VARIATIONS OF OWNER'S ESTIMATED QUANTITIES FOR HIGHWAY PROJECTS IN UNIT PRICE CONTRACTS IN SAUDI ARABIA

BY

MOHAMMAD MAHMOUD DEYAB TOMAIZEH

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This thesis, written by **Mohammad Mahmoud Deyab Tomaizeh** under the direction of his thesis advisor and approved by his thesis committee, has been presented and accepted by the Dean of Graduate Studies, in partial fulfillment of the requirements for the degree **Master of Science**.

Dr. Ali Shash (Advisor)

Dr. Khalaf Al-Ofi
Department Chairman

Dr. Sadi Assaf
(Member)

Dr. Salam A. Zummo
Dean of Graduate Studies

Dr. Bambang Trigunarsyah Suhariadi
(Member)

19/5/16
Date

This thesis is dedicated to my family and my friends.
For their endless love, support and encouragement.

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ABSTRACT

Full Name : Mohammad Mahmoud Deyab Tomaizeh.

Thesis Title : Variations of Owner's Estimated Quantities for Highway Projects in Unit Price Contracts in Saudi Arabia.

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Unit price is a common type of contracts in construction of highway projects in Saudi Arabia. Usually owners estimate the bid quantities for all required items of work and advertise them for contractors to submit their unit prices for each item. Then, the owner awards the contract to the lowest total cost while the payments are made based on actual quantities completed without responsiveness to initial bid quantities provided by owners. Therefore, this study discusses the issue of quantities variations in highway governmental construction projects under unit price contracts in Saudi Arabia. It gives a real representation of the level of quantities variations experienced by owners through analyzing five recent highway project case studies in Saudi Arabia. The results revealed that most highway construction project experience more than 10%, cost-overrun and sometimes worse. It looks for the major reasons for quantities variations and the major consequences of these variations incurred by owners and contractors, through a questionnaire survey for both highway contractors and consultants certified for designing and preparing project bill of quantities. The major resulted reasons for quantities variation were forecasting errors due to lack of data, unforeseen site conditions, forecasting errors due to poor quantities takeoff, forecasting errors due to unknown site conditions by consultants, unclear underground utilities plans, and poor coordination between public agencies. The major consequences of quantities underestimation were increased project cost, owners' difficulties in obtaining their projects funds, project delay, delay in payments to contractors, and many other practices that is special to Saudi Arabia including owners' deletion of some project items or project scope reduction to satisfy the available project budgets. This practice results in a hazardous transportation means for public use. The major consequences of quantities overestimation were increased contractor project overhead, unbalanced contracts, and many other consequences practiced by contractors and incurred by owners. Finally, the study concludes that the best way to solve this issue is to improve owners' philosophy of quantities estimation preparation, contract terms, conditions, and regulations. Doing so will maintain accurate cost estimation and bid quantities, and regulate the unit price contracts bidding and execution that in turn will overcome all consequences associated with quantities variations whether underestimation or overestimation.

Keywords: Unit Price Contracts, Quantities Underestimation, Quantities Overestimation.

ملخص الرساله

الاسم الكامل: محمد محمود ذياب طميزة

عنوان الرسالة: التغيرات في كميات العطاءات (التابعه لعقود اعادة القياس او عقود الدفع مقابل الوحده المنفذه) المحسوبه من قبل المالك لمشاريع الطرق في المملكة العربية السعودية.

التخصص: ادارة وهندسة التشييد.

تاريخ الدرجة العلمية: مايو، ٢٠١٦

ان عقود اعادة القياس هي اكثر انواع العقود المنتشرة في مجال انشاء الطرق في المملكة العربية السعودية بحيث يتولى المالك حساب الكميات لكل بند في المشروع ومن ثم يقوم بدعوة المقاولين لتقديم اسعارهم مقابل كل بند. بناء على ذلك، يتم ترسية العطاء على المقاول المتقدم باقل سعر كلي للمشروع بحيث تتم الدفعات للمقاول بناء على الكميات المنفذه بدون اي اعتبار للكميات الاساسيه للعقد المزوده من المالك والتي استخدمها المقاول لحساب اسعاره لكل بند. نتيجة لذلك، تعرض هذه الدراسه قضية التغير في الكميات الاساسيه للعقد اثناء التنفيذ وما يتبعها من نتائج. أولا، قدمت الدراسه عرضا حقيقيا لحجم التغيرات في الكميات المحسوبه من المالك اثناء تنفيذ مشاريع الطرق من خلال دراسة خمسة مشاريع طرق منفذه حديثا تحت عقود اعادة القياس بحيث اظهرت النتائج ان غالبية مشاريع الطرق تعاني من ارتفاع تكلفة المشروع بما لا يقل عن ١٠% من التكلفة الكلية المتوقعه. ثانيا، بحثت الدراسه عن اهم الاسباب التي تؤدي الى التغير في الكميات المحسوبه من خلال توزيع استبيان لكل من مقاولي الطرق والاستشاريين المؤهلين في المنطقه الشرقيه بحيث اظهرت النتائج ان العوامل التاليه هي من اهم العوامل للتغير في الكميات المحسوبه على التوالي: اخطاء في حساب الكميات بسبب نقص المعلومات عن المشروع، ظروف العمل غير المتوقعه بالموقع، اخطاء ناتجه عن ضعف حساب الكميات، اخطاء ناتجه عن قلة المعلومات عن ظروف الموقع و متطلباته، عدم وضوح مخططات الخدمات والانشاءات الموجودة تحت الارض والمزوده من المالك، وضعف التنسيق بين المؤسسات الحكوميه المتعلقه بمشاريع الطرق. ثالثا، اظهرت نتائج الدراسه ان اهم النتائج السلبيه لزيادة الكميات المقدرة من المالك على الواقع هي على التوالي: زيادة تكلفة المشروع، صعوبة تمويل المالك للمشروع، تاخر المشروع، تاخر الدفعات للمقاولين، بالاضافه الى نتيجه سلبيه مهمه اخرى -والمنتشره في السعوديه بشكل خاص-

تتعلق بحذف بعض البنود او تقليل نطاق العمل لتتناسب مع التمويل الموجود للمشروع مما ادى الى بيئة طرق غير امنه في كثير من الاحيان. واخيرا، اظهرت نتائج الدراسة ايضا أن اهم النتائج السلبيه لنقص الكميات المقدرة من المالك على الواقع تضمنت التالي: ارتفاع تكاليف المشروع غير المباشره على المقاول، عدم الاتزان في اسعار بنود المشروع المقدمه من المقاول، وغيرها الكثير. في النهاية، استخلصت الدراسه ان افضل طريقه لحل هذه المعضله هي تحسين فلسفة المالك في تحضير حساب الكميات، بنود العقود، ظروف العقود، و تنظيمات العقود للحفاظ على حساب كميات دقيقه للمشاريع و الحفاظ على نجاح عقود اعادة القياس وتنفيذها وتنظيمها والتي من شأنها ان تواجه جميع التحديات والنتائج السلبيه لمعضلة التغير في الكميات المقدرة.

كلمات مفتاحية: عقود اعادة القياس، زيادة الكميات المقدرة من المالك على الواقع، نقص الكميات المقدرة من المالك على الواقع.

CHAPTER ONE: INTRODUCTION

1.1 Background

The construction industry in Saudi Arabia is growing exponentially in all types of construction, whether infrastructure, building, residential or industrial. Therefore, cost estimation must be a major concern to all of the parties involved in the construction industry. Since cost estimation is the earliest stage to be initiated in any construction projects, the study of the problems facing estimators, and improving their skills while controlling the estimate procedures used is necessary to save both time and money.

Moreover, early accurate cost estimation is invaluable for owners to evaluate their investments before starting the project. Therefore, the more accurate the estimation the more advantage exists, not only for owners but also for every party involved in the construction industry.

Construction estimation of projects is one of the most important stages throughout the project lifecycle, especially in the early stages; this is because project estimation in the early stages defines the quantities and scope of the project. Therefore, any project event which follows will be dependent on the owner's or consultant's quantity estimation; thus the success or failure of a project will be determined by maintaining the accuracy of the estimation process.

At first, when the owner decides to start a project, his engineers will make a rough estimation of the required project to define the approximate budget needed to proceed with the construction. If the estimated budget matches the allocated budget, then the project will start, but what if the estimation process is not accurate? Then both the owner and contractor of the project will suffer, especially where unit rate contracts are concerned.

The definition of unit rate is an amount of money that is paid for every unit or piece installed in the site, and is determined by summing the direct cost, the allocated indirect cost and finally the contractor’s profit.

Estimation is the process of anticipating the quantities and costs of the project depending on the required specifications of the owner. However, in unit rate contracts, if the estimation process is not accurate, the item's estimated quantity will be higher or lower than the real quantities resulted. In both cases either the owners or contractors will experience losses.

(Shrestha et al. 2014) believed that many variable factors are involved in the construction process, which in turn complicates the prediction of any construction project cost. He also stated that the time available for authorities during the feasibility stage forces them to select between projects before the completion of project scopes, and so the estimated value of project cost is not accurate.

In addition, (Liu L., Napier Z. 2010) mentioned that the uniqueness and temporary conditions associated with construction projects limit the learning abilities of companies.

However, if the estimated quantities of a project are lower than the real quantities, then the owner will face difficulties in funding his project, assuming that he is allocated a specific and limited budget for that project because of the increased project cost. In contrast, in many cases the owner’s engineers or consultant's estimators will try to inflate the project quantities for many reasons. First, and most importantly, they desire to satisfy their owners or managers and to overcome the above problem of the owner's allocated budget for funding the project; hence, the owner will certainly not face difficulties funding his project. Secondly, they are doing approximate estimates when they don't have enough time to prepare an elaborate estimation of quantities. Finally, they will not be able to accurately anticipate the exact quantities of some items, such as excavation costs.

At that time, when the owner-provided quantities are higher than the real quantities, the contractor will experience big losses, and hence, the owner also will suffer from the contractor's reactions. The reason for the contractor's reactions is that, in unit price contracts, the contractor has to bid the quantities provided by the owner regardless of the accuracy of the quantities.

Besides, (Flyvbjerg et al. 2005) stated that the values paid and gained from infrastructure projects usually –in terms of money- exceeds hundreds of millions of dollars, with relatively high risks. Therefore, a deep knowledge of the risks associated with such projects is required to overcome any wrong decisions.

(Al-Tabtabai et al. 1999) demonstrated the high importance of preliminary cost estimates to the owners, in order to help them make a decision regarding proceeding or stopping the project based on these approximate estimates.

However, many researchers found that cost over-run and overestimation is prevalent in construction projects, especially infrastructure projects. (Lowe et al. 2006) mentioned that several studies concluded that owners are normally unhappy with the early recommended cost of their engineer's estimate.

(Eben Saleh, 1999) mentioned that due to the inaccurate, slow, and ineffective method used for the estimation of the bill of quantities in Saudi Arabia, many problems during the design, bidding, and construction stages of construction projects affects all parties involved.

In this regard, a study of the engineer’s inaccurate estimate impact is required to increase the awareness of the potential negative consequences of the inaccurate estimation of unit rate contract quantities in highway construction projects in Saudi Arabia.

1.2 Problem Statement:

Unit price contracts are commonly used in Saudi Arabia, especially in infrastructure and industrial projects. The design of unit price contracts contain a column for the quantities of each item provided by the owner with a parallel column for the unit price of that item to be filled by the contractor, called the Bill of Quantities (BOQ). Thus, the quantity is the major determinant of contract value. However, the owner or consultant estimators may not pay full attention to preparing accurate quantities, or may deliberately underestimate or overestimate the quantities to satisfy some objectives. As a result, many highway projects have experienced cost overruns due to quantity and cost underestimations. This leads to difficulties in obtaining the extra funds required to complete the project, project delays, breakdown in relations among the parties involved in the construction of highway projects, and even economic and political losses. On the other hand, quantity overestimation results in big losses for owners and also the contractors. When the contractors prepare the unit costs of items, they will calculate the variable costs of the item, which includes material, labor and equipment required to complete this item, and the fixed cost of that item which includes overhead costs related to the project or the item itself. Moreover, a high quantity of items may encourage contractors to decrease the item's cost because the fixed costs of items is always fixed, whether the quantity of the item is low or high; when the quantity is high, the fixed cost is distributed over each unit of quantity and becomes lower. Therefore, the result of quantity overestimation will shock contractors and lead them to cut corners to cover their losses. However, some contractors will attempt to unbalance the contract to cover any expected losses in the future, which in turn may cause big losses for owners in the case of overestimation and estimation errors.

Therefore, this research will discuss the extent of quantity variations in highway projects in the Eastern Province of Saudi Arabia, the reasons for these variations, and the consequences that are related to the overestimation and underestimation of quantities in Unit Price Contracts.

1.3 Research Objectives:

The main objectives of this study are the following:

1. To measure the level of variation in owner-provided estimated quantities in unit price contracts for highway projects in Saudi Arabia.
2. To identify the main reasons for the variations in owner-provided estimated quantities in unit price contracts for highway projects in Saudi Arabia.
3. To identify the impact of the variations on unit price contracts for highway projects in Saudi Arabia.

1.4 Research Significance:

This research will be able to identify the major consequences of inaccurate estimation. When such impacts and consequences become known for each party involved in construction industry, then all parties will try to develop their estimation procedures to get the most accurate estimation of quantities as well as prices. Therefore, the significance of the study is:

- To raise the owner's awareness of the importance of maintaining accurate estimation in unit price contracts.
- To encourage contractors to review the provided owner's quantities in such types of contracts.
- To improve the unit price cost estimation procedures of owners, consultants and contractors, as well as enhancing the cooperation of all parties in the estimation stage.

1.5 Research limitations:

This study will measure the level of quantity variations on unit price contracts that are used in highway projects in Saudi Arabia. Due to time and cost limitations, this study will be limited to stakeholders who are located in the Eastern Province of Saudi Arabia. Therefore, more research is required in many other regions of Saudi Arabia as well as other countries all over the world.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This section presents previous studies of this research that includes past procedures used for cost estimation, the importance of accurate estimation, and many concepts related to cost estimation including inaccurate estimation, underestimation, overestimation, factors for inaccurate estimates, and the contractor's estimation process. Moreover, it presents the concept of unit price contracts while discussing the reasons and consequences of inaccuracy of estimation, and finally, the success factors critical to maintaining accurate estimations.

2.2 Cost estimation procedures

(Bradley et al. 1990) showed a traditional approach of cost estimation that started by deriving the quantities of the work based on the data available about the project, and then applied up-to-date rates and prices with some modifications to reimburse differences due to some factors related to the project's characteristics.

Likewise, (Makovsek D. 2014) defined two estimating approaches that included the traditional and probabilistic. The traditional approach is characterized by the common feature of determined risk contingency and by dependence on historically-based estimating, parametric cost estimating, and cost-based estimation. The probabilistic approach uses historically-based estimating with a risk adjustment using quantitative analysis.

However, (Chou et al. 2006) mentioned that the state of DOTs (Departments of Transportation) use cost estimating methods that were found to be unsuitable and incorrect for preparing early estimates.

Whereas (Al-Tabtabai et al. 1999) believed that a good approach to cost estimating must have historical data combined with an estimator's knowledge, experience, and skills.

2.3 Concepts and importance of cost estimation

This section presents the need and importance of cost estimation and many concepts related to the accuracy of cost estimation, factors affecting overall estimation accuracy, and the estimation procedures used by contractors.

2.3.1 Need for accurate estimation

The need for accurate estimation is increasing in the construction industry, however, many researchers demonstrated inaccurate estimation practices. (Elfaki et al. 2014) emphasized that accuracy of the estimate is critical to guarantee the construction project's success. Therefore, accuracy and comprehension of cost estimation are critical concerns that must be appropriately addressed to maintain the optimum level of accuracy.

2.3.2 Inaccurate estimation

(Azman et al. 2011) defines accuracy as minimum errors which cover both bias and consistency. Bias is defined as the average difference between the bid cost and the estimate, whereas consistency is defined as the degree of frequent variation.

(Qdusami K. T., Onukwube H. N., 2008) showed that 5% of underestimation or overestimation is usual; he also mentioned that QS deviated by about 5-10% from the actual estimate. (Qdusami K. T., Onukwube H. N., 2008) also showed that in Singapore the deviation from the estimate ranges from an underestimation of 31.30% to an overestimation of 33.79%.

(Elfaki et al. 2014) identified many problems that may result from inaccurate estimation, including project delays, change in orders or even bankruptcy.

According to the Public Works Department (PWD) the performance reliability of the QS department is uncertain. Moreover, projects can be rejected and may lead to a court case if the estimate is underestimated, while overestimation may result in lowering the budget for other projects as stated by (Azman et al. 2011). Therefore, the PWD proposed two potential actions: a thorough review to revise the designs, and an extra budget support.

2.3.3 Cost over-run and underestimation

(Azman et al. 2011) stated that the project promoter will favor underestimation while tendering in order to obtain the required project funding, and to satisfy the client's inclination to seek low-cost options.

Many DOTs have practiced too much cost over-run in many projects (Chou et al. 2006). He also showed that about 9 of 10 transportation projects were underestimated by about 20%.

Similarly, (Liu L., Napier Z. 2010) mentioned that despite the estimation accuracy improvements, many infrastructure projects have experienced a cost over-run of about 50-100%.

2.3.4 Overestimation

(Eben Saleh, 1999) pointed out that owners usually provide a BOQ with many errors and hence variations commonly occur between the estimated and actual quantities; accordingly, the contractor's cash flow will be heavily impacted.

(Azman et al. 2011) investigated the probability of overestimation and found that owners and their estimators tend to favor overestimation to underestimation. Moreover, more than 50% of estimators agreed to overestimate the estimated value.

Similarly, as stated by (Liu L., Napier Z. 2010) the estimators will act negatively to overcome cost over-runs by adding a percent that represents a cost over-run risk.

2.3.5 Factors affecting overall estimation accuracy

(Al-Tabtabai et al. 1999) classified factors that affect highway project costs into three groups: environmental factors which comprise project location and ground conditions; the contractor's strength, which includes their proficiency and financial state; and project characteristics that involve the effect of existing utilities and the project size and type.

Also, (Enshassi et al. 2013) classified factors that affect accurate estimation into five groups: factors related to the client; factors related to the design and owners; factors related to contract requirements; project-specific factors; and factors related to market climate.

Moreover, (Elfaki et al. 2014) classified these factors into two groups: factors related to estimators; and factors related to project and design, which include project size, project nature, type of owner, probable design and scope variations, duration, bidding method, ground conditions, and material cost and its availability.

However, (Shrestha et al. 2014) concluded that it is difficult for clients to predict an accurate bid cost in unit price contracts due to the dynamic bidding process. He also identified some factors that affect the bidding design, which include project location; an item's quantity, and availability of that quantity at the execution stage; market conditions; the number of bidders, and many other factors.

Additionally, (Enshassi et al. 2005) identified four group of factors that affect estimation: financial concerns; tendering conditions, project characteristics; and the estimation procedure used. He also summarized nine factors that impact estimation accuracy: the extent of design completion; complete cost data; project type and size; the market situation; the number of bidders; a proficient estimation process; personal factors; and the estimator's experience.

Furthermore, (Qdusami K. T., Onukwube H. N., 2008) revealed many factors that affect estimation accuracy: the consultants and project team's experience; project information availability; completeness of design data; design and construction complexity; and bidding duration and market conditions.

(Oberlender G. D., Trost S. M., 2001) findings showed the drivers that affect estimation accuracy, starting with the basic design, which constitutes about 25%; team experience and cost data, which constitutes 14.3%; the time available- about 13%; the site requirements-12.4%; bidding and market conditions-11%; and many other factors which make up the remaining 24.3%.

From the above discussion, the most important factors affecting the accuracy of overall cost estimation can be summarized into six groups: (1) design and project data, that include design completion, consultant experience, completeness of project information; (2) market conditions; (3) project-related factors whether the size, type, location, complexity, existing conditions, or any other characteristics; (4) the contractor's proficiency, which include his experience, and estimation procedure; (5) bidding design, which includes bid quantities and number of bidders; (6), the estimator's experience, which is discussed below in detail; and finally (7) the time available for estimation.

2.3.6 Estimator's performance as a main factor for estimation accuracy

(Azman et al. 2011) found that QS performance is influenced by project characteristics such as contract type, sum, duration; and conditions, market conditions, the number of bidders, the project's location, and the procurement process.

(Azman et al. 2011) also indicated that QSs are not developing their estimate system based on the previous estimation errors, and hence are not improving their estimate.

However, (Bradley et al. 1990) argued that the more the estimator's capability, the more probability there was to make decisions based on objective knowledge. (Bradley et al. 1990) also indicated that estimators are not the same in quantifying variation, because they are reflecting their own personalities. Consequently, many estimators are risk-seekers while others are conservative.

(Liu L., Napier Z. 2010) recognized that estimators are more likely to make "self-protective predictions" to maintain successful contracts and satisfy owners. Whereas, (Elfaki et al. 2014) showed that most estimators make decisions based on probable gains or losses, while not taking into account the results of that decision.

Therefore, an estimator's performance is highly important, and that can include the estimator's experience, bias, personality and his perspective to risks.

2.3.7 Contractor's estimation procedure

The process of estimation requires a high cost to fulfil the high number of experts and staff needed to complete the estimate (Eben Saleh, 1999).

Contractor's bidding decisions are subjected to many factors as described by (Shrestha P. P., Pradhananga, N., 2010). These factors include competition, risk, the contractor's bidding position, and the need for work.

(Akintoye A., 2010) indicated that many contractor's estimation departments initially identify resources needed to complete the project, taking into account its quantities, quality, cost, performance, and other factors affecting performance, to determine the basic cost estimate. After that, they consider the value of the mark-up needed to recover overhead and create profits. However, those contractors generally set a mark-up that can ensure having a marginal profit that aligns with the company's strategic situation in the market.

Moreover, contractors usually apply an adjustment to prices to recover both uncertainties, such as site requirements, project location, contract conditions, and market conditions (Akintoye A., 2010).

However, (Ronai P., 2010) defined a detailed estimation process by proceeding through the steps as follows: (1) computation of basic materials' costs by calculating material quantities based on drawings and required specifications, taking into consideration any expected waste materials and the required handling and storing of these materials, then applying the latest updated costs; (2) computation of engineering costs associated with the project design, which include engineering hourly cost rates and computer time costs, as well as coordination and organizing of their work; (3) estimation of production engineering and planning costs; (4) estimation of the costs of the process plan that include production, assembly, and construction activities; (5) manufacturing activities related to the owners; (6) estimation of construction activity costs to determine the number of hours of labor and equipment needed; (7) estimation cost of testing; (8) estimation of labor allowances; (9) estimation of indirect costs and uncertainties; (10) and finally, an application of the factor value of the last three steps to obtain the final estimate.

However**,** (Gransberg, D. D., Riemer, C., 2009) preferred not to compute direct cost and apply it as a percent; instead, the contractor has to calculate the unit price by the following procedure:

- Determine the variable cost (VC) of an item that represents the cost that changes as the quantity changes
- Determine the fixed cost (FC) of an item that represents the indirect costs related to this item
- Determine the fixed the amount of profit (P) for an item, and then calculate the unit price (UP) as follows:

$UP = (FC + VC + P) / N$

N: number of units in an item

In this way, (Gransberg, D. D., Riemer, C., 2009) clarified that the contractor will always ensure recovery of variable costs without any risk (in contrast to the estimation of the total indirect cost and applying them percentagewise to all bid items). This method will also allow the contractor to ensure more precise estimation of indirect costs associated with only one item every time.

2.4 Unit price contracts

As discussed earlier, the concept of unit price is the amount of money that is paid for every unit of work installed in the site. It is used when it is not possible to calculate the exact quantities of work in a construction project. (Gransberg, D. D., Riemer, C., 2009).

Therefore, when the owner selects unit price contracting to administer the price and quantities of his project or facility, then he is trying to share the risk of the final quantities of work with the contractor.

Sometimes the bid is required to be in a unit price design because of the nature of some particular projects, especially heavy/highway projects (Manzo F. A., 1993)

2.4.1 Reasons for underestimation and overestimation of quantities in unit price contracts

(Liu L., Napier Z. 2010) recognized that owners are underestimating estimates deliberately to secure funding of the project, while contractor's bids are influenced by their manager’s objectives.

In the same way, (Makovsek D. 2014) identified three major causes of cost over-run, which include technical causes that are related to forecasting errors due to lack of data- the difficulty of prediction, and the inadequacy of the approach used; secondly, the psychological causes related to the estimator; and finally the economic and political causes that account for the imposed underestimation.

(Liu L., Napier Z. 2010) linked this behavior to optimism bias, which relates to being an over-optimistic person, and the misrepresentation of project costs to fulfil political and economic objectives.

Then, the causes for underestimation can be divided into the following groups: (1) technical reasons that represent forecasting errors due to lack of data, the difficulty of quantity prediction, and the estimation approach used; (2) an estimator's causes that include Over-optimistic behavior and misrepresentation of the project cost (3), and economic and political reasons that include funding security, and satisfaction of the owner's inclination for low cost.

Although extensive research has been conducted to investigate the factors for underestimation, little research has studied the factors inducing overestimation. However, (Gransberg, D. D., Riemer, C., 2009) provides two factor for such a practice in the USA. First, most US public agencies have awardability constraints based on the difference between the low bidder and their engineer's estimates. Secondly, there is a limited percent of contingency for the engineer's estimates. In such cases, their engineers try to inflate the quantities' estimate to ensure fulfilling the contingency of his particular project and maintain awardability of the project.

To overcome the issue of adequate budget allocation, estimators usually overestimate high value projects because of insufficient project information (Azman et al. 2011). He also added that owners are more concerned about the total cost rather than an accurate estimation. In addition, he mentioned that the estimation department usually wants to satisfy their managers rather than using the subjective judgment method.

In conclusion, the main reasons for overestimation are the inclination to overcome adequate budget allocation problems; to secure success of the project’s awardability; to satisfy manager's attitudes; the use of inappropriate judgment methods; and to cover uncertain risks.

2.4.2 Factors affecting unit cost in unit price contracts

One of the important factors in estimating unit cost is the quantity of an item. For example, if the contractor has been awarded a construction project of (X) quantity, then he will allocate staff to manage this project, but if the available staff is not sufficient (assuming that the available staff can only cover, say, (0.8X) of that quantity), at that time he will employ more people from other engineering branches to cover the extra work. However, if the real quantity of that project is found to be (0.8X), then he will find himself paying unnecessary extra salaries for newly recruited employees and even more, if that is applied for the entire contracting company including planning, procurement, contracting, and so on.

On the other hand, more quantity means continuous work and hence continuous profit. If an assumption that contractor A can finish 200 units of work daily, then what is better for this contractor- to have a continuous profit of 50 SR for the capable units of work a week, or to have a profit of 80 SR for only 500 units of work a week? The following calculations will answer the question:

Capable units of work a week (5 work days) = 5 x 200 = 1000 units

Case 1: Total profit = 1000 x 50= 50000

Case 2: Total profit = 500*80= 40000

As a conclusion, continuous work will result in full utilization of resources and hence more profit. Therefore, more quantity results in lower unit costs.

Similarly, (Akintoye A., 2010) concluded that the main factor influencing the unit cost is the work item quantity.

(Shrestha et al. 2014) figured five factors affecting unit cost: including an item's quantity; the contractor's fixed cost; the contractor's variable cost; prevailing economic conditions; and the associated risk of an item. Moreover, after investigation, he emphasized that quantity is a major driver of unit cost, providing that the fixed cost of an item is not changing. Therefore, when the quantity is increased, only the variable cost of the contractor will increase and hence there will be a greater profit margin for the contractor.

(Shrestha P. P., Pradhananga, N., 2010) mentioned another factor which also has an influence on unit cost, which is namely the number of bidders. As he concluded, a high number of bidders will result in a lower bid cost for the owner due to increased competition.

2.4.3 Inaccurate estimation of quantities in unit price contracts and consequences

Inaccuracy of estimation leads to many problems during the bidding and execution of the project. This section will present some possible consequences of underestimation and overestimation of quantities.

Consequences of underestimation

Underestimation is the act of lowering the cost or quantities of a project, and even the risks associated with that project. One of the most important impacts of such a practice is the lack of future funding of the project. An observation of (Chou et al. 2006) showed that actual costs of road projects is usually 20% greater than an engineer's estimate. Accordingly, the owners will face difficulties funding their projects.

(Liu L., Napier Z. 2010) discussed the issue of risk underestimation, citing that when the owners underestimate the risks, then they will fail to cover uncertainties. This will result in project execution difficulties, project delay, and a breakdown in the contracting relationship.

Consequences of overestimation

Overestimation is the act of cost, risk, and quantities inflation of a project. Unfortunately, many owners don’t understand the idea of unit price contracts, believing that when they are paying the contractor for every item installed they have satisfied the contractor's associated costs of that item, as cited by (Gransberg, D. D., Riemer, C., 2009). However, when the quantities installed per unit price contracts is less than the bill of quantities provided by the owner, then the contractor will not be able to cover all of the associated cost of that item, such as overhead and profit (fixed cost). Therefore, some contractors will start cutting corners if they did not adequately review the quantities before bidding. On the other hand, contractors who reviewed the quantities well, will attempt to unbalance their contracts. When they are doing so, they are covering their fixed cost of each item, including overhead and profit (Gransberg, D. D., Riemer, C., 2009).

2.4.4 Unbalanced contracts

(Gransberg, D. D., Riemer, C., 2009) classifies the unbalanced contracts into two types: mathematically and materially unbalanced contracts. A mathematically unbalanced contracts occurs when each bid item fails to carry its fair share of overhead and profit while maintaining the minimum actual cost of item. A materially unbalanced contract occurs when a bid item fails to carry its minimum actual cost, meaning that some of the item's actual cost has been shifted to another item.

Unfortunately, some contractors are using unbalanced bidding to increase their profit margin as well as their early cash flow, and hence many public agencies have accepted mathematically unbalanced contracts model as a normal reaction to quantities inflation, but none of them accepts materially unbalanced contracts. The reasons why all agencies reject materially unbalanced contracts include the fact that contractors are bidding high prices for items occurring early in the project to improve their early cash flow, which in turn overloads the owner’s cash flow to satisfy the required payments; the second factor is that the contractor finds errors in the quantities and bids high prices in those items to increase their profit, leading to the same problem as the owner (Gransberg, D. D., Riemer, C., 2009).

2.4.5 Critical success factors for accurate estimation

This section discusses some factors that will maintain accurate estimation while offering some solutions for inaccuracy during project execution on unit price contracts.

Federal Highway Administration (FHWA) provided that an engineer's estimate must be fair to result in an accurate estimation of the budget, and to allow an effective evaluation and review of that estimate.

STA's require the engineer’s estimate to be fair and justifiable when evaluated by construction contractors. However, they call for documenting estimation procedures and training of a contractor's staff.

(Gransberg, D. D., Riemer, C., 2009) present four factors for owners to maintain balanced bids. These include: reasonable mobilization of an item to fulfil the contractor's need for an early cash flow; application of a unique contingency for each project; provision of a negotiation clause in contracts for items of quantity variations in unit price contracts, to substitute for cost overrun or underrun; and finally, and most importantly, provision of accurate bid quantities.

(Eben Saleh, 1999) suggested an automated program software to estimate (BOQ) of construction projects to maintain accuracy and avoid bias, while (Elfaki et al. 2014) favored the use of a computerized system to replace the estimator’s performance. Moreover, (Enshassi et al. 2005) emphasized organizing the information needed for estimation and keeping it in a computerized system to maintain effective cost estimating.

On the other hand, (Ronai P., 2010) proposed an effective cooperation between public and private agencies to maintain accurate estimation. Further, (Chou et al. 2006) emphasized the continual updating of unit prices to maintain accuracy.

2.5 Summary and conclusion

This chapter presented some old cost estimation procedures and discussed the best approach for preparing the cost estimate, while demonstrating the increasing importance of accurate estimation and procedures that guarantee project success.

Many researchers found that underestimation and overestimation becomes usual in highway construction projects. Many DOTs showed that 90% of transportation projects practiced about 20% underestimation, whereas many other researchers indicated that more than half of the estimators agreed to overestimate their estimated quantities.

Many researchers have presented different factors affecting the overall cost estimation accuracy. These factors are mainly related to the completeness of the project design and data; market conditions; project characteristics; contractor's proficiency; bidding design; the time available for estimation; and the estimators' performance, which was of great focus and importance, as discussed by most researchers.

Unit cost estimation of items were also discussed by many researchers; (Gransberg, D. D., Riemer, C., 2009) presented the optimum procedure for determining the unit indirect cost by calculating the fixed cost that represents the indirect cost of the item, rather than allocating a percentage of project total indirect cost for that item, and finally estimating the profit.

The goal of unit price contracts was to minimize risk by sharing it between owners and contractors. However, in case of quantities variations, many factors were found to cause quantities underestimation and overestimation, and hence many consequences resulted for both cases. On the other hand, the contractors are relating to many factors when they are determining unit cost, and sometimes unbalance their bids to maintain their profit in case of quantities variation.

Therefore, many factors were presented to maintain the success of the project cost estimation and project execution.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This section presents the steps needed to fulfill the main objectives of this study. At first, the data required for completing the study were clearly defined. Secondly, the data collection method was described. Finally, the results of this study were acquired through a deep analysis of the collected data.

3.2 Data required

The study was able to show the consequences of inaccurate estimation of unit prices in construction highway projects in Saudi Arabia. In addition, the study determined the level of quantity variations based on the owner's provided Bill of Quantities (BOQ), as well as the causes behind such variations.

The variation in quantities is calculated as the ratio of the difference between the actual and estimated quantities of items that were completed in highway projects that were executed under unit price contracts. The actual quantity is defined as the quantity that is reported in the final request for payment for completed highway projects under Unit Price Contracts. The estimated quantity is defined as the quantity that is given in the Bill of Quantities (BOQ) for completed highway projects under Unit Price Contracts. Moreover, documents related to contract scope, terms and conditions, and other related bidding documents are required to investigate some probable areas causing these variations.

The main reasons for variations in quantities can be divided into three major types in unit price contracts:

1. Technical reasons: it results because of estimation forecasting errors, site requirements, and many other reasons which may include but are not limited to the following:

- Forecasting errors due to lack of data: the available information about the project, required specifications, and completeness of design is usually not explicit enough for completing the estimate.
- Forecasting errors due to difficulty of Quantity prediction; this relates to some kinds of items, whether excavation, filling, or any other items of works.
- Forecasting errors due to the estimation approach used: sometimes the estimation procedures used are not accurate enough, neglecting many elements related to the same item, and ignoring risks within the item.
- Forecasting errors because of unknown site requirements by the consultant: many contractors indicated, in direct interviews with their project managers, that most consultants did not have enough information about site, or did not study the project site well, and in many cases did not visit the site at all.
- Forecasting errors due to poor quantities take-off and quality control by the consultant: quantities take-off is the main step when measuring the quantities of a project. Therefore, poor abilities and a weak interest in controlling this step usually causes many estimating errors.
- Time available for preparing estimation: this will result in overestimation to cover mistakes resulting because of limited time for the estimate.
- Unclear underground utilities plans: this is one of the main reasons that many contractors focused on, and described it as one of the most important factors in

quantities variations and project delays. The lack of clear drawings and plans detailing utilities and underground structures, which did not match actual site utilities throughout Saudi Arabia, were a significant cause many of many problems during construction, and were protested by many contractors.

- Insufficient use of technology: consultants are not using appropriate software programs, and not using advanced and accurate quantities take-off software programs.
- Poor coordination between public agencies' works and requirements: in many cases, owners were preparing their governmental project quantities without coordination with the respective public agencies to complete their works and requirements. For example, the preparation of highway project quantities without considering the ministry of electricity works requirements, or without coordinating with the agency responsible for water facilities.

2. Factors related to the estimator's performance, which include:

- Overoptimistic behavior: it is a kind of behavior that is predicting the optimum state of the future, which many estimators practice in preparing the Bill of Quantities (BOQ).
- Misrepresentation of project cost: many estimators deviate from the actual quantities to satisfy various objectives.
- Unqualified estimators: many estimators did not have enough knowledge, experience, and skills required for accurate estimation.
- Inaccuracy in measuring risks: the contingency percent may also be applied for both quantities and risks.

- Inappropriate judgment method: quantities underestimation or overestimation may also result from mistakes in judgment related to expectations and risks.

3. Economic and political reasons:

- Overestimating to have enough budget to cover variations: the problem of frequent cost overruns of highway projects encourages the estimators to increase the quantities and cost.
- Underestimating to secure project fund: the issue of receiving funds from government or funding organizations encourages the estimators to underestimate the quantities and costs of a project to be lower in terms of money, and hence lead to a higher funding probability.
- Satisfaction of owner's inclination for low cost: owners generally predict low cost, and so many estimators try to satisfy their owner's predictions.
- To satisfy manager's attitudes: again, the estimators usually change the actual quantities to satisfy their mangers.
- Neighbors' and shopkeepers' complaints: during construction, many contractors mentioned that many neighbors and shopkeepers voiced many complaints to municipalities because of projects delay, which in many cases, caused quantities reduction or increase.

In addition, to recognize the impact of quantities variations on unit price contracts, the following presents the main factors that may affect the unit cost of unit price contracts:

- Quantity of item: the more quantity of an item, the less total cost of item is incurred.

- No. of bidders: as the number of bidders increase, more competition will be available leading to lower prices allocated to maintain award ability of the project.
- Risk associated with the work item: when there is higher probability of risks associated with an item, the cost to overcome such risks will increase. Therefore, more risk results in more cost.
- Estimation method used: an accurate method will result in accurate costs and prices of the work items.
- Economic conditions: market prices of materials will affect the unit cost of items.
- Contractor qualification: the better the qualifications of contractors, the better the resulting work quality, the better their estimation procedures and the higher the accuracy and costs of items.
- Project location: remote locations require more transportation costs, extra accommodation costs, and hence more costs and prices of items.

Secondly, to present the potential consequences of quantities variations, it was divided into two types according to the differences from actual quantities in unit price contracts:

1) Consequences of quantities underestimation: may include but are not limited to the following:

- The owners will face difficulties to obtain future funding for their projects: because of cost over-runs, the owners were asking government for extra fund to support their budget which in turn led to more difficulties and restrictions by many government regulations.

- Project delay due to lack of funds: quantities underestimation leads to cost over-run and therefore many owners were not able to complete the project using their available budget.
- Deletion of some project items or scope reduction: many owners deleted some project items or sometimes reduced the scope of highway projects by changing the initial station to another shorter station, to allow for the budget available.
- Failure of payments to contractors: again, the unexpected extra cost of the project caused many delays in payments to contractors.
- Litigation due to contract breach: in cases of extreme delay of payments to contractors, they may use their right to sue the owner.
- Increased project cost.
- Failure in completing the project: when the project budget was not enough, the project was delayed until governmental funding was provided; in many cases, the contractors were not able to complete the project without continuous and regular payments.

2) Consequences of quantities overestimation: include but are not limited to:

- Increased contractor project overhead: as discussed above, quantities overestimation will increase the contractor's overhead costs.
- Contractors cut corners: when contractors feel that they will not cover their fixed cost of any item, they will attempt to deliver this item improperly with the lowest cost, to cover losses.

- Contractors unbalance the contract: if contractors find inaccurate quantities during the estimation of item price, they will unbalance their contract to cover any expected losses that may result from quantities variations in the future.
- Contractor seeks to cover overhead through change orders: to cover their extra costs, contractors will try as much as possible to seek many change orders as they can to reduce their losses.
- Limit fund for other projects in the pipeline.

3.3 Data collection

In order to fulfill the study requirements, data was collected using the most appropriate method. Since it is not possible to study a model of highway projects due to limited access to such confidential project information, a combination of case studies of an easily accessed group of highway projects (five projects) were combined together with a questionnaire survey that was used as an additional tool for the data collection of this study.

The case study was used to measure the level of quantities variation, taking into account the scope, terms and conditions and other requirements related to bidding and execution of the project. Moreover, each project was studied thoroughly to determine: whether all of the project was underestimated or all of the project was overestimated; the share of underestimation and overestimation in the project; the type of works that were underestimated and why; the type of works that were overestimated and why; how much underestimation or overestimation of an item existed; and to identify some conditions that may be related to these variations.

An investigation of the reasons behind these variations was also interpreted after the completion of this case study. In the case when it was not able to clearly identify the main reasons for these variations, many interviews with the actual contractors who constructed the projects and consultants who prepared the bill of quantities of the above projects were conducted to identify these reasons.

The main purpose of the interview with contractors and consultants was to define the main reasons for items underestimated and overestimated; projects underestimated and overestimated; and the extent of quantities underestimation and overestimation.

To check the level of Quantity variations of consultants prepared bill of quantities, the following table is prepared to be used for this purpose:

Table 1: How to check the level of Quantities variations in BOQ

WORK DESCRIPTION			Unit	Owner's Estimated Quantity	Contractor's Unit Price (SR)	Total (SR)	Actual	
							Quantity	Price
1		**EARTHWORKS**						
	1.1	Item 1						
	1.2	Item 2						
	1.3	Item 3						
2		**CONCRETE WORKS**						
	2.1	Item 1						
	2.2	Item 2						
	2.3	Item 3						

Moreover, a view of the main issues related to causes of quantities variations was concluded from this case study. In all cases the owner was not the one who was preparing the (BOQs); instead, the consultants were always assigned to do the job of preparing the bill of quantities (BOQ), then the consultants' cost estimation department managers were the source for data. On the other hand, the cost field management, including project managers and construction managers, as well as their cost estimation department managers of grades 1, 2, and 3 contractors of highway projects were the sources of the required data.

The contractor's questionnaire (see appendix 1) consisted of five parts. The first part included questions seeking general information about the contractor such as location, number of employees, annual revenues, etc. The second part contained questions seeking information about the respondent, such as level of experience, level of education, etc. The third part contained questions seeking information about the contractor's preparation of his bid costs and prices for unit price contracts. The fourth part contained questions seeking information about the factors that cause quantities underestimation and overestimation. The fifth part included questions seeking information about the factors that affect the unit cost, as well as the potential impacts of quantities of underestimation and overestimation in unit price contracts.

In addition, the owner's representative (consultant) questionnaire (see appendix 2) consisted of five parts. The first part included questions seeking general information about the owner representative (consultant) such as location, number of employees, volume and type of projects, etc. The second part contained questions seeking information about the respondent such as experience, level of education, familiarity with estimation, etc. The third part contained questions seeking information about the consultant's preparation of bill of quantities. The fourth part contained questions seeking information about the factors that cause underestimation and overestimation on unit price contracts. The fifth part included questions seeking information on the factors that affect the unit prices, as well as the potential impacts of quantities underestimation and overestimation in unit price contracts.

Both questionnaires were sent first to several contractors and consultants to evaluate the suitability, completeness, and clarity of the questions. The feedback of this pilot study was used to modify the questionnaires before sending them to the contractors and the consultants.

3.4 Population and sample size:

The targeted participants for the contractor's questionnaire survey in this research were the grade 1, 2, and 3 contractors that build highway projects, and who were located in the Eastern Province of the Kingdom of Saudi Arabia. The list of the targeted classified participants was based on the classification system of The Ministry of Municipal and Rural Affairs in the Kingdom of Saudi Arabia. The total population number that satisfied the required classification level was 36 highway contractor companies. Since the population size was relatively small then all the contractors were sent a questionnaire and asked to participate in the study. However, as anticipated, some contractors did not respond to the questionnaire. Therefore, for statistical requirements, the minimum number of contractors to participate in this study was calculated using the Kish formula (Kish, 1995) as described below:

$n^o = (p*q)/ e^2$ ---------------------------------- (1)

$n = n^o / [1 + (n^o / N)]$ ---------------------------------- (2)

Where:

n^o = initial estimate of sample size

p = proportion of the characteristic being measured in the target population

q = 1-p

e = maximum allowed percentage of standard error

N = population size

n = sample size

To get the maximum sample size required for this study, values of (p) and (q) will be substituted as 0.5 for both. The maximum allowed percentage of standard error (e) in this study will be 10%. The total population considered for this study was 36 construction contractors (only of grades 1, 2, and 3) as obtained from the Ministry of Municipality and Rural Affairs, Eastern Province.

Applying the above formula, the sample size is:

$n^o = (0.5 * 0.5)/ (0.1)^2 = 25$

$n = 25/ [1 + (25/36)] = 14.7$

Therefore, the minimum required number of respondents was 15 construction contractors.

Moreover, the respondents were required to indicate the level of their agreement for a list of potential factors and consequences of quantities variations using a Likert scale from 1-5, where 1= strongly agree, 2= agree, 3= neutral, 4= disagree, 5= strongly disagree**.**

On the other hand, the targeted participants for the consultant's questionnaire survey in this research were all certified consultants located in the Eastern Province of the

Kingdom of Saudi Arabia. Again, the list of the targeted classified participants was based on the classification system of The Ministry of Municipal and Rural Affairs in the Kingdom of Saudi Arabia. The total population number of certified consultants located in the Eastern Province was 35 engineering and consultancy companies.

Again, all the engineering and consultancy companies were sent the questionnaires to obtain the minimum required number of responses that satisfied the statistical requirement, which was calculated and resulted in the same number of 15 companies.

3.5 Data analysis

The data collected above were analyzed using a common statistical software (SPSS), and the frequency tables of contractors 'and consultants' level of agreement were extracted to show the exact percentages.

For further comparison between different grades of contractors, chi-square test were applied to determine whether or not an association existed between different grades of contractors.

Based on this test, two hypotheses were proposed, as shown below:

Ho: Responses of highway contractors of grades 1, 2, and 3 are independent.

$H_{1:}$ Responses of highway contractors of grades 1, 2, and 3 are dependent.

After that, the *P*-value for each factor was obtained from SPSS tables. A possible rejection or acceptance of *Ho* may result, depending on the *P*-value. When the *P*-value is greater than 0.055, then the null hypothesis is accepted, (*Ho)* and hence different responses result with respect to different grades of contractors.

Moreover, the percentages of different grade of contractors' responses to different levels of agreements were also used for further clarification.

For further comparison between contractors and consultants, an F-test and T-test were applied to determine whether or not there was an association between contractors and consultants.

Two hypotheses regarding variances and means of both contractors’ and consultants’ responses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Variances between contractors’ and consultant’s responses are equal.

$H_{1:}$ Variances between contractors’ and consultants’ responses are not equal.

After that the *F*-value for each factor was obtained from SPSS tables. A possible rejection or acceptance of *Ho* may result, depending on the *F*-value. When the *F*-value is greater than (0.055), then the null hypothesis was accepted (*Ho)* and hence the variances of both contractors and consultants are equal,, and vice versa, and this determines the *T*-value selected for the means analysis below.

Therefore, further hypotheses were conducted to determine whether the means of both consultants and contractors are equal or not, as shown below:

Ho: Means of contractors’ and consultants’ responses are equal.

$H_{1:}$ Means of contractors’ and consultants’ responses are not equal.

After that the *T*-value for each factor was obtained from SPSS tables depending on whether the variances were equal or not. A possible rejection or acceptance of *Ho* may result, depending on the *T*-value. When the *T*-value is greater than (0.055), then the null hypothesis was accepted (*Ho)*, and hence the means of both contractors and consultants are equal, and vice versa.

Whenever the means were equal, then both contractors and consultants have the same responses for that factor, and vice versa.

Furthermore, an agreement index was calculated for each factor or consequence discussed above by following this equation:

Agreement index = ((Number of respondents who strongly agreed on the factor * 5) + (Number of respondents who agreed on the factor * 4) + (Number of respondents who were neutral with the factor * 3) + (Number of respondents who disagreed with the factor * 2) + (Number of respondents who strongly disagreed with the factor * 1)) / (5 * sum of all respondents).

These agreement indices were used to rank the aforementioned factors and consequences.

CHAPTER FOUR: CASE STUDIES ANALYSIS AND RESULTS

4.1 Introduction

To understand the negatives of cost estimation inaccuracy and quantities variations, and the resulting consequences in unit price contracts before and after construction of a highway governmental project, a detailed description of five governmental highway construction projects were presented and analyzed. Before that, some definitions were presented as shown below:

Governmental Entity/Owner: the governmental representative for management and control of any project funded by government, where the project is located at the same area that is under control of that representative.

Consultant: the consultant assigned by the Governmental Entity/Owner to study their projects and prepare its Bill of Quantities (BOQ); this person is sometimes different from the consultant assigned to supervise, manage, and control projects.

Contractor: represents the main contractor assigned by Governmental Entity/Owner to construct the entire project.

4.2 Case studies procedure

A Five highway construction projects, recently constructed in the Eastern Province of Saudi Arabia, were collected from two different grade 1 contractors. More than Five project managers were directly interviewed for more information and details about their projects during bidding and execution. Many issues related to project bidding, project execution, and contracts terms and conditions were discussed, and contracting documents related to these projects were also used for more explanations about project quantities variations and consequences.

4.3 Description, analysis, and results of case studies

This section presents the five case studies that were collected and analyzed to fulfill the study objectives. The following represents a description and analysis of five governmental highway construction projects.

4.3.1 Project A

Governmental Entity/Owner A intended to solve and improve the entrance to a city by eliminating traffic congestion, which had become hazardous and a threat to human lives. Entity A envisaged a complete and integrated solution through redesigning the entrance area, including the introduction of new highways, while improving the aesthetics of that entrance.

Entity A selected, based on a governing regulations for competitive bidding, a consulting office to study the project, to define the project scope, develop the detailed engineering, to prepare the project Bill of Quantities (BOQ), and hence, the project's required budget. Entity A secured the necessary funds based on the prepared project documents and invited interested grade 1 contractors through the official newspaper and the Entity's website to submit their bids for constructing the project. Only three grade 1 contractors responded to the invitation and submitted their bids after a one- month bidding stage. After bids analysis, Entity A awarded the contract to Contractor A with the lowest bid price. Finally, Consultant A, required to supervise the execution of the project, was selected after the competitive awarding process taken its place.

The importance and purpose of the project was mainly to find traffic solutions for Main Road X of about 3 kilometers length starting from the first intersection, with a newly introduced branch Street X, and ending with the second newly introduced intersection with branch Street Y.

The project scope included the following main four work disciplines:

1. Civil works: included excavation and fill of sub-base and base course layers under asphalt, binder and wearing asphalt courses, sidewalks, safety works, and road painting and markings.
2. Electrical works: included supply and installation of new lighting columns with bulbs, cable works associated with required pipes and control manholes, transformers, and distribution units.
3. Storm water drainage works: required the supply and installation of different types of pipes to maintain smooth drainage of storm water.
4. Landscaping works: required the supply and installation of different types of pipes to convey irrigation water for site landscaping.

Usually, the Construction and Projects Agency takes over the control of the construction and management processes of the site.

The project manager and cost estimation department manager of Contractor A indicated - in a direct interview with them- that the company follows cost estimation procedures in preparing bids for such governmental construction projects. The procedures depend on pricing of materials, equipment, manpower, operation, and an overhead of 7%, including contingency. The contractor were continually reviewing the BOQ provided by consultants, taking into account the quantity of items in which high quantities would be priced with a lower price than usual, and vice-versa. Moreover, whenever the contractor perceived that there was a quantity overestimation, they were always manipulating the activities completion percentage in such a way they would complete profitable items faster and delay any losing items. As a result of this practice, the contractor would always maintain the required profit in each project he handled.

The final contract value of the project was about 48,000,000 SR, with a proposed duration of 24 months. Generally, in such contract values, Owner A had asked the contractor for sufficient staff to handle the construction of the project, as shown in appendix 3.

The site of the project was handed over to Contractor A in September 2011. Then, the contractor started mobilization of his offices, equipment, and other required utilities. The construction of the project was immediately started after mobilization was completed. In order to be able to complete the project on time, Contractor A assigned the same required staff, subcontracted some project items, including storm water drainage and sidewalks, and began using a considerable volume of resources. The volume of resources used for this project (see appendix 3) was sufficient to be ahead of schedule during execution of the project..

For the first months of construction, Contractor A was always warning the owner that the project study was wrong and was not meeting the site quantities and requirements but he met with no responses. Contractor A, as represented by his senior projects manager –a recognized expert in this field- continued releasing his warnings by providing numbers to support the suspicion that the project quantities was underestimated by at least 20 million SR.

As a result, and after half of the proposed duration for project construction was spent, Governmental Entity A was convinced that the project would not be completed without asking for extra funds to allow for the quantities and budget underestimation.

Since governmental entities are not allowed to ask for more than 10% of a project's budget (which was about 4.8 million in this case) as an extra supporting budget for any project, and because of the good relations between the owner and contractor, they agreed that Contractor A would continue his construction works, funded by his own revenues without owner payments, until the owner obtained the required funds.

The owner again repeated the same steps to offer another new bid for the same project. The first project bid was closed on a value of (50,699,548 SR) and was named "Project A". The next bid was named "Project A Extension"; it was issued and awarded to the same contractor just before the completion of the first bid in such a way that the project was continually working with no gap in the construction.

The second contract value was about (23,000,000 million SR) with a proposed duration of 16 months. Therefore, the total contract value for this project was (71,000,000 SR), and the total proposed duration was 40 months.

Although the project faced many difficulties that delayed some critical activities, the actual total duration of the "Project A" and "Project A Extension" was 32 months with no suspension, instead of 40 months. However, these difficulties included:

- Existing utilities and response delay from respective utilities

- Shopkeepers’ and storekeepers’ complaints existed around that street
- Traffic agency permits delay.

During execution of the project, many risks were worrying all of the parties involved in the project, including but not limited to the following:

- The owner was worried about a project delay in case of a project extension funding delay.
- Contractor A was worried about a project suspension and its consequences.
- Risks related to existing gas pipes for ARAMCO.
- Risks related to existing fiber optics and many other utilities.

Appendix 3 shows three tables that were prepared to measure the level of quantities variations in the project. The first and second tables show "Project A" and "Project A Extension" contract quantities, their total cost, and the actual quantities and budget that "Project A" was closed on. After completing the project, "Project A Extension" was closed on the value of (22,482,731 SR). The third table presents the total actual quantities summed from both projects as an entire project, as well as any items added or deleted.

Only about 1.8 km out of the total 3 km length of the Main Road X was completed in the first bid, as many bid items were deleted to allow for the project’s available budget.

However, (Table 69 and 70 of appendix 3) can't be used to check the quantities variations for the total project items because there was a new bid (Project A Extension) that was issued to cover quantities underestimation experienced in this project. Therefore, the contract quantities of the total project that compromise both "Project A" and "Project A

Extension" will be summed from both projects as a whole project to be able to accurately estimate the quantities underestimation.

Only seven items that existed in "Project A" were totally cancelled from "Project A Extension", where two of them (1.2.1 and 1.5.3) were completed in the first bid but were underestimated by 261% and 85% respectively; two of them (1.4.3 and 2.6.3) were deleted, and the last three items (4.2.2, 1.6, and 1.7) were clearly overestimated, but were really on hold to be done later by maintenance contractors, as stated explicitly by the main contractor. Moreover, the following Items (1.5.X, 1.5.Y, 3.3.X, and 4.1.X) were added to "Project A Extension", which confirms that the owner and consultant did not have enough information about the site. It was also indicated explicitly by the contractor that the consultant did not visit the site at all.

(Table 71 of appendix 3) were accurately used to measure the size of quantity underestimation of the owner's bill of quantities (BOQ). As a result, the total project was underestimated by about 20 million SR and constituted an underestimation of about 40%. The following table clarifies the most underestimated types of work in this highway project:

Table 2 : Most underestimated work types Total Project

Type of work	Estimated budget	Actual budget	Underestimation (%)
Civil works	29173460	36653984	26%
Electrical works	8554990	14663335	71%
Storm water drainage works	11068500	12650300	14%
Irrigation works	3299920	8358667	153%
Landscape works	1367200	1834360	34%
Total project	53464070	74160646	39%

Not only was the consultant's lack of site knowledge the main reason for the project’s quantity underestimation, but also the unknown underground utilities were obviously another main reason for underestimating the underground work; this was mainly related to electrical and irrigation works which constituted the major types of works underestimation, experienced in this project as 71% and 153% respectively. Moreover, the contractor also assured that underground utilities constituted a major risk in this project, where the drawing was clear but did not match the actual existing utilities.

The following table also presents the main underestimated items in the project and how much it was underestimated:

Table 3: Main underestimated items of the Total Project

Item	**Unit**	**Contract Quantity**	**Actual Quantity**	**Underesti-mation (%)**
Subgrade cut and fill works	M3	341880	437934	28%
Existing utilities transfer	NO.	75	271	261%
Modifying existing utilities levels	NO.	15	88	487%
Base coarse fill	M3	276760	312812	13%
Binder coarse	M2	276760	302338	9%
Wearing coarse	M2	276760	290405	5%
Interlock (20*10*8 cm)	M2	78052	106546	37%
Interlock (20*10*10 cm)	M2	1000	4230	323%
RC Bumpers	NO.	4000	7400	85%
Precast vertical concrete barriers	NO.	800	1574	97%
14 m height galvanized lighting columns type A	NO.	6	23	283%
14 m height galvanized lighting columns type B	NO.	82	344	320%
lighting columns 10 m height	NO.	60	227	278%
400 watt sodium lighting bulbs	NO.	368	2883	683%
Cupper low voltage electrical cables 600/1000	LM	12500	32023	156%
Fuse boxes supply and installation type A	NO.	6	413	6783%
Fuse boxes supply and installation type B	NO.	80	181	126%
Grounding cable 16 mm Dia	LM	222	673	203%
Removing of existing lighting columns	NO.	180	273	52%
supply and installation of 400 mm FRP	LM	3150	5899	87%

supply and installation of a U.P.V.C pipes type A	LM	3191	7307	129%
supply and installation of a U.P.V.C pipes type B	LM	2325	11419	391%
supply and installation of a U.P.V.C pipes type D	LM	6250	14738	136%
supply and installation of a U.P.V.C pipes type E	LM	550	1157	110%
supply and installation of 150 mm Dia, 6 in valve	LM	20	45	125%
supply and installation of a POLYETHELENE 16 mm pipes	LM	5500	35757	550%
supply and installation of 8 liter outflowing device	NO.	5000	85882	1618%
supply and installation of 25 liter/hr Tree bubblers	NO.	80	1308	1535%
supply and installation of (Palm Trees) type A	NO.	220	507	130%

4.3.2 Project B

Project B was proposed by owner/Governmental Entity B to solve many problems in a coastal area in a city. It included developing and improving roads in that area, and finding a reasonable solution for traffic jams and safety hazards, especially in the intersection of the coastal road with a port road in that city.

The project mainly included a 4.5 km coastal road, in addition to a bridge and subway at the intersection between the coastal and the port road, which also required to construct the concrete structures, infrastructure, highway, and electrical works.

The owner is an authority that is responsible to manage and operate transport means throughout the Kingdom of Saudi Arabia. This authority is directly funded by government, where management and control of construction projects is also done by this authority's specialized departments.

Consultant B were selected, based on his design and consultancy service's lowest price, to design the project after the competitive awarding process taken its place. Consultant B had completed the design and prepared the Bill of Quantities (BOQs) and also helped in preparing the project estimate submitted to the authority's president to approve for construction.

Only contractors of the grade 1 were allowed to bid on Project B. Five contractors completed the project bidding, after 30 days of project bidding was allowed in a competitive manner.

After receiving the contractors' bids proposals, the authority analyzed the bids and awarded Project B to Contractor B for construction, taking into account his lowest price based on governmental regulations. The authority also assigned the same consultant -Consultant B- for supervision and control of the project, which is a consultant certified by the authority and considered one of the pioneers in the kingdom's consultancy services.

The importance and purpose of the project was mainly to find traffic solutions for the coastal road and port road intersection by building a bridge and subway, and developing and decreasing traffic jams by introducing a traffic light.

The project mainly included the following works:

1. Civil Works: included Earthworks and utilities, fill of subbase and base course layers under asphalt, binder and wearing asphalt courses, concrete structures and steel, and miscellaneous works including sidewalks, safety works, and storm water drainage works, which required the supply and installation of different types of pipes to maintain smooth drainage of storm water.

2. Electrical works: included the supply and installation of new lighting columns with bulbs, cables works associated with required pipes and control manholes, traffic light control underground structures, cables, and connections.
3. Traffic control devices: included road boundaries, traffic lights, traffic signs, and road paint.

However, Contractor B was not certified to construct concrete structures and steel works. Therefore, the owner withdrew this part of the work from this contractor and invited another contractor to do it.

The final contract value of Project B was about (42,403,251 SR), with a proposed duration of 18 months. Therefore, the authority had asked for sufficient staff (see appendix 4) to handle the construction of the project.

The site of the project was handed over to Contractor B in October 2012. The contractor directly started mobilization of his offices, equipment, and other required utilities. The construction of the project was started immediately after mobilization was completed.

Although Contractor B had assigned the same required staff, subcontracted some of the project items including storm water drainage and sidewalks, and were using a considerable volume of resources, the project experienced a significant delay of about 14 months, which was exceeding a three years duration instead of the proposed 18 months. Project resources volume (see appendix 4) was sufficient to meet the project volume. However, three years construction of such project is not a sufficient duration because the estimation of duration was not realistic and the project volume needs at least about 2 years to be completed. Moreover, the project also experienced many difficulties during construction that significantly delayed the project's schedule; the project was completed in September 2015.

Although the owner had a special administration team to follow up design and construction contracts that already reviewed the project design and quantities (BOQ), their review was not helpful in recognizing the quantities variations and the insufficient time given for the proposed project's duration.

On the other hand, the project faced many difficulties that delayed some critical activities, and so the actual total duration of the project exceeded the expected duration of two years. These difficulties included:

- Existing utilities and response delay from respective utilities.
- Shopkeepers' and storekeepers' complaints existed around that street.
- New installation of infrastructure utilities during construction.

During execution of the project, many risks were worrying all of the parties involved in the project, including but not limited to the following:

- The authority was worried about project delays because of initial inaccurate expectations of the project's duration.
- Contractor B was worried about project suspension and its consequences.
- Safety issues were disturbing the contractor because of some changes to traffic barrier locations.

Finally, the project payments were not delayed at any time because the authority was, and still is, using a stand-by budget to support their projects. The project bid was closed on the value of (44,856,425 SR) and completed in about thirty-six months, excluding concrete structures and steel works. However, considerable underestimation and overestimation was experienced, where deletion of many items was practiced to meet the allowed budget as shown in (Table 72 of appendix 4). Poor estimation of duration and quantities take-off by the consultant resulted in considerable cost over-run.

The table clarified how some project items were deleted or reduced to allow for the budget by showing "Project B" contract quantities, their total cost, and the actual quantities and the budget that "Project B" was closed on. All of the proposed 4.5 km coastal road was completed, but was still not fully serviced for use because many bid items were deleted to allow for the project’s available budget.

The project was underestimated by about 2.45 million SR, which constituted about 6% of the project budget, but when considering the deleted items of (2,744,474 SR) that were basically deleted to allow for the budget, the real percent exceeded 12%.

The following two tables show the main items that were underestimated in this project, and the major items that were overestimated respectively:

Table 4: Main underestimated items of Project B

Item	Unit	Contract Quantity	Actual Quantity	Underest-imation (%)
Removal of curbstone	**LM**	1880	2744	46%
Removal of existing concrete slabs and interlock	**M2**	2000	2500	25%
Removal of Newjersy concrete barriers	**LM**	2200	2875	31%
Cut and removing all of additional wastes	**M3**	100000	122693	23%
Earth Works including fills	**M3**	12000	16604	38%
Subgrade layer supply	**M3**	40000	57410	44%
Asphalt Concrete base layer 70 mm	**M2**	26000	34000	31%
Control manholes covers and Grills adjustments	**Unit**	35	42	20%
Fiberglass stream Pipe (600 mm Dia) including cut and fill	**LM**	780	1100	41%
Supply and installation of intermediate pass ways	**M2**	700	1000	43%
Cupper low voltage electrical cables	**LM**	5500	7370	34%
lighting bulb with a glass cover 250 watt	**Unit**	40	48	20%
lighting bulb with a glass cover 150 watt	**Unit**	1	3	200%
supply and installation of Galvanized pipes 50 mm	**LM**	2000	3200	60%
construction of Channels (900*900*1200) with high strength steel cover	**Unit**	5	8	60%

As shown from this table, items that were underestimated the most were the last three items that are related to electrical and underground utilities, which constitute 200%, 60%, and 60% of underestimation respectively. This result again supports the contractor's claims about incorrect utilities plans provided by the owner.

Table 5: Main overestimated items of Project B

Item	Unit	Estimated Quantity	Actual Quantity	Overesti-mation (%)
Asphalt Concrete top layer	**M2**	9600	8615	10%
Fiberglass stream Pipe (500 mm Dia)	**LM**	400	340	15%
Fiberglass stream Pipe (800 mm Dia)	**LM**	1500	1360	9%
Fiberglass stream Pipe (900 mm Dia)	**LM**	1100	999	9%
supply and installation of U.PVC pipes 3 * 150 mm as per specifications	**LM**	590	245	58%
RC foundation for electrical sub-plants	**Unit**	5	4	20%
Reflecting road signs type A	**Unit**	3501	2541	27%

However, many items were overestimated, but with a slight variation, where the above table shows the main overestimated quantities experienced in this project, which were again mainly related to underground utilities.

The following table also shows the percent underestimated based on the type of works as shown below:

Table 6: Main underestimated work types of Project B

Type of work	Estimated budget	Actual budget	Underestimation (%)
Civil works	8,708,500	10358825	19%
Electrical works	6587650	6769200	3%
Misc. Works (mainly storm water works)	20836275	22302533	7%

In conclusion, poor quality control by the consultant, together with unclear underground utilities plans, were the major reasons for project underestimation.

4.3.3 Project C

The project of Medium Voltage Supply for Warehouses Area in a camp was urgent, needed to operate the newly constructed warehouses and buildings in that camp, which was operated by the owner/Governmental Entity C in a city of the Eastern Province in Saudi Arabia. The main purpose for Project C was to supply these buildings with electricity and the required electrical machines and accessories required for operation.

Governmental Entity C is a privatized authority responsible for managing and operating a specified mean of transport throughout the Kingdom of Saudi Arabia. This Authority is still controlled and funded by the government, where contracts and official regulations related to construction always follow the general regulations related to governmental projects. However, management and control of construction projects is always done by this authority.

Similarly, the same procedure for a project's acceptance followed in governmental municipalities was followed to obtain the required approval for the authority's proposed projects.

After the approval of the project was given, the authority began looking for a consultant to finalize the project design, to define the scope, and finally to prepare the Bill of Quantities of this project. At first, an invitation was sent to consultants for that purpose, where the winner (Consultant C) was again selected based on the price and qualifications.

After that, Consultant C studied the project and prepared the Bill of Quantities (BOQs) based on the provided requirements. Consequently, the owner estimated the budget of that project based on the prepared design and BOQ.

Usually, the Projects Construction Department (PCD) takes over the following processes. This department awarded Project C, designated as "Medium Voltage Supply for Warehouses Area in a Camp" to Contractor C for electrical works construction and Consultant C1 for supervision and control of the total project.

As with other governmental entities, Project C were advertised in the official newspapers as well as on the authority's website. The bidding stage was only one month, and only four contractors applied for the project in a competitive manner. Contractor C was selected based on the lowest price and qualifications, these being the major parameters for selection.

Unlike other governmental entities, the authority has a certified list of consultants for its construction projects. Three consultants were invited to apply for the supervision and control of this project, and Consultant C1 was also selected, based on the lowest price.

The project was composed of five new buildings, which needed to be supplied with electricity, and an old building that needed to be developed, as shown below:

1. Administration Building: including supply and installation of electricity plant, pipes, cables, and required connections.
2. IT Building: including supply and installation of electricity plant, pipes, cables, electrical devices and units, and required connections.
3. Marine Administration Building: same as the IT Building.
4. Marine Pilots leisure Building: same as the IT Building.
5. Marine Air Defense Building: same as the IT Building.
6. Energy Plant Building: same as the IT Building and installation of firefighting systems.

The final contract value of Project C was (16,714,000 SR) with a proposed duration of 730 days. Moreover, Governmental Entity C had asked for sufficient staff (see appendix 5) to handle the construction of the project.

The site of the project was handed over to Contractor C on 30/05/2014. Then, the construction of the project has immediately started after mobilization has been completed.

The resources used (see appendix 5) in this project were relatively few compared to the volume of the project. This small volume of resources was a major reason for the project schedule delay during the execution of the project.

During execution, the authority found that part of the project budget would be needed to cover civil works that were not completed in these buildings. Therefore, the entity started squeezing the project bid quantities to satisfy the new budget.

Contractor C had contracted with two electrical subcontractors to complete some distinct electrical works. Moreover, the required staff was assigned and there was no delay in payments, which the contractor was using to fund his construction works during execution.

The project bid was closed on the value of (6,902,650 SR) instead of proposed bid value of (16,714,000 SR) which resulted from owner project squeeze and scope reduction. This was considered as a project cost overestimation by Contractor C.

However, the project was completed in 19.5 months, which may seem that the contractor was ahead of schedule, but he was behind schedule in all stages of construction when taking also into account that only 60% of the project was completed. This delay was due to the small volume of resources (see appendix 5) the contractor used in the project as a result of the owner project squeeze.

For the first time looking to (Table 73 of appendix 5) you will understand that the actual contract value is (6,902,650 SR) and the estimated is (16,714,000 SR) where the project has been overestimated by about 10 million. However, this is not true because the project budget was squeezed and many items of works were deleted to cover the remaining critical civil works in order to open the ground to start electrical works.

Only two items (2.7 and 4.1) were totally underestimated, as shown in the table below:

Table 7: Main underestimated items of Project C

Item	Unit	Estimated Quantity	Actual Quantity	Underestimation (%)
single core cable of 1*360 mm2 (XPLE/PVC) cable	LM	1300	1700	31%
10 KV 3*300 mm2 (XPLE) cable	LM	750	777	3.6%

In addition, many items (23 items) were totally deleted which constitute about (3,876,800 SR) as shown in (Table 74 of appendix 5). Moreover, the rest of the items were squeezed, based on their importance, which cannot be considered as a quantity overestimation because the project was squeezed and would have been underestimated if the project was totally completed. These items constitute about (5,934,550 SR) of the total project budget squeeze. The total project budget was squeezed by about (9,811,350 SR) which included (3,876,800 SR) for deleted items and (5,934,550 SR) for items squeeze.

In conclusion, the project budget was squeezed due to the remaining civil works, and the project quantities was squeezed by about 59% of the total cost. Therefore, it becomes clear that Consultant C did not have enough information about the project and even did not visit the site at all before studying the project, as indicated by the contractor.

4.3.4 Project D

During the operation of an industrial city in the Eastern Province of Saudi Arabia, Governmental Entity D was concerned about the utilities and services available to owners of industrial factories at that city. In fact, the owners of those industrial factories were complaining to the entity about many services, including roads development, weak lighting and the electrical services available, storm water drainage and many other issues. The entity was also planning to improve traffic and the aesthetics of this industrial city.

Governmental Entity D is a privatized authority responsible for managing and operating the industrial cities throughout the Kingdom of Saudi Arabia. This Authority is still controlled and funded by the government, in which contracts and official issues related to construction always follows the general regulations related to governmental projects. However, the management and control of construction projects is always done by this authority.

After acceptance of the project proposal was completed, Governmental Entity D passed the project design and contracting processes to the responsible departments that had advertised the project for design, in which a consultant was required to design the project, to define the final scope, and finally to prepare the Bill of Quantities of this project. "Consultant D1" was selected to design the project after the competitive awarding process had taken place.

The authority then selected "Contractor D" of the grade 1- only the grade 1 contractors were allowed to bid the project- to be accountable for the total construction of this project. The contractor's lowest price was again the main factor for awarding the project construction, as required by the government regulations.

The main purpose of the project was to develop the existing poor roads while introducing many new roads, and to fulfill the electrical and drainage needs of industrial factories in the city.

The project is composed of about 78 minor streets of an average length of (300-400 m) distributed throughout the industrial city. Moreover, the project included infrastructure development, traffic development, and development and organizing existing city blocks.

The project scope included the following main four work disciplines:

1. Civil works: includes excavation and fill of sub-base and base course layers under asphalt, binder and wearing asphalt courses, sidewalks, safety works, and road painting and markings.
2. Electrical works: includes supply and installation of new lighting columns with bulbs, cables works associated with required pipes and control manholes, transformers, and distribution units.
3. Storm water drainage works: required supply and installation of different types of pipes to maintain smooth drainage of storm water.
4. Landscaping works: supply and installation of different types of pipes to convey the irrigation water for site landscaping.

After receiving bids, the authority awarded the project to "Contractor D" for a value of (60,478,265 SR), with a proposed duration of 24 months. The entity had asked for a specified staff (see appendix 6) to handle the construction of the project.

The site of the project was handed over to "Contractor D" on December 2011. The contractor then started mobilization of his offices, equipment, and other required utilities after one year. The construction of the project has immediately started after mobilization has been completed.

In order to be able to complete the project on time, Contractor D assigned the same required staff, subcontracted storm water drainage, and used a considerable volume of resources. The resources volume (see appendix 6) was sufficient to meet the project schedule but many issues were obstructing the project works, including traffic permits issued by the authority, nonconforming underground structures plans, complaints of existing factory owners near the affected streets, traffic jams which developed in such a hectic climate, along with city works. These and many other existing issues were the main reasons for the project delay of about 10 months.

After a direct interview with the contractor, the project manager indicated that in most cases, when a project value was underestimated, the owner changed the station to a shorter one to cover budget issues. In case the project was important and had to be completed fully, the owner asked for an extra budget which meant time spent waiting for funding, and hence a project delay, and sometimes cancelling other projects altogether to be able to fund and complete the current working project. In case the project was not important, and only minor items (usually including curbstone works, interlock works, painting works, traffic lights, and electrical lighting works) had been left, they would close the project on the same budget, and then the owner would allow the public to use it temporarily (which is hazardous and violates safety requirements), until the owner brought his maintenance contractors to complete these items.

The project bid was closed on the value of (67,264,059 SR) and was completed in about thirty four months. However, considerable underestimation, overestimation, and items deletion was practiced to meet the allowed budget. (Table 75 of appendix 6) shows how some project items were reduced to allow for the budget.

The table also shows "Project D" contract quantities, their total cost, and the actual quantities and budget that "Project B" was closed on. All of the proposed 78 minor streets were completed but again still not fully serviced for use, because many bid items were deleted to allow for the project's available budget.

About 12 items were totally deleted, including seven electrical items (2.1.2, 2.1.3, 2.1.5, 2.18, 2.1.10, 2.1.12, and 2.1.14) and five landscaping works including (3.3, 3.7.1, 3.7.4, 3.7.5, and 3.10), which demonstrates that streets were opened for use without completing minor items related to landscaping works, in addition to some major items related to electrical and lighting works.

The project was underestimated by about 6.8 million SR, which constitutes about 11% of the project. The following table below shows the most underestimated items in the project:

Table 8: Main underestimated items of Project D

Item		Unit	Contract Quantity	Actual Quantity	Underestim-ation (%)
1.1.1	**Backfilling works**	**M2**	126500	146305	16%
1.1.2	**Asphalt Concrete base layer 70 mm**	**M2**	500500	550321	10%
1.1.3	**Asphalt Concrete top layer 50 mm**	**M2**	598500	687978	15%
2.1.4	**Low voltage 13.8 KVA Insulated Cable (X450) mm2**	**LM**	24250	42000	73%
2.1.13	**supply and installation of concrete manholes 1000*600*600 mm**	**No.**	124	184	48%
3.5.5	**POLYETHELENE pipes 1.5 in (50 mm) pipes**	**LM**	136105	186102	37%
3.12.1	**supply and installation of 3 in automatic control electrical valves**	**No.**	200	295	48%
3.13.3	**supply and installation of valves decoder**	**No.**	270	368	36%

As shown from this table, the most underestimated items are the last five items that are related to electrical and underground utilities, which constitute 73%, 48%, 37%, 48%, and 36% of the underestimation respectively. On the other hand, the project has many overestimated items with slight variations; the following table shows the most overestimated items in the project as shown below:

Table 9: Main overestimated items of Project D

Item		Unit	Estimated Quantity	Actual Quantity	Overestimation (%)
2.1.11	**supply and installation of a U.P.V.C pipes 150 mm Dia ,**	**LM**	2500	2344	6%
3.1	**removing up to (20-25 cm) of the existing soil**	**M2**	220000	206000	6%
3.2	**supply and installation of vaginatum Paspalum grass**	**M2**	3500	3122	11%

Obviously, the project quantities experienced both underestimation and overestimation; this could be a result of forecasting errors due to lack of data about the project's design and the proposed underground works. The following table also shows the percent underestimated based on the type of works:

Table 10: Main underestimated work types of Project D

Type of work	Estimated budget	Actual budget	Underestimation (%)
Civil works	32,096,000	34979832	9%
Electrical works	7439200	10488460	41%
Irrigation	20943065	21795767	4%

Electrical works are the most underestimated types of works, which is related to underground structures. This is also further evidence that underground structures are always underestimated due to a lack of clear drawings.

4.3.5 Project E

During the operation of a railway linking two cities, the owner/Governmental Entity E was worried about the low speed of the train linking these cities together. Furthermore, the operation of the train was causing too much traffic for cars that crossed gated intersections with this railway. Therefore, Governmental Entity E planned to solve this issue by constructing seven new bridges along the railway.

Governmental Entity E is a privatized authority responsible for managing and operating the industrial cities throughout the Kingdom of Saudi Arabia. This Authority is still controlled and funded by the government, in which contracts and official issues related to construction always follows the general regulations related to governmental projects. However, the management and control of construction projects is always done by this authority.

Consultant E was selected, based on his lowest price, to design the project after the competitive awarding process had taken place. After Consultant E had completed the design of the project, defined the scope and prepared the Bill of Quantities (BOQs), the authority prepared the estimated budget of that project, which was then submitted to the authority president for approval to starting bidding and construction.

The project was composed of seven bridges along the railway, and the estimated budget for the project was about (147,000,000 SR).

The owner sent invitations for three contractors to bid for this project. The bidding stage was only one month, and only three contractors of the grade 1 applied for the project in a competitive manner.

After receiving bids, the authority divided the total project into three equal parts, where each contractor was awarded a volume of work equal to about (47,000,000 SR) in order to maintain the lowest cost of the total project. Contractor E was awarded the first part, which consisted of three bridges at the following three railway stations: (285,310,520) with the name of "Construction of Bridges 285, 310, 520 along X city-Y city railway", while the next four bridges were awarded to the second and third contractors equally. However, "Project E" only represents the first part of the bid that was awarded for Contractor E.

The project manager of Contractor E indicated -in a direct interview with him- that the company had studied Project E's design again to check whether the bridge designs was safe, as is always required by the owner. The contracting company found that one bridge design was not safe, and hence, the construction was delayed about six months to allow for the design change of that bridge.

Similarly, the owner awarded Consultant E1 the project supervision and consultancy following the same procedure and bidding process. However, Consultant E1 was awarded the project supervision after one year of signing the bid with Contractor E, in which the construction was suspended another six more months after the design of the bridge had been completed by Contractor E and approved for the construction by the authority. The owner was waiting for an invited consultancy office for six months to supervise and control the construction of this project.

The importance and purpose of the project was primarily to find traffic solutions for cars and to enhance the speed of the train. The project was mainly composed of three bridges, where each bridge have the following scope of work, as shown below:

Bridges (285 and 310): included earth works, concrete works, precast works, expansion joints, bearing devices works, insulation layers works, base layers and sub- base layers work, asphalt layers work, sidewalks, safety works, and road signs and painting.

Bridge (520): includes the same types of works. However, it was delayed and excluded from the bid because of site conditions, which will be substituted after for the contractor in a new location by introducing another new bid.

The final contract value of Project E was (47,000,000 SR), with a proposed duration of six months. However, the authority had asked for a specified staff (see appendix 7) to handle the construction of the project.

The site of the project was handed over to Contractor E on 14/07/2013. But the contractor started mobilization of his offices, equipment, and other required utilities about one year later. The construction of the project has immediately started after mobilization has been completed in July 2014.

Contractor E assigned the same required staff, subcontracted some of the project items, including concrete works, and used a considerable volume of resources (see appendix 7). The volume of resources was sufficient to meet the project schedule but materials delivery was always behind schedule, which in turn caused significant delays during construction of the project. The project was completed on 25/01/2015 with an approximate delay of about two years.

During execution, the owner found that the third bridge at 520 railway station would not be able to be constructed and therefore the bridge was suspended. There, an existing building and existing communication lines was obstructive. However, Contractor E will after be substituted by offering him a new bid for the third bridge in another location.

The project bid, for only two bridges, was closed on the value of (30,834,030 SR) and completed in about thirty months. However, considerable underestimation, overestimation, and items deletion was practiced to meet the allowed budget. (Table 76 of appendix 7) clarifies how some project items were reduced to allow for the budget.

For the bridge at railway station 285, there was a considerable overestimation in many items that almost exceeded 40%, as shown in the table below:

Table 11: Main overestimated items at railway station 285 of Project E

Item		Unit	Estimated Quantity	Actual Quantity	Overestimation (%)
1.1	Excavation for foundations	M3	10,000	1,858	81%
4.1	Expansion joint with 20 mm	LM	115	68	41%
7.1	Execute sub base coarse thickness 20 cm	M2	27,000	14,015	48%
7.2	Execute base coarse with thickness 20 cm	M3	27,001	14,181	47%
8.1	prime coat to base course	M2	25,000	14,181	43%
8.2	Asphalt Concrete base (Binder) layer 70 mm	M2	24,000	10,191	58%
8.3	Tack coat to binder course	M2	24,000	10,191	58%
8.4	Asphalt Concrete top wearing layer 50 mm	M2	28,000	15,597	44%
11.1	road marking	LM	8,800	5,718	35%
12.1	eye cat	UNIT	40	20	50%

The main items that were overestimated represents excavation, base layers fill, and asphalt concrete layers. The same applies for the second bridge at railway station 310 as shown in the table below:

Table 12: Main overestimated items at railway station 310 of Project E

Item		Unit	Estimated Quantity	Actual Quantity	Overestimation (%)
1.1	Earth Works including excavation for foundations	M3	11,500	2,014	82%
2.1	plain concrete below footing	M3	140	44	69%
2.6	reinforced concrete for Piles of Abutment	M3	925	790	15%
4.1	Expansion joint with 20mm	LM	115	78	32%
7.1	Execute sub base coarse thickness 20 cm	M2	22,000	18,805	15%
7.2	Execute base coarse thickness 20 cm	M3	26,000	19,858	24%
8.1	prime coat to base course	M2	26,000	19,858	24%
8.2	Asphalt Concrete base (Binder) layer 70 mm as per specifications	M2	20,000	14,755	26%
8.3	Tack coat to binder course	M2	20,000	14,755	26%
8.4	Asphalt Concrete top layer (wearing coarse) 50 mm as per specifications	M2	27,000	21,782	19%
11.1	road marking	LM	7,700	6,993	9%
12.1	eye cat	UNIT	40	19	53%

However, most of the overestimated items in this bridges experienced approximately 20% overestimation, excluding items (1.1, 2.1, and 12.1)-which exceeded 50% overestimation, which represents foundation excavation, plain concrete, and cats' eye installation respectively.

Again, the main items that were overestimated represent excavation, base layer fill, plain concrete below footing, and asphalt concrete layers.

On the other hand, considerable underestimation was practiced in many items for both bridges 285 and 310 railway stations, as shown in the following tables respectively:

Table 13 Main underestimated items at railway station 285 of Project E

Item		Unit	Estimated Quantity	Actual Quantity	Underestimation (%)
1.2	Backfilling works, min 300mm thick	M3	135,000	154,348	14%
2.1	plain concrete below footing	M3	225	289	28%
2.4	reinforced concrete for abutment	M3	450	579	29%
12.2	road signs	UNIT	875	1,344	54%
13.1	fix bridge guard rail	LM	170	260	53%

Table 14: Main overestimated items at railway station 310 of Project E

Item		Unit	Estimated Quantity	Actual Quantity	Underestimation (%)
1.2	Backfilling works, min 300mm thick	M3	165,000	220,717	34%
2.2	plain concrete below approach SOG	M2	430	508	18%
2.3	reinforced concrete for footing	M3	380	650	71%
2.4	reinforced concrete for abutment	M3	450	741	65%
2.5	reinforced concrete for approach SOG	M3	125	149	19%
6.1	Polyethylene sheet below slab	M2	700	955	36%
6.2	Water proofing membrane horizontally under foundation	M2	350	401	15%
6.3	Water proofing membrane vertically for walls	M2	1,000	1,220	22%
9.1	base for new jersey barrier	LM	1,800	2,178	21%
9.2	new jersey barrier	LM	1,800	2,178	21%
12.2	road signs	UNIT	1,005	1,656	65%
13.1	fix bridge guard rail	LM	170	265	56%

As shown, the most underestimated items were road signs, fixed bridge guard rails, and reinforced concrete for abutments that exceeded 50% in both bridges, excluding reinforced concrete for abutment in bridge 285, which experienced only 29% underestimation.

These types of underestimated and overestimated items confirm that incomplete data and design requirements were primary reasons for some forecasting errors during estimation, and difficulty of prediction is responsible for forecasting errors, especially in excavation and backfilling items.

Moreover, the item of "curbstone (91.5*15*30 cm)" was deleted from bridge 285, which constituted a budget of about (327,320 SR), and about (374,080 SR) from bridge 310 to allow for enough budget.

For the first look, you will understand that the project was underestimated by only about (1 Million SR), or 3.3% underestimation. However, deleted items and squeezed items constitute (701,400 SR) and (2,370,336 SR) respectively, where they substantially relieved the lack of the allocated project budget. These alone add on an extra 11.5%.

4.4 Case Studies Summary and Conclusion

The above five case studies are highway projects that were constructed in the Eastern Province of Saudi Arabia. Highway the grade 1 contractors completed these projects recently. Different five governmental entities of these projects awarded their projects based on the lowest price and the grade 1 qualification. They also awarded these project's designs to five different consultants, who are different from the assigned supervision and control consultants, except for Project B that were assigned the same consultant for both design and supervision.

The following table summarizes the types of parties that were involved in the projects discussed:

Table 15: Summary of parties involved in projects as shown in case studies

Project	Type of owner	Contractor Qualification	Designer	Supervision Consultant
A	Public Agency	1	A	A1
B	Public Agency	1	B	B
C	Privatized Governmental Entity	1	C	C1
D	Privatized Governmental Entity	1	D	D1
E	Privatized Governmental Entity	1	E	E1

The following table also shows these projects 'main scope and provides a brief description:

Table 16: Main scope and s a brief description of case studies projects

Project	Purpose	Scope	Brief Description
A	Eliminate congestion	Civil, Electrical, Storm water, and Landscaping	Development of entrance area to a city
B	Eliminate congestion and intersection safety hazards	Civil, Electrical, and traffic control devices	Introduce 4.5 Km road and intersections
C	Provide electrical supply	Totally Electrical	5 building electrical supply in a camp
D	Utilities development	Civil, Electrical, Storm water, and Landscaping	Roads and Infrastructure development of industrial city
E	Eliminate train low speed	Totally Civil	Introducing two bridges

These projects experienced much underestimation and overestimation in many items.

However, the projects in total were underestimated as shown below in the table:

Table 17: Total underestimation experienced in case studies

Project	Contract Value (SR)	Final Value (SR)	Difference (SR)	Deleted items (SR)	Squeezed Items (SR)	Underestimation	
						(SR)	%
A	53,464,070	74,160,646	20,696,576	0	0	20,696,576	38.71
B	42,403,251	44,856,425	2,453,174	2,744,474	0	5,197,648	12.26
C	16,714,000	6,902,650	-9,811,350	3,876,800	5,934,550	0	0.00
D	60,478,265	67,264,059	6,785,794	0	0	6,785,794	11.22
E	29,845,088	30,834,030	988,942	701,400	2,370,336	4,060,678	13.61

This chapter concludes that in many cases there was more than 30% cost overrun in some projects, whereas in most cases the projects experienced more that 10% underestimation (cost overrun). Moreover, the three main reasons for quantities variations experienced in these case studies were:

- Estimation errors due to lack of data
- Unknown site requirements by consultants due to no visits conducted for their project's sites in many cases.
- Most importantly the unclear underground utilities plans and drawings

Where the most important consequences of quantities underestimation concluded from this study were:

- Increased project cost
- Deletion of some project items or scope reduction
- Project delay due to lack of fund
- Failure in completing the project

CHAPTER FIVE: RESULTS, ANALYSIS

5.1 Introduction

This chapter presents the analysis procedure and results of the data collected through the questionnaire survey, including characteristics of contractors and consultants, their procedures for estimation, the main reasons for quantities variation, and finally the consequences of quantities variations in unit price contracts for highway governmental projects in Saudi Arabia.

5.2 Procedure for questionnaire data collection

Two sets of the questionnaire were sent to two groups of respondents: highway contractors of grades 1, 2, and 3 and certified consultants located in the Eastern Province of Saudi Arabia. The number of distributed questionnaires were 32, and 30 for specified grades highway contractors and certified consultants in the eastern region respectively. Taking into account the reliability of data, only completed questionnaires were considered in the analysis. Accordingly, 28 highway contractor, and 21 certified consultant-filled questionnaires were used in the final analysis; 87.5% of contractor and 70% of consultant responses were valid, as shown in the following table:

Table 18: Questionnaires sent, returned, and valid returned

Number of Questionnaires	Contractors' questionnaires	Consultants' questionnaires
Sent	32	30
Returned	29	26
Percentage of returned	91%	87%
Valid returned	28	21
Percentage of valid returned	87.5%	70%

5.3 Characteristics of Participants

The prepared questionnaires were grouped into two different groups, comprising highway contractors and certified consultants located in the Eastern Province of Saudi Arabia. This section presents the main characteristics of both contractors and consultants who participated in the study.

5.3.1 Characteristics of highway contractors

This section presents the main characteristics of the contractors who participated in the study including: their classification and types of projects, organization experience in the construction industry, number of employees, volume of annual revenues, and percent of common type of contracts they execute.

- **Contractors classification**

The table below shows that most contractors were classified with grade 1 in highways and infrastructures: where 46% of highway contractors are grade 1, only 25% of highway contractors are grade 2, and 29% of highway contractors are grade 3. The results show also that most contractors are certified at a level of grade 1 in infrastructure.

Table 19: Types of projects that contractors were qualified in

Type of projects	% of Grade 1	% of Grade 2	% of Grade 3
Highway	46%	25%	29%
Infrastructure	64%	21%	7%
Buildings	32%	7%	32%

This enhanced the accuracy of the results of the study because of the extensive experience of those participants.

Since infrastructure works are considered complementary works for highway projects, then it is intuitive to understand that all grade 1 highway contractors have the same grade for infrastructure projects and that is what is found on the results of this study. Therefore, when referring to grade 1 highway in the next parts, then it is also referring to grade 1 infrastructure.

- **Organization experience in construction industry**

The results showed that 57% of organizations were in business for more than 20 years, with this experience distributed among highway of grade 1 contractors, highway of grade 2 contractors, and highway of grade 3 contractors as 28%, 18%, and 11% respectively. Around 32% of the contractors were in business between 15 and 20 years. Only 11% highway contractors of grade 3 had been in business fewer than 15 years.

Table 20: Organization experience in construction industry

Organization experience in construction industry	Highway Grade 1	Highway Grade 2	Highway Grade 3	All contractors
10 to Less than 15	0	0	11%	11%
15 to Less than 20	18%	7%	7%	32%
More than 20	28%	18%	11%	57%

About 60% of grade 1 highway contractors, about two-thirds of grade 2 highway contractors, and about one-third of grade 3 had been in business for more than 20 years**.**

- **Number of employees**

It was found that most contractors had more than 1200 employees, which demonstrates their high capability for performing such huge highways projects. The results indicated that 18% of highway contractors employed more than 900 employees but fewer than 1200, 25% employed 300 to fewer than 600, and only 11% employed fewer than 300.

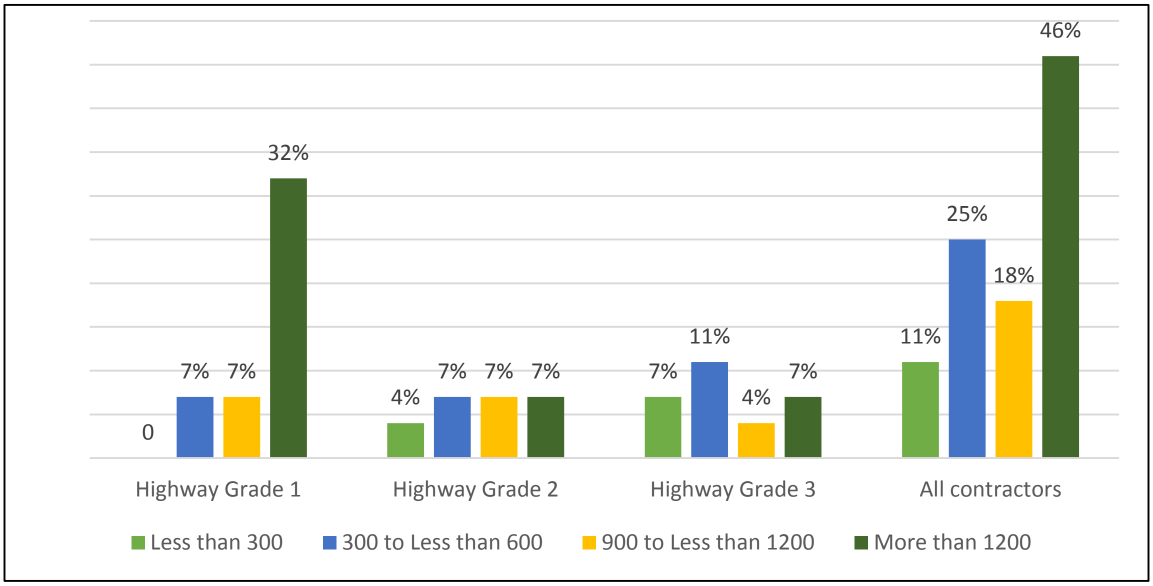

Figure 1: Contracting organization number of employees

The results also indicated that more than two-thirds of highway grade 1 contractors, more than one-quarter of highway grade 2 contractors, and one-quarter of highway grade 3 contractors employed more than 1200 employees, which in turn tells that most contractors have a good foundation of human resources and employees who are helping to manage their projects proficiently.

- **Annual revenues**

The results presented in the table below indicated that 21% of contractors had annual revenues of (300 to 400 million Saudi Riyal), and all of them were grade 1 highway contractors.

Table 21: Organization annual revenues (Million SR)

Annual revenues (Million SR)	Highway Grade 1	Highway Grade 2	Highway Grade 3	All contractors
Less than 100	11%	0	18%	29%
100 to Less than 200	7%	11%	11%	29%
200 to Less than 300	3%	0	0	3%
300 to Less than 400	21%	0	0	21%
More than 400	4%	4%	0	8%
Unknown	0	11%	0	11%

Another 8% of grades1 and 2 highway contractors had more than 400 Million Saudi Riyal. 11% of grade 2 contractors refused to answer this. The remaining contractors, representing 60%, had different annual revenues.

- **Types of executed contracts**

Most contractors said that more than 50% of their contracts were unit price contracts. 64% of contractors entered into unit price contracts more than 50% of the time, and are distributed among highway contractors of the different grades, as shown in the table below:

Table 22: Type of contracts entered by contractors

Type of contracts	Highway Grade 1	Highway Grade 2	Highway Grade 3	All contractors
More than 50% projects executed were Lump Sum	18%	4%	14%	36%
More than 50% projects executed were Unit Price	28%	21%	15%	64%

As shown above, about two-thirds grade 1 highway contractors entered unit price contracts more than lump sum contracts, whereas about 85% of grade 2 highway contractors entered into unit price projects more than lump sum contracts, and only about half of grade 3 contractors were doing so, which in turn demonstrates high skills in bidding, more inclination for risk sharing, and the common usage of these contracts in such construction projects.

- **Respondent's characteristics, Contractors**

This section covers the main characteristics of highway contractors' respondents, including their level of education, job title, experience with current employer, and total experience in the construction industry in Saudi Arabia.

- **Education level**

The results indicated that 74% of respondents were civil engineers, 7% were mechanical engineers, 15% were electrical engineers, and only 4% held an accounting degree. This volume of engineers enhanced the accuracy of the study, especially because the study focused on highway projects that requires engineering knowledge and skills.

Table 23: Education level and positions of contractors' respondents

Bachelor in	Highway Grade 1	Highway Grade 2	Highway Grade 3	All contractors
Civil Engineering	35%	17%	22%	74%
Mechanical Engineering	7%	0	0	7%
Electrical Engineering	4%	4%	7%	15%
Accounting	0	4%	0	4%

The results also shows that about half of civil engineers were representing grade 1 highway contractors. About three-quarters of grades 1, two-thirds of highway contractors, and two-thirds of grade 3 highway contractors were civil engineers, which enriched the study since most highway projects represent mainly civil works.

- **Job title**

Most respondents belonged to project management departments in their companies. As shown above, 46% of respondents were titled as a project managers, 15% were technical managers, 8% were CEOs, and 46% held different titles. It can be concluded that about 80% of respondents were following up on project sites, and were kept up-to-date during construction, which in turns helped in developing the results of the study accurately.

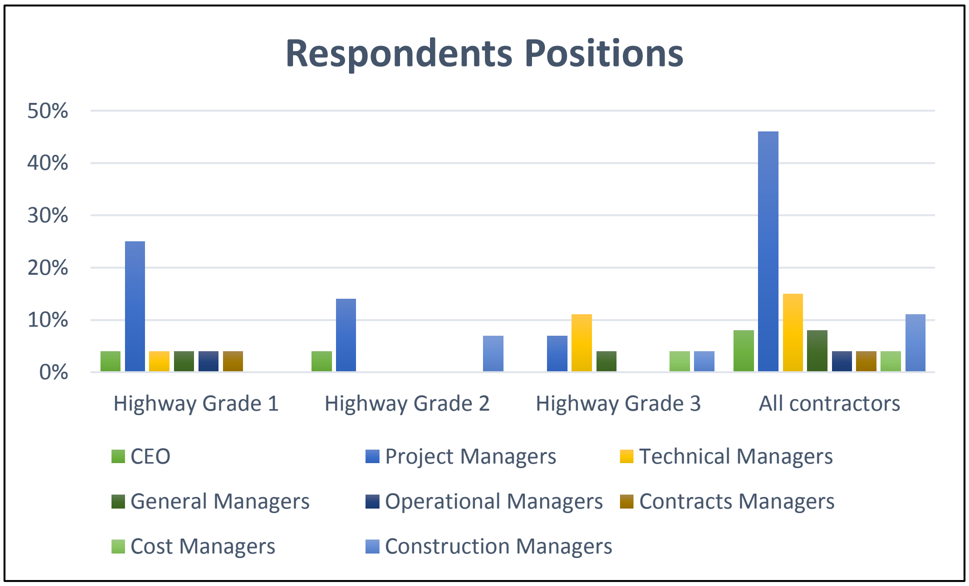

Figure 2: Contractors' respondents' positions in their organizations

The results also shows that more than 60% of grade 1 highway contractors, and 56% of grade 2 highway contractors were project managers; these are typically the most involved management personnel in projects everywhere.

- **Experience**

The results indicated that the level of total experience of the participants was significantly different compared to their experience with their current employer. The results indicated that 51% of respondents had more than 15 years of experience in the construction industry and, interestingly, indicated that 28% of respondents had experience of 10 to 15 years.

Table 24: Total experience and current employer experience of contractors' respondents in (years)

Experience (years)	**Highway Grade 1**	**Highway Grade 2**	**Highway Grade 3**	**All contractors**
Less than 5	7%	0	0	7%
5 to less than 10	4%	0	10%	14%
10 to less than 15	17%	7%	4%	28%
15 to less than 20	11%	7%	4%	22%
More than 20	7%	11%	11%	29%
Experience (years) in the current employer				
Less than 5	25%	0	7%	32%
5 to less than 10	7%	0	10%	17%
10 to less than 15	0	10%	4%	140%
15 to less than 20	7%	4%	4%	15%
More than 20	7%	11%	4%	22%

More than three-quarters of grade 1 highway contractors had more than 10 years of experience in the construction industry in Saudi Arabia, the same percent of grade 2 highway contractors had more than 10 years of experience. However, it is exciting to notice that also two-thirds of grade 3 highway contractors had more than 10 years of experience.

On the other hand, it is interesting to note that more than half of the grade 1 highway contractors were employed for less than five years in their current organization, and 32% of highway contractors were also employed for the last five years in their current companies.

5.3.2 Characteristics of certified consultants

This section presents the main characteristics of the certified consultants who participated in the study including: their number of employees, volume of annual revenues, types of projects they were certified to provide consultancy services for, the organization's major clients, and the percent of contracts executed.

- **Number of employees**

It was found that most consultants (57%) had fewer than 50 employees, which demonstrates their small volume of works and the low requirements for large project execution.

Table 25: Consultancy company number of employees and annual revenues

Organization number of employees	**All Certified Consultants**
Less than 50	57%
50 to Less than 100	5%
100 to Less than 150	14%
150 to Less than 200	14%
More than 200	10%
Annual revenues (Million SR)	
Less than 15	62%
15 to Less than 30	5%
30 to Less than 45	14%
45 to Less than 60	5%
More than 60	14%

The results indicated interestingly that 5% of consultants have employed 50 to less than 100 employers, and only about 10% have employed more than 200 employees.

- **Annual revenues**

The results presented in the table above indicated that about 62% of consultants had annual revenues less than (15 million Saudi Riyal). Only 5% of consultants had annual revenues of 15 to less than 30 million Saudi Riyal. It is exciting to know that only 14% of consultants had annual revenues over than 60 million Saudi Riyal. It is interesting to realize that all of those consultants employed more than 150 employees.

- **Types of projects certified to provide consultancy services for**

The results indicated that all consultants were certified to provide consultancy services for building projects, whereas only 43% and 24% of them were certified to provide consultancy services for infrastructure and highway projects respectively.

Table 26: Type of Projects certified to provide consultancy for

Type of Projects certified to provide consultancy for	All Consultants
Highways	24%
Infrastructure	43%
Buildings	100%

It is interesting to know that all consultants that were certified to provide consultancy services for infrastructure projects were also certified to provide consultancy services for highway projects.

- **Type of clients were dealt with**

Most consultant said that more than 50% of their clients were private. 62% of consultants dealt with private clients more than governmental clients, as shown in the table below:

Table 27: Type of clients that certified consultants dealt with

Type of clients	All Consultants
More than 50% clients were Private	62%
More than 50% clients were Governmental	38%
Totally Private	24%
Totally Governmental	24%

The results also indicated that 24% were only dealing with private clients, while the same percent was also only dealing with governmental clients. It is interesting to note that most consultants that were only dealing with government clients had annual revenues of more than 45 Million Saudi Riyal and had more than 150 employees, which in turn demonstrates their high capabilities in such governmental construction projects.

- **Respondent's characteristics, consultants**

This section covers the main characteristics of the certified consultants' respondents including their level of education, job title, experience with current employer, and total experience in the construction industry in Saudi Arabia.

  - **Education level**

The results indicated that 81% of respondents held a Bachelor degree in engineering, 9.5 % held a Bachelor and master degrees in engineering, and also 9.5 % held a Bachelor, master and PhD degrees in engineering. This volume of engineers enhanced the accuracy of the study, especially because the study focused on highway projects that required engineering knowledge and skills, and in addition, those with a master and PhD enriched the study because of their sufficient knowledge and education.

Table 28: Education level and education discipline of consultancy company respondents

Degree	All Consultants
Only Bachelor	81%
Only Master	9.5%
PhD	9.5%
Bachelor in	
Architectural Engineering	67%
Civil Engineering	33%

The results also showed that two-thirds of respondents were architectural engineers. Also, the last third had civil engineering degrees, which enriches the study since most of the highway projects represents civil works.

- **Job title**

Most respondents belonged to project management departments in their companies. About 53% of respondents were project managers following project sites, or were kept updated of the project's progress; 9% of respondents were operational and construction managers who had strong backgrounds in project design and management, and the last 38% had different positions related mainly to the design and estimation of projects.

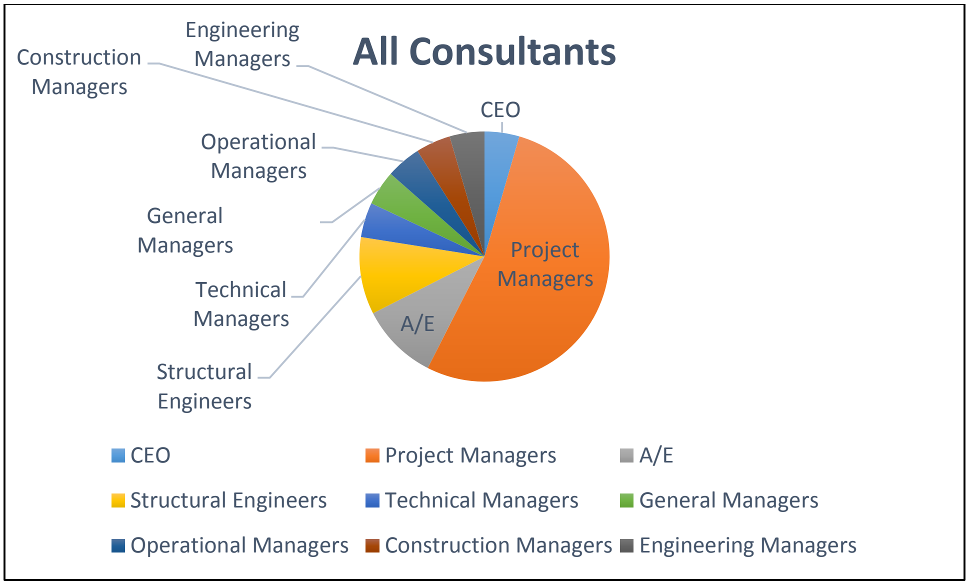

Figure 3: Consultants' respondents' positions in their organizations

As shown above, it can be concluded that all respondents had a strong foundation of knowledge and experience in construction, project design, and project management within the construction industry in Saudi Arabia.

- **Experience**

The results indicated that the level of total experience of participants was significantly different compared to their experience with their current employer. The results indicated that 57% of respondents had more than 10 years of experience in the construction industry, and interestingly indicated also that 29% of respondents had experience of between 5 to 10 years.

Table 29: Total and current employer experience in (years) of consultancy company respondent

Total Experience (years)	All Consultants
Less than 5	14%
5 to less than 10	29%
10 to less than 15	29%
15 to less than 20	9%
More than 20	19%
Experience (years) with current employer	
Less than 5	52%
5 to less than 10	24%
10 to less than 15	10%
15 to less than 20	0
More than 20	14%

It is interesting to know that more than 52% of consultants had less than five years of experience with the current employer, and 24% had five to less than ten years of experience with the current employer. However, it is exciting to note that only 14% of respondents had more than 20 years of experience within their current employers.

5.4 Unit cost estimation

This section presents the main procedures and practices followed by contractors when preparing the unit cost of items during the bidding stage. It determines the percentage of contractors that recalculate the estimated quantities provided by the owner, and those who do not review these quantities. Those contractors who reviewed and recalculated the quantities provided were tested for their objective of quantities recalculation, the percentage of highway projects with quantities that are different from their recalculated quantities, their reaction when they realized a quantities overestimation or quantities overestimation had occurred, whether they approved their quantities or owner quantities for cost estimation, and the procedure their companies followed to prepare the unit cost for each item in the Bill of Quantities (BOQ). Those who did not recalculate the owners' estimated quantities were tested for their reasons behind not recalculating the estimated quantities provided by the owner.

- **Percentage of contractors recalculating the owners' estimated quantities and those who did not, and their objectives**

Concerning the recalculation of quantities by contractors, the following hypotheses conducted for the possible rejection or acceptance of *Ho*:

Ho: Different grades of contractors have different responses whether they are doing quantities recalculation of owners prepared bill of quantities.

H_1: All contractors of different grades have responded the same whether they are doing quantities recalculation of owners prepared bill of quantities.

For the comparison of grades 1, 2, and 3 contractors, chi-square test was applied and the *P*-value (0.04) showed that the null hypothesis is rejected, which means that all contractors recalculated quantities provided by the owner and that is because it becomes common that inaccurate quantities and estimation errors cost contractors many losses if they were not aware of it in the bidding stage.

The results intuitively indicated that most contractors recalculated the estimated quantities provided by the owner, where the rest do not. It is also interesting to know that only 7% of contractors did not recalculate the quantities provide by the owners, who justified that by the presence of a negotiation clause in the contracts in case of quantities variations.

Table 30: Percentages of contractors recalculating owners' quantities and their objectives

Contractors group	Highway Grade 1	Highway Grade 2	Highway Grade 3	All contractors
Recalculating owners estimated quantities	46%	18%	29%	93%
Not recalculating owners estimated quantities	0	7%	0	7%
Objective for quantities recalculation				
Verify the owner’s estimate	39%	17%	21%	95%
Design the proper construction method	7%	4%	4%	15%
Properly price the contract	42%	25%	25%	92%

On the other hand, concerning the objective of recalculation of quantities by contractors, more than 90% of them were doing so for the objective of verifying the owner, and for the objective of appropriately pricing the bid estimate because they wanted to take care of their prices by playing with items of inaccurate estimates, and only 15% of them were doing so for the objective of designing the proper construction method.

- **The percentage of highway projects quantities deviation compared to contractors' estimate**

Concerning the percentage of highway projects quantities deviation compared to contractors' estimate, the results indicated that different grades of contractors had different responses toward the percentage of highway projects quantities deviation and that is may be because of their different backgrounds and their different estimation procedures.

For further pairwise comparison, the results indicated about 18% of contractors said that less than 5% of their quantity estimate varied compared to the owner's quantity estimates. It is also interesting to know that about 31% of those contractors agreed that 5% to less than 25% of their estimate was different than the owner’s estimates; about 29% of those contractors agreed that 25% to less than 50% of their estimate was different than the owner’s estimates, and about 15% of those contractors agreed that 50% to less than 75% of their estimate was different than the owner’s estimates.

Table 31: Percentage of highway projects quantities deviation compared to contractors' estimate

% of estimated quantities deviated compared to contractors' estimate	Highway Grade 1	Highway Grade 2	Highway Grade 3	All contractors
Less than 5	4%	7%	7%	18%
5 to less than 25	17%	7%	7%	31%
25 to less than 50	14%	4%	11%	29%
50 to less than 75	11%	0	4%	15%
More than 75	0	0	0	0

However, most contractors who recalculated the estimated quantities provided by the owner agreed that their estimations were significantly different than the owners' estimates for more than 5%, which is relatively significant. More than 90% of the grade 1 highway contractors, more than half of the grade 2 highway contractors, and about three-quarters of the grade 3 highway contractors agreed that they usually found more than 5% to less than 75% difference between their estimate and the owners' estimates.

- **Contractors' reaction when they realized a quantities overestimation or quantities overestimation**

Concerning contractors' reaction when they realized a quantities overestimation or quantities overestimation, the required hypotheses conducted and found that contractors had different responses toward contractors' reaction when they realized a quantities underestimation or quantities overestimation was found for different grades.

For further pairwise comparison, all contractors agreed to determine the unit costs based on the company's estimated quantities when they found a quantities underestimation or quantities overestimation, except for one contractor who usually informed the owner/consultant when he did so.

- **Procedures followed to prepare the unit cost for each item in the Bill of Quantities (BOQ).**

Concerning contractors' procedures followed to prepare the unit cost for each item in the Bill of Quantities (BOQ), the following hypotheses conducted for the possible rejection or acceptance of *Ho*:

Ho: Different grades of contractors have different procedures to prepare the unit cost for each item in the Bill of Quantities (BOQ).

H_1: All contractors of different grades were calculating the unit cost of an item following the procedure below:

Unit cost of item = (Labor cost + Equipment cost + Material cost) + Item indirect cost (as a percent of the total indirect cost)

For the comparison of grades 1, 2, and 3 contractors, CHI-SQUARE test was applied and the *P*-value (0.538) showed that the null hypothesis is accepted, which means that contractors followed different procedure with respect to their grades.

For further pairwise comparison, the result indicated that nearly all contractors were calculating the unit cost of an item following the procedure below:

Unit cost of item = (Labor cost + Equipment cost + Material cost) + Item indirect cost (as a percent of the total indirect cost)

Whereas only 11% of them were calculating the unit cost of an item following the procedure below:

Unit cost of item = (Labor cost + Equipment cost + Material cost) + Item fixed cost.

Three-quarters of contractors were using unit prices from the company's historical records as a supplement to verify their estimates.

Table 32: Procedures followed to prepare the unit cost for each item in the Bill of Quantities (BOQ).

Procedures followed to prepare the unit cost for each item in (BOQ)	Highway Grade 1	Highway Grade 2	Highway Grade 3	All contractors
Use unit prices from company's historical records	43%	14%	22%	77%
(Labor cost + Equipment cost + Material cost) + Item indirect cost (as a percent of the total indirect cost)	46%	14%	22%	82%
(Labor cost + Equipment cost + Material cost) + Item fixed cost	7%	4%	0	11%

The results indicated that all contractors that were using the second procedure for items' unit cost estimation were grade 1, and 2 highway contractors. Nearly all grade 1 highway contractors were using unit prices from company's historical records as a supplement to verify their estimates.

5.5 Consultants' BOQ preparation

This section presents the main procedures and practices followed by consultants when preparing the bill of quantities of unit price contracts. It determines the main role of the consultancy company in business, determines whether they prepare the bill of quantities in house or outsource this activity, determines the number of allocated estimators for preparing the bill of quantities for a major construction project, defines the average experience of estimators contributing to this activity, identifies the main procedures consultants used for preparing the bill of quantities, determines the percentage of highway projects with actual quantities that are significantly different from their estimated quantities, reviews how frequently they update their estimation procedures, and finally determines the frequency that their clients review the organization's estimated quantities in the Bill of Quantities.

- **Main role of consultancy company in business**

The results indicated that most consultants were doing engineering design, whereas all of those doing engineering design are also doing structural design. 85% of consultants were doing both engineering and structural design, whereas the rest of them were doing only one job that is different than engineering or structural design which represents only 5% for those doing only regional planning, only preparation of the bill of quantities, or only construction supervision.

Table 33: Main role of Consultancy Company in business

Consultant role	All Consultants
Engineering Design	85%
Structural Design	85%
Only Regional Planning	5%
Only Preparation of BOQ	5%
Only Construction Supervision	5%
Regional Planning	48%
Preparation of BOQ	52%

As shown in the table above, for those doing engineering and structural design, more than 50% of them were also doing both regional planning and preparation of bill of quantities, which in turn enriched this study results.

- **Preparation of the bill of quantities whether in-house or not**

The table below shows that less than one-quarter of consultants were not preparing bill of quantities in-house; instead they are outsourced this activity for other consultants.

Table 34: Preparation of consultants' bill of quantities whether in-house or not

Consultant role	All Consultants
In-house BOQ preparation	76%
No in-house BOQ preparation	24%

On the other hand, 76% of consultants prepared the bill of quantities in-house.

- **Number of allocated estimators for preparing the bill of quantities for a major construction project**

Concerning consultant allocation of estimators for preparing the bill of quantities for a major construction project, many hypotheses conducted which resulted in no association between consultants responses with respect to their number of employees, annual revenues, or different rules toward preparation of the bill of quantities.

For further pairwise comparison, the results indicated that most consultants usually assign three to five estimators to be accounted for the preparation of a major project bill of quantities. About two-thirds of consultants usually assign three to five estimators whereas about one-quarter of them assign fewer than three estimators; only 5% of them assign five to seven estimators, and the same percent assign more than seven estimators to be accountable for the preparation of bill of quantities for a major construction project.

Table 35: Number of allocated estimators for preparing the bill of quantities for a major construction project in Consultancy Company

Number of estimators assigned for major project	All Consultants
Less than 3	24%
3 to less than 5	66%
5 to less than 7	5%
More than 7	5%

The results above are unsatisfactory, especially for major highway projects. There is a common weak interest for bill of quantities preparation followed by consultants.

- **Average experience of estimators contributing in the preparation of the bill of quantities**

Concerning consultant allocation of expert estimators for preparing the bill of quantities for a major construction project, the following hypotheses conducted for the possible rejection or acceptance of *Ho*:

Ho: Consultants with different numbers of employees, consultants with different annual revenues, consultants with different rules toward preparation of the bill of quantities, or consultants with a different number of estimators' allocation for a major project, allocate estimators with different average experience to a major construction project estimation.

$H_{1:}$ Most consultants allocate more than five estimators with an average experience of 10 years or more for a major construction project estimation.

For the comparison between consultants, a chi-square test was applied and the *P*-value (0.035, 0.797, 0.476, 0.452) showed that all the null hypothesis was accepted, except for number of employees, which means that there was no association between consultants responses with respect to their annual revenues, different rules toward preparation of the bill of quantities, or different numbers of estimators allocated for a major construction project estimation. However, there was an association between consultant's volume of employees and their average experience; the lower the number of employees in organization, the more those with an average experience of 5-15 years were assigned for major project estimation.

The results also showed that most consultants usually assign estimators with an average experience of five to less than ten years to be responsible for the preparation of a major project bill of quantities. Two-thirds of consultants usually assign estimators with average experience of five to less than ten years, whereas 9% of them assign estimators with average experience from less than 5 years, only 19% of them assign estimators with average experience from 10 to less than 15 years, and only 5% of them assign estimators with average experience more than 15 years to be accountable for the preparation of bill of quantities for a major construction project.

Table 36: Average experience of estimators contributing in preparation of Bill of quantities

Average experience (years)	All Consultants
Less than 5	9%
5 to less than 10	67%
10 to less than 15	19%
More than 15	5%

The results above again is unsatisfactory especially in a major highway projects. Again, there is a common poor interest for bill of quantities preparation followed by consultants.

- **Procedures consultants used for preparing the bill of quantities**

The results showed that 85% of consultants are doing Item identification using work breakdown structure, only 5% are doing only manual quantities take-off, and only 10% are doing only automated quantities take-off.

Table 37: Procedures consultants used for preparing the bill of quantities

Average experience (years)	All Consultants
Item identification using work breakdown structure	85%
Only Manual Quantities Take-off	5%
Only Automated Quantities Take-off	10%
Supplementary Item identification using existing templates	5%
Supplementary Manual Quantities Take-off	25%
Supplementary Automated Quantities Take-off	30%
Supplementary use of historical data	15%
Supplementary use of experience	20%
Based on the contractors estimation procedures	10%

A major percent (30%) of consultants were doing automated quantities take-off, 25% were doing manual quantities take-off, and 20% of consultants were utilizing their experience.

- **Percentage of construction projects with actual quantities that are significantly different from consultants' estimated quantities**

Concerning consultant percentage of construction projects with actual quantities that are significantly different from their estimated quantities, the following hypotheses conducted for the possible rejection or acceptance of *Ho*:

Ho: Consultants with different number of employees, consultants with different annual revenues, consultants of different rules toward preparation of the bill of quantities, consultants with different number of estimators' allocation for a major project, or with different average experience of estimators allocated for a major project have different percentages of construction projects with actual quantities that are significantly different from their estimated quantities.

H_1: Most consultants told that the percentage of construction projects with actual quantities that are significantly different from their estimated quantities were less than 5%.

For comparison between consultants, a chi-square test was applied and the *P*-value (0.651, 0.587, 0.082, 0.035, and 0.214) showed that all the null hypothesis was accepted, except for the fourth hypothesis regarding the number of estimators.

This means that there was no association between consultant responses with respect to their number of employees, annual revenues, different rules toward preparation of the bill of quantities, different average experience of estimators allocated for a major project, or with the different number of estimators' allocation for a major project. However, there was an association between the percentage of construction projects with actual quantities that were significantly different from their estimated quantities, and the average number of estimators involved; the fewer estimators involved, the more the percentages of projects with actual quantities were significantly different from their estimated quantities.

The results showed that 53% of consultants admitted that 5% to less than 25% of actual projects estimates were significantly different than their estimates, and 9% of consultants also admitted that 25% to less than 50% of actual projects estimates were significantly different than their estimates, whereas 38% of consultants admitted that less than 5% of actual projects estimates were significantly different than their estimates.

Table 38: Percentage of construction projects with actual quantities that are significantly different from consultants' estimated quantities

Percentage of construction projects with actual quantities that are significantly different from their estimated quantities	All Consultants
Less than 5	38%
5 to less than 25	53%
25 to less than 50	9%

- **Consultants update frequency of their estimation procedures**

Concerning consultant update frequency of their estimation procedures, the following hypotheses conducted for the possible rejection or acceptance of *Ho*:

Ho: Consultants with different number of employees, consultants with different annual revenues, consultants with different rules toward preparation of the bill of quantities, consultants with different numbers of estimators' allocated for a major project, with different average experience of estimators allocated for a major project, or with different percentages of construction projects with actual quantities that are significantly different from their estimated quantities, have different update frequencies for their estimation procedures.

$H_{1:}$ Most consultants update their estimation procedures every 12 months or more.

For the comparison between consultants, a chi-square test was applied and the *P*-value (0.816, 0.287, 0.835, 0.710, 0.669, and 0.167) showed that all of the null hypothesis was accepted, which means that different consultants had different update frequencies regardless of their characteristics.

The results showed that 62% of consultants updated their estimation procedures every 12 months, only 28% updated their estimation procedures every 6 months, 5% updated their estimation procedures every 18 months, and 5% do not ever update their estimation procedures.

Table 39: Consultants' update frequency of their estimation procedures

Consultants' update frequency of their estimation procedures	All Consultants
Every 6 months	28%
Every 12 months	62%
Every 18 months	5%
Never	5%

The results are really encouraging, as they showed that 90% of consultants updated their estimation procedures every one year or less. However, this strong interest and awareness must be reflected in their accuracy of their estimates. It is believed that many consultants did not update their procedures, as shown in the results, in which case many of them believed that they had to answer positively.

- **Owners' review frequency of consultants prepared quantities**

The results showed that 38% of consultants believed that owners always reviewed their estimates always, 10% of consultants believed that owners reviewed their estimates very often, 14% of consultants believed that owners reviewed their estimates often, and 38% of consultants believed that owners sometimes reviewed their estimates.

Table 40: Owners' review frequency of consultants prepared quantities

Owners' review frequency of consultants prepared quantities	All Consultants
Always	38%
Very often	10%
Often	14%
Sometimes	38%

5.6 Reasons behind quantities variations

The main reasons for variations in quantities was divided into three major types in unit price contracts, as shown below:

1. **Technical reasons**: it resulted because of estimation technical issues that was included but are not limited to the following reasons:

Table 41 presents the number of respondents who had different levels of agreements toward technical reasons for quantities variations with respect to their contracting company's the grades, while showing the agreement indices for each the grade of contractor and for all contractors used for ranking of factors in descending order, as shown in the table below:

Table 41: Contractors agreement indices for technical reasons

Technical Reasons Factors	Grade 1	Grade 2	Grade 3	All
Forecasting errors due to lack of data	86%	94%	88%	89%
Poor coordination between public agencies	83%	86%	88%	85%
Unforeseen site conditions	86%	77%	88%	84%
Forecasting errors due to unknown site conditions by consultant	78%	83%	88%	82%
Unclear underground utilities	75%	94%	78%	81%
Forecasting errors due to poor consultant takeoff	77%	86%	85%	81%
Limited time for estimation	71%	91%	83%	79%
Forecasting errors due to difficulty of prediction	66%	83%	80%	74%
Forecasting errors due to estimation method	68%	77%	83%	74%
Insufficient use of technology	60%	77%	85%	71%
Overestimating to cover forecasting errors	68%	77%	63%	69%

However, the following table shows the results of a chi-square test that was used to determine if an association existed between different responses toward the technical reason factors of different grades of contractors.

Table 42: Chi-square test for technical reasons

Technical Reasons Factors	Chi-Square Tests		
	Value	**Df**	**Asymp. Sig. (2-sided)**
Forecasting errors due to lack of data	4.351a	4	.361
Forecasting errors due to difficulty of prediction	11.032a	6	.087
Forecasting errors due to estimation method	4.498a	6	.610
Forecasting errors due to unknown site conditions by consultant	6.481a	6	.371
Forecasting errors due to poor consultant takeoff	18.869a	6	**.004**
Unforeseen site conditions	8.727a	6	.190
Overestimating to cover forecasting errors	6.011a	6	.422
Limited time for estimation	7.154a	6	.307
Unclear underground utilities	11.260a	4	**.024**
Insufficient use of technology	11.790a	6	.067
Poor coordination between public agencies	3.007a	6	.808

On the other hand, further comparisons between consultants and contractors' responses were conducted to determine different perspectives of those parties toward the technical reasons for quantities variations. The following table shows the resulting frequencies of consultants' responses toward technical reasons factors, and their agreement indices in descending order, as shown in table 43 below:

Table 43: Consultants agreement indices for technical reasons

Technical Reasons Factors	Agreement index
Forecasting errors due to lack of data	**87%**
Unclear underground utilities	**83%**
Poor coordination between public agencies	**79%**
Unforeseen site conditions	**79%**
Limited time for estimation	**72%**
Insufficient use of technology	**72%**
Forecasting errors due to difficulty of prediction	**70%**
Forecasting errors due to unknown site conditions by consultant	**68%**
Forecasting errors due to poor consultant takeoff	**68%**
Forecasting errors due to estimation method	**66%**
Overestimating to cover forecasting errors	**65%**

The following table also shows the F-test and T-test used to determine if there was any agreement between contractors' and consultants' responses regarding technical reasons factors.

Table 44: F-test and T-test for technical reasons

Technical Reasons Factors	Comparison	Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	T	Sig. (2-tailed)
Forecasting errors due to lack of data	Equal variances assumed	3.271	.108	.380	.714
	Equal variances not assumed			.380	.715
Forecasting errors due to difficulty of prediction	Equal variances assumed	1.492	.257	.486	.640
	Equal variances not assumed			.486	.643
Forecasting errors due to estimation method	Equal variances assumed	.004	.949	.515	.621
	Equal variances not assumed			.515	.621
Forecasting errors due to unknown site conditions by consultant	Equal variances assumed	.966	.354	.411	.692
	Equal variances not assumed			.411	.692
Forecasting errors due to poor consultant takeoff	Equal variances assumed	2.261	.171	.529	.611
	Equal variances not assumed			.529	.614
Unforeseen site conditions	Equal variances assumed	3.390	.103	.467	.653

	Equal variances not assumed			.467	.656
Overestimating to cover forecasting errors	Equal variances assumed	.015	.905	.717	.494
	Equal variances not assumed			.717	.494
Limited time for estimation	Equal variances assumed	.981	.351	.691	.509
	Equal variances not assumed			.691	.512
Unclear underground utilities	Equal variances assumed	.307	.595	.413	.691
	Equal variances not assumed			.413	.692
Insufficient use of technology	Equal variances assumed	.174	.688	.597	.567
	Equal variances not assumed			.597	.568
Poor coordination between public agencies	Equal variances assumed	1.934	.202	.363	.726
	Equal variances not assumed			.363	.727

The following are the main technical reasons that were studied in this research, together with a conclusion of the major results:

- **Forecasting errors due to lack of data:**

In order to study this factor with respect to the different grades of contractors, the following hypotheses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Different responses of highway contractors of the grades 1, 2, and 3 were expected for the factor of forecasting errors due to lack of data.

H_1: Most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the factor of forecasting errors due to lack of data.

For the comparison between different the grades of highway contractors, a chi-square test was applied and the *P*-value (0.361) obtained from table 42 shows that the null hypothesis was accepted, which means that different responses of highway contractors of the grades 1, 2, and 3 resulted from the factor of forecasting errors due to lack of data.

The results in table 40 above showed that half of respondents strongly agreed, and less than half agreed on the factor of forecasting errors due to lack of data. Almost all the grade 1, 2, and 3 contractors agreed on this factor.

Agreement indices of 86%, 94%, and 88% were recorded for the grades 1, 2, and 3 contractors respectively, where a total of 89% (1st rank of agreement index) were recorded for all contractors, which in turn confirms the significance of this factor for causing quantities variations, which are clearly noticed in the construction industry.

For further comparison between contractors and consultants, further hypotheses regarding variances and means of both contractors' and consultants' responses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Variances between contractors and consultants responses are equal.

$H_{1:}$ Variances between contractors and consultants responses are not equal.

The resulting F-test value obtained from table 44 for this factor was (0.108), which means that the null hypothesis was accepted and the variances were equal.

Therefore, further hypotheses were conducted to determine whether the means of both consultants and contractors were equal or not, as shown below:

Ho: Means of contractors and consultants responses are equal.

$H_{1:}$ Means of contractors and consultants responses are not equal.

The resulting T-test value obtained from table 44 for this factor was (0.718), which means that the null hypothesis was accepted and their means were equal.

Therefore, both contractors and consultants agreed on their level of agreements toward this factor. Moreover, the results in table 43 revealed that consultants' agreement index of 87%

(1st rank) was recognized for this factor. This strong agreement toward the lack of data was concluded by many researchers and is usually practiced by owners in Saudi Arabia.

- **Forecasting errors due to difficulty of Quantity prediction:**

After studying this factor with respect to the different grades of contractors, it was found that the *P*-value (0.087) obtained from table 42 shows that the null hypothesis was accepted, which means that the different responses of highway contractors of the grades 1, 2, and 3 resulted from the factor of forecasting errors due to the difficulty of quantity prediction.

The results in table 40 above showed that about 15% of respondents strongly agreed, and about half agreed, on the factor of forecasting errors due to the difficulty of quantity prediction. About half of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and more than three-quarters of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices 66%, 83%, and 80% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 74% (8th rank of the agreement index) were recorded for all contractors, which is in normal agreement for this factor causing quantities variations, and supports that which is usually experienced in some excavation and fill items. For further comparison between contractors and consultants, the results in table 44 revealed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 43 revealed that the consultants' agreement index of 70% (7th rank) was recognized for this factor. This normal agreement toward the difficulty of prediction errors resulted because of the presence of excavation, fill, and other troubled estimated items.

- **Forecasting errors due to estimation approach used:**

After studying this factor with respect to the different grades of contractors, the results indicated that different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of forecasting errors due to the estimation approach used.

The results showed that 22% of respondents strongly agreed and 32% agreed on the factor of forecasting errors due to the estimation approach used. It is interesting also to know that 43% of respondents were neutral regarding this factor. About 40% of the grade 1 highway contractors, more than half of the grade 2 highway contractors, and more than three-quarters of the grade 3 highway contractors agreed or strongly agreed on this factor. Agreement indices of 68%, 77%, and 83% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 74% (9^{th} rank of agreement index) were recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations, and is supported by many researchers.

For further comparison between contractors and consultants, the results in table 44 revealed that both contractors and consultants agreed on their level of agreements toward this factor based on significant values of the F-test and T-test. Moreover, the results in table 43 revealed that the consultants' agreement index of 66% (10^{th} rank) was recognized for this factor. This low agreement (close to neutral level) toward the estimation method used was concluded by many researchers but prejudiced by many respondents.

- **Forecasting errors because of unknown site requirements by consultant**

After studying this factor with respect to the different grades of contractors, it was found that different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of forecasting errors, because of unknown site requirements by the consultant.

The results showed that 36% of respondents strongly agreed, and 46% agreed, on the factor of forecasting errors because of unknown site requirements by the consultant. About one-third of the grade 1 highway contractors, more than one-third of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors strongly agreed on this factor, whereas about half of the grade 1 highway contractors, more than a quarter of the grade 2 highway contractors, and about two-thirds of the grade 3 highway contractors agreed on this factor.

Agreement indices of 78%, 83%, and 88% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 82% (4^{th} rank of agreement index) was recorded for all contractors, which is a strong agreement toward this factor for causing quantities variations, and is supported by the case studies discussed above.

For further comparison between contractors and consultants, the results in table 44 revealed that both contractors and consultants agreed on their level of agreements toward this factor based on significant values of the F-test and T-test. Moreover, the results in table 43 revealed that the consultants' agreement index of 68% (8^{th} rank) was recognized for this factor. This normal agreement toward unknown site conditions by consultant is not adequate, but again was prejudiced by consultants, since it is one of the most important factors for quantities inaccuracy (the 4^{th} ranked factor by contractors) in Saudi Arabia.

- **Forecasting errors due to poor quantities take-off and quality control by consultant:**

In order to study this factor with respect to the different grades of contractors, the following hypotheses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Different responses of highway contractors of the grades 1, 2, and 3 were expected for the factor of forecasting errors due to poor quantities take-off and quality control by the consultant.

$H_{1:}$ Most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the factor of forecasting errors due to poor quantities take-off and quality control by the consultant.

For the comparison between different the grades of highway contractors, a chi-square test was applied and the *P*-value (0.004) obtained from table 42 shows that the null hypothesis was rejected, which means that it is correct that most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the factor of forecasting errors due to poor quantities take-off and quality control by consultant.

The results showed that 32% of respondents strongly agreed, and half of them agreed, on the factor of forecasting errors due to poor quantities take-off and quality control by consultant. Only about 15% of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors strongly agreed on this factor, whereas about more than two-thirds of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and none of the grade 3 highway contractors agreed on this factor.

Agreement indices of 77%, 86%, and 85% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 81% (6^{th} rank) of agreement index was recorded for all contractors, which is a strong agreement toward this factor for causing quantities variations, and is supported by the case studies discussed above, and is usually experienced due to poor capabilities and a low interest in accurate estimations.

For further comparison between contractors and consultants, the results in table 44 revealed that both contractors and consultants agreed on their level of agreements toward this factor based on significant values of the F-test and T-test. Moreover, the results in table 43 revealed that the consultants' agreement index of 68% (9th rank) was recognized for this factor. This normal agreement toward poor quantities take-off by consultant is not adequate, but again was prejudiced by consultants, since it is one of the important factors for quantities inaccuracy (the 6th ranked factor by contractors of the 81% agreement index) in Saudi Arabia.

- **Unforeseen site conditions**

After studying this factor with respect to the different grades of contractors, the results indicated that different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of unforeseen site conditions.

The results showed that 36% of respondents strongly agreed, and more than half agreed, on the factor of unforeseen site conditions. About half of the grade 1 highway contractors, only one of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors strongly agreed on this factor, whereas about half of the grade 1 highway contractors, more than half of the grade 2 highway contractors, and about two-thirds of the grade 3 highway contractors agreed on this factor.

Agreement indices of 86%, 77%, and 88% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 84% (3rd rank) of agreement index was recorded for all contractors, which is a strong agreement toward this factor for causing quantities variations that normally arise in the construction industry due to temporary construction works and the hectic climate.

For further comparison between contractors and consultants, the results in table 44 revealed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 43 revealed that the consultants' agreement index of 79% (4th rank) was recognized for this factor. This strong agreement toward unforeseen site conditions factor led to the conclusion that this is normal in the construction industry everywhere.

- **Overestimating to cover estimation forecasting errors**

After studying this factor with respect to the different grades of contractors, it was found that different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of overestimating to cover estimation forecasting errors.

The results showed that only 15% of respondents strongly agreed, and 31% agreed, on the factor of overestimating to cover estimation forecasting errors. It is interesting to know that 36% of contractors were neutral and 18% disagreed with this factor. About half of the grade 1 highway contractors, more than half of the grade 2 highway contractors, and more than one-quarter of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 68%, 77%, and 63% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 69% (11th rank) of agreement index was recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations that normally occurs to satisfy owners, and maintain a good record of low cost-overrun projects to cover lack of project budget in the future, but it is still not very common in Saudi Arabia.

For further comparison between contractors and consultants, the results in table 44 revealed that both contractors and consultants agreed on their level of agreements toward this factor based on significant values of the F-test and T-test. Moreover, the results in table 43 revealed that the consultants' agreement index of 65% (11th rank) was recognized for this factor. The low normal agreement toward this factor also had the same rank by contractors, and could be justified the same way.

- **Time available for preparing estimation:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the *P*-value (0.307) obtained from table 42, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of time available for preparing estimations.

The results showed that 40% of respondents strongly agreed, and 29% agreed, on the factor of time available for preparing estimation. It is also interesting to know that 21% and 10% were neutral or disagreed with this factor. About a quarter of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors strongly agreed on this factor, whereas more than a quarter of the grade 1 highway contractors, only one of the grade 2 highway contractors, and about one-third of the grade 3 highway contractors agreed on this factor.

Agreement indices of 71%, 91%, and 83% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 79% (7th rank) of agreement index was recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations that normally occur due to the short periods allowed for project design and quantities preparation by owners, in order to expedite their project's construction to fulfill the increasing need and importance of such highway projects.

For further comparison between contractors and consultants, the results in table 44 revealed that both contractors and consultants agreed on their level of agreements toward this factor based on significant values of the F-test and T-test. Moreover, the results in table 43 revealed that the consultants' agreement index of 72% (5th rank) was recognized for this factor. This normal agreement toward the time available for estimation led to the conclusion that this usually occurred due to the short periods allowed for project design and quantities preparation by owners in Saudi Arabia.

- **Unclear underground utilities plans:**

In order to study this factor with respect to the different grades of contractors, the following hypotheses conducted for the possible rejection or acceptance of *Ho*:

Ho: Different responses of highway contractors of the grades 1, 2, and 3 were expected for the factor of unclear underground utilities plans.

H_1: Most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the factor of unclear underground utilities plans.

For the comparison between different the grades of highway contractors, a chi-square test was applied and the *P*-value (0.024) obtained from table 42 shows that the null hypothesis was rejected, which means that it is correct that most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the factor of unclear underground utilities plans.

The results showed that 26% of respondents strongly agreed, and 53% agreed, on the factor of unclear underground utilities plans. More than two-thirds of the grade 1 highway contractors, all of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 75%, 94%, and 78% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 81% (5th rank of agreement index) was recorded for all contractors, which is a strong agreement toward this factor for causing quantities variations, and is not only supported by the case studies above but is also always criticized by contractors as the most important factor for quantities variations.

For further comparison between contractors and consultants, the results in table 44 revealed that both contractors and consultants agreed on their level of agreements toward this factor based on significant values of the F-test and T-test. Moreover, the results in table 43 revealed that the consultants' agreement index of 83% (2nd rank) was recognized for this factor. This strong agreement toward unclear underground utilities was also concluded to be a main factor for variations by five case studies and all contractors.

- **Insufficient use of technology:**

After studying this factor with respect to the different grades of contractors, the results indicated that- based on the P-value (0.067) obtained from table 42- different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of insufficient use of technology.

The results showed that 19% of respondents strongly agreed, and 35% agreed, on the factor of insufficient use of technology. It is also important to know that 32% and 14% of contractors were neutral or disagreed with this factor. Only one-quarter of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and more than three-quarters of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 60%, 77%, and 85% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 71% (10^{th} rank of agreement index) was recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations. This agreement toward this factor is mainly because of many estimation errors often practiced by consultants.

For further comparison between contractors and consultants, the results in table 44 revealed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 43 revealed that the consultants' agreement index of 72% (6^{th} rank) was recognized for this factor. This normal agreement toward insufficient use of technology factor was concluded by many researchers and is usually practiced by owners in Saudi Arabia.

- **Poor coordination between public agencies works and requirements:**

After studying this factor with respect to the different grades of contractors, it was found that- based on the P-value (0.808) obtained from table 42 - different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of poor coordination between public agencies works and requirements.

The results showed that 36% of respondents strongly agreed, and 57% agreed, on the factor of poor coordination between public agencies works and requirements. More than two-thirds of the grade 1 highway contractors, more than a quarter of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors strongly agreed on this factor, whereas more than half of the grade 1 highway contractors, about three-quarters of the grade 2 highway contractors, and about two-thirds of the grade 3 highway contractors agreed on this factor.

Agreement indices of 83%, 86%, and 88% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 85% (2nd rank of agreement index) was recorded for all contractors, which is a strong agreement toward this factor for causing quantities variations. This strong agreement toward this factor is mainly because many contractors were and still suffering from design changes induced by many public agencies during construction.

For further comparison between contractors and consultants, the results in table 44 revealed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 43 revealed that the consultants' agreement index of 79% (3rd rank) was recognized for this factor. This strong agreement toward this factor due to continuous design changes is induced by many public agencies during construction to enforce their special works requirements, and unfortunately more of late.

2. Factors related to estimator's performance:

These factors resulted because of an estimator's errors during the estimation process.

Table 45 presents the number of respondents who had different levels of agreements (frequencies) toward quantities variations factors related to estimators' performance with respect to their contracting company's the grades. In addition, the agreement indices for each the grade of contractors, as well as the total contractors' agreement index, were found and entered in descending order, as shown in the table below:

Table 45: Agreement indices for estimator's performance factors

Estimators Performance Factors	Grade 1	Grade 2	Grade 3	All contractors
Unqualified estimators	75%	83%	88%	81%
Inaccuracy in measuring risks	72%	77%	95%	80%
Inappropriate judgment method	69%	84%	90%	78%
Misrepresentation of cost	77%	73%	78%	76%
Overoptimistic behavior	68%	84%	78%	74%

However, table 46 shows the results of a chi-square test that was used to determine if there was any association between different responses toward estimators' performance factors of different the grades of contractors.

Table 46: Chi-square test for estimators' performance factors

Estimators Performance Factors	**Chi-Square Tests**		
	Value	**Df**	**Asymp. Sig. (2-sided)**
Overoptimistic behavior	**4.313a**	**6**	**.634**
Misrepresentation of cost	**3.709a**	**6**	**.716**
Unqualified estimators	**4.498a**	**6**	**.610**
Inaccuracy in measuring risks	**15.533a**	**6**	**.016**
Inappropriate judgment method	**10.667a**	**6**	**.099**

On the other hand, further comparison between consultants' and contractors' responses were conducted to determine different perspectives of those parties toward quantities variations factors related to performance of estimators. Table 47 shows the resulting frequencies of the consultants' responses toward these factors, as well as the agreement levels of each factor in a descending order.

Table 47: Consultants' agreement indices for estimators' performance factors

Estimators' Performance Factors	Agreement index
Inappropriate judgment method	**70%**
Inaccuracy in measuring risks	**69%**
Unqualified estimators	**68%**
Misrepresentation of cost	**68%**
Overoptimistic behavior	**65%**

The following table also shows the F-test and T-test used to determine if there was any agreement between contractors' and consultants' responses regarding factors related to estimators' performance.

Table 48: F-test and T-test for estimators' performance factors

Estimators Performance Factors	Comparison	Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	T	Sig. (2-tailed)
Overoptimistic behavior	Equal variances assumed	1.371	.275	.356	.731
	Equal variances not assumed			.356	.732
Misrepresentation of cost	Equal variances assumed	.287	.607	.423	.684
	Equal variances not assumed			.423	.685
Unqualified estimators	Equal variances assumed	.595	.463	.375	.717
	Equal variances not assumed			.375	.720
Inaccuracy in measuring risks	Equal variances assumed	.517	.493	.431	.678
	Equal variances not assumed			.431	.679
Inappropriate judgment method	Equal variances assumed	.022	.886	.389	.708
	Equal variances not assumed			.389	.708

- **Overoptimistic behavior:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the *P*-value (0. 33) obtained from table 46, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of estimators' over-optimistic behavior.

The results showed that 15% of respondents strongly agreed, and 46% agreed, on the factor of estimators' over-optimistic behavior. It is also interesting to know that 35% of contractors were neutral. About two-thirds of the grade 1 highway contractors, all of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 68%, 84%, and 78% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 74% (5^{th} rank of agreement index) was recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations. This normal agreement toward this factor is mainly because many estimators are more than optimistic toward risks when they are doing their estimation.

For further comparison between contractors and consultants, the results in table 48 revealed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 47 revealed that the consultants’ agreement index of 65% (5^{th} rank) was recognized for this factor. This low normal agreement toward this factor was due to consultant optimism, but is still not an adequate result because of some consultants' bias.

- **Misrepresentation of project cost:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the *P*-value (0.634) obtained from table 46, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of estimators' misrepresentation of project cost.

The results showed that 14% of respondents strongly agreed, and 53% agreed, on the factor of misrepresentation of project cost. About half of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors strongly agreed on this factor, whereas about 40% of the grade 1 highway contractors, more than a quarter of the grade 2 highway contractors, and about two-thirds of the grade 3 highway contractors strongly agreed on this factor.

Agreement indices of 77%, 73%, and 78% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 76% (4^{th} rank of agreement index) was recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations. This normal agreement toward this factor may result when estimators deliberately deviate from actual quantities to satisfy various objectives.

For further comparison between contractors and consultants, the results in table 48 revealed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 47 revealed that the consultants’ agreement index of 68% (4^{th} rank) was recognized for this factor. This normal agreement toward this factor was due to deliberate actions by consultants to satisfy some objectives.

- **Unqualified estimators:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.716) obtained from table 46, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of unqualified estimators.

The results showed that 28% of respondents strongly agreed, and 36% agreed, on the factor of unqualified estimators. More than two-thirds of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and more than three-quarters of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 75%, 83%, and 88% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 81% (1st rank of agreement index) was recorded for all contractors, which is a strong agreement toward this factor for causing quantities variations. This strong agreement was expected, because estimators' errors becomes apparent because of the frequent cost-overruns usually experienced in highway projects.

For further comparison between contractors and consultants, the results revealed that both contractors and consultants agreed on their level of agreements toward this factor based on F-test and T-test values shown in table 48. Moreover, the results in table 47 revealed that the consultants' agreement index of 68% (3rd rank) was recognized for this factor. This normal agreement toward this factor was due to low experience, knowledge, and skills of some consultants but again still biased by some consultants as ranked the first and strongly agreed by contractors.

- **Inaccuracy in measuring risks:**

In order to study this factor with respect to the different grades of contractors, the following hypotheses conducted for the possible rejection or acceptance of *Ho*:

Ho: Different responses of highway contractors of the grades 1, 2, and 3 were expected for the factor of inaccuracy in measuring risks.

H_1: Most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the factor of inaccuracy in measuring risks.

For the comparison between different the grades of highway contractors, a chi-square test was applied and the *P*-value (0.016) obtained from table 46 shows that the null hypothesis was rejected, which means that it is correct that most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the factor of inaccuracy in measuring risks.

The results showed that 26% of respondents strongly agreed, and 46% agreed, on the factor of inaccuracy in measuring risks. About two-thirds of the grade 1 highway contractors, about two-thirds of the grade 2 highway contractors, and all of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 72%, 77%, and 95% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 80% (2nd rank of agreement index) was recorded for all contractors, which is a strong agreement toward this factor for causing quantities variations. This strong agreement is clearly comprehended by contractors because many problems usually occur during construction of highway projects, which are mainly related to underground structures risks.

For further comparison between contractors and consultants, the results revealed that both contractors and consultants agreed on their level of agreements toward this factor based on the F-test and T-test values shown in table 48. Moreover, the results in table 47 revealed that the consultants' agreement index of 69% (2nd rank) was recognized for this factor. This normal agreement toward this factor was due to the difficulty of predicting risks associated with individual items or the total project.

- **Inappropriate judgment method:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.099) obtained from table 46, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of inappropriate judgment method.

The results showed that 23% of respondents strongly agreed, and 49% agreed, on the factor of inappropriate judgment method. More than half of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and all of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 69%, 84%, and 90% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 78% (3rd rank of agreement index) was recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations. The normal agreement could be justified due to many judgment mistakes related to expectations and risks experienced by consultants.

For further comparison between contractors and consultants, the results in table 48 revealed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 47 revealed that the consultants' agreement index of 70% (3rd rank) was recognized for this factor. This normal agreement toward this factor was due to estimation errors by the consultants. In addition, this group of factors did not have strong agreement among consultants because it was entirely directed to check the significance of poor estimator performance, when it is difficult for consultants to admit that they are poor estimators and make many errors.

3. Economic, Social, and political reasons:

These factors are related to the economic, social, and political situation during the estimation process. Table 49 presents the number of respondents who had different levels of agreements toward quantities variations factors related to the economic, social, and political situation with respect to their contracting company's the grades. Furthermore, the agreement indices for each the grade of contractors, and for the total contractors, were also presented in a descending order, as shown in the table below:

Table 49: Contractors agreement indices for Economic, Political, and Social Factors

Economic, Political, and Social Factors	Grade 1	Grade 2	Grade 3	All
Underestimating to secure fund	63%	67%	93%	73%
To satisfy managers attitudes	68%	73%	78%	72%
Overestimating to have enough budget	71%	73%	65%	70%
Satisfaction of owner inclination for low cost	65%	63%	83%	70%
Neighbors and shopkeepers complaints	57%	63%	73%	63%

However, table 50 shows the results of a chi-square test used to determine if there was any association between different responses of different the grades of contractors.

Table 50: Chi-square test for Economic, Political, and Social Factors

Economic, Political, and Social Factors	Chi-Square Tests		
	Value	Df	Asymp. Sig.
Overestimating to have enough budget	6.986a	8	.538
Underestimating to secure fund	13.673a	6	**.034**
Satisfaction of owner inclination for low cost	9.130a	6	.166
To satisfy managers attitudes	7.814a	6	.252
Neighbors and shopkeepers complaints	10.225a	8	.250

On the other hand, further comparison between consultants and contractors' responses were conducted to determine different perspectives of those parties toward quantities variations factors related to economic, social, and political issues. Table 51 below shows the resulting frequencies of responses for consultants, as well as their total agreement indices toward these factors.

Table 51: Consultants agreement indices for Economic, Political, and Social Factors

Economic, Political, and Social Factors	**Agreement index**
Overestimating to have enough budget	**67%**
Satisfaction of owner inclination for low cost	**65%**
Neighbors and shopkeepers complaints	**63%**
Underestimating to secure fund	**60%**
To satisfy managers attitudes	**57%**

The following table also shows the F-test and T-test used to determine if there was any agreement between contractors’ and consultants’ responses regarding these factors.

Table 52: F-test and T-test for Economic, Political, and Social Factors

Economic, Political, and Social Factors	Comparison	Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	T	Sig.
Overestimating to have enough budget	Equal variances assumed	.368	.561	.583	.576
	Equal variances not assumed			.583	.576
Underestimating to secure fund	Equal variances assumed	.417	.537	.723	.490
	Equal variances not assumed			.723	.491
Satisfaction of owner inclination for low cost	Equal variances assumed	.931	.363	.577	.580
	Equal variances not assumed			.577	.581
To satisfy managers attitudes	Equal variances assumed	.004	.952	.588	.572
	Equal variances not assumed			.588	.572
Neighbors and shopkeepers complaints	Equal variances assumed	.733	.417	.480	.644
	Equal variances not assumed			.480	.644

- **Overestimating to have enough budget to cover variations:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.538) obtained from table 50, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of overestimating to have enough budget to cover variations.

The results showed that 22% of respondents strongly agreed, and 29% agreed, on the factor of overestimating to have enough budget to cover variations. It is important to know that 26%, and 10% of contractors were neutral or disagreed with this factor. About one-third of the grade 1 highway contractors, more than one-third of the grade 2 highway contractors, and more than half of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 71%, 73%, and 65% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 70% (3rd rank of agreement index) was recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations. This normal agreement toward this factor was mainly for the sake of maintaining the required budget to overcome owners' complaints for continuous cost-overruns experienced in such highway projects.

For further comparison between contractors and consultants, the results in table 52 revealed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 51 revealed that the consultants’ agreement index of 67% (1st rank) was recognized for this factor. This normal agreement toward this factor was due to the reaction of consultants toward continuous cost-overruns.

- **Underestimating to secure project funds:**

In order to study this factor with respect to the different grades of contractors, the following hypotheses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Different responses of highway contractors of the grades 1, 2, and 3 were expected for the factor of underestimating to secure project funds.

H_1: Most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the factor of underestimating to secure project funds.

For the comparison between different the grades of highway contractors, a chi-square test was applied, and the *P*-value (0.034) obtained from table 50 shows that the null hypothesis was rejected, which means that it is correct that most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the factor of underestimating to secure project funds.

The results showed that one-quarter of respondents strongly agreed, and 29% agreed, on the factor of underestimating to secure project funds. It is also important to know that a quarter of them were neutral, and about 18% disagreed with this factor. About one-third of the grade 1 highway contractors, more than one-third of the grade 2 highway contractors, more than two-thirds of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 63%, 67%, and 93% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 73% (1st rank of agreement index) was recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations. This normal agreement toward this factor was often practiced by owners to ease the process of securing their project funds, as cited by (Gransberg, D. D., Riemer, C., 2009). For further comparison between contractors and consultants, the results in table 52 indicated that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 51 revealed that the consultants' agreement index of 60% (4th rank) was recognized for this factor. This normal agreement toward this factor was due to the practice of cost underestimation by owners to secure funds of their projects.

- **Satisfaction of owner's inclination for low cost:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.166) obtained from table 50, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of satisfaction of owner's inclination for low cost.

The results showed that only 11% of respondents strongly agreed, and 36% agreed, on the factor of satisfaction of owner's inclination for low cost. It is interesting to know that 39% of contractors were neutral and 11% disagreed with this factor. More than one-third of the grade 1 highway contractors, more than a quarter of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 65%, 63%, and 83% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 70% (4th rank of agreement index) was recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations. A normal agreement was expected, because many consultants are more interested in satisfying an owners' inclination for low cost instead of maintaining accurate estimates.

For further comparison between contractors and consultants, the results in table 52 revealed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 51 revealed that the consultants' agreement index of 65% (2^{nd} rank) was recognized for this factor. This normal agreement toward this factor was because many consultants are more interested in satisfying an owners' inclination for low cost instead of maintaining accurate estimates.

- **To satisfy managers' attitudes:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.252) obtained from table 50, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of satisfying a manager's attitudes.

The results showed that only 19% of respondents strongly agreed, and 36% agreed, on the factor of satisfying manager's attitudes. It is also important to know that 29% were neutral and 13% disagreed with this factor. About half of the grade 1 highway contractors, less than half of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors agreed or strongly agreed on this factor.

Agreement indices of 68%, 73%, and 78% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 72% (2^{nd} rank of agreement index) was recorded for all contractors, which is a normal agreement toward this factor for causing quantities variations. A normal agreement was expected because many estimators are interesting more to satisfy attitudes of their managers instead of maintaining accurate estimates.

For further comparison between contractors and consultants, the results in table 52 showed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 51 revealed that the consultants' agreement index of 57% (2nd rank) was recognized for this factor. This neutral response toward this factor was because estimators refrain from admitting that they are satisfying objectives of managers instead of being professional estimators.

- **Neighbors' and shopkeepers' complaints:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.250) obtained from table 50, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of neighbors' and shopkeepers' complaints.

The results showed that only 19% of respondents strongly agreed, and only 15% agreed, on the factor of neighbors' and shopkeepers' complaints. It is important to indicate that 31% of them were neutral and a quarter of them disagreed or strongly disagreed with this factor. Only two of the grade 1 highway contractors, three of the grade 2 highway contractors, and about half of the grade 3 highway contractors agreed or strongly agreed with this.

Agreement indices of 57%, 63%, and 73% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 63% (5th rank of agreement index) was recorded for all contractors, which is a low agreement level-close to neutral-toward this factor for causing quantities variations. A low agreement (close to neutral) was expected because owners and contractors were more interested in the overall sake of the project than satisfying the complaints of neighbors and shopkeepers in the case of project delay.

For further comparison between contractors and consultants, the results in table 52 revealed that both contractors and consultants agreed on their level of agreements toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 51 revealed that the consultants' agreement index of 63% (3^{rd} rank) was recognized for this factor. This normal agreement toward this factor was usually the result of complaints voiced by the public around the construction area during construction, but these experiences were minimal. In addition, all of these factors in this group had low agreement levels by consultants, as admission points to a low degree of professionalism.

5.7 The main factors that may affect unit cost of unit price contracts

After the analysis of responses collected, the results of the main factors that may affect the unit cost of unit price contracts is shown below. Table 53 presents the number of respondents who had different levels of agreements (frequencies) toward unit cost estimation factors, with respect to their contracting company's grades. Furthermore, severity indices for each the grade of contractor are shown, as well as for the total number of contractors, in descending order.

Table 53: Contractors severity indices for Unit Cost Estimation Factors

Unit Cost Estimation Factors	Grade 1	Grade 2	Grade 3	**All**
Project location	85%	90%	95%	89%
Contractor qualification	78%	87%	93%	85%
Quantity of item	82%	87%	88%	84%
Economic conditions	66%	97%	93%	81%
Associated risk of an item	77%	83%	85%	81%
Estimation method used	65%	83%	83%	74%
No. Of bidders	60%	80%	83%	71%

However, table 54 shows the results of a chi-square test that was used to determine if there was any association between different responses toward these factors of different the grades of contractors.

Table 54: Chi-square test for Unit Cost Estimation Factors

Economic, Political, and Social Factors	**Chi-Square Tests**		
	Value	**Df**	**Asymp. Sig. (2-sided)**
Quantity of item	**4.442a**	**6**	**.617**
No. Of bidders	**13.034a**	**8**	**.111**
Associated risk of an item	**3.742a**	**4**	**.442**
Estimation method used	**10.643a**	**6**	**.100**
Economic conditions	**14.366a**	**6**	**.026**
Contractor qualification	**4.568a**	**6**	**.600**
Project location	**4.708a**	**4**	**.319**

On the other hand, further comparisons between consultants and contractors' responses were conducted to determine different perspectives of those parties toward unit cost estimation factors. Table 55 shows the resulting frequencies of responses for consultants, in addition to their severity indices toward these factors.

Table 55: Consultants agreement indices for Unit Cost Estimation Factors

Unit Cost Estimation Factors	Severity Index
Quantity of item	**87%**
Contractor qualification	**78%**
Economic conditions	**74%**
Project location	**74%**
Associated risk of an item	**71%**
No. Of bidders	**64%**
Estimation method used	**60%**

The following table also shows the F-test and T-test used to determine if there was any agreement between contractors and consultants responses regarding these factors.

Table 56: F-test and T-test for Unit Cost Estimation Factors

Unit Cost Estimation Factors	Comparison	Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	T	Sig.
Quantity of item	Equal variances assumed	.074	.792	.330	.750
	Equal variances not assumed			.330	.750
No. Of bidders	Equal variances assumed	.029	.868	.320	.757
	Equal variances not assumed			.320	.757
Associated risk of an item	Equal variances assumed	.200	.666	.534	.608
	Equal variances not assumed			.534	.608
Estimation method used	Equal variances assumed	.187	.677	.722	.491
	Equal variances not assumed			.722	.493
Economic conditions	Equal variances assumed	.100	.760	.531	.610
	Equal variances not assumed			.531	.610
Contractor qualification	Equal variances assumed	3.252	.109	.481	.644
	Equal variances not assumed			.481	.645
Project location	Equal variances assumed	5.181	.052	.378	.716
	Equal variances not assumed			.378	.720

- **Quantity of item:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0. 617) obtained from table 54, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of quantity of item.

The results showed that 57% of respondents agreed that the quantity of item is a very severe factor, 21% also agreed that this factor is somewhat severe, and 18% agreed that this factor is severe. About half of the grade 1 highway contractors, more than three-quarters of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors agreed on the very severe level of this factor, whereas about one-third of the grade 1 highway contractors, more than a quarter of the grade 2 highway contractors, and about one-third of the grade 3 highway contractors agreed on the severity of this factor.

Severity indices of 82%, 87%, and 88% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 84% (3rd rank) of the severity index was recorded for all contractors, which is indicates the high severity of this factor as a driver for contractor unit cost preparation. This very severe level of this factor is normal in the construction industry because more quantities means more profits and vice versa.

For further comparison between contractors and consultants, the results in table 56 revealed that both contractors and consultants agreed on their level of severity toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 55 revealed that the consultants' severity index of 87% (1st rank) was recognized for this factor. This high severity of the quantity of item factor was expected, because it is a very important factor for contractors, since more quantity is a driver for more profit.

- **Number of bidders:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.111) obtained from table 54, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of number of bidders.

The results showed that 28% of respondents agreed that number of bidders is a very severe factor, 32% agreed that this factor is somewhat severe, and 22% agreed that this factor is severe. None of the grade 1 highway contractors, more a quarter of the grade 2 highway contractors, and more than three-quarters of the grade 3 highway contractors agreed on the very severe level of this factor, whereas about two-thirds of the grade 1 highway contractors, more than half of the grade 2 highway contractors, and only one of the grade 3 highway contractors agreed on the severity of this factor.

Severity indices of 60%, 80%, and 83% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 71% (7th rank) of the severity index were recorded for all contractors, which is a high severity of this factor as a driver for contractor unit cost preparation. A high severity for this factor resulted because many contractors take into account their competitors, whereas few do not consider other competitors, especially when they have more work to do.

For further comparison between contractors and consultants, the results in table 56 revealed that both contractors and consultants agreed on their level of severity toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 55 revealed that the consultants' severity index of 64% (6th rank) was recognized for this factor. This high severity toward this factor reported by consultants may be because of the high level of competition they undergo in the bidding stage.

- **Risk associated with work item:**

In order to study this factor with respect to the different grades of contractors, the following hypotheses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Different responses of highway contractors of the grades 1, 2, and 3 were expected for the factor of risk associated with the work item.

H_1: Most highway contractors of the grades 1, 2, and 3 agreed on the level of severity of the factor of risk associated with the work item.

For the comparison between different the grades of highway contractors, a chi-square test was applied and the *P*-value (0.01) obtained from table 54 shows that the null hypothesis was rejected, which means that most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the factor of risk associated with the work item.

The results showed that 36% of respondents agreed that the risk associated with the work item is a very severe factor, 25% agreed that this factor is somewhat severe, and 36% agreed that this factor is severe. About one-third of the grade 1 highway contractors, about half of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors agreed on the very severe level of this factor, whereas more than two-thirds of the grade 1 highway contractors, about half of the grade 2 highway contractors, and about two-thirds of the grade 3 highway contractors agreed on the severity of this factor.

Severity indices of 77%, 83%, and 85% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 81% (5^{th} rank) of the severity index were recorded for all contractors, which is a strong agreement toward this factor as a driver for contractor unit cost preparation. This very severe level was expected, again due to the fact that different requirements, complications, and technical difficulties in construction are associated with each item and that's why contractors consider the risks associated with each item.

For further comparison between contractors and consultants, the results in table 56 indicated that both contractors and consultants agreed on their level of severity toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 55 revealed that the consultants' severity index of 71% (5th rank) was recognized for this factor. This high level of severity was also usually experienced by consultants in those highway projects which drove them to agree on the high severity of this factor.

- **Estimation method used:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.1) obtained from table 54, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of estimation method used.

The results showed that 19% of respondents agreed that the estimation method used is a very severe factor, 43% agreed that this factor is somewhat severe, and 25% agreed that this factor is severe. It is also interesting to know that 11% of the grade 1 contractors told that that this factor is only somewhat severe. Only one of the grade 1 highway contractors, one of the grade 2 highway contractors, and about one-third of the grade 3 highway contractors agreed on the high severity of this factor, whereas more than two-thirds of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and about one-quarter of the grade 3 highway contractors agreed on the severity of this factor. Severity indices of 65%, 83%, and 83% were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 74% (7th rank) of the severity index were recorded for all contractors, which is a high severity for this factor as a driver for contractor unit cost preparation. This high severity is resulted primarily because of different estimations used by different contractors.

For further comparison between contractors and consultants, the results in table 56 revealed that both contractors and consultants agreed on their level of severity toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 55 revealed that the consultants' severity index of 60% (7^{th} rank) was recognized for this factor. This normal severity toward this factor was because different estimation methods may result in different results for quantities and prices.

- **Economic conditions:**

In order to study this factor with respect to the different grades of contractors, the following hypotheses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Different responses of highway contractors of the grades 1, 2, and 3 were expected for the factor of economic conditions.

H_1: Most highway contractors of the grades 1, 2, and 3 agreed on the level of severity of the factor of economic conditions.

For the comparison between different the grades of highway contractors, a chi-square test was applied and the *P*-value (0.026) obtained from table 54 shows that the null hypothesis was rejected, which means that most highway contractors of the grades 1, 2, and 3 agreed on the level of severity of the factor of economic conditions.

The results showed that 43% of respondents agreed that economic conditions are a very severe factor, 26% agreed that this factor is somewhat severe, and 18% agreed that this factor is severe. Only two of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and about two-thirds of the grade 3 highway contractors agreed on the very severe level of this factor, whereas about two-thirds of the grade 1 highway contractors, only one of the grade 2 highway contractors, and about one-third of the grade 3 highway contractors agreed on the severity of this factor.

Severity indices of 66%, 97%, and 93% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 81% (3rd rank) of the severity index were recorded for all contractors, which is a strong agreement toward this factor as a driver for contractor unit cost preparation. This strong agreement is normal in the construction industry because of the current economic conditions of Saudi Arabia, as contractors are encouraged to lower their prices in order to get work in such poor construction industry conditions.

For further comparison between contractors and consultants, the results of table 56 demonstrated that both contractors and consultants agreed on their level of severity toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 55 revealed that the consultants' severity index of 74% (3rd rank) was recognized for this factor. This high severity toward this factor was because many contractors lowered their prices in order to get more work in the current poor economic conditions.

- **Contractor qualification:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.6) obtained from table 54, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of contractor qualification.

The results showed that 43% of respondents agreed that contractor qualification is a very severe factor, 36% agreed that this factor is somewhat severe, and 8% agreed that this factor is severe. About one-third of the grade 1 highway contractors, more than one-third of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors agreed on the very severe level of this factor, whereas about half of the grade 1 highway contractors, more than a third of the grade 2 highway contractors, and about one-third of the grade 3 highway contractors agreed on the severity of this factor.

Severity indices of 78%, 87%, and 93% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 85% (2nd rank) of the severity index were recorded for all contractors, which is a strong agreement toward this factor as a driver for contractor unit cost preparation. A strong agreement resulted because higher qualifications of contractors leads to a high quality product, and that implies higher prices and vice versa.

For further comparison between contractors and consultants, the results in table 56 indicated that both contractors and consultants agreed on their level of severity toward this factor, based on significant values of the F-test and T-test. Moreover, the results in table 55 revealed that the consultants' severity index of 78% (2nd rank) was recognized for this factor. This high severity toward this factor was because of the different grades of qualifications involved in highway construction, and the resulting different qualities of highway construction products.

- **Project location:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.319) obtained from table 54, different responses of highway contractors of the grades 1, 2, and 3 resulted for the factor of project location.

The results showed that 54% of respondents agreed that project location is a very severe factor, 32% agreed that this factor is somewhat severe, and 11% agreed that this factor is severe. About half of the grade 1 highway contractors, more than one-third of the grade 2 highway contractors, and more than three-quarters of the grade 3 highway contractors agreed on the very severe level of this factor, whereas more than half of the grade 1 highway contractors, more than one-third of the grade 2 highway contractors, and about one-quarter of the grade 3 highway contractors agreed on the severity of this factor.

Severity indices of 85%, 90%, and 95% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 89% (1^{st} rank) of the severity index was recorded for all contractors, which is a strong agreement toward this factor as a driver for contractor unit cost preparation. The high agreement with this factor resulted mainly because remote projects imply more accommodation or transportation costs, and hence higher prices are expected and vice versa.

For further comparison between contractors and consultants, further hypotheses regarding variances and means of both contractors' and consultants' responses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Variances between contractors' and consultants' responses are equal.

H_1: Variances between contractors' and consultants' responses are not equal.

The resulting F-test value for this factor was (0.052) which means that the null hypothesis was rejected and the variances were not equal.

Therefore, further hypotheses were conducted to determine whether the means of both consultants and contractors were equal or not, as shown below:

Ho: Means of contractors' and consultants' responses are equal.

H_1: Means of contractors' and consultants' responses are not equal.

The resulting T-test value for this factor was (0.720) which means that the null hypothesis was accepted and their means were equal.

Therefore, both contractors and consultants agreed on their level of agreements toward this factor. Moreover, the results in table 55 revealed that the consultants' severity index of 74% (4th rank) was recognized for this factor. This high severity toward this factor was because of extra costs incurred related to accommodation, transportation and many other services in the case of remote projects, which in turn affect the unit cost of items.

5.8 The main consequences of quantities underestimation

After the analysis of responses collected, the results of the main consequences that may result due to quantities underestimation is shown in table 57 below. This table presents the number of respondents who had different levels of agreements (frequencies) toward potential quantities underestimation consequences, with respect to their contracting company's grades. In addition, agreement indices were calculated and presented in a descending order, as shown in the table below:

Table 57: Contractors agreements indices for Quantities Underestimation Consequences

Quantities Underestimation Consequences	Grade 1	Grade 2	Grade 3	**All**
Project delay due to lack of fund	83%	100%	95%	90%
Increased project cost	83%	83%	93%	86%
Failure of payments to contractors	83%	83%	93%	86%
Deletion of some project items or scope reduction	75%	93%	90%	84%
Failure in completing the project	75%	87%	93%	83%
Owners difficulty in obtaining future fund	74%	90%	85%	81%
Litigation due to contract breach	71%	70%	80%	73%

However, table 58 shows the results of a chi-square test that was used to determine if there was any association between different responses toward these consequences of the different grades of contractors.

Table 58: Chi-square test for Quantities Underestimation Consequences

Quantities Underestimation Consequences	Chi-Square Tests		
	Value	Df	Asymp. Sig. (2-sided)
Owners difficulty in obtaining future fund	6.694a	6	.350
Project delay due to lack of fund	9.515a	4	**.049**
Deletion of some project items or scope reduction	7.804a	6	.253
Failure of payments to contractors	5.500a	6	.481
Litigation due to contract breach	13.283a	6	**.039**
Failure in completing the project	8.350a	6	.214
Increased project cost	11.928a	6	.064

In addition, further comparisons between consultants and contractors' responses were conducted to determine the different perspectives of those parties toward the potential consequences of quantities underestimation. Table 59 shows the resulting frequencies of responses and the agreement indices of consultants toward these consequences.

Table 59: Consultants agreements indices for Quantities Underestimation Consequences

Quantities Underestimation Consequences	Agreement index
Project delay due to lack of fund	**84%**
Increased project cost	**82%**
Deletion of some project items or scope reduction	**81%**
Owners difficulty in obtaining future fund	**81%**
Failure in completing the project	**78%**
Failure of payments to contractors	**75%**
Litigation due to contract breach	**70%**

The following table also shows The F-test and T-test used to determine if there was any agreement between contractors and consultants responses regarding these consequences.

Table 60: F-test and T-test for Quantities Underestimation Consequences

Quantities Underestimation Consequences	Comparison	Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	T	Sig.
Owners difficulty in obtaining future fund	Equal variances assumed	.254	.628	.322	.756
	Equal variances not assumed			.322	.756
Project Delay due to lack of fund	Equal variances assumed	.789	.400	.333	.748
	Equal variances not assumed			.333	.748
Deletion of some project items or scope reduction	Equal variances assumed	1.630	.237	.409	.693
	Equal variances not assumed			.409	.694
Failure of payments to contractors	Equal variances assumed	5.694	.044	.352	.734
	Equal variances not assumed			.352	.736
Litigation due to contract breach	Equal variances assumed	.177	.685	.419	.686
	Equal variances not assumed			.419	.686
Failure in completing the project	Equal variances assumed	.242	.636	.414	.690
	Equal variances not assumed			.414	.690
Increased project cost	Equal variances assumed	.834	.388	.447	.667
	Equal variances not assumed			.447	.667

- **The owners will face difficulties to obtain future funding for their projects:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.35) obtained from table 58, different responses of highway contractors of the grades 1, 2, and 3 resulted for the consequence of owners' difficulties to obtain future funding for their projects.

The results showed that 40% of respondents strongly agreed, and 43% agreed, on the consequence of owners' difficulties to obtain future funding. Only two of the grade 1 highway contractors, about half of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors strongly agreed on this consequence, whereas more than half of the grade 1 highway contractors, about half of the grade 2 highway contractors, and more than one-quarter of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 74%, 90%, and 85% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 81% (6^{th} rank) of the agreements index was recorded for all contractors, which is a strong agreement toward this consequence for quantities variations. This strong agreement with this consequence resulted mainly because there are governmental regulations that restrict supplying additional funds for a highway project for more than 10% of the project cost.

For further comparison between contractors and consultants, the results in table 60 indicated that both contractors and consultants agreed on their level of agreements toward this consequence based on significant values of the F-test and T-test. Moreover, the results in table 59 revealed that the consultants' agreement index of 81% (4^{th} rank) was recognized for this consequence. This strong agreement toward this consequence was because of many projects delays experienced due to lack of a budget, and strict governmental regulations for funding support issues.

- **Project delay due to lack of funds:**

In order to study this consequence with respect to the different grades of contractors, the following hypotheses conducted for the possible rejection or acceptance of *Ho*:

Ho: Different responses of highway contractors of the grades 1, 2, and 3 were expected for the consequence of project delay due to lack of funds.

$H_{1:}$ Most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the consequence of project delay due to lack of funds.

For the comparison between different the grades of highway contractors, a chi-square test was applied and the *P*-value (0.049) obtained from table 58 shows that the null hypothesis was rejected which means that it is correct that most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the consequence of project delay due to lack of funds.

The results showed that 57% of respondents strongly agreed, and 35% agreed, on the consequence of project delay due to lack of funds. About one-third of the grade 1 highway contractors, nearly all of the grade 2 highway contractors, and more than three-quarters of the grade 3 highway contractors strongly agreed on this consequence, whereas more than two-thirds of the grade 1 highway contractors, none of the grade 2 highway contractors, and more than one-quarter of the grade 3 highway contractors agreed on this consequence. Agreement indices of 83%, 100%, and 95% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 90% (1st rank) of the agreements index was recorded for all contractors, which is a very strong agreement toward this consequence for quantities variations. This highly strong agreement with this consequence could be justified for excessive delays that were and are still experienced, especially in highway projects in Saudi Arabia, which in turn may be a result of incomplete designs and unclear underground utilities.

For further comparison between contractors and consultants, the results in table 60 revealed that both contractors and consultants agreed on their level of agreements toward this consequence, based on significant values of the F-test and T-test. Moreover, the results in table 59 revealed that the consultants' agreement index of 84% (1st rank) was recognized for this consequence. This strong agreement toward this consequence was because excessive delays resulted because of poor quantities estimation.

- **Deletion of some project items or scope reduction:**

After studying this factor with respect to the different grades of contractors, the results indicated that, based on the P-value (0.253) obtained from table 58, different responses of highway contractors of the grades 1, 2, and 3 resulted for the consequence of deletion of some project items or scope reduction.

The results showed that only 40% of respondents strongly agreed, and 39% agreed, on the consequence of deletion of some project items or scope reduction. It is interesting to show that 14% of contractors were neutral. About a quarter of the grade 1 highway contractors, more than half of the grade 2 highway contractors, and half of the grade 3 highway contractors strongly agreed on this consequence, whereas more than third of the grade 1 highway contractors, more than a quarter of the grade 2 highway contractors, and half of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 75%, 93%, and 90% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 84% (4th rank) of the agreements index was recorded for all contractors, which is a strong agreement toward this consequence for quantities variations. This result was noticeably clear in the above project case studies that were followed by the owners to allow for the available allocated project budget.

For further comparison between contractors and consultants, the results in table 60 showed that both contractors and consultants agreed on their level of agreements toward this consequence, based on significant values of the F-test and T-test. Moreover, the results in table 59 revealed that the consultants' agreement index of 81% (3rd rank) was recognized for this consequence. This high agreement toward this consequence was normal, due to the usual practices followed by owners in case of inadequate project budgets, which is also supported by the results of case studies.

- **Failure of payments to contractors:**

After studying this factor with respect to the different grades of contractors, the results revealed that, based on the P-value (0.481) obtained from table 58, different responses of highway contractors of the grades 1, 2, and 3 resulted for the consequence of failure of payments to contractors.

The results showed that only 40% of respondents strongly agreed, and 53% agreed, on the consequence of failure of payments to contractors. More than one-third of the grade 1 highway contractors, only one of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors strongly agreed on this consequence, whereas about half of the grade 1 highway contractors, almost all of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 83%, 83%, and 93% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 86% (3rd rank) of the agreements index was recorded for all contractors, which is a strong agreement toward this consequence for quantities variations. This result is obvious, and is often criticized by contractors dealing with government highway projects.

For further comparison between contractors and consultants, further hypotheses regarding variances and means of both contractors' and consultants' responses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Variances between contractors and consultants responses are equal.

$H_{1:}$ Variances between contractors and consultants responses are not equal.

The resulting F-test value for this factor was (0.044) which means that the null hypothesis was rejected and the variances were not equal.

Therefore, further hypotheses were conducted to determine whether the means of both consultants and contractors were equal or not, as shown below:

Ho: Means of contractors and consultants responses are equal.

$H_{1:}$ Means of contractors and consultants responses are not equal.

The resulting T-test value for this consequence was (0.736), which means that the null hypothesis was accepted and their means were equal.

Therefore, both contractors and consultants agreed on their level of agreements toward this consequence. Moreover, the results in table 59 revealed that the consultants' agreement index of 75% (6^{th} rank) was recognized for this consequence. This normal agreement toward this consequence was because many contractors suffer from payment delays in the Saudi Arabian construction industry, especially with highway projects.

- **Litigation due to contract breach:**

In order to study this consequence with respect to the different grades of contractors, the following hypotheses conducted for the possible rejection or acceptance of *Ho*:

Ho: Different responses of highway contractors of the grades 1, 2, and 3 were expected for the consequence of litigation due to contract breach.

$H_{1:}$ Most highway contractors of the grades 1, 2, and 3 agreed or strongly agreed with the consequence of litigation due to contract breach.

For the comparison between the different grades of highway contractors, a chi-square test was applied and the *P*-value (0.039) obtained from table 58 shows that the null hypothesis was rejected, which means that it is correct that most highway contractors of the grades 1, 2, and 3 agreed about their responses with the consequence of litigation due to contract breach.

The results showed that only 12% of respondents strongly agreed, and 47% agreed, on the consequence of litigation due to contract breach. It is interesting to show that 24% of contractors were neutral and 14% disagreed with this consequence. Only one of the grade 1 highway contractors, one of the grade 2 highway contractors, and one of the grade 3 highway contractors strongly agreed on this consequence, whereas more than one-third of the grade 1 highway contractors, more than one-third of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 71%, 70%, and 80% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 73% (7^{th} rank) of the agreements index was recorded for all contractors, which is a normal level agreement toward this consequence for quantities variations. This normal agreement with this consequence resulted mainly because many contractors are suffering from payment delays by owners of highway projects, and where, in many cases contractors prefer not to sue the owners.

For further comparison between contractors and consultants, the results in table 60 indicated that both contractors and consultants agreed on their level of agreements toward this consequence, based on significant values of the F-test and T-test. Moreover, the results in table 59 revealed that the consultants' agreement index of 70% (7th rank) with the lowest agreement level in underestimation consequences was recognized for this consequence. This agreement toward this consequence was a normal outcome of delays in agreed payments.

- **Failure in completing the project:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.214) obtained from table 58, different responses of highway contractors of the grades 1, 2, and 3 resulted for the consequence of failure in completing the project.

The results showed that only 36% of respondents strongly agreed, and 43% agreed, on the consequence of failure in completing the project. It is interesting to show that 14% of contractors were neutral and 4% disagreed with this consequence. About one-third of the grade 1 highway contractors, more than a quarter of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors strongly agreed on this consequence, whereas more than one-third of the grade 1 highway contractors, more than half of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 75%, 87%, and 93% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 83% (6th rank) of the agreements index was recorded for all contractors, which is a strong agreement toward this consequence for quantities variations. This strong agreement with the consequence of failure in completing a project is a usual outcome of the practice of owners' deletion of some project items or a scope reduction.

For further comparison between contractors and consultants, the results in table 60 indicated that both contractors and consultants agreed on their level of agreements toward this consequence, based on significant values of the F-test and T-test. Moreover, the results in table 59 revealed that the consultants' agreement index of 78% (5th rank) was recognized for this consequence. This agreement toward this consequence is a normal outcome of the deletion of project items or scope reduction, in the case of cost-overruns, which is also supported by the case studies' results above.

- **Increased project cost:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.064) obtained from table 58, different responses of highway contractors of the grades 1, 2, and 3 resulted for the consequence of increased project cost.

The results showed that 43% of respondents strongly agreed, and 42% agreed, on the consequence of increased project cost. More than quarter of the grade 1 highway contractors, more than half of the grade 2 highway contractors, and more than two-thirds of the grade 3 highway contractors strongly agreed on this consequence, whereas more than two-thirds of the grade 1 highway contractors, none of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 83%, 83%, and 93% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 86% (2nd rank) of the agreements index was recorded for all contractors, which is a strong agreement toward this consequence for quantities variations. This result concluded the first objective of this study, which is related to quantities variation, which in most cases leads to cost-overrun.

For further comparison between contractors and consultants, the results in table 60 revealed that both contractors and consultants agreed on their level of agreements toward this consequence, based on significant values of the F-test and T-test. Moreover, the results in table 59 revealed that the consultants' agreement index of 82% (2nd rank) was recognized for this consequence. This high agreement toward this consequence was because it is the most frequent and experienced consequence of quantities underestimation of highway projects in Saudi Arabia.

5.9 The main Consequences of quantities overestimation

After SPSS analysis of responses collected, the results of the main consequences that may result due to quantities overestimation is shown below. Table 61 presents the number of respondents who had different levels of agreements toward potential quantities overestimation consequences, with respect to their contracting company's grades. Additionally, agreement indices were also shown in the table below:

Table 61: Contractors' agreements indices for Quantities Overestimation Consequences

Quantities Overestimation Consequences	Grade 1	Grade 2	Grade 3	**All**
Increased contractor project overhead	88%	93%	93%	90%
Contractors Seek To Cover Overhead Through Change Orders	85%	90%	93%	88%
Contractors cut corners to recover overhead	80%	90%	80%	82%
Contractors unbalance the bid	77%	77%	85%	79%
Limited fund for other projects in the pipeline	74%	77%	75%	75%

However, table 62 shows the results of chi-square test that was used to determine if there is any association between different responses toward these consequences of different grades of contractors.

Table 62: Chi-square test for Quantities Underestimation Consequences

Quantities Overestimation Consequences	**Chi-Square Tests**		
	Value	**Df**	**Asymp. Sig. (2-sided)**
Increased contractor project overhead	**1.824a**	**2**	**.402**
Contractors cut corners to recover overhead	**3.242a**	**6**	**.778**
Contractors unbalance the bid	**8.988a**	**6**	**.174**
Contractors seek to cover overhead through change orders	**2.891a**	**4**	**.576**
Limited fund for other projects in the pipeline	**5.175a**	**6**	**.522**

On the other hand, further comparisons between consultants and contractors' responses were conducted to determine different perspectives of those parties toward potential quantities underestimation consequences. Table 63 shows the resulting frequencies of responses for consultants and their agreement indices toward these consequences.

Table 63: Consultants' agreement indices for Quantities Overestimation Consequences

Quantities Overestimation Consequences	Agreement index
Increased contractor project overhead	**75%**
Contractors cut corners to recover overhead	**75%**
Contractors unbalance the bid	**74%**
Contractors seek to cover overhead using change orders	**73%**
Limited fund for other projects in the pipeline	**70%**

The following table also shows The F-test and T-test used to determine if there was any agreement between contractors and consultants responses regarding these consequences.

Table 64: F-test and T-test for Quantities Overestimation Consequences

Quantities Overestimation Consequences	Comparison	Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	T	Sig. (2-tailed)
Increased Contractor Project Overhead	Equal variances assumed	13.336	.006	.322	.749
	Equal variances not assumed			.322	.752
Contractors Cut Corners To Recover Overhead	Equal variances assumed	.649	.444	.374	.718
	Equal variances not assumed			.374	.718
Contractors Unbalance The Bid	Equal variances assumed	.609	.457	.499	.631
	Equal variances not assumed			.499	.631
Contractors Seek To Cover Overhead Through Change Orders	Equal variances assumed	5.505	.047	.470	.651
	Equal variances not assumed			.470	.651
Limited Fund For Other Projects In The Pipeline	Equal variances assumed	.810	.394	.325	.753
	Equal variances not assumed			.325	.756

- **Increased contractor project overhead:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.402) obtained from table 62, different responses of highway contractors of the grades 1, 2, and 3 resulted for the consequence of increased contractor project overhead.

The results showed that 50% of respondents strongly agreed, and 46% agreed, on the consequence of increased contractor project overhead. More than one-third of the grade 1 highway contractors, more than two-thirds of the grade 2 highway contractors, and about two-thirds of the grade 3 highway contractors strongly agreed on this consequence, whereas about two-thirds of the grade 1 highway contractors, more than one-quarter of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 88%, 93%, and 93% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 90% (1^{st} rank) of the agreements index was recorded for all contractors, which is a very strong agreement toward this consequence for quantities variations. This is a normal outcome for quantities overestimation, and results because of design changes, or scope reduction, or any other reason by the owners. This results in lower profits realized by contractors.

For further comparison between contractors and consultants, further hypotheses regarding variances and means of both contractors' and consultants' responses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Variances between contractors and consultants responses are equal.

H_1: Variances between contractors and consultants responses are not equal.

The resulting F-test value for this factor was (0.006), obtained from table 64, which means that the null hypothesis was rejected and the variances were not equal.

Therefore, further hypotheses were conducted to determine whether the means of both consultants and contractors were equal or not, as shown below:

Ho: Means of contractors and consultants responses are equal.

H_1: Means of contractors and consultants responses are not equal.

The resulting T-test value for this consequence obtained from table 64 was (0.752), which means that the null hypothesis was accepted and their means were equal.

Therefore, both contractors and consultants agreed on their level of agreements toward this consequence. Moreover, the results in table 63 revealed that the consultants' agreement index of 75% (1st rank) was recognized for this consequence. This normal agreement toward this consequence was because many consultants believe that a contractor's extra costs are incurred due to quantities overestimation.

- **Contractors cut corners to recover overhead:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.778) obtained from table 62, different responses of highway contractors of the grades 1, 2, and 3 resulted for the consequence of cutting corners by contractors.

The results showed that 32% of respondents strongly agreed, and 47% agreed, on the consequence of cutting corners by contractors. It is interesting to show that 14% of contractors were neutral and 4% disagreed with this consequence. About one-third of the grade 1 highway contractors, and more than one-third of the grade 2 highway contractors, and more than one-quarter of the grade 3 highway contractors strongly agreed on this consequence, whereas about half of the grade 1 highway contractors, and more than one-third of the grade 2 highway contractors, and more than half of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 80%, 90%, and 80% f were recorded for the grades 1, 2, and 3 contractors respectively, whereas a total of 82% (3rd rank) of the agreements index was recorded for all contractors, which is a strong agreement toward this consequence for quantities variations. This strong agreement could be justified because of the usual low qualities practiced by contractors in the case of profit loss.

For further comparison between contractors and consultants, the results in table 64 revealed that both contractors and consultants agreed on their level of agreements toward this consequence, based on significant values of the F-test and T-test. Moreover, the results in table 63 revealed that the consultants' agreement index of 75% (2nd rank) was recognized for this consequence. This normal agreement toward this consequence was because many consultants experience low qualities in the case of project overestimation or scope reduction.

- **Contractors unbalance the bid:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.174) obtained from table 62, different responses of highway contractors of the grades 1, 2, and 3 resulted for the consequence of unbalancing the contract by contractors.

The results showed that 30% of respondents strongly agreed, and 39% agreed, on the factor of consequence of unbalancing the contract by contractors. It is interesting to show that 24% of contractors were neutral and 4% disagreed with this consequence. About a quarter of the grade 1 highway contractors, only one of the grade 2 highway contractors, and more than half of the grade 3 highway contractors strongly agreed on this consequence, whereas more than one-third of the grade 1 highway contractors, and more than half of the grade 2 highway contractors, and more than a quarter of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 77%, 77%, and 85% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 79% (4^{th} rank) of the agreements index was recorded for all contractors, which is a normal agreement toward this consequence for quantities variations. This is not really an adequate result, because nearly all contractors unbalance their bids to maintain their profit margin in the case of quantities overestimation, but they are biased in answering such an important question.

For further comparison between contractors and consultants, the results in table 64 revealed that both contractors and consultants agreed on their level of agreements toward this consequence, based on significant values of the F-test and T-test. Moreover, the results in table 63 revealed that the consultants' agreement index of 74% (3^{rd} rank) was recognized for this consequence. This normal agreement toward this consequence was because many contractors were found to have many loose items in their bids.

- **Contractor seeks to cover overhead through change orders:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.576) obtained from table 62, different responses of highway contractors of the grades 1, 2, and 3 resulted for the consequence of the contractors' usual practice of covering overhead through change orders.

The results showed that 47% of respondents strongly agreed, and 43% agreed, on the contractors practice to cover overhead through change orders. More than one-third of the grade 1 highway contractors, and more than one-third of the grade 2 highway contractors, and about two-thirds of the grade 3 highway contractors strongly agreed on this consequence, whereas more than half of the grade 1 highway contractors, and more than one-third of the grade 2 highway contractors, and more than one-third of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 85%, 90%, and 93% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 88% (2^{nd} rank) of the agreements index was recorded for all contractors, which is a strong agreement toward this consequence for quantities variations. This strong agreement reflects the common practice of seeking change orders by contractors in case they experience lower profit margins.

For further comparison between contractors and consultants, further hypotheses regarding variances and means of both contractors' and consultants' responses were conducted for the possible rejection or acceptance of *Ho*:

Ho: Variances between contractors and consultants responses are equal.

$H_{1:}$ Variances between contractors and consultants responses are not equal.

The resulting F-test value for this factor was (0.047), which means that the null hypothesis was rejected and the variances were not equal.

Therefore, further hypotheses were conducted to determine whether the means of both consultants and contractors were equal or not, as shown below:

Ho: Means of contractors and consultants responses are equal.

H_1: Means of contractors and consultants responses are not equal.

The resulting T-test value for this consequence was (0.651) which means that the null hypothesis was accepted and their means were equal.

Therefore, both contractors and consultants agreed on their level of agreements toward this consequence. Moreover, the results in table 63 revealed that the consultants' agreement index of 73% (4th rank) was recognized for this consequence. This normal agreement toward this consequence was because many contractors were always complaining about the need to substitute their profit losses due to overestimation or scope reduction.

- **Limit funds for other projects in the pipeline:**

After studying this factor with respect to the different grades of contractors, it was found that, based on the P-value (0.522) obtained from table 62, different responses of highway contractors of the grades 1, 2, and 3 resulted for the consequence of limited funds for other projects in the pipeline.

The results showed that only 8% of respondents strongly agreed, and 63% agreed, on the consequence of limited funds for other projects in the pipeline. It is interesting to show that 18% of contractors were neutral and 8% disagreed with this consequence. Only one of the grade 1 highway contractors, one of the grade 2 highway contractors, and none of the grade 3 highway contractors strongly agreed on this consequence, whereas more than half of the grade 1 highway contractors, more than one-third of the grade 2 highway contractors, and nearly all of the grade 3 highway contractors agreed on this consequence.

Agreement indices of 74%, 77%, and 77% were recorded for the grade 1, 2, and 3 contractors respectively, whereas a total of 75% (2nd rank) of the agreements index was recorded for all contractors, which is a normal agreement toward this consequence for quantities variations. This result is not really significant, because owners always allocate a specified separate budget for each project.

For further comparison between contractors and consultants, the results in table 64 revealed that both contractors and consultants agreed on their level of agreements toward this consequence, based on significant values of the F-test and T-test. Moreover, the results in table 63 revealed that the consultants' agreement index of 70% (5th rank) was recognized for this consequence. This normal agreement toward this consequence was because many owners reduced the scopes of some projects to satisfy other important requirements in other projects.

5.10 Summary of questionnaires results

As discussed earlier, many factors for quantities variations, unit cost estimation factors, and consequences of quantities variations had different level of agreements. Table 65 below summarizes the most important factors for quantities variations whether it is technical reasons, estimators performance related reasons, or economic, social, and political reasons.

Table 65: most important factors for quantities variations based on perspectives of contractors and consultants

Quantities variations factors	Agreement index for contractors	Agreement index for consultants	Caused by
Forecasting errors due to lack of data	**89%**	**87%**	**Owners and consultants**
Poor coordination between public agencies	**85%**	**79%**	**Owners**
Unforeseen site conditions	**84%**	**79%**	**Site**
Forecasting errors due to unknown site conditions by consultant	**82%**	**68%**	**Consultants**
Unclear underground utilities	**81%**	**83%**	**Owners**
Forecasting errors due to poor consultant take-off	**81%**	**68%**	**Consultants**
Unqualified estimators	**81%**	**68%**	**Consultants**
Inaccuracy in measuring risks	**80%**	**69%**	**Consultants**
Limited time for estimation	**79%**	**72%**	**Owners**

As shown in table 65 above, the most important factors with the highest agreement indices based on contractors' perspectives were: Forecasting errors due to lack of data, Poor coordination between public agencies, Unforeseen site conditions, Forecasting errors due to unknown site conditions by consultant, Unclear underground utilities, and Forecasting errors due to poor consultant take-off respectively, which are really the most important factors for quantities variation in the Saudi Arabian construction industry. However, the most important factors with the highest agreement indices, based on consultants" perspectives, were Forecasting errors due to lack of data, Unclear underground utilities, Poor coordination between public agencies, Unforeseen site conditions, and Limited time for estimation respectively. Moreover, the first six important factors, based on contractors' perspectives, were technical reasons factors and the first seven important factors, based on consultants' perspectives, were also technical reasons factors; this demonstrates the significance and importance of technical reasons as major drivers for quantities variations, whereas economic, social, and political factors had the lowest agreement indices, especially Satisfaction of owner inclination for low cost, Neighbors’ and shopkeepers’ complaints, Overestimating to have enough budget, and Underestimating to secure funds factors for both contractors and consultants.

The table also shows that important differences between contractors and consultant's responses of more than 10% in their agreement indices found for the following factors: Forecasting errors due to unknown site conditions by consultant, Forecasting errors due to poor consultant take-off, unqualified estimators, and inaccuracy in measuring risks. This may be justified due to bias of consultant responses because these factors imply that consultants are poorly doing their works. In addition, significant factors showed in the table above are mainly caused by owners and consultants. Forecasting errors due to lack of data, which was supported by many researchers as an important factor for quantities variations, is always caused by owners and consultants. Poor coordination between public agencies, unclear underground utilities, and limited time for estimation are important factors caused by owners, whereas Forecasting errors due to unknown site conditions by consultant, Forecasting errors due to poor consultant take-off, unqualified estimators, and Inaccuracy in measuring risks are caused by consultant's poor abilities.

On the other hand, table 66 presents the most severe factors for the estimation of unit cost, which, for contractors, were project location, contractor qualification, and quantity of item; conversely, quantity of item, contractor qualification, and economic conditions were the most severe factors for consultants.

Table 66: Most important factors for unit cost based on perspectives of contractors and consultants

Unit Cost Estimation Factors	Severity index (contractors)	Severity Index
Project location	89%	74%
Contractor qualification	85%	78%
Quantity of item	84%	87%
Economic conditions	81%	74%
Associated risk of an item	81%	71%
Estimation method used	74%	60%
Number Of bidders	71%	64%

The table shows that project location is more important for contractors than consultants, of more than 10% difference in agreement indices, because contractors are more aware of extra costs they incurred due to remote sites. Not only project location is more important for contractors, but nearly all of unit cost estimation factors are more important for contractors since they are the ones who are involved in and affected because of these factors.

However, the most important consequences of quantities underestimation and quantities overestimation are shown below, in tables 67 and 68 respectively:

Table 67: Most common consequences of quantities underestimation based on perspectives of contractors and consultants

Quantities Underestimation Consequences	Agreement Index of contractors	Agreement index of consultants
Project delay due to lack of fund	90%	84%
Increased project cost	86%	82%
Failure of payments to contractors	86%	75%
Deletion of some project items or scope reduction	84%	81%
Failure in completing the project	83%	78%
Owners difficulty in obtaining future fund	81%	81%
Litigation due to contract breach	73%	70%

The table above shows that Project delay due to lack of fund, Increased project cost, Failure of payments to contractors, and deletion of some project items or scope reduction were the most common consequences experienced due to quantities underestimation in

Saudi Arabia, for both contractors and consultants. In addition, more agreement indices are recorded by contractors because they are more involved and usually experience these consequences in reality.

Table 68: Most common consequences of quantities overestimation based on perspectives of contractors and consultants

Quantities Overestimation Consequences	Agreement Index of contractors	Agreement index of consultants
Increased contractor project overhead	90%	75%
Contractors Seek To Cover Overhead Through Change Orders	88%	73%
Contractors cut corners to recover overhead	82%	75%
Contractors unbalance the bid	79%	74%
Limited fund for other projects in the pipeline	75%	70%

The above table shows that increased contractor project overhead was the most common consequences experienced due to quantities overestimation in Saudi Arabia, for both contractors and consultants. Again, more agreement indices are recorded by contractors because they experience these consequences where consultants do not.

However, consequences of quantities overestimation exhibited lower agreement indices than consequences of quantities underestimation, which in turn indicates that quantities underestimation is more common than quantities overestimation in highway construction projects in Saudi Arabia.

CHAPTER SIX: SUMMARY OF THE STUDY, CONCLUSION AND RECOMMENDATIONS

This chapter presents the summary of this study, the methodology that were used to collect the data in order to satisfy the main objectives of the study, major and minor findings of the study, and recommendations for further studies.

6.1 Summary of the study

Cost estimation is of great importance for all parties involved in the construction industry. Its importance is greater than any project engineering and construction activities since it is the earliest activity required before starting any construction project. It also becomes greater due to estimation inaccuracy and quantities variations experienced in most construction projects especially highway projects in Saudi Arabia.

Therefore, the study aimed to measure the extent of quantities variations practiced in construction highway projects in Saudi Arabia, to find the major reasons for quantities variations, and to find the major consequences of quantities variations experienced in construction of highway projects in Saudi Arabia.

The first objective was fulfilled through five case studies that represented five construction highway projects that were recently constructed in the eastern province of Saudi Arabia. These case studies were used to measure the difference of the estimated quantities for a highway project and the actual quantities that were installed in the site of the project. Moreover, many reasons and consequences of quantities variations were clearly resulted after completing these case studies.

The second and third objectives were fulfilled through a questionnaire survey distributed for both contractors and consultants that are involved in the construction industry in the eastern province of Saudi Arabia. Two sets of questionnaires were prepared and sent for contractors and consultants to collect the required data. 28 contractors and 20 consultants have responded for these questionnaires in which their data were used to find the major reasons and consequences of quantities variations.

6.2 Findings

This section provides the major findings of this study while presenting many other minor findings that were resulted throughout the study.

6.2.1 Major findings

The major findings of the study that can be concluded from the results presented in chapter 5 are listed below:

- In most cases, highway construction projects experienced more that 10% underestimation (cost overrun), and in many cases there was more than 30% cost overrun in some highway construction projects.
- Based on the results of the case studies, the most important reasons for quantities variations included estimation errors due to lack of data, unknown site requirements by consultants due to no visits conducted for their projects' sites (in many cases), and most importantly, the unclear underground utilities plans and drawings. The most important consequences of quantities underestimation concluded from these case studies included increased project cost, deletion of some project items or scope reduction, project delay due to lack of funds, and failure in completing the project.

- More than 90% of grade 1 highway contractors, more than half of grade 2 highway contractors, and about three-quarters of grade 3 highway contractors agreed that they usually found more than 5% to less than 75% difference between their estimate and the owners' estimates.
- The results showed that 53% of consultants admitted that 5% to less than 25% of actual projects estimates were significantly different than their estimates, and 9% of consultants admitted that 25% to less than 50% of actual projects estimates were significantly different than their estimates, whereas 38% of consultants admitted that less than 5% of actual projects estimates are significantly different than their estimates. There is an association between the percentage of construction projects with actual quantities that are significantly different from their estimated quantities, and the average number of estimators involved, where the lower the number of estimators involved, the more the percentages of projects with actual quantities that are significantly different from their estimated quantities.
- The results showed that grade 1, 2, and 3 contractors had different responses toward technical reasons factors for quantities variations, except for forecasting errors due to poor quantities take-off and quality control by consultant factor, and unclear underground utilities plans factor, in which nearly all contractors of different grades agreed or strongly agreed with these factors.
- The results showed that grade 1, 2, and 3 contractors had different responses toward factors related performance of estimators for quantities variations, except for inaccuracy in measuring risks factor, in which nearly all contractors of different grades had similar levels of agreements with this factor.

- Technical reason factors recorded the most agreement indices levels, which demonstrated its importance and significance for quantities variations, whereas economic, social, and political factors recorded the lowest agreement indices levels as a quantities variations factors.
- All contractors and consultants had similar responses toward factors of quantities variations, unit cost estimation factors, and consequences of quantities variations.
- Forecasting errors due to lack of data, Poor coordination between public agencies, Unforeseen site conditions, Forecasting errors due to unknown site conditions by consultant, Unclear underground utilities, and Forecasting errors due to poor consultant take-off recorded the highest agreement indices respectively (more than 80%) as the most important factors for quantities variations by contractors.
- Forecasting errors due to lack of data, Unclear underground utilities, Poor coordination between public agencies, Unforeseen site conditions, and Limited time for estimation recorded the highest agreement indices respectively (close to 80%) as the most important factors for quantities variations by consultants.
- Project location, contractor qualification, and quantity of item were the most severe factors for unit cost estimation for contractors with the highest agreement indices respectively (more than 84%), whereas quantity of item, contractor qualification, and economic conditions are the most severe factors for unit cost estimation for consultants with the highest agreement indices respectively (more than 74%).
- The results showed that grade 1, 2, and 3 contractors had different responses toward economic, social, and political reasons factors for quantities variations, except for the

Underestimating to secure project funds factor, on which nearly all contractors of different grades agreed or strongly agreed with these factors.

- Project delay due to lack of funds, Increased project cost, and Deletion of some project items or scope reduction were the most common consequences experienced due to quantities underestimation in Saudi Arabia (with more than 84% agreement indices), for both contractors and consultants.

- The results showed that half of contractors strongly agreed and 43% agreed on the factor of forecasting errors due to lack of data. Nearly all of the grade 1, 2, and 3 highway contractors agreed on this factor.
- The results showed that 36% of respondents strongly agreed and 46% agreed on the factor of forecasting errors because of unknown site requirements by the consultant. Nearly all of the grade 1, and 3, and more than half of the grade 2 highway contractors agreed on this factor.
- The results showed that 32% of respondents strongly agreed, and half of them agreed on the factor of forecasting errors due to poor quantities take-off and quality control by the consultant. Nearly all of the grade 1, and 3 and all of the grade 2 highway contractors agreed on this factor.

- The results showed that 36% of respondents strongly agreed, and more than half of them agreed on the factor of unforeseen site conditions.

- The results showed that 26% of respondents strongly agreed, and 53% agreed on the factor of unclear underground utilities plans. More than two-thirds of the grade 1 highway contractors, all of the grade 2 highway contractors, and more than two- thirds of grade 3 highway contractors agreed or strongly agreed on this factor.

- The results showed that 36% of respondents strongly agreed, and 57% agreed, on the factor of poor coordination between public agencies works and requirements. Nearly all of the grade 1, and all of the grade 2 and 3 highway contractors agreed on this factor.

- The results showed that 57% of respondents agreed that quantity of item is a very severe factor, 21% also agreed that this factor is somewhat severe, and 18% agreed that this factor is severe. Nearly all of the grade 1, and all of the grade 2 and 3 highway contractors agreed on this factor severity.

- The results showed that 36% of respondents agreed that risk associated with work item was a very severe factor, 25% agreed that this factor was somewhat severe, and 36% agreed that this factor was severe.
- The results showed that 43% of respondents agreed that economic conditions was a very severe factor, 26% agreed that this factor was somewhat severe, and 18% agreed that this factor was severe.
- The results showed that 43% of respondents agreed that contractor qualification was a very severe factor, 36% agreed that this factor was somewhat severe, and 8% agreed that this factor was severe.

- The results showed that 54% of respondents agreed that project location was a very severe factor, 32% agreed that this factor was somewhat severe, and 11% agreed that this factor was severe.

- The results showed that 40% of respondents strongly agreed, and 43% agreed, on the consequence of owner's difficulties to obtain future funding.

- The results showed that 57% of respondents strongly agreed, and 35% agreed, on the consequence of project delay due to lack of funds. Nearly all of the grade 1, and 2 highway contractors, and all of the grade 3 highway contractors agreed on this consequence.

- The results showed that only 40% of contractors' respondents strongly agreed, and 53% agreed, on the consequence of failure of payments to contractors. Nearly all of the grade 1, and 2 highway contractors, and all of the grade 3 highway contractors agreed on this consequence.

- The results showed that 43% of contractors' respondents strongly agreed, and 42% agreed, on the consequence of increased project cost. Nearly all of the grade 1, and 2 highway contractors, and all the grade 3 highway contractors agreed on this consequence.

- The results showed that 50% of contractors' respondents strongly agreed, and 46% agreed, on the consequence of increased contractor project overhead.

6.2.2 Minor findings

Many minor findings of the study were concluded from the results presented in chapter 5 are listed below:

- Based on my collected data, all grade 1 highway contractors had the same grade for infrastructure projects. This can be found in most contracting companies.

- The results revealed that 57% of surveyed contracting organizations were in business for more than 20 years and about 60% of grade 1 highway contractors, about two-thirds of grade 2 highway contractors, and about one-third of grade 3 were in business for more than 20 years**.**
- Most contractors had more than 1200 employees, which demonstrates their high capability for performing such huge highways projects.
- The results revealed that 64% of contractors enter unit price contracts more than 50% of the time. About two-thirds of grade 1 highway contractors, about 85% of grade 2 highway contractors, and about half of grade 3 contractors had entered into unit price projects more than lump sum, which in turn demonstrates high skills in bidding, more inclination for risk sharing, and common usage of these contracts in such construction projects.
- The results revealed that 74% of contractors' respondents were engineers, and especially civil engineers. It also revealed that 51% of them had more than 15 years of experience in the construction industry, whereas 28% of respondents had an experience of 10 to 15 years, which is fair enough.
- It was found that most consultants (57%) had less than 50 employees, which demonstrates their small volume of works and low requirements for large projects execution. It also indicated that about 62% of consultants had annual revenues less than (15 million Saudi Riyal).
- The results indicated that all consultants were certified to provide consultancy services for building projects, whereas only 43% and 24% of them were certified to provide consultancy services for infrastructure and highway projects respectively.

- Most consultants said that more than 50% of their clients were private. 62% of consultants dealt with private clients more than governmental ones. The results also indicated that 24% only dealt with private clients, while the same percent also only dealt with governmental clients.
- The results indicated that 81% of consultants' respondents held a bachelor degree in engineering, 9.5 % held bachelor’s and master ‘s degrees in engineering, and also 9.5 % held bachelor, master’s and Ph.D. degrees in engineering.
- The results indicated that 57% of consultants' respondents had more than 10 years of experience in the construction industry, and interestingly also indicated that 29% of respondents had experience of between 5 to 10 years.
- The results indicated that most contractors recalculated the estimated quantities provided by the owner, where the rest did not. More than 90% of them were doing so for the objective of verifying the owner’s numbers and for the objective of appropriate pricing of the bid estimate, and that is because they wanted to take care of their prices by playing with items of inaccurate estimates. It is also interesting to know that only 7% of contractors were not recalculating the quantities provide by the owners, and this was justified by the presence of a negotiation clause in the contracts in case of quantities variations.
- The results indicated about 18% of contractors said that less than 5% of their quantity estimates varied, compared to owner's quantity estimates. It is also interesting to know that about 31% of those contractors agreed that 5% to less than 25% of their estimate was different than the owners’ estimates, about 29% of those contractors agreed that 25% to less than 50% of their estimate was different than the owners’

estimates, and about 15% of those contractors agreed that 50% to less than 75% of their estimate was different than the owners' estimates.

- All contractors agreed to determine the unit costs based on the company's estimated quantities when they found a quantities overestimation or quantities overestimation, except for one contractor who usually informed the owner/ consultant when he did.
- The result indicated that nearly all contractors calculated the unit cost of an item following the procedure below:
- Unit cost of item = (Labor cost + Equipment cost + Material cost) + Item indirect cost (as a percent of the total indirect cost)
- Whereas only 11% of them calculated the unit cost of an item following the procedure below:
- Unit cost of item = (Labor cost + Equipment cost + Material cost) + Item fixed cost.
- Three-quarters of contractors used unit prices from the company's historical records as a supplement to verify their estimates. The results indicated that all contractors that used the second procedure for items' unit cost estimation were grade 1, and 2 highway contractors. Nearly all grade 1 highway contractors used unit prices from the company's historical records as a supplement to verify their estimates.

- The results indicated that 85% of consultants were doing both engineering and structural design, whereas the remainder did only one job that was different from engineering or structural design.
- The results indicated that 76% of consultants prepared the bill of quantities in-house.
- About two-thirds of consultants assigned three to five estimators, whereas about one-quarter of them assigned fewer than three estimators to be responsible for the

preparation of bill of quantities for a major construction project. The results above are unsatisfactory, especially where major highway projects are concerned. There is a common weak interest for bill of quantities preparation followed by consultants.

- The results also showed that two-thirds of consultants assigned estimators with average experience from five to less than 10 years, whereas only 19% of them assigned estimators with average experience from 10 to less than 15 years to be responsible for the preparation of bill of quantities for a major construction project, which is unsatisfactory, especially where major highway projects are concerned.
- There was an association between the consultant's volume of employees and their average experience, where it was seen that the lower the number of employees in the organization, the more those with average experience of 5-15 years are assigned for major project estimation.
- The results shows that 85% of consultants did Item identification using a work breakdown structure, only 5% did only manual quantities take-off, and only 10% did only automated quantities take-off. A major percent, 30% of consultants did automated quantities take-off, 25% did manual quantities take-off, and 20% of consultants used their experience.
- The results shows that 62% of consultants updated their estimation procedures every 12 months, and only 28% updated their estimation procedures every 6 months.
- The results shows that 38% of consultants believed that owners always reviewed their estimates, 10% of consultants believed that owners very often reviewed their estimates, 14% of consultants believed that owners often reviewed their estimates, and 38% of consultants believed that owners sometimes reviewed their estimates.

6.3 Conclusion

The study of cost estimation demonstrated its high importance before the construction of projects, due to many resulted problems in the case of inaccurate estimation of cost and quantities. Since unit price contracts are the most commonly used contracts for bidding in highway construction projects in Saudi Arabia, and because contractors under unit price contracts are only paid for each piece of work installed in the site, it was imperative to study the accuracy of cost estimation in such contracts due to the significant and severe consequences of erroneously prepared estimates on both the owners and contractors. The results revealed that most highway construction projects experience more than 10%, and sometimes worse, cost-overrun due to many reasons. Major reasons for quantities variations were found from previous research, including forecasting errors due to lack of data, unforeseen site conditions, and forecasting errors due to poor quantities take-off. Many other major reasons were found locally and were exclusive to the construction industry in Saudi Arabia, including forecasting errors due to unknown site conditions by the consultant, because governmental regulations force owners to assign consultants to design and study their highway projects completely, unclear underground utilities plans that generally do not match the actual existing utilities on sites, which results in extra works , and poor coordination between public agencies, in which many public agencies usually ask for their regular or additional requirements during construction and even sometimes after completing project construction. The first local factor was mainly because of consultant's poor abilities whereas all local factors were mainly because of owner's regulations, reduced studies and proceedings, and poor practices respectively.

Contractors and consultants agreed on the most important factors affecting unit cost estimation in unit price contracts. These factors mainly included project location, contractor qualification, economic conditions, and quantity of item.

As a result of quantities variations due to poor estimation of quantities, many problems were and still are experienced in the highway construction industry during construction. Quantities underestimation was usually suffered by the owners of highway projects in Saudi Arabia. However, this is usually the case in many countries in the world. Many researchers studied the consequences of quantities underestimation, and focused on several major consequences, including increased project cost, owners' difficulties in obtaining their projects funds, project delay, delay in payments to contractors, and sometimes litigation due to breaching the contracts with contractors. These consequences are also practiced in Saudi Arabia. In addition, another practice owners of highway projects in Saudi Arabia usually do is related to deletion of some project items, or reducing the project scope to satisfy the available project budget. This practice means that the project bid will be closed without completing the project by deleting some items, which normally includes sidewalks, road signs, light bulbs, and many other items, which in turn becomes hazardous for the public to use.

Therefore, this study aimed to raise the awareness of the consequences of quantities variations on highway projects under unit price contracts in Saudi Arabia. It concludes that the only solution for such a problem is to maintain accurate cost estimations of unit price contracts, maintain clear drawings for underground utilities, and to include a negotiation clause in unit price contracts to allow for price negotiations in case of quantities variations.

6.4 Recommendations

Based on the results of this study, the following recommendations have been made for owners, consultants, and contractors. Whereas future recommendations were also presented below:

6.4.1 Recommendations for owners

The owners of highway projects in Saudi Arabia are advised to:

- Take the proper steps regarding the preparation of accurate quantities.
- Solve the main issues for quantities variations that are related to their utilities drawings and actual underground structures.
- To be selective when they are awarding their project designs and studies to a consultancy company.
- Have a selected certified and well-qualified list of consultants for their highway project's design, and especially for the bill quantities preparation.
- Train their available consultants and make them aware of the consequences of their inaccurate project quantities.
- Always review their consultants' design and quantities.

6.4.2 Recommendations for consultants

Consultancy companies that study highway projects in Saudi Arabia are advised to:

- Have a well-structured department that is specialized for design and quantities preparation in their companies.

- Assign a very qualified, well-educated, and highly experienced staff for project design and quantities preparation.
- Have enough information about site conditions and requirements before the design and preparation of quantities.
- Require consultants to maintain accurate estimates, as much as possible, to overcome all problems of quantities variations.
- Include a negotiation clause in case of quantities variations, to save the rights of all involved parties.

6.4.3 Recommendations for contractors

Contractors of different grades of highway projects in Saudi Arabia are advised to:

- Change their estimation procedure of the unit cost by replacing a fixed cost for each item, instead of distributing project indirect cost as a percentage for each item to in an attempt to alleviate the consequences of any items overestimation.

- Inform the owners when they find any significant project quantities variations during the bidding stage to maintain a successful execution during construction.
- Balance their contracts to maintain reliable contracts and good relations with owners.

6.4.4 Recommendations for future studies

- More research is required in many other regions of Saudi Arabia, as well as many countries in the world.

- This study only addresses quantities variations in highway projects. Therefore, it would be interesting to study this issue in many other governmental projects, such as residential, commercial, and more importantly, in huge industrial projects which are becoming common in Saudi Arabia.
- This study only focuses on quantities variations in highway projects. It would be exciting also to study cost variations incurred by contractors in Saudi Arabia.

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Vitae

Name:	Mohammad Mahmoud Deyab Tomaizeh
Nationality:	Palestinian
Date of Birth:	01/04/1989
Email:	g201307970@kfupm.edu.sa, deyab_tomaizeh@yahoo.com
Address:	Khubar, Saudi Arabia
Academic Background:	Bachelor degree in Civil Engineering.

QUESTIONNAIRE #1: Questionnaire for contractors

بسم الله الرحمن الرحيم

Ministry of Education
King Fahd University of Petroleum & Minerals
COLLEGE OF ENVIRONMENTAL DESIGN
Dept. of Construction Engineering & Management
(036)

وزارة التعليم
جامعة الملك فهد للبترول و المعادن
كلية تصاميم البيئة
قسم هندسة وإدارة التشييد
(٠٣٦)

Dear Participant,

I am, **Mohammad Mahmoud Tomaizeh,** is a graduate student in the department of Construction Engineering and Management, College of Environmental Design, King Fahd University of Petroleum & Minerals. I am conducting a research, as part of my master's thesis requirements, under the supervision of Prof. Ali Shash. The study title is **"Variations of Owner's Estimated Quantities for highway projects in Unit Price Contracts in Saudi Arabia"**. The study looks into the quantities variations usually experienced in highway governmental projects in unit price contracts in Saudi Arabia, and aims to identify the major reasons and consequences of these variations. Because of your good experience in governmental **construction/design** projects, you are invited to participate in this study by completing the attached questionnaire.

This research is expected to enhance the cost estimation procedures and bidding practices followed by owners, consultants, and contractors that are handling governmental highway projects in Saudi Arabia. The questionnaire is short and should not take more than 15 minutes of your valuable time. The questionnaire will be analyzed in aggregate -not individually. All the data that you provide in the questionnaire will be treated with high confidentiality.

If you would like to be briefed with the results of this study, please contact me on my mobile/e-mail at any time.

Thank you in anticipation of your participation in the success of this research. Your positive participation and active contribution are valued and very much appreciated.

Best regards,

Mohammad Tomaizeh,
CEM Department, K.F.U.P.M
P. O. Box 1627, Dhahran 31261
Mobile +966598881286
E-mail: g201307970@kfupm.edu.sa

Dr. Ali A. Shash
CEM Department, K.F.U.P.M
P.O Box 1627, Dhahran 31261
Office Tel. # 03 860 3731
Mobile: +9665054569776

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This research is expected to enhance the cost estimation procedures and bidding practices followed by owners, consultants, and contractors that are handling governmental highway projects in Saudi Arabia. The questionnaire is short and should not take more than 15 minutes of your valuable time. The questionnaire will be analyzed in aggregate -not individually. All the data that you provide in the questionnaire will be treated with high confidentiality.

If you would like to be briefed with the results of this study, please contact me on my mobile/e-mail at any time.

Thank you in anticipation of your participation in the success of this research. Your positive participation and active contribution are valued and very much appreciated.

This Questionnaire is for contractor and contains five parts as shown below:

Part 1: General information:

This section contains question seeking information about your organization. You are kindly requested to provide the information in the given spaces next to the questions.

1. How many years has your organization been in business?
   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. 20 years and more [ ]
2. What are the type of projects which your organization build?
   a. Highways [ ]
   Grade 1 [ ] Grade 2 [ ] Grade 3 [ ]
   Other, ________
   b. Buildings [ ]
   Grade 1 [ ] Grade 2 [ ] Grade 3 [ ]
   Other, ________
   c. Infrastructure [ ]
   Grade 1 [ ] Grade 2 [ ] Grade 3 [ ] Other, ________
   d. Others, please specify______________________
   Grade 1 [ ] Grade 2 [ ] Grade 3 [ ]
   Other, ________
3. Where is the location of your company headquarter?
   a. Dammam [ ]
   b. Khobar [ ]
   c. Dhahran [ ]
   d. Jubail [ ]
   e. Others, please specify________________________

4. What is the number of employees in your company?
    a. Less than 300 [ ]
    b. 300 to less than 600 [ ]
    c. 600 to less than 900 [ ]
    d. 900 to less than 1200 [ ]
    e. 1200 or more [ ]
5. What is the annual revenue of your company?
    a. Less than SR 100 Million [ ]
    b. SR 100 Million to less than SR 200 Million [ ]
    c. SR 200 Million to less than SR 300 Million [ ]
    d. SR 300 Million to less than SR 400 Million [ ]
    e. SR 400 Million or more [ ]
6. What are the common types of contracts that your organization inter to execute projects?
    a. Lump Sum__________% of contracts.
    b. Unit Price __________% of contracts.
    c. Others, please specify __________% of contracts.

    Total = 100%

<u>Part 2:</u> Respondent's characteristics:

This section contains question seeking information about individual completing the questionnaire. You are kindly requested to provide the information in the given spaces next to the questions.

Name: (Optional) ____

Current Title: ____

1. What is your level of Education?
    a. BS in Engineering
        i. Civil Engineering [ ]
        ii. Mechanical Engineering [ ]
        iii. Electrical Engineering [ ]
        iv. Others, please specify________________
    b. BA in Accounting [ ]

c. BA in Finance [ ]
d. Others, Please specify_______________

2. How long have you been working for the current employer?
   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. 20 years and more [ ]
3. How long have you been working in the construction industry?
   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. 20 years and more [ ]

<u>Part 3:</u> Unit Cost Estimation

This part of the questionnaire contains question seeking information regarding the preparation of your company to the unit prices of the items in a Bill of Quantities (BOQ) and hence the bid price. You are kindly requested to provide the information in the given spaces next to the questions.

1. Does your company recalculate the quantities of items listed in the Bill of Quantities (BOQ)?
   a. Yes [ ] If "Yes" please continue and ignore question number 6
   b. No [ ] If "No" Please go to question number 6 and continue.
2. What is the objective of the quantity recalculation? (You may select more than one answer)
   a. Verify the owner's estimate [ ]
   b. Design the proper construction method [ ]
   c. Properly price the contract [ ]
   d. Other, please specify_____________
3. What is the percentage of highway projects with quantities that are different from your recalculated quantities?

a. Less than 5% [ ]
b. 5% to less than 25% [ ]
c. 25% to less than 50% [ ]
d. 50% to less than 75% [ ]
e. 75% to 100% [ ]

4. What do you do in case of owner's overestimation or underestimation of quantities?
   a. Determine the unit costs based on company's estimated quantities [ ]
   b. Determine the unit costs based on owner's provided quantities [ ]
   c. Other, please specify______________
5. How does your company prepare the Unit Cost for each items in the Bill of Quantities (BOQ)? (You may select more than one answer)
   a. Use unit prices from company's historical records [ ]
   b. For each item, determine the item total cost as follows:
      (Labor cost + Equipment cost + Material cost) + Item indirect cost (as a percent of the total indirect cost) [ ]
   c. For each item, determine the item total cost as follows:
      (Labor cost + Equipment cost + Material cost) + Item fixed cost [ ]
   d. Other, please specify______________.
6. What are the reasons for not reviewing Owners listed Bill of Quantities (BOQ)? (You may select more than one answer)
   a. Trusting the owner's estimate [ ]
   b. Limited time available [ ]
   c. Negotiation clause in case of quantities variations [ ]
   d. You are not taking care of quantities estimate [ ]
   e. Other, please specify______________

Part 4: Variations in project quantities

This section contains questions seeking information about variations in the Bill of Quantities (BOQs) of Unit Price Contracts.

1. **The following is a list of potential factors that may lead to quantities variations in Bill of Quantities. You are kindly requested to indicate your level of agreement by placing (✓) in the boxes next to each factor:**

Factors for quantities variations	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
Technical reasons					
Forecasting errors due to lack of data	[ ]	[ ]	[ ]	[ ]	[ ]
Forecasting errors due to difficulty of prediction	[ ]	[ ]	[ ]	[ ]	[ ]
Factors for quantities variations	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Technical reasons					
Forecasting errors due to estimation approach used	[ ]	[ ]	[ ]	[ ]	[ ]
Forecasting errors because of unknown site requirements by consultant	[ ]	[ ]	[ ]	[ ]	[ ]
Forecasting errors due to poor quantities take-off and quality control by consultant	[ ]	[ ]	[ ]	[ ]	[ ]
Unforeseen site conditions	[ ]	[ ]	[ ]	[ ]	[ ]
Overestimating to cover estimation forecasting errors	[ ]	[ ]	[ ]	[ ]	[ ]
Limited time for estimation	[ ]	[ ]	[ ]	[ ]	[ ]
Unclear underground utilities plans	[ ]	[ ]	[ ]	[ ]	[ ]
Insufficient use of technology	[ ]	[ ]	[ ]	[ ]	[ ]
Poor coordination between public agencies works and requirements	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify a. ____________________ b. ____________________ c. ____________________	 [ ] [ ] [ ]	 [ ] [ ] [ ]	 [ ] [ ] [ ]	 [ ] [ ] [ ]	 [ ] [ ] [ ]
Estimator's performance					
Overoptimistic behavior	[ ]	[ ]	[ ]	[ ]	[ ]
Misrepresentation of cost	[ ]	[ ]	[ ]	[ ]	[ ]
Unqualified estimators	[ ]	[ ]	[ ]	[ ]	[ ]
Inaccuracy in measuring risks	[ ]	[ ]	[ ]	[ ]	[ ]
Inappropriate judgment method	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify a. ____________________ b. ____________________ c. ____________________	 [ ] [ ] [ ]	 [ ] [ ] [ ]	 [ ] [ ] [ ]	 [ ] [ ] [ ]	 [ ] [ ] [ ]

Social, Economic and political reasons					
Overestimating to have enough budget to cover variations	[ ]	[ ]	[ ]	[ ]	[ ]
Underestimating to secure project fund	[ ]	[ ]	[ ]	[ ]	[ ]
Satisfaction of owner's inclination for low cost	[ ]	[ ]	[ ]	[ ]	[ ]
To satisfy manager's attitudes	[ ]	[ ]	[ ]	[ ]	[ ]
Neighbors and shopkeepers complaints	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify a. ____________________ b. ____________________ c. ____________________					

<u>Part 5</u>: Effect of Variations on Unit Prices

This section contains questions seeking information about factors affecting contractor's unit cost of Unit Price Contracts as well as potential consequences of quantities variations on Unit Price Contracts.

1. **The following is a list of potential factors that may affect Unit Costs of Unit Price Contracts (UPC). You are kindly requested to indicate the level of severity of these factors on unit prices by placing (✓) in the boxes next to each factor:**

Factors	Very Severe	Somewhat Severe	Severe	Somewhat Not Severe	No Effect
Quantity of item	[ ]	[ ]	[ ]	[ ]	[ ]
Number of bidders	[ ]	[ ]	[ ]	[ ]	[ ]
Associated risk of an item	[ ]	[ ]	[ ]	[ ]	[ ]
Estimation method used	[ ]	[ ]	[ ]	[ ]	[ ]
Economic conditions	[ ]	[ ]	[ ]	[ ]	[ ]
Contractor qualification	[ ]	[ ]	[ ]	[ ]	[ ]
Project location	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify a. ____________________ b. ____________________ c. ____________________	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]

See the next Page

2. **The following is a list of potential consequences of owner's quantities underestimation/overestimation in Unit Price Contracts (UPC). You are kindly requested to indicate your level of agreement by placing (✓) in the boxes next to each consequence:**

Consequences	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Underestimation					
Owner's Difficulty in obtaining future funding for the project	[ ]	[ ]	[ ]	[ ]	[ ]
Project delay due to lack of fund	[ ]	[ ]	[ ]	[ ]	[ ]
Deletion of some project items or scope reduction	[ ]	[ ]	[ ]	[ ]	[ ]
Failure of payments to contractors	[ ]	[ ]	[ ]	[ ]	[ ]
Litigation due to contract breach	[ ]	[ ]	[ ]	[ ]	[ ]
Failure in completing the project	[ ]	[ ]	[ ]	[ ]	[ ]
Increased project cost	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify					
a. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]
b. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]
c. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]
Overestimation					
Increased contractor project overhead	[ ]	[ ]	[ ]	[ ]	[ ]
Contractor cut corners to recover overhead	[ ]	[ ]	[ ]	[ ]	[ ]
Contractor unbalance the bid	[ ]	[ ]	[ ]	[ ]	[ ]
Contractor seeks to cover overhead through change orders.	[ ]	[ ]	[ ]	[ ]	[ ]
Limit fund for other projects in the pipeline	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify					
d. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]
e. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]
f. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]

End of the Questionnaire

Thank you

QUESTIONNAIRE #2: Questionnaire for consultants

Ministry of Education
King Fahd University of Petroleum & Minerals
COLLEGE OF ENVIRONMENTAL DESIGN
Dept. of Construction Engineering & Management
(036)

وزارة التعليم
جامعة الملك فهد للبترول والمعادن
كليـــة تصاميـــم البيئـــة
قسم هندسة وإدارة التشييد
(٠٣٦)

Dear Participant,

I am, **Mohammad Mahmoud Tomaizeh,** is a graduate student in the department of Construction Engineering and Management, College of Environmental Design, King Fahd University of Petroleum & Minerals. I am conducting a research, as part of my master's thesis requirements, under the supervision of Prof. Ali Shash. The study title is **"Variations of Owner's Estimated Quantities for highway projects in Unit Price Contracts in Saudi Arabia"**. The study looks into the quantities variations usually experienced in highway governmental projects in unit price contracts in Saudi Arabia, and aims to identify the major reasons and consequences of these variations. Because of your good experience in governmental **construction/design** projects, you are invited to participate in this study by completing the attached questionnaire.

This research is expected to enhance the cost estimation procedures and bidding practices followed by owners, consultants, and contractors that are handling governmental highway projects in Saudi Arabia. The questionnaire is short and should not take more than 15 minutes of your valuable time. The questionnaire will be analyzed in aggregate -not individually. All the data that you provide in the questionnaire will be treated with high confidentiality.

If you would like to be briefed with the results of this study, please contact me on my mobile/e-mail at any time.

Thank you in anticipation of your participation in the success of this research. Your positive participation and active contribution are valued and very much appreciated.

Best regards,

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Mobile +966598881286
E-mail: g201307970@kfupm.edu.sa

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If you would like to be briefed with the results of this study, please contact me on my mobile/e-mail at any time.

Thank you in anticipation of your participation in the success of this research. Your positive participation and active contribution are valued and very much appreciated.

This Questionnaire is for consultant preparing (BOQ) and contains five parts as shown below:

Part 1: General information:

This section contains questions seeking information about your organization. You are kindly requested to provide the information in the given spaces next to the questions.

Name of Consultancy Company (optional)

____

1. Where is the location of your organization?
   a. Dammam [ ]
   b. Khobar [ ]
   c. Dhahran [ ]
   d. Jubail [ ]
   e. Others, please specify__________________________
2. What is the number of employees in your organization?
   a. Less than 50 [ ]
   b. 50 to less than 100 [ ]
   c. 100 to less than 150 [ ]
   d. 150 to less than 200 [ ]
   e. 200 or more [ ]
3. What is the volume of your organization's annual revenues?
   a. Less than 15 million SR [ ]
   b. 15 million SR to less than 30 million SR [ ]
   c. 30 million SR to less than 45 million SR [ ]
   d. 45 million SR to less than 60 million SR [ ]
   e. 60 million SR or more [ ]
4. What are the types of projects that your organization is certified to provide consultation services for it i.e. design? (you may select more than one answer)
   a. Highways [ ]
   b. Buildings [ ]
   c. Infrastructure [ ]
   d. Others, please specify________________________

5. Who are your major clients for highway projects?
    a. Government _________% of projects.
    b. Private _________% of projects.
    c. Others, please specify _________% of contracts.

<u>Part 2:</u> Respondent's characteristics:

This section contains question seeking information about individual completing the questionnaire. You are kindly requested to provide the information in the given spaces next to the questions.

Name (optional): ____

Current Title: ____

1. What is your level of Education?
    a. BA in Architecture [ ]
    b. BS
        i. Civil Engineering [ ]
        ii. Mechanical Engineering [ ]
        iii. Electrical Engineering [ ]
        iv. Others, please specify_________________
    c. Master [ ]
    d. PhD [ ]
2. How long have you been working for the current employer?
    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. 20 years and more [ ]
3. How long have you been working as a consultant?
    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. 20 years and more [ ]

<u>Part 3:</u> Bill of Quantities Preparation

This part of the questionnaire contains question seeking information about your organization preparation of the Bill of Quantities of unit price contracts. You are kindly requested to provide the information in the given spaces next to the questions.

1. What is your company role in highway projects? (you may select more than one answer)
   a. Engineering design [ ]
   b. Structural design [ ]
   c. Regional Planning [ ]
   d. Preparation of bill of quantities (BOQ) [ ]
   e. Other, please specify______________
2. Does your organization prepare Bills of Quantities in-house?
   a. Yes [ ] If "Yes" please continue
   b. No [ ] If "No" please go to Part 4
3. How many estimators are usually involved in preparing a Bill of Quantities (BOQ) for a major highway project?
   a. Less than 3 [ ]
   b. 3 to less than 5 [ ]
   c. 5 to less than 7 [ ]
   d. More than 7 [ ]
4. What is the average experience of the estimators who are preparing Bill of Quantities (BOQs) for highway projects in your organization?
   a. Less than 5 years [ ]
   b. 5 to less than 10 years [ ]
   c. 10 to less than 15 years [ ]
   d. More than 15 years [ ]
5. How does your organization prepare a Bill of Quantities for a particular highway project? (You may select more than one answer)
   a. Item identification using work breakdown structure [ ]
   b. Item identification using existing templates [ ]

c. Manual Quantities Take Off [ ]
d. Automated Quantities Take Off [ ]
e. Based on historical data [ ]
f. Based on owner's available budget [ ]
g. Based on your experience [ ]
h. Based on owner objectives [ ]
i. Based on item potential risks [ ]
j. Based on the contractors estimation procedures. [ ]
k. Others, please specify______________________

6. What is the percentage of highway projects with actual quantities that are significantly different from your estimated quantities?
   a. Less than 5% [ ]
   b. 5% to less than 25% [ ]
   c. 25% to less than 50% [ ]
   d. 50% to less than 75% [ ]
   e. 75% to 100% [ ]
7. How often do your clients review your organization's estimated quantities in the Bill of Quantities (BOQs)?
   a. Always [ ]
   b. Sometimes [ ]
   c. Very often [ ]
   d. Often [ ]
   e. Never [ ]
8. How frequently does your organization update its estimation procedures?
   a. Every 6 months [ ]
   b. Every 12 months [ ]
   c. Every 18 months [ ]
   d. Every 24 months [ ]
   e. Others, please specify_______________

<u>Part 4</u>: Variations in project quantities

This section contains questions seeking information about variations in the Bill of Quantities (BOQs) of Unit Price Contracts.

2. The following is a list of potential factors that may lead to quantities variations in Bill of Quantities. You are kindly requested to indicate your level of agreement by placing (✓) in the boxes next to each factor:

Factors for quantities variations	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Technical reasons					
Forecasting errors due to lack of data	[ ]	[ ]	[ ]	[ ]	[ ]
Forecasting errors due to difficulty of prediction	[ ]	[ ]	[ ]	[ ]	[ ]
Forecasting errors due to estimation approach used	[ ]	[ ]	[ ]	[ ]	[ ]
Forecasting errors because of unknown site requirements by consultant	[ ]	[ ]	[ ]	[ ]	[ ]
Forecasting errors due to poor quantities take-off and quality control by consultant	[ ]	[ ]	[ ]	[ ]	[ ]
Unforeseen site conditions	[ ]	[ ]	[ ]	[ ]	[ ]
Overestimating to cover estimation forecasting errors	[ ]	[ ]	[ ]	[ ]	[ ]
Limited time for estimation	[ ]	[ ]	[ ]	[ ]	[ ]
Unclear underground utilities plans	[ ]	[ ]	[ ]	[ ]	[ ]
Insufficient use of technology	[ ]	[ ]	[ ]	[ ]	[ ]
Poor coordination between public agencies works and requirements	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify					
a. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]
b. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]
c. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]
Estimator's performance					
Overoptimistic behavior	[ ]	[ ]	[ ]	[ ]	[ ]
Misrepresentation of cost	[ ]	[ ]	[ ]	[ ]	[ ]
Unqualified estimators	[ ]	[ ]	[ ]	[ ]	[ ]
Inaccuracy in measuring risks	[ ]	[ ]	[ ]	[ ]	[ ]
Inappropriate judgment method	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify					
a. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]
b. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]
c. ____________________	[ ]	[ ]	[ ]	[ ]	[ ]

Social, Economic and political reasons					
Overestimating to have enough budget to cover variations	[ ]	[ ]	[ ]	[ ]	[ ]
Underestimating to secure project fund	[ ]	[ ]	[ ]	[ ]	[ ]
Satisfaction of owner's inclination for low cost	[ ]	[ ]	[ ]	[ ]	[ ]
To satisfy manager's attitudes	[ ]	[ ]	[ ]	[ ]	[ ]
Neighbors and shopkeepers complaints	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify a. ____________________ b. ____________________ c. ____________________					

<u>Part 5</u>: Effect of Variations on Unit Prices

This section contains questions seeking information about factors affecting contractor's unit cost of Unit Price Contracts as well as potential consequences of quantities variations on Unit Price Contracts.

3. **The following is a list of potential factors that may affect Unit Costs of Unit Price Contracts (UPC). You are kindly requested to indicate the level of severity of these factors on unit prices by placing (✓) in the boxes next to each factor:**

Factors	Very Severe	Somewhat Severe	Severe	Somewhat Not Severe	No Effect
Quantity of item	[ ]	[ ]	[ ]	[ ]	[ ]
Number of bidders	[ ]	[ ]	[ ]	[ ]	[ ]
Associated risk of an item	[ ]	[ ]	[ ]	[ ]	[ ]
Estimation method used	[ ]	[ ]	[ ]	[ ]	[ ]
Economic conditions	[ ]	[ ]	[ ]	[ ]	[ ]
Contractor qualification	[ ]	[ ]	[ ]	[ ]	[ ]
Project location	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify d. ____________________ e. ____________________ f. ____________________	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]

4. **The following is a list of potential consequences of owner's quantities underestimation/overestimation in Unit Price Contracts (UPC). You are kindly requested to indicate your level of agreement by placing (✓) in the boxes next to each consequence:**

Consequences	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Underestimation					
Owner's Difficulty in obtaining future funding for the project	[ ]	[ ]	[ ]	[ ]	[ ]
Project delay due to lack of fund	[ ]	[ ]	[ ]	[ ]	[ ]
Deletion of some project items or scope reduction	[ ]	[ ]	[ ]	[ ]	[ ]
Failure of payments to contractors	[ ]	[ ]	[ ]	[ ]	[ ]
Litigation due to contract breach	[ ]	[ ]	[ ]	[ ]	[ ]
Failure in completing the project	[ ]	[ ]	[ ]	[ ]	[ ]
Increased project cost	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify g. ____________________ h. ____________________ i. ____________________	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]
Overestimation					
Increased contractor project overhead	[ ]	[ ]	[ ]	[ ]	[ ]
Contractor cut corners to recover overhead	[ ]	[ ]	[ ]	[ ]	[ ]
Contractor unbalance the bid	[ ]	[ ]	[ ]	[ ]	[ ]
Contractor seeks to cover overhead through change orders.	[ ]	[ ]	[ ]	[ ]	[ ]
Limit fund for other projects in the pipeline	[ ]	[ ]	[ ]	[ ]	[ ]
Others, please specify j. ____________________ k. ____________________ l. ____________________	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]	[ ] [ ] [ ]

End of the Questionnaire

Thank you

CASE STUDY PROJECT A: Estimated and Actual Quantities of Project Items, resources, and assigned staff

Project A:

- **Volume of project A resources**

1) Asphalt Groups, each group included the following:

- Paver machine
- steel roller
- 5 rubber roller
- steel metal roller
- Compressor
- Milling machine
- Water tank
- many trucks

2) equipment:

- Paver machine
- 4 graders
- 2 dozers
- 4 dynamic rollers
- 2 water tanks
- 2 Backhoes
- Boom truck
- 2 loaders
- Many trucks

3) Curb machine plus 2 Backhoe

4) Painting Group

5) Concrete workers group

6) Electrical group

7) Storm water drainage group- subcontracted

8) Sidewalks group- subcontracted

- **Staff required and assigned:**
  - Project Manager > 15 years' experience.
  - Project Engineer > 10 years' experience.
  - Electrical Engineer > 10 years' experience.
  - Mechanical Engineer > 10 years' experience.
  - QA/QC > 7 years' experience.
  - 2 surveyors > 10 years' experience.

Table 69: Measure of the level of quantities variations of Project A

Project Title		Project A						
Owner		Governmental Entity A						
Contractor		Contractor A						
Consultant		Consultant A and Consultant A1						
WORK DESCRIPTION			**UNIT**	**Owners estimated QTY.**	**Contr-actor's Unit Price (SR)**	**TOTAL (SR)**	**Actual**	
							Quantity	**Price**
1		**<u>Civil WORKS</u>**						
	1.1	**Earth Works**						
	1.1.1	Earth Works including cut, fill and removing all of additional wastes (Subgrade layer) as per specifications	M2	341,880	12	4,102,560	388,660	4,663,920

	1.2	**Utilities transfer**						
	1.2.1	Transfer of existing utilities	NO.	75	600	45,000	271	162,600
	1.2.2	Transfer of firefighting water hydrant and reinstallation	NO.	15	5,000	75,000	0	0
	1.3	**Backfilling works**						
	1.3.1	Backfilling works, MINIMUM 300MM THK. Base coarse AS PER ASTM D-3282 IT SHOULD COMPACTED TO 100% OF MAXIMUM DRY DENSITY AS PER ASTM + MC1	M2	276,760	17	4,704,920	280,608	4,770,336
	1.4	**Asphalt**						
	1.4.1	Asphalt Concrete base layer 70 mm as per specifications	M2	276,760	14	3,874,640	269,094	3,767,316
	1.4.2	Asphalt Concrete top layer (wearing coarse) 50 mm as per specifications	M2	276,760	12	3,321,120	163,277	1,959,324
	1.4.3	Removing existing top layer of asphalt and compaction under this layer	M2	10,000	21	210,000	0	0
	1.5	**Interlock and curbstone works**						
	1.5.1	Interlock (20*10*8 cm) including supply, installation, removing existing pavements, and supply and compaction of base coarse layer under slabs as per specifications	M2	78,052	75	5,853,900	64,694	4,852,050

	1.5.2	Interlock (10*10*20 cm) including supply, installation, removing existing pavements, and supply and compaction of base coarse layer under slabs as per specifications	M2	1,000	100	100,000	2,642	264,200
	1.5.3	RC Bumpers 350kg/m3 as per specifications	LM	4,000	700	2,800,000	7,400	5,180,000
	1.5.4	Curbstone (91.5*15*30 cm)	LM	57,000	70	3,990,000	48,430	3,390,100
	1.5.5	Precast vertical concrete barriers 110 cm height and 22 cm base	No.	800	400	320,000	519	207,600
	1.6	**Safety works**						
	1.6.1	Road safety kit						
	1.6.2	Type A	No.	70	1,100	77,000	124	136,400
	1.6.3	Type B	No.	37	1,100	40,700	6	6,600
	1.6.4	Type C	No.	25	1,100	27,500	6	6,600
	1.6.5	Type D	No.	79	1,100	86,900	6	6,600
	1.6.6	Type E	No.	38	1,100	41,800	6	6,600
	1.7	**Paints**						
	1.7.1	White and yellow thermoplastic paint for lines and arrows of roads	M2	2,000	25	50,000	0	0
	1.7.2	White and yellow Ceramics Marks for lines and arrows of roads	No.	138,518	11	1,523,698	77,765	855,415
		Subtotal				**31,244,738**		**30,235,661**
2		**ELECTRICAL WORKS**						
	2.1	lighting columns 30 m height 1000 watt as per specifications	No.	54	46,000	2,484,000	47	2,162,000

	2.2	14 m height galvanized lighting columns conic section including footings as per specifications						
	2.2.1	with only one rib	No.	6	5,000	30,000	0	0
	2.2.2	with two ribs	No.	82	4,900	401,800	0	0
	2.3	lighting columns 10 m height with two ribs including footings as per specifications	No.	60	9,100	546,000	181	1,647,100
	2.4	lighting bulb with a glass cover including supply, installation, and supply and installation of electrical cables as per specifications						
	2.4.1	1000 watt sodium	No.	216	2,200	475,200	188	413,600
	2.4.2	600 watt sodium	No.	6	3,000	18,000	0	0
	2.4.3	400 watt sodium	No.	368	900	331,200	181	162,900
	2.4.4	250 watt sodium	No.	60	900	54,000	181	162,900
	2.5	Cupper low voltage electrical cables 600/1000 volts to be installed inside 4 in type 3 pipes including supply, installation, and cut and fill of earth layers for installation of electrical cables as per specifications	LM	12,500	110	1,375,000	8,851	973,610
	2.6	Fuse boxes supply and installation including 10 A fuses as per specifications						
	2.6.1	One rib Column	No.	6	100	600	0	0
	2.6.2	Two rib column with two bulbs	No.	80	100	8,000	181	18,100
	2.6.3	Two rib column with four bulbs	No.	82	250	20,500	0	0

	2.6.4	Grounding cable 16 mm Dia with 1.5 m height as per specifications	No.	222	120	26,640	182	21,840
	2.7	A closed transformation and distribution unit including transformer 220-380/13800 volts including supply and installation as per specifications						
	2.7.1	100 KVA	No.	8	50,000	400,000	10	500,000
	2.7.2	150 KVA	No.	1	75,000	75,000	3	225,000
	2.8	Payment of electrical supply fees for the above unit supply						
	2.8.1	100 KVA	No.	8	25,000	200,000	2	50,000
	2.8.2	150 KVA	No.	1	25,000	25,000	2	50,000
	2.9	supply and installation of a group of protection pipes for closed units 6 in Dia, 0.5 cm thickness, 1.8 m length in a footing of 60 * 60 * 70 cm as per specifications	No.	36	750	27,000	52	39,000
	2.10	Removing of existing lighting columns as per specifications	No.	180	400	72,000	273	109,200
	2.11	Removing of existing transformers as per specifications	No.	10	1,500	15,000	8	12,000
	2.12	supply and installation of control room manholes of 70 * 70 * 70 cm as per specifications	No.	281	850	238,850	45	38,250
		Subtotal				**6,823,790**		**6,585,500**
3		**Storm water drainage**						

	3.1	supply and installation of pipes including cut, fill, and leveling of all soil types as per specifications	LM	8,200	130	1,066,000	10,695	1,390,350
	3.2	supply and installation of aggregate layer of all required sizes under pipes as per specifications	LM	8,200	75	615,000	10,695	802,125
	3.3	supply and installation of FRP with 10000 N/m2 and 100 pounds/in as per specifications						
	3.3.1	400 mm pipe	LM	3,150	520	1,638,000	5,873	3,053,960
	3.3.2	500 mm pipe	LM	3,250	590	1,917,500	3,049	1,798,910
	3.3.3	600 mm pipe	LM	700	650	455,000	737	479,050
	3.3.4	700 mm pipe	LM	340	800	272,000	370	296,000
	3.3.5	800 mm pipe	LM	870	900	783,000	659	593,100
	3.4	supply and installation of a U.P.V.C pipes 400 mm Dia type 4 including cut, fill, and leveling of all soil types as per specifications	LM	3,150	600	1,890,000	2,327	1,396,200
	3.5	supply and installation of fiberglass circular control room manholes of 120 mm Dia and 18 mm thickness as per specifications	No.	110	6,300	693,000	150	945,000
	3.6	supply and installation of fiberglass drainage room manholes of 120 mm Dia and 12 mm thickness as per specifications	No.	245	5,500	1,347,500	214	1,177,000

		Subtotal				**10,677,000**		**11,931,695**
4		**Irrigation works**						
	4.1	supply and installation of a U.P.V.C pipes class 5 including related requirements as per specifications						
	4.1.1	U.P.V.C 160 mm Dia pipes	LM	3,190	130	414,700	7,086	921,180
	4.1.2	U.P.V.C 110 mm Dia pipes	LM	2,325	110	255,750	9,128	1,004,080
	4.1.3	U.P.V.C 75 mm Dia pipes	LM	3,600	90	324,000	0	0
	4.1.4	U.P.V.C 63 mm Dia pipes	LM	6,250	75	468,750	187	14,025
	4.2	supply and installation of a gate retention valve including related requirements as per specifications						
	4.2.1	150 mm Dia, 6 in valve	No.	20	1,200	24,000	3	3,600
	4.2.2	100 mm Dia, 4 in valve	No.	15	950	14,250	4	3,800
		Subtotal				**1,501,450**		**1,946,685**
		Total				**50,246,978**		**50,699,541**

Table 70: Measure of the level of quantities variations of Project A Extension

Project Title		Project A Extension						
Owner		Governmental Entity A						
Contractor		Contractor A						
Consultant		Consultant A and Consultant A1						
WORK DESCRIPTION			**UNIT**	**Owners estimated QTY.**	**Contr-actor's Unit Price (SR)**	**TOTAL (SR)**	**Actual**	
							Quantity	**Price**
1		**Civil WORKS**						
	1.1	**Earth Works**						
	1.1.1	Earth Works including cut, fill and removing all of additional wastes (Subgrade) as per specifications	M2	78,200	9	703,800	49,274	443,466
	1.2	**Utilities transfer**						
	1.2.1		**Existed item in the first bid and cancelled in the 2d bid**					
	1.2.2	raising up or down the levels of existing utilities	NO.	3	1,500	4,500	88	132,000
	1.3	**Backfilling works**						
	1.3.1	Backfilling works, MINIMUM 300MM THK. Base coarse AS PER ASTM D-3282 IT SHOULD COMPACTED TO 100% OF MAXIMUM DRY DENSITY AS PER ASTM + MC1	M2	63,000	16	1,008,000	32,204	515,264
	1.4	**Asphalt**						
	1.4.1	Asphalt Concrete base layer 70 mm as per specifications	M2	63,000	12	756,000	33,244	398,928
	1.4.2	Asphalt Concrete top layer (wearing coarse) 50 mm as per specifications	M2	63,000	12	756,000	127,128	1,525,536
	1.4.3		**Existed item in the first bid and cancelled in the 2d bid**					
	1.5	**Sidewalks works**						

	1.5.X	Combined concrete slabs 10 cm thickness 8mm steel bars Dia including expansion and shrinkage joints, and removing all the required soil layers as per specifications	M2	1,000	100	100,000	126	12,600
	1.5.1	Interlock (20*10*8 cm) including supply, installation, removing existing pavements, and supply and compaction of base coarse layer under slabs as per specifications	M2	63,135	70	4,419,450	41,852	2,929,640
	1.5.2	Interlock (10*10*20 cm) including supply, installation, removing existing pavements, and supply and compaction of base coarse layer under slabs as per specifications	M2	4,200	85	357,000	1,588	134,980
	1.5.3		**Existed item in the first bid and cancelled in the 2d bid**					
	1.5.4	Curbstone (91.5*15*30 cm)	LM	5,500	60	330,000	19,905	1,194,300
	1.5.5	Precast vertical concrete barriers 110 cm height and 22 cm base as per specifications	No.	1,200	400	480,000	1,055	422,000
	1.5.Y	Galvanized steel barriers in the required spaces as per specifications	LM	3,200	800	2,560,000	3,200	2,560,000
	1.6		**Existed item in the first bid and cancelled in the 2d bid**					
	1.7		**Existed item in the first bid and cancelled in the 2d bid**					
		Subtotal				**11,474,750**		**10,268,714**
2		**ELECTRICAL WORKS**						

	2.1	lighting columns 30 m height 1000 watt as per specifications	No.	16	45,000	720,000	0	0
	2.2	14 m height galvanized lighting columns conic section including footings as per specifications						
	2.2.1	with only one rib	No.	20	4,500	90,000	23	103,500
	2.2.2	with two ribs	No.	20	4,500	90,000	344	1,548,000
	2.3	lighting columns 10 m height with two ribs including footings as per specifications	No.	47	9,000	423,000	46	414,000
	2.4	lighting bulb with a glass cover including supply, installation, and supply and installation of electrical cables as per specifications						
	2.4.1	1000 watt sodium	No.	64	2,200	140,800	0	0
	2.4.2	600 watt sodium	No.	12	3,000	36,000	0	0
	2.4.3	400 watt sodium	No.	269	900	242,100	2,702	2,431,800
	2.4.4	250 watt sodium	No.	47	900	42,300	46	41,400
	2.5	Cupper low voltage electrical cables 600/1000 volts to be installed inside 4 in type 3 pipes including supply, installation, and cut and fill of earth layers for installation of electrical cables as per specifications						
	2.5.1	4*35 mm2 cable	LM	5,500	110	605,000	23,171	2,548,755
	2.5.2	4*25 mm2 cable	LM	1,000	90	90,000	0	0
	2.5.3	4*16 mm2 cable	LM	1,000	70	70,000	0	0
	2.5.4	4*10 mm2 cable	LM	1,000	50	50,000	0	0
	2.6	Fuse boxes supply and installation including 10 A fuses as per specifications						
	2.6.1	One rib Column	No.	67	100	6,700	413	41,300

	2.6.2	Two rib column with two bulbs	No.	22	250	5,500	0	0
	2.6.3		**Existed item in the first bid and cancelled in the 2d bid**					
	2.6.4	Grounding cable 16 mm Dia with 1.5 m height as per specifications	No.	15	120	1,800	491	58,920
	2.7	A closed transformation and distribution unit including transformer 220-380/13800 volts including supply and installation as per specifications						
	2.7.1	100 KVA	No.	2	50,000	100,000	12	600,000
	2.7.2	150 KVA	No.	4	75,000	300,000	0	0
	2.8	Payment of electrical supply fees for the above unit supply						
	2.8.1	100 KVA	No.	2	25,000	50,000	12	300,000
	2.8.2	150 KVA	No.	4	25,000	100,000	0	0
	2.9	supply and installation of a group of protection pipes for closed units 6 in Dia, 0.5 cm thickness, 1.8 m length in a footing of 60 * 60 * 70 cm as per specifications	No.	24	750	18,000	0	0
	2.10	Removing of existing lighting columns as per specifications	No.	350	400	140,000	0	0
	2.11	Removing of existing transformers and distribution panels as per specifications	No.	10	5,000	50,000	0	0
	2.12	supply and installation of control room manholes of 70 * 70 * 70 cm as per specifications	No.	10	850	8,500	0	0

	2.13	supply and installation of aggregate layer of all required sizes under pipes as per specifications	LM	1,000	70	70,000	0	0
	2.14	supply and installation of LED LIGHTS 1P 67 around lands as per specifications	No.	700	800	560,000	0	0
	2.15	supply and installation of LED LIGHTS 1P 67 around Palm trees as per specifications	No.	300	2,500	750,000	0	0
	2.16	supply and installation of POLLAR light units 85 cm height with two bulbs 80 watt 36 watt1P 67 around lands as per specifications	No.	100	1,800	180,000	0	0
	2.17	supply and installation of Metal distribution Panel 380/230V as per specifications	No.	4	2,500	10,000	0	0
	2.18	**Subtotal**				**4,949,700**		**8,087,675**
3		**Storm water drainage**						
	3.1	supply and installation of pipes including cut, fill, and leveling of all soil types as per specifications	LM	1,000	80	80,000	281	22,480
	3.2	supply and installation of aggregate layer of all required sizes under pipes as per specifications	LM	700	75	52,500	281	21,075
	3.3	supply and installation of FRP with 10000 N/m2 and 100 pounds/in as per specifications						
	3.3.X	300 mm pipe	LM	2	1,000	2,000	0	0
	3.3.1	400 mm pipe	LM	350	520	182,000	26	13,520

	3.3.2	500 mm pipe	LM	350	590	206,500	22	12,980
	3.3.3	600 mm pipe	LM	50	650	32,500	78	50,700
	3.3.4	700 mm pipe	LM	40	800	32,000	25	20,000
	3.3.5	800 mm pipe	LM	80	900	72,000	0	0
	3.4	supply and installation of a U.P.V.C pipes 400 mm Dia type 4 including cut, fill, and leveling of all soil types as per specifications	LM	350	600	210,000	311	186,600
	3.5	supply and installation of fiberglass circular control room manholes of 120 mm Dia and 18 mm thickness as per specifications	No.	10	8,000	80,000	3	24,000
	3.6	supply and installation of fiberglass drainage room manholes of 120 mm Dia and 12 mm thickness as per specifications	No.	30	8,000	240,000	14	112,000
		Subtotal				**1,189,500**		**463,355**
4		**Irrigation works**						
	4.1	supply and installation of a U.P.V.C pipes with all accessories including related requirements as per specifications						
	4.1.1	U.P.V.C 160 mm Dia pipes	LM	1,060	370	392,200	221	81,770
	4.1.2	U.P.V.C 110 mm Dia pipes	LM	776	290	225,040	2,291	664,390
	4.1.3	U.P.V.C 75 mm Dia pipes	LM	1,200	120	144,000	0	0
	4.1.4	U.P.V.C 63 mm Dia pipes	LM	2,080	100	208,000	713	71,300
	4.1.X	U.P.V.C 50 mm Dia pipes	LM	550	70	38,500	1,157	80,990

	4.2	supply and installation of a gate retention valve including related requirements as per specifications						
	4.2.1	150 mm Dia, 6 in valve	No.	10	1,200	12,000	42	50,400
	4.2.2		**Existed item in the first bid and cancelled in the 2d bid**					
	4.3	supply and installation of a U.P.V.C pipes with all accessories for the purpose of irrigation network including related requirements as per specifications						
	4.3.1	U.P.V.C 50 mm Dia pipes	LM	1,200	55	66,000	0	0
	4.3.2	U.P.V.C 40 mm Dia pipes	LM	4,500	20	90,000	1,488	29,760
	4.3.3	U.P.V.C 25 mm Dia pipes	LM	1,000	17	17,000	1,266	21,522
	4.4	supply and installation of a POLYETHELENE 16 mm pipes with all accessories for the purpose of irrigation network including related requirements as per specifications	LM	5,500	7	38,500	35,757	250,299
	4.5	supply and installation of an automatic release 75 mm3 valve including related requirements as per specifications	No.	80	300	24,000	76	22,800
	4.6	supply and installation of 8 liter outflowing including related requirements as per specifications	No.	5,000	2	10,000	85,882	171,764
	4.7	supply and installation of 25 liter/hr Tree bubblers including related requirements as per specifications	No.	80	4	320	1,308	5,232

	4.8	supply and installation of 2 in emergency valves including related requirements as per specifications	No.	18	600	10,800	16	9,600
	4.9	supply and installation of remote control system using UHF including related requirements as per specifications	No.	1	55,000	55,000	4	220,000
		Subtotal				**1,331,360**		**1,679,827**
5		**Farming works**						
	5.1	supply and installation of (Ground Cover) of the following types: sessevium red, Carissa grandiflora prostrate, cyndodon dactylon grassing, seasonal flowers-petunia hybrida including related requirements as per specifications	M2	12,000	50	600,000	10,562	528,100
	5.2	supply and installation of (Palm Trees) of the following type: phoenix-dactylifera 7 m height, and 60 cm Dia including related requirements as per specifications	No.	220	2,200	484,000	507	1,115,400
	5.3	supply and installation of (Palm Trees) of the following type: NUCIFERA-COCOS 7 m height, and 60 cm Dia including related requirements as per specifications	No.	44	2,800	123,200	57	159,600

	5.4	supply and installation of (Small Trees) of the following type: Atriplex Halimus 7 m height, and 60 cm Dia including related requirements as per specifications	No.	8,000	20	160,000	1,563	31,260
		Subtotal				**1,367,200**		**1,834,360**
		Total				**20,312,510**		**22,333,931**

Table 71: Measure of the level of quantities variations of Total Project

Project Title		Total Project						
Owner		Governmental Entity A						
Contractor		Contractor A						
Consultant		Consultant A and Consultant A1						
WORK DESCRIPTION			**UNIT**	**Owners estimated QTY.**	**Contr-actor's Unit Price (SR)**	**TOTAL (SR)**	**Actual**	
							Quantity	**Price**
1		**Civil WORKS**						
	1.1	**Earth Works**						
	1.1.1	Earth Works including cut, fill and removing all of additional wastes (Subgrade) as per specifications	M2	341,880	9	3,076,920	437,934	3,941,406
	1.2	**Utilities transfer**						
	1.2.1	Transfer of existing utilities	NO.	75	600	45,000	271	162,600
	1.2.2	raising up or down the levels of existing utilities	NO.	15	1,500	22,500	88	132,000
	1.3	**Backfilling works**						
	1.3.1	Backfilling works, MINIMUM 300MM THK. Base coarse AS PER ASTM D-3282 IT SHOULD COMPACTED TO 100% OF MAXIMUM DRY DENSITY AS PER ASTM + MC1	M2	276,760	16	4,428,160	312,812	5,004,992
	1.4	**Asphalt**						
	1.4.1	Asphalt Concrete base layer 70 mm as per specifications	M2	276,760	12	3,321,120	302,338	3,628,056
	1.4.2	Asphalt Concrete top layer (wearing	M2	276,760	12	3,321,120	290,405	3,484,860

		coarse) 50 mm as per specifications						
	1.4.3	Removing existing top layer of asphalt and compaction under this layer	M2	10,000	21	210,000	0	0
	1.5	**Sidewalks works**						
	1.5.X	Combined concrete slabs 10 cm thickness 8mm steel bars Dia including expansion and shrinkage joints, and removing all the required soil layers as per specifications	M2	1,000	100	100,000	126	12,600
	1.5.1	Interlock (20*10*8 cm) including supply, installation, removing existing pavements, and supply and compaction of base coarse layer under slabs as per specifications	M2	78,052	70	5,463,640	106,546	7,458,220
	1.5.2	Interlock (10*10*20 cm) including supply, installation, removing existing pavements, and supply and compaction of base coarse layer under slabs as per specifications	M2	1,000	85	85,000	4,230	359,550
	1.5.3	RC Bumpers 350kg/m3 as per specifications	M2	4,000	700	2,800,000	7,400	5,180,000
	1.5.4	Curbstone (91.5*15*30 cm)	LM	57,000	60	3,420,000	68,335	4,100,100

	1.5.5	Precast vertical concrete barriers 110 cm height and 22 cm base as per specifications	No.	800	400	320,000	1,574	629,600
	1.5.Y	Galvanized steel barriers in the required spaces as per specifications	LM	3,200	800	2,560,000	3,200	2,560,000
	1.6	**Safety works**	Not found in "Project A Extension"					
	1.7	**Paints**	Not found in "Project A Extension"					
		Subtotal				**29,173,460**		**36,653,984**
2		**ELECTRICAL WORKS**						
	2.1	lighting columns 30 m height 1000 watt as per specifications	No.	54	45,000	2,430,000	47	2,115,000
	2.2	14 m height galvanized lighting columns conic section including footings as per specifications						
	2.2.1	with only one rib	No.	6	4,500	27,000	23	103,500
	2.2.2	with two ribs	No.	82	4,500	369,000	344	1,548,000
	2.3	lighting columns 10 m height with two ribs including footings as per specifications	No.	60	9,000	540,000	227	2,043,000
	2.4	lighting bulb with a glass cover including supply, installation, and supply and installation of electrical cables as per specifications						
	2.4.1	1000 watt sodium	No.	216	2,200	475,200	188	413,600
	2.4.2	600 watt sodium	No.	6	3,000	18,000	0	0
	2.4.3	400 watt sodium	No.	368	900	331,200	2,883	2,594,700

	2.4.4	250 watt sodium	No.	60	900	54,000	227	204,300
	2.5	Cupper low voltage electrical cables 600/1000 volts to be installed inside 4 in type 3 pipes including supply, installation, and cut and fill of earth layers for installation of electrical cables as per specifications						
	2.5.1	4*35 mm2 cable	LM	12,500	110	1,375,000	32,023	3,522,475
	2.5.2	4*25 mm2 cable	LM	1,000	90	90,000	0	0
	2.5.3	4*16 mm2 cable	LM	1,000	70	70,000	0	0
	2.5.4	4*10 mm2 cable	LM	1,000	50	50,000	0	0
	2.6	Fuse boxes supply and installation including 10 A fuses as per specifications						
	2.6.1	One rib Column	No.	6	100	600	413	41,300
	2.6.2	Two rib column with two bulbs	No.	80	250	20,000	181	45,250
	2.6.3	Two rib column with four bulbs	No.	82	250	20,500	0	0
	2.6.4	Grounding cable 16 mm Dia with 1.5 m height as per specifications	No.	222	120	26,640	673	80,760
	2.7	A closed transformation and distribution unit including transformer 220-380/13800 volts including supply and installation as per specifications						
	2.7.1	100 KVA	No.	8	50,000	400,000	22	1,100,000
	2.7.2	150 KVA	No.	1	75,000	75,000	3	225,000

	2.8	Payment of electrical supply fees for the above unit supply						
	2.8.1	100 KVA	No.	8	25,000	200,000	14	350,000
	2.8.2	150 KVA	No.	1	25,000	25,000	2	50,000
	2.9	supply and installation of a group of protection pipes for closed units 6 in Dia, 0.5 cm thickness, 1.8 m length in a footing of 60 * 60 * 70 cm as per specifications	No.	36	750	27,000	52	39,000
	2.10	Removing of existing lighting columns as per specifications	No.	180	400	72,000	273	109,200
	2.11	Removing of existing transformers and distribution panels as per specifications	No.	10	5,000	50,000	8	40,000
	2.12	supply and installation of control room manholes of 70 * 70 * 70 cm as per specifications	No.	281	850	238,850	45	38,250
	2.13	supply and installation of aggregate layer of all required sizes under pipes as per specifications	LM	1,000	70	70,000	0	0
	2.14	supply and installation of LED LIGHTS 1P 67 around lands as per specifications	No.	700	800	560,000	0	0

	2.15	supply and installation of LED LIGHTS 1P 67 around Palm trees as per specifications	No.	300	2,500	750,000	0	0
	2.16	supply and installation of POLLAR light units 85 cm height with two bulbs 80 watt 36 watt1P 67 around lands as per specifications	No.	100	1,800	180,000	0	0
	2.17	supply and installation of LED LIGHTS 1P 67 around lands as per specifications	No.	4	2,500	10,000	0	0
		Subtotal				**8,554,990**		**14,663,335**
3		**<u>Storm water drainage</u>**						
	3.1	supply and installation of pipes including cut, fill, and leveling of all soil types as per specifications	LM	8,200	80	656,000	10,976	878,080
	3.2	supply and installation of aggregate layer of all required sizes under pipes as per specifications	LM	8,200	75	615,000	10,976	823,200
	3.3	supply and installation of FRP with 10000 N/m2 and 100 pounds/in as per specifications						
	3.3.X	300 mm pipe	LM	2	1,000	2,000	0	0
	3.3.1	400 mm pipe	LM	3,150	520	1,638,000	5,899	3,067,480
	3.3.2	500 mm pipe	LM	3,250	590	1,917,500	3,071	1,811,890

	3.3.3	600 mm pipe	LM	700	650	455,000	815	529,750
	3.3.4	700 mm pipe	LM	340	800	272,000	395	316,000
	3.3.5	800 mm pipe	LM	870	900	783,000	659	593,100
	3.4	supply and installation of a U.P.V.C pipes 400 mm Dia type 4 including cut, fill, and leveling of all soil types as per specifications	LM	3,150	600	1,890,000	2,638	1,582,800
	3.5	supply and installation of fiberglass circular control room manholes of 120 mm Dia and 18 mm thickness as per specifications	No.	110	8,000	880,000	153	1,224,000
	3.6	supply and installation of fiberglass drainage room manholes of 120 mm Dia and 12 mm thickness as per specifications	No.	245	8,000	1,960,000	228	1,824,000
		Subtotal				**11,068,500**		**12,650,300**
4		**Irrigation works**						
	4.1	supply and installation of a U.P.V.C pipes with all accessories including related requirements as per specifications						
	4.1.1	U.P.V.C 160 mm Dia pipes	LM	3,190	370	1,180,300	7,307	2,703,590
	4.1.2	U.P.V.C 110 mm Dia pipes	LM	2,325	290	674,250	11,419	3,311,510
	4.1.3	U.P.V.C 75 mm Dia pipes	LM	3,600	120	432,000	0	0
	4.1.4	U.P.V.C 63 mm Dia pipes	LM	6,250	100	625,000	14,738	1,473,800

	4.1.X	U.P.V.C 50 mm Dia pipes	LM	550	70	38,500	1,157	80,990
	4.2	supply and installation of a gate retention valve including related requirements as per specifications						
	4.2.1	150 mm Dia, 6 in valve	No.	20	1,200	24,000	45	54,000
	4.2.2	100 mm Dia, 4 in valve	No.	15	950	14,250	4	3,800
	4.3	supply and installation of a U.P.V.C pipes with all accessories for the purpose of irrigation network including related requirements as per specifications						
	4.3.1	U.P.V.C 50 mm Dia pipes	LM	1,200	55	66,000	0	0
	4.3.2	U.P.V.C 40 mm Dia pipes	LM	4,500	20	90,000	1,488	29,760
	4.3.3	U.P.V.C 25 mm Dia pipes	LM	1,000	17	17,000	1,266	21,522
	4.4	supply and installation of a POLYETHELENE 16 mm pipes with all accessories for the purpose of irrigation network including related requirements as per specifications	LM	5,500	7	38,500	35,757	250,299
	4.5	supply and installation of an automatic release 75 mm3 valve including related requirements as per specifications	No.	80	300	24,000	76	22,800

	4.6	supply and installation of 8 liter outflowing device including related requirements as per specifications	No.	5,000	2	10,000	85,882	171,764
	4.7	supply and installation of 25 liter/hr Tree bubblers including related requirements as per specifications	No.	80	4	320	1,308	5,232
	4.8	supply and installation of 2 in emergency valves including related requirements as per specifications	No.	18	600	10,800	16	9,600
	4.9	supply and installation of remote control system using UHF including related requirements as per specifications	No.	1	55,000	55,000	4	220,000
		Subtotal				**3,299,920**		**8,358,667**
5		**Farming works**						
	5.1	supply and installation of (Ground Cover) of the following types: sessevium red, Carissa grandiflora prostrate, cyndodon dactylon grassing, seasonal flowers-petunia hybrida including related requirements as per specifications	M2	12,000	50	600,000	10,562	528,100

	5.2	supply and installation of (Palm Trees) of the following type: phoenix-dactylifera 7 m height, and 60 cm Dia including related requirements as per specifications	No.	220	2,200	484,000	507	1,115,400
	5.3	supply and installation of (Palm Trees) of the following type: NUCIFERA-COCOS 7 m height, and 60 cm Dia including related requirements as per specifications	No.	44	2,800	123,200	57	159,600
	5.4	supply and installation of (Small Trees) of the following type: Atriplex Halimus 7 m height, and 60 cm Dia including related requirements as per specifications	No.	8,000	20	160,000	1,563	31,260
		Subtotal				**1,367,200**		**1,834,360**
		Total				**53,464,070**		**74,160,646**

CASE STUDY PROJECT B: Estimated and Actual Quantities of Project Items, resources, and assigned staff

Project B:

- **Volume of project B resources**

1) 2 Asphalt Groups, each group included the following:

- Paver machine
- steel roller
- 5 rubber roller
- steel metal roller
- Compressor
- Milling Machine
- Water tank
- many trucks

2) Equipment for soil works:

- Paver machine
- 4 graders
- 2 Dozers
- Hydraulic Excavator
- 4 dynamic rollers
- 2 water tanks
- 2 Backhoes
- 2 Boom trucks
- 2 loaders
- Many trucks

3) Curb machine plus 2 Backhoe

4) 1 Painting Group

5) 1 Concrete workers group

6) 2 electrical groups

7) 4 Sidewalks groups– subcontracted.

8) 2 storm water drainage group– subcontracted.

- **Staff required and assigned:**
  - Project Manager > 15 years' experience.
  - Project Engineer > 7 years' experience.
  - QA/QC > 10 years' experience.
  - 2 surveyors > 10 years' experience.

Table 72: Measure of the level of quantities variations of Project B

Project Title		Project B						
Location								
Owner		Governmental Entity B						
Contractor		Contractor B						
Consultant		Consultant B						
WORK DESCRIPTION			**UNIT**	**Owners estimated QTY.**	**Contr-actor's Unit Price (SR)**	**TOTAL (SR)**	**Actual**	
							Quantity	**Price**
1		**Civil WORKS**						
	1.1	**Earth Works and utilities**						
	1.1.2	Removal of curbstone	LM	1,880.00	5.00	9,400	2,744	13,720
	1.1.3	Removal of existing concrete slabs and interlock	M2	2,000.00	7.00	14,000	2,500	17,500
	1.1.5	Removal of Newjersy concrete barriers	LM	2,200.00	15.00	33,000	2,875	43,125

	1.1.7	Removal of existing binder and wearing coarse layers	M2	80,000.00	5.00	400,000	90,654	453,270
	1.1.8	Excavation of Earth Works including cut and removing all of additional wastes (Subgrade layer) as per specifications	M3	100,000.00	8.00	800,000	122,693	981,544
	1.1.9	Earth Works including fill as per specifications	M3	12,000	13.00	156,000	16,604	215,852
	1.1.10	Subgrade layer supply as per specifications	M3	40,000	19.00	760,000	57,410	1,090,790
		Subtotal				**2,172,400**		**2,815,801**
	1.3	**Backfilling works**						
	1.3.1	Backfilling works, MINIMUM 300MM THK. Base coarse AS PER ASTM D-3282 IT	M3	40,000	48	**1,920,000**	53,000	**2,544,000**
	1.4	**Asphalt**						
	1.4.1	Supply and installation of MC1 as per specifications	M2	135,000	1.5	202,500	160,000	240,000
	1.4.2	Asphalt Concrete base layer 70 mm as per specifications	M2	26,000	233	6,058,000	34,000	7,922,000
	1.4.3	Asphalt Concrete top layer (wearing coarse) 50 mm as per specifications	M2	9,600	255	2,448,000	8,615	2,196,825
		Subtotal				**8,708,500**		**10,358,825**
	1.5	**Steel and Concrete Works**						
	1.5.1	Steel grade 60	Ton	0	4,550	0	0	0
	1.5.2	Concrete for above ground bridges structures (3500 PSI)	M3	0	875	0	0	0

	1.5.3	Precast concrete for beams (4000 PSI)	M3	0	1,200	0	0	0
	1.5.4	Concrete for underground bridges structures (2800 PSI)	M3	0	725	0	0	0
	1.5.5	Concrete for supporting concrete structures around bridge (2500 PSI)	M3	0	700	0	0	0
	1.5.6	Concrete for retaining wall concrete structures around bridge (2800 PSI)	M3	0	650	0	0	0
	1.5.7	Execute Flexibles bearing devices (120 ton max)	Unit	0	8,000	0	0	0
	1.5.8	Execute Flexibles bearing devices (180 ton max)	Unit	0	10,000	0	0	0
	1.5.9	Expansion joint less than 50 mm	LM	0	6,000	0	0	0
	1.5.10	Expansion joint with 50-100mm	LM	0	7,000	0	0	0
	1.5.11	Pre-stressed Steel	Ton	0	14,750	0	0	0
	1.5.12	Preparing and installation of steel for supporting concrete structures around bridges	Ton	0	7,000	0	0	0
	1.5.13	RC Piles (1.0 m Dia)	M3	0	3,000	0	0	0
	1.5.14	RC Piles (1.2 m Dia)	M3	0	3,900	0	0	0
	1.5.15	Bearing Tests for RC Piles (1.0 m Dia)	Unit	0	175,000	0	0	0
	1.5.16	Bearing Tests for RC Piles (1.2 m Dia)	Unit	0	300,000	0	0	0
	1.5.17	Bridges Concrete Barriers	LM	0	700	0	0	0
	1.5.18	Supply and installation of refill material as per specifications	M3	0	75	0	0	0
	1.5.19	Waterproofing membrane	M2	0	40	0	0	0

	1.5.20	Bituminous Paint	M2	0	10	0	0	0
		Subtotal				**0**		**0**
	1.6	**Miscellaneous Works**						
	1.6.1	Supply and installation of one face newjersy barriers	LM	8,145	360	2,932,200	7,808	2,810,880
	1.6.3	Precast Curbstones	LM	18,200	55	1,001,000	20,460	1,125,300
	1.6.5	Water drainage sinks	Unit	1	5,000	5,000	6	30,000
	1.6.6	Control Manholes	Unit	1	5,000	5,000	2	10,000
	1.6.7	Inlets	Unit	1	5,000	5,000	4	20,000
	1.6.8	Fiberglass storm water drainage channels including cut and fill	Unit	150	9,000	1,350,000	156	1,404,000
	1.6.9	Control manholes with circular covers including cut and fill	Unit	42	13,000	546,000	47	611,000
	1.6.10	Drainage channels Grills	KG	5,900	15	88,500	6,600	99,000
	1.6.11	Control manholes covers and Grills adjustments	Unit	35	750	26,250	42	31,500
	1.6.13	Fiberglass stream Pipe (400 mm Dia) including cut and fill	LM	1,680	600	1,008,000	2,000	1,200,000
	1.6.14	Fiberglass stream Pipe (500 mm Dia) including cut and fill	LM	400	650	260,000	340	221,000
	1.6.15	Fiberglass stream Pipe (600 mm Dia) including cut and fill	LM	780	750	585,000	1,100	825,000
	1.6.17	Fiberglass stream Pipe (800 mm Dia) including cut and fill	LM	1,500	950	1,425,000	1,360	1,292,000
	1.6.18	Fiberglass stream Pipe (900 mm Dia) including cut and fill	LM	1,100	1,050	1,155,000	999	1,048,950
	1.6.21	Supply and installation of Geotex	M2	320,000	25	8,000,000	367,195	9,179,875

		fabric ground cladding						
	1.6.22	Supply and installation of Geogerd 770 g/m3 (CE 163) ground cladding	M2	182,900	13	2,377,700	179,531	2,333,903
	1.6.26	Supply and installation intermediate pass ways	M2	700	95	66,500	1,000	95,000
	1.6.27	Road Paints	Unit	1	125	125	1	125
		Subtotal				**20,836,275**		**22,302,533**
2		**ELECTRICAL WORKS**						
	2.1	Payment of electrical supply fees for the above unit supply	LS	4	25,000	100,000	4	100,000
	2.2	Supply and installation of electrical sub-plant - 400/13800 volts (100 KVA) including supply and installation as per specifications	Unit	3	45,000	135,000	3	135,000
	2.3	Supply and installation of electrical sub-plant - 400/13800 volts (150 KVA) including supply and installation as per specifications	Unit	1	65,000	65,000	1	65,000

	2.4	Cupper low voltage electrical cables (4*16 mm2) including supply, installation, and cut and fill of earth layers for installation of electrical cables as per specifications	LM	4,300	55	236,500	5,000	275,000
	2.5	Cupper low voltage electrical cables (4*25 mm2) including supply, installation, and cut and fill of earth layers for installation of electrical cables as per specifications	LM	5,500	85	467,500	7,370	626,450
	2.6	Cupper low voltage electrical cables (4*4 mm2) including supply, installation, and cut and fill of earth layers for installation of electrical cables as per specifications	LM	300	20	6,000	320	6,400
	2.7	Cupper low voltage electrical cables (1*16 mm2) including supply, installation, and cut and fill of earth layers for installation of electrical cables as per specifications	LM	6,500	15	97,500	7,370	110,550
	2.8	Cupper low voltage electrical cables (1*10 mm2) including supply, installation, and cut and fill of earth layers for installation of electrical cables as per specifications	LM	4,300	12	51,600	5,000	60,000

	2.9	Cupper low voltage electrical cables (1*2.5 mm2) including supply, installation, and cut and fill of earth layers for installation of electrical cables as per specifications	LM	8,000	10	80,000	8,600	86,000
	2.10	lighting columns 20 m height with 2 Bulbs as per specifications	Unit	100	31,000	3,100,000	102	3,162,000
	2.11	lighting columns 20 m height with 4 Bulbs as per specifications	Unit	4	31,000	124,000	4	124,000
	2.12	lighting columns 20 m height with 5 Bulbs as per specifications	Unit	8	31,500	252,000	8	252,000
	2.13	lighting bulb with a glass cover 600 watt Sodium (IP 54) including supply, installation of electrical cables as per specifications	Unit	272	900	244,800	268	241,200
	2.14	lighting bulb with a glass cover 250 watt HG (IP 54) including supply, installation of electrical cables and all required works as per specifications	Unit	40	1,500	60,000	48	72,000
	2.15	lighting bulb with a glass cover 150 watt Sodium (IP 65) including supply, installation of electrical cables as per specifications	Unit	1	3,000	3,000	3	9,000
	2.16	Grounding connections for lighting columns	Unit	120	1,500	180,000	114	171,000

	2.17	Grounding connections for electrical plants	Unit	4	3,000	12,000	4	12,000
	2.18	Grounding connections for high traffic signals	Unit	1	1,500	1,500	1	1,500
	2.19	supply and installation of U.PVC pipes 3 * 150 mm as per specifications	LM	590	325	191,750	245	79,625
	2.20	supply and installation of U.PVC pipes 1 * 110 mm as per specifications	LM	6,000	25	150,000	6,323	158,075
	2.21	supply and installation of Galvanized pipes 50 mm as per specifications	LM	2,000	90	180,000	3,200	288,000
	2.22	construction of Channels (900*900*1200) with high strength steel cover	Unit	5	3,300	16,500	8	26,400
	2.23	construction of Channels (900*1800*1200) with high strength steel cover	Unit	5	4,800	24,000	5	24,000
	2.24	construction of Channels (600*600*1000) with high strength steel cover	Unit	90	850	76,500	120	102,000
	2.25	RC footing for 20 m lighting columns as per specifications	Unit	120	5,000	600,000	114	570,000
	2.26	RC foundation for electrical sub-plant as per specifications	Unit	5	3,000	15,000	4	12,000
	2.27	Traffic lights control unit (8 stages)	Unit	1	65,000	65,000	0	0
	2.28	Traffic lights head (3*200 mm)	Unit	1	9,000	9,000	0	0

	2.29	Traffic lights head (3*100 mm)	Unit	1	7,000	7,000	0	0
	2.30	Traffic lights head (2*200 mm)	Unit	1	6,500	6,500	0	0
	2.31	control button for pedestrian traffic lights	Unit	1	5,000	5,000	0	0
	2.32	traffic light Cantilever support	Unit	1	11,000	11,000	0	0
	2.33	traffic light Pedestal support	Unit	1	8,000	8,000	0	0
	2.34	Traffic control units supplied with wireless ring installed inside sidewalks	Unit	1	6,000	6,000	0	0
		Subtotal				**6,587,650**		**6,769,200**
3		**<u>Traffic Control Devices</u>**						
	3.1	Reflecting PVC White road paints	M2	14,850	24	356,400	0	0
	3.2	Reflecting PVC Yellow road paints	M2	6,250	22	137,500	0	0
	3.3	Reflecting road signs type A	Unit	3,501	26	91,026	2,541	66,066
	3.4	Reflecting PVC traffic control road signs	M2	800	45	36,000	0	0
	3.5	Ceramic road marks	Unit	1,500	10	15,000	0	0
	3.6	Aluminum ground boards	M2	175	780	136,500	0	0
	3.7	Aluminum boards for high signals	M2	55	850	46,750	0	0
	3.8	one columns traffic lights supports I.P.E	Kg	1,200	16	19,200	0	0
	3.9	Double columns traffic lights supports I.P.E	Kg	8,500	16	136,000	0	0
	3.10	Triple columns traffic lights supports I.P.E	Kg	2,000	16	32,000	0	0

	3.11	Pipes traffic lights supports I.P.E	Unit	85	650	55,250	0	0
	3.12	Upper traffic lights supports I.P.E	Ton	2	12,000	24,000	0	0
	3.13	Cantilever traffic lights supports I.P.E	Ton	75	12,000	900,000	0	0
	3.14	Gantry traffic lights supports I.P.E	Ton	15	12,000	180,000	0	0
	3.15	Road boundaries signs	Unit	60	200	12,000	0	0
	3.16	One face signs for kilometers	Unit	4	200	800	0	0
						2,178,426		**66,066**
		Total				**42,403,251**		**44,856,425**

CASE STUDY PROJECT C: Estimated and Actual Quantities of Project Items, resources, and assigned staff

Project C:

- **Volume of project C resources**
  - Project Manager > 15 years' experience.
  - Electrical Engineer > 10 years' experience.
  - Electrical Engineer > 5 years' experience.
  - Mechanical Engineer > 10 years' experience.
  - QA/QC > 7 years' experience.
  - 1 surveyor > 10 years' experience.
- **Staff assigned:**
  1) 4 Electrical groups with their required tools
  2) equipment:
  - 3 Backhoes
  - 2 Boom trucks
  - 2 loaders
  - Many trucks

Table 73: Measure of the level of quantities variations of Project C

<table>
<tr><td colspan="2">Project Title</td><td colspan="7">Project C</td></tr>
<tr><td colspan="2">Location</td><td colspan="7">Dammam</td></tr>
<tr><td colspan="2">Owner</td><td colspan="7">Governmental Entity C</td></tr>
<tr><td colspan="2">Contractor</td><td colspan="7">Contractor C</td></tr>
<tr><td colspan="2">Consultant</td><td colspan="7">Consultant C, Consultant C1</td></tr>
<tr><td colspan="3" rowspan="2">WORK DESCRIPTION</td><td rowspan="2">UNIT</td><td rowspan="2">Owners estimated QTY.</td><td rowspan="2">Contr-actor’s Unit Price (SR)</td><td rowspan="2">TOTAL (SR)</td><td colspan="2">Actual</td></tr>
<tr><td>Quanti ty</td><td>Price</td></tr>
<tr><td></td><td></td><td><u>ELECTRICAL WORKS</u></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

1		**Administration Building**						
	1.1	supply and installation of a 10 KV 3*300 mm2 (XPLE) inside PVC Pipes including required works as per specifications	LM	750	450	337,500	633	284,850
	1.2	supply and installation of a PVC Pipes 160 mm including required works as per specifications	LM	750	320	240,000	705	225,600
	1.3	supply and installation of RC control room manholes of as per SEC specifications	NO.	15	5,000	75,000	7	35,000
	1.4	supply and installation electricity Plant including the following: 1) A transformer of 1500 KVA, 13.8 KV, 230, 400 V as per specifications 2) RMU Vacuum 3)ACB 230/400V	NO.	2	343,900	687,800	2	687,800
	1.5	supply and installation of 630 RMU Vacuum as per specifications	NO.	2	35,000	70,000	1	35,000
	1.6	supply and installation single core cable of 1*360 mm2 (XPLE/PVC) inside PVC Pipes including required works as per specifications	LM	15,000	360	5,400,000	2,450	882,000

	1.7	supply and installation Fiber optical cable including required works as per specifications	LM	3,500	50	175,000	2,565	128,250
	1.8	supply and installation distribution frame in 42 unit machine including required works as per specifications	LM	2	10,000	20,000	0	0
		Subtotal				**7,005,300**		**2,278,500**
2		**IT Building**						
	2.1	supply and installation of a 10 KV 3*300 mm2 (XPLE) inside PVC Pipes including required works as per specifications	LM	500	450	225,000	370	166,500
	2.2	supply and installation of a PVC Pipes 160 mm including required works as per specifications	LM	500	320	160,000	190	60,800
	2.3	supply and installation of RC control room manholes of as per SEC specifications	NO.	10	5,000	50,000	0	0
	2.4	supply and installation electricity Plant including the following: 1) A transformer of 1500 KVA, 13.8 KV, 230, 400 V as per specifications 2) RMU Vacuum 3)ACB 230/400V	NO.	2	326,550	653,100	2	653,100

	2.5	supply and installation of 630 RMU Vacuum as per specifications	NO.	2	35,000	70,000	2	70,000
	2.6	supply and installation of required paths and all works and equipment required as per specifications	LM	50	1,500	75,000	0	0
	2.7	supply and installation single core cable of 1*360 mm2 (XPLE/PVC) inside PVC Pipes including required works as per specifications	LM	1,300	360	468,000	1,700	612,000
	2.8	supply and installation of Electrical generator that 550 KVA and 320/400 V engine including required works as per specifications	NO.	1	350,000	350,000	1	350,000
	2.9	supply and installation of 800 A ATS unit including required works as per specifications	NO.	1	30,000	30,000	0	0
	2.10	supply and installation FSM 144 Fiber optical cable using SCADA system including required works as per specifications	LM	600	50	30,000	170	8,500

	2.11	supply and installation distribution frame ODF using SCADA system in 42 unit machine including required works as per specifications	NO.	2	10,000	20,000	0	0
		Subtotal				**2,131,100**		**1,920,900**
3		**Marine Administration Building**						
	3.1	supply and installation of a 10 KV 3*300 mm2 (XPLE) inside PVC Pipes including required works as per specifications	LM	550	450	247,500	497	223,650
	3.2	supply and installation of a PVC Pipes 160 mm including required works as per specifications	LM	550	320	176,000	210	67,200
	3.3	supply and installation of RC control room manholes of as per SEC specifications	NO.	10	5,000	50,000	1	5,000
	3.4	supply and installation electricity Plant including the following: 1) A transformer of 1500 KVA, 13.8 KV, 230, 400 V as per specifications 2) RMU Vacuum 3)ACB 230/400V	NO.	1	320,650	320,650	1	320,650

	3.5	supply and installation of 630 RMU Vacuum as per specifications	NO.	1	35,000	35,000	0	0
	3.6	supply and installation FSM 144 Fiber optical cable using SCADA system including required works as per specifications	LM	550	50	27,500	0	0
	3.7	supply and installation distribution frame ODF using SCADA system in 42 unit machine including required works as per specifications	NO.	2	10,000	20,000	0	0
	3.8	supply and installation single core cable of 1*360 mm2 (XPLE/PVC) inside PVC Pipes including required works as per specifications	LM	1,000	360	360,000	0	0
		Subtotal				**1,236,650**		**616,500**
4		**Marine Pilots leisure Building**						
	4.1	supply and installation of a 10 KV 3*300 mm2 (XPLE) inside PVC Pipes including required works as per specifications	LM	750	450	337,500	777	349,650
	4.2	supply and installation of a PVC Pipes 160 mm including required	LM	750	320	240,000	420	134,400

		works as per specifications						
	4.3	supply and installation of RC control room manholes of as per SEC specifications	NO.	15	5,000	75,000	4	20,000
	4.4	supply and installation electricity Plant including the following: 1) A transformer of 1500 KVA, 13.8 KV, 230, 400 V as per specifications 2) RMU Vacuum 3)ACB 230/400V	NO.	1	320,650	320,650	1	320,650
	4.5	supply and installation of 630 RMU Vacuum as per specifications	NO.	1	35,000	35,000	0	0
	4.6	supply and installation FSM 144 Fiber optical cable using SCADA system including required works as per specifications	LM	750	50	37,500	730	36,500
	4.7	supply and installation distribution frame ODF using SCADA system in 42 unit machine including required works as per specifications	NO.	2	10,000	20,000	0	0

	4.8	supply and installation single core cable of 1*360 mm2 (XPLE/PVC) inside PVC Pipes including required works as per specifications	LM	750	360	270,000	110	39,600
		Subtotal				**1,335,650**		**900,800**
5		**Marine Air Defense Building**						
	5.1	supply and installation of a 10 KV 3*300 mm2 (XPLE) inside PVC Pipes including required works as per specifications	LM	1,200	450	540,000	1,080	486,000
	5.2	supply and installation of a PVC Pipes 160 mm including required works as per specifications	LM	1,200	320	384,000	380	121,600
	5.3	supply and installation of RC control room manholes of as per SEC specifications	NO.	20	5,000	100,000	4	20,000
	5.4	supply and installation of 630 RMU Vacuum as per specifications	NO.	2	35,000	70,000	0	0
	5.5	supply and installation electricity Plant including the following: 1) A transformer of 1500 KVA, 13.8 KV, 230, 400 V as per specifications	NO.	1	317,000	317,000	1	317,000

		2) RMU Vacuum 3)ACB 230/400V						
	5.6	supply and installation FSM 144 Fiber optical cable using SCADA system including required works as per specifications	LM	1,200	50	60,000	800	40,000
	5.7	supply and installation distribution frame ODF using SCADA system in 42 unit machine including required works as per specifications	NO.	2	10,000	20,000	0	0
	5.8	supply and installation single core cable of 1*360 mm2 (XPLE/PVC) inside PVC Pipes including required works as per specifications	LM	1,500	360	540,000	0	0
		Subtotal				**2,031,000**		**984,600**
6		**Energy Plant Building**						
	6.1	supply and installation of RC control room manholes for MV SWITCH GEAR as per SEC specifications	NO.	1	275,000	275,000	0	0

	6.2	supply and installation of MV SWITCH GEAR 6.9/13.8 KVA as per SEC specifications	NO.	10	137,500	1,375,000	0	0
	6.3	supply and installation of BUS BAR COUPLER as per SEC specifications	NO.	2	185,900	371,800	0	0
	6.4	supply and installation of a 10 KV 3*300 mm2 (XPLE) inside PVC Pipes including required works as per specifications	LM	250	450	112,500	0	0
	6.5	supply and installation electricity Plant including the following: 1) A transformer of 1500 KVA, 13.8 KV, 230, 400 V as per specifications 2) RMU Vacuum 3)ACB 230/400V	NO.	1	270,000	270,000	0	0
	6.6	supply and installation FSM 144 Fiber optical cable using SCADA system including required works as per specifications	LM	8,000	50	400,000	4,027	201,350
	6.7	supply and installation distribution frame ODF using SCADA system in 42 unit machine including required	NO.	2	10,000	20,000	0	0

		works as per specifications						
	6.8	supply and installation of firefighting alarm system including required works as per specifications	NO.	1	50,000	50,000	0	0
	6.9	supply and installation of automatic fire fighting system including required works as per specifications	NO.	1	30,000	30,000	0	0
	6.10	supply and installation of Split AC UNITS including required works as per specifications	NO.	8	5,000	40,000	0	0
	6.11	supply and installation of grounding cables system including required works as per specifications	NO.	1	30,000	30,000	0	0
		Subtotal				**2,974,300**		**201,350**
		Total				**16,714,000**		**6,902,650**

Table 74: Main deleted items of Project C

Item		**UNIT**	**Owners estimated QTY.**	**Contractor's Unit Price (SR)**	**TOTAL (SR)**	**Actual**	
						Quantity	**Price**
2.3	supply and installation of RC control room manholes	NO.	10	5,000	50,000	0	0

2.6	supply and installation of required paths and all works and equipment required	LM	50	1,500	75,000	0	0
2.9	supply and installation of 800 A ATS unit	NO.	1	30,000	30,000	0	0
2.11	supply and installation distribution frame ODF using SCADA system	NO.	2	10,000	20,000	0	0
3.5	supply and installation of 630 RMU Vacuum	NO.	1	35,000	35,000	0	0
3.6	supply and installation FSM 144 Fiber optical cable using SCADA system	LM	550	50	27,500	0	0
3.7	supply and installation distribution frame ODF using SCADA system	NO.	2	10,000	20,000	0	0
3.8	supply and installation single core cable of 1*360 mm2 (XPLE/PVC)	LM	1,000	360	360,000	0	0
4.5	supply and installation of 630 RMU Vacuum	NO.	1	35,000	35,000	0	0
4.7	supply and installation distribution frame	NO.	2	10,000	20,000	0	0

	ODF using SCADA system						
5.4	supply and installation of 630 RMU Vacuum	NO.	2	35,000	70,000	0	0
5.7	supply and installation distribution frame ODF using SCADA system	NO.	2	10,000	20,000	0	0
5.8	supply and installation single core cable of 1*360 mm2 (XPLE/PVC)	LM	1,500	360	540,000	0	0
6.1	supply and installation of RC control room manholes	NO.	1	275,000	275,000	0	0
6.2	supply and installation of MV SWITCH GEAR 6.9/13.8 KVA	NO.	10	137,500	1,375,000	0	0
6.3	supply and installation of BUS BAR COUPLER	NO.	2	185,900	371,800	0	0
6.4	supply and installation of a 10 KV 3*300 mm2 (XPLE)	LM	250	450	112,500	0	0
6.5	supply and installation electricity Plant	NO.	1	270,000	270,000	0	0
6.7	supply and installation distribution frame	NO.	2	10,000	20,000	0	0

	ODF using SCADA system						
6.8	supply and installation of firefighting alarm system	NO.	1	50,000	50,000	0	0
6.9	supply and installation of automatic fire fighting system	NO.	1	30,000	30,000	0	0
6.10	supply and installation of Split AC UNITS	NO.	8	5,000	40,000	0	0
6.11	supply and installation of grounding cables system	NO.	1	30,000	30,000	0	0
	Total				**3,876,800**		

CASE STUDY PROJECT D: Estimated and Actual Quantities of Project Items, resources, and assigned staff

Project D:

- **Volume of project D resources used**

1) 2 Asphalt Groups, each group included the following:

- Paver machine
- steel roller
- 5 rubber roller
- steel metal roller
- Compressor
- Milling machine
- Water tank
- many trucks

2) equipment:

- Paver machine
- 4 graders
- 2 dozers
- 4 dynamic rollers
- 2 water tanks
- 2 Backhoes
- Boom truck
- 2 loaders
- Many trucks

3) Curb machine plus 2 Backhoe

4) Painting Group

5) Concrete workers group

6) Electrical group

7) Storm water drainage group- subcontracted

8) Sidewalks group- subcontracted

- **Staff required and assigned:**
  - Project Manager > 15 years' experience.
  - Project Engineer > 7 years' experience.
  - Electrical Engineer > 10 years' experience.
  - Mechanical Engineer > 10 years' experience.
  - QA/QC > 7 years' experience.
  - Safety Engineer > 7 years' experience.
  - 2 surveyors > 10 years' experience.

Table 75: Measure of the level of quantities variations of Project D

Project Title		Project D						
Location								
Owner		Governmental Entity D						
Contractor		Contractor D						
Consultant		Consultant D-Consultant D1						
WORK DESCRIPTION			**UNIT**	**Owners estimated QTY.**	**Contr-actor's Unit Price (SR)**	**TOTAL (SR)**	**Actual**	
							Quantity	**Price**
1		**Civil WORKS**						
	1.1	**Earth works and sidewalks**						

	1.1.1	Backfilling works, MINIMUM 200 MM THK. Base coarse AS PER ASTM D-3282 IT including mixing with SLAGE, SHOULD COMPACTED TO 100% OF MAXIMUM DRY DENSITY	M2	126,500	70	8,855,000	146,305	10,241,350
	1.1.2	Asphalt Concrete base layer 70 mm including MC1 as per specifications	M2	500,500	12	6,006,000	550,321	6,603,852
	1.1.3	Asphalt Concrete top layer (wearing coarse) 50 mm as per specifications	M2	598,500	10	5,985,000	687,978	6,879,780
	1.1.4	Interlock (10*10*20 cm) including supply, installation, removing existing pavements, and supply and compaction of base coarse layer under slabs as per specifications	M2	53,000	75	3,975,000	52,326	3,924,450
	1.1.5	Curbstone						
	1.1.5.1	Curbstone (91.5*15*30 cm)	LM	88,000	60	5,280,000	88,090	5,285,400
	1.1.5.2	Curbstone (50*15*30 cm)	LM	35,000	50	1,750,000	36,000	1,800,000
	1.2	**Manholes works**						
	1.2.1	supply and installation of manholes covers 350 ton, 40 cm Dia as per specifications	No.	49	5,000	245,000	49	245,000
		Subtotal				**32,096,000**		**34,979,832**
2		**ELECTRICAL WORKS**						

	2.1	lighting columns 30 m height 1000 watt as per attached drawings and specifications						
	2.1.1	13.8 KVA key sub-plant as per specifications	No.	4	110,000	440,000	4	440,000
	2.1.2	Medium voltage 13.8 KVA Insulated Cable (X110) mm2 as per specifications	LM	0	290	0	0	0
	2.1.3	Low voltage 13.8 KVA Insulated Cable (X110) mm2 as per specifications	LM	0	18	0	0	0
	2.1.4	Low voltage 13.8 KVA Insulated Cable (X450) mm2 as per specifications	LM	24,250	150	3,637,500	42,000	6,300,000
	2.1.5	Low voltage 13.8 KVA Insulated Cable (X125) mm2 type LSF as per specifications	LM	0	35	0	0	0
	2.1.6	lighting columns 12 m height 1000 watt as per specifications	No.	714	3,200	2,284,800	774	2,476,800
	2.1.7	400 watt (HPS) lighting bulb with a glass cover for a 12 m lighting columns including supply, installation, and supply, installation of electrical cables, and commissioning as per specifications	No.	714	850	606,900	774	657,900
	2.1.8	supply and installation and any testing needed to adjust existing grounding system as per specifications	No.	0	5,000	0	0	0

	2.1.9	13.8 KVA electrical grounding key sub-plant as per specifications	No.	4	15,000	60,000	4	60,000
	2.1.10	supply and installation of a U.P.V.C pipes 50 mm Dia and 80 cm depth including cut, fill, and leveling of all soil types as per specifications	LM	0	20	0	0	0
	2.1.11	supply and installation of a U.P.V.C pipes 150 mm Dia and 80 cm depth including cut, fill, and leveling of all soil types as per specifications	LM	2,500	40	100,000	2,344	93,760
	2.1.12	supply and installation of concrete manholes 1200*900*900 mm including cut, fill, and leveling of all soil types as per specifications	No.	0	300	0	0	0
	2.1.13	supply and installation of concrete manholes 1000*600*600 mm including cut, fill, and leveling of all soil types as per specifications	No.	124	2,500	310,000	184	460,000
	2.1.14	Removing existing lighting columns and all related wastes as per specifications	No.	0	0	0	0	0
		Subtotal				**7,439,200**		**10,488,460**
##		**<u>Farming and irrigation works</u>**						

	3.1	removing up to (20-25 cm) of the existing soil and supply another new layer of soil as per specifications	M2	220,000	20	4,400,000	206,000	4,120,000
	3.2	supply and installation of vaginatum Paspalum grass with all accessories including related requirements as per specifications	M2	3,500	14	49,000	3,122	43,708
	3.3	supply and installation of seasonal flowers with all accessories including irrigation system and requirements as per specifications	No.	0	6	0	0	0
	3.4	supply and installation of conocarpus trees (1-1.5 m) with all accessories and requirements as per specifications	No.	455	80	36,400	455	36,400
	3.5	supply and installation of a POLYETHELENE pipes with all accessories for the purpose of irrigation network including related requirements as per specifications						
	3.5.1	6 in (160 mm) pipes	LM	14,500	65	942,500	16,500	1,072,500
	3.5.2	4 in (110 mm) pipes	LM	21,850	38	830,300	27,845	1,058,110
	3.5.3	3 in (90 mm) pipes	LM	4,400	30	132,000	4,394	131,820
	3.5.4	2 in (63 mm) pipes	LM	2,420	19	45,980	2,920	55,480
	3.5.5	1.5 in (50 mm) pipes	LM	136,105	13	1,769,365	186,102	2,419,326
	3.5.6	1 in (32 mm) pipes	LM	19,620	11	215,820	18,610	204,710

	3.6	supply and installation of a tree Pillar 1 gallon/minute with all accessories for the including related requirements as per specifications	No.	8,780	14	122,920	8,776	122,864
	3.7	supply and installation of a tree Plastic Gun Sprinkle from 1-360 degrees with all accessories for the including related requirements as per specifications						
	3.7.1	Covers a radius of (3-3.7 m)	No.	0	22	0	0	0
	3.7.2	Covers a radius of (3.7-4.6 m)	No.	3,600	30	108,000	3,598	107,940
	3.7.3	Covers a radius of (4.3-5.2 m)	No.	101	30	3,030	101	3,030
	3.7.4	Covers a radius of (4.9 - 5.8 m)	No.	0	30	0	0	0
	3.7.5	Covers a rectangle of (1.5*1.0*10 m)	No.	0	30	0	0	0
	3.8	supply and installation of a tree 1/2 in Circular Sprinkle Covers a radius of (7.7-5.2 m) with all accessories for the including related requirements as per specifications	No.	8,905	500	4,452,500	8,902	4,451,000
	3.9	supply and installation of a tree 1/2 in Circular Sprinkle Covers a radius of (6.7-9.1 m) with all accessories for the including related	No.	2,000	50	100,000	2,000	100,000

		requirements as per specifications						
	3.1	supply and installation of a tree 1/2 in seasonal flowers dot Sprinkle with all accessories for the including related requirements as per specifications	No.	0	7	0	0	0
	3.11	supply and installation of air, washing and control valves on highway streets with all accessories for the including related requirements as per specifications						
	3.11.1	supply and installation 1 in Gate valves with all accessories for the including related requirements as per specifications	No.	75	8,500	637,500	73	620,500
	3.11.2	supply and installation 2 in Gate valves with all accessories for the including related requirements as per specifications	No.	21	6,300	132,300	21	132,300
	3.11.3	supply and installation of washing 2 in valves with all accessories for the including related requirements as per specifications	No.	35	700	24,500	33	23,100

	3.11.4	supply and installation of 2 in air valves with all accessories for the including related requirements as per specifications	No.	100	800	80,000	99	79,200
	3.11.5	supply and installation of 1 in copper or bronze valves with all accessories for the including related requirements as per specifications	No.	460	800	368,000	460	368,000
	3.12	supply and installation of automatic control valves with all accessories for the including related requirements as per specifications						
	3.12.1	supply and installation of 3 in automatic control electrical valves with all accessories for the including related requirements as per specifications	No.	200	1,400	280,000	295	413,000
	3.12.2	supply and installation of 2 in automatic control electrical valves with all accessories for the including related requirements as per specifications	No.	450	500	225,000	450	225,000
	3.12.3	supply and installation of 1.5 in automatic control electrical valves with all accessories for the including related	No.	60	400	24,000	56	22,400

		requirements as per specifications						
	3.13	Automatic Decoder control system with all accessories for the including related requirements as per specifications						
	3.13.1	supply and installation of automatic control unit to control irrigation system with all accessories for the including related requirements as per specifications	No.	5	22,000	110,000	5	110,000
	3.13.2	supply and installation of control cables to control irrigation system type AWG14	LM	47,250	10	472,500	47,250	472,500
	3.13.3	supply and installation of valves decoder with all accessories for the including related requirements as per specifications	No.	270	500	135,000	368	184,000
	3.13.4	supply and installation of grounding cables system for valves decoder and control unit with all accessories for the including related requirements as per specifications	No.	45	1,400	63,000	45	63,000

	3.13.5	supply and installation of connector points for connecting cables system with all accessories for the including related requirements as per specifications	No.	1,350	25	33,750	1,343	33,575
	3.13.6	supply and installation of Discs filters 400 gallon/unit with all accessories for the including related requirements as per specifications	No.	6	30,000	180,000	6	180,000
	3.14	stream drainage system						
	3.14.1	removing of stream drainage existing system and install a new one with the same dimensions as per specifications	LM	5,700	761	4,337,700	5,664	4,310,304
	3.15	Switch Gears						
	3.15.1	supply and installation of 1/1 switch gear	No.	1	280,000	280,000	1	280,000
	3.15.2	supply and installation of 1/2 switch gear with all accessories for the including related requirements as per specifications	No.	1	352,000	352,000	1	352,000
		Subtotal				**20,943,065**		**21,795,767**
		Total				**60,478,265**		**67,264,059**

CASE STUDY PROJECT E: Estimated and Actual Quantities of Project Items, resources, and assigned staff

Project E:

- **Volume of resources used in Project E**

1) 2 Asphalt Groups, each group included the following:

- Paver machine
- steel roller
- 3 rubber roller
- steel metal roller
- Compressor
- Water tank
- many trucks
- 15 operators and workers

2) equipment:

- Paver machine
- 2 graders
- 3 dynamic rollers
- 3 water tanks
- 2 Backhoes
- 2 Cranes
- 2 loaders
- Many trucks

3) Curb machine plus 2 Backhoe
4) Painting Group
5) 3 Concrete workers group – subcontracted.

6) Sidewalks group

- **Staff required and assigned:**
  - Project Manager > 15 years' experience.
  - Project Engineer > 7 years' experience.
  - Materials Engineer > 7 years' experience.
  - Safety Engineer > 7 years' experience.
  - QA/QC > 7 years' experience.
  - 2 surveyors > 10 years' experience.

Table 76: Measure of the level of quantities variations of Project E

Project Title		Project E						
Location		Dammam-Riyadh Highway						
Owner		Governmental Entity E						
Contractor		Contractor E						
Consultant		Consultant E/ Consultant E1						
WORK DESCRIPTION			**UNIT**	**Owners estimated QTY.**	**Contr-actor's Unit Price (SR)**	**TOTAL (SR)**	**Actual**	
							Quantity	**Price**
		Bridge 285						
1		**EARTH WORKS**						
	1.1	Earth Works including excavation for foundations, blinding, and removing all of additional wastes as per specifications	M3	10,000	35	350,000	1,858	65,030
	1.2	Backfilling works, MINIMUM 300MM THK. AS PER ASTM D-3282 IT SHOULD COMPACTED TO 95% OF MAXIMUM DRY DENSITY AS PER ASTM	M3	135,000	18	2,430,000	154,348	2,778,264

		Subtotal				**2,780,000**		**2,843,294**
2		**<u>Concrete WORKS</u>**						
	2.1	plain concrete below footing	M3	225	511	114,975	289	147,679
	2.2	plain concrete below approach SOG	M2	430	51	21,973	411	21,002
	2.3	reinforced concrete for footing	M3	445	2,400	1,068,000	455	1,092,000
	2.4	reinforced concrete for abutment	M3	450	3,175	1,428,750	579	1,838,325
	2.5	reinforced concrete for approach SOG	M3	125	2,160	270,000	120	259,200
	2.6	**Subtotal**				**2,903,698**		**3,358,206**
3		**<u>Precast works</u>**						
	3.1	Precast works for concrete beams, Pre-Stressing works for concrete beams, and Installation of concrete I beam	LM	390	5,712	2,227,680	390	2,227,680
	3.2	reinforced concrete for deck slab including median and end barrier	M3	185	2,675	494,875	215	575,125
	3.3	reinforced concrete for diaphragms	LM	50	1,637	81,850	41	67,117
	3.4	reinforced concrete for deck (Girder) stoppers	M3	10	3,207	32,070	8	25,656
	3.5	**Subtotal**				**2,836,475**		**2,895,578**
4		**<u>Expansion Joints</u>**						
	4.1	Expansion joint with 20mm	LM	115	167	19,205	68	11,356
	4.2	Expansion joint with 100mm	LM	35	2,340	81,900	34	80,028
	4.3	**Subtotal**				**101,105**		**91,384**
5		**<u>Bearing Devices Work</u>**						
	5.1	Execute bearing devices	Unit	20	5,845	116,900	20	116,900
6		**<u>Insulation Layers Work</u>**						

	6.1	Polyethylene sheet below slab	M2	900	13	12,060	823	11,028
	6.2	Water proofing membrane horizontally under foundation	M2	350	75	26,250	354	26,550
	6.3	Water proofing membrane vertically for walls	M2	1,000	91	91,000	1,041	94,731
		Subtotal				**129,310**		**132,309**
7		**<u>Base layers and Sub Base layers Work</u>**						
	7.1	Execute sub base coarse with thickness 20 cm	M2	27,000	20	540,000	14,015	280,300
	7.2	Execute base coarse with thickness 20 cm	M3	27,001	25	675,025	14,181	354,525
		Subtotal				**1,215,025**		**634,825**
8		**<u>Asphalt Layers Work</u>**						
	8.1	prime coat to base course	M2	25,000	3	62,500	14,181	35,453
	8.2	Asphalt Concrete base (Binder) layer 70 mm as per specifications	M2	24,000	25	600,000	10,191	254,775
	8.3	Tack coat to binder course	M2	24,000	2	48,000	10,191	20,382
	8.4	Asphalt Concrete top layer (wearing coarse) 50 mm as per specifications	M2	28,000	20	560,000	15,597	311,940
		Subtotal				**1,270,500**		**622,550**
9		**<u>Median Barrier Work</u>**						
	9.1	base for new jersey barrier	LM	1,850	601	1,111,850	1,788	1,074,588
	9.2	new jersey barrier	LM	1,850	350	647,500	1,788	625800
		Subtotal				**1,759,350**		**1,700,388**
10		**<u>Curb Stone Work</u>**						
	10.1	Curbstone (91.5*15*30 cm)	LM	2,450	134	327,320	0	0

11		**<u>Road Paints Work</u>**						
	11.1	road marking	LM	8,800	13	117,568	5,718	76,392
12		**<u>Road Signs Work</u>**						
	12.1	eye cat	UNIT	40	2,171	86,840	20	43420
	12.2	road signs	UNIT	875	40	35,000	1,344	53760
		Subtotal				**121,840**		**97,180**
13		**<u>Bridge Guard Rail Work</u>**						
	13.1	fix bridge guard rail	LM	170	367	62,390	260	95,420
		Subtotal				**13,741,481**		**12,664,426**
		Bridge 310						
1		**<u>EARTH WORKS</u>**						
	1.1	Earth Works including excavation for foundations, blinding, and removing all of additional wastes as per specifications	M3	11,500	35	402,500	2,014	70,490
	1.2	Backfilling works, MINIMUM 300MM THK. AS PER ASTM D-3282 IT SHOULD COMPACTED TO 95% OF MAXIMUM DRY DENSITY AS PER ASTM	M3	165,000	19	3,135,000	220,717	4,193,623
		Subtotal				**3,537,500**		**4,264,113**
2		**<u>Concrete WORKS</u>**						
	2.1	plain concrete below footing	M3	140	511	71,540	44	22,484
	2.2	plain concrete below approach SOG	M2	430	52	22,360	508	26,416
	2.3	reinforced concrete for footing	M3	380	2,542	965,960	650	1,652,300
	2.4	reinforced concrete for abutment	M3	450	3,175	1,428,750	741	2,352,675
	2.5	reinforced concrete for approach SOG	M3	125	2,160	270,000	149	321,840

	2.6	reinforced concrete for Piles of Abutment		925	2,175	2,011,875	790	1,718,250
		Subtotal				**4,770,485**		**6,093,965**
3		**Precast works**						
	3.1	Precast works for concrete beams, Pre-Stressing works for concrete beams, and Installation of concrete I beam	LM	390	5,715	2,228,850	390	2,228,850
	3.2	reinforced concrete for deck slab including median and end barrier	M3	185	2,675	494,875	368	984,400
	3.3	reinforced concrete for diaphragms	LM	50	1,637	81,850	41	67,117
	3.4	reinforced concrete for deck (Girder) stoppers	M3	10	3,207	32,070	8	25,656
		Subtotal				**2,837,645**		**3,306,023**
4		**Expansion Joints**						
	4.1	Expansion joint with 20mm	LM	115	167	19,205	78	13,026
	4.2	Expansion joint with 100mm	LM	35	2,340	81,900	41	95,940
		Subtotal				**101,105**		**108,966**
5		**Bearing Devices Work**						
	5.1	Execute bearing devices	Unit	20	5,845	116,900	20	116,900
6		**Insulation Layers Work**						
	6.1	Polyethylene sheet below slab	M2	700	13	9,380	955	12,797
	6.2	Water proofing membrane horizontally under foundation	M2	350	75	26,250	401	30,075
	6.3	Water proofing membrane vertically for walls	M2	1,000	91	91,000	1,220	111,020
		Subtotal				**126,630**		**153,892**

7		**Base layers and Sub Base layers Work**						
	7.1	Execute sub base coarse with thickness 20 cm	M2	22,000	20	440,000	18,805	376,100
	7.2	Execute base coarse with thickness 20 cm	M3	26,000	25	650,000	19,858	496,450
		Subtotal				**1,090,000**		**872,550**
8		**Asphalt Layers Work**						
	8.1	prime coat to base course	M2	26,000	3	65,000	19,858	49,645
	8.2	Asphalt Concrete base (Binder) layer 70 mm as per specifications	M2	20,000	25	500,000	14,755	368,875
	8.3	Tack coat to binder course	M2	20,000	2	40,000	14,755	29,510
	8.4	Asphalt Concrete top layer (wearing coarse) 50 mm as per specifications	M2	27,000	20	540,000	21,782	435,640
		Subtotal				**1,145,000**		**883,670**
9		**Median Barrier Work**						
	9.1	base for new jersey barrier	LM	1,800	601	1,081,800	2,178	1,308,978
	9.2	new jersey barrier	LM	1,800	350	630,000	2,178	762,300
		Subtotal				**1,711,800**		**2,071,278**
10		**Curb Stone Work**						
	10.1	Curbstone (91.5*15*30 cm)	LM	2,800	134	374,080	0	0
11		**Road Paints Work**						
	11.1	road marking	LM	7,700	13	102,872	6,993	93,426
12		**Road Signs Work**						
	12.1	eye cat	UNIT	40	2,175	87,000	19	41,325
	12.2	road signs	UNIT	1,005	40	40,200	1,656	66,240
		Subtotal				**127,200**		**107,565**
13		**Bridge Guard Rail Work**						

	13.1	fix bridge guard rail	LM	170	367	62,390	265	97,255
		Subtotal				**16,103,607**		**18,169,603**
		Total				**29,845,088**		**30,834,030**