COST ESTIMATION PRACTICES OF CONTRACTORS IN THE KINGDOM OF SAUDI ARABIA

BY

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I dedicate this thesis to my beloved parents, for believing in me and supporting me by prayers and advices.

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ABSTRACT

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Project cost estimation is a significant step in the project construction cycle. Based on the cost estimation, the project parties could decide the profitability of the project. Project cost estimation is defined as the process of estimating the project total cost by expecting the achieved productivity in the site during the execution process for future activities. Although it is an important step in the project cycle life, however there is a lack of resources that discuss and analyze the practices and qualifications of cost estimation unit and cost estimators in Saudi Arabia. This research aims to explore the estimation units and estimation process in grade 1, 2 and 3 building contractors in the eastern province of Saudi Arabia. Furthermore, the research intends to identify the qualified estimator characteristics and duties and evaluate the qualifications of the working estimators. Also the research aims to find the major common problems in the estimation industry. The research methodology was depending on developing a questionnaire in order to collect data that contribute in achieving the research objectives. The questionnaire was distributed to different building contractors in the eastern province in the Kingdom through personal visits and emails. The collected data was analyzed by using statistical methods, such as, importance index, T-test method, One-way ANOVA and Spearmen's rho correlation. The most important result was proving grade of the contractor does not affect the level of estimator qualifications, duties or general skills. Moreover, it has been

found that all grades of building contractors in the eastern province of Saudi Arabia are sharing the same estimation problems. These estimation problems has been compared with a previous study done in 1991 and it was found that the ranking of the problems based on the importance index has become different. The result of the analysis process shows that the cost estimation unit has three main characteristics. These characteristics are: 1. small work force (5 employees or less). 2. Specialized cost estimation department and 3. Direct reporting system to the general manager. Moreover, the research shows that Microsoft Excel and Primavera Professional Project Manager are the most common used software combination for preparing project cost estimate in Saudi Arabia. Also, it is found that the method of unit price is the common method for preparing project cost estimate. In addition, it was found that the common used items in the takeoff process are manual from drawing and specifications, computer software and bill of quantities. Furthermore, the analysis shows that the leading two most problems in cost estimation in Saudi Arabia have not been changed during the last 25 years. These leading problems are tough competition and contract period. Also, the analysis shows that experience is far more preferred than education for the estimator qualifications. Additionally, knowledge of cost estimation software was the leading desired qualification of the estimator. The analysis have also shown that general working skills, brain strength skills, management skills, and social and communication skills, in that particular order, identify as the characteristics of qualified cost estimators.

ملخص الرسالة

الاسم الكامل: عبدالله رزق مسلم الشاعر

عنوان الرسالة: ممارسات تقدير التكلفة لدى المقاولين في المملكة العربية السعودية

التخصص: إدرة تشييد و بناء

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يعتبر تقدير تكلفة المشروع مرحلة مهمة من مراحل المشاريع الإنشائية. تقدير تكلفة المشروع بشكل صحيح يحدد إممكانية ربح الأطراف المرتبطة بالمشروع من مقاولين و ملاك. مرحلة تقدير التكلفة في المشاريع الإنشائية تتم عن طريق توقع الإنتاجية لإتمام نشاطات المشروع في الموقع خلال مراحل التنفيذ. بالرغم من أهمية مرحلة تقدير تكاليف المشاريع, توجد ندرة للمراجع العلمية التي تناقش تفاصيل هذا الموضوع في المملكة العربية السعودية. أيضاً العديد من المشاريع في المملكة تواجه مشاكل مالية قد تكون ناتجة عن أمور مرتبطة بمرحلة تقدير تكلفة المشروع. لذلك هذه الدراسة تهدف لدراسة أقسام تقدير التكلفة و تفاصيل عملية تقدير التكلفة لمقاولي البناء من الدرجة الأولى و الثانية و الثالثة في المنطقة الشرقية من المملكة العربية السعودية. بالإضافة إلى ذلك تهدف هذه الدراسة إلى تحديد مواصفات و مؤهلات و واجبات مقدري التكلفة للشريحة المعنية في الدراسة. و تهدف الدراسة لتحديد أكثر المشاكل حدوثاً و شيوعاً في أقسام تقدير التكلفة للمشاريع الإنشائية.

اعتمدت هذه الدراسة على جمع المعلومات عن طريق إنشاء استبيان يهدف لإجابة أهداف الرسالة وتم توزيعه على المقاولين في المنطقة الشرقية. تم توزيع الاستبيان عن طريق رسائل البريد الإلكترونية و الزيارات الشخصية لمكاتب المقاولين. بعد جمع المعلومات و البيانات المعنية بموضوع الدراسة تم تحليل هذه المعلومات بطرق إحصائية علمية كمعيار الأهمية و دلالة معامل الإرتباط. و كانت من أهم النتائج المكتشفة في هذه الدراسة, إثبات أن درجات تصنيف المقاولين لا تؤثر على نوعية المشاكل التي تواجههم و لا على مؤهلات و واجبات مقدر التكلفة. أثناء مرحلة تحليل البيانات تم مقارنة قائمة المشاكل الحديثة بقائمة لنفس المشاكل من دراسة سابقة تمت في عام 1991 و تم ملاحظة أن ترتيب أهمية المشاكل واجه بعض التغيرات على مر السنوات. بالرغم من هذه التغيرات ما زالت مشكلتي المنافسة الشديدة بين المقاولين و مشكلة الوقت الزمني للمشروع المشاكل متصدرة الترتيب في القائمة الجديدة و القديمة. من

النتائج المهمة أيضاً أن أقسام تقدير التكلفة في المملكة تتميز بثلاث خصائص: أولاً طاقم عمل صغير يتكون من أقل من خمس موظفين و ثانيا شركات المقاولات تملك أقسام خاصة لتقدير التكلفة بأسماء خاصة و ثالثاً يتواصل قسم تقدير التكلفة بطريقة مباشرة مع المدير العام للشركة. و أوضحت الدراسة أيضا أن برنامجي المايكروسفت ايكسيل و برامافيرا يعتبران أكثر البرامج الإلكترونية شيوعاً في عملية تقدير التكلفة. و أوضحت الدراسة أيضا أن طريقة التسعير بالوحدة هي الطريقة الأكثر استخداماً لتقدير التكلفة. بالنسبة لطرق أخذ الكميات أظهرت النتائج أن رسومات و بيانات المشروع بالإضافة لبرامج الحاسب الآلي و فواتير الكميات هي الطرق الأفضل لإتمام العملية بنجاح. و أظهرت الدراسة أيضاً تفضيل الخبرة العملية على المستوى العلمي لمقدرالتكلفة. و تم ملاحظة أن معرفة استخدام برامج الحاسب الآلي المختصة بتقدير التكلفة هي أكثر المؤهلات رغبةً لدى المقاولين. أظهرت النتائج أن أهم مواصفات مقدر التكلفة يمكن ترتيبها من الأهم إلى الأقل أهمية كما يلي: مهارات العمل العامة يليها المهارات العقلية و يليها المهارات الإدارية و أخيراً مهارات التواصل الإجتماعية.

CHAPTER 1

INTRODUCTION

1.1 Overview

Construction cost estimation is a general statement related to every project from its early stages to the final handover of the project. Construction cost estimate gains its importance in the construction industry because it's related to the project capital. Construction cost estimation aims to provide the clients with their financial liability in the projects and the effect of the major design decision on the project cost (Skitmore, 1994). Although it is consider an essential step in the construction industries, most people misunderstand this statement or applying it in the wrong way. To avoid such problems a clear definition of this statement should be provided. Based on Oxford English dictionary the word estimate means "A written statement indicating the likely price that will be charged for specific work". Also, the basic word estimate could be defined as the assessment of the total cost of something within a reasonable range. This definition could be more related to construction industry if the assessment part was the project future activities (Pratt, 2004). In general construction cost estimation is the process of estimating the project total cost by expecting the achieved productivity in the site during the execution process for future activities (Kiziltas, 2010). The estimation process usually covers the cost of main resources such as manpower, materials and equipment to complete the project in

accordance with plans and specifications (Al-Harbi, p. 1993). From the definition it is clear that the estimation process is very critical process and gains its importance from its relation with the project capital. Moreover, construction cost estimation is crucial in the tendering process because it could jeopardize the company future profit by preparing an inaccurate cost estimate (Hackett, 2007).

1.2 Problem Statement

With the rapid growth in the construction industries around the Kingdom of Saudi Arabia during the last decade a lot of new construction companies have been established. However, the construction industry in kingdom of Saudi Arabia are still facing problems of lack of resourcing which discuss and analyze the practices of the cost estimation units and the estimation process. Moreover, due to the construction industry booming the need for increasing the staff member becomes a necessity for construction companies. However the need of hiring a new people in short time could affect the quality of work. This affect shown clearly in the estimating department, since a lot of projects in the kingdom executed over the determined budget and facing a lot of financial problems. Several construction companies have project budgeting problems as a result of hiring a novice estimator or hiring an accountant to do estimators duties. Therefore, in order to avoid such problems there is a huge need to understand the used mechanism for hiring an estimator in the construction companies. Understanding the hiring mechanism will depend on determining the required estimator characteristics by the local construction companies. Moreover, Knowledge of the qualities that characterize the expert and non-expert estimator will be important in solving the budgeting problems. Therefore, what

are the main characteristics of the cost estimation unit in Saudi Arabia? And what are the required estimator characteristics by the local construction companies for recruitment purposes?

Project budgeting problems occurs due to the estimating department errors and problems. Therefore, identifying the most repetitive occurring problems in the estimating department will be useful for improving of the estimating process which will reflect well on improving the estimated projects budget. Therefore, what are the most occurring problems facing the estimators during their work in the projects in the kingdom?

1.3 Research Objectives

The main objective of this research is to study the practices that are followed by grade 1, 2, and 3 building contractors in the Eastern Province of Saudi Arabia in order to prepare project estimates. Studying the practices will cover three main aspects: estimation department, estimation process and employees characteristics. Specifically, the study aims to

- Identify the characteristics of the estimating units of grade 1, 2, and 3 building contractors in the Eastern Province of Saudi Arabia.
- Identify the methods that grade 1, 2, and 3 building contractors in the Eastern Province of Saudi Arabia use to estimate projects costs.
- Identify the qualifications of cost estimators who are working for grade 1, 2, and 3 building contractors in the Eastern Province of Saudi Arabia.
- Identify the characteristics of qualified cost estimators.

- Pin down the major problems and challenges faces the estimators during their work of preparing project cost estimates for projects that grade 1, 2, and 3 building contractors in the Eastern Province of Saudi Arabia bid for.

1.4 Research Significant

Accurate estimates consider one of the main pillars in the process of making the decision for parties to involve in the project. Based on the accurate estimate the contractors and other parties will decide whether the return from the project is adequate for the resources that are employed in the project or not. In other world the good quality estimate will be one of the main indicators for the project profitability. There are several factors controlling the process of developing a good quality accurate estimate, one of these factors is the estimator. The role of the estimator considers critical for the financial success of any project. Therefore, based on the previous facts the significance of this study shows clearly by determining the main characteristics that define the good quality estimator. This study aims to show for firms that the investing in hiring a good experience estimator or providing training programs for the estimators will return well for the firm's since assigning a non-professional estimator for estimation duties could causes more losses for the firms than hiring a professional estimator.

Moreover, this study could decrease the number of estimating error and increase the quality of the estimate by focusing on the main problems facing the estimators in the Kingdom of Saudi Arabia. Analyzing the list of ranked estimation problems helps contractors to improve the quality of works, which will reflect on improving the general atmosphere of the construction industries in the Kingdom. Also, by knowing the common

problems that are facing the estimator the contractors could use this study as a tool to improve their estimation departments.

In a country racing the time to develop and improve especially in the construction field such as the kingdom, project cost estimation studies is very crucial. However, based in the preliminary search that has been conduct to develop this introduction, the amount of studies and research discussing the same topic in the kingdom are rare and outdated. Therefore, there is a clear need to discuss this topic in depth. This study promises to provide a valuable and up to date information and data that will enrich the content of the project cost estimation in the kingdom of Saudi Arabia.

Moreover, during the current economics fluctuation and crises any research related to project capital considers valuable. The economics fluctuation reflects on the contractor's decision of investing in any project. Such critical economics situation makes the contractors and investors pay more attention to any factors that could increase their revenue. Therefore, a study about the estimator characteristics and common estimator problems will become valuable and crucial nowadays in the construction industry.

1.5 Scope and Limitation

This study will be limited to contractors' cost estimation practices and estimator qualifications. Due to time and cost constraints this study will be limited to Grade 1, 2, and 3 contractors that are located in the Eastern Province of Saudi Arabia. Moreover, this study is limited to building contractors that are located in Eastern Province of Saudi Arabia. The study is limited by the informant level in building Contractor, since the required data is divided to two parts. First part is seeking information from construction

cost estimator and the other part is seeking information from top management level, project managers

CHAPTER 2

LITERATURE REVIEW

This chapter presents the cost estimation practices as reported in the literature review. The following sections present the construction cost estimation methods, Construction cost estimation process, cost estimation accuracy, Estimator Characteristics, Estimator qualifications, and Problems facing cost estimators.

2.1 Methods of Construction Cost Estimation

Developing accurate cost estimate for a project consider a critical step as a result of the effect of this step on determining the project budget and profitability. And this will lead to increase the probability of completing the project with the estimated budget (Venkataraman, 2008). Therefore, the appropriate method of estimation should be used correctly for each type of project in order to increase the accuracy of the process. Based on the available project information the methods of estimation could be determined. In addition, the process of choosing the appropriate method of estimation could be affected by other factors such as the type of the project, the delivery system used to construct the project and the nature of the contract (Pratt, 2004). In general, estimation method could be divided into two main parts: preliminary and detailed estimating techniques based on the amount of used and available information (Pratt, 2004). However, before elaborating on these two methods there is one basic type of estimation should be explained. This basic estimation method knows as conceptual estimate.

Conceptual estimating is defined as the process of using the ideas and notions of the project owner that he has about the project construction to develop approximate cost estimation for the project (Pratt, 2004). This method is not a definite estimation method; however it is used in the very early step of the project to produce a rough estimation for the project cost. In developing the conceptual estimate the estimator must be careful and accurate as possible because the feasibility decision in investing in the project will depend on the conceptual estimate and other factors (Pratt, 2004).

Preliminary estimate generated during the early stages of the project by using the preliminary drawing and specification that explain the general scope of the project (Pratt, 2004). By developing a general scope for the project the estimator will have an imagination about the size, shape and layout of the design which could help him in developing the preliminary estimate (Pratt, 2004). However, the level of available information is not adequate to generate a detailed estimation yet (Pratt, 2004). The preliminary estimation could be handful in many ways, for instance it could indicate if the preliminary design is within the contractor capability or not (Pratt, 2004). Moreover, preliminary estimate assist the designer in considering an alternative design option that could be more efficient with the project budget (Pratt, 2004).

Detailed estimate consider one of the most used methods of estimation in the construction industries. The preparation process for the detailed estimate include collecting, recovering and handling a huge amounts of project information in short time (Al-Harbi, p. 1993). To collect the required information, the project scope of work must be well defined by using the detailed drawing and specification (Pratt, 2004). The collected information could be related to any of the following stages of the project; procurement

stage, fabrication stage and installation stage (Carr, 1989). Mr. David Pratt in his book "Fundamentals of construction estimating "summarized the process of developing a detailed estimate in six steps as follow:

1. Quantity takeoff; it is the process of measuring the work done by the contractor by using a standardized methods and rules.
2. Recap quantity; it is the process of sorting and listing the takeoff quantities from the last step in order to facilitate the pricing process.
3. Pricing the recap.
4. Pricing the subcontractor.
5. Pricing the general expenses.
6. Summary and bid; the bid will be ready to submit after summarizing all the estimated prices and adding the contractor mark-up.

Rather than the preliminary estimate the detailed estimate consider more accurate method of estimation (Pratt, 2004). This high level of accuracy in this method is obtained from using the project full designs in the detailed estimating process (Pratt, 2004). As a result of using the project full designs the detailed estimates consume more time comparing with the preliminary estimate (Pratt, 2004). Moreover, a detailed estimate is appearing as handful method for contractor when it is used in preparing the estimate for lump-sum projects; because it is anticipate the value of the bid to avoid any surprises (Pratt, 2004).

Regardless of the last deviation of the estimation methods; Vencataraman and Pinto in their book "cost and value management in project" divided the estimation methods in more detailed manner as follow:

1. Order or magnitude estimate (Ballpark estimate): this method becomes useful when the amount of project information or time to develop detailed estimate is not enough. Also, it is used for the initial rough estimation for the required resources to execute the project. The margin of error in the Ballpark method is around ±30 percent.
2. Feasibility estimate: the complete preliminary designs and the initial scope of work are the main base line to develop the feasibility estimate. Therefore the margin of error in this method is less comparing with the ballpark method with percent of ±10.
3. Definitive estimate: this method depends mainly on the completion of final designs works. At this stage of the project the amount and quality of the available information would lead to generate more accurate cost estimate. The percent of margin of error drops in this method to ±5 percent.
4. Comparative estimate: this estimation method depends on the historical data that were collected from the previous similar projects.

In addition to all the previous methods the new technology presents new ideas that can be implemented in the estimation process in order to improve the process accuracy. One of these new technologies is building information modeling (BIM). The definition of building information modeling is the process of using the computer programs to generate a digital representation of the physical and functional characteristics of the project. By using the BIM technology, the estimator will be able to extract the quantities, areas and volumes of the materials efficiently (Kim, 2013). Moreover, the BIM technology could accelerate the estimation process which will be useful during the biding phase due to the

fact of high competiveness in this phase. Comparing with the traditional estimation methods the BIM technology is faster by 80% and more accurate by 3% (Kim, 2013). Moreover, 45% of the cost estimation for the project could be saved by utilizing the BIM technology in the estimation process (Degenaar, 2013). However, generating the BIM required complete design drawings for the entire project to be used in the modeling process which could not be available yet in this early stage of the project (Kim, 2013). Therefore, despite of all the advantages of the BIM technology, generating the BIM is a difficult process and required high level of coordination between the involved departments.

2.2 Construction Cost Estimation Process

The estimation process depends mainly in the type and the purpose of the estimate. Usually the purposes of estimate are feasibility study, budget determination, bid evaluation issues, control estimate, value engineering, evaluate progress, life cycle costing analysis and project cost analysis. The importance of each estimating purposes vary from one country to another base on the requirement of the construction industry situation in the country. In Saudi Arabia estimates are prepared for three main purposes, which are: feasibility study, budget estimate and bid evaluation estimate – design estimate -. The following lists explain the estimating process for each estimating purpose in Saudi Arabia. The list developed based on information from the research "Cost Estimation Practice for Buildings by A/E Firms in the Eastern Province, Saudi Arabia" by Al-thunaian Saleh.

2.2.1 Feasibility Cost Estimation

- Definition of the project scope, details and the extra client requirements

- Evaluate the project site and the project location
- Use records from previous projects to determine the rate/unit size of construction form with adding allowances for special requirements.
- Define major equipment prices from suppliers
- Forecast the project development time cycle and utilize appropriate price indices
- Adjust the cost based on the company overhead and contingency

2.2.2 Budget Cost Estimate Process

- List and divide activities from tender documents to groups
- Develop quantities takeoff for materials and equipment
- Obtain prices for materials from suppliers
- Use records from previous projects to determine the rate/unit size of construction form
- Add allowances for especial requirements
- Adjust the cost based on the company overhead and contingency and to reflect the price index.

2.2.3 Design Cost Estimation

- Develop list of activities based on the disciplines individual estimates
- Develop bill of quantities for equipment, labor and materials
- Obtain prices for materials and from suppliers
- Use records from previous projects to determine the cost of labor and equipment
- Add cost of contingency, price index and project management

2.3 Construction Cost Estimation Accuracy

Developing an accurate estimate is essential part of the project, because determining the required budget for completing the project according to the plans and specifications is depending mainly on the estimation process. The final actual cost of most projects exceeds the estimated cost as a result of generating an inaccurate estimate from the beginning (Oberlender, 2001). Therefore, the real challenge in generating an estimate is generating an estimate with accurate reflection of reality. The process of generating an accurate estimate could be affected by a lot of factors such as estimator skills, amount of available information and the used technique (Skitmore, 1994).. This section will focus on the estimator skills factor that effect estimation accuracy level (Skitmore, 1994). The accuracy of estimate could be divided into two main parts which are accounting accuracy and job performance based estimation accuracy (Moore, 2008).

The first part the accounting accuracy is referred to the accuracy of the calculations during the takeoff and pricing process (Moore, 2008). Improving the accounting accuracy depend on spending more time on reviewing the numbers and the drawing to ascertain the required accuracy (Moore, 2008). Moreover, the accounting accuracy could improve by using the computer software in the calculation process (Pratt, 2004). However, the estimator must be understand all the data that feed the computer, because based on the input data the output data will be affected (Pratt, 2004). Also, the accounting accuracy affected by the amount of the available information from the design drawings and specification.

In the second part, the job performance based estimation accuracy (JPEA); the accuracy is related to the skills of the estimator himself (Moore, 2008). In this part the estimator

judgment and his ability of decision making play the main roles in increasing the estimation accuracy (Moore, 2008). For instance, estimators usually use the data from one point view without considering other factors that could affect the estimation accuracy (Moore, 2008). The used data should include work environment in order to add more detailed to the estimation process (Moore, 2008). Another example, estimator could use the total average hours for completing the work in the estimation process and his result will show that the used hours for completing the project is less than the estimated hours (Moore, 2008). However, the average data could not show the underestimated and overestimated parts of the project which could affect the accuracy of the estimation process for future project, because this data are usually used as historical data reference in the future for similar projects (Moore, 2008). Also, it is important for the estimator to understand the similarities between the current project and the historical data to develop an accurate estimate (Carr, 1989).

Regardless of the accuracy types, the estimation accuracy in general could improve by implementing a well-organized estimation method from the beginning of the process (Pratt, 2004). Moreover, implementing a well-organized estimation method will reflect into employing the project resources more effectively (Pratt, 2004). Also implementing a standard international estimating format such as the Construction Specification Institute (CSI) format could decrease the estimate errors and improve the estimate accuracy (Al-Harbi, p. 1993).

Another important factor that could affect the accuracy of the estimation process is contingency situations. Contingency situation could be divided into two types in the estimation process (Carr, 1989). First type is the expected value of possible identified

event such as predicting increase in the amount of used material during the construction. In this situation the estimator could indicate this possibility of change in the estimate (Carr, 1989). In the second part of the contingency situation the situation will be more complex and tricky because the change in estimation will occur as a result of unforeseen events such as equipment breakdown (Carr, 1989). The second part of the contingency situation considers as a margin of error in the estimate, therefore the estimator must pay more attention for this type to avoid such problems (Carr, 1989). Since the rule of the estimator skill's obviously affecting the accuracy level of estimate, it is important to define the required skills and qualification.

2.4 Estimator Characteristics

The estimation process depends on a combination of several aspects such as: data, calculation, analysis, technique and judgment (Ashworth, 1988). The estimator characteristics are the main key to utilize the previous aspects in more efficient way, which will lead to improve the estimation quality. The effect of the estimator characteristics shown clearly in the aspects that relate to the judgment and analysis for preparing the estimate. Skill, experience and professional judgment considers the three main required characteristics for preparing the estimate (Rajpatty, 2008).

Estimators play an important role in improving the quality of the estimation process. Many estimating error in the construction project occurred as a result of employing non expert estimator for the estimation process. Moreover, nowadays a lot of estimation problems occur as result of delegating the estimation process for accountants with no experience in the construction industry. Most companies' falls in this dilemma as a result of considering the estimation process as a counting or quantifying process without

considering the construction aspect of the process (Barerett, 2008). As a result of employing the wrong personal for the estimation process, companies suffer from losses caused by projects being either over budget or under budget (Kiziltas, 2010). Therefore, an estimate consider reliable when accurate historical data was used for generating the estimate and experience estimators were involved in the process (Kiziltas, 2010). However, during the estimation process estimators should cooperate and involve with other department in the company such as field supervisor and management in order to generate accurate high quality estimates (Pratt, 2004).

One important characteristic of the experienced estimator is to have a comprehensive vision for the estimated activity from the preparation phase to the finishing phase in order to avoid ignoring any part during the estimation process (Carr, 1989). This problem appears clearly when the estimator does not have an experience in the construction industries. Estimator with comprehensive vision will be able to include other cost elements beyond the construction cost such as insurance, permits, warehousing and transportation cost depending on the level of details required in the estimates (Carr, 1989). Moreover, an experience estimator will be able to imagine the final form of the project by integrating the historical data with his experiences and use this image to improve the accuracy of the estimation process (Barerett, 2008). Also, an experienced estimator will be able to address some effective miscellaneous aspects of the project and that will give the experienced estimator advancement comparing with novice estimator. For instance, the experienced estimator will consider factors that could be ignored by the novice estimator such as inflation rate, risk rate, licenses issue, cost of debt and cost of capital (Rajpatty, 2008).

Another major difference between experienced estimator and novice estimator is the ability of decision making in the issues related to the estimation process and the amount of needed information to reach to decision by each party (Kiziltas, 2010). The experienced estimator could observe more information than the novice estimator from the drawing and specification which will reflect positively on the accuracy and quality of the estimation process (Kiziltas, 2010). In addition, an experienced estimator has more capability compared with novice estimator to determine important factors that could affect the estimation process such as the production rate of activities (Kiziltas, 2010).

2.5 Estimator Qualifications

The process of preparing a good quality estimate depends heavily on the skills and the qualifications of the estimators (Skitmore, 1994). Previously the estimator role was limited on preparing an estimate that fit the considered total price which is done nowadays by the quantity surveyor (Hackett, 2007). Modern construction industry gives the estimator more duties than before such as: dealing pre tender information, working with contracts and working with design team (Hackett, 2007). Therefore, several studies around the world discussed the required skills and qualification of the estimator in the modern construction industry. Most of these studies develop a ranked list of the required qualifications and competencies base on the feedback of construction companies in the area of the studies. Generally the list of required qualifications covers the estimator education level, estimator experiences and estimators skills. One of the best ranked estimator qualifications list was provided by James A.Hackett and Carolyn M.Hicks in their published paper “Estimating as a Profession in UK Construction”. The list covers 18 required estimator competencies in UK construction companies as follow:

1. Estimating skills
2. Ability to prepare, select and appraise bids
3. Intelligence and cognitive ability
4. Good personal qualities
5. Team work ability and good communication skills
6. Good knowledge related to construction
7. Information technology (IT) skills
8. Ability to measure work and prepare bill of quantities
9. Relevant experience
10. Risk management
11. Knowledge of contracts law and contract
12. Negotiating skills
13. Provide contract financial advice to client
14. Good formal education
15. Professional training
16. Management skills
17. Commercial business acumen
18. Provide post contract financial and construction advice to client.

2.6 Problems Facing Cost Estimator

Between 1989 and 1991 a study was conducted by Kamal Al harbi, David Johnston and Habib Fayadh under a name of "building construction detailed estimating practice in Saudi Arabia". The study was built after interviewing a randomly selected 24 building contractors in the eastern province of the kingdom. Part of the study was focused in the

issue of ranking problems facing cost estimators in preparing the cost estimate. Twenty problems have been identified and ranked as follow:

1. Tough competition
2. Contract period
3. Inadequate drawing and specification
4. Poor project scope definition
5. Unforeseeable change in material prices
6. Requirements change by owner
7. Current workload
8. Judgment errors
9. Inadequate time
10. Lack of historical data based on similar jobs
11. Lack of experience for similar jobs
12. Unfamiliarity with government law and regulations
13. Omission of work item
14. Shortage of confidence in work force
15. Difficulty and complexity of project
16. Shortage of productivity information in Saudi Arabia
17. Content of arbitration clauses
18. Shortage of cost data indices in Saudi Arabia
19. Mathematical errors such as calculation errors
20. Subcontracted work

CHAPTER 3

RESEARCH METHODOLOGY

This chapter presents the steps that were followed to achieve the objectives of this study. The chapter is divided into four sections. The first section explains what type of information and data were gathered and how do they relate to the objectives of this research. The second section focuses on data collection methodology of choice, and elaborates on said methodology. The third section discusses the targeted sample for data collection, the location and quantity of involved population. The fourth and last section of this chapter describes how the data was statistically analyzed, also provides brief introductions to explain the parameters of every used method.

3.1 Required Data

The nature of the required data is derived directly from the research objectives and effective variables. Collected data was divided into five categories, one for each of the five objectives of the research. In the following paragraphs, these five data categories will be introduced and properly related to their corresponding research objective:

3.1.1 Data of the cost estimation unit characteristics

The first objective of this research was related to cost estimation unit, therefore, the first category of required data follows accordingly. The data collected covers work-force size of the unit, the location of the unit in the organizational structure, for how long the units have been active, and the reporting process through the cost estimation unit.

3.1.2 Data of method of cost estimation

The second objective of this research is about the cost estimation processes and the implemented methods by the cost estimation unit. Generally, this part aims to find which estimation methods are commonly used in the area, and collect more detailed information about the main steps of each method. Gathered information is divided into five types in order to reflect the second research objective. These information types are:

1. Cost estimation software.
2. Cost estimation methods
3. Tools for quantity takeoff
4. Factors affecting construction methods
5. Types of data used for determining productivity.

3.1.3 Data of estimator job qualifications

The third category of the required data is related to the third research objective. This objective is, identifying the qualifications of the current estimators in the estimation unit in building contractors in Eastern Province of Saudi Arabia. In order to identify estimator qualifications there were two types of involved data, the first type is data about job duties of the estimator in the cost estimation unit. Such as analyzing blueprints and documentation, and consulting clients. The second type of data is about the requirements for project cost estimation job. Examples for the second type are: level of education and knowledge, years of experience and training and finally personal characteristics.

A clearer list of the estimator duties and a complete list of the cost estimation job requirements are provided in the appendix A.

3.1.4 Data of qualified cost estimator

The fourth section of the required data is focusing on the fourth objective of the research, which is defining the characteristics of qualified estimator. Characteristics of qualified cost estimator are defined by determining the required estimator skills. Estimator's skills cover four aspects of estimator personality. These aspects are: cognitive strength and abilities, communication and social skills, general working skills, and management skills. The complete list of estimator skills is available in appendix A. Example for some of the skills and their classification under the four mentioned aspects are shown in the following:

- General working skills: active listening, reading comprehension, active learning, monitoring, quality control analysis, problem sensitivity.
- Management skills: time management, management of personal resources, management of material resources, management of financial resources.
- Brain strength skills: negotiation skill, near vision, critical thinking, complex problem solving, number facility, judgment and decision making, fluency of idea, persuasion skill, operation analysis.
- Communication and social skills: coordination ability, social perceptiveness, actively looking for way to help people, instructing.

3.1.5 Data of cost estimation problems

The fifth section of the required data aims to pin down the major common problems facing estimators in the working environment in the eastern province of Saudi Arabia. Problems were obtained from the literature review in a list containing twenty problems.

The list was developed by Kamal Al harbi, David Johnston and Habib Fayadh in their paper “building construction detailed estimating practice in Saudi Arabia”. The list was developed based on studying the practices of cost estimation unit in Eastern Province of Saudi Arabia in the year of 1991.

The listed problems could be divided into three parts. The first part covers problems related to work conditions in the estimation unit in the company and the general environment for the estimation industry in Saudi Arabia. These kinds of problems need government effort and cooperation to be solved and improve. The second part covers relationship between the owner, contractor and designer. In order to solve this type of problems a clear effort from owner, contractor and designer is required. The third part covers the nature of the project itself. This part of problems requires improvement on the cost estimation unit in the company, which in turn, requires an effort from the building contractors. The list contains problems such as tough competition, period of contract, judgment errors and inadequate time. The complete list is divided under the previous three parts in Table 1, also the full list is provided in the literature review under the section “Problems are facing cost estimators”.

Collecting data about cost estimation problems in Saudi Arabia is required to answer the research fifth objective, which is, identifying the major problems in the cost estimation industry in Saudi Arabia and figure out if there is any correlation between the present data and the past data.

Table 1 Cost Estimation Problems Classification

Problems related to general environment in the construction industry	Problems related to relationship between owner, contractor and designer	Problems related to project condition
Tough competition	Contract period	Current work load
Unforeseeable change in material prices	Incomplete project scope definition	Portion of work to be subcontracted
Lack of data indices in Saudi Arabia	Change of owner requirements	Work item omission
Lack of historical data	Inadequate drawings and specifications	Lack of experience in similar job
Lack of productivity information in Saudi Arabia	Content of arbitration clauses	Lack of confidence in work force
Unfamiliarity with government regulations		Difficulty of project
		Judgment error
		Calculation error

3.2 Nature of Respondents

The objectives of the study mandate the collection of data from two respondents types in contractors' organizations. The first respondent type is the cost estimating unit employee who works in preparing cost estimates. People falling under this type of respondents were requested to provide information related to: the cost estimation unit, cost estimation methods, cost estimation process and problems facing estimators; since they have the required knowledge and experience. In addition, project cost estimators are able to rank the major common problems in the estimation field and pin down any new problems. The

second respondent type is the top management employees; they were requested to evaluate their cost estimators and to determine the desired qualification of cost estimators. Top management levels such as project managers are able to determine the job description and the job requirements for the estimator which fulfills the objective of this research.

3.3 Data Collection Tool

The method of choice to collect the required was a survey questionnaire. Two sets of questionnaires were developed to collect the required data. The first questionnaire aimed to collect data from cost estimators and the second questionnaire aimed to collect data from top management employees in estimating departments. The purpose of developing two sets of questionnaires was to take the right information from the right source.

The cost estimator questionnaire consists of four parts. The first part contains questions seeking information on the contractor organization such as location, size, grade, annual construction volume, etc. The second part contains questions seeking information about the respondents such as job title, experience, education, etc. The third part contains questions seeking information about the cost estimation unit such as name of cost estimation unit, cost estimation methods, resources, productivity selection methods, etc. The fourth part lists potential estimating problems and requests the key informant to indicate his level of agreement with these problems. A copy of the cost estimators' questionnaire appears in Appendix A.

The top management questionnaire was used to collect data from top management level. This questionnaire consists of four parts as well. The first part is seeking information about the informant and level of satisfaction of the top management level for current cost

estimation unit in the company. The second part lists the job requirements for estimator and requests the key informant to indicate his level of agreement with the requirements under two situations which are actual working condition and based on the informant opinion. The third part lists the estimator duties and requests the key informant to indicate his level of agreement with the duties based on the actual working condition. The fourth part lists the required estimator skills and requests the key informant to indicate his level of agreement with the skills under two situations which are actual working condition and based on the informant opinion.

3.4 Population and Sampling

The targeted participants for the survey questionnaire in this research are building contractor companies that are located in the Eastern Province of the kingdom of Saudi Arabia. The scope of this research is limited to building contractor companies of grade one, two and three. The list of the targeted classified participant was obtained from the classification of The Ministry of Municipal and Rural Affairs in the kingdom of Saudi Arabia. The total population number is 93 building contractor companies. The 93 building contractor companies are distributed on grades 1, 2 and 3 as follow:

- 22 grade 1 building contractors
- 29 grade 2 building contractors
- 42 grade 3 building contractors

The targeted population size is small, and it is anticipated that not all contacted contractors would cooperate and participate in the questionnaire. Therefore, for the

reliability of the study findings, Kish formula was used to determine the acceptable required number of responses from grade 1, 2 and 3 building contractors as follow:

$$n_0 = \frac{pq}{e^2}$$

$$n = \frac{n_0}{1 + \frac{n_0}{N}}$$

$where : p = 0.5 \quad , \quad q = (1 - p) = 0.5 \quad , \quad e\,(\text{desired level of precision}) = 10\%\,,$

$N = population$

The minimum required respondents of each grade obtained from Kish formula is illustrated in Table 2. The total required minimum number of respondent was found to be 42.

Table 2 Require Respondent Number of Contractors from Each Grade

Contractor Grade	**Population**	**Required number of respondent**
Grade 1	22	12
Grade 2	29	13
Grade 3	42	17
Total	93	42

3.5 Data analysis

This section explains all statistical methods that will be used on the analysis process for the collected data. A brief introduction for each method has been provided through the following subsections. In the introduction of each method, the parameters and equations of each method have been stated and explained.

3.5.1 Importance Index

Since the survey questionnaire was designed on the basis of a point scale system, the mean score of each item of the questionnaire is to be calculated. The obtained measurements are then used to rank items through calculation of their importance using the following formula:

$$Importance\ Index = (\sum_{i=1}^{5} W_i \times f_{xi}) \times \frac{100}{4n}$$

Where W_i = weight given to ith response

f_{xi} =Response frequency

n = total number of response

The importance index is to be used for the ranking process both for estimator characteristics and for the common problems in the estimation field. The ranking will be utilized in finding any correlation between the collected data and any previous data from old researches.

3.5.2 Spearman's Rho Correlation

Spearman's rho correlation method is utilized in this research to find the correlation between the lists of cost estimation problems in Saudi Arabia during the interval from 1991 to 2016. Spearman's rho correlation is defined as a statistical method used to find the strength of monotonic relationship between paired ranked data. A Monotonic relationship is defined as the state of a function where the relationship between the data does not change dramatically over the range of the data. Spearman's correlation method calculates a coefficient and based on this coefficient the correlation level is determined. The coefficient ranges between 0 and 1. When it is near to 0, the correlation is considered very weak, and when it is near to 1, the correlation is considered very strong. The following formula describes the spearman's correlation coefficient (r) calculation:

$$r = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

Where

d = the difference between the ranks of corresponding values

n = number of value in each data set

3.5.3 Hypothesis Testing: The ANOVA and T-test Methods

In order to test the collected data and make a valid comparison, two hypothesis testing methods were implemented in this research, the T-test method and the One-way ANOVA test. The One-way ANOVA is a test used to compare two or more means of different groups (Five Step Hypothesis Testing Procedure, n.d.). The T-test method is used to find the difference between two means of populations. However the T-test is usually used for small sample size ("T-Test Definition", 2010). Both tests were performed using the Minitab 17 software.

CHAPTER 4

RESULTS ANALYSIS AND DISCUSSION

The analysis process consisted of two levels: general analysis, and hypotheses analysis. General analysis is related to finding general information such as: importance index, percentages, data comparison and ranking the lists by importance. Also, in general analysis, two statistical methods were used to study, compare and find the correlation between some of the collected data. These methods were T-test method and Spearmen's rho coefficient. Hypotheses analysis is the second and deeper level of analysis, where four hypotheses were developed and tested. The four hypotheses were built to test the correlation between the grade of the contractor and estimating problems, qualification of estimator, estimator's duties and general skills of estimator. To test the four hypotheses, One-way ANOVA method was utilized. In addition, this chapter answers the research five objectives.

4.1 Characteristics of the participants

The questionnaires were sent separately based on the type of the informant and type of required data. Building contractor companies from grades 1, 2 and 3 in Eastern Province of Saudi Arabia received two different separate surveys each. One directed to the cost estimators and another one directed to the top management level (project managers). Some questionnaires were sent through email. But the most of the surveys were printed and distributed by hand to the targeted participants through personal visits. The

distribution methods were depending mainly on the accessibility to the targeted participants and their respondents.

According to Kish formula, 42 different building contractors in the eastern province of Saudi Arabia is the required number of participants. However, participation wasn't guaranteed, the researcher aimed to widen the distribution process including all (93) of the building contractors of grade one, two and three based on the provided information from the website of the Ministry of Municipal and Rural Affairs in the Kingdom. The researcher visited (63) and sent emails to the other (30) different building contractors from grade one, two and three in order to guarantee collecting the minimum number of responses.

During the visits the idea and objectives of the research were explained for the participant contractors. Most of the personal visits were done at two trips in two different days or more for the same contractor, since the majority of the participants ask for time to fill the questionnaire. The total collected responses were (34). Out of the (30) emails sent, only (10) responded and out of the 63 visits only 24 agreed to participate. This means that 36.6% participated in the study which is considered above the typical norm of 20-30% response rate in most postal questionnaire surveying the construction industry.

The (34) responses were divided through the building contractor grades as follow:

- (13) responses form grade one
- (10) responses from grade two
- (11) responses from grade three

Referring to Table 3, most of the building contractors companies that were involved in the research are located in Khobar (21 companies), Dammam (9 companies) and Dhahran (4 companies). Moreover, 16 companies that were involved in the research have been in the business for twenty years or more. Noting that the annual construction volumes of grade one companies were equal 300 million or more, 100 million to less than 200 million for grade two, and less than 100 million for grade three, where all the annual construction volumes are in Saudi Riyal. Therefore, the collected data have a reasonable variation which will reflect well on the analysis process.

Table 3 Participants Location

Company Location	Participants Number
Khobar	21
Dammam	9
Dhahran	4
Total	34

4.1.1 Characteristics of Cost Estimator

Referring to Table 4, the results indicated that 16 of the participating cost estimators have 15 years or more of experience. The remaining participants have experience periods varying as follows: 5 participants with (10 to less than 15) experience years, 12 participants with (5 to less than 10) experience years and finally one participant with less than five years of experience. For experience related to project cost estimation 14 participants have less than five years' experience, 5 participants have (5 to less than 10) experience years, 5 participants have (10 to less than 15) experience years and finally 10

participants have fifteen years of experience or more. Figure 1 shows distribution of the percentages of the participants through the experiences options.

Referring to Table 5, the results indicated that 32 of the participants are bachelor's degree holders and two are diploma holders. The field specialty distribution of the participants is as follow: 26 participants are civil engineer, 6 participants are mechanical engineer, one participant is electrical engineer and the last one is undetermined. Since 16 participants have an equal to 15 years or more general experience the quality of the collected data are decent and reflect the real working condition and situations. Meanwhile, the majority of the participants is bachelor's degree holders and is specialized in civil engineering which gives the data more credibility, because the sample is concerned with building contractors. Obtaining data from such quality participants gives credential to the data and, hence, reliability to the obtained results.

Table 4 Summary of Cost Estimator Experience

	General Experience	**Experience Related to Cost Estimation**
15 years or more	16 participants	10 participants
10 to less than 15 years	5 participants	5 participants
5 to less than 10 years	12 participants	5 participants
Less than 5 years	1 participant	14 participants

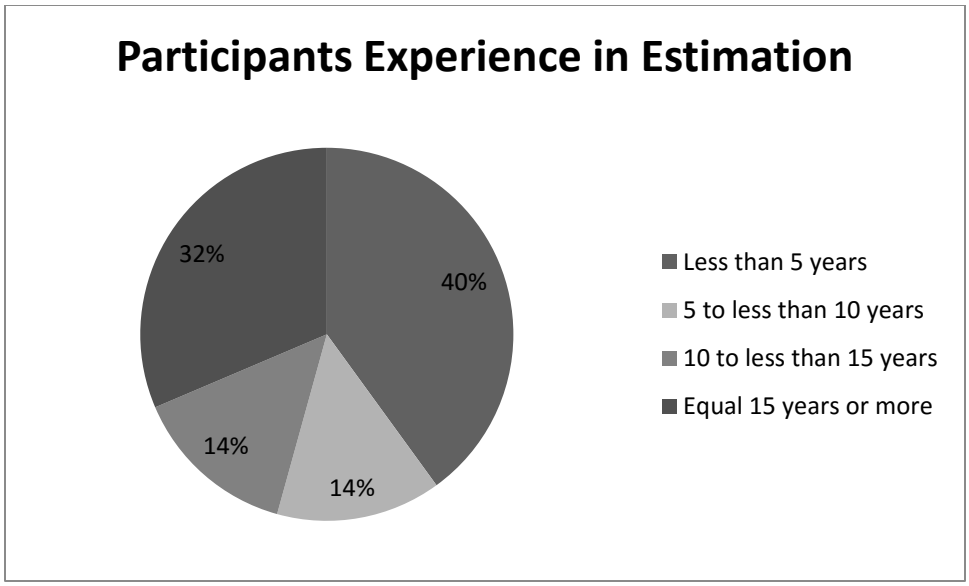

Figure 1 Participants Experience in Estimation

Table 5 Specialty of Cost Estimator Participants

Engineering Specialty	Number of participants
Civil engineering	26
Mechanical engineering	6
Electrical engineering	1
Other	1
Total	34

4.1.2 Characteristics of Top Management

As shown in Table 6, the results indicated that 14 of the participating cost estimators have 15 years or more of experience. The remaining participants have experience periods varying as follows: 7 participants with (10 to less than 15) experience years, 13 participants with (5 to less than 10) experience years. For experience related to project cost estimation 7 participants have less than five years' experience, 15 participants have (5 to less than 10) experience years, 2 participants have (10 to less than 15) experience years and finally 10 participants have fifteen years of experience or more. Figure 2 shows distribution of the percentages of the participants through the experiences options.

Continuing to Table 7, 3 of the participants are master's degree holders, 29 of the participants are bachelor's degree holders and two are diploma holders. The field specialty distribution of the participants is as follow: 25 participants are civil engineers, 5 participants are mechanical engineers, 2 participants are electrical engineers and the last two are architectural engineers. Since 14 participants have an equal to 15 years or more general experience the quality of the collected data are assumed to be good and reflect the real working condition and situations. Moreover, meanwhile the majority of the participants is bachelor degree holder and specialized in civil engineering which will give the data more credibility, because the sample is concerned with building contractors. Obtaining data from such quality participants gives credential to the data and, hence, reliability to the obtained results.

Table 6 Summary of Top Manager Experience

	General Experience	Experience Related to Project Management
15 years or more	14 participants	10 participants
10 to less than 15 years	7 participants	2 participants
5 to less than 10 years	13 participants	15 participants
Less than 5 years	0 participant	7 participants

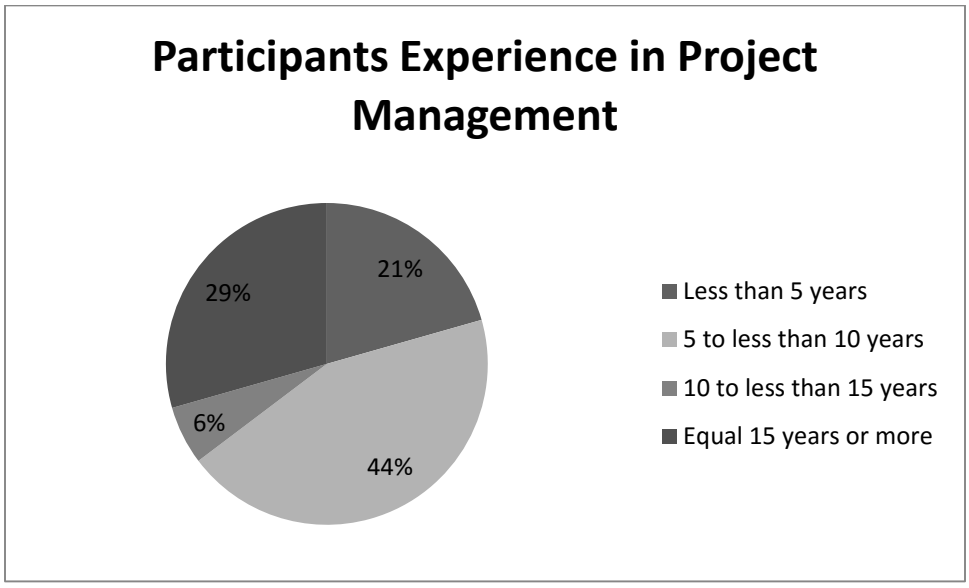

Figure 2 Participants Experience in Project Management

Table 7 Specialty of Top Manager Participants

Manager Specialty	Number of participants
Civil engineering	25
Mechanical engineering	5
Electrical engineering	2
Architectural engineering	2
Total	34

4.2 Cost Estimation Unit

Cost estimation unit defines the department that is responsible for preparing and developing an estimate in building contractors companies. Studying cost estimation units and determining their characteristics is helpful in understanding the details of the estimation process. The information in this section starts with analyzing the characteristics of cost estimation units in Saudi Arabia. Then the section is divided into two subsections. These subsections are: use of software in estimation unit and adopted estimation method. The adopted estimation method subsection covers: estimation methods, quantity take off process, construction method selection process and productivity determination. The collected data in this section is helpful in understanding the estimation process and in determining the used methods and techniques in the estimation process.

In order to study the estimation unit characteristics, the participants were asked about specific information related to names of the unit, unit human resources and reporting system of the unit. Based on the found results, cost estimation units are named with different names in Saudi Arabia. Table 9 provides a summary for the names of the estimation unit and the frequency of repetition of the name of that unit in the studied population. The most common mentioned names by the participants were estimation department and tendering department, which are the most logical simple names. Knowing that estimation units in contractors in Saudi Arabia have special names under the company is proving the fact that there is a special department for cost estimation in the companies.

The human resources in the cost estimation unit were found to be mostly less than five employees as illustrated inTable 8. The majority of the participnats , 22 participants, defined their human resources in the estimation unit with less than 5 employees. This might be due to the fact of using computer software in the estimation process which could reduce the need for human resources in the estimation unit. Also the size of the building contractor company could affect the size of the human resources in the estimation unit. Small and medium size contractors are expected to have smalle size human resources in their departments.

The reporting system in the estimation unit based on the found results explained as follow: the majority of the participants are reporting directly to the general manager in their companies. 19 participants confirmed that the estimation department in their companies is reporting directly to the general manager. The remaining participants are reporting to the operation manager. Defining the duties of the general manager and the operation manger in the company plays an important role in finding the authority at which the estimation unit operates under, which could be a justification on the found results.

In summary, the main characteristics of the estimating units for grade 1, 2 and 3 building contractors in Saudi Arabia that were found after analyzing the data are three characteristics. These characteristics are:

1. Small work force (5 employees or less).

2. Specialized cost estimation department.

3. Direct reporting system to the general manager.

Table 8 Number of Employee in Estimation Department

Number of Employee	Selection Frequency
Less than 5	22
5 to less than 10	6
10 to less than 15	2
More than 15	4

Table 9 Names of Cost Estimation Units in Saudi Arabia

Used Name	**Frequency**
Estimation department	9
Tendering department	8
Estimation section	3
Estimation unit	1
Contracting department	3
Project control department	3
Cost management department	5
Cost contract department	2
Total	34

4.2.1 Use of Software in Estimation Unit

The data shows that the participants have six software options to use with the possibility of utilizing combination of software. Brief definition for the mentioned cost estimation computer software in the collected data is provided in the following lines:

- Building information modeling (BIM): a 3D modeling software helps engineers, architectures and construction professionals by providing an insight to more efficient plan, design, construct and manage buildings.
- Microsoft Excel: is part of the Microsoft Office package produced by Microsoft. The software is using the spreadsheet system to organize, format and calculate data with formulas.
- Aspen capital cost estimator: is cost estimation software used mainly in projects related to the oil and gas, refining and chemical industry.
- KBase: is designed for use during the estimating lifecycle to generate both conceptual and detailed estimates. It uses a unique approach where equipment, with associated plant bulks, is represented by comprehensive design-based installation models
- Timberline estimating software: "This software offers detailed as well as conceptual takeoff capabilities. It also offers several electronic takeoff solutions, which speed up the estimate generation process even further"
- Primavera professional project management: this software uses the interactive grant chart to generate plan schedules and control large scale project. The software could handle and organize a project of up to 100,000 activities with unlimited resources.

- Microsoft project professional: is the most popular project management software produced by Microsoft. The software used to assist project managers in developing plans, assigning resources to tasks, tracking progress, managing budgets and analyzing workloads.

In reference to Table 10 and Table 11, the results of the analysis show that the most used software is Microsoft Excel with a 26 selection frequency. The second used program is Primavera Professional Project Manager with a 17 selection frequency. However, more than half of the participants (20 participants) chose more than one choice. The most selected combination of used estimation software program is Microsoft Excel and Primavera Professional Project Manager with a selection rate of 7 out of 20. Moreover, CCS Candy Estimation software was mentioned under the criteria of "other" twice in the collected data.

As shown clearly in Table 10, Microsoft Excel and Primavera were the most used software in the estimation process. This could be the result of the huge popularity of the Microsoft Excel since it is part of the Microsoft office, which is a very common software package locally and internationally. Moreover, the price of Microsoft Excel is affordable and economically efficient compared to other estimation software. Also, the majority of the employees are familiar with the Microsoft office specially Microsoft Excel. Therefore, no intensive employees training sessions are required for Microsoft Excel. All these factors give Microsoft Excel the popularity in project cost estimation field.

The second most common project cost estimation software in Saudi Arabia was Primavera Professional Project Manager. This could be a result of the multi-use for the

software. Primavera professional project manager is used in different parts of construction project such as planning and project cost control. Since it is already available and spread through companies in the construction field in the Kingdom, it gained its popularity. Recently, during the last decade, a decent part of construction companies started to concentrate on training their employees for primavera professional project manager in order to catch up with the new trend in the construction industry. All these points would explain the high rank of primavera professional project manager compared to other computer software.

Table 10 Software Combination for Preparing an Estimate

Software Combination	Selection times	Rank
Excel, Primavera	7	1
Excel, Primavera, Microsoft project professional	2	2
BIM, Excel, Primavera	2	2
Aspen Capital, Primavera, Microsoft project professional	2	2
Excel and other than software mentioned in the list	2	2
Aspen Capital, Primavera	1	3
Excel, Timberline, Primavera, Microsoft project professional	1	3
Excel, Timberline	1	3
Excel, Microsoft project professional	1	3
All the list of the software	1	3

Table 11 Common Ranked Estimation Software

Estimation Software	Selection times
Microsoft Excel	26
Primavera Professional Project Manager	17
Microsoft project professional	7
Aspen Capital Cost Estimator	6
BIM	5
Timberline	3
Other	3
Aspen Capital Cost Estimator (Kbase)	1

4.2.2 Adopted Estimation Method

The estimation process is governed by: estimation method, quantity take off method, factors influencing the selection of the construction method and productivity determination. The following sections describe the common practices implemented by the surveyed population.

4.2.2.1 Estimation Method

Approximately, a quarter (9 participants) of the participants chose both of the two listed methods: resource method and unit price method. As shown in Table 12: the remaining participants selected one method and were divided as follow: 8 participants selected the resource method and 17 participants selected the unit price method. Half of the participants used the unit price method since it's depends on using unit prices from previous work and the company data.

The unit price method gains its popularity in Saudi Arabia due to many factors. One important factor is the low uncertainty level usually involved in the unit price estimation process. Examples on these uncertainties are: drawing or specification changes, prices fluctuation and work quantity. Since the unit price method entitle the contractors to be paid on the basis of quantity of work completed during the project construction duration, the risk will decrease. Moreover, most unit price contracts enable the contractors to adjust the price of the contract in the case of changes in drawings or in the quantity of work (Pratt, 2004). The ability to adjust the prices in the unit price method might be used to avoid the material prices fluctuation risk as well. These reasons might decrease the uncertainty level and risks that faces the contractors during the estimation process. Also,

they could explain the popularity of the unit price estimation method in Saudi Arabia and justify the found result as well.

Table 12 summary of The Selected Estimation Method

Estimation Method	Participants Number
Unit price method	17
Resource method	8
Both methods	9
Total	34

4.2.2.2 Quantity Take-Off

Referring to Table 13 the used tools for quantity take off based on the participant's selection is indicated. The majority of the participants selected more than one tool or method. The most selected combination of tools was manual from drawing and specifications, computer software and bill of quantities with total selection number of 9. This combination is the leading one since it depends on computer software such as Microsoft Excel. Also, it depends on one of the important factors of the estimation process which is project drawing and specifications. These drawing and specifications provides project activity sequence which be used in quantity take off process. Moreover, bill of quantities –the detailed statement of work, prices, dimensions, and other details- is used. These three elements cover and summarize the process quantities take off perfectly and effectively. The second combination was manual from drawing and specifications and bill of quantities with total selection time of 7.

Since the construction industry has improved during the last twenty years and the use of computer software in all industries has become a popular trend, it is logical to find that the leading combination of methods for quantity take off involves computer software. Using the computer software in quantity take off process leads to increased efficiency. Using computer software in quantity take off process provides a consistent work that could be helpful in assessment or comparison for future similar work. Also, using computer software will decrease the calculation error by eliminating human error factor that could be involved in the process. Therefore, by involving the computer software in the quantity take off process, the estimation units will be able to develop a consistent database with fixed standards that could be used in future projects. Moreover, combining the use of computer software with the manuals and bill of quantities provides the estimator with a comprehensive vision of project progress. Also, combining these methods together enables the estimator to check the quantity take off in detail and monitor the process properly (Pratt, 2004). These reasons could justify the found results. Table 13 illustrates all the selected combinations for the quantity take off ranked from the most selected one to the least selected one. Moreover, AutoCAD software was mentioned under the criteria of other once in the questionnaire.

Table 13 Summary of The Used Tools Combination for Quantity Take-off

Combination of Method to Calculate Quantity Take Off	Selection Frequency
Manual from drawing and specifications, Computer software, Bill of quantities	9
Manual from drawing and specifications, Bill of quantities	7
Manual from drawing and specifications, Computer software	4
Manual from drawing and specifications, 3-D BIM models	2
Manual from drawing and specifications, Computer software, Digitizers	1
Bill of quantities, Digitizers	1
Manual from drawing and specifications, Computer software, 3-D BIM models	1
Manual from drawing and specifications, 3-D BIM models	1
All the list	1

4.2.2.3 Construction Method Selection

More than half of the participants selected more than one factor for the factors that could affect the selection process for the construction method. Table 14 illustrated all the possible combination and the selection frequency for each combination. The most common combination of factors was two different combinations and both of them selected 8 times. The first combination of these two is the entire factor: company historical data, availability of resource and project complexity. The second combination that got selected 8 times is company historical data and availability of resources. Company historical data are involved in the two common combinations since the most common method for estimation is unit price method as mentioned before. Hence unit price method as explained before depends mainly on the company historical data. Moreover, the combination of availability of resources and project complexity got selected 6 times. The last combination, company historical data and project complexity, was selected only once. The remaining participants whom selected only one factor are divided into the factor as following: company historical data (4 participants), availability of resources (3 participants) and project complexity (5 participants).

Since the selection of the construction method is considered a very critical step in project cycle life, the first ranked combination was all listed factors as shown in Table 14. This could be a result of the strong relation between the listed factors and construction method. Therefore, most of the participants have selected all factors or more than one factor. Historical data provide the estimators with an idea for the wanted work and give them a chance to avoid any expected similar problems from the past. Moreover, considering having historical data base as one of the factor for selecting the construction method for a project could increase the work efficiency on the project. The improvement of work efficiency could be achieved through using procurement information or forecasting upcoming problems based on the company historical data.

Resources availability also plays an important role on selecting the proper construction method. Resource availability provides a clear idea for the contractors about their capacity in the project. Considering the resources in the process of selecting construction method could increase project profitability for the involved contractors through efficient resources management. In addition, taking in consideration the project complexity factor during the selection process for proper construction method is important. Project complexity defines the scope of work, work familiarity and the required resources. Defining these elements facilitates the selection process for construction methods. Considering these entire factors during the selection process seems as a wise decision to be made and could justify the found result in this section.

Table 14 Summary of the Construction Method Selection Factors

Selected Factors	Selection Frequency
Historical data, resource availability and project complexity	8
Historical data and resource availability	8
Resource availability and project complexity	6
project complexity	5
Historical data	4
Resource availability	3
Total	34

4.2.2.4 Productivity Determination

In respect to the information about the used data to determine the productivity the participants were selecting from four options. These options are stander government productivity chart, company historical data, both of the previous options or other data. Figure 3 illustrate the participant selection with the percentage. The most selected option is company historical data then both options then the stander government productivity chart.

Since, the quality of the government standard charts is not high and the details of the charts are not sufficient, the contractors in Saudi Arabia tend to develop their own estimation historical database (Al-Harbi, 1993). Company historical data is the most selected factor since it provides the estimator with an idea about the current project based on old similar projects. Also, historical database provides the contractors with a definition of their capabilities and resources. Determining the capability and limitation of the

contractors for a project are considered one of the main factors in developing a good quality cost estimate. Using historical database in determining productivity might improve the estimate quality by combining current project parameters with experiences from similar old projects. Company historical database could be useful for increasing the project efficiency by saving time in the process of productivity determination, which might explain the found results in this section.

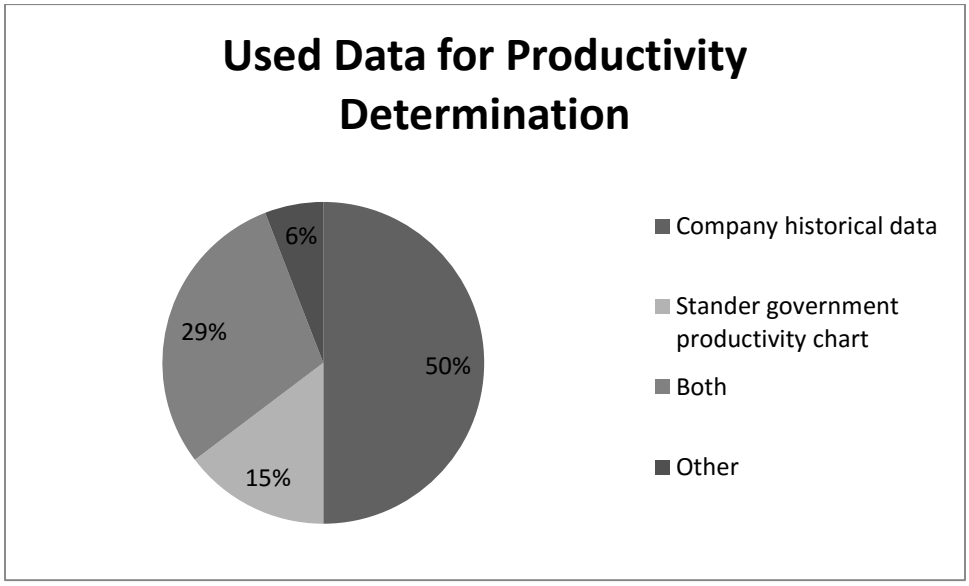

Figure 3 Used Data for Productivity Determination

4.2.2.5 Summary

From the summary of the information provided in this section we could fulfill and answer the research second objective which is identifying the method and process that building contractors used to prepare an estimate in Saudi Arabia. Hence identifying the method and process utilized in preparing cost estimate depends on five types of information as explained on this section of the research. These information types are cost estimation software, cost estimation methods, tools for quantity takeoff, factors for selecting construction methods and used data for determining productivity. We found that the most

common used software combination for preparing project cost estimate in Saudi Arabia is Microsoft Excel and Primavera Professional Project Manager. Furthermore, half of the participants confirm that they are using the unit price method for preparing project cost estimation which is utilize the company historical data. Also, regarding the quantity takeoff process it is found that the common used items in the process are manual from drawing and specifications, computer software and bill of quantities. For the selection process of the construction method it is found that the most affecting factors are company historical data, availability of resources and project complexity. And for identifying the used data in the process of productivity determination the analysis result shows that company historical data is leading one with half of the participants answer.

4.3 Estimation problems

The collected data in this section aims to determine the common problems in project cost estimation industries. The data was provided by cost estimators since they are more involved in the estimation process. The used list of problems was from a previous old research as explained before in the literature review. One of the objectives of this research is to compare the results of this study with the result of the old study. And since both researches, the old research and this research, were collecting data from grade 1, grade 2 and grade 3 building contractors in the eastern province of Saudi Arabia, the comparison is considered fair.

The collected data were analyzed in three different levels. The levels are: ranking the list based on the importance index, compare the two lists by using the T-test method and find any correlation between the lists by using spearmen’s rho correlation method. The following subsections describe the analysis and commentate on the results.

4.3.1 Importance Index

The first level of analysis was finding the importance or severity index for each problem using the formula number (3). The importance index is helpful for the ranking process for the listed problems. Also, the importance index is used in the next section in order to compare the new list with old list by using T-test method. A high severity index associated with a specific problem indicates that this problem is popular in the field of construction industry in Saudi Arabia. More details are shown in Table 15. Table 16 shows the ranked problems based in the importance index for both researches. It was observed that the ranking orders of most of the problems have been changed compared with the ranked list from 1991 research. However the level of changes was different form one problem to another. Some problems ranking have change significantly and some change slightly.

The first two leading problems have not changed from 1991 until 2016. These problems are: tough competition and contract period. The limited number of projects compared with the high number of building contractors in Saudi Arabia could explain the leading of tough competition. Moreover, the project awarding system in Saudi Arabia depends on competitive bidding prices, which increases the competition between the contractors (Al-Harbi, 1993). Since the kingdom is one of the biggest oil countries around the world, the relation between the oil prices and the construction industry may play a role in increasing the competition (Al-Harbi, 1993).

The second leading problem is contract period. Problems with contract period could appear when there is a need for shorting the construction period. In this situation, crash utilization of the available resources usually used, leading to increased costs on

contractors. Hence, the problem of contract period is logical to be one of the leading problems (ranked 2nd).

The next six places in the new list have changed significantly compared with the old list. These problems are related to poor relationship between the owner, contractor and designer. Examples are: incomplete project scope definition, change of owner requirements and inadequate drawings and specifications. The ninth place in the new list is “Lack of cost data indices in Saudi Arabia” where it was ranked in the eighteenth place in the old list. This change might be justified by assuming that the estimation process in 1991 was not dependent on cost data indices as it is now, since in 1991 there was no data indices in the first place (Al-Harbi, 1993).

Problems related to lack of information about experience in similar project, historical data and productivity information are listed in the places 13, 14 and 15 respectively. This ranking was expected since it was found in the previous section, section 4.2, that most of the participants used company historical database in the estimation processes. Using company historical data in the estimation process reduces the risk of these problems and causes the low ranking.

Another huge change between the two lists was moving the last problem in the old list to the eleventh place in the new list. The moved problem is “portion of the work to be subcontracted”. The change in the ranking of this problem could be due to the increase of the number of building contractors in Saudi Arabia, changes in the law governing subcontracting, increased complexity of projects requiring specialized subcontractors. The increase in project numbers could have resulted in shortage of contractor’s resources,

inducing subcontracting to cover for this shortage. Also, the increase in size and complexity of projects could increase the need to use specialized subcontractors to achieve certain types of work. For example: hiring technology subcontractors in infrastructure projects and façade contractors in high rise buildings. Therefore, this increase in subcontracting could be the reason for the increased problems in this field. Hence, the change in the ranking between 1991 and 2016 lists is reasonable.

One of the noticed changes was changing the rank of the problem “Unfamiliarity with government regulations”. The problem was ranked in twelfth 1991 list and moved down to 19 in 2016. This change might means that the contractor awareness about government regulation has increased since 1991. This change could be considered as evidence on the improvement in the cost estimation field in Saudi Arabia. This change could be a result of the general improvement in the environment of the construction industry in the kingdom. Improving the communication process between the government representative and contractors could be a justification for this change. The communication processes have been improved by utilizing and implementing the new technologies in the process, such as: internet websites. This could summarize the most noticeable changes between the ranked list of estimation problems in 1991 and 2016.

Table 15 Importance Index for Estimation Problems

Problems For Grade one contractor	Importance Index from 2016	Importance Index From 1991
1. Tough competition	87.5	72.92
2. Inadequate time	70.58823529	58.33
3. Difficulty of project	55.88235294	45.83
4. Changes of owner requirements	72.79411765	64.58
5. Calculation error	51.47058824	39.58
6. Contract period	74.26470588	69.79
7. Judgment errors	55.88235294	60.42
8. Portion of work to be subcontracted	61.76470588	38.54
9. lack of experience in similar jobs	58.82352941	52.08
10. Work item omission	61.02941176	51.04
11. Incomplete drawing and specification	71.32352941	68.75
12. Lack of cost data indices in Saudi Arabia	63.23529412	42.71
13. Current work load	67.64705882	62.5
14. Unfamiliarity with government regulations	53.67647059	51.04
15. Incomplete project scope definition	72.79411765	68.75
16. Lack of historical data of similar jobs	57.35294118	57.29
17. Unforeseeable change in material prices	66.91176471	67.71
18. Lack of productivity information in Saudi Arabia	57.35294118	44.79
19. Lack of confidence in workforce	57.35294118	51.04
20. Content of arbitration clauses	62.5	43.75

Table 16 Comparison between Estimation Problems from 1991 to 2016

Estimating problems from 2016	Estimating problems from 1991
1. Tough competition	1. Tough competition
2. Contract period	2. Contract period
3. Incomplete project scope definition	3. Inadequate drawing and specification
3. Changes of owner requirements	3. Incomplete project scope definition
5. Inadequate drawing and specification	5. Unforeseeable changes in materials prices
6. Inadequate time	6. Changes of owner requirements
7. Current workload	7. Current workload
8. Unforeseeable changes in materials prices	8. Judgment error
9. Lack of cost data indices in Saudi Arabia	9. Inadequate time
10. Content of arbitration clauses	10. Lack of historical data for similar jobs
11. Portion of work to be subcontracted	11. Lack of experience in similar jobs
12. Work item omission	12. Unfamiliarity with government regulations
13. Lack of experience in similar jobs	12. Work item omission
14. Lack of historical data for similar jobs	12. Lack of confidence in workforce
14. Lack of productivity information in Saudi Arabia	15. Difficulty of project
14. Lack of confidence in workforce	16. Lack of productivity information in Saudi Arabia
17. Difficulty of project	17. Content of arbitration clauses
17. Judgment error	18. Lack of cost data indices in Saudi Arabia
19. Unfamiliarity with government regulations	19. Calculation error
20. Calculation error	20. Portion of work to be subcontracted

4.3.2 T-test Method

The second level of analysis was done by using the T-test method. The T-test has been carried out using the software Minitab. The T-test method uses the calculated importance index, from the first analysis level, to build a valid statistical comparison between the new data and the old data. The comparison of two samples is done through a value called "P-Value" as explained in chapter three under the data analysis section. Carrying out the test, the resulting P-Value was found to be equal to (0.011). Since the P-Value is less than (0.05) there is a significant difference between the two lists. The difference is in the favor of the new data because it have bigger mean than the old data. Figure 4 shows the analysis part from the Minitab software.

The result of the analysis seems reasonable since the time difference between the collected data was around 25 years. This result might be due to the improvement and the involvement of new factors that have changed the construction industries around the world during these last 25 years. Utilization of computer software is one of the greatest new factors that appeared in the project cost estimation during recent years. The difference between the two lists might be explained by the globalization factor of the construction industry. The globalization factor plays an important role in making the result reasonable since Saudi construction market is containing more international companies than the past. Also, new technologies are used nowadays in construction which also relates to the estimation process.

In the past the construction industry in the kingdom was facing multiple factors that affected the estimation process. Some of these factors could be gulf war, bad

infrastructure and limited resources. All these factors made the difference between the estimation problems in 2016 and 1991 logical and reasonable.

Two-Sample T-Test and CI: Index 2016; Index 1991

```
Two-sample T for Index 2016 vs Index 1991

             N   Mean  StDev  SE Mean
Index 2016  20  64.01   8.89      2.0
Index 1991  20   55.6   11.0      2.5


Difference = mu (Index 2016) - mu (Index 1991)
Estimate for difference:  8.44
95% CI for difference:  (2.03; 14.84)
T-Test of difference = 0 (vs not =): T-Value = 2.67  P-Value = 0.011  DF = 38
Both use Pooled StDev = 9.9992
```

Figure 4 T-test Result for Comparing Estimation Problems between 1991 and 2016

4.3.3 Spearman's Rho Correlation

The third level of analysis was implementing the spearmen's rho to find any correlation between the old and new list of problems in estimation practices. Spearman's correlation method calculates a coefficient which is used to measure the correlation level between the two samples, as was illustrated in chapter 3, section 3.1.2. In our case, the coefficient was equal to (0.69) which means there is a strong correlation between the two samples. The observed correlation was that the importance index of most of the items in the new study has increased compared with the list from the old study, regardless of the ranking.

4.3.4 Summary

The analyses in this part conclude that the leading two most common problems in cost estimation in Saudi Arabia have not changed during the last 25 years. These leading problems are tough competition and contract period. The first leading problem from 25 years until now is tough competition, which is related to the general environment of the cost estimation industry in Saudi Arabia. This gives us a clear indication that there is a

need for improvement of the rules and regulations in the Saudi construction industry. Problems related to poor relationship between the owner, contractor and designer appears next in the list. Examples are: incomplete project scope definition, change of owner requirements and inadequate drawings and specifications. Problems related to the project aspect and conditions such as, difficulty of project and lack of experience, appears in the lowest part of the list. It is found that problems related to the general environment of the cost estimation practices and the relationship between owners and contractors are the leading problems.

4.4 Evaluation of Cost Estimator

This section presents the evaluation of cost estimators and the desired qualities, which a cost estimator should acquire. The evaluation covers three subjects: estimator's job requirements, estimator's duties and estimator's skills.

4.4.1 Cost Estimator's Job Requirements

The analyzed data in this section covers a list of requirements for estimation job. The participants were asked to answer this section twice. First time according to the working conditions in their companies, and the second one based on participants' beliefs and opinions. A valid comparison was built based on the collected data between the actual requirements and the desired requirements by the worker in the estimation field.

Minitab software was utilized to make the comparison using the T-test method. The T-test method showed that the P-Value equals to (0.029). Since the P-Value is less than (0.05) there is a significant difference between the actual requirements and the desired requirements. Table 18 shows the requirements ranked from high to low importance for

the actual and desired conditions. Furthermore, a full summary of the detailed analysis is provided in Figure 5 and Table 17.

The results of the analysis seem reasonable, because comparison was made between the actual requirements and the desired requirements. Moreover, during the researcher's visits to companies, it was observed that there are clear demands to make the requirements different than the used requirements. Moreover, since all the listed requirements are good qualities for an employee, a lot of the participants under the desired section chose the high criteria for most of the requirements. Therefore, the difference between the actual requirements and the desired requirements is logical and justifiable.

The first leading requirement in the actual section is “ability to prepare, select and appraise tender”. The ability to prepare, select and appraise tender required a good logic and clear understanding for the estimation process. This level of knowledge could be reached with experience and practice. And since participants have a good experience level, the leading requirement is expected to describe the current situation in the estimation unit (the actual situation). In contrast, the leading requirement in the desired table is “Knowledge of cost estimating software and techniques”. This is a reasonable result since technology is heavily involved in the construction industry in general and more specifically to the project cost estimation as stated in section 4.2.

Also, it was found that the requirement stating “the experience in similar job” is ranked second and third in the actual requirements and the desired requirements, respectively. This could be a result of the fact that the majority of the contractors are requiring an experience for hiring new engineer in the project management department such as

estimation department. Working in cost estimation department involves dealing with risks associated with project budget. This risk could be reduced by having an estimator with good experience. Also the qualification that states “education level” appears in the sixth place in both the actual requirements and the desired requirements. That is a clear evidence for preference of experience over education in the cost estimation field in the construction industry in Saudi Arabia. The preference of experience over education level could be a result of knowing that most of the engineering colleges in Saudi Arabia don’t teach their students any extensive course in the undergraduate level about project cost estimation.

Another observation has been made related to the requirements about the communication and teamwork. It is found that communication and teamwork takes the sixth place on the actual requirements list, and the third place on the desired requirement list. This seems as an area for improvement in the cost estimation industry field. The quality of cost estimate could be improved by revising the work and checking the estimation process by more than one person. This could explain the high place of “communication and team work” on the desired requirement list.

The requirement of “English language” is listed third in the actual list and second in the desired list. This might be a result of using the English language in the international companies as the main language. Also the English language is the main language for most of the estimation computer software. All these reason could justify the found results. Moreover, the location of this research could justify this point. Since the study is focusing on the eastern province of Saudi Arabia, and most of the big contractors in the

eastern province are working with ARAMCO which mandates the use of English language in their business.

Familiarity with government regulations and requirements appeared in the bottom part of the list in both situations, actual and desired. Government regulations and requirements are usually provided on the internet and everybody could reach them easily. Therefore, this requirement has low significant compared with the other requirements. As a matter of fact, familiarity with government regulations and requirements is part of the local working experience. However, this part of experience could be learned easily and gained by practice.

Another requirement appeared in bottom part of the actual and desired list was “risk management “. Companies usually have a special department which is responsible for the risk management duties. Therefore, the found result is logical since the estimators are required to prepare an estimate in the first place.

The requirement related to the nationality is in the bottom of both lists, actual and desired requirements. This result conforms with the fact that the majority of the participants, 32 participants, in the survey were expatriate. This indicates that the nationality is not an important requirement for estimators in Saudi Arabia.

The findings described in this section concluded the answer for the third research objective related to identifying the qualifications for cost estimator in building contractors in Saudi Arabia.

Two-Sample T-Test and CI: Mean (Act); Mean (Des)

```
Two-sample T for Mean (Act) vs Mean (Des)

             N   Mean  StDev  SE Mean
Mean (Act)  16  2.489  0.357    0.089
Mean (Des)  16  2.770  0.336    0.084


Difference = mu (Mean (Act)) - mu (Mean (Des))
Estimate for difference:  -0.281
95% CI for difference:  (-0.532; -0.031)
T-Test of difference = 0 (vs not =): T-Value = -2.29 P-Value = 0.029 DF = 30
Both use Pooled StDev = 0.3467
```

Figure 5 T-test Result for Comparing Actual and Desired Requirements

Table 17 Importance Index for Actual and Desired Requirements

Job Requirements	Importance index in Actual	Ranking	Importance index desired	Ranking
Bachelor's degree in Engineering	66.91176471	6	72.79	6
English Language	69.85294118	3	76.47	2
Knowledge of business and management principles	63.23529412	10	74.26	5
Knowledge of administrative and clerical procedures and systems	53.67647059	13	61.76	13
Knowledge of principles and processes for providing customer and personal services	63.97058824	9	69.11	11
Knowledge of raw materials, production processes, quality control, costs, and other techniques	67.64705882	4	72.79	6
Through knowledge of construction	66.91176471	6	72.79	6
Ability to prepare, select and appraise tender	72.05882353	1	72.79	6
Experience in similar jobs	71.32352941	2	75.74	3
Professional training	58.82352941	12	67.65	12
Familiarity with government regulations	52.20588235	14	59.56	15
Knowledge of contracts and contract law	63.23529412	10	71.32	10
Saudi nationality	38.97058824	16	45.59	16
Communications and teamwork skills	66.91176471	6	75.74	3
Knowledge of cost estimating software and techniques	67.64705882	4	77.94	1
Risk management	52.20588235	14	61.76	13

Table 18 Comparison between Actual and Desired Requirements

Actual requirements	Desired requirements
1. Ability to prepare, select and appraise tender	1. Knowledge of cost estimating software and techniques
2. Experience in similar jobs	2. English Language
3. English Language	3. Experience in similar jobs
4. Knowledge of raw materials, production processes, quality control, costs, and other techniques	3. Communications and teamwork skills
4. Knowledge of cost estimating software and techniques	5. Knowledge of business and management principles
6. Bachelor's degree in Engineering	6. Bachelor's degree in Engineering
6. Through knowledge of construction	6. Through knowledge of construction
6. Communications and teamwork skills	6. Knowledge of raw materials, production processes, quality control, costs, and other techniques
9. Knowledge of principles and processes for providing customer and personal services	6. Ability to prepare, select and appraise tender
10. Knowledge of business and management principles	10. Knowledge of contracts and contract law
10. Knowledge of contracts and contract law	11. Knowledge of principles and processes for providing customer and personal services
12. Professional training	12. Professional training
13. Knowledge of administrative and clerical procedures and systems	13. Knowledge of administrative and clerical procedures and systems
14. Familiarity with government regulations	13. Risk management
14. Risk management	15. Familiarity with government regulations
16. Saudi nationality	16. Saudi nationality

4.4.2 Cost Estimator's Job Duties

For the estimator duties, the participants were asked to judge the level of importance for a list of twenty different duties. Based on the collected data the twenty duties are ranked based on their importance index as follow and Table 19 shows duties with their importance index and ranking level:

1. Prepare estimates for use in selecting vendors or subcontractors
2. Prepare estimates used by management for purposes such as planning, organizing, and scheduling work
3. Establish and maintain tendering process, and conduct negotiations
4. Visit site and record information about access, drainage and topography, and availability of services such as water and electricity
5. Identify and quantify cost factors, such as production time, materials, and labor expenses
6. Consult with clients, vendors, personnel in other departments or construction foremen to discuss and formulate estimates and resolve issues
7. Confer with engineers, architects, owners, contractors and subcontractors on changes and adjustments to cost estimates
8. Prepare and maintain a directory of suppliers, contractors and subcontractors
9. Review material and labor requirements, to decide whether it is more cost-effective to produce or purchase components
10. Analyze blueprints and other documentation to prepare time, cost, materials, and labor estimates

11. Assess cost effectiveness of products, projects or services, tracking actual costs relative to bids as the project develops
12. Making Decisions and Solving Problems
13. Conduct special studies to develop and establish standard hour and related cost data or to effect cost reduction
14. Set up cost monitoring and reporting systems and procedures
15. Use sophisticated computer software to calculate estimates
16. Develop project plans for the duration of the project
17. Consult with industry experts to discuss estimates and resolve issues
18. Resolving Conflicts and Negotiating with Others
19. Prepare cost and expenditure statements and other necessary documentation at regular intervals for the duration of the project
20. Assesses the potential development site for its appropriateness for building

This ranking is useful in order to understand the required qualifications of cost estimators. It shows that the cost estimation job requires office work and site visits in some occasions. Also, it shows the involvement of the cost estimation department with other departments such as planning department. The result of this section provides the cost estimators in Saudi Arabia with a clear idea about their job duties. These types of information would be helpful especially for newly employed cost estimators in order to understand their company's expectations from them.

The analysis of this section shows the priority of the duties that have direct relation to the estimation process. Duties such as preparing estimates for tendering process and choosing vendors and subcontractors appears on the top of the list. Also, duties related to site visit

and quantity take off shows in the top five on the list. This is a predictable result since these duties are the main parameters of the estimation job. In contrast, duties that are related to planning issues or resolving conflict shows in the bottom of the list as expected, since theses duties have no direct effect on the estimation process.

Also, the found result shows the duty of "Use sophisticated computer software to calculate estimates" in the rank 15 of the list. This ranking is not logical since nowadays the majority of the cost estimation departments around the world use computer software in the estimation process as found in the previous part of the research "use of software in estimation unit". Moreover, this low rank conflicts with the found result in the previous section "Cost estimator's requirements". The result from the previous section emphasizes on the importance of using cost estimating software in the estimation process, where it was ranked first on the desired requirements and fourth on the actual requirements. This conflict might happen as a result of listing using computer software in both lists: requirements and duties in the survey. This might have confused the participants during answering the survey. The duties list was focused on the estimator's job responsibility and the point of "using computer software" is a job requirement more than a job responsibility. Therefore, the researcher might hold the responsibility of this conflict between the found results.

Table 19 Importance Index and Ranking for Duties

Duties	Importance Index	Ranking
Assesses the potential development site for its appropriateness for building	53.67647059	20
Analyze blueprints and other documentation to prepare time, cost, materials, and labor estimates	66.91176471	9
Assess cost effectiveness of products, projects or services, tracking actual costs relative to bids as the project develops	64.70588235	11
Consult with clients, vendors, personnel in other departments to discuss and formulate estimates and resolve issues	69.11764706	6
Confer with engineers, architects, owners, contractors and subcontractors on changes to cost estimates	68.38235294	7
Prepare estimates used by management for purposes such as planning, organizing, and scheduling work	73.52941176	2
Prepare estimates for use in selecting vendors or subcontractors	76.47058824	1
Review material and labor requirements, to decide whether it is more cost-effective to produce or purchase components	66.91176471	9
Prepare cost and expenditure statements and documentation at regular intervals for the duration of the project	59.55882353	19

Duties	Importance Index	Ranking
Prepare and maintain a directory of suppliers, contractors and subcontractors	67.64705882	8
Set up cost monitoring and reporting systems and procedures	63.23529412	14
Establish and maintain tendering process, and conduct negotiations	73.52941176	2
Conduct special studies to develop and establish standard hour and related cost data or to effect cost reduction	63.97058824	13
Visit site and record information about access, drainage and topography, and availability of services such as water and electricity	73.52941176	2
Consult with industry experts to discuss estimates and resolve issues	60.29411765	17
Use sophisticated computer software to calculate estimates	62.5	15
Develop project plans for the duration of the project	61.76470588	16
Identify and quantify cost factors, such as production time, materials, and labor expenses	71.32352941	5
Making Decisions and Solving Problems	64.70588235	11
Resolving Conflicts and Negotiating with Others	60.29411765	17

4.4.3 Cost Estimator's General Skills

The collected data in this section contains a list of general skills for estimator job. The participants were asked to answer this section twice. First time according to the working conditions in their companies, and the second time, based on participants' beliefs and opinions. A comparison was built based on the collected data between the actual situation and the desired situation by the workers in the cost estimation field.

Minitab software was utilized in order to make the comparison by using the T-test method. The T-test method showed that the P-Value equal (0.000). Since the P-Value less than (0.05) there is a significance difference between the actual require skills and the desired required skills. Figure 6 shows the details of the T-test method and the result of the test. Table 21 shows the general required skills ranked from the highest value of importance index to the lowest for actual and desired situation. Furthermore, a full detailed table that shows the skills and their calculated importance index is provided in and Table 20. Since all the skills are considered good general qualities for any employee, a lot of the participants ranked these skills high under the desired section. Therefore, the difference between the actual requirements and the desired requirements is logical and justifiable.

From Table 21, we notice that personal skills are the leading skills in the desired skills ranked list. Most of these leading skills are related to communication, such as negotiation skills, which are ranked first in the actual and second in the desired skill lists. The second group in the list consists of skills related to cognitive strength such as critical thinking, complex problem solving and number facilitation. Both general working skills and cognitive ability skills are ranked above the management skills in both lists indicating

their importance. It was also found that social skills are ranked lowest in both lists actual and desired, for instance, the skills of ‘actively looking for ways to help people” ranks 24 and 23 for actual and desired estimator skills, respectively. The social skills expected to be in the bottom of the list since it was found that estimation units mostly consist of five employees or less. With this low number of employees in the department, the need for social skill might be less important.

In summary, the following arrangement of four types of skills: general working skills, brain strength skills, management skills and finally social skills identify the characteristics of qualified cost estimators based on the analyzed data.

Two-Sample T-Test and CI: Mean; Mean (Des)

```
Two-sample T for Mean vs Mean (Des)

             N   Mean  StDev  SE Mean
Mean        25  2.768  0.210    0.042
Mean (Des)  25  2.995  0.191    0.038


Difference = mu (Mean) - mu (Mean (Des))
Estimate for difference:  -0.2268
95% CI for difference:  (-0.3410; -0.1125)
T-Test of difference = 0 (vs not =): T-Value = -3.99 P-Value = 0.000 DF = 48
Both use Pooled StDev = 0.2009
```

Figure 6 T-test Result for Actual and Desired General Skills

Table 20 Importance Index for Actual and Desired General Skills

Skills	Importance Index (Actual)	Ranking	Importance Index (Desired)	Ranking
Active Listening	72.05882353	9	80.15	3
Reading Comprehension	66.91176471	15	76.47	11
Time Management	67.64705882	13	79.41	6
Management of Personnel Resources	64.70588235	20	73.52	15
Writing ability	77.20588235	2	80.15	3
Critical thinking	73.52941176	6	79.41	6
Active learning	72.79411765	8	76.62	11
Speaking ability	77.20588235	2	81.62	1
Complex problem solving	69.85294118	11	78.67	8
Coordination ability	71.32352941	10	77.94	9
Social Perceptiveness	65.44117647	18	71.32	18
Judgment and Decision Making	67.64705882	13	75.74	13
Negotiation skills	79.41176471	1	80.88	2
Monitoring	73.52941176	6	72.79	16
Instructing	64.70588235	20	66.18	25
Management of Financial Resources	60.29411765	25	66.91	24
Quality Control Analysis	63.97058824	22	69.85	20
Actively looking for ways to help people	61.02941176	24	68.38	23
Persuasion skills	68.38235294	12	69.85	20
Operations Analysis	63.23529412	23	68.94	22
Management of Material Resources	66.91176471	15	71.32	18
Number Facility; the ability to add, subtract, multiply, or divide quickly and correctly	75.73529412	4	77.94	9
Near Vision; the ability to see details at close range	74.26470588	5	80.15	3
Fluency of Ideas	66.91176471	15	75	14
Problem Sensitivity	65.44117647	18	72.79	16

Table 21 Comparison between Actual and Desired General Skills

Actual Skills	Desired Skills
1. Negotiation skills	1. Speaking ability
2. Writing ability	2. Negotiation skills
3. Speaking ability	3. Near Vision
4. Number Facility	4. Writing ability
5. Near Vision	5. Active Listening
6. Critical thinking	6. Time Management
7. Monitoring	7. Critical thinking
8. Active learning	8. Complex problem solving
9. Active Listening	9. Coordination ability
10. Coordination ability	10. Number Facility
11. Complex problem solving	11. Reading Comprehension
12. Persuasion skills	12. Active learning
13. Time Management	13. Judgment and Decision Making
14. Judgment and Decision Making	14. Fluency of Ideas
15. Reading Comprehension	15. Management of Personnel Resources
16. Management of Material Resources	16. Problem Sensitivity
17. Fluency of Ideas	17. Monitoring
18. Problem Sensitivity	18. Management of Material Resources
19. Social Perceptiveness	19. Social Perceptiveness
20. Management of Personnel Resources	20. Quality Control Analysis
21. Instructing	21. Persuasion skills
22. Quality Control Analysis	22. Operations Analysis
23. Operations Analysis	23. Actively looking for ways to help people
24. Actively looking for ways to help people	24. Management of Financial Resources
25. Management of Financial Resources	25. Instructing

4.5 Hypothesis Testing

Hypothesis analysis section focuses on testing four different hypotheses. All hypotheses were developed by finding a relationship between the grade of the contractors and the collected data. The four hypotheses study the effect of changing the contractor grade on the estimation problems, estimator's job requirements, estimator's duties and estimator's general skills. The utilized method for testing hypothesizes was One-Way ANOVA.

4.5.1 First Hypothesis

First hypothesis aims to study the correlation of variation of contractor grades and the level of estimation problems. The null hypothesis statement is "Contractors faces similar estimation problems regardless of their grades". Therefore the alternative hypothesis is "Grade 1, grade2 and grade 3 contractors' faces different estimation problems".

In order to use One-Way ANOVA to test the hypothesis, we must calculate the mean of the entire data that relates to the section of estimation problems. The calculated mean and the contractor grade classification were used in the testing process as the main test factors. The Minitab software calculated the mean of responses for each grade and then made the comparison by finding the P-Value. The P-Value was equal (0.35) which is greater than (0.05). Since the P-Value is greater than (0.05), the three classifications grade 1, 2 and 3 share the same problems. Therefore, the null hypothesis was tested and considered true.

This proves that changing the contractor's grade has no relation to estimation problems in the construction field in Saudi Arabia. Figure 7 shows the details of testing the hypothesis by using the Minitab software. The result of the test seemed reasonable,

because all the participants share the same working conditions such as field of specialty, location and working regulations and environment. Furthermore, the classification system does not depend on the types of obstacles facing the building contractors companies during preparing an estimate. Rather, the classification system depends on the annual construction volume and other factor that also appears not to be related to estimation problems such as total employee number. Also, since the provided list of problems in the questionnaire was general and not focusing mainly on the resource of the contractor, the result of testing the hypothesis seems logical. Therefore, the final result of denying the difference in estimation problems between building contractors grade is rational decision.

One-way ANOVA: Part D Average (Problems) versus Classification

Source	DF	SS	MS	F	P
Classification	2	0.921	0.461	1.09	0.350
Error	31	13.135	0.424		
Total	33	14.057			

S = 0.6509 R-Sq = 6.55% R-Sq(adj) = 0.53%

Level	Mean	StDev	Grouping
Grade 1	2.7665	0.6651	A
Grade 2	2.4444	0.4693	A
Grade 3	2.4227	0.7498	A

Pooled StDev = 0.6509

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Classification

Individual confidence level = 98.04%

Figure 7 First Hypothesis One-way ANOVA Test

4.5.2 Second Hypothesis

Second hypothesis aims to study the correlation of variation of contractor grades and requirements for estimator's career. The statement of the null hypothesis is "Contactors shares the same estimator's requirements regardless of their grades". Therefore the alternative hypothesis is stated as follow "Grade 1, grade 2 and grade 3 contractors have different estimator's requirements".

In order to use One-Way ANOVA to test the hypothesis the mean of the entire data related to the section of estimator's job requirements were calculated. The calculated mean and the contractor grade classification were used in the testing process as the main test parameters. The Minitab software calculated the mean of responses for each grade and then made the comparison by finding the P-Value. Since the collected data was divide to two types: actual and desired requirements. The hypothesis was tested twice: once for the actual work requirements and the other one for the desired requirements. The P-Value for actual requirements was equal (0.941) which is greater than (0.05). Also, the P-Value for desired requirements was greater than (0.05) with a value Equal (0.759). Since the P-Value is greater than (0.05) in both situation actual and desired, the three classifications grade 1, 2 and 3 share the same estimator's job requirements. Therefore, the null hypothesis was tested and considered true. Figure 8 and Figure 9 shows the details of testing the hypothesis by using the Minitab software for actual and desired requirements respectively.

The results could be summarized through the following points. First, since most of the listed requirements in the questionnaire are considered good logical requirements and aimed to improve the estimation unit, common sense would reject any difference in the

estimator requirements between the contractor grades. In addition, the selection process for desired requirements depends on the wishes of the participants. Therefore, most of the participants selected the high value of the requirements as very important. This behavior explains the similarity condition between contractors grade. Consequently, the result of testing the hypothesis is logical by proving the null hypothesis in both cases the actual and the desired requirements.

One-way ANOVA: Part B Average (Actual Requirm versus Classification

Source	DF	SS	MS	F	P
Classification	2	0.084	0.042	0.06	0.941
Error	31	21.224	0.685		
Total	33	21.308			

S = 0.8274 R-Sq = 0.39% R-Sq(adj) = 0.00%

Level	Mean	StDev	Grouping
Grade 1	2.5402	0.9003	A
Grade 2	2.4167	0.5257	A
Grade 3	2.4830	0.9207	A

Pooled StDev = 0.8274

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Classification

Individual confidence level = 98.04%

Figure 8 Second Hypothesis One-way ANOVA Test (Actual)

One-way ANOVA: Part B Average (Desired requirm versus Classification

Source	DF	SS	MS	F	P
Classification	2	0.253	0.127	0.23	0.795
Error	31	16.971	0.547		
Total	33	17.224			

S = 0.7399 R-Sq = 1.47% R-Sq(adj) = 0.00%

Level	Mean	StDev	Grouping
Grade 1	2.8705	0.7149	A
Grade 2	2.7292	0.3737	A
Grade 3	2.6761	0.9597	A

Pooled StDev = 0.7399

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Classification

Individual confidence level = 98.04%

Figure 9 Second Hypothesis One-way ANOVA Test (Desired)

4.5.3 Third Hypothesis

Third hypothesis aims to study the correlation of variation of contractor grades and estimators' duties. The null hypothesis statement is “Contractors shares the same level of estimator’s duties regardless of their grades”. In contrast, the alternative hypothesis is stated as follow “Grade 1, grade 2 and grade 3 contractors have different level of estimator’s duties”.

In order to use One-Way ANOVA to test the hypothesis, the mean of the entire responses that related to the section of estimator duties were calculated. The calculated mean and the contractor grade classification were used in the testing process as the main test parameters. The Minitab software calculated the mean of responses for each grade and then made the comparison by finding the P-Value. The P-Value was equal (0.091) which is greater than (0.05). Since the P-Value is greater than (0.05), the three classifications grade 1, 2 and 3 share the same estimator duties. Therefore, the null

hypothesis tested and considered true. Figure 10 shows the details of testing the hypothesis by using the Minitab software.

The hypothesis was built under the condition of when the contractor grade decreases, the human resources in the estimation unit will decrease. However, the participants answers show that the majority of them (22 participants) built there estimation unit with less than five employees. Therefore, the acceptance of the null hypothesis complies with the previous fact. Furthermore, since the participants share the same working conditions, the level of duties should be the same, regardless of the contractor grade.

One-way ANOVA: Part C Average (Duties) versus Classification

Source	DF	SS	MS	F	P
Classification	2	2.381	1.190	2.59	0.091
Error	31	14.253	0.460		
Total	33	16.634			

S = 0.6781 R-Sq = 14.31% R-Sq(adj) = 8.79%

Level	Mean	StDev	Grouping
Grade 1	2.3286	0.8318	A
Grade 2	2.8389	0.4256	A
Grade 3	2.8864	0.6173	A

Pooled StDev = 0.6781

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Classification

Individual confidence level = 98.04%

Figure 10 Third Hypothesis One-way ANOVA Test

4.5.4 Fourth Hypothesis

Fourth hypothesis aims to study the relationship between the effects of the classification system of contractor on the general skills for estimators in the eastern province of Saudi Arabia. The null hypothesis statement is “Contactors shares the same estimator’s general skills regardless of their grades”. In contrast the alternative hypothesis is stated as follow “Grade 1, grade 2 and grade 3 contractors have different estimator’s general skills”.

In order to use One-Way ANOVA to test the hypothesis the mean of the entire responses that related to the section of estimator’s general skills were calculated. The calculated mean and the contractor grade classification were used in the testing process as the main test parameters. The Minitab software calculated the mean of responses for each grade and then made the comparison by finding the P-Value. Since the collected data was divide to two types: actual and desired requirements. The hypothesis was tested twice: once for the actual required general skills and the other one for the desired required general skills. The P-Value for actual requirements was equal (0.137) which is greater than (0.05). Also, the P-Value for desired requirements was greater than (0.05) with a value Equal (0.134). Since the P-Value is greater than (0.05) in both situation actual and desired, we conclude that the three classifications grade 1, 2 and 3 share the same required estimator general skills. Therefore, the null hypothesis was tested and considered true. Figure 11 and Figure 12 shows the details of testing the hypothesis by using the Minitab software for actual and desired required general skills respectively.

Since most of the listed skills in the questionnaire are consider general good logical skills and aimed to improve the estimation unit and increase the efficiency of the estimator, the logical sense would reject any difference in the estimator requirements between the

contractor grades. Moreover, since hiring people with high general skill will definitely increase the quality of the produced work, the results of the test are considered rational.

One-way ANOVA: Part D Average (actual Skills) versus Classification

Source	DF	SS	MS	F	P
Classification	2	1.830	0.915	2.12	0.137
Error	31	13.395	0.432		
Total	33	15.225			

S = 0.6573 R-Sq = 12.02% R-Sq(adj) = 6.35%

Level	Mean	StDev	Grouping
Grade 1	2.5000	0.8408	A
Grade 2	2.8711	0.4093	A
Grade 3	3.0255	0.5352	A

Pooled StDev = 0.6573

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Classification

Individual confidence level = 98.04%

Figure 11 Fourth Hypothesis One-way ANOVA Test (Actual)

One-way ANOVA: Part D Average (Desired Skills) versus Classification

Source	DF	SS	MS	F	P
Classification	2	1.581	0.790	2.15	0.134
Error	31	11.422	0.368		
Total	33	13.003			

S = 0.6070 R-Sq = 12.16% R-Sq(adj) = 6.49%

Level	Mean	StDev	Grouping
Grade 1	2.7829	0.7281	A
Grade 2	3.3200	0.4147	A
Grade 3	2.9968	0.5616	A

Pooled StDev = 0.6070

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Classification

Individual confidence level = 98.04%

Figure 12 Fourth Hypothesis One-way ANOVA Test (Desired)

CHAPTER 5

SUMMERY OF THE STUDY, FINDINGS AND RECOMMENADATIONS

This chapter provides a summary for the research. Under the summary section a brief introduction about each chapter was provided. Also, the study findings are presented in this chapter as bullet point. The conclusion of the study is presented in this section followed with some recommendations. The recommendations are divided into two parts. First part related to the contractors and the second part relate to the future researchers how are welling to study the same topic of this research.

5.1 Summary of the Study

Project cost estimation is a significant step in the project construction cycle life. Based on cost estimates, the project parties could decide the profitability of the project. Project cost estimation is defined as the process of estimating the project total cost by expecting the achieved productivity in the site during the execution process for future activities. Project cost estimation process aims to cover the cost of main resources, such as: manpower, materials, and equipment to complete the project in accordance with plans and specifications within the planned project duration. There is a need to study cost estimation practices in the local industry, since there is no sufficient literature about the subject in Saudi Arabia.

This research was focused on achieving five objectives. The First objective was to explore the estimation unit in the building contractors companies in the eastern province of Saudi Arabia from grade 1, 2 and 3. The second objective was to explain the details of the estimation process in Saudi Arabia. The Third objective aimed to find the major common problems in the estimation industries. The last two objectives were to study the qualifications of cost estimators who are working for grade 1, 2, and 3 building contractors in the Eastern Province of Saudi Arabia and identifying the require qualifications for the estimator job.

The data collection tool was a survey questionnaire that was developed and distributed to all building contractor companies from grade 1, 2 and 3 operating in the eastern province of Saudi Arabia. The used methods for distributing the questionnaire were personal visits for the participants and sending emails. 34 building contractor companies' responded and answered the questionnaire.

The collected data was then analyzed using statistical methods with the aid of computer software. The extent of compliance of the actual and the desired estimators' characteristics was measured using the T-test. Hypothesis testing was done through One-Way ANOVA, and Spearman's Rho was used to compare the results of this study with a previous similar study. The findings of the analysis are summarized in the upcoming section.

5.2 Findings

The research results and findings are summarized in the following list:

- The majority of people who are working in the estimation process are bachelor degree holders specialized in civil engineering.
- Most of cost estimation units in construction companies in Saudi Arabia have less than five employees.
- Unit price estimation method is the most common method.
- The most common used estimation software is Microsoft Excel and then Primavera professional project manager. And the most common used combination of estimation software is Microsoft Excel and Primavera.
- The most common combination of tools to find the quantities take off is computer software, bill of quantities and manual drawings and specifications.
- Company historical data is the most important factor in the selection process for construction method
- Company historical data is the dominant factor in the process of productivity determination.
- The ranking of estimation problems in 2016 is different from the ranking in 1991. However, tough competition and contract period are still the leading problems.
- The estimation problems which were reported in 1991 are still prevailing with the same intensity.
- There is a significant difference between the actual requirement and the desired requirement for an estimator job. Examples for some of the major differences are:

ability to prepare, select and appraise tender and communication and team work skills.

- It was found that experience is preferred over educational background in both the actual requirement and the desired requirement for an estimator job.
- It was found that the types of estimator's skills are ranked as follow: general working skills, cognitive skills, management skills and social skills.
- It was found that the variation of the grade of the contractor is not associated with the estimation problems, estimator's job requirements, estimator's duties and estimator's general skills. That is, all contractors have the same requirements and face the same problems, regardless of their grade.
- It was found that duties with direct relation to cost estimation process are the leading in the rank of importance for estimator duties. Duties such as prepare estimates for use in selecting vendors or subcontractors, prepare estimates used by management for purposes, identify and quantify cost factors, establish and maintain tendering process, and conduct negotiations are the leading duties.

5.3 Conclusion

This research is an effort to enrich the library of construction engineering and management in Saudi Arabia, since there are not enough resources discussing the same topic. This research provides a general view for the cost estimation practices in contractor in Saudi Arabia through two parts. First part studies the estimation unit and the utilized processes for preparing an estimate. Also the first part covers the major common problems in the field of project cost estimation in Saudi Arabia. The second part is focusing on the estimator characteristics. This research discusses estimator characteristics

through determining the actual and desired estimator's qualification, estimator's duties and the actual and desired estimator's general skills. The result of the analysis process shows that the cost estimation unit characteristics are divided to three parts. These characteristics are small work force (5 employees or less), all the estimation activities are done in special cost estimation department in the company and the reporting system of the estimation work is directly to the general manger. Moreover, the research shows that Microsoft Excel and Primavera Professional Project Manager are the most common used software combination for preparing project cost estimate in Saudi Arabia. Also, it is found that the method of unit price is the common method for preparing project cost estimate. Regarding quantity takeoff process it is found that the common used items in the process are manual from drawing and specifications, computer software and bill of quantities. Furthermore, the analysis shows that the leading two most problems in cost estimation in Saudi Arabia have not been changed during the last 25 years. These leading problems are tough competition and contract period. Also, the analysis shows the preference of the experience on the education for the estimator qualifications. Additionally, knowledge of cost estimation software was leading on the list of desired qualification for estimator. Regarding the estimator's skills the analysis shows that general working skills, brain strength skills, management skills and finally social and communication skills is the rank that could identify the characteristics of qualified cost estimators.

Furthermore, the most important result was proving grade of the contractor does not affect the level of estimator qualifications, duties or general skills. Moreover, it was found that all grades of building contractors in the eastern province of Saudi Arabia are

sharing the same estimation problems. Regarding the estimation problems it was found that the ranking of the problems based on the importance index become different compared with the ranked problems from the previous research in 1991. However, the spearmen's correlation value proves that there is a strong correlation between the two lists. Finally, this research hopes to be an added value for the researchers and contractors and people who are involved in the construction industry in the Kingdom of Saudi Arabia.

5.4 Recommendations

- Contractors are advised to have a special department for cost estimation with a direct reporting system to the general manager.
- Contractors are advised to have a historical database to facilitate the process of cost estimation and to produce more accurate estimates.
- Contractors are advised to improve their current estimation department by focusing on improving the following skills: general working skills, cognitive skills and technological skills through training and learning courses.
- Contractors are advised to consider the following skills in the training program for their cost estimator: speaking ability, negotiation skills, near vision, writing ability, active listening, time management, critical thinking, complex problem solving and coordination ability.
- Contractors are advised to consider the following when hiring or promoting an engineer to the cost estimation position.: knowledge of cost estimation software, English language, experience in similar job, team working skills, knowledge of business and management principles, bachelor's degree in Engineering,

knowledge of construction and knowledge of raw materials, production processes, quality control, costs, and other techniques.

- Contractors are advised to hire cost estimators with a prior experience in the estimation process while taking into consideration their educational background.
- Contractors are advised to have training programs related to computer software that could be used in the cost estimation process. Examples are: Microsoft Excel and Primavera professional project management.
- Contractors are advised to improve the communication and team work skills between their employees in order to improve the working environment in the estimation department by providing incentives and working seminars that encourage the employees to communicate well and improve their team working skills. Also, conducting and encouraging social activities between employees will reflect well on improving communication and team working skills.
- Contractors are advised to consider: preparing estimates for use in selecting vendors or subcontractors, preparing estimates used by management, identifying and quantifying cost factors, establishing and maintaining tendering process, conducting negotiations, consulting with clients, vendors, personnel in other departments, conferring with engineers, architects, owners, contractors and subcontractors on changes and adjustments to cost estimates and preparing and maintaining a directory of suppliers, contractors and subcontractors in the job duties for cost estimator, since these duties reflects the perspective of the expert estimator in the local cost estimation field.

- Contractors are advised to limit the duties of their cost estimators to duties directly related to cost estimation to improve the cost estimation process without distraction by other unrelated duties.

5.5 Recommendations for Future Studies

- Researchers who are willing to study the project cost estimation in Saudi Arabia are recommended to focus on the topic of competition between contractors during the bidding process since the bidding process is depending on the project cost estimation.
- Researchers who are willing to study the project cost estimation in Saudi Arabia are recommended to focus on evaluating the difference between estimators with high education level and estimators with good years of experience. This will be helpful to understand the effect of the education and the experience on quality of project cost estimate.

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APPENDIX

QUESTIONNAIRE

Survey Questionnaires

<u>Estimator section</u>

Part A: Company Information

This section contains questions seeking information about your company. Please answer the following questions by filling the spaces or by placing a tic (√) in the boxes next to selected answer for multiple choice questions:

a) Name of your company:-
_____(optional)

b) Location of your company:
   a. Damamm [ ]
   b. Khobar [ ]
   c. Dhahran [ ]
   d. Other, please specify _____

c) Your company has been in business for
   a. Less than 5 years [ ]
   b. 5 to less than 10 years [ ]
   c. 10 to less than 15 years [ ]
   d. 15 to less than 20 years [ ]
   e. Equal 20 years or more [ ]

d) The total number of employees in your company is:
   a. Less than 500 employees [ ]
   b. 500 to less than 1000 employees [ ]
   c. 1000 to less than 1500 employees [ ]
   d. 1500 to less than 2000 employees [ ]
   e. Equal 2000 employees or more [ ]

e) The type of project that your company builds are: (you may select more than one answer)
   a. Building [ ]
   b. Infrastructure [ ]
   c. Industrial [ ]
   d. Highway [ ]
   e. Other, please specify_____

f) Your company classification in the building sector based on the Ministry of Municipal and Rural Affairs in the Kingdom:

a. Grade 1 [ ]
b. Grade 2 [ ]
c. Grade 3 [ ]
d. Other, please specify, _____

g) Your firm's annual construction volume in million Saudi Riyals:
   a. Less than 100 [ ]
   b. 100 – less than 200 [ ]
   c. 200 – less than 300 [ ]
   d. Equal 300 or more [ ]

h) The percentage of work that your company obtains from the various sectors in Saudi Arabia:
   a. Public …….%
   b. Semipublic …….%
   c. Private ……%
   d. Other, specify_____ …….%

Total = 100%

i) The number of construction projects your company involved in now is_____

j) The number of construction projects for Saudi public and semipublic sectors your company have been involved in is_____

Part B: Respondent Information

This part of the questionnaire contains questions seeking information about the respondent to this questionnaire. You are kindly requested to provide the necessary information in the given spaces next to the questions or by placing a tic (√) in the boxes next to selected answer for multiple choice questions:

a) Your job title is _____

b) Total years of experience:
   a. Less than 5 years [ ]
   b. 5 – less than 10 years [ ]
   c. 10 – less than 15 years [ ]
   d. Equal 15 years or more [ ]

c) The number of years you have been working with your current employer is:
   a. Less than 5 years [ ]
   b. 5 – less than 10 years [ ]
   c. 10 – less than 15 years [ ]
   d. Equal 15 years or more [ ]

d) The number of years you have been preparing cost estimates for construction projects:
   a. Less than 5 years [ ]
   b. 5 – less than 10 years [ ]
   c. 10 – less than 15 years [ ]
   d. Equal 15 years or more [ ]

e) Your level of education:
   a. Bachelor degree [ ]
   b. Diploma degree [ ]
   c. Other, please specify, _____

f) Your field of specialty
   a. Mechanical [ ]
   b. Electrical [ ]
   c. Civil [ ]
   d. Other, please specify,_____

g) Your nationality:
   a. Saudi [ ]
   b. Expatriate [ ]

Part C: Cost Estimation Unit

This section contains questions seeking information about the estimation unit in your company. You are kindly requested to provide the necessary information in the given spaces next to the questions. Also, please place a tic (√) in the boxes next to selected answer for multiple choice questions:

a) What is the name of the cost estimation unit in your company?

_____

b) What is the title of the head of the cost estimation unit in your company?

_____

c) To whom does the head of the cost estimation unit report to?
   a. General Manager [ ]
   b. Operation Manager [ ]
   c. Other, please specify _____

d) How many employees are in the cost estimation unit?
   a. Less than 5 employees [ ]
   b. 5 to less than 10 employees [ ]
   c. 10 to less than 15 employees [ ]
   d. Equal 15 employees or more [ ]

e) Which of the following softwares are used in the process of preparing an estimate: (you may select more than one answer)
   a. Building information modeling (BIM) [ ]
   b. Microsoft Excel [ ]
   c. Aspen Capital Cost Estimator [ ]
   d. Aspentech Capital Cost Estimator (KBase) [ ]
   e. Timberline Estimating Software [ ]
   f. Primavera professional project management [ ]
   g. Microsoft project professional [ ]
   h. Others, please specify _____

f) What is the used method for developing an estimate in your company?
   a. Recourse method as following: [ ]
      (You may select more than one answer)
      i. Activity definition ( )
      ii. Quantity of work determination ( )
      iii. Construction method selection and resources definition ( )

iv. Productivity determination ( )
v. Pricing ( )
vi. Others, please specify _____

b. Unit price method as following: [ ]
(You may select more than one answer)
i. Activity definition ( )
ii. Quantity of work determination ( )
iii. Use of unit price from previous work ( )
iv. Pricing ( )
v. Others, please specify _____

g) Used methods for quantity take off: (you may select more than one answer)
a. Manual from drawing and specifications [ ]
b. Computer software [ ]
c. 3-D BIM models [ ]
d. Bill of quantities [ ]
e. Digitizers [ ]
f. Others, please specify,_____

h) Used method to select the construction method: (you may select more than one answer)
a. Based on company historical data [ ]
b. Based on the availability of resources [ ]
c. Based on the project complexity [ ]
d. Others, please specify,_____

i) Used tools for productivity determination: (you may select more than one answer)
a. Stander government productivity chart [ ]
b. Company historical data [ ]
c. Others, please specify,_____

Part D: Estimation Problems

The following is a list of potential problems that may face cost estimators in preparing an accurate cost estimate for the construction of a project in Saudi Arabia. You are kindly requested to indicate, based on the actual working conditions in your company, the level of agreement by placing a tic (√) in the boxes next to these potential problems:

Estimating Problems	Level of Agreement				
	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
1. Tough competition	[ ]	[ ]	[ ]	[ ]	[ ]
2. Inadequate time	[ ]	[ ]	[ ]	[ ]	[ ]
3. Difficulty of project	[ ]	[ ]	[ ]	[ ]	[ ]
4. Changes of owner requirements	[ ]	[ ]	[ ]	[ ]	[ ]
5. Calculation error	[ ]	[ ]	[ ]	[ ]	[ ]
6. Contract period	[ ]	[ ]	[ ]	[ ]	[ ]
7. Judgment errors	[ ]	[ ]	[ ]	[ ]	[ ]
8. Portion of work to be subcontracted	[ ]	[ ]	[ ]	[ ]	[ ]
9. lack of experience in similar jobs	[ ]	[ ]	[ ]	[ ]	[ ]
10. Work item omission	[ ]	[ ]	[ ]	[ ]	[ ]
11. Incomplete drawing and specification	[ ]	[ ]	[ ]	[ ]	[ ]
12. Lack of cost data indices in Saudi Arabia	[ ]	[ ]	[ ]	[ ]	[ ]
13. Current work load	[ ]	[ ]	[ ]	[ ]	[ ]
14. Unfamiliarity with government regulations	[ ]	[ ]	[ ]	[ ]	[ ]
15. Incomplete project scope definition	[ ]	[ ]	[ ]	[ ]	[ ]
16. Lack of historical data of similar jobs	[ ]	[ ]	[ ]	[ ]	[ ]
17. Unforeseeable change in material prices	[ ]	[ ]	[ ]	[ ]	[ ]
18. Lack of productivity information in Saudi Arabia	[ ]	[ ]	[ ]	[ ]	[ ]
19. Lack of confidence in workforce	[ ]	[ ]	[ ]	[ ]	[ ]
20. Content of arbitration clauses	[ ]	[ ]	[ ]	[ ]	[ ]
21. Others, please specify	[ ]	[ ]	[ ]	[ ]	[ ]
a. _____	[ ]	[ ]	[ ]	[ ]	[ ]
b. _____ c. _____	[ ]	[ ]	[ ]	[ ]	[ ]

<u>Top management section</u>

Part A: Respondent Information

This part of the questionnaire contains questions seeking information about the respondent to this questionnaire. You are kindly requested to provide the necessary information in the given spaces next to the questions by placing a tic (√) in the boxes next to selected answer for multiple choice questions:

a) Your job title is _____

b) Total years of experience:
   a. Less than 5 years [ ]
   b. 5 – less than 10 years [ ]
   c. 10 – less than 15 years [ ]
   d. Equal 15 years or more [ ]

c) The number of years you have been working with your current employer is:
   a. Less than 5 years [ ]
   b. 5 – less than 10 years [ ]
   c. 10 – less than 15 years [ ]
   d. Equal 15 years or more [ ]

d) The number of years you have been construction projects manager:
   a. Less than 5 years [ ]
   b. 5 – less than 10 years [ ]
   c. 10 – less than 15 years [ ]
   d. Equal 15 years or more [ ]

e) Your level of education:
   a. Master degree [ ]
   b. Bachelor degree [ ]
   c. Diploma degree [ ]
   d. Other, please specify, _____

f) Your field of specialty
   a. Mechanical [ ]
   b. Electrical [ ]
   c. Civil [ ]
   d. Other, please specify,_____

g) Your nationality:
   a. Saudi [ ]
      Expatriate [ ]

a) What is your level of satisfaction for the work of the cost estimation department in your company?
   a. Excellent [ ]
   b. Satisfactory [ ]
   c. Somewhat satisfactory [ ]
   d. Not satisfactory [ ]

Part B: Estimator's Job Requirement

The following is a list of a job requirement for an estimator. You are kindly requested to measure the level of importance of each job requirement , firstly as actually practiced in your company and secondly as per what you believe is the best practice by placing a tic (√) in the boxes next to these job requirements:

Estimation Job Requirements	Importance Level									
	Actual					Desired				
	Very Low	Low	Medium	High	Very High	Very low	Low	Medium	High	Very high
1. Bachelor's degree in Engineering	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
2. English Language	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
3. Knowledge of business and management principles	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
4. Knowledge of administrative and clerical procedures and systems	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
5. Knowledge of principles and processes for providing customer and personal services	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
6. Knowledge of raw materials, production processes, quality control, costs, and other techniques	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
7. Through knowledge of construction	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
8. Ability to prepare, select and appraise tender	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
9. Experience in similar jobs	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
10. Professional training	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
11. Familiarity with government regulations	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
12. Knowledge of contracts and contract law	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
13. Saudi nationality	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
14. Communications and teamwork skills	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
15. Knowledge of cost estimating software and techniques	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
16. Risk management	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
17. Other, please specify	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
a. _____	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
b. _____										
c. _____	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Part C: Estimator's Duties and Responsibilities

The following is a list of potential duties and responsibilities for a construction cost estimator. You are kindly requested to measure the level of importance of these duties and responsibilities, based on the actual working condition in your company, by placing a tic (√) in the boxes next to these job duties:

Estimator Duties	Importance Level				
	Very Low	Low	Medium	High	Very High
1. Assesses the potential development site for its appropriateness for building	[ ]	[ ]	[ ]	[ ]	[ ]
2. Analyze blueprints and other documentation to prepare time, cost, materials, and labor estimates.	[ ]	[ ]	[ ]	[ ]	[ ]
3. Assess cost effectiveness of products, projects or services, tracking actual costs relative to bids as the project develops.	[ ]	[ ]	[ ]	[ ]	[ ]
4. Consult with clients, vendors, personnel in other departments or construction foremen to discuss and formulate estimates and resolve issues.	[ ]	[ ]	[ ]	[ ]	[ ]
5. Confer with engineers, architects, owners, contractors and subcontractors on changes and adjustments to cost estimates.	[ ]	[ ]	[ ]	[ ]	[ ]
6. Prepare estimates used by management for purposes such as planning, organizing, and scheduling work.	[ ]	[ ]	[ ]	[ ]	[ ]
7. Prepare estimates for use in selecting vendors or subcontractors.	[ ]	[ ]	[ ]	[ ]	[ ]
8. Review material and labor requirements, to decide whether it is more cost-effective to produce or purchase components.	[ ]	[ ]	[ ]	[ ]	[ ]
9. Prepare cost and expenditure statements and other necessary documentation at regular intervals for the duration of the project.	[ ]	[ ]	[ ]	[ ]	[ ]
10. Prepare and maintain a directory of suppliers, contractors and subcontractors.	[ ]	[ ]	[ ]	[ ]	[ ]
11. Set up cost monitoring and reporting systems and procedures.	[ ]	[ ]	[ ]	[ ]	[ ]
12. Establish and maintain tendering process, and conduct negotiations.	[ ]	[ ]	[ ]	[ ]	[ ]
13. Conduct special studies to develop and establish standard hour and related cost data or to effect cost reduction.	[ ]	[ ]	[ ]	[ ]	[ ]
14. Visit site and record information about access, drainage and topography, and availability of services such as water and electricity.	[ ]	[ ]	[ ]	[ ]	[ ]
15. Consult with industry experts to discuss estimates and resolve issues	[ ]	[ ]	[ ]	[ ]	[ ]
16. Use sophisticated computer software to calculate estimates	[ ]	[ ]	[ ]	[ ]	[ ]
17. Develop project plans for the duration of the project	[ ]	[ ]	[ ]	[ ]	[ ]
18. Identify and quantify cost factors, such as production time, materials, and labor expenses	[ ]	[ ]	[ ]	[ ]	[ ]
19. Making Decisions and Solving Problems	[ ]	[ ]	[ ]	[ ]	[ ]
20. Resolving Conflicts and Negotiating with Others	[ ]	[ ]	[ ]	[ ]	[ ]

Part D: Required Skills for a Cost Estimator

The following is a list of potential skills that a cost estimator must acquire. You are kindly requested to measure the level of importance of each skill , firstly as actually practiced in your company and secondly as per what you believe is the best practice by placing a tic (√) in the boxes next to these skills and abilities:

Estimator Abilities and Skills	Importance Level									
	Actual					Desired				
	Very Low	**Low**	**Med**	**High**	**Very High**	**Very Low**	**Low**	**Mid**	**High**	**Very High**
1. Active Listening	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
2. Reading Comprehension	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
3. Time Management	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
4. Management of Personnel Resources	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
5. Writing ability	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
6. Critical thinking	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
7. Active learning	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
8. Speaking ability	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
9. Complex problem solving	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
10. Coordination ability	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
11. Social Perceptiveness	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
12. Judgment and Decision Making	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
13. Negotiation skills	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
14. Monitoring	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
15. Instructing	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
16. Management of Financial Resources	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
17. Quality Control Analysis	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
18. Actively looking for ways to help people	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
19. Persuasion skills	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
20. Operations Analysis	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
21. Management of Material Resources	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
22. Number Facility**;** the ability to add, subtract, multiply, or divide quickly and correctly.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
23. Near Vision**;** the ability to see details at close range	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
24. Fluency of Ideas	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
25. Problem Sensitivity	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

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