretaries			
Payroll clerk			
Accounts payable clerks			
—			
—			
—			
Total office nonreimbursable salaries			
Benefits @ 40% of total office salaries			
Office/shops rent			4
Depreciation of capital expenditures			4
Office utilities and communication			2
Office supplies			0.50
Office equipment (rented, if owned depreciated)			0.50
Office maintenance			
Advertising/jobs procurement/public relations			1
Associations and clubs dues			1
Licenses and fees			1
Donations/sponsored research			2
Trade journals subscriptions and books			1
Travel			2
Entertainment			1
Company sponsored training programs			2
Accounting services			3
Legal services			
Estimating and project management (not salaries)			2
Consulting fees (legal, CPA, etc.)			2
Home office vehicles, depreciation			5
Home office vehicles, operation expenses			
Insurance expenses			6
Total anticipated home office expense		100	100

g- Check list for site visit query

Checklist for site visit by Popescu et al. (2003,P.p 723-740). (only part not all; you should return to the book)

Project Title ______________________ Date ______________

Project Location ______________________

		Date	By Whom	Phone/Fax/Email
1.0	Site Characteristics	______	______	______
2.0	Subsurface Exploration	______	______	______
3.0	Excavation	______	______	______
4.0	Weather Conditions	______	______	______
5.0	Site Accessibility	______	______	______
6.0	Water	______	______	______
7.0	Waste Water Disposal	______	______	______
8.0	Electricity	______	______	______
9.0	Natural Gas	______	______	______
10.0	Communication	______	______	______
11.0	Security	______	______	______
12.0	Medical/Environmental	______	______	______
13.0	Personnel Availability	______	______	______
14.0	Subcontractors' Availability	______	______	______
15.0	Local Materials' and Suppliers' Availability	______	______	______
16.0	Construction Equipment Availability	______	______	______
17.0	Local Office Facilities	______	______	______
18.0	Local Housing and Recreational Availabilities	______	______	______
19.0	Local Financial Institutions	______	______	______
20.0	Local Insurance Availabilities	______	______	______
21.0	Local Legal and Audit Requirements	______	______	______

1.0 Site Characteristics

1.1 Draining conditions ______________________

1.2 Slope of ground ______________________

1.3 Trees in area (size, diameter, species) ______________________

1.4 Boulders (size, easy to remove?) ______________________

1.5 Nearby community information (Foreign Projects) ______________________

Population: ____________ Predominant Language: ____________

Predominant Religion: ____________ Predominant Profession: ____________

Name and distance of the nearest community from site: ______________________

Type of government: Democratic ( ) Dictatorial ( )

Key persons that make decisions in local government:

Name	Position	Address	Phone No.

Community attitudes regarding environmental issues: ______________________

____

____

____

2.0 Subsurface Exploration

2.1 Secure subsurface investigation reports ( ) Check

2.2 Water table characteristics:

Depth average: ____________ Source: ____________

Water table fluctuations due to seasonal changes: Low ____________ High ____________

Secure water analysis ( ) Check

3.0 Excavation

3.1 Underpinning of adjacent structures required? ( ) No ( ) Yes

If yes, type, length? ______________________

3.2 Shoring necessary? ( ) No ( ) Yes

If yes, type, length? ______________________

Local Supplier/Subcontractor: ____________ Phone No. ____________

Another checklist (Dagostino and Peterson, 2011,P.p 29)

SITE VISIT CHECKLIST
Local Projects

Estimator: ____________ Date: ____________
Job Number: ____________ Location: ____________
Project Name: ____________ ____________

Distance from Office: ____________
Weather Conditions: ____________
Access and Roads: ____________
Sidewalk Crossing: ____________
Site Conditions: ____________
Adjacent Structures: ____________
Obstructions: ____________
Shoring or Underpinning: ____________
Depth of Topsoil: ____________
Soil Data: ____________
Ground water: ____________
Soil Disposal Location: ____________
Distance to Borrow Pit: ____________
Local Sand & Gravel: ____________
Electrical Service: ____________
Telephone: ____________
Sewer & Water Services: ____________
Parking and Storage: ____________
Security Needs: ____________
Temporary Fences Required: ____________
Garbage Disposal: ____________
Toilets: ____________
Site History: ____________
Possible Contamination: ____________
Other Comments: ____________

h- Example for removing top soil pricing by Popescu et al. (2003,P.p 197-200).

Assume the following:

Plot area to be stripped of topsoil = 6000 m^2.

Depth of Excavation = 0.15 m.

The stripping will be carried out using a 150 kW dozer.

The productivity is estimated at 83 m^3/hr.

Mobilization and demobilization time is estimated at 4 hours.

Dozer Rate =$ 75 per hour.

Dozer Operating Cost =$25.85 per hour.

Equipment Operator Rate = $28.85 per hour.

Solution:

Volume of topsoil to be stripped = 6000 m^2 × 0.15 m = 900 m^3.

Work hours required for topsoil stripping = 900 m^3 ÷ 83 m^3/hr = 11 hr.

Pricing:

Equipment Cost = [(11 hour + 4 hour) × $ 75 per hour] + (11 hour ×

$25.85 per hour) = $1,409.35.

Labour Cost = 15 hour × $28.85 per hour = $432.75.

Total cost approximately $2.05 per m^3.

APPENDIX 9

Bid summary

PROJECT: Pedestrian Bridge
LOCATION:
DATE:
ESTIMATOR: DJP

Add-ons 1:
Small tools: 5.00%
Payroll 25.00%
Add:

Add-ons 2:
50% Bond: 0.73%
Insurance: 1.50%

SUMMARY

DESCRIPTION	LABOR	MATL.	EQUIP.	SUBTOTAL 1	GENERAL EXPENSES	ADD-ONS 1	SUBTOTAL 2	ADD-ONS 2	SUBTOTAL 3	FEE	ADJUST	TOTAL	PAY QUANTITY	UNIT	UNIT PRICE
101 Clear Site	—	—	3,000	3,000	—	—	3,000	—	3,000	—	—	3,000	—	—	3,000.00
201 Common Dry	15,067	—	17,897	32,964	13,610	4,520	51,094	1,137	52,231	2,612	—	54,842	6,168	cu. yd.	8.89
301 Common B/fill	13,392	—	9,698	23,090	12,097	4,018	39,204	872	40,077	2,004	—	42,080	2,309	cu. yd.	18.22
302 Pit Run	9,856	22,800	35,840	68,496	8,903	2,957	80,356	1,788	82,143	4,107	—	86,251	1,792	cu. yd.	48.13
401 Class "A"	538	4,181	0	4,719	486	161	5,366	119	5,486	274	—	5,760	39	cu. yd.	147.69
402 Class "B"	108,402	106,090	11,751	226,243	97,918	32,521	356,681	7,936	364,617	18,231	—	382,848	1,022	cu. yd.	374.61
403 Class "D"	939	3,315	200	4,454	848	282	5,584	124	5,708	285	—	5,994	15	cu. yd.	399.57
404 Slope Protection	48,383	49,959	2,005	100,347	43,704	14,515	158,565	3,528	162,094	8,105	—	170,198	273	cu. yd.	623.44
405 Wearing Surface	5,796	5,697	760	12,253	5,235	1,739	19,227	428	19,655	983	—	20,638	25	cu. yd.	825.51
406 Nonshrink Grout	1,720	1,760	—	3,480	1,554	516	5,550	123	5,673	284	—	5,957	8	cu. ft.	744.60
500 Rebar	67,850	213,095	—	280,945	61,288	20,355	362,588	8,068	370,655	18,533	—	389,188	212	ton	1,835.79
600 Guardrail	22,223	12,016	—	34,239	20,074	6,667	60,980	1,357	62,336	3,117	—	65,453	200	foot	327.27
700 Expn. Joints	12,210	25,410	—	37,620	11,029	3,663	52,312	1,164	53,476	2,674	—	56,150	198	foot	283.59
800 P.C. Concrete	1,223	5,560	8,127	14,910	1,105	—	16,015	356	16,371	819	—	17,190	25	ton	687.58
	307,599	449,883	89,278	846,760	277,849	91,913	1,216,522	27,001	1,243,523	62,026	—	1,305,549	—	—	—

Figure shows Unit-Price Bid Summary, pratt, (2011,b, P.p. 383)

PROJECT: Pedestrian Bridge GROSS FLOOR AREA: LOCATION: DATE: CONTRACTOR:	SCHEDULE OF PRICES			
ITEM	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT $**
100 Site Clearance	Allowance	—	—	3,000.00
200 EXCAVATION				
201 Common dry	6100	cu. yd.	$8.89	54,229.00
300 BACKFILL				
301 Common	1500	cu. yd.	$18.22	27,330.00
302 Pit-run	3100	cu. yd.	$48.13	149,203.00
400 CONCRETE				
401 Class "A"	37	cu. yd.	$147.69	5,464.53
402 Class "B"	1030	cu. yd.	$374.61	385,848.30
403 Class "D"	17	cu. yd.	$399.57	6,792.69
404 Slope protection	250	cu. yd.	$623.44	155,860.00
405 Wearing surface	27	cu. yd.	$825.51	22,288.77
406 Nonshrink grout	25	cu. ft.	$744.60	18,615.00
500 REINFORCING STEEL	195	ton	$1,835.79	357,979.05
600 GUARDRAIL	180	feet	$327.27	58,908.60
700 EXPANSION JOINTS	201	feet	$283.59	57,001.59
800 PRECAST CONCRETE	26	ton	$687.58	17,877.08
SUBTOTAL:	—	—	—	1,320,397.61
10% Allowance for extra work	—	—	—	132,039.76
BID TOTAL:				1,452,437.37

Figure shows the Schedule of Prices, pratt, (2011,b, P.p. 384)

PROJECT: House Example
FLOOR AREA: 1080 SF
LOCATION:
DATE:
ESTIMATOR: ABF

ESTIMATE SUMMARY

DESCRIPTION		LABOR $	MATL. $	EQIUP. $	SUBS. $	OTHER $	TOTAL $
OWN WORK							
EXCAVATION & FILL		2,858	1,436	2,498	—	—	6,792
CONCRETE WORK		1,056	6,847	450	—	—	8,353
FORMWORK		9,703	1,341	—	—	—	11,044
MISCELLANEOUS		1,481	782	59	—	—	2,322
MASONRY		1,512	1,368	—	—	—	2,880
ROUGH CARPENTRY		10,636	9,241	—	—	—	19,877
FINISH CARPENTRY		6,520	15,154	—	—	—	21,674
EXTERIOR FINISHES		5,112	4,738	—	—	—	9,850
INTERIOR FINISHES		10,123	9,003	—	—	—	19,126
	Subtotal 1:	49,001	49,910	3,007	0	0	101,918
SUBCONTRACTORS							
PLUMBING		—	—	—	12,700	—	12,700
HEATING AND VENTILATING (Included with Plumbing)				—	—	—	—
ELECTRICAL		—	—	—	7,815	—	7,815
	Subtotal 2:	49,001	49,910	3,007	20,515	0	122,433
GENERAL EXPENSES		12,390	2,200	12,574	2,600	—	29,764
	Subtotal 3:	61,391	52,110	15,581	23,115	0	152,197
ADD-ONS							
FINANCING	Nil	—	—	—	—	—	—
SMALL TOOLS	5% of Labor	—	—	—	—	3,070	3,070
PAYROLL ADDITIVE	25% of Labor	—	—	—	—	15,348	15,348
BUILDING PERMIT	$7.00/1000 of Bid	—	—	—	—	1,386	1,386
PERF. BOND	Nil	—	—	—	—	—	—
LAB. & MATL. BOND	Nil	—	—	—	—	—	—
INSURANCE	$5.00/1000 of Bid	—	—	—	—	990	990
FEE	Lump Sum	—	—	—	—	25,000	25,000
	Subtotal 4:	0	0	0	0	27,376	197,990
ADJUSTMENT		—	—	—	—	—	—
						BID TOTAL:	197,990

Price per S.F. = $183.32

Figure shows House Example: Estimate Summary, pratt, (2011,b, P.p. 388)

APPENDIX 10

a- English version of evaluation tool

Evaluation tool for cost estimate of Yemeni's construction projects

Personnel information (optional)

1- Name:……………………………. 2- experience year:……….
3- Job position:………………….......4- work's year in firm:………
5- Academic qualification: …………………..

This tool is used to assess the knowledge acquired by Yemeni engineers; thus the weaknesses and strengths area cab be known in order to improve and develop the efficiency and effectiveness in the collection of knowledge in the first section.

In the second section, it measures the extent of professional practice for engineers in the use of techniques and methods in the process of estimating the construction projects costs; thus the shortcomings areas can be improved and overcome by identifying them as well as study them and apply.

Moreover, the extent of evaluation in this tool from 0-10 degrees, which indicates the number (0) no practicing or gained knowledge by the firm's engineers, and the number (10), indicates full knowledge or complete application.

Evaluate the following points according to your knowledge and experience.

Model core	section	Areas	Factors	score
Knowledge cost estimate	Construction cost	Direct cost	Concept of direct cost	
			labour, equipment, tools, and subcontractor direct cost	
			Classification of salary, travelling, purchasing, and renting cost.	
		Indirect cost	Classification of material, labour, equipment, etc.	
			Classification of indirect cost for permits, taxes, safety tools, and grantees.	
			Risk allowances	
	Cost estimation methods and techniques	Preliminary estimate	Understanding preliminary estimate	
			Using Historical data for estimating projects	
			Analogy (similarity)	
			Multiple regression	
			Artificial neural network	
		Detailed estimate	Detailed estimate and bottom up technique	
			Spec, drawings, documents, and information	
		Definitive estimate	End project estimate	
	Types of contracts and delivery systems	Acquiring project	Design- Bid- Build	
			Construction Management delivery	
			Design- Build Delivery	
		contracts	Lump-sum	
			Unit price	
			Cost plus	

Model core	section	Areas	Factors	score
	Critical factors	Spec.	Complex degree	
			Work quality	
			Specification types	
			Drawings	
			Required information	
			Contract requirement	
			Consultant importance	
			Site study	
		Marketing factors	Material cost	
			Market conditions	
			Available technology	
			Competition importance	
			Market inflation	
			Fees	
			Client financial status	
		Management and planning factors	Project duration	
			Project management quality	
			Documentation	
			Project team requirement	
			Contract requirement	
			Waste of materials	
		Risks and regulations	Risks, political, and other risk.	
			Laws and regulations	
	Safety considerations	Law and regulation	Safety and Health laws	
			Compensation and regulation	
		Cost and safety tools	Safety tools	
			Safety and Health cost	
	Cost index	Cost index	Cost index	
			Cost index usage	
			Foreign cost index	
Preliminary estimate	Preliminary estimate	Traditional methods	Square meter	
		Modern methods	Multiple regression	
			ANN	
Detailed estimate	Base estimate	Base estimate	Scope base line	
			Resources calendars	
			Project schedule	
			HR plan	
			Risk register	
			enterprise environment factors	
			Organizational process assets	
	measurements	measurements	Items of construction projects	
			Jobsite Overhead	
			Surety Bonds, Insurance, and Taxes	
			General Overhead	
			Contingencies, and Profit	
			Bottom-up technique	
	Query	Site visit	Site properties	
			Services available	
			Resources available	
		Review bid documents	Review bid documents	

Model core	section	Areas	Factors	score
	Pricing	Pricing	Machines and tools	
			Items of construction project	
			Subcontractor offers	
	Management review	Managemen t review	Estimate process	
			Pricing process	
	Bid summary	Bid summary	Estimate and pricing summary	
			Closing the bid	

b- Arabic version of evaluation tool

تقييم الأداء في تقدير تكاليف مشاريع التشييد في اليمن

معلومات شخصية (اختياري):

1- الاسم: .... 2- سنوات الخبرة:..

3- مسمى الوظيفة :.. 4- مدة العمل في الشركة:..................................

5- المؤهل الأكاديمي : جامعي ☐ دراسات عليا ☐

أداة تقييم المعرفة والممارسات المهنية في تقدير تكاليف مشاريع التشييد في اليمن

هذه الأداة تستخدم لتقييم المعرفة المكتسبة لدى لمهندسين اليمنيين، وبالتالي معرفة جوانب الضعف والقوة، كما أنه من خلالها يتم تحسين وتطوير الكفاءة والفاعلية في التحصيل المعرفي في القسم الأول.

أما بالنسبة للقسم الثاني، فهو يقيس مدى الممارسة المهنية للمهندسين في استخدام التقنيات والطرق في عملية تقدير تكاليف مشاريع التشييد، وبالتالي معرفة جوانب النقص والذي يمكن تحسينه والتغلب عليه من خلال التعرف عليه ودراسته وتطبيقه.

علاوة على ذلك، فإن مدى التقييم في هذه الاداة من 0-10 درجة، حيث يدل الرقم (0) على عدم تطبيق او المام مهندسي الشركة بهذه المعرفة او الممارسة، أما الرقم (10) فيدل على المعرفة التامة او التطبيق الكامل.

القسم الأول (الجانب المعرفي)

قيبم النقاط التالية بحسب المامك ومعرفتك بها.

1- تصنيف تكاليف مشروع التشييد		التقييم
1- التكاليف المباشرة (المتغيرة)	التكاليف المباشرة للمشروع	
	تكاليف المواد، العمالة، الأدوات، المعدات، ومقاولي الباطن.	
	تصنيف وتحديد جميع الرواتب، أجور السفر، الشراء، والايجار	
2- التكاليف الغير مباشرة (الثابتة)	تصنيف تكاليف التوصيل للمواد، العمالة، المعدات وغيره.	
	تصنيف التكاليف الغير مباشرة من تصاريح، ضرائب، أدوات السلامة، الضمانات وغيرها.	
	بدلات المخاطر	
2- طرق وتقنيات تقدير التكاليف		
1- التقدير المبدئي	التقدير المبدئي لتقدير تكاليف مشاريعنا	
	استخدام المعلومات التاريخية من المشاريع السابقة لتقدير مشاريعنا	
	استخدام درجة التشابه بين المشاريع لتقدير التكاليف المبدئية	
	تقنية الانحدار المتعدد لتقدير التكاليف	
	تقنية الشبكة العصبية الاصطناعية لتقدير التكاليف	
2- التقدير التفصيلي	التقدير التفصيلي و تقنية التقدير الصاعد الى اعلى	

	استخدام جميع المواصفات، الرسومات، الوثائق، والمعلومات عند التقدير التفصيلي.	
3- التقدير النهائي	نقوم بعمل تقدير نهائي للمشروع بعد نهاية جميع الاعمال	
3- أنواع العقود وأنظمة اكتساب المشاريع		
1- اكتساب المشاريع	نظام التصميم – العطاء-البناء من الأنظمة الشائعة في شركتنا	
	نظام اكتساب المشروع بحسب المراحل من الأنظمة المعروفة لدينا في شركتنا	
	نظام التصميم والتنفيذ أحد الأنظمة المعروفة لدينا في شركتنا	
2- العقود	لدينا معرفة بعقود المقطوعية (الثمن الكلي)	
	لدينا معرفة بعقود ثمن الوحدة	
	لدينا معرفة بعقود التكلفة زائدا نسبة استرداد	
4- العوامل الحرجة المؤثرة على تقدير التكلفة		
1- المواصفات	درجة تعقيد المشروع	
	جودة الاعمال	
	أنواع المواصفات	
	الرسومات	
	المعلومات المطلوبة	
	متطلبات العقد	
	أهمية الاستشاري	
	أهمية دراسة موقع المشروع	
2- العوامل السوقية	تكاليف المواد	
	الظروف السوقية	
	المتطلبات التكنولوجية المتوفرة	
	أهمية المنافسون	
	آثار التضخم السوقي	
	الرسوم المفروضة	
	الوضع المالي للعميل	
3- عوامل تخطيطية وادارية	زمن المشروع	
	جودة إدارة المشروع	
	عملية التوثيق	
	متطلبات فريق المشروع	
	فترة الإنجاز المحددة بالعقد	
	الفاقد في المواد	
4- المخاطر واللوائح	المخاطر والأوضاع السياسية والمخاطر الأخرى.	
	اللوائح والأنظمة.	
5- الاعتبارات الامنية		
1- اللوائح والانظمة	قوانين الصحة والسلامة المهنية	
	العقوبات والأنظمة داخل الموقع بالنسبة للصحة والسلامة المهنية	
2- التكاليف والمعدات	معدات السلامة	
	تكاليف السلامة المهنية	
6- مؤشر التكلفة		
مؤشر التكلفة	مؤشر التكلفة	
	استخدام مؤشرات التكلفة	
	رصد وتوثيق مؤشرات خاصة بالشركة	

القسم لثاني :التقدير المبدئي والتفصيلي

قييم التالي بحسب الممارسة المهنية للمؤشر

1- التقدير المبدئي		التقييم
1- الطرق التقليدية	طريقة سعر المتر المربع في تقدير التكاليف	
2- الطرق الحديثة	تقنية الانحدار المتعدد للتنبؤ بالتكاليف	
	تقنية الشبكة العصبية الاصطناعية للتنبؤ	

3- التقدير التفصيلي		التقييم
1- تقدير الاساسيات		
1- المعرفة الاساسية	خط أساس النطاق (بيان نطاق المشروع، هيكلة تجزئة العمل، قاموس هيكلة تجزئة العمل)	
	سجلات الموارد (البشرية، المواد، الأدوات والمعدات)	
	جدول زمني (كميات، نوع الموارد، والفترة الزمنية)	
	خطة الموارد البشرية للمشروع	
	سجل المخاطر	
	العوامل البيئية المؤثرة في المشروع	
	أصول العمليات التنظيمية (سياسات، قوالب، معلومات تاريخية، دروس مستفادة)	
2- قياس الكميات وتحديدها		
1- أساليب القياس والتحديد	لدينا معرفة كاملة بعمليات قياس الكميات لجميع بنود الاعمال الانشائية.	
	تحديد وقياس أعمال الموقع الأخرى	
	تحديد جميع الضمانات، الضرائب، والتأمينات	
	تحديد كافة النفقات العامة ونفقات الطوارئ	
	تحديد نسب المخاطر والارباح	
	استخدام تقنية التقدير الصاعد	
3- الاستفسارات		
1- خصائص الموقع	دراسة خصائص الموقع	
2- توفر الخدمات	تحديد جميع الخدمات المتوفرة والممكنة	
3- توفر الموارد	دراسة مدى توفر الموارد	
4- 4- مراجعة وثائق العطاء	تحديد جميع الاستفسارات بعد دراسة الرسومات والمواصفات والموقع.	
4- عملية التسعير		
1- الاليات	تسعير جميع المعدات والاليات الخاصة والمؤجرة	
2- بنود اعمال التشييد	تسعير جميع بنود أعمال التشييد	
3- عروض واعمال مقاولي الباطن	تسعير جميع أعمال وعروض مقاولي الباطن	
5- المراجعة الادارية		
1- عمليات التقدير	مراجعة الإدارة عمليات التقدير خطوة بخطوة	
2- عملية التسعير	مراجعة الإدارة عملية التسعير	
6- تلخيص وقفل العطاء		
1- التلخيص	تلخيص جميع عمليات التقدير والتسعير للمشروع	
	قفل العطاء وتسليمه للمالك	

APPENDIX 11

Results of evaluation tool

Score was from 0= 10, the neutral was= 5.

Model core	section	Areas	Factors	Mean	Areas Mean
Knowledge cost estimate	Construction cost	Direct cost	Concept of direct cost	7.5	6.6
			labour, equipment, tools, and subcontractor direct cost	7	
			Classification of salary, travelling, purchasing, and renting cost.	5.5	
		Indirect cost	Classification of material, labour, equipment, etc. indirect cost.	7.5	6.5
			Classification of indirect cost for permits, taxes, safety tools, and grantees.	8	
			Risk allowances	4	
	Cost estimation methods and techniques	Preliminary estimate	Understanding preliminary estimate	5	3.7
			Historical data	2	
			Analogy (similarity)	3	
			Multiple regression	2.5	
			Artificial neural network	6	
		Detailed estimate	Detailed estimate and bottom up technique	7.5	7.5
			Spec, drawings, documents, and information	7.5	
		Definitive estimate	End project estimate	8	8
			Design- Bid- Build	7.5	7

Model core	section	Areas	Factors	Mean	Areas Mean
	Types of contracts and delivery systems	Acquiring project	Construction Management delivery	4	
			Design- Build Delivery	9.5	
		contracts	Lump-sum	4.5	6.8
			Unit price	7.5	
			Cost plus	6.5	
	Critical factors	Spec.	Complex degree	7.5	5.4
			Work quality	5.5	
			Specification types	2.5	
			Drawings	7.5	
			Required information	4.5	
			Contract requirement	6.5	
			Consultant importance	4	
			Site study	4.5	
		Marketing factors	Material cost	6	5
			Market conditions	8	
			Available technology	1	
			Competition importance	0.5	
			Market inflation	8	
			Fees	5.5	
			Client financial status	5.5	
		Management and planning factors	Project duration	5	4.4
			Project management quality	5	
			Documentation	4.5	
			Project team requirement	3	
			Contract requirement	6	
			Waste of materials	3	
		Risks and regulations	Risks, political, and other risk.	0.5	2.8
			Laws and regulations	5	

Model core	section	Areas	Factors	Mean	Areas Mean
	Safety considerations	Law and regulation	Safety and Health laws	6	5
			Compensation and regulation	4	
		Cost and safety tools	Safety tools	2.5	3.8
			Safety and Health cost	5	
	Cost index	Cost index	Cost index	1	2
			Cost index usage	4.5	
			Foreign cost index	0.5	
Preliminary estimate	Preliminary estimate	Traditional methods	Square meter	5	5
		Modern methods	Multiple regression	3	3
			ANN	3	
Detailed estimate	Base estimate	Base estimate	Scope base line	7	6.6
			Resources calendars	7.5	
			Project schedule	7	
			HR plan	8	
			Risk register	5	
			enterprise environment factors	8	
			Organizational process assets	3.5	
	measurements	measurements	Items of construction projects	3	4.4
			Jobsite Overhead	3	
			Surety Bonds, Insurance, and Taxes	3.5	
			General Overhead	4	
			Contingencies, and Profit	6.5	
			Bottom-up technique	6.5	
	Query	Site visit	Site properties	6	6
			Services available	7.5	
			Resources available	4.5	

Model core	section	Areas	Factors	Mean	Areas Mean
		Review bid documents	Review bid documents	3.5	3.5
	Pricing	Pricing	Machines and tools	7	6.8
			Items of construction project	7.5	
			Subcontractor offers	6	
	Management review	Management review	Estimate process	6.5	7.3
			Pricing process	8	
	Bid summary	Bid summary	Estimate and pricing summary	6.5	6.3
			Closing the bid	6	