MULTI-CRITERIA DECISION MAKING MODEL FOR THE SELECTION OF A CONSTRUCTION CONTRACTOR IN SAUDI ARABIA

BY

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A Thesis Presented to the
DEANSHIP OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

In

CONSTRUCTION ENGINEERING & MANAGEMENT

MAY, 2012

KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS

DHAHRAN 31261, SAUDI ARABIA

DEANSHIP OF GRADUATE STUDIES

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IN THE NAME OF ALLAH, THE MOST GRACIOUS AND THE MOST MERCIFUL

DEDICATION

I dedicate this work to My Beloved

Parents,

Brothers, and Sisters,

Grandfathers, and Grandmothers,

For their Support, patience, continuous prayers and Encouragement led to this accomplishment

ACKNOWLEDGEMENT

All praise and thanks are due to Almighty Allah, Most Gracious and Most Merciful, for his immense beneficence and blessings. He bestowed upon me health, knowledge and patience to complete this work. May peace and blessings be upon prophet Muhammad (PBUH), his family and his companions.

Thereafter, acknowledgements are due to KFUPM for the support extended towards my research through its remarkable facilities and for granting me the opportunity to pursue graduate studies. My sincere appreciation and prayers are due to all those experts and professionals who referenced in this study and those who have filled and returned the study questionnaire forms.

I acknowledge, with deep gratitude and appreciation, the inspiration, the encouragement, the valuable time and the continuous guidance given to me by my thesis advisor, Dr. Ali Shash. I am also grateful to my Committee members, Dr. Sadi Assaf, and Dr. Ashraf Elazouni for their constructive guidance and support, their valuable suggestions and comments throughout the study.

Special thanks are due to my colleagues at the university, Fadi Fatayer, Abdulsamee' Halahla, Mohammed Amro, Allam Fatayer, Mohammed Abu Shosheh and many others for their help and prayers.

Finally, I have tried my best to avoid any mistakes or inaccurate data and information in this study. I apologize for any mistake that was beyond my understanding and knowledge, and may ALLAH forgive me.

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THESIS ABSTRACT

Name	:	MOHAMMAD HISHAM A. ABU NEMEH
Title	:	**Multi Criteria Decision Making Model For the Selection of a Construction Contractor in Saudi Arabia**
Degree	:	Master of Science
Major Field	:	Construction Engineering & Management
Date	:	May, 2012

Construction industry is very risky and complex; it requires a lot of management and arrangements in order to achieve all parties' objectives and requirements.
One of the most important and complicated process in construction industry that encounters construction clients in Saudi Arabia and abroad, is how to come up with the best construction contractor that will meet owner and project requirements. Because the success selection of the best contractor will lead to the success project as a whole ,this research aims to (1) investigate the current bidding system implemented by universities in Saudi Arabia., (2) determine criteria that shall be considered when selecting a contractor by universities in Saudi Arabia, and (3) develop efficient multi criteria selection model based on Analytical hierarchy process (AHP) for selecting construction contractors by universities in Saudi Arabia. Universities were selected to conduct this study in order to concentrate on one type of projects which is building stock. To achieve these objectives, exhaustive literature review was performed followed by developing and administering a questionnaire survey to the project management departments of thirteen universities at Saudi Arabia. Responds were gathered from nine out of thirteen. The results affirmed that most of universities highly depend on the lowest price when awarding contracts. In addition to that, the finding detected that respondents were not satisfied with the current bidding system due to large problems associated with it such as; poor project performance and delay of project completion time. Another interesting feature in the results illustrated that none of the project management department at universities implemented any decision support system during the evaluation or selection of construction contractor. The research also presented that three criteria out of sixteen namely: "contractor submit complete bid documents", "contractor classification", and "bid price" constitute about 50% of the impact on the final decision of construction contractor selection. Finally, the developed model that is based on Analytical hierarchy process (AHP) improves the selection process; where instead of using one criterion (lowest price) to select construction contractor other fifteen criteria were identified. The proposed model can be easily used by any universities, and at the same time the model had all capabilities to assess the criteria that impact on the construction contractor selection.

خلاصة الرسالة

اسم الطالب الكامل : محمد هشام عبدالقادر أبونعمة

عنوان الرسالة : نموذج اتخاذ القرار لاختيار مقاول التشييد في المملكة العربية السعودية بناءً على معايير متعددة

التخصص : هندسة و إدارة التشييد

تاريخ الشهادة : جمادى الآخرة 1433هـ.

صناعة التشييد و البناء من أكثر الصناعات مخاطرةً و تعقيداً ، فهي تحتاج الكثير من الترتيبات و االتنظيم من أجل تحقيق أهداف و متطلبات جميع الأطراف.
واحدة من أكثر العمليات أهميةً و تعقيداً في صناعة التشييد و التي تواجه المالك في المملكة العربية السعودية و خارجها هي كيفية اختيار مقاول البناء الأفضل القادر على تحقيق متطلبات المالك و المشروع. ولأن النجاح في اختيار المقاول الأفضل سيؤدي الى نجاح المشروع ككل، فإن هذا البحث يهدف إلى (1) التعرف والتحقق من نظام المناقصات الحالي المتبع من قبل الجامعات في المملكة العربية السعودية. (2) تحديد المعايير التي يجب أخذها بعين الاعتبار عند اختيار مقاول البناء لتنفيذ مشاريع الجامعات. (3) انشاء نموذج فعال يعتمد على عملية التحليل الهرمي (AHP) لاختيار مقاول البناء من قبل الجامعات في المملكة العربية السعودية. وقد تم اختيار الجامعات لإجراء هذه الدراسة للتركيز على نوع واحد من المشاريع ألا و هو البنايات. لتحقيق أهداف الدراسة، فإنه تم إجراء مراجعة أدبية شاملة للدراسات السابقة المتعلقة بكيفية اختيار مقاول البناء، تبعها ارسال استبيان الدراسة الى ادارات المشاريع لثلاث عشرة جامعة في المملكة العربية السعودية. وقد تم الحصول على 9 ردود على الاستبيان. أكدت النتائج أن معظم الجامعات تعتمد بشكل كبير على أدنى سعر عند اختيار مقاول البناء. بالإضافة لذلك فإن النتائج كشفت عن عدم رضى المجيبين على نظام المناقصات الحالي المتبع من قبل الجامعات نتيجة للمشاكل الكبيرة المرتبطة به مثل: التنفيذ السيء وغير المتقن للمشروع و التأخر في انهاء تنفيذ المشروع في الوقت المحدد.
ومن النتائج المثيرة للدهشة أيضاً هي عدم استخدام أي من أنظمة دعم القرار من قبل ادارات المشاريع في الجامعات سواء عند تقييم المقاولين أو عند اختيار مقاول البناء. و البحث أشار أن هناك 3 معايير من أصل 16 معياراً تشكل ما نسبته 50% من التأثير على القرار النهائي لإختيار مقاول البناء، و هذه المعايير الثلاثة هي: "تقديم وثائق العطاء كاملة من قبل المقاول" و "تصنيف المقاول" و "سعر العطاء المقدم من المقاول". و أخيراً فإن النموذج الذي تم بناؤه و الذي يعتمد على عملية التحليل الهرمي (AHP) سيحسن من عملية الاختيار، فبدلاً من الاعتماد على معيار واحد أثناء عملية الاختيار لمقاول البناء فإنه تم ايجاد 15 معياراً آخر. كما و يمكن استخدام هذا النموذج بشكل سهل من قبل أي من الجامعات، و في الوقت نفسه فإن النموذج المقترح لديه كل الامكانات لتقييم المعايير التي تؤثر على إختيار مقاول البناء في المملكة العربية السعودية.

درجة الماجستير في العلوم
جامعة الملك فهد للبترول والمعادن
الظهران ، المملكة العربية السعودية
مايو 2012م

CHAPTER 1

INTRODUCTION OF STUDY

1.1 BACKGROUND

Many of the changes happened in construction industry all around the world at the early of the twentieth century; it becomes the first factors to measure the development of countries. Therefore, a lot of money were spent and will be spent in this sector specially for enhancing infrastructure facilities that include highways, tunnels, bridges, schools, hospitals, water and sewer treatment systems.

Saudi Arabia is one of these countries that give strong attention to this sector, they laid out national development plans. Since 1970, about nine development plans have been adopted and the recent one was approved on August 9, 2010. Saudi Arabia spent billions of dollars especially in the last three decades to improve the infrastructure facilities. According to the Ministry of Finance and Economic information, the planning stage of education sector development includes constructing: around 25 technology colleges, 28 technical institutes and 50 industrial training centers. In addition to that, during the following five years (2010-2014) more than one million homes will be built.

Furthermore, in health care area, there are plans to build more than 400 centers for emergency care, 117 hospitals and 750 primary centers of health care. These future

investments in construction sector can relish productively with powerful execution of projects by construction contractors. However, there are a lot of researches performed to solve the problems encountered in construction industry. One of these problems is how to select the most appropriate contractor to perform a project. Many of tendering systems are available and implemented in construction industry. However, the open tendering system is considered the most popular one and used excessively by construction clients for awarding the contract. In reality, most of construction contractor selection is based significantly on the lowest price which is not suitable especially when the construction owner's doesn't have enough experience and the likely cost of the project is not clear.

Therefore, it is imperative to find different methods that consider criteria other than the lowest price in implementing tendering process such as experience, current workload, financial stability, safety, etc. to avoid troubles that will happen through selecting the lowest bidder.

Through extensive literature review, there are several methods proposed from researchers that depend on multi criteria decision making process (MCDM) and can be employed to contract selection. These methods embrace multi attribute analysis (MAA), evidential reasoning approach (ER), multi attribute utility theory (MAUT), bespoke approaches (BA), cluster analysis (CA), analytical hierarchy process (AHP), analytical network process (ANP), goal programming (GP), and fuzzy set theory (FST).

1.2 STATEMENT OF THE PROBLEM

The owner performs many decisions through the whole life of the project. One of these decisions is how to select a contractor during bidding phase to construct the facility.

Many questions will come to his mind during this process because the contractor selection process is not a simple decision, but it is a multi-criteria decision approach that requires a lot of concentration and efforts to perform it.

The success selection of an appropriate contractor is vital because it will lead to the success of the project as a whole due to the significant roles that the contractor plays during construction. However, as all countries around the world, Saudi Arabia government follows designated system in awarding contracts which based on the lowest price and it will be presented in details in the next chapter. There is an agreement from construction professionals that this method for contractor selection does not provide or achieve owner expectations because of its problems associated with it such as cost overruns, contractor failure, poor quality, increasing changes and claims. In addition to that, the implementation of the current prequalification system is inadequate to identify the contractor competence (Bubshait and Al-Gobali 1995). Hence, there is necessitating in performing the selection of a contractor, efficient and effectual, in order to have a fully productive harvest of the future construction industry investments.

Most of the construction projects handled by government in Saudi Arabia implement traditional approach delivery system Design-Bid-Build “DBB”. According to Saudi

Competitions and Procurements Regulation Systems, the bid is awarded to the lowest bidder. Al-Hazmi (1987) determined the problems and shortcomings associated when awarding contract to the lowest bidder such as cost overruns, poor quality, change order, and contractor bankruptcy.

During competitive bidding phase, the problems associated with determination of ability and responsibility of contractors to perform a project may arise. Thus, depending on the lowest price is not a reasonable method. Moreover, the decision of a client will be based on subjective judgment, which cannot be considered a sequential structured way in designating qualified contractors. Consequently, it is very essential for award authorization to examine contractor financial and personnel resources, equipment to carry out the task, and his capability to comply with the required quality and schedule.

Unfortunately, the selection of a competent contractor, especially in public sector, faces many problems like: unavailability of qualified consultants, management pressure to meet budget and time limitations, and owners don’t have enough experience and knowledge on decision support systems that is available for contractor evaluation and selection (Al-Busaad 1997).

This research aims to develop efficient and effectual model for contractor selection that assists an owner in selecting the most appropriate construction contractor based on multiple factors or criteria.

1.3 RESEARCH QUESTIONS

The current selection process implemented in Saudi Arabia is criticized from different disciplines due to its dependency only on the lowest bid price. Therefore, this research is performed to justify that the selection of a contractor should be based on other criteria rather than the lowest price such as time, quality, safety, etc.

There are many questions which arose to justify conducting this research, these questions are:

1. How is the construction contractor selected in Saudi Arabia?
2. What are the criteria considered to select a construction contractor?
3. What is the importance of any of these criteria?
4. Is the financial criterion the most important one?

1.4 RESEARCH JUSTIFICATION

Clients do not accept to award contract to an unsuitable contractor. Banaitiene and Banatis (2006) indicated that there are three reasons if this happens: First of all, selecting inappropriate criteria for contractor qualification evaluation. Secondly, Significance attributed to the criteria is inappropriate. Finally, the approach applied to evaluate or select a contractor is inappropriate.

If the client selects an unqualified contractor to perform the project, several problems will be stem from; before, during, and after construction due to several reasons such as poor

performance, weakness of financial stability, and inadequate consideration for safety at the worksites, etc.

The shortcomings related to the selection of unqualified contractors include:

- Project performance becomes poor (El wardani et al. 2006).
- Owner outlooks will not be met (El wardani et al. 2006).
- Some of the building will be a failure.(Fatani 1985)
- Some contractors are subjected to bankruptcy (Al-Hazmi 1987)
- Number of claims will be increased (Aitah 1988)
- Price changes and cost overruns (Banaitiene and Banatis 2006)
- Delay in project completion date (Al-Hazmi 1987)

Al-khalil and Al-Ghafly (1999) indicated that the frequency of delayed projects is most likely related to the contractor classification grade.

Delay is considered costly to an owner and a contractor. The owner loses through not using a project to gather revenues and rising in the overhead cost of supervision and contract administration while the contractor loses through increasing overhead cost, and loss opportunities to get new projects due to financial capability reduction (Al-khalil and Al-Ghafly 1999).

This research is conducted in order to avoid all of the problems mentioned above associated with the selection of unqualified contractors.

1.5 RESEARCH OBJECTIVES

The research is performed to check the criteria required to select a contractor and to assist construction clients on coming up with the suitable contractor employing decision support system.

In order to obtain these, the objectives of the study can be summarized as follows:

1. To investigate the current contractor selection approach implemented by universities in Saudi Arabia.
2. To determine the criteria that shall be considered when selecting a contractor by universities in Saudi Arabia
3. To develop efficient multi criteria selection model based on Analytical hierarchy process (AHP) for selecting contractors by universities in Saudi Arabia.

1.6 SIGNIFICANCE OF STUDY

Because most of the budget will be spent during the construction process of any project, this research will assist in identifying the critical criteria for the selection of a contractor, and the model that will be developed will make the contractor selection process more efficient. In addition to that, this model can enhance the contractor attention to the owner needs and incorporate the objectives of a public policy in the construction procurement. Furthermore, this system will assist the contractors in providing new possibilities when selecting subcontractors.

The proposed model will have many advantages including:

1. It can be employed for any construction project.
2. It can exclude or at least minimize the bad selection process.
3. An appropriate contractor will be selected through fair methods.
4. It can be used to abandon the contractor selection process that is highly dependent on the lowest price.

1.7 SCOPE AND LIMITATIONS

The scope of the research is not only to determine the criteria needed for the contractor selection through conducting exhaustive literature review and questionnaire survey, but also to evaluate the information that involves a multi criteria decision making ability using Analytical hierarchy process. Whereas the research is limited to the following scope:

1. The research will be conducted in Saudi Arabia, so that all criteria which will be used and the results obtained are limited to this country and may be applied on the gulf countries because of the resemblances among them.
2. It is assumed that the person who has responsibility to award contract is fair, and has efficient ability to perform a selection process.
3. The evaluation of the data will be employed for establishing the proposed model based on AHP.
4. The study will concentrate on the implementation of AHP as one means for a decision support system and will not discuss the best methods for a contractor selection.

1.8 THESIS ORGANIZATION

This study will be presented in six chapters as depicted below:

1. Chapter One: include introduction on the study, objective of study, the reason why this study will be performed, scope and limitation and the significance of this study.
2. Chapter Two: literature review that involves information about a bidding process, criteria for a contractor selection, different methodologies employed for the selection, and general information about analytical hierarchy process (AHP) and its procedures for implementation.
3. Chapter Three: Research methodology describes how the objectives of the study will be acquired.
4. Chapter Four: Data analysis and results obtained from a questionnaire.
5. Chapter Five: Development of AHP model for the selection of a construction contractor based on the assessment of information obtained from a questionnaire and performs validation on the model.
6. Chapter Six: Conclusion and recommendation of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter involves presenting general information about a project development process, previous studies conducted and dealt with a contractor selection, problems associated with procurement process, prequalification criteria and selection models, criteria for a contractor selection, the tendering process and the methods for awarding contracts, and the current bidding system implemented in Saudi Arabia.

2.2 PROJECT DEVELOPMENT PROCESS

According to Archibal (1976) Project development process can be defined as “the entire process required for generating a new system, new product, new plant or other specified result”. Also, the construction project can be defined as a group of activities connected together to form a task, and work together to attain a specific aim through numerous phases called project development process or project life cycle.

During the life cycle of a project, many efforts must be spent such as team working, decision making, technical capabilities, schedule techniques and coordination to achieve owner and project goals.

The life cycle for any project under Design-Bid-Build “DBB” delivery system consists of the phases shown in **Error! Reference source not found.** that are common to anyone ncorporated in a construction industry.

Feasibility Study	Design Process	Procurement	Construction	Operation & Maintenance

Figure 2.1: Project development process

2.2.1 Feasibility Study

This is the first step in the life cycle of the project. During this phase the examination of feasibility and unfeasibility of the project will be performed. There are several things that need to be analyzed and evaluated such as, economic feasibility, technical feasibility, scope of the work, site analysis, size and type of building, environmental and social impacts of the project, etc. During this stage, most of the work is performed by the owner only or sometimes with the assistance of consultants or the third party that may be engaged to conduct the feasibility studies.

2.2.2 Design Phase

This phase can be divided into two stages. First, the preliminary design that involves initiating a project from an organization, evaluating different alternatives, preparing preliminary plans, drawings, specifications of the project which will be reviewed by the clients prior going on detailed drawings, preliminary cost estimates, and preliminary landscape. Moreover, this preliminary process requires great cooperation and

coordination among different disciplines like architectural, civil, geologists, mechanical, electrical.

Secondly: detailed design, normally done by engineers and designers, that includes analysis and design of project items, refining the preliminary design, providing detailed plans and specifications, revising cost estimates, and performing a final decision on construction techniques, materials, and equipment requirements.

Based on the outcome of the design, the construction drawings and specifications are aggregated together to prepare for bidding, and to illustrate in depth all of the construction works that will be performed to who is interested in submitting the bid.

Construction documents are used to solve any conflicts that may arise between different trades during construction; in addition to that, it can be used to obtain required permits.

2.2.3 Procurement Phase

This research will be concentrated in the third stage of the project life cycle that is due to its crucial for the success of the project. During this phase, the selection of the best or appropriate contractor who meets all requirements to build the project will be conducted. Moreover, the contract between a client and a contractor is developed.

However, the selection of the procurements and contracting always depends on the construction client decision. The consultant who is a specialist professional gives advice

in terms of procurements method, contractual issues, tendering process, price analysis and cost for completion.

The different operations involved in this phase are:

1. Setting up bid documents such as, instruction to bidders, invitation to bid, etc, to be ready for bidding.
2. Performing a bid advertisement in order to attract contractors to bid.
3. Providing bidders with bid documents.
4. Performing examination on a contractor qualification.
5. Performing meetings with contractors and suppliers.
6. Receiving tenders.
7. Helping an owner in negotiation a process and in the preparation of an agreement between him and a contractor.

2.2.4 Construction Phase

Construction is the process of translating construction documents (plans and specifications) into a physical facility. In this phase, the contractor is asked to complete a project within specified cost, time and quality.

During this phase, the project manager or the agent of the owner (owner representative) performs many activities including: monitoring the construction process to ensure that every element is performed and installed according to what it has been planned,

monitoring costs and schedules, coordinating works between contractors or subcontractors, administrating changes, and participating in dispute resolutions.

2.2.5 Operation and Maintenance Phase

This is one of the most important phases because the judgments must be performed to determine if the project meets its intended objectives or not. This phase involves operating and maintaining the facility. It also includes transferring operational responsibility of the facility to operations at the outset of the initial occupancy.

2.3 PREVIOUS STUDIES

There are a lot of studies performed that dealt with a contractor evaluation or selection, either through employing prequalification or post-qualification process.

Assaf and Jannadi (1994) developed a model for a contractor prequalification selection that based on weighted comparisons of prequalification factors, they identified all prequalification factors that are essential to owners and performed a comparison to determine preferences of these factors to an owner in order to prequalify contractors and meet owners' requirements.

Park (2009) proposed a model for a bid evaluation based on the whole life cost using Analytical hierarchy process to assist decision makers or a public sector client in coming up with an appropriate design-builder.

Waara and Brochner (2006) explained how public owners can be able to use multiple-criteria in the awarding of construction contracts. They used terms price and non-price criteria in the evaluation of a contractor either in relative or absolute merits.

Watt et al. (2010) found an experimental design method that shows how to quantify the most common nine important criteria applied in the actual assessment and the selection of construction contractors. They used Discrete Choice Experiment; through it, respondents can perform an evaluation of contractors' characteristics as a function of weight assigned to each criterion. The results indicated that the most important criteria for a contractor selection are; technical expertise, past project performance and cost, whereas, the reputation and workload are less important.

Holt (1998) suggested a contractor selection method based on two stages; prequalification, then evaluation of tenders.

Alarcon and Mourgues (2002) based on studying the potential of contractors to meet client requirements, provided models that include additional criterion "contractor performance prediction" in order to evaluate tenders. Also, this model considers the most essential characteristics of projects and contractors affecting project performance and eliminates the dependency on bid price in tender evaluation or final selection. Furthermore, it is possible to adjust or update contractor information in order to give the process more confidence for long-term.

Anagnostopoulos and Vavatsikos (2006) suggested a model based on an analytical hierarchy process to help public authorities in performing contractor prequalification. This model consists from qualitative criteria and sub-criteria which are translated into quantitative indicators, from which the evaluation can be performed on candidate contractors.

Al-dughaither (2006) built up models based on an analytical hierarchy process that consists from four levels to perform prequalification of contractors in order to overcome complexities associated with this process such as; lack of group consensus and subjectivity. The model provides decision makers systematic and structured process to deal with and assess construction organizations.

Al-Shehri (2001) conducted a study to investigate the requirements of contractors' prequalification and suggested a model to get rid of or at least reduce subjectivity in a qualified contractors' selection.

Trivedi et al. (2011) provided a model based on implementation of Fuzzy modified Analytical hierarchy process (FAHP) that assists in construction contractor selection and rank the appropriate contractor for a housing project.

Manideepak et al. (2009) presented two methods for the selection of the most appropriate contractor in construction industries which are: Fuzzy decision theory method and fuzzy analytical hierarchy approach.

Alsugair (1999) developed a framework for a bid evaluation of construction contractors in Saudi Arabia depending on using post-qualification of contractors and surety company evaluation. In this framework he determined the factors that have significant impact on bid evaluation in Saudi Arabia. Furthermore, he carried out an evaluation procedure. He also indicated that it is possible to implement this framework during a prequalification process.

Tarawneh (2004) performed an evaluation on prequalification criteria used in Jordan to identify the awareness of clients on the essential magnitude on prequalification criteria and to enhance contractor chances in being prequalified for a client. He found that after a prequalification of contractors, public clients put more weight on price.

Banaitiene and Banatis (2006) analyzed the criteria employed for construction contractors' qualification in Lithuania and abroad.

Huang (2011) analyzed the theoretical approaches for the evaluation of a contractor and checked the real criteria for the contractors' selection in the construction management approach. In his research, he found that the lowest price often have troubles with the project completion.

2.4 DESIGN-BID BUILD (DBB) DELIVERY SYSTEM

Several arrangements can be used in order to organize the relationship between the parties of the projects specially the correlation between the owner and the contractor or the contractors, so that the client should take on one of these arrangements for his project.

It is important for an owner to understand that each delivery system has its own characteristics which will have an impact on the time, the cost, and the quality of the project, such characteristics include: risks distribution between the owner and the contractor, pre-tender and post tender processes, and the usefulness of project controlling and monitoring.

The most common delivery system is a traditional approach (design-bid-build) that is used widely at public projects in Saudi Arabia. This approach is linear in nature. Once the design is 100% complete, the owner goes to the bidding process to select a contractor. Normally the owner will select the contractor with the lowest bid through this arrangement and award the contract to that entity. Then the actual construction starts. The most important disadvantages in this delivery system is that there is no overlap between the design and the construction, so it will take more time than it will take in the fast-track approach. Moreover, the economic conflicts exist between the parties of the contract. But one of advantages of this method is that all the bid documents are completed before the outset of the construction which provides a better prediction of a project cost and fairness in a contractor evaluation. Figure 2.2 shows this type of delivery system.

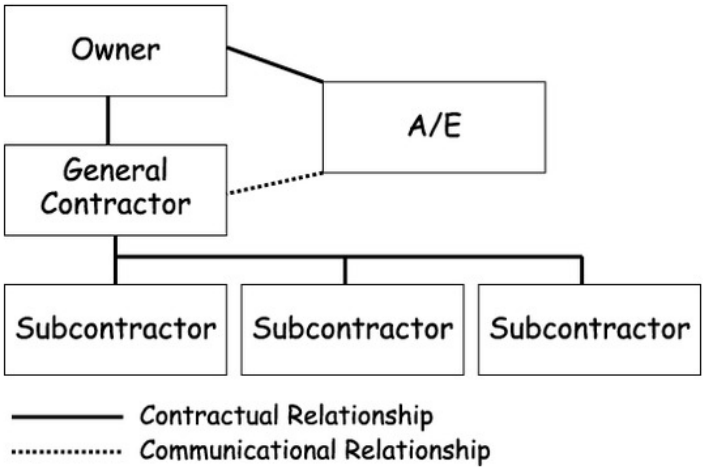


Figure 2.2: Traditional design-bid-build delivery system

2.5 CONTRACT AWARD METHOD

The selection of a suitable contractor for the project is very essential for the project success. The selection of the contractor is conducted in two stages: first, the prequalification stage: whereas the second stage is the bid evaluation (Trivedi et al. 2011).

There are several methods to award contracts. The most popular one is awarding a bid based only on the lowest price which subject to many critiques from many organizations and countries due to dilemmas correlated with it, such as delays, cost overruns, and poor quality.

Alarcon and Mourgues (2002) stated that during the prequalification process, contractors are classified in groups based on factors such as: liquidity, experience, patrimony, etc. After that, prequalified contractors submit their bids. Then these bids are assessed

depending on an economic and a technical criterion. Afterwards, the total scores are calculated in order to award a contract regarding the final score.

Holt et al. (1995) determined problems associated with this traditional awarding approach which represented by deficiency of universal method to select contractors, subjective analysis overreliance, and confidence on prequalification results for a long period of time.

Other methods to award a contract are: open tendering, restricted tendering, and negotiation as mentioned by Banaitiene and Banatis (2006).

2.6 TENDERING AND ESTIMATION PROCESS

The tendering process involves several stages including prequalification, a decision to a bid, estimating and tendering a process.

2.6.1 Prequalification

Prequalification can be defined as a process in which contractors are screening by an owner based on several criteria in order to identify competence and qualified contractors who have capability to participate in project bidding.

Also prequalification can be defined as the exclusion of ineffectual contractors from a bidding process based on predefined criteria in order to enhance a contractor selection process and diminish collapse in meeting client's requirements (Anagnostopoulos & Vavatsikos 2006).

In this process, the contractor is requested to submit different documents that assist a construction owner on evaluation including a contractor CV, a company organization, a financial status report, resources, capital, experience, equity structure, etc.

According to Alsugair (1999) the evaluation of financial and technical capabilities at prequalification is done before issuing bid documents of a project like; plans, specifications, etc. while at post-qualification the financial, technical capabilities and bid evaluation are assessed at the same time.

Banaitiene and Banatis (2006) indicated that an owner when selecting a contractor, he evaluates its competence and examines if a contractor is meeting specified requirements, legal, financial and technical. Then he performed a comparison qualification among different contractors.

The major goal of a prequalification process is to help both construction clients and contractors in making a decision. All participants in the projects will benefit from the prequalification process, the contractor guarantee that he is reasonable even basis with his competition, while the owner and the consultant eliminate the problems associated with the selection of an unqualified or inappropriate contractor (Bubshait and Al-Gobali 1995). In other words the major goal of the prequalification process is to help clients in getting the number of reasonable, competitive and experienced contractors in order to facilitate the bid evaluation process, and assigning the accurate weight for each criterion.

2.6.1.1 Sources of contractor information

Related to Al-shehri (2001), it is possible to get information about a contractor through two ways either internal or external.

The internal data are considered more reliable compared with other sources of data because the decision maker obtains data from the past performance projects, through monthly reports and debating with clients who are in a direct contact with a contractor. Whereas, the external data can be obtained through: questionnaire that a contractor will fill. Some data were obtained from banks, subcontractors, suppliers, and others can be obtained through visiting projects currently completed by the contractor.

2.6.1.2 Prequalification procedure:

Anagnostopoulos and Vavatsikos (2006) stated that the prequalification process can be conducted through five steps:

1. Performing tendering invitation.
2. Interested applicants who meet the owner requirements that submit their proposals.
3. Based on specified criteria, the selection of potential contractors is done by public authorities.
4. Contractors in the short list should submit their price offers.
5. Finally, the selection of a winner contractor.

2.6.1.3 Advantages and disadvantages of prequalification system

Many of the previous studies discussed the advantages and disadvantages of using a prequalification process (Russell 1996, Al-shehri 2001). The followings are summary of pros and cons of employing the prequalification process:

The advantages of prequalification are:

- Assuring that a low prime contractor and his subcontractors are competent to perform the activities without becoming overloaded.
- Exclusion of unqualified contractors with limited experience or financial resources.
- Reducing the number of bidders by keeping only the qualified ones.
- Protecting a contractor from awarding a contract that beyond is his capability.
- Performing an evaluation and a contract awarding process quickly.
- Transferring a subjective judgment into objective when selecting bidders.
- The selection of unqualified contractors will be avoided.
- Minimizing the bid solicitation cost.
- Affording a discipline and structure to a process.
- Giving enough time for a contractors' investigation.
- Eliminating low cost favoritism.

The disadvantages of process are:

- The prequalification process may become out of date, so it is necessary to update qualification information during the bid (Huang 2011)
- Realistic determination of responsibility is complicated.

- It includes additional screening that can be considered as a burden on the bidder and generates workload for the client.
- Qualified contractors may choose not to participate.
- Risk and information are considered the major factors that impact on quality assurance.
- It makes limitation on the contractors' ability to go to new areas that don't have previous experience on it.

2.6.2 Decision to Bid

After prequalification, all contractors in the short list are invited to bid. Then the contractor reviews all documents and specifications to take an action either to bid or not. Also the decision to bid is greatly influenced by several factors such as: the company current workload, the company overhead, the resource availability, the contract type, the type of the project, the location of the project, the advanced payment, the bonds required, the liability period and the liquidated damages.

2.6.3 Project Estimation Process

This process involves the generating cost estimate of the bid. In conducting this process, several works must be made including: defining tasks to complete the estimate, the detailed study for the construction method, the site investigation, identifying subcontracted items, determining the quantities of the work and the material required, determining personnel resources required to complete a project and their costs,

determining the direct cost of a project, calculating the indirect cost and preparing a report for tendering.

2.6.4 Tendering Process

In this process the final decision to bid or not should be made through the following stages:

1. Evaluating the estimated cost provided from the estimator.
2. Adding some general overhead cost that involves administrator expenses, and head office expenses.
3. Adding allowance for the risk and the profit to the direct cost.
4. Performing a final adjustment before preparing the bill to be ready for the bid submission.

2.7 BID EVALUATION

Bid evaluation is considered one of the most important challenges that encounter owners and consultants in both private and public sectors.

The evaluation involves the assessment of the bid submitted from prequalified contractors and checks the ability of a contractor to deliver a project within a predetermined budget, time and desirable quality.

Huang (2011) presented different models and frameworks to evaluate contractors' bids and choose the most suitable one including: Cost consideration framework, TOPSIS and

SAWG gray systems, prequalification method, construction management at a risk method and multi-criteria evaluation models.

Alsugair (1999) indicated that the way applied for a bid evaluation at public sectors is mostly awarding a contract to the lowest price contractors because public owners revealed that the greatest value for their money has been gained.

There are different methods used for contractors' bid evaluation as exhibited by Russell 1996 involving: a two-step prequalification, dimensional weighting, and dimension wide strategy.

According to Alsugair (1999) the most important factors that can be used in bid evaluation are depicted in Figure 2.3 and can be summarized to include:

1. Bidding financial evaluation.
2. Understanding the bid.
3. Location of a project.
4. Contractor qualification.
5. Contractor experience and reputation.
6. Completion of bid documents.
7. Contractor organization.
8. Submission of alternate offers.
9. Foreign companies.

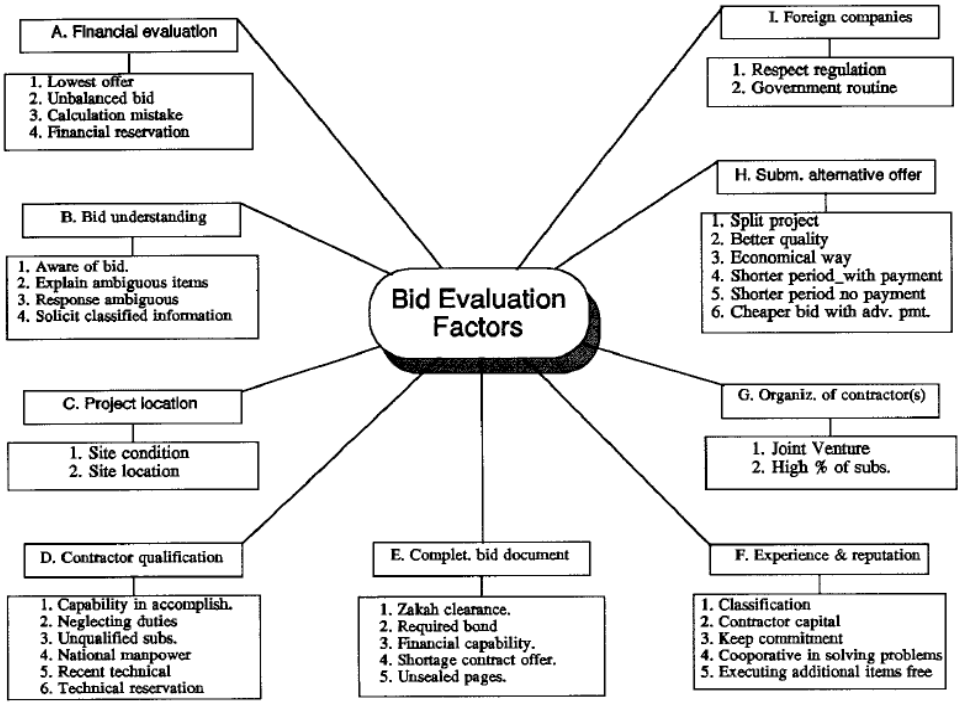


Figure 2.3: Factors considered for bid evaluation (Al-Sugair 1999)

2.8 CONTRACTOR SELECTION CRITERIA

A contractor selection is a multi-criteria decision. It is a very important decision that an owner must make in order to obtain a facility without problems in cost, time, safety, and quality. Waara and Brochner (2006) pointed out using multi-criteria used up resources of administrative inside unit of procuring and entities that bid for contracts.

To perform that there are a lot of criteria which must be determined before selection, these depend on the clients of the facility if it is public or private. This also depends on the type of the project.

According to Park (2009), contractors and subcontractors considered cost as the most important factor for all the stages of the project.

The followings are some of previous studies that aim to determine the most important criteria for implementing a contractor selection process:

1. Assaf and jannadi (1994) in their proposed model use these criteria: financial stability, past performance, availability of staff, company organization, quality performance, experience in procurement, manpower resources, current workload, experience in project geographic location, failure in contract completion, office location, safety and claim attitude.
2. Park (2009) adopted these factors: project organization, type of a project and its size, type of a contract, construction, human resources, cost, risk, quality of materials and health. Furthermore, Park suggested criteria for Design-Builder selection (figure 2.4).

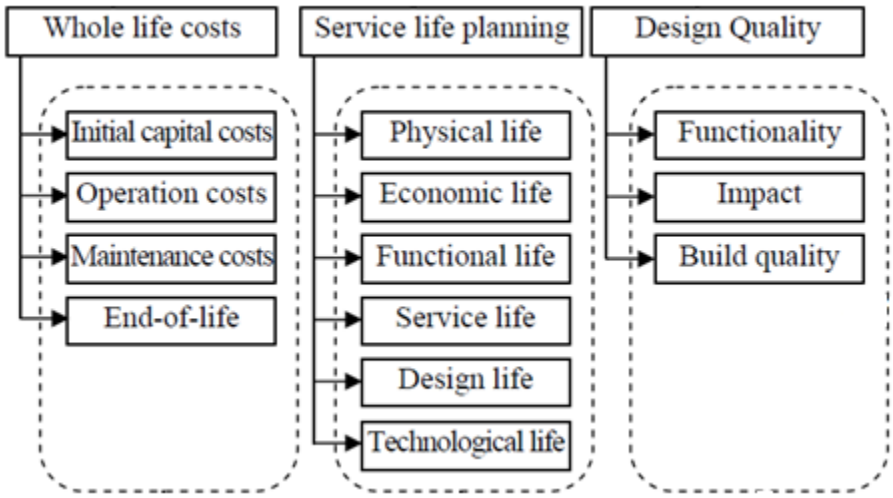


Figure 2.4: Criteria for Design-Builder selection

3. Bubshait and Al-Gobali (1995) found the most important criteria for the prequalification of contractors that include: Experience, financial stability, quality control and quality assurance, staff ability management, planning methods, material handling and cost control, scheduling equipment resources, claim attitude and references, scheduling, safety, and location of home office (Table 2-1)

Table 2-1: Prequalification criteria in Saudi Arabia (Bubshait & Al-Gobali 1995)

Work experience & Past performance	Equipment resources
Financial stability	Safety
Quality control & quality assurance	Reference and claim attitude
Contractor organization	Home office location
Management capability	Purchasing expertise
Capacity of contractor	Material handling
Planning, Scheduling and cost control expertise and techniques	

4. Hatush and Skitmore (1997) conducted study in UK and determined twenty factors that have significant impact on the contractor selection process as shown in table 2-2
5. Palaneeswarans and kumaraswary (1999) found that the criteria used for a contractor evaluation can be classified in three groups, first: responsiveness that includes realism, completeness, and promptness. Secondly: responsibility that involves current and past performance, quality, safety policy, and conformance to laws, regulations and standards. Thirdly: competency that embraces different resources (financial, manpower and equipment), past experience and project specific knowledge, constraints like current workload and guarantees.

Table 2-2: Criteria for bid evaluation (Hatush and Skitmore 1997)

No.	Criteria	No.	Criteria
1.	Financial status	11.	Business experience
2.	Personnel management	12.	OSHA application
3.	Capabilities	13.	Safety experience
4.	Bank facilities	14.	Credit facilities
5.	Project management organization	15.	Skill workers
6.	Previous un-complete work	16.	Financial capabilities
7.	Management knowledge	17.	Equipment
8.	External relationship	18.	Knowledge increase ratio
9.	Contractor and client relationship	19.	Experience
10.	Safety requirements	20.	Job experience

6. Ng and Skitmore (1999) determined thirty five factors for a contractor evaluation or prequalification based on the study they performed in the UK construction industry. These factors are summarized in table 2-3.
7. Fox (1996) found that the ability of a contractor to complete a project on time is the most essential criteria for a contractor selection. Also, he recommended that the criteria which should be considered for the selection are: time of completion, bid price, quality of work, contractor organization, previous and current experience and financial capability
8. Efni (2004) indicated that the criteria were implemented for the selection of a contractor are: previous work experience, workloads, work records, completion time, technical knowledge, and cost

Table 2-3: Criteria for the prequalification of a contractor in UK (Ng & Skitmore 1999)

Performance	Firm stability	Quality standard
Financial stability	Relationship with consultant	Technology level
Reputation	Cooperative outlook	Failed contract
Capacity of work	Competitiveness	Progress of work
Fraudulent activity	Quality control and assurance	Credit rating
Claims and disputes	Relationship with subcontractor	Working capital
Management capability	Relationship with client	Health and safety
Contract form	Procurement method	Response to instruction
Specialized trade	Length of time in business	Integrity
Resources	Project complexity	Location
Size of project	Amount of subcontracting work	No. of previous bid
Type of project	Previous debarment	

9. Anagnostopoulos & Vavatsikos (2006) determined criteria and sub-criteria in their hierarchy level that include financial performance (credit ratio, current ratio, asset turnover ratio, etc), technical performance (resources and experience), safety and health policy (compensation paid to labor accidents, safety and health investment), and public work past performance (cost overruns, schedule overruns, claims issued at executed contracts). All of these criteria and sub-criteria are displayed in figure 2.5
10. Trivedi et al. (2011) suggested six criteria to be used for a contractors' evaluation, namely financial turnover, manpower resources, equipment resources, post experience, past performance, and affordable similar projects.

11. Manideepak et al. (2009) based on previous studies proposed bid amount, financial soundness, technical ability, management capability, safety and health records and reputation as criteria to be applied for the evaluation and the selection of a contractor.

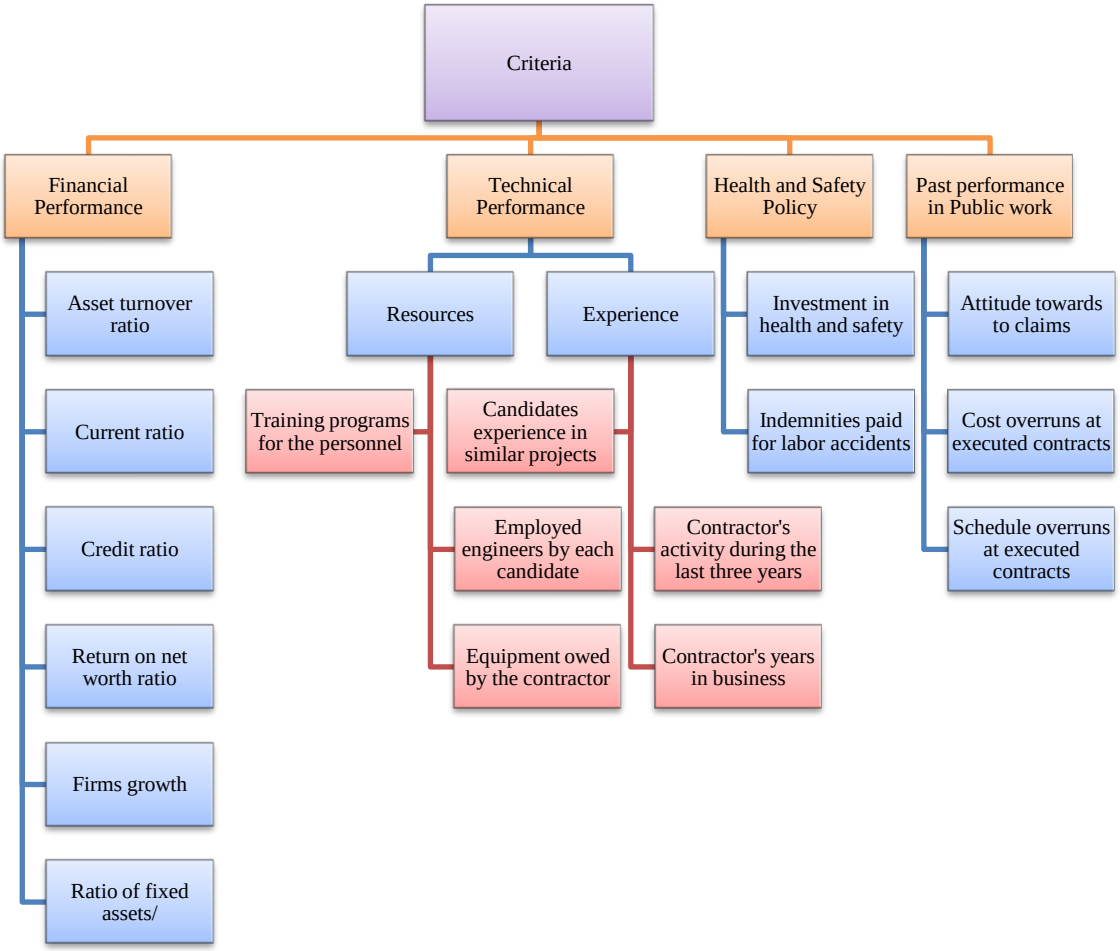


Figure 2.5: Contractor selection criteria (Anagnostopoulos & Vavatsikos 2006)

12. Waara and Brochner (2006), in the evaluation of contractors, benefitted from the criteria which were used at Swedish municipalities. These criteria and sub-criteria are presented in Table 2-4.

Table 2-4: Swedish municipalities' criteria (Waara and Brochner 2006)

EC directive Article 53: Examples	Swedish public procurement Act: Examples	Municipal examples of criteria and subcriteria
Quality	Quality	Quality, quality assurance system, quality plan
Price	Cost	Bid price, unit price
Functional characteristics, Technical merit	Performance, technical features	Function, technical solution, Technical design
Environmental characteristics	Environmental impact	Environmental characteristics, environmental management system, corporate environmental policy
Running costs	Running costs	Operation costs, maintenance costs, life-cycle costs
After-sales service and technical assistance	Service, technical support	Service, responsiveness, availability
Delivery date	Delivery date	Project duration
—	—	Contractors' capabilities, skills, training, references, past experience, and past performance
—	—	Project realization, construction methods
—	—	Financial capacity, solidity
—	—	Health and safety
—	—	Conformity with bidding documents

13. Tarawneh (2004) used about thirty one prequalification criteria evaluation including: contractor ability to provide high quality, detailed, execute project, handle with safety requirements, managerial capability, financial stability, previous track record, past experience, current workload and obligations, reputation, ability to predict construction problems and to provide creative solutions, etc.

14. Al-dughaither (2006) indicated that it is very important to introduce and investigate several criteria such as; financial stability, capacity, operation and equipment, technical experience, performance record, managerial capabilities, and safety records in order to ensure that only competence and experienced contractors are permitted to enter the contract or submit their bid. Also as depicted in figure 2.6, he developed a model based on an analytical hierarchy process for contractors prequalification.

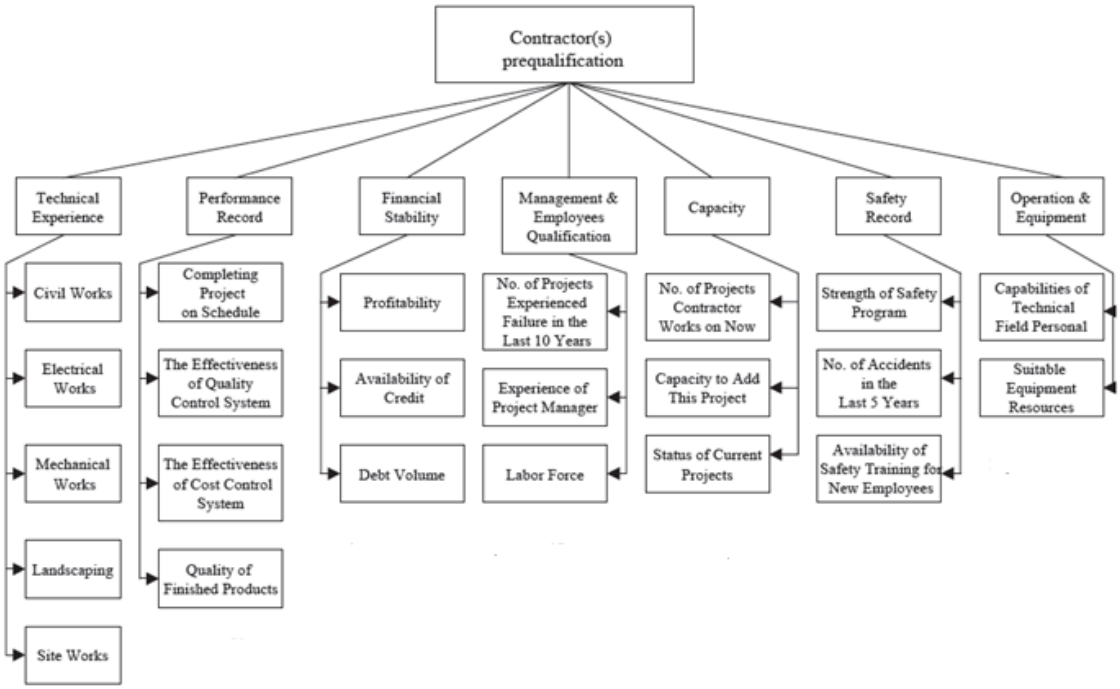


Figure 2.6: A pre-qualification multi-criteria decision making model (Al-dughaither 2006)

15. Watt et al. (2010) determined the criteria that an evaluator can weigh contractors and their likelihood performance that involved: quality, track record, expertise, relevant experience, safety record, capability, and cost. Moreover, he determined the relative importance of each criterion compared with others (figure 2.7)

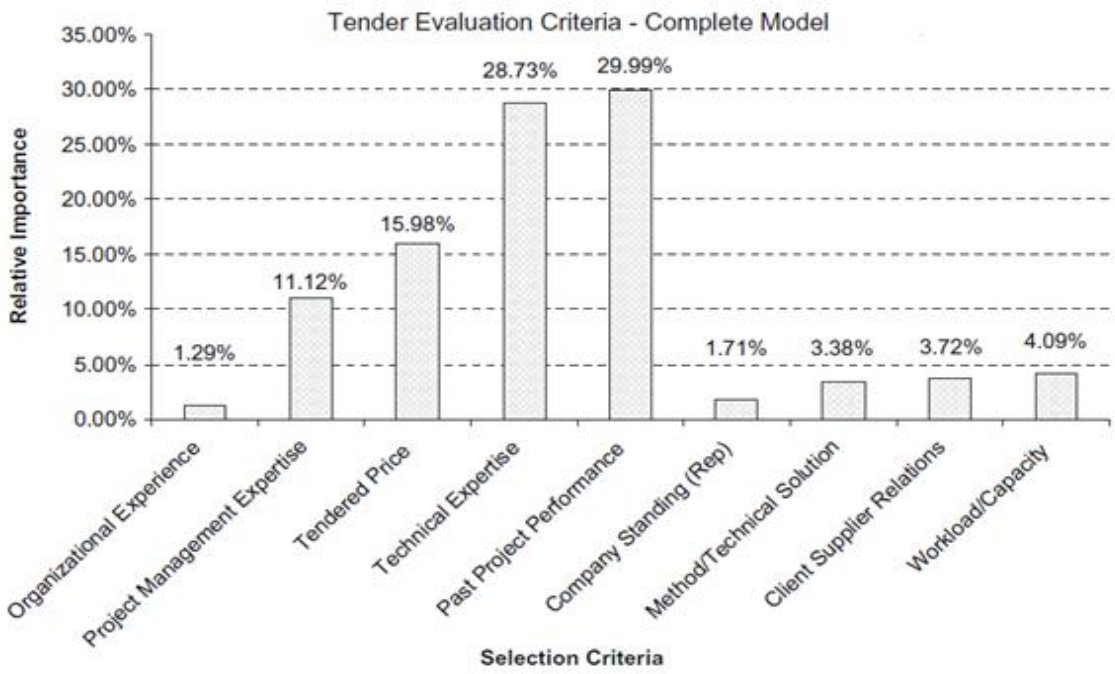


Figure 2.7: Relative importance of contractor evaluation criteria (Watt et al. 2010)

16. Banaitiene and Banatis (2006) showed that the most important criteria to be used for a prequalification process are: financial strength, work capacity, experience and quality, technical personnel, project characteristics like type, work schedule, complexity, project location, and type of contract, etc. (Table 2-5)

Table 2-5: Contractor evaluation criteria (Banaitiene and Banatis 2006)

Bid Price	Insurance
Legal Activity	Competitiveness
Adequacy of contractor	Clients' appreciation
Claims & contractual disputes	Quality assurance
Failed contracts	Experience
Bankruptcy possibilities	Environmental protection
Qualification of technical personnel	Safety and health at work
Type and size of past projects	

17. Huang (2011) listed most significant factors that should be employed through a contractor qualification process including: Financial standing such as:(financial stability, profit, turnover), technical ability such as: (experience, personnel, equipment), management capability such as: (project management system, quality control system, past performance), safety, current projects involving size, number, project location, past failures, and past owner cooperation with contractors.

Regarding to Watt et al. (2010), it is obvious that contractor selection criteria and their significance differ depending on organizational objectives and industry sectors. Therefore, it is required from evaluators through actual contractor selection to take into his account that each contractor as a function of all identified criteria and their weightings assigned at the same time.

2.9 ANNOUNCING CRITERIA TO CONTRACTOR

Waara and Brochner (2006) conducted study in Turkey and indicated that if an owner declares all criteria to contractors, then the behavior of contractors will be similar to that happened under the lowest price awarding method. But if contractor capabilities for non-price criteria are not sufficient compared with other competitors, the contractor will resort to one of the following alternatives:

1. The contractor decides not to submit to this bid because the weights on these criteria may give him indicators that he will not be able to complete the project.
2. Submitting a lower price bid than competing bids.
3. Trying to enhance his capabilities by investing in criteria that have some shortcomings.

2.10 CONTRACTOR SELECTION MODEL

The selection of a contractor is a multi criteria decision problem. It embraces different components which are (Trivedi et al. 2011):

1. The goals that you want to achieve as an owner.
2. Decision makers engaged in the process of decision making correlated with their preferences on evaluation criteria.
3. Evaluation criteria.
4. Decision alternatives.
5. Uncontrollable and uncertain variables.
6. Outcomes related with each alternative attribute pair.

According to Anagnostopoulos & Vavatsikos (2006) and Park (2009), there are a lot of models made in a contractor selection either during prequalification or final evaluation (Table 2-6), but the most familiar model that was excessively implemented is analytical hierarchy process (AHP) which will be used in developing a model for this research. Therefore, it will be debated in more details.

After a literature review investigation, the contractor selection models can be categorized into two major groups, practical and theoretical. The major discrepancy between these two groups is that the practical models are simpler and more practical and implemented in reality, whereas the theoretical ones are still in immaturity.

According to Jack and Samual (1989), the basic model concepts are:

1. Models do not perform a decision. Therefore, the decision maker is responsible for making the decision.
2. All models regardless of their complexity reflect partial representation of reality. Therefore, no model can be able to yield an optimal decision.

Table 2-6: models for contractor selection (Anagnostopoulos & Vavatsikos 2006)

Method	Developed By
Aggregated weighing	Russell and Skibniewski (1990))
Analytic Hierarchy Process (AHP)	AI-Subhi A1-Harbi (2001), Anagnostopoulos et al. (2004), Fong and Choi (2000), Topcu (2004)
Bespoke approach	Holt (1998)
Cluster analysis	Holt (1996), Holt (1998)
Contractor prequalification based on three groups of criteria	Palaneeswaran and Kumaraswamy (2001)
Dimensional weighting	Russell and Skibniewski (1988), S6nmez et al. (2002)
Dimensional-wide strategy	Russell and Skibniewski (1988), Sonmez et al. (2002)
Evidential Reasoning	Sonmez et al. (2002)
Fuzzy sets model	Nguyen (1985), Lin and Chen (2004)
General Performance Model	Alarcon and Mourges (2002)
Knowledge-intensive model	Russell et al. (1990)
Multi-attribute analysis	Holt et al. (1995b)
Multi-attribute utility theory	Hatush and Skitmore (1998)
Multiple regression method	Holt (1998)
Multivariate discriminate analysis	Holt (1998), Skitmore and Marsden (1988)
Performance Assessment Scoring System (PASS)	Kumaraswamy (1996)
Prequalification formula	Russell and Skibniewski (1988), SOnmez et al. (2002)
Risk analysis	Jaselskis and Russell (1992)
Simplified quality assessment	RICS (1997)
Subjective judgment	Russell and Skibniewski (1988), SOnmez et al. (2002)
Two-step prequalification	Russell and Skibniewski (1988), S6nmez et al. (2002)

The followings are some practical models implemented for contractor assessment and derived from literature review:

1. The ELECTRE Model
2. The Weighted Sum Model (WSM)
3. The TOPSIS Model
4. The Weighted Product Model (WPM)
5. Goal Programming
6. Analytic Hierarchy Process

2.10.1 Multi-Criteria Decision Making (MCDM)

Multi-criteria decision making (MCDM) is one of the most popular methods of decision making. It was introduced at the early of the seventies of the twentieth century to assist a decision maker in understanding the problem and identifying the appropriate decision (Zeleny 1992). It can be implemented to research associated with a contractor selection (Fong and Choi, 2000) and a project procurement selection (Al-Hazmi and Caffer 2000).

According to Fuller and Carlsson (1996), there are large numbers of researches that have been developed in this field due to its vitality and effectuality.

Choosing a contractor becomes naturally a multi-criteria decision making problem due to implementing several criteria during evaluation. Therefore, the procurer before selecting the appropriate contractor required to verify all the criteria and must be able to identify the best techniques to appraise the criteria.

There are different methods for MCDM that can be able to utilize and obtain an optimum decision. Some of these methods will be discussed in the next section.

There are many MCDM methods which are available and can be utilized to obtain an optimum decision. Each method has its own characteristics. Moreover, there are many ways to categorize these methods including first: the number of decision makers in the decision process either a single decision maker or a group of decision makers, so this is the most common method. Secondly: operation approach, and finally based on the type of data either it is deterministic, stochastic or fuzzy.

The followings are the main multi criteria decision making process:

2.10.1.1 ELECTRE method

ELECTRE refers to the elimination and the choice expressing reality. It is one of outranking methods, which is a branch of MCDM. It is available in numerous variations such as: ELECTRE I, II, III, IV (Goicoechea et al. 1982).

ELECTRE I can be implemented to create a partial ranking and select a set of alternatives. ELECTRE II can be used to rank the alternatives, whereas ELECTRE III is implemented to create an outranking degree to represent outranking credibility between two alternatives.

The outranking methods are based on pair-wise comparison among alternatives. Therefore, they give an ordinal ranking or sometimes a partial ordering, only of the alternatives which indicate that the preferred alternatives but without determining how much.

The basic elements of this method are measuring both concordance and discordance for all alternatives to find the alternative with the highest concordance value and the lowest discordance value.

ELECTRE methods can be implemented once the decision maker wants to embrace at least three criteria in the model. However, there are some of the shortcomings in this method:

1. The interactions or dependencies among criteria are ignored during outranking.
2. It is purely dependent on the performance of an alternative against a given set of criteria.
3. The concordance and discordance index does not consider the weights of subsets of a criterion.

2.10.1.2 The Weighted Sum Model (WSM)

According to Fishburn (1967), the weighted sum model (WSM) is the most familiar method suitable for single dimensional problems where all the units are identical. Therefore, this method has a lot of complexity, and inappropriate when dealing with multi-dimensional problems. Herath and Prato (2006) indicated that the WSM has a

capability to solve problems over a discrete decision space, rank a few predetermined alternatives, and choose the most suitable alternative based on multiple criteria.

2.10.1.3 TOPSIS method

TOPSIS Acronym stands for Technique for Order Preference by Similarity to Ideal Solution. It was created by Yoon and Hwang (1981) to be used as an alternative for ELECTRE model. This model is based largely on the geometrical features. Therefore, in order to select the best alternatives, it is essential to find the shortest distance from the ideal solution and the farthest distance from the negative ideal solution as illustrated by Triantaphyllou (2000). It is easy to determine ideal and negative ideal solution because TOPSIS method supposes that each criterion has a tendency of monotonically increasing or decreasing utility. Moreover, the Euclidean distance approach was suggested to assess the relative closeness of the alternatives which can be derived from a series of comparison of relative distances.

2.10.1.4 Weighted Product Model (WPM)

The Weighted Product Model (WPM) is very analogous to the Weighted Sum Model (WSM). The major distinction between these two methods is that the WPM uses multiplication rather than addition as indicated in the name itself, it can also be used for both single and multi-dimensional MCDM problems, and it uses relative values rather than actual ones (Triantaphyllou 2000).

In this method, the alternatives are compared with others through multiplying a number of ratios for each criterion. After that, each ratio is raised to the power equivalent to the relative weight of corresponding criterion.

2.10.1.5 Goal Programming (GP)

The Goal Programming (GP) is one of MCDM technique which was developed by Charnes and Cooper (1961), and works well once there are multiple and often conflicting objectives.

In this technique the decision maker should establish goals for all the objectives that are anticipated to be achieved, and the best alternative can be determined as one that has minimum weighted sum of deviations from the established goals.

GP can be considered as one form of the linear programming method, wherein linear programming determines the point that optimizes a single objective, whereas (GP) identifies the point that best satisfy the set of goals in the decision problem where deviation variables with assigned priorities and weights are minimized.

In this technique, it is necessary to assign target levels for all objectives, to deal with these targets as goals to seek and not as absolute constraints. After that and according to Ravindran (2007), the attempts to find an optimal solution will be initiated.

2.10.1.6 Fuzzy Set Theory (FST)

Fuzzy set theory (FST) is implemented successfully when it is complex for a decision maker to give accurate numerical values for attributes or criteria and when the judgment of the decision maker is not crisp, which makes the evaluation process unclear and hard. Therefore, this technique can be considered as a qualitative human judgment and handle with uncertainty.

2.10.1.7 Multi Attribute Analysis (MAA)

Multi-Attribute Analysis is preferred from a decision maker and implemented excessively in many industries due to its simplicity. In this method a decision alternative with respect to several of those alternative's criteria should be considered. Holt (1998) indicated that this technique can be employed in the qualification and the selection of bidders taking into account several criteria or attributes for evaluation.

MAA formula can be expressed as:

$$A\ Crj = \sum_{i=1}^{n} V_{ij} W_i$$

Where: A Crj = Score for contractor

V_{ij} = variable (attribute) i score respect of contractor j

W_i = maximum score

N = the number of attribute considered in the analysis

2.10.1.8 Dimension-wide Strategy

A dimension-wide strategy is recommended from Russell and Skibniewski (1988). During this method the owner determines the most important dimension and evaluates contractors based on it. Then the contractors who pass the previous evaluation will be moved to evaluate with respect to the next most important dimension; otherwise the contractor will be discarded from the contractor list and will not involve in subsequent evaluation steps. It is obvious that the most important thing here is that at each evaluation step, the contractor is assessed for that dimension only. This process will proceed until all evaluation steps are performed and a qualified contractor list is achieved.

2.10.1.9 Subjective Judgment

In some cases, and as pointed out by Russell and Skibniewski (1988), construction clients may be forced to make a prequalification or a contractor selection based on a subjective judgment which is an unstructured approach. However, this approach may lead to make faulty or inaccurate decisions due to its deficiency of rational techniques.

In this approach the decision may be made based on the previous experience of the decision maker in the similar type of projects or the previous relationship with the contractor.

2.11 ANALYTICAL HIERARCHY PROCESS (AHP)

Analytical hierarchy process (AHP) is one of multi criteria decision making techniques. It was developed by Saaty at the early of the eighties to provide simplicity in understanding, analyzing complicated problems, and evaluating alternatives based on multiple criteria. Depending on Saaty (1994) AHP is one of the most common MCDM methods because it can be implemented to numerous types of decision problems such as transportation planning, artificial intelligence, portfolio management, and manufacturing system design.

According to Saaty (1980), it can be applied to provide relative priorities on a ratio scale for a set of alternatives based on the decision maker judgment and the consistency of the alternative comparison during the decision making process.

AHP considers experience, human judgment and perception in the decision making process. Because each project has unique characteristics, AHP contractor selection model provides construction client flexibility in adding or declining the elements of the problem hierarchy concerning an individual project (Fong and Choi 2000). In this research the model for a construction contractor selection will be developed based on AHP approach due to its ability to assist the client in selecting the most suitable contractor from various numbers of alternatives. Moreover, the following reasons support using AHP for this study:

- Its capability to integrate tangible and intangible factors in a systematic way.
- Its ability to solve construction problems regardless of its complexity.

- It simplifies a problem by breaking it from larger elements to smaller ones in a logical manner.
- Its ability to examine judgments issued from a decision maker, and measure their consistency.
- It does not require numerical judgment from the decision maker
- It can be applied using software available in the market like Ms Excel, expert choice that can be able to determine matrix equation and directly provide meaningful results.
- Its ability to at least minimize or transfer a subjective judgment into an objective decision.

2.11.1 Application of Analytical Hierarchy Process (AHP)

AHP is one of the most common MCDM methods because it can be implemented to numerous types of decision problems such as transportation planning, artificial intelligence, portfolio management, and manufacturing system design, etc.

The followings are some of the selection problems which were solved by using AHP:

- Project procurement system selection model (Al-Hazmi and Caffer 2000).
- Application of AHP in project management. It can be used for the prequalification of contractors (Al-Harbi 2001).
- A multi-criteria approach in engineering problems such as a contractor and subcontractor selection, and for selecting the most appropriate project delivery system (Al-khalil 2002).
- Advanced automation and or conventional construction process (Hastak 1998).

2.11.2 Advantages for Implementing AHP

1. The modeling and measurement approach are simple for evaluation.
2. The AHP is very simple and flexible.
3. It is possible for a decision maker to acquire consistent and objective evaluation to use the model that impresses harsh interdependencies, homogeneity of favorites, and originality. In other words it is possible to control the consistency of a decision.
4. It can be used to determine the relative weights or relative impact of numerous factors on the likelihood outcomes and predict outcomes. These predictions can be used to evaluate different courses of actions as pointed out by Al-Subaiei (2001).

2.11.3 AHP Procedures

The steps for applying AHP were illustrated by Saaty in his series of publications. These steps were divided into four principles including decomposition, prioritization, synthesis, and inconsistency measurement.

2.11.3.1 Decomposition

The purpose of decomposition principle is to convert an unmanageable problem into one under controllable to assist a decision maker in understanding it thoroughly and try to come up with the best solution or alternative.

This technique consists of the following steps:

1. Defining the problem and identifying the major goal.
2. Identifying different alternatives that will be considered to achieve a major goal.

3. Determining the criteria and sub-criteria to be used for assessing each alternative.
4. Constructing the problem in the hierarchy as depicted in figure 2.8 where the top level represents the major goal in term of problem statement, the next level represents the criteria that will be used to evaluate alternatives, in some cases these criteria may be broken down into a smaller level depending on the amount of details required in the model, whereas the bottom level represents different choices or alternatives from which one or more of these can be used to accomplish the major goal. The simplest hierarchy consists of three levels.

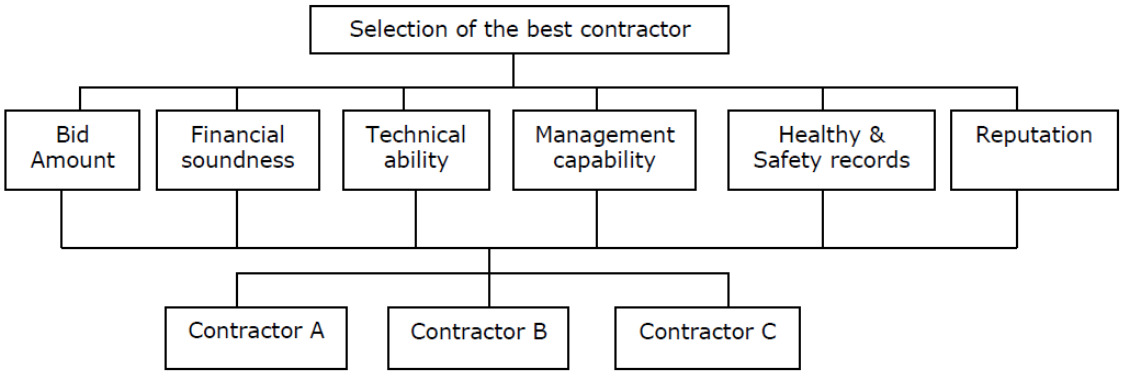


Figure 2.8: Different Hierarchy levels

2.11.3.2 Create prioritization

The next principle after constructing the hierarchy is prioritizing each criterion involved in a decision making process at a given level in the hierarchy to identify the preference of each criterion among other criteria with regard to the criterion at the superior level.

To do this the following steps should be performed:

1. Creating pair-wise comparison matrices (size n x n) in which a decision maker performs a judgment on relative preferences of each element with respect to other elements at a higher level of the hierarchy. According to Saaty (1994) pair-wise is preferred because the decision maker executes the comparison between two elements at the same time. AHP pair-wise comparisons use the relative scale measurement shown in table 2-7. The pair-wise comparisons are made in terms of which elements dominate the other.
2. Basically, the number of judgment required to develop or fill a set of matrices in step one is equal to $\frac{n\,(n-1)}{2}$. The reciprocals are automatically determined or assigned for each pair-wise comparison.
3. Repeating the pair-wise comparison for each level in the hierarchy.

Table 2-7: AHP pair-wise comparison scale

Preference in numerical rating	Preference in linguistic variables
9	Extremely importance
8	Very strongly to extremely
7	Very strongly importance
6	Strongly to very strongly
5	Strongly importance
4	Moderately to strongly
3	Moderately importance
2	Equally to moderately
1	Equally importance

2.11.3.3 Synthesis

The synthesis principle is used to determine the relative weights of the criteria with respect to the criterion in the next level by gathering priorities throughout all the level of the hierarchy to attain a final consequence. This process should be performed for all paired-wise comparison matrices through using normalized eigenvector. The following steps are applied to obtain these relative preferences:

1. For each paired-wise comparison matrix divides each element in the column by the sum of the entries for that column to obtain normalized matrix in which the sum of the entries for each column is equal to one.
2. After that, the average of the entries for each row in the normalized matrix is calculated to obtain priority vector (local priority).
3. Combining the criterion priorities and the priorities of each decision alternative relative to each criterion to develop an overall priority (global priority) ranking of the decision alternative based on the final score for each alternative. In other words, the overall priority of the current level elements is calculated by adding the products of their local priorities by the priority of the corresponding criterion of the immediately higher level. Then, the overall priority of a current level element is used to calculate the local priorities of the immediately lower level which use it as a criterion till the lowest level of the hierarchy is reached. The priorities of the lowest level elements (alternatives) provide the relative contribution of the elements in achieving the overall goal (Anagnostopoulos & Vavatsikos 2006).

2.11.3.4 Inconsistency measurement

Sometimes the judgments of the decision maker may not be consistent with one another. One of the major advantages of AHP is to judge the rate of consistency. In other words, AHP has a capability to control the consistency of the decision.

Estimating consistency for (n x n) matrix can be performed through the following steps:

1. Determining the maximum Eigen-value (λ_{max}) of the matrix through dividing the entries of the weighted sum matrix by their respective priority vector entry. Then calculating the average of these values to acquire (λ_{max}).
2. Determining the consistency index (CI) using the following expression:

   $$CI = \frac{\lambda_{max-n}}{n-1}$$

   Where:

   CI: Consistency index.

   $\lambda_{max:}$ largest Eigen-value

   n: number of rows or columns.

If consistency index is very small then the decision maker judgments are consistent enough to provide proper weights for their goal. This leads to conclude that the perfect decision maker has consistency index (CI) which is equal to zero.

3. Selecting a proper value of random consistency index (R.C.I) from table 2-8. These values have been determined for matrix with different dimensions.

Table 2-8: Average random consistency index values

N	1	2	3	4	5	6	7	8	9	10	11	12
R.C.I	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54

4. Calculate the consistency ratio (CR) or what is called rate of consistency index by dividing consistency index (CI) by the random consistency index (R C I).

$$CR = \frac{C.I}{R.C.I}$$

According to Saaty (1980), if consistency ratio (CR) is less than or equal to 0.1, then the judgments are acceptable and satisfied; otherwise, the inconsistency may exist in the matrix and the results of the AHP are meaningless, thus the judgment should be revised.

2.12 DECISION SUPPORT SYSTEM (DSS)

Decision support system is a computer based system that is used to enhance the feature and the quality of decision making. It operates using algorithms and models to interpret and analyze information.

There are several decision support systems at an affordable in the market such as: Precision Tree, Expert Choice Professional that will be used in this research for the selection of an appropriate contractor, Decision Programming Language, etc.

Expert choice is used for establishing a model, performing pair-wise comparison and conducting sensitivity analysis. In addition to that, expert choice is preferred to use in this research due to some proper features such as: it is flexible and precious software to

conduct multi-criteria decision analysis; it does not require numerical judgment, its capability to recheck the decision, simplify the problem and perform many of AHP computations.

2.13 CONSTRUCTION CONTRACTOR SELECTION CRITERIA

As presented in chapter two, there are numerous criteria that can be employed for a contractor prequalification or selection. In this section, the criteria which will be used in the proposed AHP model will be explained.

These criteria have been chosen based on the literature review. The questionnaire will assist in identifying if these criteria are applicable or not during the evaluation or the selection of the construction contractor in Saudi Arabia. Furthermore, the relative importance or weights of each of these criteria with respect to others will be determined.

2.13.1 Financial Stability

Financial stability is one of the major factors that should be considered in the contractor selection process. This criterion involves an assessment of the financial status for each candidate contractor.

According to Russell (1990), the financial capability for each contractor is measured in terms of credit availability, profitability and efficiency of a contractor, debt to equity ratio, and firm strength. If the financial strength of the selected contractor is not adequate,

then many problems may arise during the execution of a project such as extend project completion time, poor quality and safety, and attitude to issuing claims increases, etc.

2.13.2 Past Performance and Work Experience

Past project performance, experience, performance records are other synonyms for this criterion. Regardless of the name of this criterion, it is used for assessing contractor project records to identify if he dealt with similar project scope and complication in the past or currently.

This criterion can be measured through investigating the satisfaction of the past clients who handled with the contractor, investigating the contractor performance history such as: effectiveness of quality control system, effectiveness of cost control system, quality of finished product (quality achievement), attitudes towards claims, completion project on predetermined time and budget, number of years in business, and similar type of projects conducted in the past

2.13.3 Technical Expertise

Technical expertise is another important criterion that is interested in measuring the ability of a contractor to complete a project as it is specified in the contract documents and achieving contract requirements.

This criterion can be measured through investigating technology level employed by a contractor, investigating human resource capability, and examining machinery and testing facilities.

2.13.4 Management & Manpower Qualification (Managerial Capability)

This criterion is concerned with the qualification and the experience of administrative staff, engineering professionals, and craftsmen. It is obvious that if the construction contractor has superior management strategies, then the likelihood for the success of the construction project increases. This is consistent with what Clough and Sears (1994) found. They indicated that the financial success of the project depends totally on the quality of its management. Another study conducted by Russell (1991) confirmed that about eight out of fourteen enterprises don't succeed due to deficiency experience of management and technical staff.

2.13.5 Current Workload (Capacity)

Current workload sometimes called the current project on hand. This criterion measured the ability of the candidate contractor to achieve his commitment in the contract, and check if the current commitment of the contractor can influence on his performance and hindered him in accomplishing the project goals.

Contractor workload can be appraised through examining availability of human resources, availability of equipments and financial resources, percentage of work to be subcontracted, and number of projects the contractor working on.

2.13.6 Safety Records

Al-Gobali (1994) indicated that if a contractor has an excellent safety record, then the construction accidents can be minimized which in turn lead to reducing construction costs.

Accidents occurred at construction sites may lead to the loss of life which thereby impact on the premium rates on the subsequent projects for the same contractor.

Contractor safety record can be measured through investigating the strength of the safety program implemented by contractor firm, number of accidents in the last few years, availability of safety training for new employees, contractor investment in health and safety, and indemnities paid for labor accidents.

2.13.7 Operation and Equipment Resources

Al-Gobali (1994) found that the availability of suitable machinery and maintenance plan are significant criteria influencing on contractor performance. Al-Hazmi (1987) indicated that the shortage in equipment will lead to the delay of the project.

This criterion can be evaluated through inspecting suitable equipment resources, capabilities of technical field personal, availability of equipments, and availability of personnel.

2.13.8 Financial Evaluation of Bid

The financial evaluation of a bid required an owner to assess the preliminary cost, the labor cost, the machinery cost, the material cost, the schedule of the rate, the unit price for each item, existing mistakes in calculations, and examining if an unbalanced bid exists which is a deception from a contractor resort to it in order to enhance his cash flow and increase his profitability.

Basically, the tender price is the most significant criterion considered by construction clients during selection.

2.13.9 Home Office Location

This is one of the most important factors considered for the evaluation of contractors. It is interested in the geographical location of the contractor office. It is noticed that from the previous conducted projects, the contractor attention and support improve as the contractor office is closer to the project site. This is right idea because many services are rendered to the employees at the project site by the head office such as: project financing, staffing, visas, housing, recruitment, passports, ticketing, catering, material purchasing, machinery renting, assessment of contract amendments, evaluation and approve change orders, and resolve disputes.

2.13.10 Contractor Company

Sometimes it is necessary for construction clients during evaluation to determine whether a contractor is local or foreign due to the fact that the foreign contractor may not be familiar with the regulation of the country which will impact on the project completion time and cost.

2.13.11 Familiarity of Contractor with Project Location

Russell (1991) found that the risk carried by the contractor and the probability of the contractor failure may be increased if a contractor does not have knowledge on the geographic location, local and environmental conditions of the project. Moreover, Al-Hazmi (1987) indicated that the project completion time may be extended.

2.13.12 Quality Program

Using a quality program will enhance the final product. Russell and Skibniewski (1988) confirmed that it is essential to consider the quality program criterion in prequalification process. This criterion is measured in terms of company reputation, quality policy pursued by the contractor, quality control and quality assurance.

2.13.13 Track Record

This criterion is concerned with the previous construction records, the punishments records on the contractor. It is possible from this criterion to assess the capability of the contractor to execute the work or the project.

2.13.14 Relationship Between Owner and Contractor

The construction client prefers to work with the contractor who worked with him before and who finished the former projects at predetermined time, a budget and at a desired quality. Therefore, the relationship or familiarity of the construction clients with the contractor has a significant impact on the client decision during the selection process.

2.13.15 Complete Bid Documents

Usually, construction clients discard incomplete bids, so that contractors decided to bid should submit complete bid documents to the client, including zakah clearance, required bonds, financial offer and shortage contract offer in order to increase his chance of winning the contract.

2.13.16 Environmental Management

This criterion is concerned with the environmental management system and the environmental policy pursued by the contractor to reduce the negative impact of the construction on the environment.

2.13.17 Contractor Classification

Al-khalil and Al-Ghafly (1999) denoted that the public contracts are open for bidding depending on classifications system that was issued by the Ministry of Public work and housing in Saudi Arabia. The construction work in this classification system is subdivided into 12 categories and contractors were ranked into five grades. The small contractors were assigned grade five, whereas, large contractors were assigned grade one.

Each contractor can be classified in one or more category of construction and will be assigned grade for each category. Moreover, it is not permitted for the contractor to submit to any bid that is exceeding his limit.

2.14 ESTABLISHING AHP HIERARCHY

Hierarchy of AHP composed of several levels. The highest level represents the goal of the problem statement, followed by the criteria that should be considered to accomplish the goal, and downward to the lowest level whereby alternatives are selected. Figure 2.9 depict the hierarchy structure employed for this study that composes of goal, major criteria, and different alternatives.

Level one in the hierarchy shows the goal of this research which is the selection of the most appropriate construction contractor. The next level (level two) appears the criteria that impact on the selection. These criteria have been categorized into sixteen classes. Finally, the lowest level (level three) in the hierarchy shows the alternative solutions to select the construction contractor.

The factors used in the evaluations or the selections of the construction contractor are divided into sixteen categories:

- Financial stability
- Past performance
- Technical expertise
- Managerial capability

- Current workload (capacity)
- Operation and equipment resources
- Safety records
- Financial evaluation of bid
- Home office location
- Project location
- Quality program
- Track record
- Familiarity of client with contractor
- Complete bid document
- Environmental management
- Contractor classification

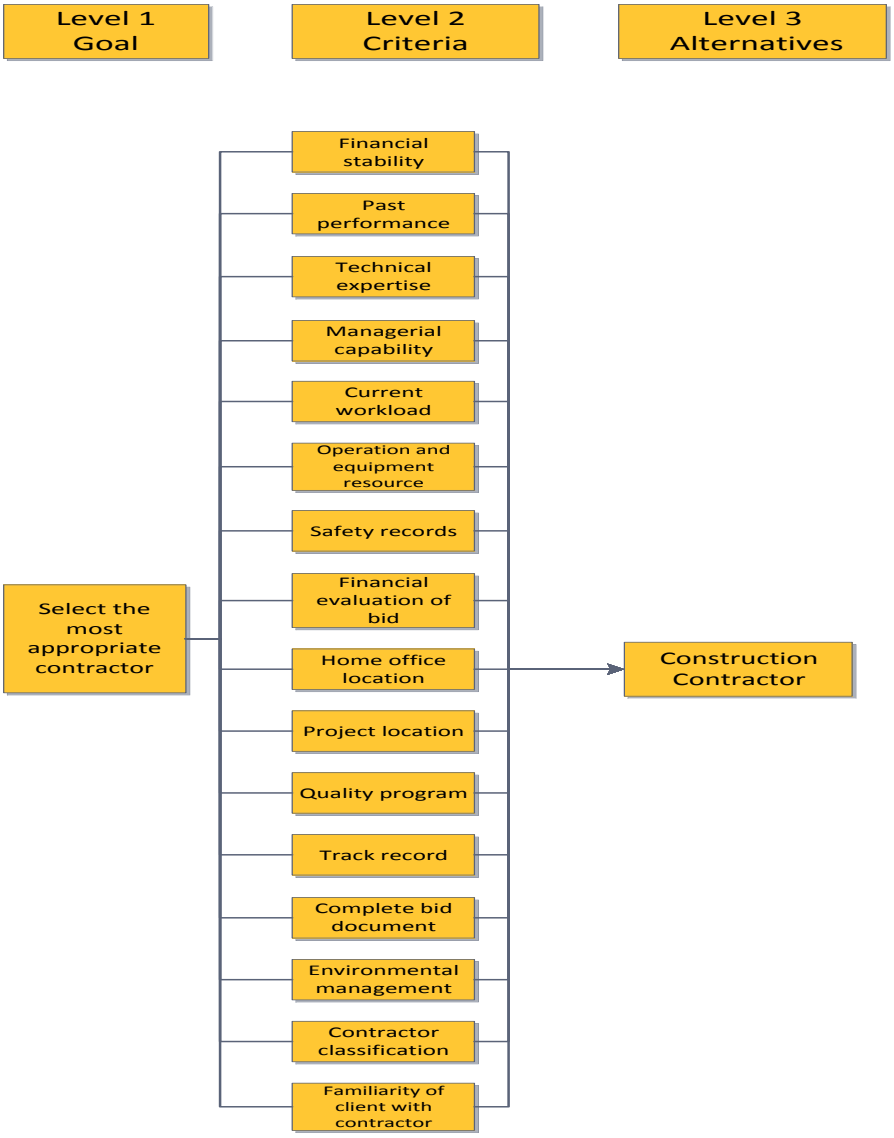


Figure 2.9: Analytical Hierarchy for construction contractor selection

2.15 CURRENT SAUDI BID AWARDING SYSTEM

Al-khalil and Al-Ghafly (1999) pointed out that the public contracts are open for bidding depending on classifications system that was issued by Ministry of Public work and housing in Saudi Arabia. The construction works in this classification system is subdivided into 12 categories and contractors were ranked into five grades.

The small contractors were assigned grade five, whereas, large contractors were assigned grade one. Each contractor can be classified in one or more category of construction and will be assigned grade for each category. Moreover, it is not permitted for a contractor to submit to any bid that is exceeding his limit.

The followings are the awarding contract process that is used in Saudi Arabia based on Saudi Competitions and Procurements Regulation Systems that was issued six years ago at 1427 (Hijri):

1. Preparation and advertisement of tender documents:
    a. Announcing the competition in the official newspaper (Um-Alqura), and in two local newspapers, once at least, and at the site of the advertiser.
    b. The period between the dates of issuance of the first announcement in the official newspaper and the final deadline for submission of offers should not be less than thirty days.
    c. At the time of the announcement of tender, it is not permitted to determine a certain degree of classification, or qualification requirements on the applicants.
2. Bid Submission:
    a. Offers submitted by registered mail, or by hand shall be written on the original forms received from the government, sealed, and placed in sealed envelopes to ensure the confidentiality and not to open it.
    b. The applicant is given a receipt that proves the date and the time of submission.
    c. Any offer delivery to the government after the deadline for the submission of offers will be discarded.

d. The applicants should take into account the classification of works intended to submit and the financial limits of his classification degree. Thus, any offer contrary to that is ruled out.

e. Applicants must submit its price according to the conditions, specifications and the bills of the quantities approved by the government agency, and shall not perform any amendment or cancel any item of the documents or specifications.

f. The offer must be signed from the bidder and must be sealed.

3. Bid Opening:

a. The minister or the head of the independent department issue decision to form a committee or more to open the bids.

b. Opening bids at the time and the day fixed for that should not exceed the day following the last day for submitting bids. Moreover, the committee must complete all bid openings at the same session.

c. Bid opening committee should ensure the compatibility of bids with the regulations, and prove the number of bids submitted in the minutes.

d. The committee should declare to the bidder or their representative the name of the offerer and his total prices.

e. After that all bids are forward to Bid Inspection Committee.

4. Bid Inspection:

a. The minister or the head of the independent department issue decision to form a committee to examine and check the bids.

b. Bid inspection committee recommend awarding a contract to the bidder with the lowest price and who has the best technical capabilities.

c. Bid inspection committee should review the bill of quantities and prices stated in the bid and make the necessary corrections.

d. Bid inspection committee can enter in a negotiation process with the lowest bidder based on the following cases:

- If the bid is considered too high comparing to the market.
- If the scope of work will be changed to be compatible with an assigned government budget.
- If the price of the bid is too low in order to evaluate the competence and the ability of the contractor to complete a project within the quoted price.

5. Signing the contract with the winner bidder.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter discusses the methodology adopted to achieve the objectives of this research including: the required data and the way to collect them, Analytical Hierarchy Process (AHP) concepts, and how the model will be developed and validated.

To achieve the objective of this study, the research plan consists of five phases which are: determining the required date, the collection of the data through literature review and developing a questionnaire survey, the analysis of the data obtained from the questionnaire, developing an AHP model, and model validation.

3.2 REQUIRED DATA

This part describes the required data which will assist in achieving the study objectives. These data embrace the followings:

1. The most important criteria implemented for the construction contractor selection in the universities of Saudi Arabia.
2. The Analytical Hierarchy Process (AHP) concepts.

3. Information on existing projects or previous constructed projects such as: the number of the contractors participated in the bidding process, the technical and the financial information about each contractor participating in that bid, and who the winner is.

3.3 DATA COLLECTION

Data required achieving research objectives were collected through carrying out two research activities. Some of data were acquired by performing extensive literature review, whereas other data were obtained through using a quantitative research process that is based on a questionnaire survey. Then, the data obtained can be used in developing a model based on an Analytical Hierarchy Process (AHP).

Each method adopted in this study will be described in details in the following sections.

3.3.1 Literature Review

The literature review is the starting point for any research. It is very essential due to the extensive benefits attained by the researcher. This assists him in gaining knowledge on the research topic and the findings of the previous work conducted on the same field.

For this research, the literature review was performed to get information about the contractor selection criteria, Analytical hierarchy process (AHP), and a background idea on the tendering system used by universities at Saudi Arabia. Therefore, any topic related to this study was reviewed. Moreover, conducting literature review assisted in understanding and reviewing the previous studies that describe several methods for the contractors' selection or evaluation.

Basically, the major sources of information are: articles that were published on refereed journals, Google scholar, books from library, previous master and PhD thesis, Saudi Competitions and Procurements Regulation Systems, etc.

The information obtained are re-directed, revised and presented on tables, figures and notes to assist in understanding them thoroughly.

3.3.2 Questionnaires

A questionnaire is one of the most important techniques for capturing data from the experts. It consists of a set of questions designed in a structural way to collect the necessary data from respondents who assist in achieving the research objectives. The questionnaire is prepared to be straightforward and clear.

The significances of performing a questionnaire are:

1. Verifying that the criteria gathered from literature review are applicable or affective on the contractor selection process.
2. If there are other criteria which can be added to that found in literature to enhance the selection process.
3. Determining the relative importance for each criterion with respect to other criteria.
4. Developing an efficient multi criteria selection model based on Analytical hierarchy process (AHP) for selecting contractors in Saudi Arabia using the expert choice software.

3.3.2.1 Questionnaire survey

The questionnaire survey was distributed to the respondents involved in the construction contractor selection at the general project departments of the universities in Saudi Arabia. Universities were selected in this study in order to ensure concentration on one type of the construction projects which is building.

Most of the questions in the questionnaire are open ended in order to acquire accurate and more reliable data from respondents. The questionnaire consists of four sections:

- Section I of the questionnaire consists of questions seeking general information about respondents such as: the name, the contact information, the level of education, the job title, the role during the selection of the construction contractor, and the experience in providing the tendering services.
- Section II of the questionnaire contains questions seeking information related to the first objective of this study which is investigating the current practice of the contractor selection process implemented by universities at Saudi Arabia. This section consists of diverse questions related to the current practices of tendering system and the selection process adopted by universities in Saudi Arabia. One of these questions asked respondents to rate the degree of importance of factors that are used in qualifying contractors through choosing one of the following assessment terms: extremely important, very important, important, not important and extremely not important. The importance index for each factor was determined using the following formula (Kometa and Olomolaiye 1997):

Relative Importance Index (RII) = $\frac{\sum_{i=1}^{5} Wi}{A * N} \times 100\%$

Where:

W: weight given by respondents to each factor used for qualifying contractors and range between 1 and 5

A: maximum weight, in this case A = 5

N: sample size

Furthermore, some of the questions at this section aim to check the applicability of the decision support system during the selection of the construction contractor by the project management department at the universities.

- Section III of the questionnaire aims to identify the criteria employed during the selection. It consists of sixteen criteria. Moreover, the respondents can put additional criteria if are used during the selection or the evaluation of the contractors by their organization.
- Section IV of the questionnaire asks the respondents to conduct a pair-wise comparison between the criteria adopted for the contractor selection in order to determine the relative importance of each criterion with respect to others.

Sections II, III, and IV consist of the data required to get the objectives of this study. Furthermore, the third and fourth sections of questionnaire are very essential because both sections will serve the heart of this study which is developing AHP model for the construction contractor selection.

3.3.2.2 Pilot test of questionnaire survey

Pilot testing of a questionnaire (Appendix A) was performed through conducting meeting with the director general projects at King Fahed University of Petroleum and Minerals before distributing it to respondents in other universities.

The reason for conducting pilot test was to check the sufficiency of questions, identify that all questions are clear and no ambiguity exists in the questionnaire, check order and layout of questions, examine the sufficiency of spaces provided to answer each question, and determine the expected time to complete the filling of the questionnaire.

The comments and the suggestions obtained from pilot test were appraised and considered during the preparation of the final edition of the questionnaire.

3.3.2.3 Population and Sample

The population consists of all the government owned universities in Saudi Arabia. There are about 28 universities. Thirteen universities are fully operational and the remainings are under development. Therefore, it was decided to select all the fully operational universities because they have great experience in construction processes and in awarding projects to contractors. The questionnaire was sent to the thirteen universities in Saudi Arabia by e-mail due to the long distances between provinces in Saudi Arabia, which hindered making face to face meetings. The respondents to the questionnaire should have experience or involved in awarding the contract process. The universities that will be involved in this research are:

- King Fahd University of Petroleum and Minerals
- King Abdul Aziz University
- Umm Al-Qura University
- The Islamic University of Al-Madinah Al-Munawarah
- Dammam University
- King Saud University
- King Khalid University
- Imam Muhammad bin Saud Islamic University
- Taif University
- King Faisal University
- Taybah University
- Najran University
- Qasim University

3.4 DATA ANALYSIS

This phase involves the analysis of the data received from the responses to the questionnaire survey. The data in sections I, II, and III of the survey were analyzed statistically to investigate and understand the current practices for awarding the contracts adopted by universities, whereas section IV of the questionnaire survey was analyzed using the AHP in order to determine the relative weight for each criterion with respect to others and identifying relative priorities for a specified set of criteria in a ratio scale. AHP consists of four major steps:

1. Creating a problem in the hierarchy in order to become understandable and facilitate decision making.
2. Performing a pair-wise comparison for all the levels of the hierarchy.
3. Determining the weights for decision criteria through calculating Eigen value.
4. Synthesis of the weights for all the levels to get the final results.

3.5 MODEL DEVELOPMENT

During this phase, the model was developed based on the knowledge acquired from the literature review and the data obtained from the questionnaire survey analysis. These data were used as an input for AHP model. The model was established using the expert choice software.

3.6 MODEL VALIDATION

The interview was carried out with construction clients for the purpose of verifying or validating the efficiency of the proposed model.

During the interview, the interviewee was asked to provide information about the previous project and apply the proposed model on this project to investigate if the developed model was consistent to what happened in reality when awarding contracts. Figure 3.1 displays a summary of the research methodology.

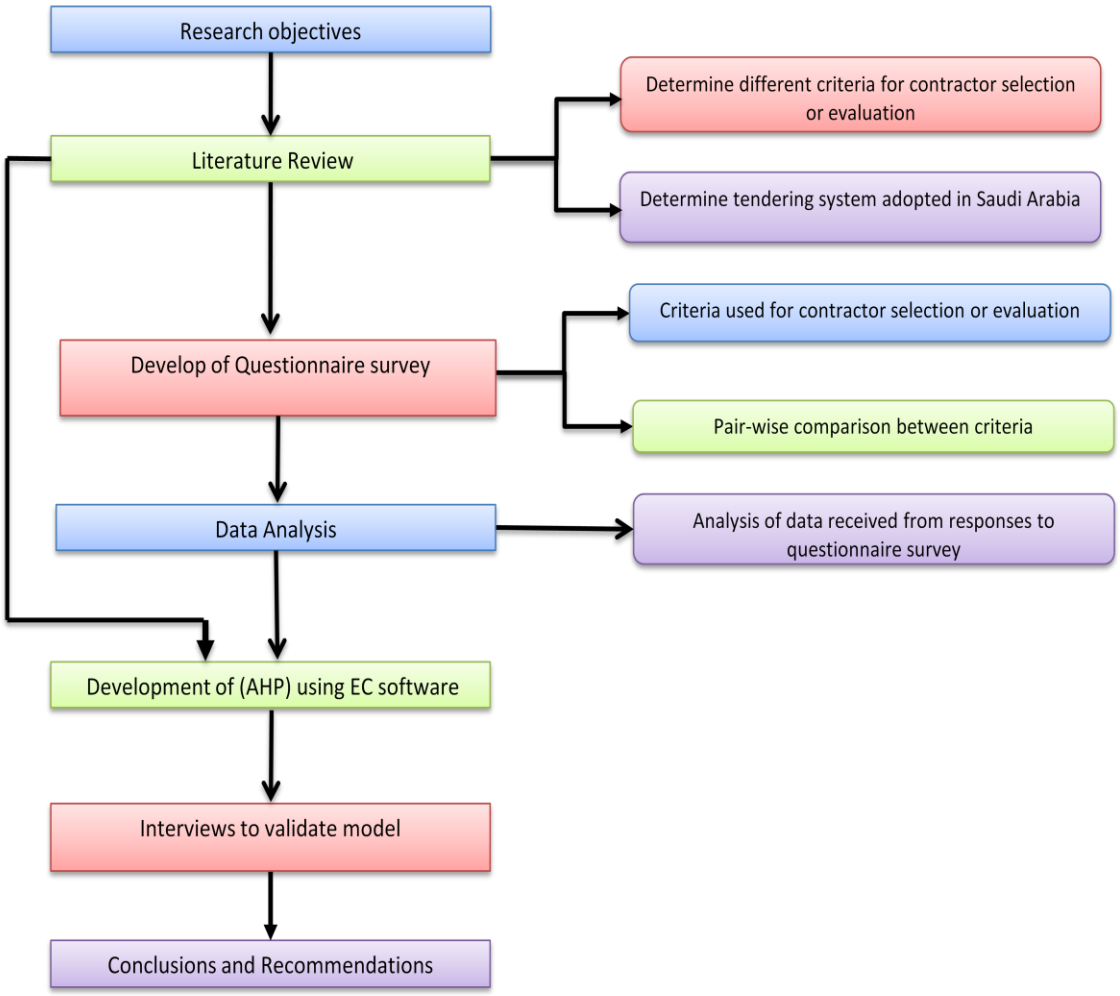


Figure 3.1: Research methodology

CHAPTER 4

Data Analysis and Results

4.1 INTRODUCTION

This chapter presents analysis of the data gathered from the questionnaire survey in order to investigate the current practice of the construction contractor selection process adopted by universities at Saudi Arabia, to identify the most important criteria implemented during a construction contractor selection, and implementing these criteria as input data to develop AHP model for the selection of the construction contractor.

4.2 QUESTIONNAIRE SURVEY DISTRIBUTION

Pilot-tested questionnaire was sent to the project management departments of thirteen universities in Saudi Arabia on 28th of March 2012 to 10th April 2012. All of questionnaires were sent by email after that telephone call which was made to ensure that the questionnaire received from right respondents, and to pursue the respondents who didn't reply to the questionnaire on predetermined time. The respondents after completing the filling of the questionnaire survey return it back either by facsimile or by email.

The responses to the questionnaire survey were gathered from the project management departments which are nine out of thirteen universities in Saudi Arabia. Seven respondents return the questionnaire through the email; whereas the remaining two participants return the questionnaire through the facsimile.

4.3 DATA ANALYSIS

This part presents the analysis of the data for four sections of the questionnaire survey that have been received from respondents (general project management departments of nine universities at Saudi Arabia). Figure 4.1 displays the percentage of the participants who respond to the questionnaire survey; it shows that about 69% (nine out of thirteen) of the project management departments at the universities in Saudi Arabia, which the questionnaire was directed to , respond to the questionnaire. Analysis of the data received was conducted through employing a straightforward descriptive statistical process such as percentages, graphics, tables and summary of the results.

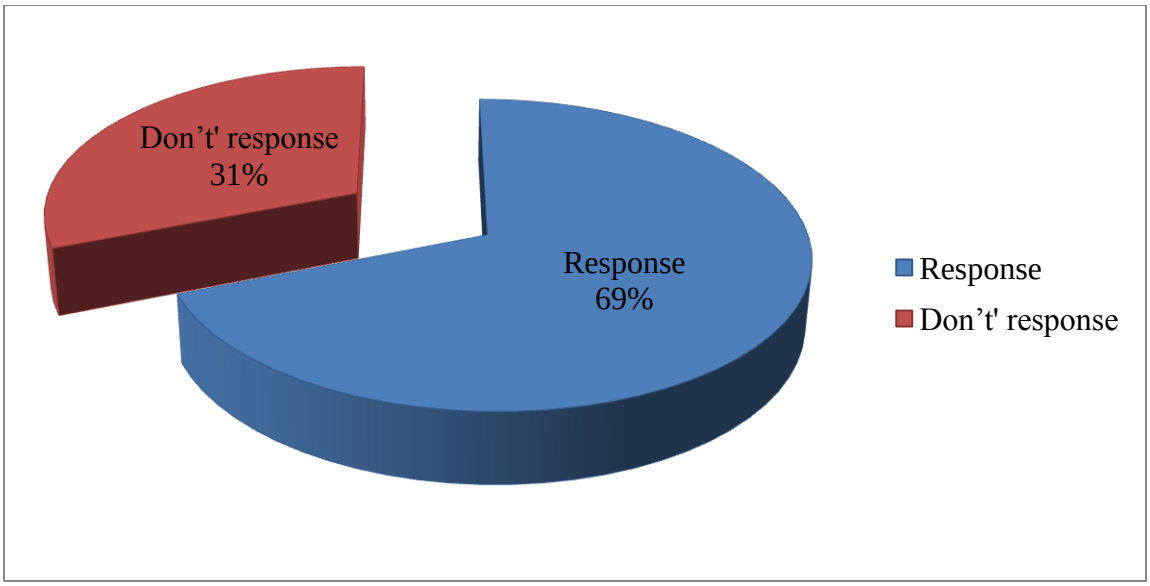


Figure 4.1: Participants response to the questionnaire survey

4.3.1 Respondents’ Characteristics

This section aims to investigate the characteristics of the respondents who respond to the questionnaire survey through answering several questions such as; the contact information of respondents like: the name, the telephone number, the Facsimile and the Email address. It was remarkable from the received questionnaire that most of the respondents fill this optional data. Other information required includes: the respondent’s level of education, the respondent’s job title, the respondent’s role during the selection or the prequalification of the construction contractor, the respondent’s experience in providing the tendering services, and finally the number of the bids evaluated by the respondent over the last five years.

4.3.1.1 Respondents level of education

The results as illustrated in figure 4.2 indicated that about 67% of the respondents (6 out of 9) had a bachelor degree, followed by the respondents having a master degree with 22% of (2 out of 9). The strange thing in the results is that only one respondent out of nine had a PhD degree.

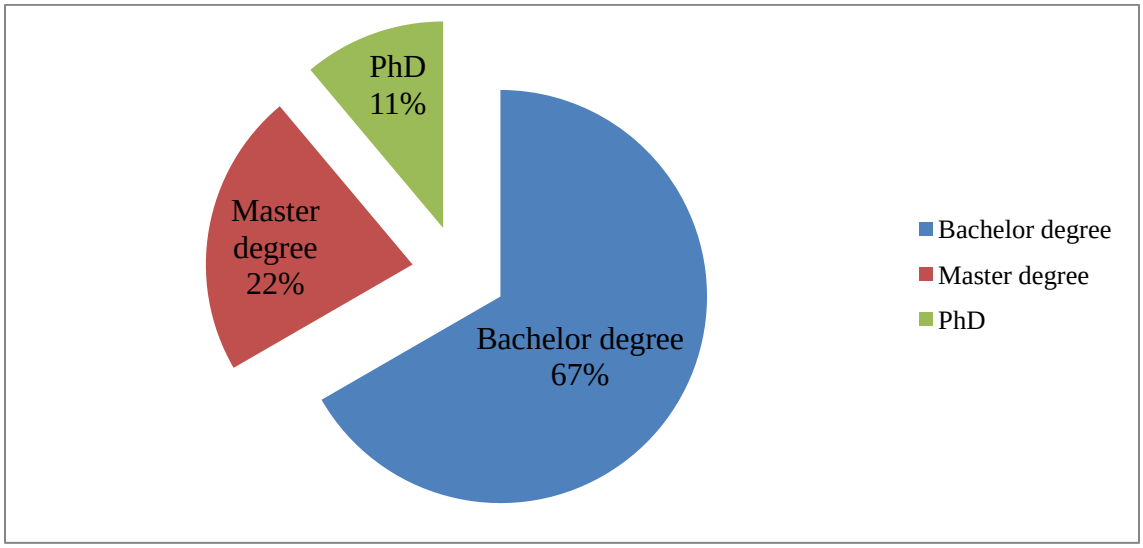


Figure 4.2: Respondents' level of education

4.3.1.2 Respondents job title

As displayed in figure 4.3, it is found that the majority of the respondents (5 out of 9), about 56% were civil engineers, 33% (3 out of 9) were general managers, whereas remaining 11% of respondents were project managers.

It is obvious from these results that none of the respondents is one of the other three options (an architect, a cost manager, and a director) which indicate that most of the

persons involved in the bidding evaluations and the selection of the construction contractors are civil engineers or managers.

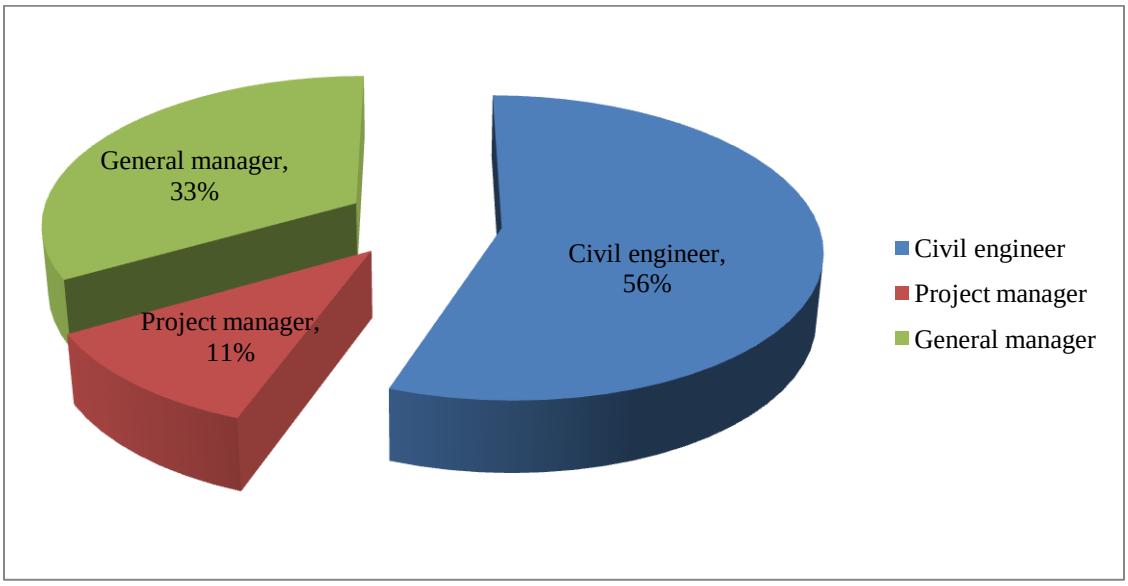


Figure 4.3: Job title of respondents

4.3.1.3 Role of respondents during selection

Figure 4.4 depicted that 44% of the respondents (4 out of 9) were assessments or evaluators, followed by the respondent providing advisory services with 33% (3 out of 9), while 22% of the respondents (2 out of 9) were decision makers. The results revealed that all the respondents were involved during the selection or the evaluation of the construction contractors that give strengthen to the data acquired from them.

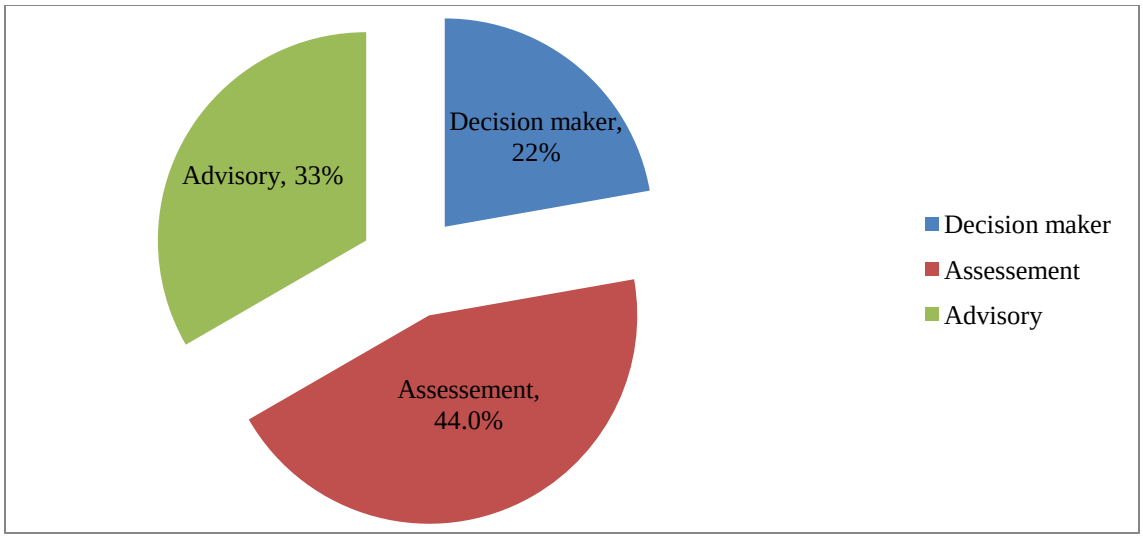


Figure 4.4: Respondents' role during the selection of a construction contractor

4.3.1.4 Experience of respondents in providing tendering services

As illustrated in figure 4.5, about 22% of the respondents (2 respondents) had less than 5 years of experience in performing bidding services, 11% of the respondents (1 respondent) had work experience between 5 to 10 years, 22% of the respondents (2 respondents) had work experience between 10 to 20 years and the majority of respondents- about 44% (4 respondents) had work experience more than 20 years. It is obvious that most of respondents- about 66% had work experience more than 10 years in providing the tendering service which awards more reliability to the data.

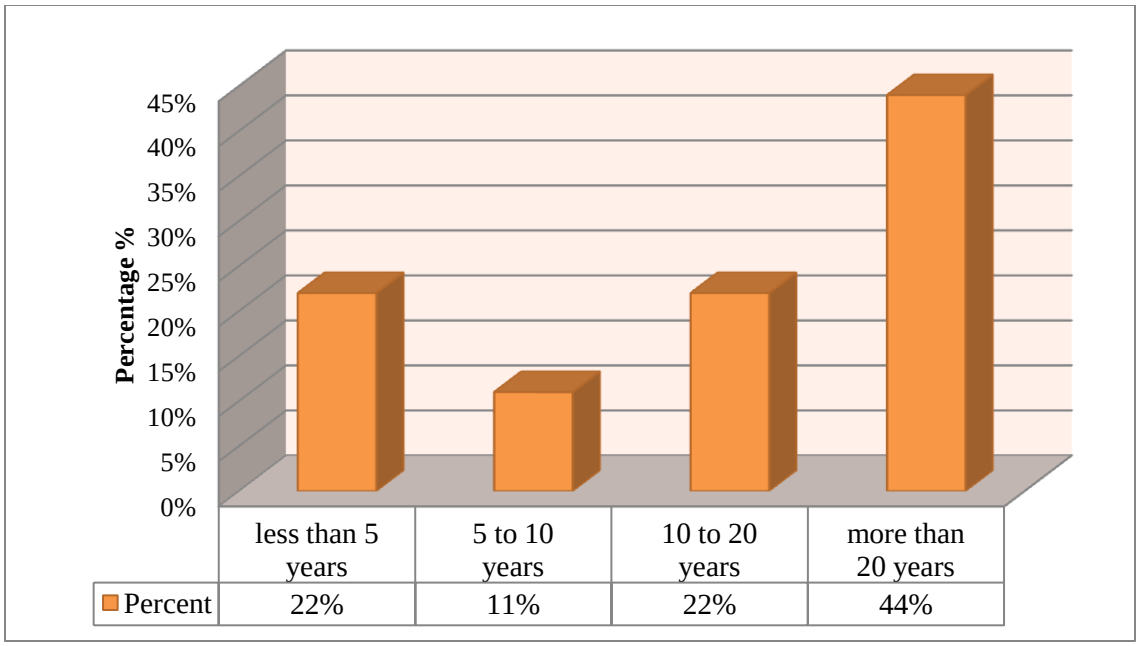


Figure 4.5: Experience of respondents in providing tendering services

4.3.1.5 Number of bids evaluated by respondents

Figure 4.6 demonstrated that about 66% of the respondents distributed equally among the first three choices (22% for each) participated in the evaluation bids between “1 to 5”, “6 to 10”, and “11 to 15” bids, while the remaining 33% of respondents (3 out of 9) have been participated in evaluation more than 15 bids.

The findings indicated that more than half of the respondents participated in evaluating more than 10 bids over the last five years .This also gives the data more credibility and reliability.

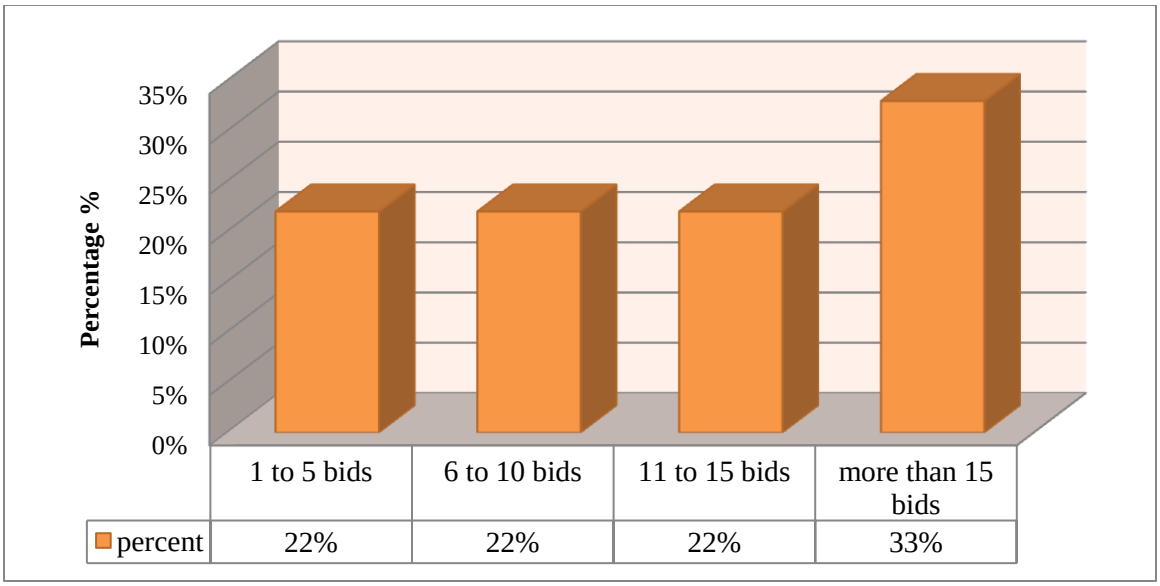


Figure 4.6: Number of bids respondents participated in evaluation of contractor

4.3.2 Current Practice for Tendering System and Selection Process

The identification of the current tendering system is very important in order to understand how the construction contractors and their bids are evaluated and how one of these contractors participated in the bid is selected to construct the project. Therefore, the first objective of this study is to understand and investigate the current tendering and the selection process adopted by the universities at Saudi Arabia.

This objective can be achieved through section II of the questionnaire survey. The questions of this section were created through reviewing literature and reviewing Saudi Competitions and Procurements Regulation Systems.

Section II of the questionnaire survey consists of twenty diverse questions; most of these questions are open-ended.

4.3.2.1 Bidding system employed by university

Figure 4.7 depicted that a high percentage of the respondents- about 78% (7 out of 9)- specified that the open bidding system is the most widely implemented for the construction contractor selection arrangements. While the remaining 22% of the respondents (2 out of 9) indicated that the closed bidding system is applied for the tendering process. Figure 4.7 also illustrates that none of the respondents implements the negotiated bidding arrangement when conducting the bidding process.

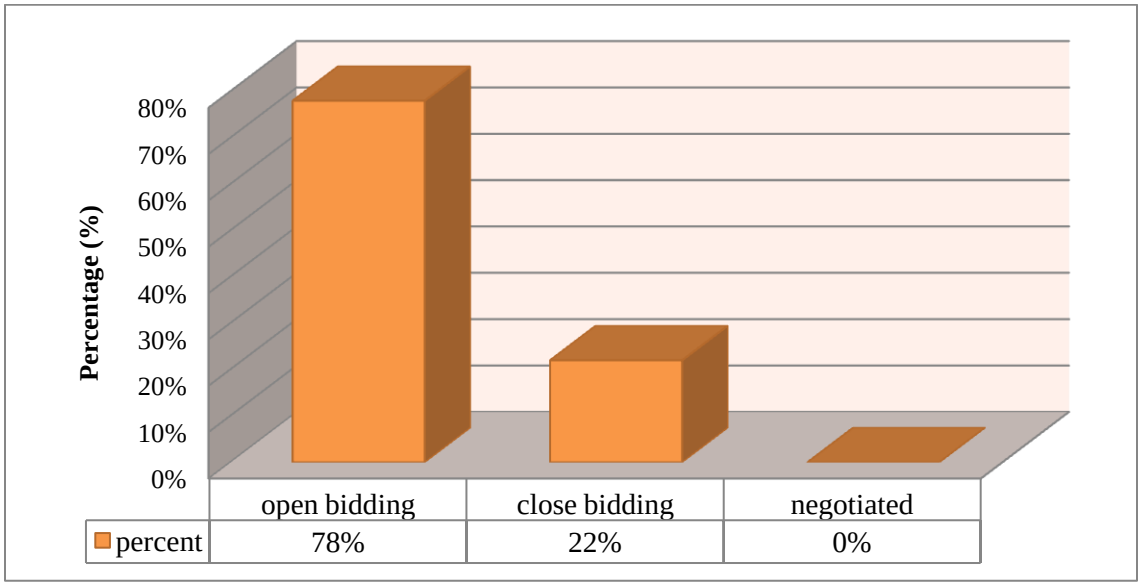


Figure 4.7: Bidding system employed by organization

4.3.2.2 Time of qualifying contractors

As illustrated in figure 4.8, the majority of the respondents- about 67% (6 out of 9)- pointed out that the qualification conducted after the contractors submitting their bids (post qualification).

In addition to that, figure 4.8 shows that none of respondents stated that their organization carrying out qualification either before the contractors submitting their bids (prequalification) or periodically qualification (contractors' qualified list). Two respondents out of nine indicated that the qualification is not existed in their organization. One of the respondents claimed that according to the regulations when a contractor classification exists, then qualification is not required; otherwise, the qualification should be conducted periodically before submitting bids.

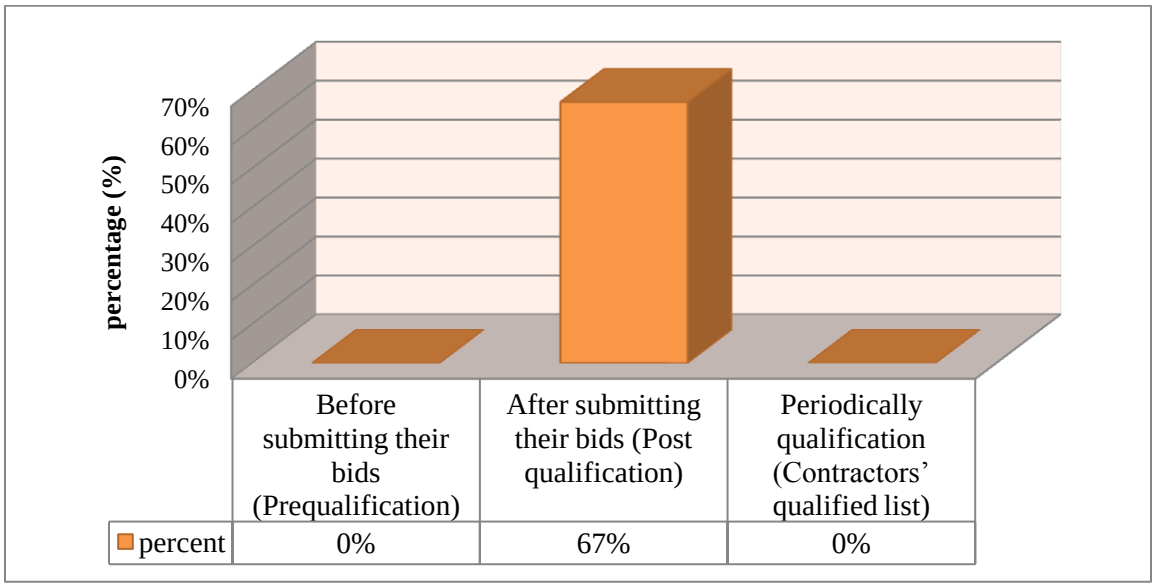


Figure 4.8: Time of conducting qualification for contractors

4.3.2.3 Potential factors for qualifying contractors

Respondents were requested to rate the degree of importance of fifteen factors used during the contractors' qualification through selecting one of the following terms: extremely important, very important, important, not important, and extremely not important.

Based on the value of importance index, the scale that is used to classify each level of importance, ranging from extremely importance to extremely not importance, is developed with intervals as shown in table 4-1.

Table 4-1: Weighted importance and classification

Classification	**Assigned weight**
Extremely not important	0 - < 12.5%
Not important	12.5 – < 37.5%
Important	37.5 – < 62.5%
Very important	62.5 – < 87.5%
Extremely important	87.5 – 100%

Table 4-2 illustrates a summary of relative importance index (RII) and the rate of importance for each parameter used during the contractor qualification. Table 4.2 also shows that none of the parameters was rated as “extremely important”, 12 parameters were rated as “very important”, and 3 parameters were rated as “important”. In addition to that, none of the parameters was rated as “not important” or “extremely not important”.

The most five significant parameters considered during the contractors’ qualification in descending order are “contractor financial stability”, “contractor experience”, “contractor quality performance”, “availability of manpower resources”, and “contractor current workload”.

While the contractor home office location parameter is the least important parameter considered for the contractor qualification.

Table 4-2: Rate of importance of contractor qualification parameters

Qualifying parameters used for contractor qualification		Importance index (%)	Rate of importance	Rank
1	Contractor financial stability	84.4	V. I.	1
2	Contractor experience	84.4	V. I.	2
3	Contractor quality performance	77.8	V.I.	3
4	Availability of equipment resources	73.3	V. I.	6
5	Availability of manpower resources	77.8	V. I.	4
6	Contractor current workload	75.6	V. I.	5
7	Contractor past performance	73.3	V. I.	7
8	Contractor safety records	64.4	V. I.	11
9	Contractor claim attitudes	51.1	I.	14
10	Contractor home office location	40.0	I.	15
11	Procurement experience of contractor	62.2	I.	13
12	Contractor familiarity with location of project	65.0	V. I.	10
13	Management staff availability of contractor	64.4	V. I.	12
14	Amount of work performed by contractor	68.9	V. I.	8
15	Planning, scheduling and cost control techniques adopted by contractor	68.9	V. I.	9

E.I.: Extremely important, V.I.: Very important, I.: Important, N.I.: Not important, E.N.I: Extremely not important

4.3.2.4 Set prequalification as condition on contractors

As illustrated in figure 4.9, among 9 respondents to the questionnaire survey, only 3 respondents (33% of respondents) pointed out their university set prequalification as a condition on the construction contractor to participate in a bid. In contrast, vast majority

of the respondents- about 67% (6 respondents)- stated that their university never set a prequalification as a condition on the contractors to participate in the bid.

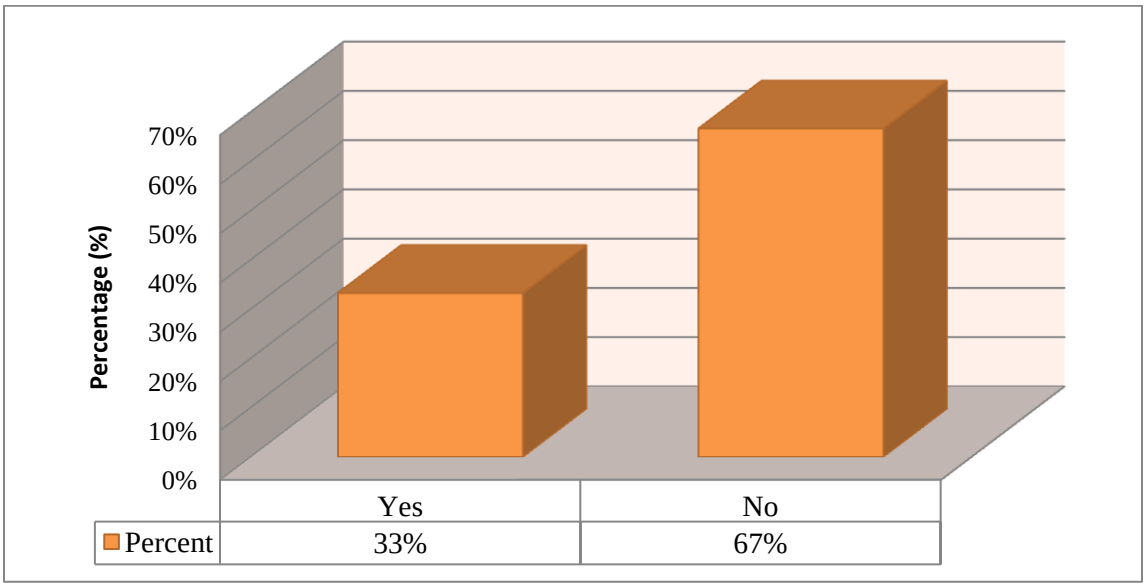


Figure 4.9: Set prequalification as condition on contractors to participate in bidding

4.3.2.5 Prequalification purpose

The respondents, who stated that their universities set a prequalification as a condition on the contractor to participate in the bid, were requested to identify the purpose of the prequalification for their universities. The respondents were requested to select all the options that apply. As illustrated in figure 4.10, among all those 3 respondents, all respondents (100%) agreed that they conduct a prequalification in order to exclude unqualified contractors and 2 respondents out of 3 (66.7% of respondents) indicated that they perform the prequalification in order to provide a shortlist. One respondent out of three (33.3%) indicated that the purpose of carrying out the prequalification is to provide enough time for the contractor investigation.

Figure 4.10 also demonstrates that none of the respondents stated that their universities conduct the prequalification in order to comply with the company regulation, the public accountability, or conduct it as a standard procedure.

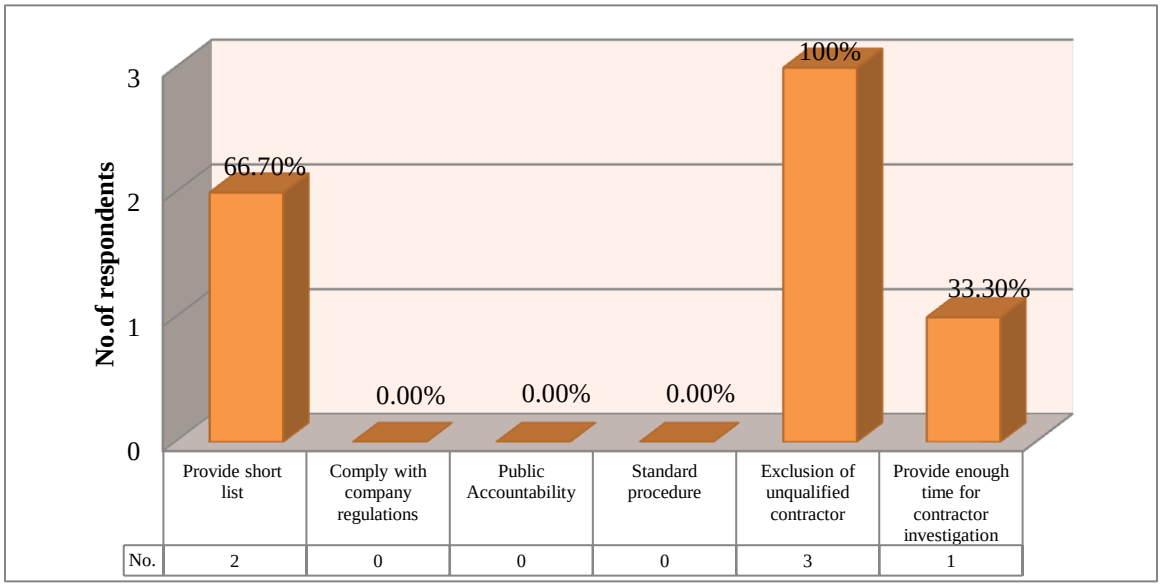


Figure 4.10: Purposes of conducting prequalification for contractors

4.3.2.6 Update contractors' information

The respondents, who stated that their universities set a prequalification as a condition on the contractor to participate in a bid, were also requested to identify when their organization updates the information of contractors in the qualified list. Figure 4.11 depicts that two respondents out of three (66.7%) indicated that their organization updating information of contractors in the qualified list yearly, while one respondent out of three (33.3%) denoted that updating information is not required. None of the respondents specified that their organization updates the information of contractors either monthly or every six months.

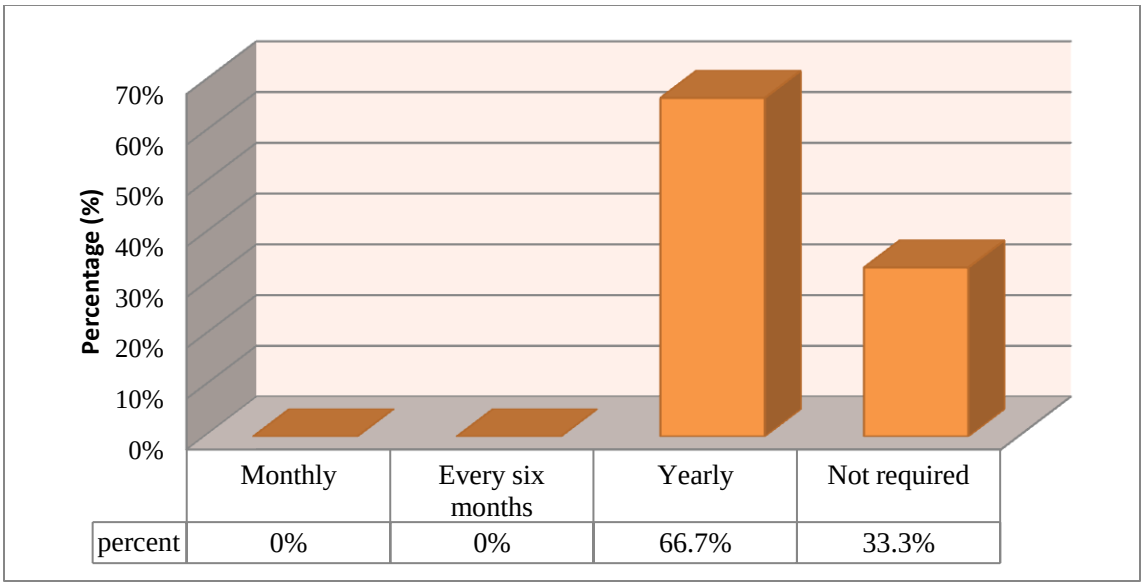


Figure 4.11: Period of updating information of contractors in the qualified list

4.3.2.7 Guideline to identify maximum number of contractors in the qualified list

Again, the respondents who, stated that their universities set a prequalification as a condition on the contractor to participate in a bid, were requested to specify the guideline their organization followed in determining the maximum number of contractors in the qualified list. Figure 4.12 illustrates that among 3 respondents, 2 out of 3 (66.7%) stated that there is no guideline implemented by his organization to determine the maximum number of contractors in the qualified list, 1 respondent out of 3 (33.3%) denoted that their organization depends on the information which is already available to determine the maximum number of contractors in the qualified list. None of the respondents specified that they pursued organization internal guideline in determining the maximum number of the qualified list.

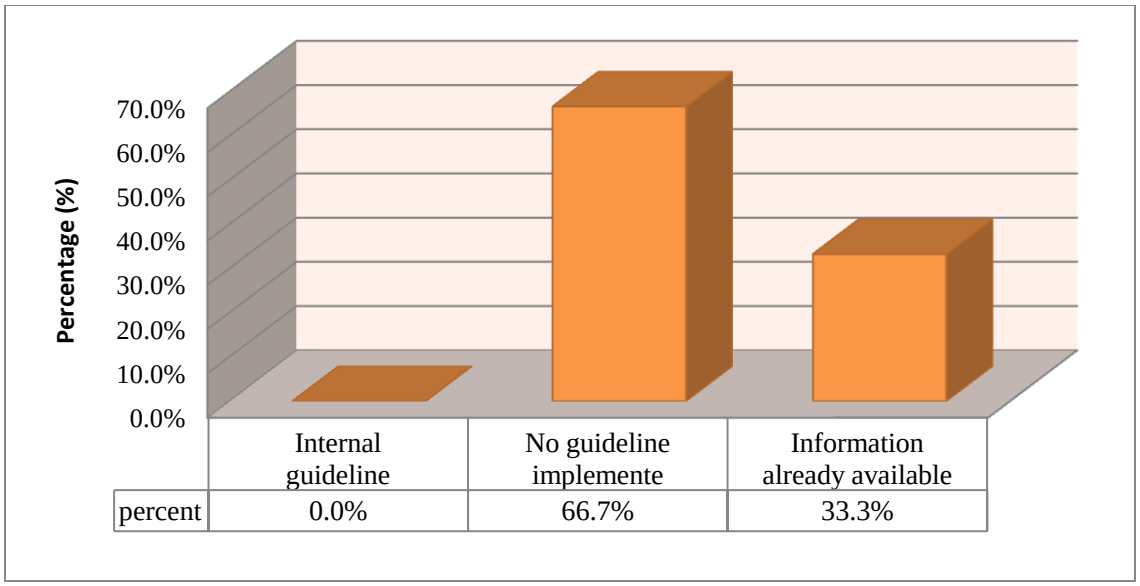


Figure 4.12: Guideline for determining maximum number of contractors in qualified list

4.3.2.8 Using same criteria for evaluation of contractors

Respondents were requested to specify whether their universities use the same criteria to assess the contractors for all projects or not, regardless the nature of the project. Figure 4.13 shows that two third of respondents (6 out of 9) denoted that their university implements the same criteria for all projects. Whereas, other one third of respondents (3 out of 9) stated that their university never uses the same criteria to evaluate contractors for all projects, the criteria selected depend on the nature of the project itself.

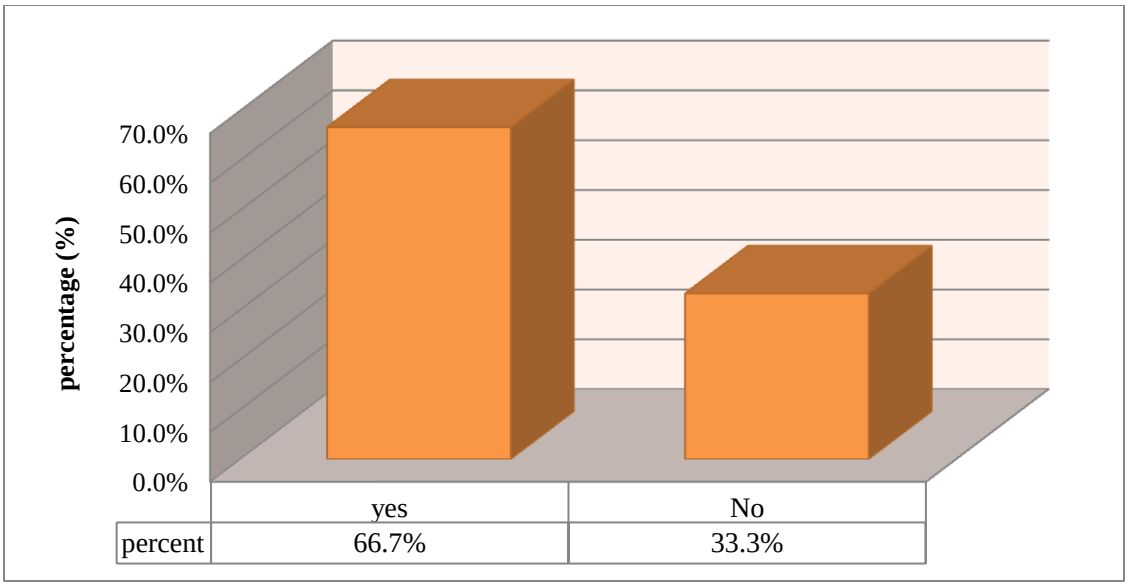


Figure 4.13: Using same criteria for evaluation of contractors for all projects or not

4.3.2.9 Determine criteria for evaluation of contractors for each project

Respondents, who identified that their universities never implement the same criteria to evaluate contractors for all projects, were requested to specify how their universities determine the criteria required to evaluate contractors for each project. Figure 4.14 depicts that all three respondents (100%) specified that their universities consider the requirements for each project as a major factor for determining the criteria to evaluate the contractors for that project. Figure 4.14 also presents that none of the respondents specified that their universities use any other three options as a way to determine the criteria for the contractors' evaluation.

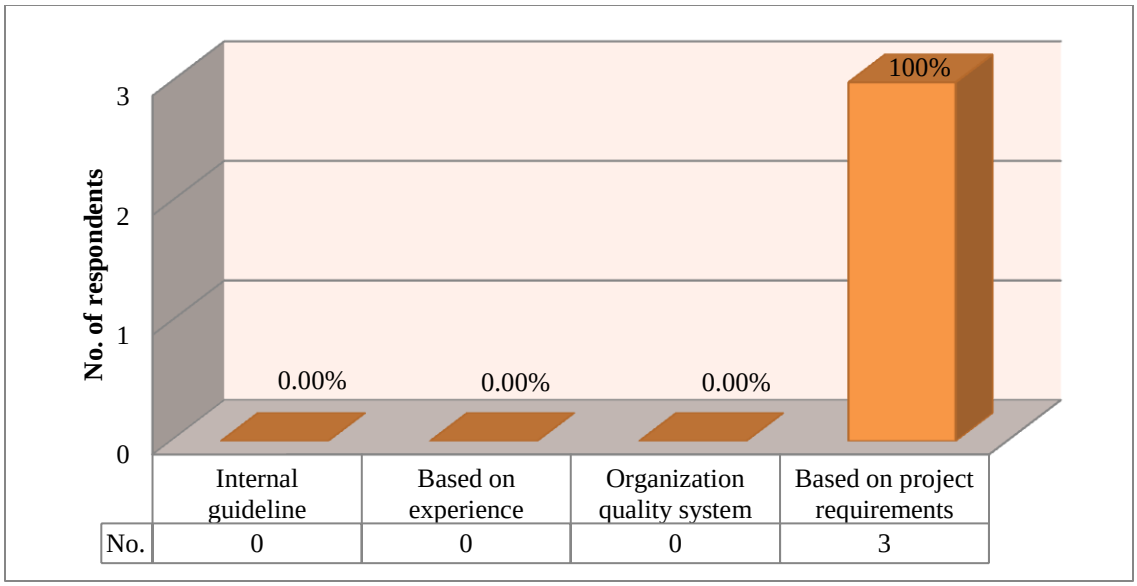


Figure 4.14: Ways for determining criteria for contractors' evaluation for each project

4.3.2.10 Information required from contractor

As exemplified in Figure 4.15, all 9 respondents (100%) stated that a contractor should submit the management staff CV, two third of respondents stated that contractors should submit information about their financial details, 44.4% of the respondents (4 out of 9) denoted that the contractor should submit information about their "safety policy" and "quality assurance policy". Moreover, figure 4.15 displays that one third of the respondents (3 out of 9) specified that the contractors should submit a completed questionnaire and information about the method statement. Some of the respondents stated that the contractor when participating in a bid should submit a material catalogue, current and previous experience certificates, a contractor classification certificate, and a bank guarantee certificate.

Figure 4.15: Information required from contractors

4.3.2.11 Liability for assessment of contractor information

Figure 4.15 demonstrates that the vast majority of respondents- about 44.4% (4 out of 9) indicated that the evaluation of the contractor information is the liability of the tendering department of the organization. Two respondents out of nine (22.2%) pointed out that a project manager is accountable for assessment of the contractor information. One respondent out of nine (11.1%) specified that the financial department of the organization is liable to do that job. Figure 4.16 also displays that none of the respondents identified that the evaluation of contractor data is the responsibility of the director. Some respondents specified that the contractor data evaluation is the responsibility of the technical committee which is formed based on the type of the project, or the liability of the bid inspection committee.

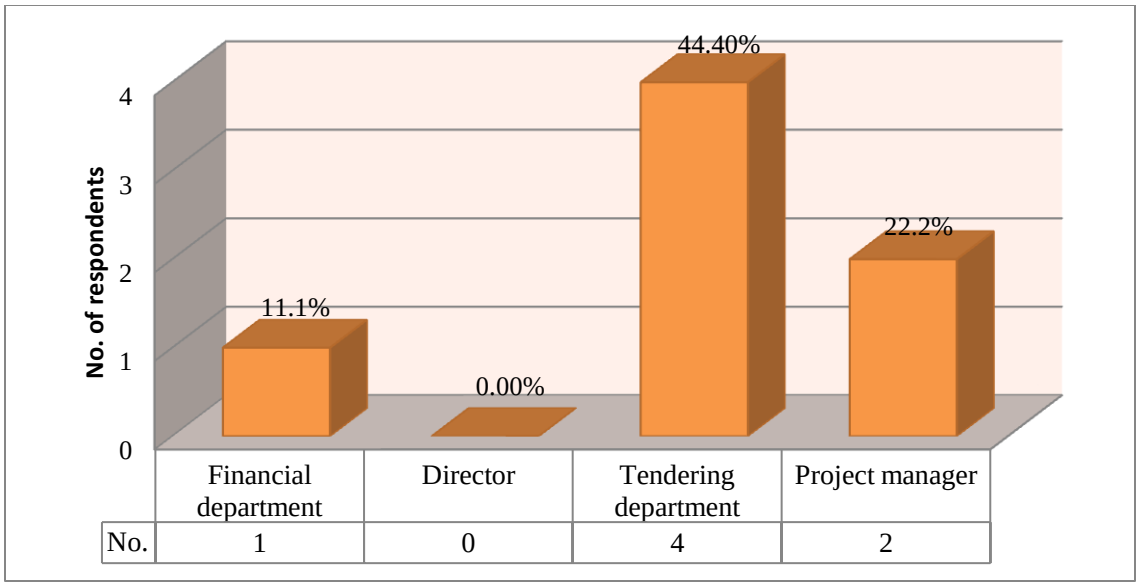


Figure 4.16: Liability for evaluation of contractor data

4.3.2.12 Methods adopted to evaluate decision criteria for contractor selection

As illustrated in figure 4.17, about 55.6 % of respondents (5 out of 9) specified that their universities depends on experience when evaluating the decision criteria, 11.1% of respondents (1 respondent) denoted that their universities carry out statistical analysis to assess the decision criteria, while 22.2% of respondents (2 respondents out of 9) indicated that the evaluation decision criteria were conducted through professional judgment, other 22.2% of respondents (2 out of 9) ensured that their organization evaluated the decision criteria through rating criteria with weight. Furthermore, figure 4.17 also pointed out 22.2% of respondents specified that their organization evaluated the decision criteria through rating without weight, none of the respondents confirmed that their universities never conduct the evaluation on the decision criteria.

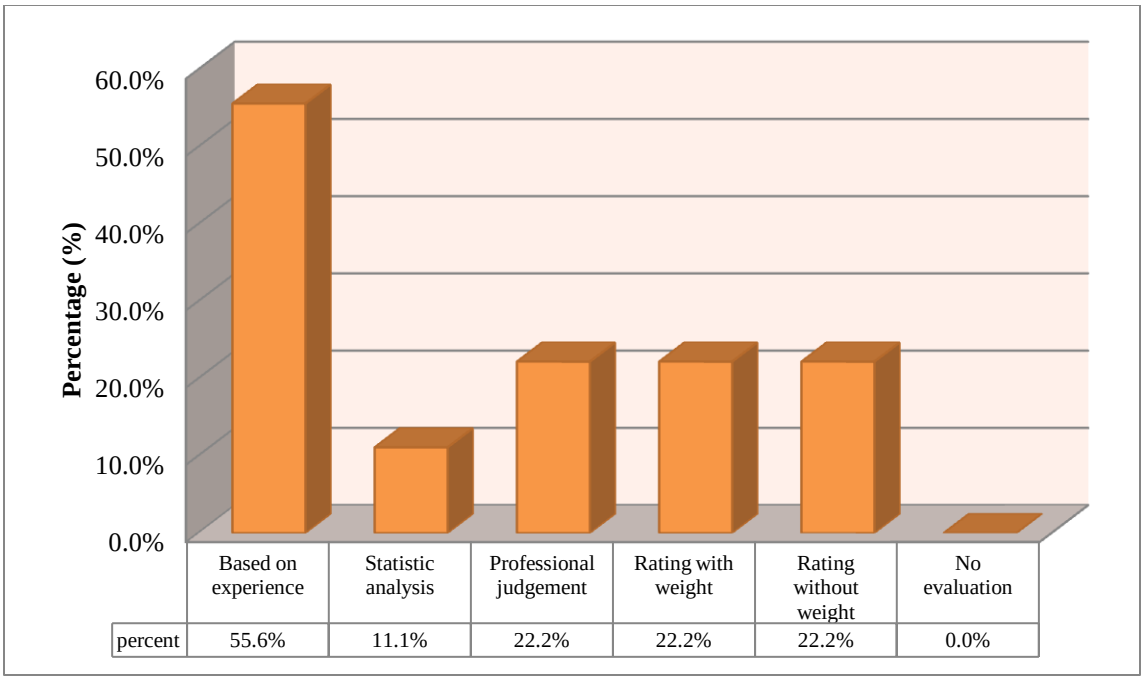


Figure 4.17: Alternative methods to evaluate decision criteria

4.3.2.13 Methods to perform final decision to select contractor

As illustrated in figure 4.18, the vast majority of respondents- about 77.8% (7 out of 9) specified that the final decision of their universities to come up with one contractor or more to perform a project depends entirely on the lowest price, other 22.2% of respondents (2 respondents) indicated that the final decision for the selection of their universities depends on multi-criteria. None of the respondents denoted that the final decision of their organization depends on the familiarity of the organization with the contractor who performs the previous project with their universities and who finished the former projects at predetermined time, within a budget and at a desired quality.

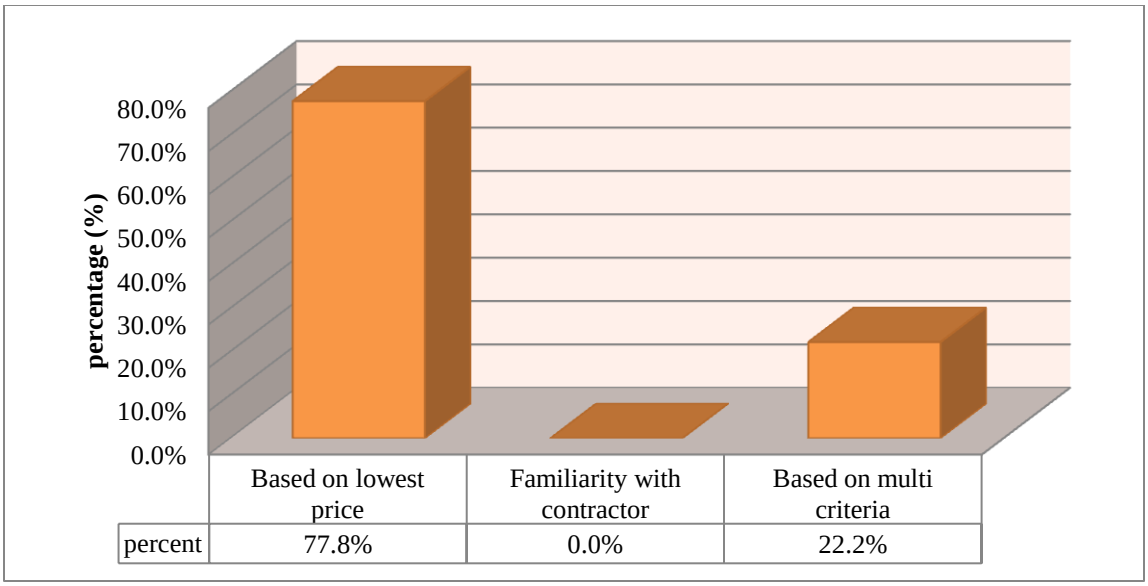


Figure 4.18: Methods of performing final decision to select contractor

4.3.2.14 Responsibility to conduct final selection of contractor

Figure 4.19 displays that the vast majority of the respondents- about 88.9 % (8 out of 9) signified that the final selection of a contractor is one responsibility of the bid awarding committee. The remaining 11.1% of respondents (only one respondent) denoted that conducting the final selection is the liability of the tendering department. Figure 4.19 also demonstrates that none of the respondents specified a director or a senior project manager to be responsible for performing the final selection of the construction contractor.

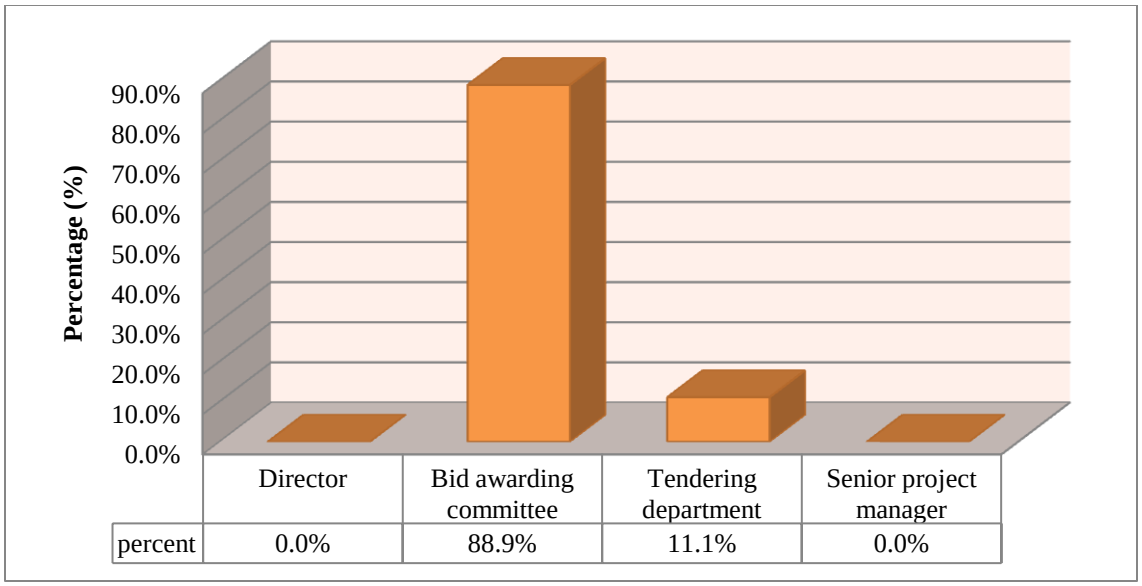


Figure 4.19: Liability to perform final selection of construction contractor

4.3.2.15 Problems associated with the current awarding contract

As shown in figure 4.20, all respondents (100%) affirmed that, depending on the current process for the contractor selection result in awarding a contract to an inappropriate contractor.

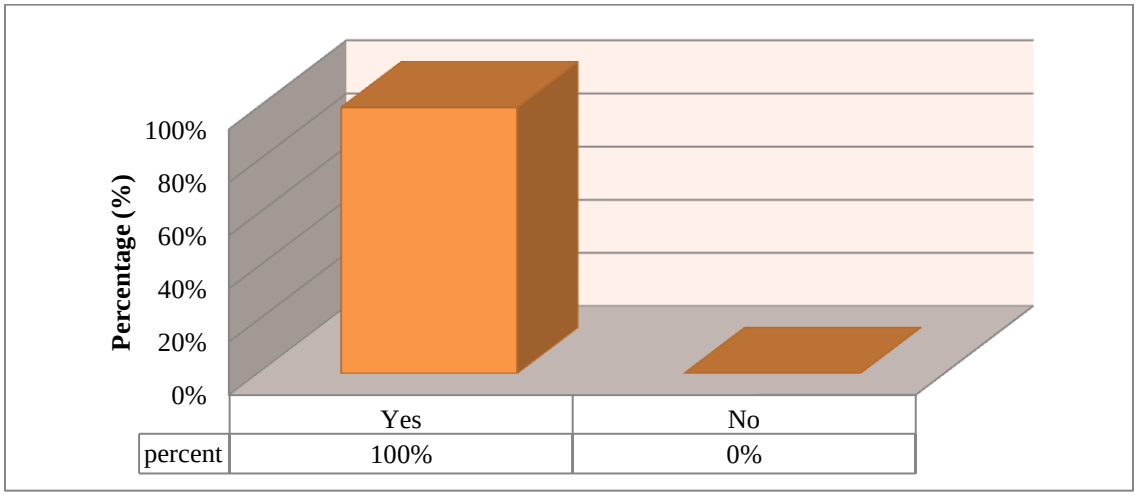


Figure 4.20: Awarding contract to inappropriate contractor using current process

Figure 4.21 illustrates that respondents agreed unanimity that the selection of an inappropriate contractor will lead to “a poor project performance”, followed by 88.9% of respondents (8 out of 9) who identified that “the project will be delayed” due to the poor contractor selection, whereas five respondents out of nine (55.6%) stated that the selection of unqualified contractors result in “increase issuing of claims”. Figure 4.21 also demonstrates that 22.2% of respondents (2 respondents) indicated that the awarding contract to an improper contractor results in “cost overruns”, and only one respondent denoted that “the contractor bankruptcy” is one problem associated with a poor contractor selection.

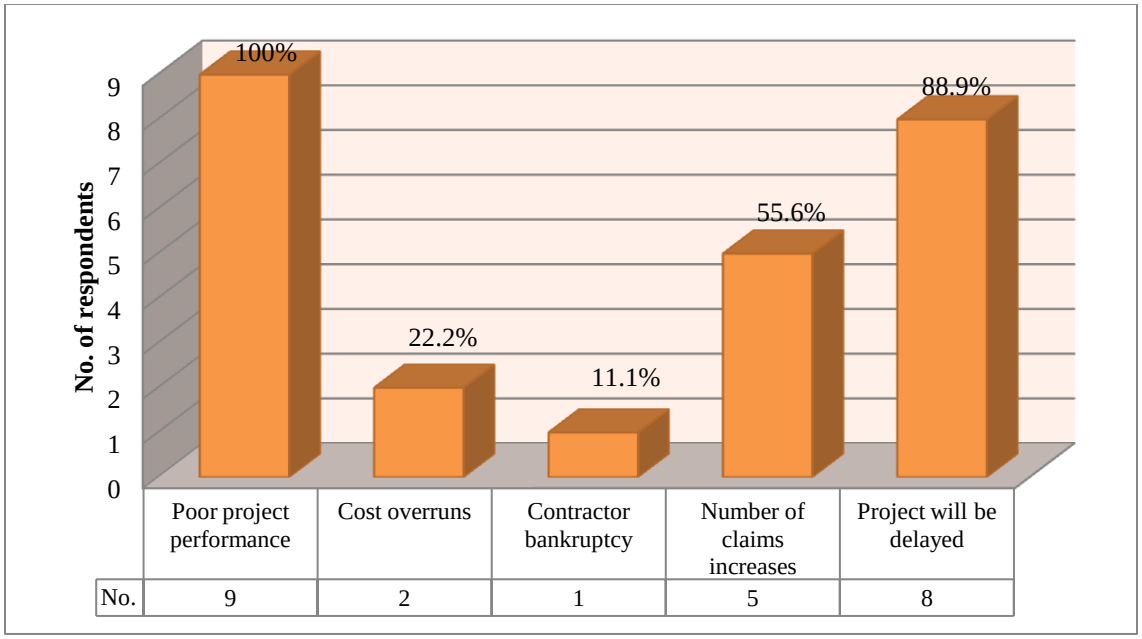


Figure 4.21: Problems associated with selection of improper contractor

4.3.2.16 Advantages of current selection process

Figure 4.22 illustrates that 55.6% of respondents (5 out of 9) stated that the current selection process assists in accelerating the contract awarding process. Moreover, the same percentage of respondents indicated that one major advantage of the current selection process is confining participation in the contract on the classified contractor only. Figure 4.22 also shows that 33.3% of respondents (3 out of 9) declared that using the current selection process results in minimizing both the bid evaluation time and the bid evaluation cost, and none of the respondents stated that participation in the contract is confined only on a qualified contractor. About two third of the respondents also stated that these advantages are not significant and don't have great impact on the final product. Therefore, it is obvious that most of the respondents were not satisfied with the current bidding system.

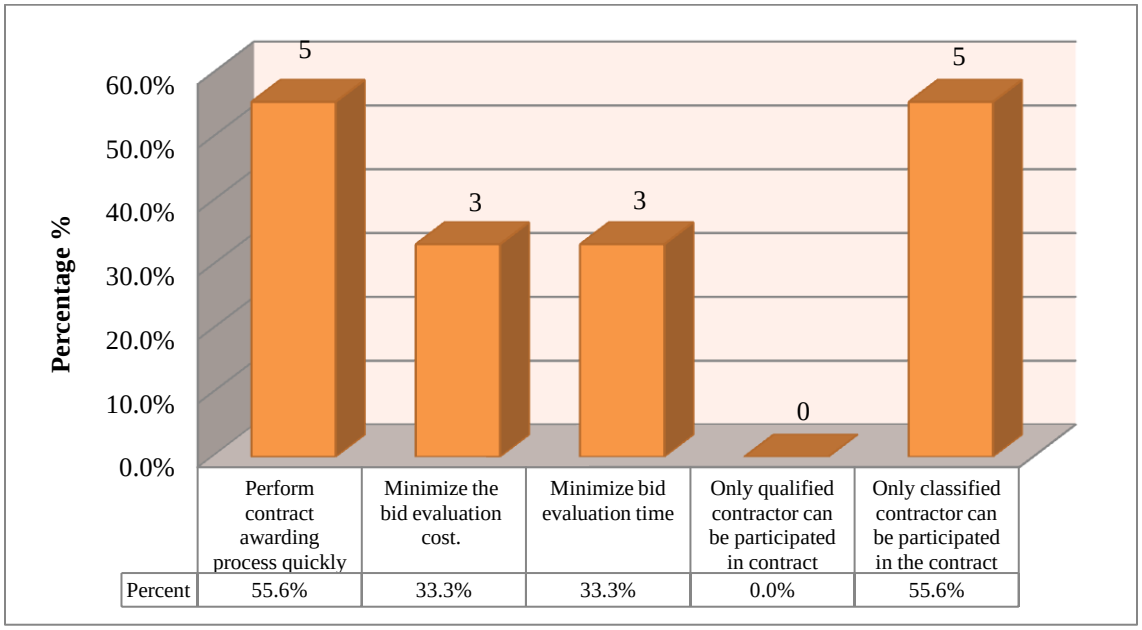


Figure 4.22: Advantages associated with current selection process

4.3.2.17 Implementation of decision support system

The last part of section II of the questionnaire survey aims to investigate the knowledge and the awareness of the universities with the significant of implementation of the decision support systems during the evaluation or the selection of the construction contractor. Figure 4.23 shows that the vast majority of respondents- about 77.8%- never heard about the implementation of the decision support system in the evaluation or the selection of the contractor, only 2 respondents out of 9 (22.2%) indicated that they heard about the use of the decision support system when selecting the construction contractors.

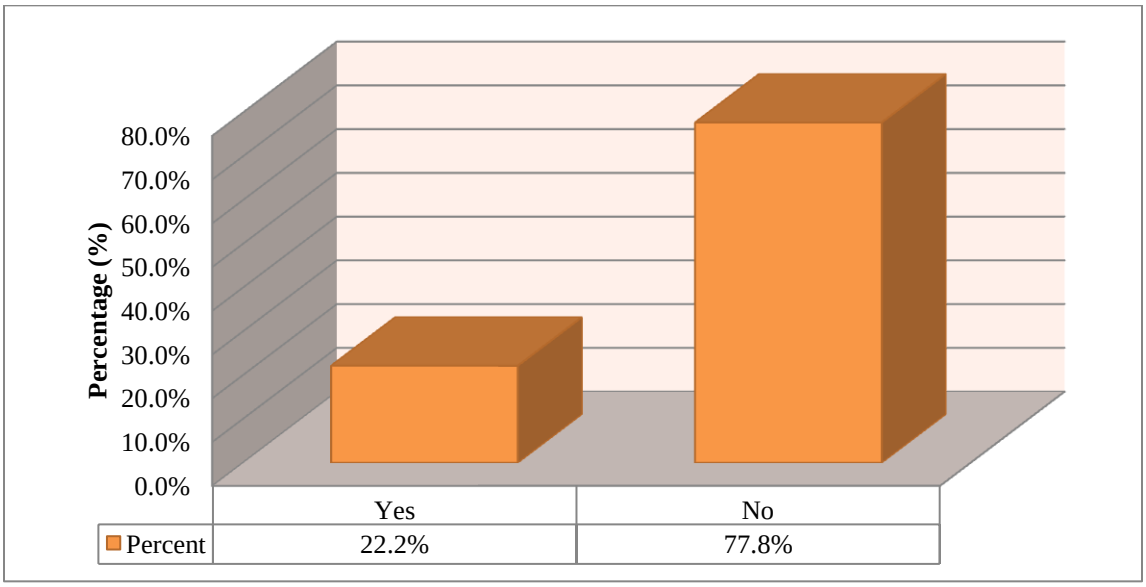


Figure 4.23: Awareness about using decision support system for contractor selection

In addition to that, figure 4.24 displays that one third of the respondents heard about the employment of the analytical hierarchy process as a tool for the evaluation of the contractors, whereas the vast majority of the respondents, about two third, never know anything about that process.

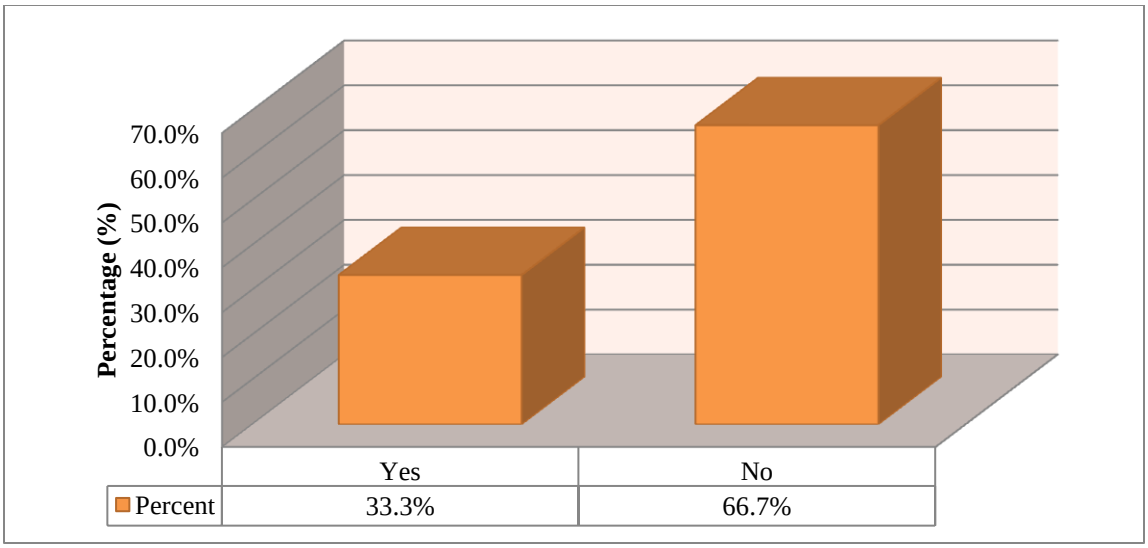


Figure 4.24: Respondents knowledge about implementation of AHP

Whereas figure 4.25 demonstrates that the respondents unanimously affirmed that their universities never implement any decision support system during the selection or the evaluation of the construction contractors.

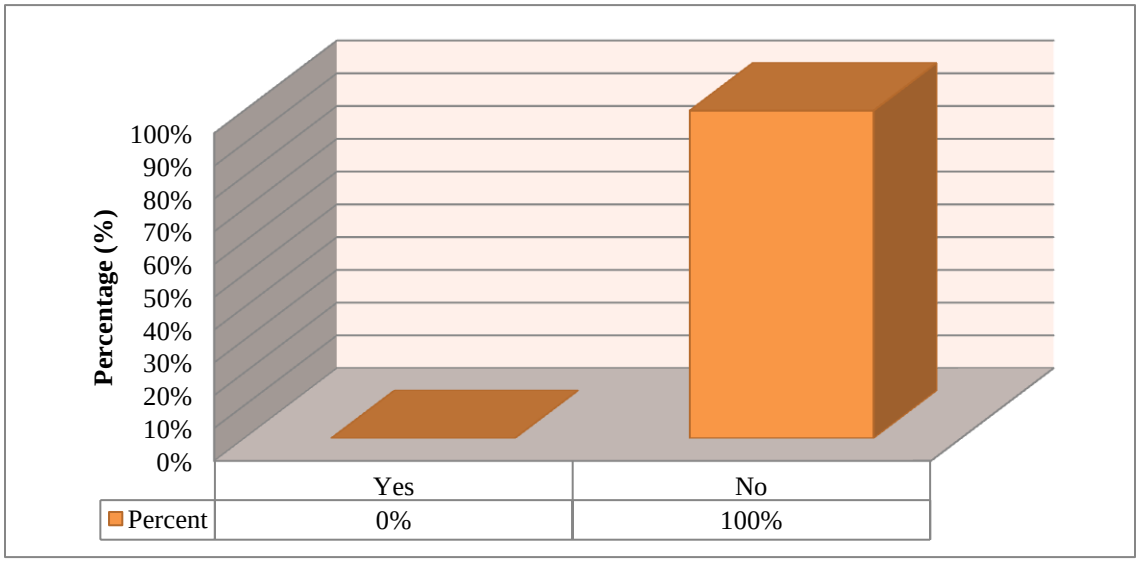


Figure 4.25: Level of implementation of any DSS during contractor selection

4.3.3 Contractor Selection Criteria

Determining criteria to evaluate or select a construction contractor to execute a project is very important in order to guarantee that the selection is done through a fair method and the selection of an unqualified contractor is avoided. Therefore, the second objective of this study is identifying the criteria that shall be considered when selecting the construction contractor. This objective has been attained through section III of the questionnaire survey (Appendix A).

Sixteen criteria were found from literature. Respondents were requested to identify which of these criteria are usually used in the evaluation or the selection of the construction contractors and which are not used.

Table 4-3 displays the percentage of implementation of each criterion; there are two cases for each criterion either used or not depending on the percentage assigned to it from the respondents. The certain criterion was identified to be usually used during the evaluation if at least 50% of respondents said yes they use this criterion during the evaluation or the selection; otherwise, the criterion is identified to be not used. In the case where half of the respondents said yes and the other half said no, then this criterion is assigned “undecided criterion”.

For example, the respondents unanimously (response exceeds 50%) denoted that the contractor financial stability criterion is usually used during the contractor selection. Because 100% of the respondents (nine out of nine) agreed that this criterion is used

during the contractor selection, then the contractor financial stability is one of the criteria that shall be considered when performing the selection of the construction contractor.

Table 4-3: Criteria for contractor selection

No.	Criteria	Yes	No	Allocation
1	Contractor financial stability	100%	0%	Used
2	Contractor past Performance (performance record)	100%	0%	Used
3	Contractor technical expertise	77.8%	22.2%	Used
4	Contractor managerial Capability	33.3%	66.7%	Not used
5	Contractor current workload (Capacity)	77.8%	22.2%	Used
6	Contractor safety records	33.3%	66.7%	Not used
7	Operation & equipment resources possess by contractor	44.4%	55.6%	Not used
8	Bid price	100%	0%	Used
9	Contractor home office location	11.1%	88.8%	Not used
10	Familiarity of contractor with geographical location of project	22.2%	77.8%	Not used
11	Quality control system implemented by contractor	33.3%	66.7%	Not used
12	Past penalties on contractor	55.6%	44.4%	Used
13	Familiarity of owner with contractor	44.4%	55.6%	Not used
14	Contractor submitted complete bid documents including bonds, zakah clearance, financial offer, etc	100%	0%	Used
15	Environmental management strategies adopted by contractor to reduce impact of construction on environment	0%	100%	Not used
16	Contractor classification	100%	0%	Used

Table 4-3 also shows that there is an agreement from all the respondents that the "environmental management strategies adopted by the contractor to reduce the impact of the construction on the environment" is not a factor considered for the selection of the construction contractor. Moreover, there is the diversity of the opinions from the respondents on the other fifteen factors. But from the analysis of the data, it is obvious that eight out of sixteen criteria can be determined as usually implemented during the construction contractor selection namely: "The contractor financial stability", "The contractor past performance", "The contractor technical expertise", "The contractor current workload", "The bid price", "The past penalties on a contractor", "The contractor submitted complete bid documents including bonds, zakah clearance, financial offer, etc", and The contractor classification".

4.3.4 Pair-Wise Comparison between Criteria

A pair-wise comparison starts after creating the problem in a hierarchy in order to identify the relative importance of the criteria at each level in the hierarchy.

The pair-wise comparison is the method adopted in order to make a comparison between two criteria with respect to another criterion in the level above. It can be conducted using the expert choice software. The pair-wise comparisons were performed in the top-down approach at each level in the hierarchy. Therefore, all the criteria under any node were compared with each other regarding the node itself.

The respondents in section IV of the questionnaire survey (Appendix A) were requested to conduct the pair-wise comparison between the criteria in order to determine the importance of each criterion with respect to others and identify the overall priorities of the criteria.

In the previous sections, respondents were requested to identify whether the sixteen factors mentioned used or not during the selection or the evaluation of the construction contractor. Because there is unanimously among respondents one factor that is not used, and there is a difference in the perspectives among them on fifteen factors, in this section respondents were asked to perform a pair-wise comparison between those fifteen factors based on their experience and knowledge in the contractor selection and the evaluation process using the scale from 1 to 9 as illustrated in table 4-4 and explained in depth in chapter two of this research.

Table 4-4: Pair-wise comparison scale

Points scale	**Description**
1	Equally importance
3	Moderately importance
5	Strongly importance
7	Very strongly importance
9	Extremely importance
2,4,6,8	Intermediate values, for example, a value of 6 means that the degree of importance is between strongly importance which is (5) and very strongly importance which is (7).

Basically, According to Saaty (1980) the number of judgment required to be performed by each respondent is equal to $\frac{n\,(n-1)}{2}$. Thus each respondent was asked to conduct 105

paired comparisons ($\frac{15\,(15-1)}{2} = 105$). After that, the expert choice software was used to determine the overall rank of each identified criteria.

Because it is not easy to perform manual calculations for 15x15 matrix, the comparison made by one respondent among only three criteria are taken as an example as explained in table 4-5. These criteria were assigned the alphabet order where "A" represents the contractor financial stability, "B" represents the contractor past performance and "C" refers to the contractor technical expertise.

Table 4-5: Pair-wise comparison between three criteria from one respondent

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria
Financial stability			✓															Past Performance
Financial stability					✓													Technical expertise
Past Performance											✓							Technical expertise

In order to determine the priority of each criterion and check the consistency of the judgment, the following steps should be conducted:

1. Creating a pair-wise comparison matrix. In this case matrix 3x3 as shown in table 4-6.

Table 4-6: Pair-wise comparison matrix

Criteria	**A**	**B**	**C**
A	1	7	5
B	1/7	1	1/3
C	1/5	3	1

2. Once, the pair-wise comparison matrix created this matrix which is synthesized through dividing each item of the matrix by the summation of its column as shown in table 4.7
3. After synthesizing the matrix, the priority vector is determined through calculating the row averages of the synthesized matrix as illustrated in table 4-7.

Table 4-7: Synthesized pair-wise comparison matrix

Criteria	**A**	**B**	**C**	**Priority vector**
A	0.74	0.64	0.79	0.723
B	0.11	0.09	0.05	0.083
C	0.15	0.27	0.16	0.193

4. Check judgment consistency through pursuing the following steps:
   a. Determining the weighted sum matrix as follows:

$$0.723\begin{bmatrix}1\\1/7\\1/5\end{bmatrix}+0.083\begin{bmatrix}7\\1\\3\end{bmatrix}+0.193\begin{bmatrix}5\\1/3\\1\end{bmatrix}=\begin{bmatrix}2.269\\0.251\\0.587\end{bmatrix}$$

   b. Dividing each item in the weighted sum matrix by their particular priority vector

$$\frac{2.269}{0.723}=3.138,\qquad \frac{0.251}{0.083}=3.024,\qquad \frac{0.587}{0.193}=3.041$$

   c. Determining λ_{max} through calculating the average of values obtained in part b.

$$\lambda\text{max}=\frac{3.138+3.024+3.041}{3}=3.068$$

   d. Determining the consistency index CI.

$$\text{CI}=\frac{\lambda_{\text{max}-n}}{n-1}=\frac{3.068-3}{3-1}=0.034$$

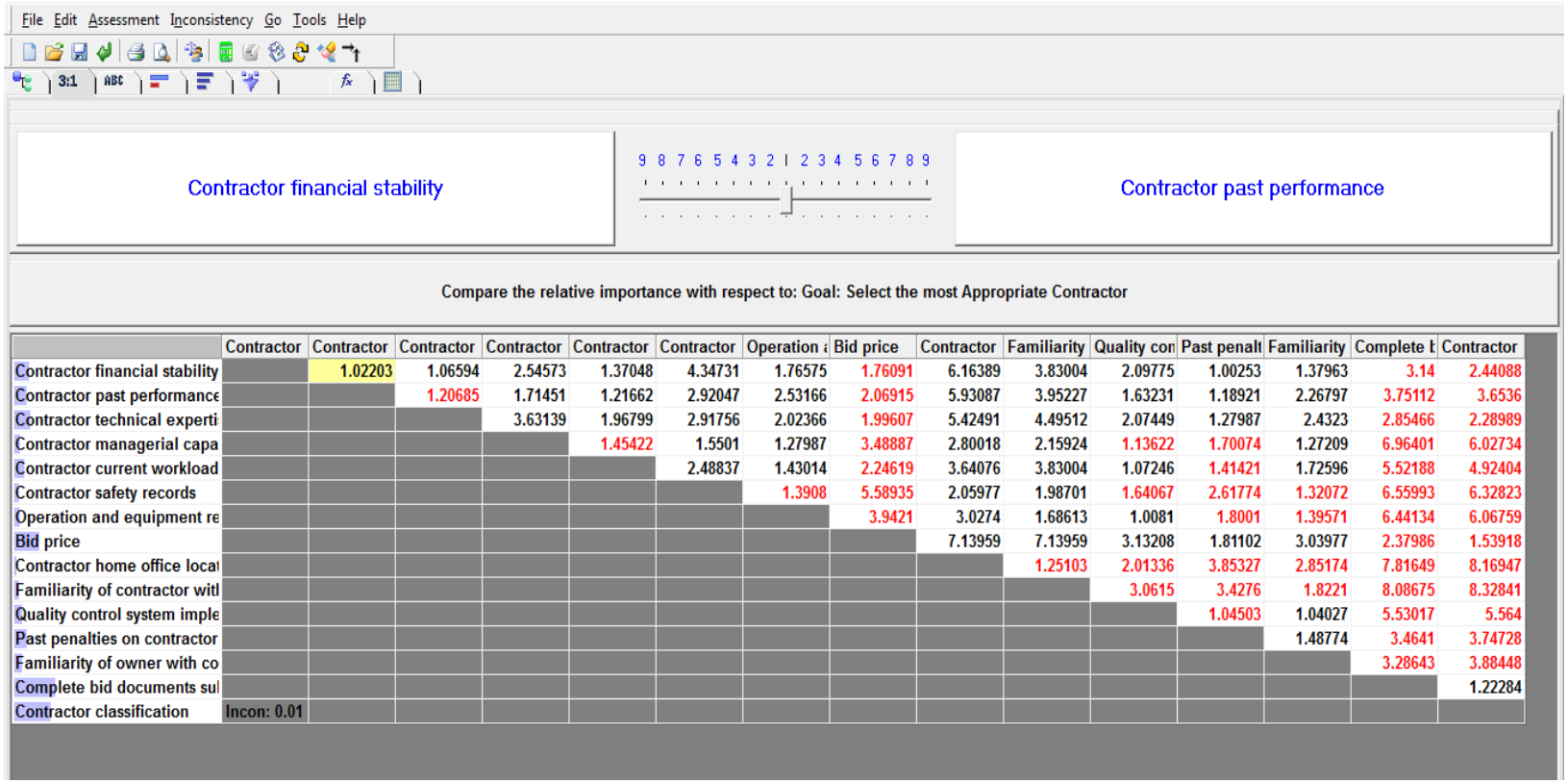
e. Choosing a suitable value for the random consistency from table 2-8. The R.C value corresponding to matrix size 3x3 is equal to 0.58

f. Determining the consistency ratio using the following formula

$$CR = \frac{C.I}{R.C.I} = \frac{0.034}{0.58} = 0.059$$

Because the value of consistency ratio is less than 0.1, the judgment is satisfactory and the results are acceptable.

Figure 4.26 displays 15x15 pair-wise comparison matrix among the criteria as obtained from the Expert Choice Software. The values that appear in black indicated that the criterion in the row is more important than the criterion in the column, while the values that appear in red designated that the criterion in the column is more important than the criterion in the row by a specified value. The results of the matrix are shown in figure 4.27 as obtained from the expert choice software.



	Contractor	Contractor	Contractor	Contractor	Contractor	Contractor	Operation a	Bid price	Contractor	Familiarity	Quality con	Past penalt	Familiarity	Complete b	Contractor
Contractor financial stability		1.02203	1.06594	2.54573	1.37048	4.34731	1.76575	1.76091	6.16389	3.83004	2.09775	1.00253	1.37963	3.14	2.44088
Contractor past performance			1.20685	1.71451	1.21662	2.92047	2.53166	2.06915	5.93087	3.95227	1.63231	1.18921	2.26797	3.75112	3.6536
Contractor technical experti				3.63139	1.96799	2.91756	2.02366	1.99607	5.42491	4.49512	2.07449	1.27987	2.4323	2.85466	2.28989
Contractor managerial capa					1.45422	1.5501	1.27987	3.48887	2.80018	2.15924	1.13622	1.70074	1.27209	6.96401	6.02734
Contractor current workload						2.48837	1.43014	2.24619	3.64076	3.83004	1.07246	1.41421	1.72596	5.52188	4.92404
Contractor safety records							1.3908	5.58935	2.05977	1.98701	1.64067	2.61774	1.32072	6.55993	6.32823
Operation and equipment re								3.9421	3.0274	1.68613	1.0081	1.8001	1.39571	6.44134	6.06759
Bid price									7.13959	7.13959	3.13208	1.81102	3.03977	2.37986	1.53918
Contractor home office locat										1.25103	2.01336	3.85327	2.85174	7.81649	8.16947
Familiarity of contractor witl											3.0615	3.4276	1.8221	8.08675	8.32841
Quality control system imple												1.04503	1.04027	5.53017	5.564
Past penalties on contractor													1.48774	3.4641	3.74728
Familiarity of owner with co														3.28643	3.88448
Complete bid documents sul															1.22284
Contractor classification	Incon: 0.01														

Figure 4.26: 15x15 Pair-wise comparison matrix

Figure 4.27: Importance of each criterion

4.3.4.1 Determining priorities

After completing the pair-wise comparisons, the relative weights for the criteria is determined, then the relative priorities for each criterion is identified and the results were synthesized in order to come up with the overall priority. Table 4-8 shows the rank and the priorities of each criterion combined from nine respondents to the questionnaire survey using the expert choice software. It is obvious that the most important five criteria considered for the selection of the construction contractors in descending order are: “the contractor submitted complete bid documents”, “the contractor classification”, “the bid price”, “the contractor technical expertise” and “the contractor financial stability”. Comparing to the analysis of section III of the questionnaire survey, these five criteria were determined as usually implemented during the construction contractor selection. The first three criteria (the contractor submit complete bid documents, the contractor

classification, and the bid price) constitute about 50% of the impact on the final decision of the construction contractor selection.

Table 4-8: Priority index and rank of criteria

Criteria	Priority index	Rank
Contractor financial stability	7.0%	5
Contractor past Performance (performance record)	6.4%	6
Contractor technical expertise	7.7%	4
Contractor managerial Capability	3.4%	11
Contractor current workload (Capacity)	4.8%	8
Contractor safety records	2.4%	13
Operation & equipment resources possess by contractor	3.2%	12
Bid price	11.5%	3
Contractor home office location	1.4%	15
Familiarity of contractor with geographical location of project	1.7%	14
Quality control system implemented by contractor	3.8%	9
Past penalties on contractor	5.6%	7
Familiarity of owner with contractor	3.7%	10
Contractor submitted complete bid documents including bonds, zakah clearance, financial offer, etc	19.7%	1
Contractor classification	17.7%	2

4.3.4.2 Consistency estimation

After calculating the relative priorities, the decision maker is invited to review their decision and make the necessary adjustment if the high inconsistency exists.

The expert choice software allows the decision maker to determine inconsistency directly after calculating priorities. Figure 4.27 displays the inconsistency value for the matrix analyzed, which is equal to 0.01. As the inconsistency value is less than 0.1, the results are acceptable.

4.4 DISCUSSION OF RESULTS

This section presents a discussion of results obtained from the questionnaire survey. Basically, the questionnaire was sent to the project management department of thirteen universities at Saudi Arabia, but nine respondents were received. The analysis of the respondents' characteristics indicated that all the respondents have a good experience and knowledge about the process of the selection of the construction contractor.

The results revealed that the open bidding system is the system which is implemented by the universities at Saudi Arabia during the selection of the construction contractor. This fact is compatible with Al-khalil and Al-Ghafly (1999) study, which pointed out that the public contracts are open for bidding. Other important findings from this research are that none of the universities carrying out a qualification before the contractors submitting their bids (prequalification). This is due to the commitment to the Saudi competition and procurement regulation system which stated that it is not permitted to determine a certain degree of classification, or qualification requirements on the applicants.

The research also shows that the most significant five parameters which are considered during the contractors' qualification are: "the contractor financial stability", "the

contractor experience", "the contractor quality performance", "the availability of manpower resources", and "the contractor current workload". One of the most observable aspects of the results is that most of respondents indicated that their universities use the same criteria to evaluate the construction contractors for all the projects. In addition to that, the findings present that the evaluation of the construction contractor data is the liability of the tendering department as illustrated in figure 4.16 where more than 44% of the respondents indicated that the tendering department has the responsibility to assess the information of the construction contractor.

However, one exciting fact is that the universities in awarding the contracts depend entirely on the lowest price as explained in figure 4.18, where more than 77% of the participants in the questionnaire specified that the final decision of their universities when selecting a construction contractor depends entirely on the lowest price. This fact is due to the commitment of the universities with Saudi competition and procurement regulation system which stipulated that when awarding a contract, it is recommended to select the bidder with the lowest price and who has the best technical capabilities. Other important results are that the final selection of the construction contractors at universities is the responsibility of the bid awarding committee as illustrated in figure 4.19, where the vast majority of the respondents, about 90%, signified that the final selection is one responsibility of the bid awarding committee.

The research detects that the respondents were not satisfied with the current bidding system due to the large problems derived from applying it, there is unanimously that the

current process used to award a contract will result in the selection of an inappropriate contractor because it depends on the lowest price which is not always the best choice. The results also display that the most important problems associated with the selection of the inappropriate contractor are the poor project performance and the delay in project completion time. This is due to the fact that the inappropriate construction contractor may resort to sacrifice the quality in order to maintain his profitability, which in turn results in the suspension of work or the reimplementation of work, and sometimes the owner may withdraw the project from the contractor who didn't comply with the conditions and the specifications of the contract. Therefore, the owner starts searching to find a new contractor to pursue the work, and this process requires a plenty of time which in turn leads to the delay in the project completion date.

The research findings also presented that the respondents identified that the advantages associated with the current selection process is accelerating the contract awarding process and confining the participation in the contract on the classified contractor. This finding is viewed to be acceptable because the universities depend in selecting the construction contractor on the lowest price, which don't require a plenty of time to analyze every bid, and at the same time don't deplete many resources in implementing this task. Therefore, the awarding process is performed quickly. At the same time, only the classified contractors should participate in the contract, thus any contractor submits the bid beyond his limit should be rejected directly.

However, one interesting feature in the results is that all the universities didn't implement any decision support system in the evaluation or the selection of the construction contractor.

Furthermore, this research assists in determining the most important criteria required to select the construction contractor, where the pair-wise comparison is conducted among the criteria. The most important five criteria considered for the selection of the construction contractors in descending order are: "the contractor submitted complete bid documents", "the contractor classification", "the bid price", "the contractor technical expertise" and "the contractor financial stability". The final decision of the construction contractor selection is largely impacted by the first three criteria (the contractor submits complete bid documents, the contractor classification, and the bid price). This is due to the fact that any contractor submits an incomplete bid should be rejected, also any contractor submits a bid beyond his limit should be rejected too, whereas according to the Saudi competition and procurement regulation system, it is recommended to award the contract to the bidder with the lowest price and who has the best technical capabilities.

CHAPTER 5

DEVELOPMENT OF AHP MODEL

5.1 INTRODUCTION

This chapter displays the process of developing a model for the selection of an appropriate construction contractor based on an analytical hierarchy process (AHP), illustrates a model operation, and validates the developed model.

5.2 EXPERT CHOICE SOFTWARE

In order to develop a model for the selection of the construction contractor, the software which is called the expert choice (EC) has been used for this job. This software analyzing data depends entirely on the analytical hierarchy process (AHP) that was discussed in details in this research in chapter two

The expert choice is used to conduct this study because it assists individuals and groups in the analysis, assessment, synthesis and facilitates the decision making process and provides a justification of the complicated decisions.

The developed model is used to assist the construction clients in selecting the most appropriate contractor from diverse alternatives and identified multi-criteria. The

proposed model can be implemented from any university at Saudi Arabia. Figure 5.1 displays the sequential steps required to establish the model.

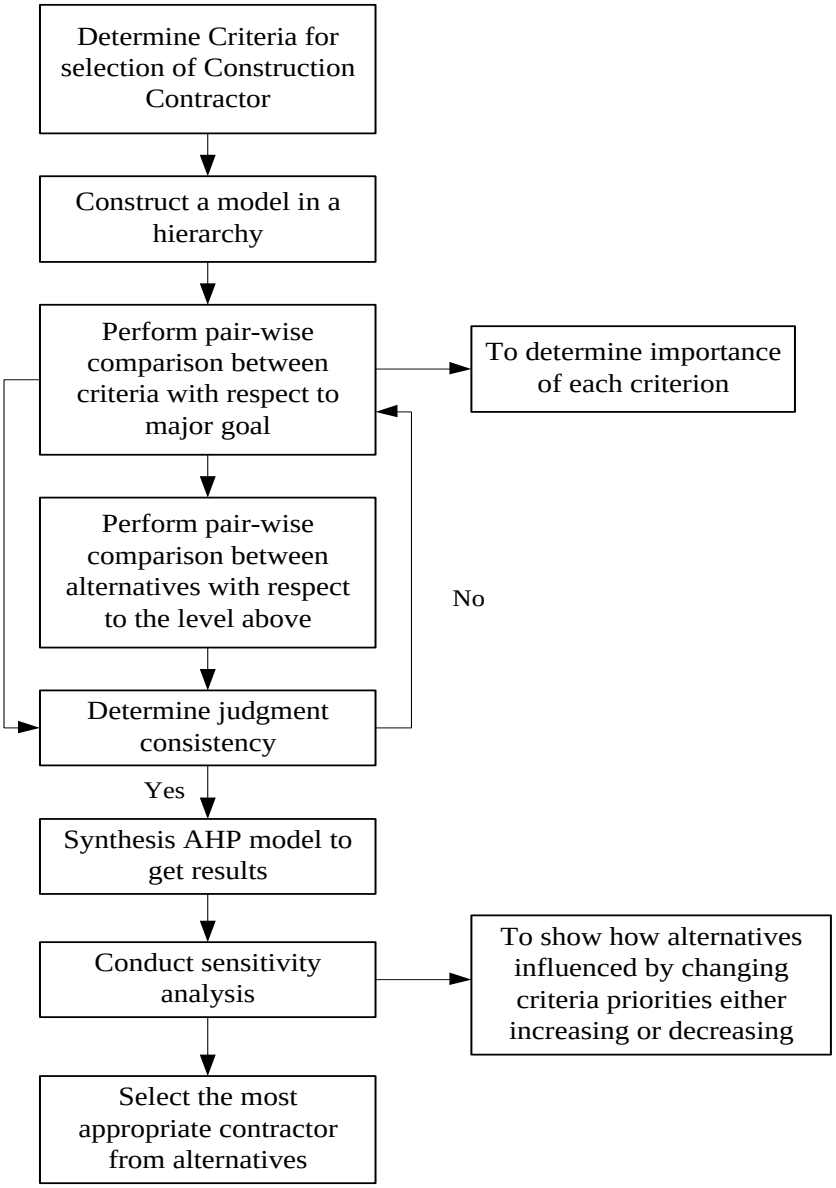


Figure 5.1: Sequential steps required for establishing proposed model

5.3 DEVELOPING PROPOSED MODEL

Six steps were required to develop the construction contractor selection model. These steps are explained and identified as follows:

5.3.1 Determine Criteria Impacted on Contractor Selection Decision

This step involves identifying all the criteria influenced on the selection of the most appropriate contractor. These criteria were determined from the analysis of section III of the questionnaire survey at chapter four. Fifteen factors were identified including the following: the contractor financial stability, the contractor past performance (performance record), the contractor technical expertise, the contractor managerial capability, the contractor current workload (capacity), the contractor safety records, the operation & the equipment resources possessed by the contractor ,the bid price, the contractor home office location, the familiarity of the contractor with the geographical location of the project, the quality control system implemented by the contractor, the contractor track record (the past penalties on the contractor), the familiarity of the owner with the contractor, the contractor submitted complete bid documents including bonds, zakah clearance, the financial offer, etc, and the contractor classification.

There is a consensus from all the respondents that the environmental management strategies adopted by the contractor to reduce the impact of the construction on the environment is never used as a criterion to evaluate the construction contractors, thus this criterion has not been considered when establishing the model.

5.3.2 Construct a Hierarchy

As displayed in figure 5.2, the second step in developing a model is constructing a problem in a hierarchy starting from the top level that represents the major goal of the study and moving down to the lowest level that represents the various alternatives from which one alternative will be selected to achieve the major goal.

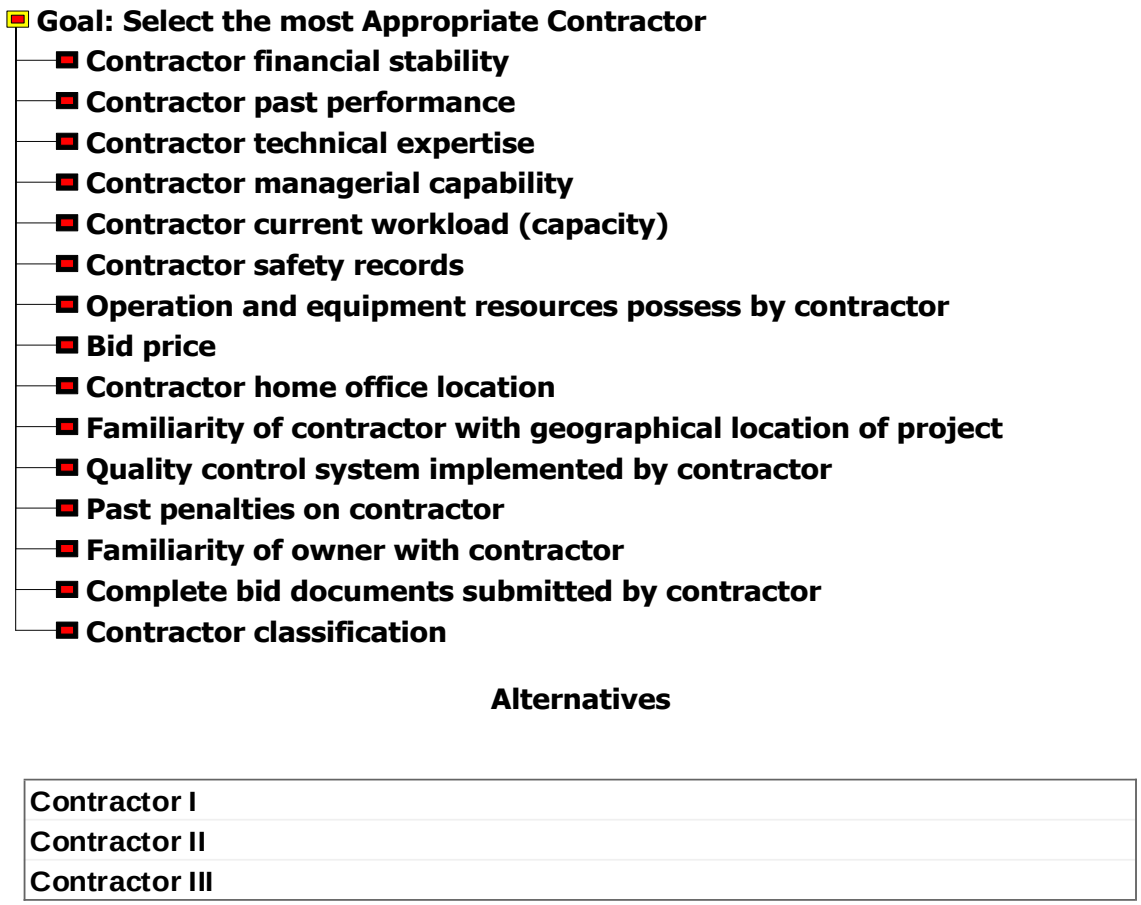


Figure 5.2: Hierarchy model established at Expert Choice

5.3.3 Perform Pair-Wise Comparison

Once the model is constructed, the decision maker is asked to perform a pair-wise comparison between the identified criteria with respect to the major goal .The pair-wise comparison is one of the major advantages of the expert choice software that assists in providing accurate ratio scale priorities because factors are located in pairs and comparisons were conducted between them without considering other factors. Figure 5.3 displays the pair-wise comparison matrix established at the expert choice software

As illustrated in figure 5.4, the judgments during the pair-wise comparison are recorded throughout each level in the hierarchy. Furthermore, figure 5.4 depicts the pair-wise comparison between two criteria “the contractor financial stability and the contractor technical expertise”, that the respondents assigned a rating of 1 which indicated that two criteria are equally important with respect to the major goal .The expert choice provides three ways to perform the pair-wise comparison namely: numerical judgments, verbal judgments, and graphical judgments (According to Expert Choice V 11 help). It is recommended to make the judgments from the “bottom up” because the importance of the criteria depends on the alternatives being considered. Therefore, first compare the alternatives with respect to each criterion, after that compare the criteria with respect to the major goal.

Figure 5.5 displays a pair-wise comparison between alternatives at level 3 with respect to the financial stability criterion at level 2.

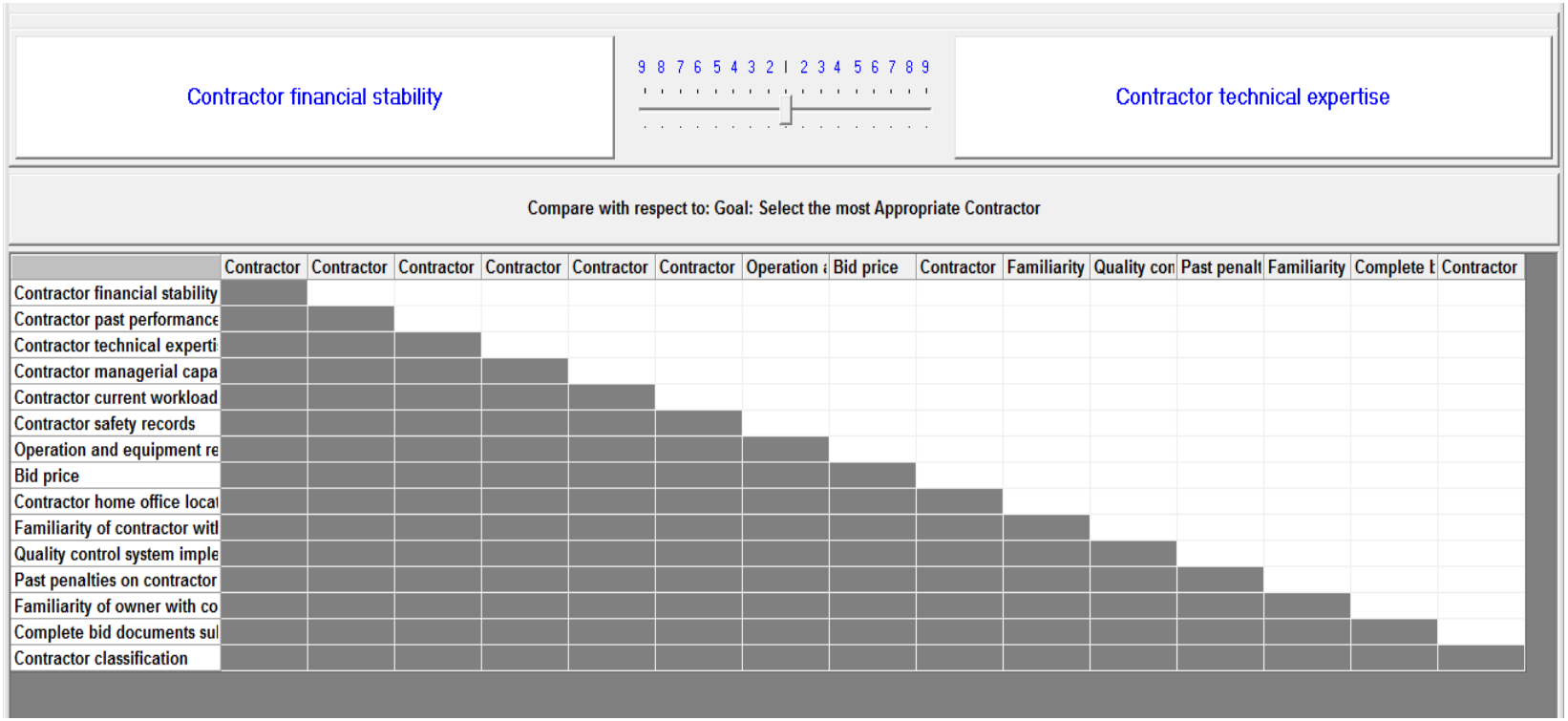
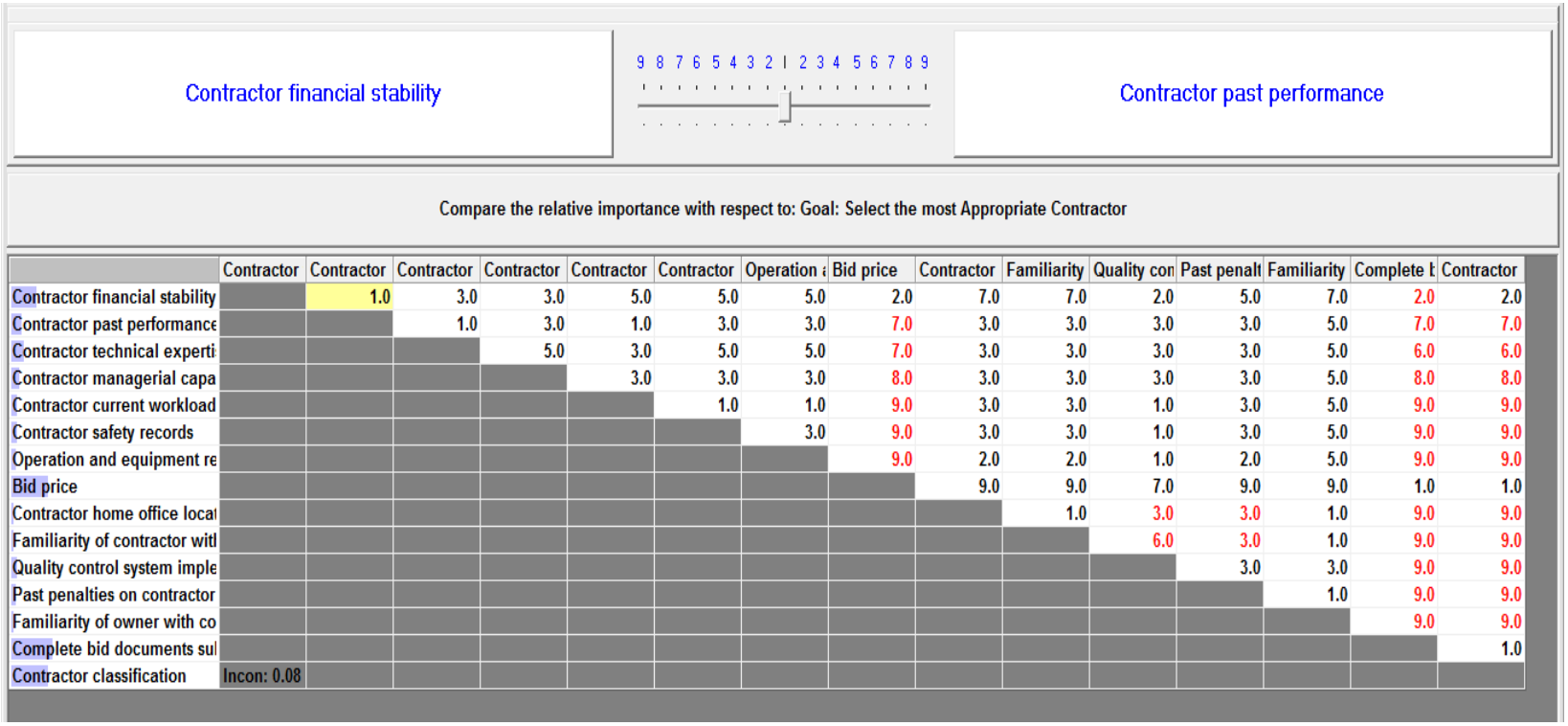


Figure 5.3: Numerical pair-wise comparison matrix established at Expert Choice



	Contractor	Contractor	Contractor	Contractor	Contractor	Contractor	Operation a	Bid price	Contractor	Familiarity	Quality con	Past penalt	Familiarity	Complete b	Contractor
Contractor financial stability		1.0	3.0	3.0	5.0	5.0	5.0	2.0	7.0	7.0	2.0	5.0	7.0	2.0	2.0
Contractor past performance			1.0	3.0	1.0	3.0	3.0	7.0	3.0	3.0	3.0	3.0	5.0	7.0	7.0
Contractor technical experti				5.0	3.0	5.0	5.0	7.0	3.0	3.0	3.0	3.0	5.0	6.0	6.0
Contractor managerial capa					3.0	3.0	3.0	8.0	3.0	3.0	3.0	3.0	5.0	8.0	8.0
Contractor current workload						1.0	1.0	9.0	3.0	3.0	1.0	3.0	5.0	9.0	9.0
Contractor safety records							3.0	9.0	3.0	3.0	1.0	3.0	5.0	9.0	9.0
Operation and equipment re								9.0	2.0	2.0	1.0	2.0	5.0	9.0	9.0
Bid price									9.0	9.0	7.0	9.0	9.0	1.0	1.0
Contractor home office locat										1.0	3.0	3.0	1.0	9.0	9.0
Familiarity of contractor witl											6.0	3.0	1.0	9.0	9.0
Quality control system imple												3.0	3.0	9.0	9.0
Past penalties on contractor													1.0	9.0	9.0
Familiarity of owner with co														9.0	9.0
Complete bid documents sul															1.0
Contractor classification	Incon: 0.08														

Figure 5.4: Numerical judgments between criteria at level 2 with respect to major goal at level 1 performed by one respondent

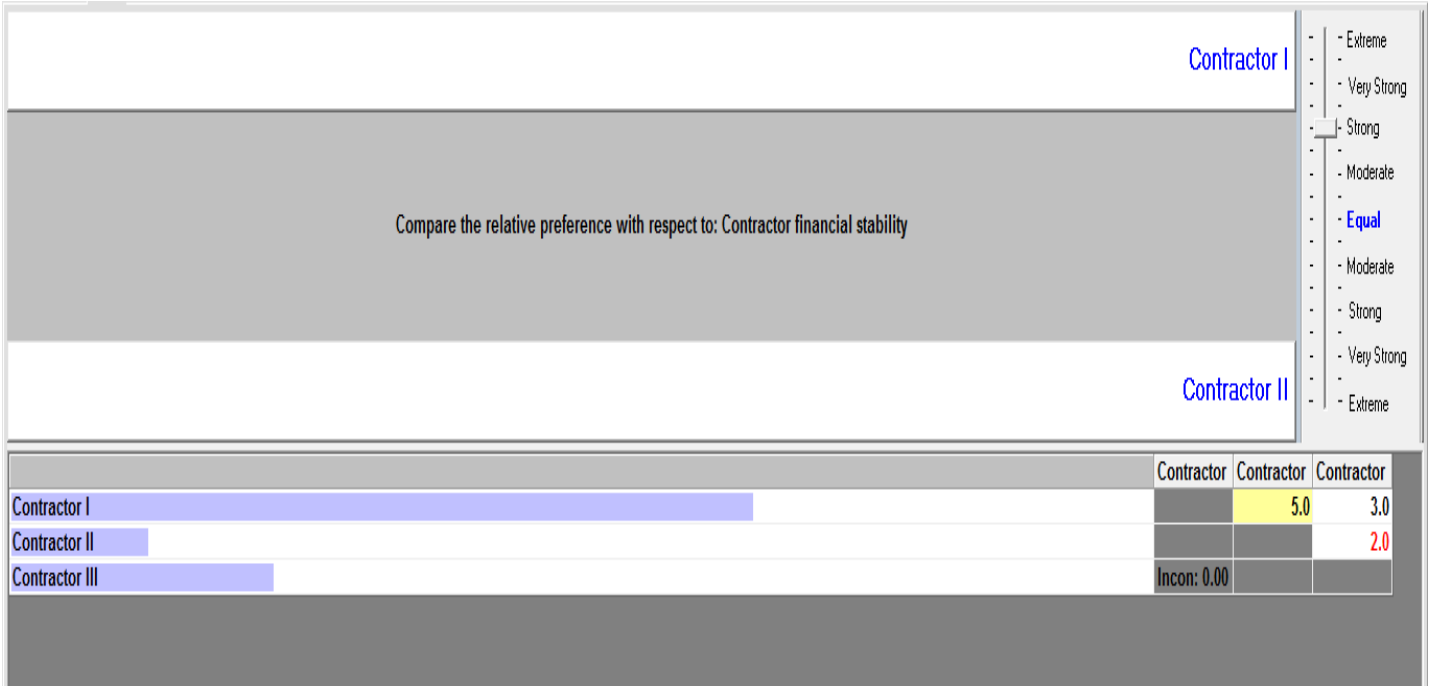


Figure 5.5: Verbal judgment between alternatives with respect to financial stability

5.3.4 Judgment Consistency

The objective of this step is to identify possible errors in the judgments and measure the logical inconsistency of the decision maker judgment. For example, if the decision maker believe that A is more significant than B and B is more significant than C and after that the decision maker states that C is more significant than A, then inconsistency exists in the judgment of the decision maker. Moreover, inconsistency can be considered when there are missing judgments.

The judgment can be considered reasonable if the consistency ratio is less than 0.1; otherwise, the decision maker judgment should be reviewed and revised. If inconsistency ratio is equal to zero, then the judgment can be considered as complete consistent.

Figure 5.4 displays that the inconsistency for this respondent is 0.08 which is less than 0.1; therefore this respondent has a consistent judgment, and the results are acceptable.

5.3.5 Synthesis AHP Model to Get Results

This step is very essential because it involves combining priorities throughout the hierarchy in order to obtain overall outcomes. After performing all the pair-wise comparisons for the entire model, the data are synthesized to get an overall preference. Moreover, synthesis includes transforming the local priorities of each part in the model into global priorities.

Synthesis also involves ranking the alternative with respect to the major goal, and displays how each alternative was appraised with respect to each criterion. Figures (from 5.6 to 5.20) display the priority index and the inconsistency measurement of different alternatives with respect to each criterion of fifteen identified criteria.

Figure 5.21 shows priorities of a different alternative (the construction contractors) with respect to the major goal. Figure 5.21 also illustrates that the priority index of contractor I is equal to 0.386, the priority index of contractor II which is 0.287, while contractor III has a weight of 0.327. The overall inconsistency is equal to 0.07. Therefore, contractor I is the best alternative that should be selected because it has the highest priority index score.

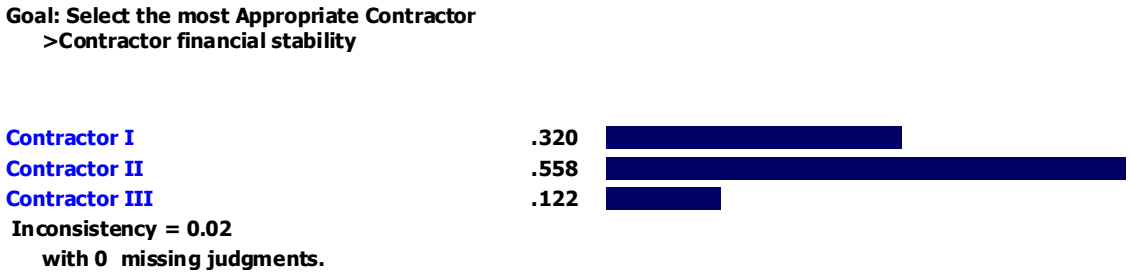


Figure 5.6: Alternatives overall priorities with respect to contractor financial stability

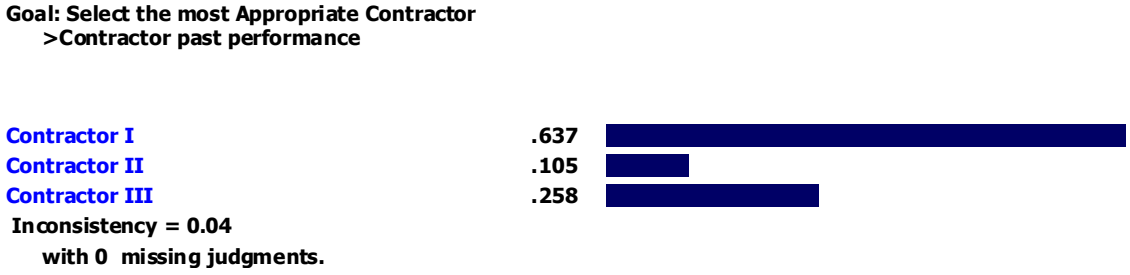


Figure 5.7: Alternatives overall priorities with respect to contractor past performance

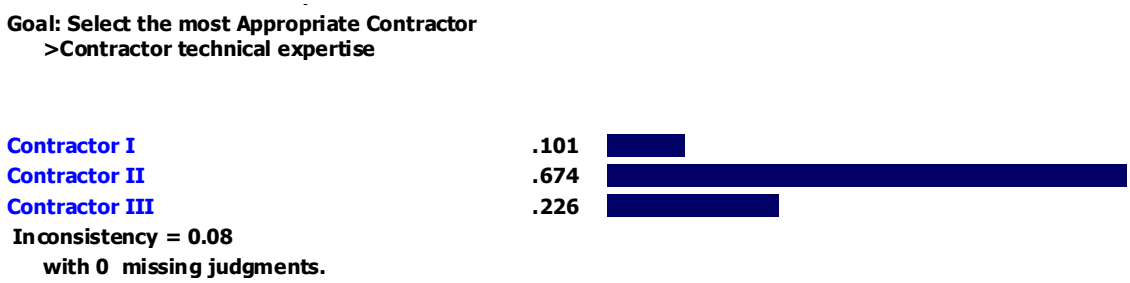


Figure 5.8: Alternatives overall priorities with respect to contractor technical expertise

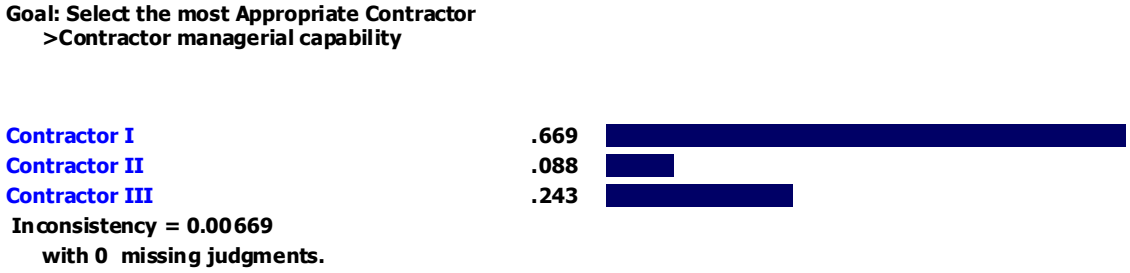


Figure 5.9: Alternatives overall priorities with respect to contractor managerial capability

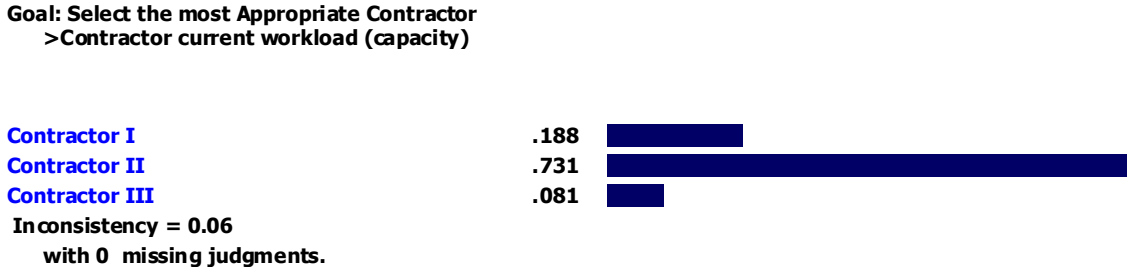


Figure 5.10: Alternatives overall priorities with respect to contractor current workload

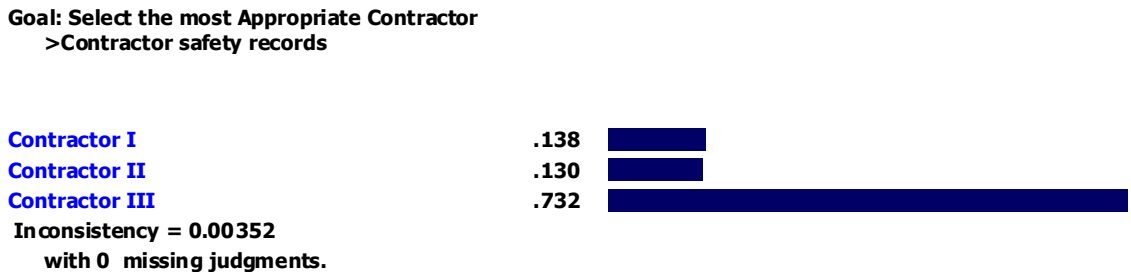


Figure 5.11: Alternatives overall priorities with respect to contractor safety records

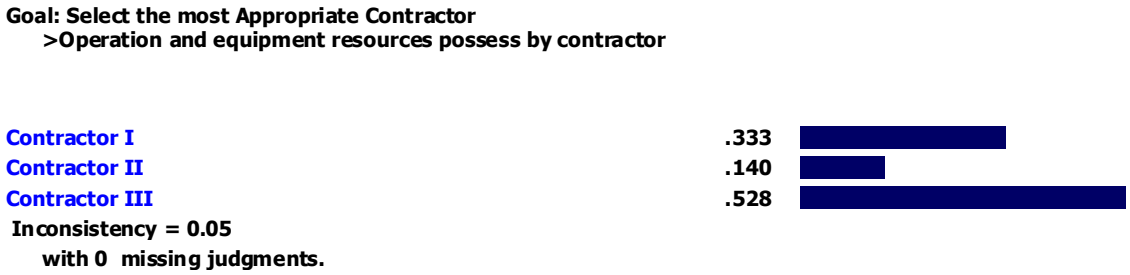


Figure 5.12: Alternatives overall priorities with respect to operation & equipment possess by contractor

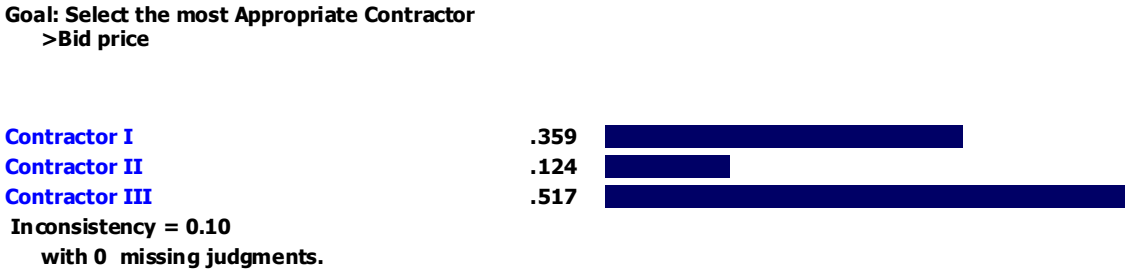


Figure 5.13: Alternatives overall priorities with respect to bid price

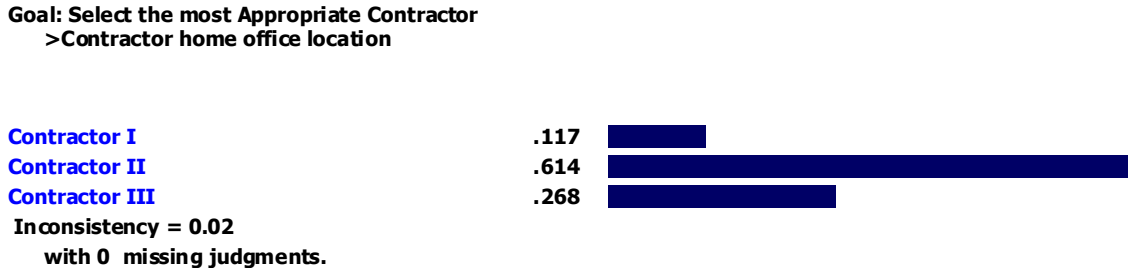


Figure 5.14: Alternatives overall priorities with respect to contractor home office location

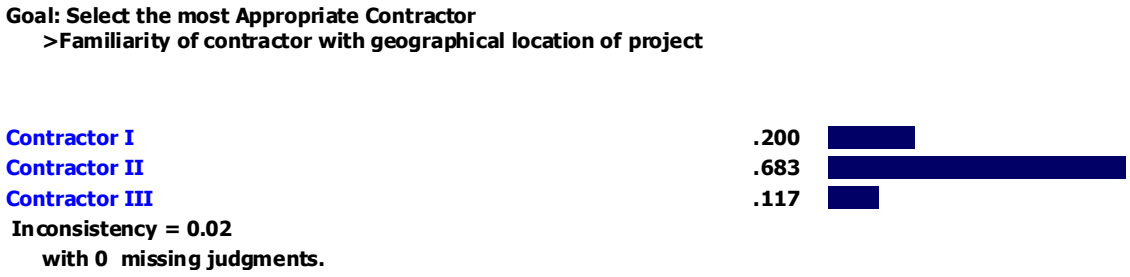


Figure 5.15: Alternatives overall priorities with respect to familiarity of contractor with geographical location of project

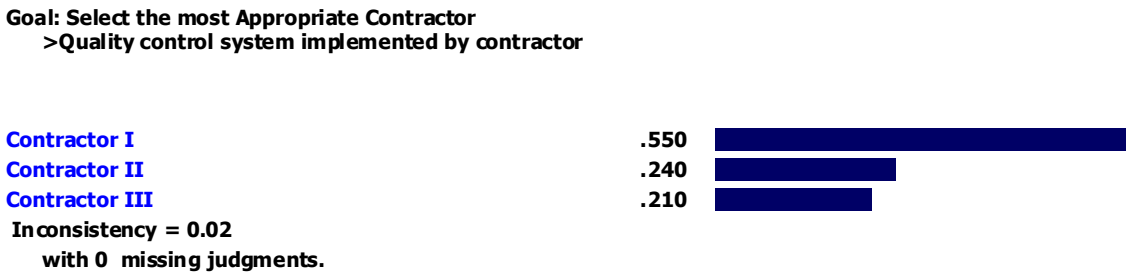


Figure 5.16: Alternatives overall priorities with respect to contractor quality control system

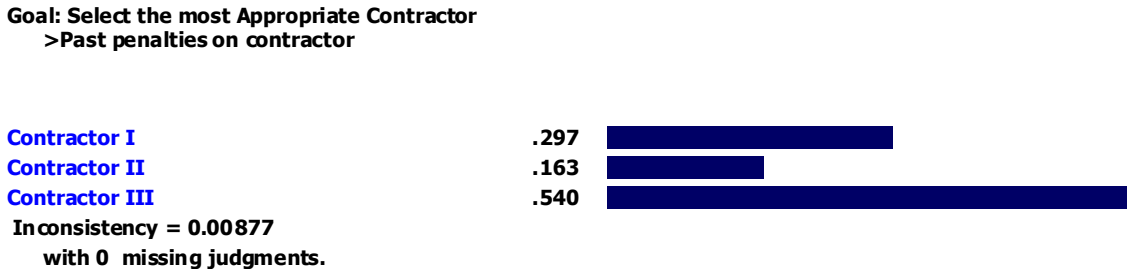


Figure 5.17: Alternatives overall priorities with respect to past penalties on contractor

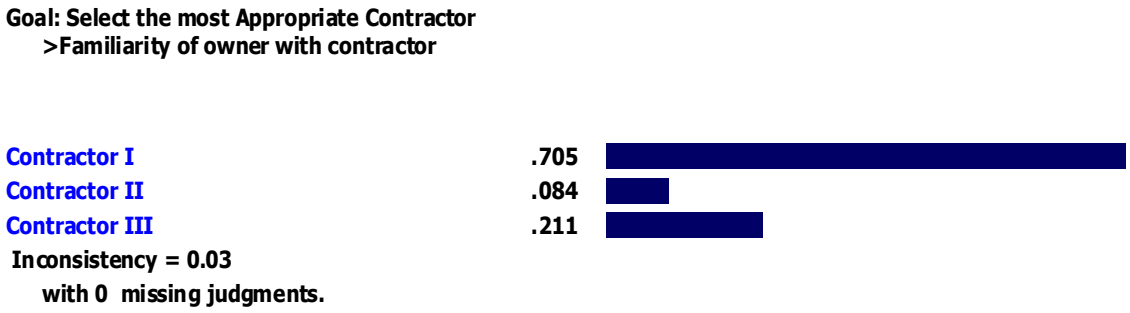


Figure 5.18: Alternatives overall priorities with respect to familiarity of owner with contractor

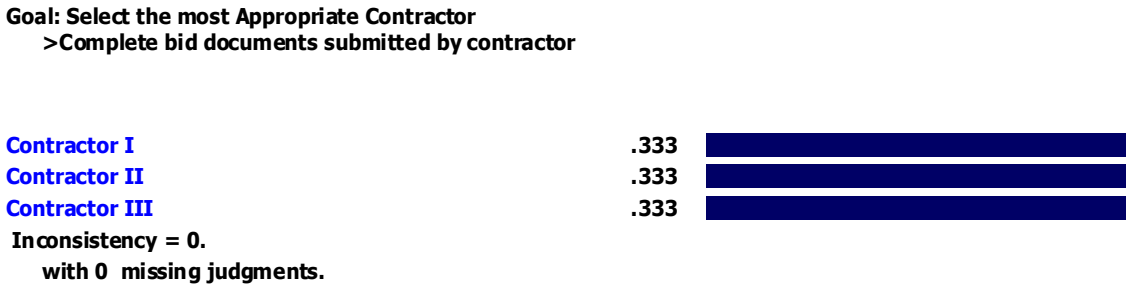


Figure 5.19: Alternatives overall priorities with respect to complete bid document submitted by contractor

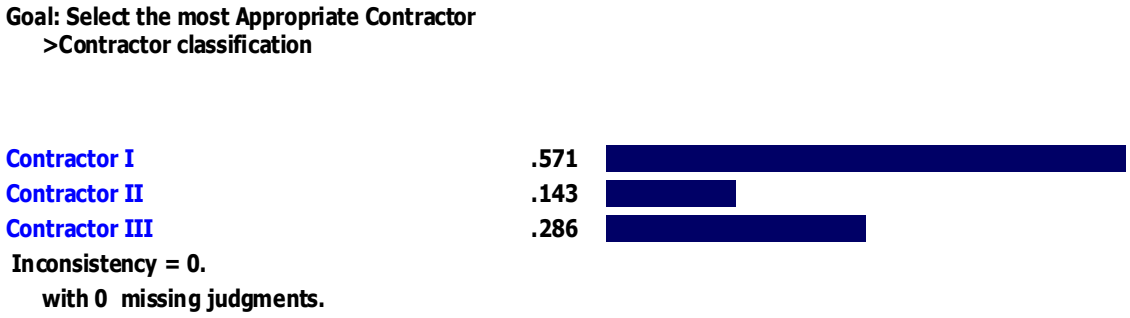


Figure 5.20: Alternatives overall priorities with respect to contractor classification

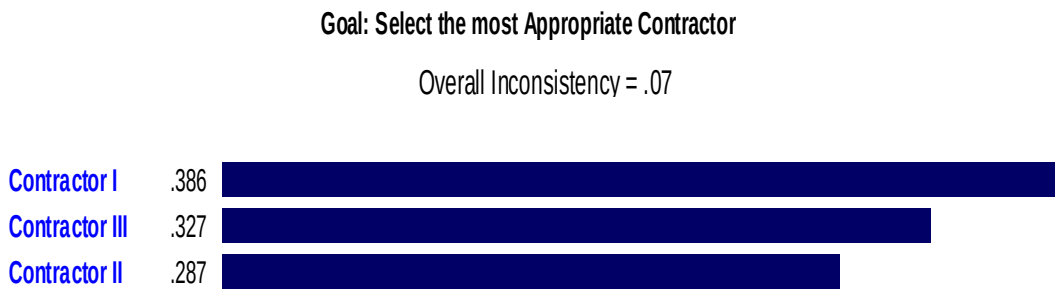


Figure 5.21: Overall priorities of different alternative with respect to major goal

5.3.6 Conduct Sensitivity Analysis

The sensitivity analysis shows the sensitivity of alternatives with respect to the major goal or with respect to the factors that are under the major goal when the model has more than three levels. To perform the sensitivity analysis, the priorities of the criteria are changed, either increasing or decreasing, and observe how these changes impact on the priorities of the alternatives.

The expert choice software provides five different types of sensitivity analysis namely: performance, dynamic, gradient, head to head, and two dimensional.

Each sensitivity analysis graph has its own characteristics and own unique menu commands that can be compared to what-if analysis because all the findings are temporary.

What-if analysis can be conducted with the sensitivity analysis to identify how an overall outcome would vary if the priorities of the criteria were altered.

5.3.6.1 Performance sensitivity

As depicted in figure 5.22, the performance sensitivity analysis displays how the alternatives were ranked relative to other alternatives with respect to each criterion or with respect to overall.

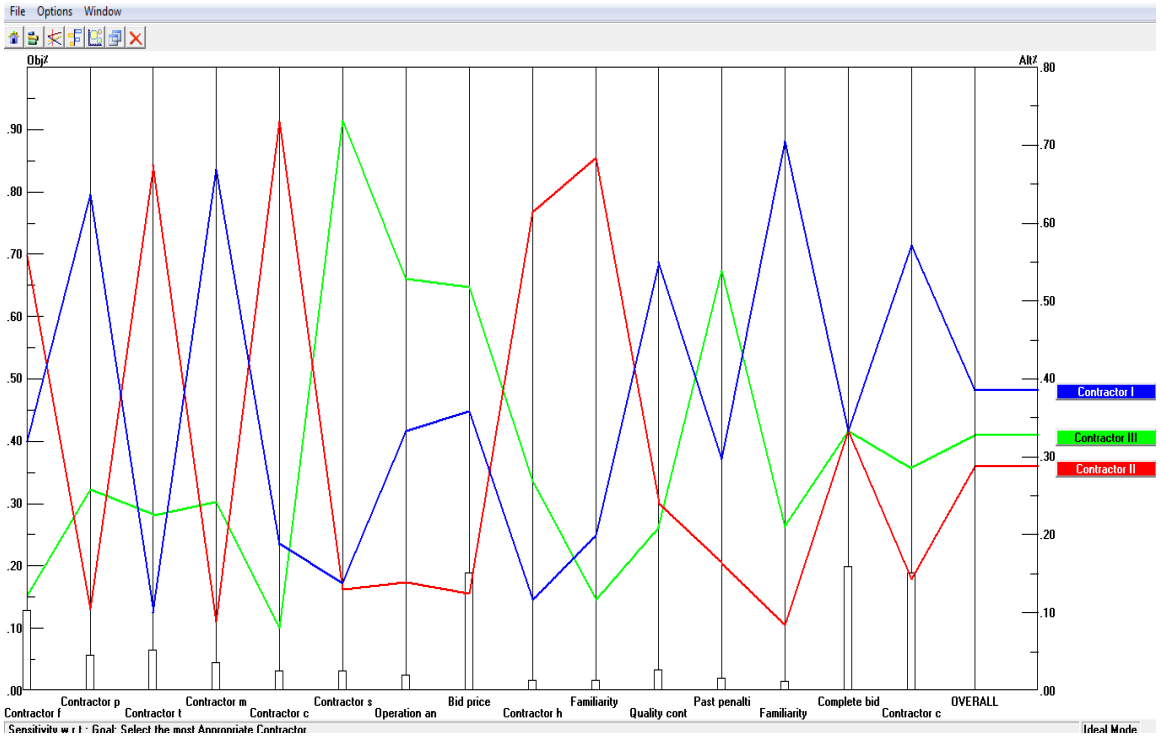


Figure 5.22: Performance sensitivity analysis

5.3.6.2 Dynamic sensitivity

As described in figure 5.23, the dynamic sensitivity analysis shows how the changing of the priority of the criteria impacts on the priorities of the various alternatives. If a decision maker believes that the weight given to that criterion required increasing or decreasing, the decision maker can be able to drag that the criterion bar to the right or the

left to change the criterion priority and observe the effect of the changes on the alternatives.

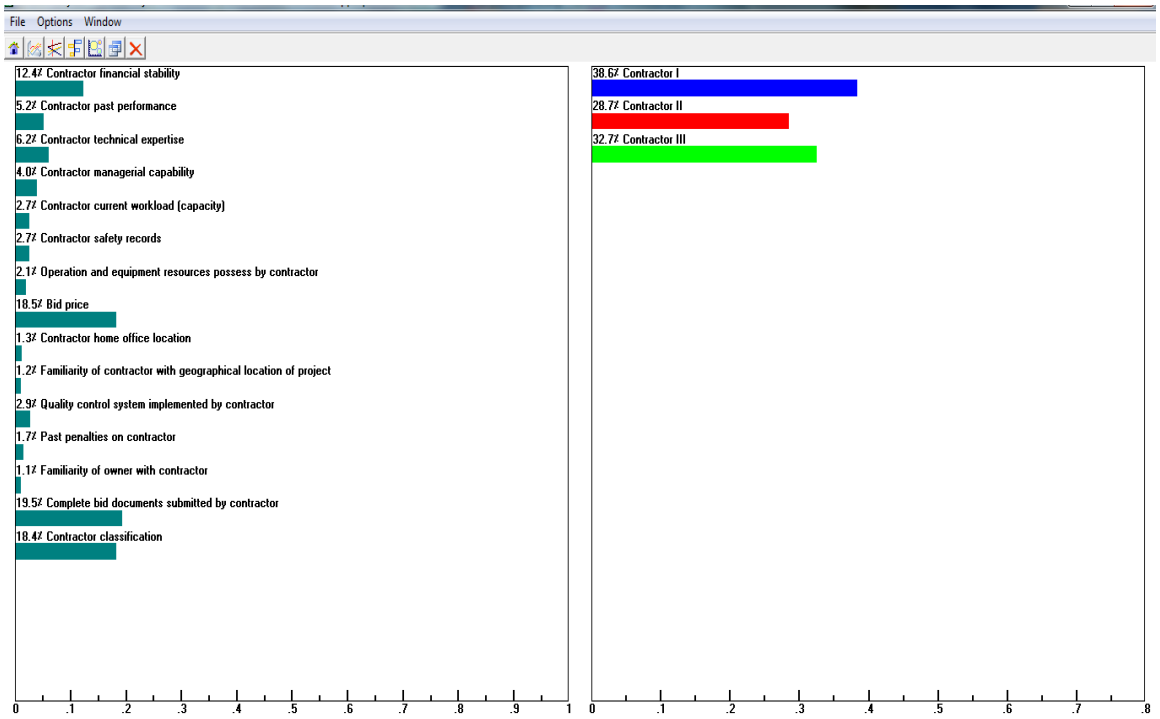


Figure 5.23: Dynamic sensitivity analysis

5.3.6.3 Gradient sensitivity

As illustrated in figure 5.24, the gradient sensitivity graph displays the priorities of the alternatives with respect to one criterion at a time. The criterion priority (the contractor financial stability) is indicated by a red vertical line.

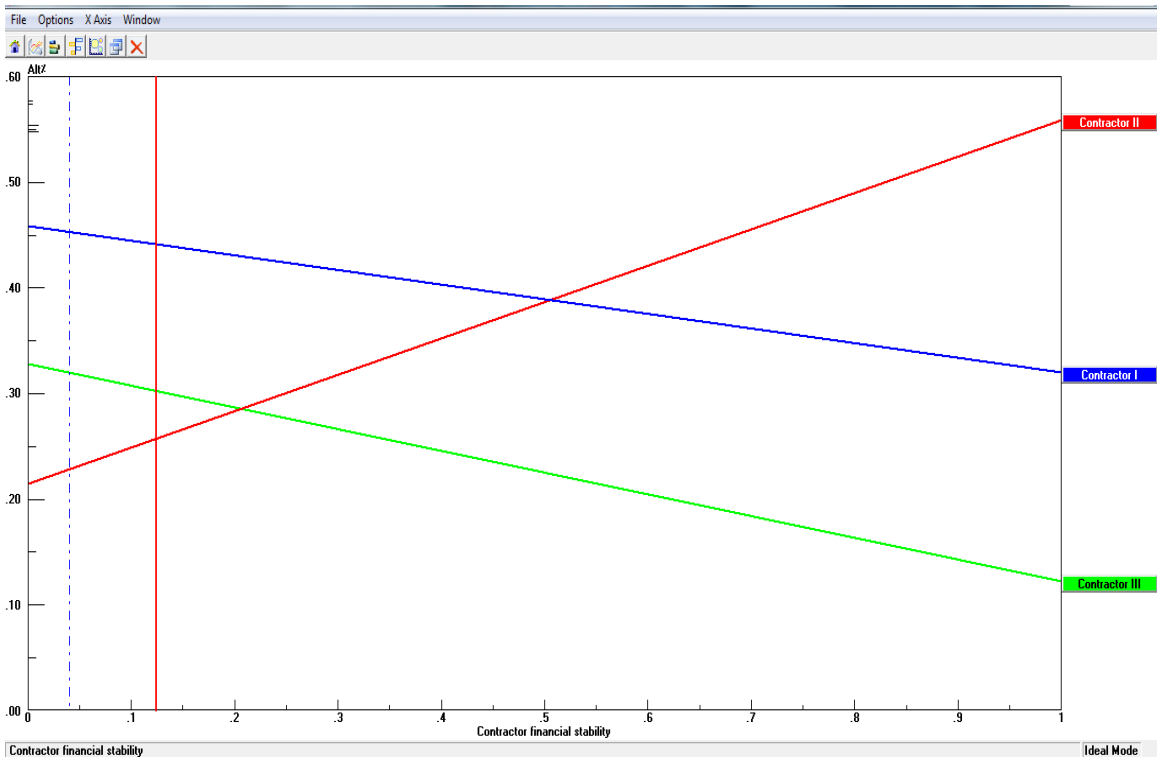


Figure 5.24: Gradient sensitivity analysis

5.3.6.4 Head to head sensitivity

The head to head sensitivity graph illustrates the priorities of two alternatives compared to one another with respect to each criterion as well as overall. One of the alternatives is displayed on the right side of the graph, whereas another alternative is placed on the left side. As shown in figure 5.25, if the right-hand alternative is more preferable compared with the left-hand, the horizontal bar will be presented towards the right and vice versa, whereas if the two options are equally preferred then no bar is appeared. Figure 5.25 also presents that contractor I is better than contractor II.

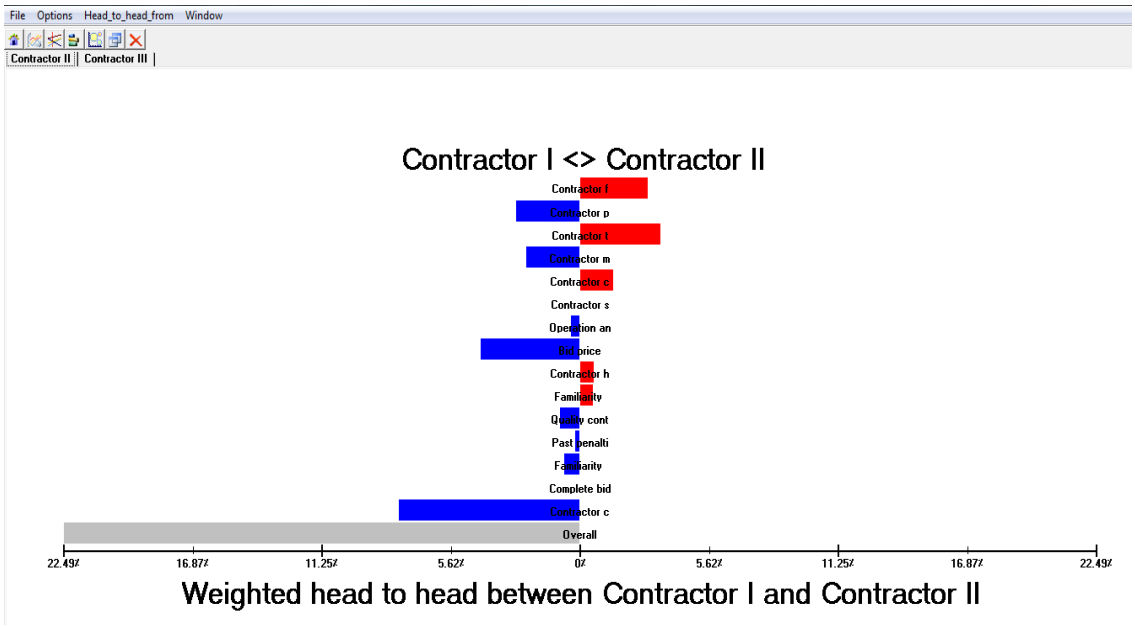


Figure 5.25: Head to head sensitivity graph

5.3.6.5 Two-dimensional sensitivity

As depicted in figure 5.26, the two-dimensional sensitivity graph displays the behavior of the alternatives with respect to any two criteria at a time. One of the criteria is located at the X-axis and the other criterion is located at Y-axis. The plot area is divided into four parts, and the alternatives are represented by a circle.

The alternative that appears in the upper right part is considered the most preferable alternative with respect to the criteria on the two axes (in this case contractor II), whereas the alternative in the lower left part is less favorable (in this case contractor III).

Furthermore, the alternatives appearing either in the lower right or upper left parts of the graph will designate that there is a conflict between the two selected criteria.

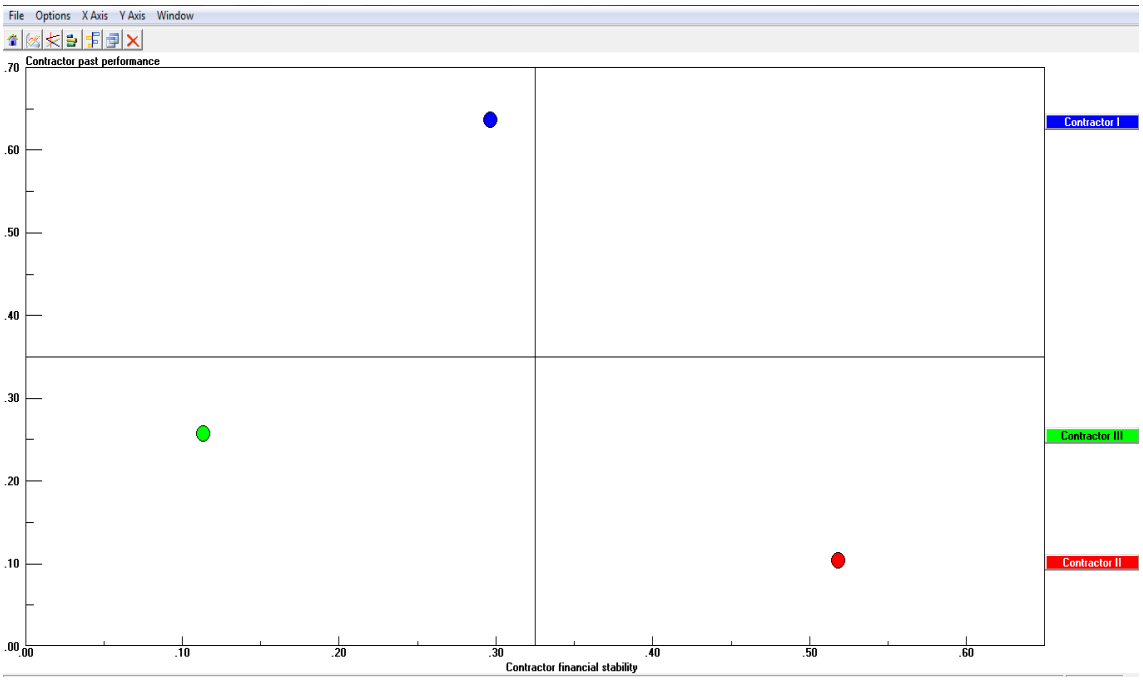


Figure 5.26: Two-dimensional sensitivity graph

5.3.7 Select Alternative with the Highest Priority Index

After obtaining the weights of all the criteria and the alternatives for the entire model, the alternative with the highest weight is the best choice for achieving the major goal. Contractor I had the priority index 38.6%, therefore, it is the best selected alternative. Figure 5.27 displays construction contractor selection model hierarchy with priorities.

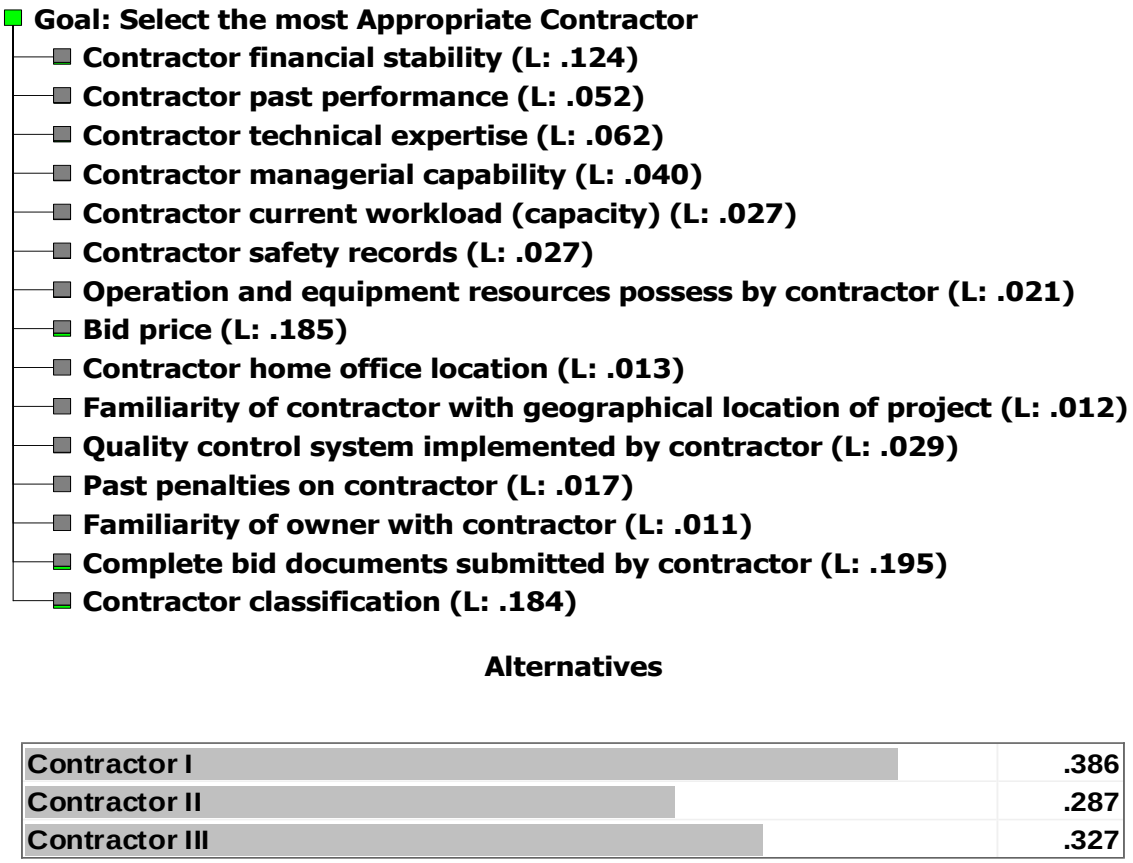


Figure 5.27: Construction contractor selection model with overall priorities

5.4 SUMMARY

This chapter has presented a proposed model for the selection of the construction contractor based on the analytical hierarchy process. The proposed model was established using the Expert Choice Software V 11 in order to avoid the cumbersome calculations, facilitate the decision making process, and provide the justification of the complicated decisions.

CHAPTER 6

CONCLUSION & RECOMMENDATIONS

6.1 INTRODUCTION

This chapter discusses a summary of the overall research, followed by a conclusion obtained from the research, then recommendations in order to enhance the construction contractor selection process at Saudi Arabia in general, and at universities in particular, and finally directions of the future researches.

6.2 SUMMARY OF THE RESEARCH AND FINDINGS

The selection of the construction contractor is one of the most difficult decisions that is performed by the construction clients because this decision is not simple, but it is a multi-criteria decision that required a lot of concentration and efforts to perform it. Therefore, this research aims to achieve three objectives; first: investigating the current practice for the selection of the construction contractor adopted by the universities at Saudi Arabia, secondly: determining the criteria that shall be considered in the selection, thirdly: assisting the construction clients in coming up with the most proper construction contractor using one of the decision support systems called the analytical hierarchy process.

This research consists of six chapters. The followings are summary of these chapters:

1. Chapter one (introduction) includes an introduction on the study, the objective of study, the reason why this study will be performed, the scope and the limitation of the research, and the significance of the study.
2. Chapter Two (literature review) involves information about the bidding process, the criteria for the contractor selection, the different methodologies employed for the selection, the general information about the analytical hierarchy process (AHP) and its procedures for the implementation.
3. Chapter Three (Research methodology) describes how the objectives of the study will be acquired.
4. Chapter Four (Data analysis and results) involves an analysis of the questionnaire survey received from nine universities out of thirteen which the questionnaire was sent to, and displays the findings of the research.
5. Chapter Five (Development of AHP model) involves the development of the theoretical model for the selection of the construction contractor using the expert choice software which in turn depends entirely on the analytical hierarchy process. This model assists in deriving the prioritization of the different criteria considered in the selection.

The methodology adopted to achieve the objectives of this research consists of three main steps. First, the extensive literature reviews were performed, then the questionnaire survey was developed and administered to thirteen universities at Saudi Arabia (a total of

nine out of thirteen were received), and finally a theoretical model was developed and validated.

The results related to the first objective of the research indicated that the open bidding system is the most widely implemented by the universities at Saudi Arabia during the selection of the construction contractor. Another notable finding indicated that none of the universities carrying out qualification before the contractors submitting their bids (prequalification). However, one exciting result displayed that most of the universities in awarding contracts depend entirely on the lowest price. Moreover, there is unanimously from all the respondents that the current process used to award a contract will result in the selection of an inappropriate contractor. The results also presented that the knowledge and the experience of the project management department at the universities in the decision support system are very limited. Therefore, all the universities don't implement any decision support system in the evaluation or the selection of the construction contractor.

The findings related to objective two of the study display that fifteen criteria were determined and considered in the selection. The relative importance of each criterion was determined through conducting a pair-wise comparison.

The third objective of the research was achieved through using the data acquired from the questionnaire survey as an input to the proposed model. The developed model based

entirely on the analytical hierarchy process (AHP), and the expert choice software was used to establish that model.

6.3 CONCLUSION

The conclusions of this research can be summarized as follows:

- Most universities depend entirely on the lowest price when awarding contracts in order to comply with the Saudi Competition and Procurement Regulation System.
- The respondents are not satisfied with the current bidding system due to the large problems derived from its application. The current process used to award the contract results in selecting inappropriate contractors which in turn results in the poor project performance and the delay in the project completion time. But the respondents indicated that the sole advantage associated with the current selection process is accelerating the contract awarding process and confining participation in the contract on the classified contractor.
- One interesting feature in the results obtained is that none of the project management department at universities implemented any decision support system in the evaluation or the selection of the construction contractor.
- The most important five criteria considered for the selection of contractors, in descending order, are: “the contractor submitted complete bid documents”, “the contractor classification”, “the bid price”, “the contractor technical expertise” and “the contractor financial stability”.

- “The contractor submitted complete bid documents”, “the contractor classification”, and “the bid price” constitute about 50% of the impact on the final decision of the decision maker of the construction contractor selection.
- The developed model that is based on the analytical hierarchy process (AHP) improves the selection process; whereas instead of using one criterion (the lowest price) to select the construction contractor, other fifteen criteria were determined. The proposed model can be easily used by any universities, and at the same time the model had all the capabilities to assess the criteria that influence on the construction contractor selection. In addition to that, the proposed model shows how the alternatives impact through changing the priorities of the criteria.

6.4 RECOMMENDATIONS

In order to enhance the selection of the construction contractor process at Saudi Arabia, the following recommendations should be considered:

- It is recommended for the construction clients to use the proposed model where there are fifteen criteria considered in the selection instead of one criterion.

  Flexibility is one excellent feature that exists in the proposed model because each construction client can input his own data to the model and the proposed model will give him the priorities of the different criteria as well as the alternatives based in his evaluation.
- It is recommended to support the bid awarding committee and give them a plenty of time to analyze each bid carefully.

- It is recommended to make the convergence in views among the persons who called that the financial proposal of the bid is a more important criterion for the evaluation and with those who called for the use of the multiple criteria in the evaluation and the selection of the construction contractor.
- It is recommended to give the bid evaluators training courses in the evaluation and the selection of the construction contractors in order to refine their capabilities.
- The existence of the cost engineer at “the bid inspection committee” or “the bid awarding committee” is advised due to his capability in analyzing the prices of each item in the bid.
- It is recommended to create a data base among the universities that involves a list of the contractors who previously dealt with by any university, and it involves information about each one of them.

6.5 DIRECTIONS OF FUTURE RESEARCHES

For conducting a further research, it is advisable to make the same study and enlarge the sample size to involve both public and private sectors at Saudi Arabia due to the fact that the process adopted by the private sector may differ from that used by the public and the conduct comparison between two sectors. Another direction for the future researches is implementing a different decision support model, and performing comparisons between that model and the results of this model. Another recommendation for the future research is to improve the proposed model by expanding the current model beyond three levels through identifying the sub-criteria which support the main criteria.

REFERENCES

1. Alarcon, L & Mourgues, C 2002,'Performance Modeling for Contractor Selection', *Journal of Management in Engineering, vol*. 18, no. 2

2. Al-Busaad, S 1997,'Assessement of Application of Life Cycle Cost on Construction Projects', Master thesis presented to King Fahd University of Petroleum and Minerals (KFUPM), Dhahran, Saudi Arabia

3. Al-dughaither, K 2006,'A Multi-Criteria Decision Making Model for Contractors Prequalification', *Joint International Conference on Computing and Decision Making in Civil and Building Engineering*, Montreal, Canada

4. Al-Gobali, K 1994, 'Factors considered in Contractor Prequalification Process in Saudi Arabia', Thesis presented to the King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia in partial fulfillment for the degree of Master of Science.

5. Al-Harbi, K 2001**,**'Application of the AHP in project management', *International Journal of Project Management*. vol. 19, PP 19–27.

6. Al-Hazmi, M 1987,'Causes of Delay in Large Building Construction Projects', Master thesis presented to King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia

7. Al-Hazmi, T & Caffer, R 2000,'Project Procurement System Selection Model', *Journal of Construction Engineering & Management*, vol. 126, no. 3, PP 176-184.

8. Al-Subaiei, M 2001,'Project Delivery Methods Selection Model: AHP Approach', *Master of Engineering Report*, King Fahd University of Petroleum and Minerals.

9. Aitah, R 1988,'Performance Study of the Lowest Bidder Bid Awarding System in Government Project- Saudi Arabia', Master thesis presented to King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia

10. Al-Khalil, M & Al-Ghafly, M 1999,'Delay in Public utility projects in Saudi Arabia', *International Journal of Project Management*, vol. 20, PP 469-474

11. Al-Khalil, M 2002,'Selecting the Appropriate Project Delivery Method Using AHP', *International Journal of Project Management*, vol. 17, no. 2

12. Alsugair, A 1999,'Framework for Evaluation Bids of Construction Contractors', *Journal of Management in Engineering*, vol. 15, no. 2

13. Anagnostopoulos, K & Vavatsikos, A 2006,'An AHP Model For Construction Contractor Prequalification', *Operational Research. An International Journal*, vol. 6, no. 3

14. Assaf, S & Jannadi, M 1994,'A multi-criterion decision-making model for contractor prequalification selection', *Journal of Building Research and Information*, vol. 22, no. 6

15. Assaf, S & Al-Shehri, A 2001,'Contractor Prequalification', Ms of Engineering Report presented to King Fahed University of Petroleum and Minerals

16. Banaitiene, N & Banaitis, A 2006,'Analysis of Criteria for Contractors' Qualification Evaluation', *Technological and Economic Development of Economy*, vol. XII, no. 4

17. Bubshait, A & Al-Gobali, K 1995,'Factors Considered in Contractor Prequalification in Saudi Arabia', *Fourth Saudi engineering conference*, vol. 1

18. Clough, R & Sears, G 1994,'Construction Contracting', *John Wiley & Sons Inc*. New York.

19. Efni, U 2004, 'Subcontractor Selection Using Fuzzy Logic. Theory', UTM. Master Program.

20. El Wardani, M & Messner, J & Horman, M 2006,'Comparing procurement methods for design-build projects Factors Considered in Contractor Prequalification in Saudi Arabia', *J. Constr. Eng. Manage.*, vol.132, no. 3, PP 230–238.

21. Fatani, M 1985,'Construction Supervision: Past Experience', *Second Saudi Engineers Conference*, vol.5, University of Petroleum, Dhahran, Saudi Arabia, PP 2855–2878.

22. Fishburn, P 1967,'Additive Utilities with Incomplete Product Set: Applications to Priorities and Assignments', *Operations Research Society of America (ORSA),* Baltimore, MD, USA.

23. Fong, P & Choi S 2000,'Final contractor Selection Using the Analytical Hierarchy Process', Construction *Management and Economics*. vol. 18, no. 5, PP 547-557

24. Fuller, R & Carlsson, C 1996,'Fuzzy Multiple Criteria Decision Making: Recent Developments', Fuzzy Sets and Systems, vol. 78, PP 139-153.

25. Goicoechea, A & Hansen, D & Duckstein, L 1982,'Multi objective decision analysis with engineering and business applications', John Wiley & Sons, New York, NY.

26. Hastak, M 1998,'Advanced Automation or Conventional Construction Process', *Automation in Construction*, PP 299-314

27. Hatush, Z & Skitmore, M (1997),'Criteria for Contractor Selection', *Journal of Construction Management and Economics*, vol. 15, no.1, PP 19-38.

28. Herath, G & Prato, T 2006,'Using Multi-criteria Decision Analysis in Natural Resource Management: Empirical Applications', *Ashgate Publications Limited*.

29. Holt, G & Olomaiye, P & Harris, F 1995,'A review of contractor selection practice in the U.K. construction industry', *Build Environ*, vol. 30, no. 4, PP 553–561.

30. Holt, G 1998,'Which contractor Selection Methodology', *International Journal of Project Management*, vol. 16, PP 153-164.

31. Huang, X 2011,'An Analysis of the Selection of Project Contractor in the Construction Management Process', *International Journal of Business and Management*, vol. 6, no. 3

32. http://news.gulfjobsmarket.com/saudi-development-plan-approval-sets-385-billion-in-motion-7861600-news

33. Jack, M & Samual, M 1989, *Journal of Project Management*, Wiley John and Son Publications.

34. Kometa, S & Olomolaiye, P 1997,'Evaluation of Factors Influencing Construction Client Decision to build', *Journal of Management Engineering*, vol. 13, PP 77-86

35. Manideepak, G & Bhatla, A & Pradhan, B 2009,'Methodologies for Contractor Selection in Construction Industry', ACSGE, BITS Pilani, India

36. Manoharan, R 2005,'Subcontractor Selection Method Using Analytical Hierarchy Process', M sc. Thesis presented to University of Technology, Malaysia

37. Ministry of Finance and National Economy, https://mol.gov.sa

38. Ng, S & Skitmore, R 1999, 'Client and Consultant Perspective of Pre-qualification Criteria', *Journal Building and Environment*, vol. 34, PP 607-621

39. Park, S 2009,'whole Life Costing Bid Evaluation for Design-Build in Korea', Ph. D Thesis presented to University of Reading.

40. Park, S 2009,'Whole Life Performance Assessment: Critical success Factors', *Journal of Construction Engineering and Management*, vol. 135, no. 11

41. Palaneswaran, E & Kumaraswamy, M 1999,'Contractor Selection for Design/Build Project', *Journal of Construction Engineering and Management*, PP 331-339.

42. Ravindran, A 2007,'Operations Research and Management Science Handbook', *CRC Publications.*

43. Russell, J 1990,'Model for owner prequalification of contractors', *Journal of Management in Engineering*, ASCE, vol.6, no. 1, PP 59–75.

44. Russell, J 1996,'Constructor Prequalification - Choosing the Best Constructor and Avoiding Constructor Failure', *New York, NY: ASCE Press*

45. Russell, J 1991,'Contractor Failure: Analysis', *Journal of Performance of Constructed Facilities*, ASCE, vol. 5, no. 3, PP 163-180.

46. Russell, J & Skibniewski, M 1988, 'Decision Criteria in Contractor Prequalification', *Journal of Management in Engineering*, vol. 4, no. 2, PP148-164.

47. Saaty, T.L 1980,'The Analytic Hierarchy Process', McGraw-Hill, New- York

48. Saaty, T.L 1985,'Decision making for leaders. Belmont', California, Life Time Leaning Publications

49. Saaty, T.L 1990,'How to make a decision: the analytic hierarchy process', *European Journal of Operational Research*, North-Holland, vol.48, PP 9-26

50. Saaty, T.L & Kearns, KP 1991,'Analytical planning: the organization of systems', The analytic hierarchy process series, *RWS Publications Pittsburgh, USA*, vol.4

51. Saaty, T.L 1994a,'Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process', *Rws Publications, Pittsburgh, PA*.

52. Structuresnw.com. (May, 2011), "*Building Design and Construction Process"* http://www.structuresnw.com/Library/articles/Building%20Design%20Process.pdf

53. Tarawneh, S 2004,'Evaluation of Pre-qualification Criteria: Client Perspective; Jordan Case Study', *Journal of Applied Sciences*, vol. 4, no. 3

54. Triantaphyllou, E 2000,'Multi-Criteria Decision Making Methods: A Comparative Study', *Kluwer Academic Publications*.

55. Trivedi, M & Pandey, M & Bhadoria, S 2011,'Prequalification of Construction Contractor Using a FAHP', *International Journal of Computer Applications*, vol. 28, no. 10

56. Waara, F & Brochner, J 2006,'Price and Nonprice Criteria for Contractor Selection', *Journal of Construction Engineering and Management*, vol. 132, no. 8

57. Watt, D & Kayis, B& Willey, K 2010,'The Relative Importance of Tender Evaluation and Contractor Selection Criteria', *International Journal of Project Management*, vol. 28, no. 1

58. Zeleny, M 1982,'Multiple Criteria Decision Making', *McGraw-Hill Series in Quantitative Methods for Management*, McGraw-Hill New York

APPENDIX – A (QUESTIONNAIRE SERVEY)

King Fahd University of Petroleum and Minerals
College of Environmental Design
Construction Engineering & Management Department

Dear Sir,

<u>Subject:</u> Study on multi-criteria decision making model for the selection of construction contractor in Saudi Arabia

The study is being performed on the evaluation and selection process of construction contractor in Saudi Arabia. The major purposes of the researcher are to understand the current contractor selection approach implemented in Saudi Arabia, determine the criteria which shall be considered when selecting contractor in Saudi Arabia, verify if the client organization is employed any decision support system during selection process, and develop efficient multi criteria selection model based on Analytical Hierarchy Process (AHP).

At the end of this researchو it is expected that the results acquired will facilitate the contractor selection process that is carried out by construction client.

The questionnaire consists of four sections. Each section aims to gather different information from the respondents as follows:

a. Section I: general information about the respondents.
b. Section II: tendering system and selection process adopted by the client organization.
c. Section III: criteria and sub-criteria used for evaluation.
d. Section IV: pair-wise comparison between criteria to determine the relative importance for each criterion compared with others.

Please, when answering the questions, put tick (✓) on the appropriate space and leave other spaces blank. Some questions require you to write your answer in the space provided if possible.

I will appreciate your assistance in filling this questionnaire. Please be assured that the data will be maintaining confidential and will be applied only for educational purposes.

Kindly, after filling this questionnaire return it to the following address:

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Section I: Respondents' Characteristics

This section contains questions seeking general information about the organization and the person who fills this questionnaire. You are kindly requested to provide the requested information either by writing in the spaces allocated for your answer or by placing tick (✓) in the boxes next to the answers.

1. Respondent Information

Name (Optional)	
Telephone no (Optional)	
Facsimile (Optional)	
E-Mail Address (Optional)	

2. What is your level of education?

Bachelor degree		Master degree	
PhD			
Others, please specify			

3. What is your job title?

Civil engineer		Project manager	
Architect		Cost manager	
General manager		Director	
Others, please specify			

4. What is your role during the selection or prequalification of a construction contractor?

Decision maker		Advisory	
Assessment			
Others, please specify			

5. How long have you been providing services in tendering process?

Less than 5 years		5-10 years	
10-20 years		More than 20 years	

6. How many bids have you participated in the evaluation of contractors over the last five years?

1 to 5		11 to 15	
6 to 10		More than 15	

Section II: Tendering Process

This section contains questions seeking information on the current practices which your organization is following in selecting contractors for executing its projects.

1. How do you describe the bidding system which is usually employed by your organization?

Open bidding		Negotiated bidding	
Close bidding			
Others, please specify			

2. When do you qualify contractors?

a	Before submitting their bids (Prequalification)	
b	After submitting their bids (Post qualification)	
c	Periodically qualification (Contractors' qualified list)	
d	Other, please specify:	

3. The followings are potential factors that are used in qualifying contractors. You are kindly requested to evaluate the importance of each parameter to the qualification of contractors by placing a tick (√) in the scale next to each parameter.

Qualifying parameters	Extremely important	Very important	Important	Not important	Extremely not important
Contractor financial stability					
Contractor experience					
Contractor quality performance					
Availability of equipment resources					
Availability of manpower resources					
Contractor current workload					
Contractor past performance					

Qualifying parameters	Extremely important	Very important	Important	Not important	Extremely not important
Contractor safety records					
Contractor claim attitudes					
Contractor office location					
Procurement experience of contractor					
Contractor familiarity with location of project					
Management staff availability of contractor					
Amount of work performed by contractor					
Planning, scheduling and cost control techniques adopted by contractor					

4. Does your organization set a prequalification as a condition on contractors to participate in bidding for projects?

Yes		No	

If No, please go to question 8
If yes, please continue

5. What is the purpose of prequalification? (check all that applies)

Provide short list		Comply with company regulations	
Public Accountability		Standard procedure	
Exclusion of unqualified contractor		Provide enough time for contractor investigation	
Others, please specify			

6. How often does your organization update the information of contractors in the qualified list?

Monthly		Every 6 months	
Yearly		Not required	
Others, please specify			

7. What is the guideline you pursued in determining the maximum number of contractors in the qualified list?

Internal guideline		information already available	
No guideline implemented			
Others, please specify			

8. Does your organization use the same criteria for the evaluation of contractors for all projects?

Yes		No	

If yes, please go to question 10
If No, please continue

9. How do you decide which criteria will be used for the evaluation of contractors for each project?

Internal guideline		Based on experience	
Organization quality system		Based on project requirements	
Others, please specify			

10. What is the information that should be submitted from the contractor? (Check all that applies)

Method statement		Completed questionnaire	
Safety policy		Quality assurance policy	
Management staff CV		Financial details	
Others, please specify			

11. Who is (are) liable for appraising the contractor data? (Check all that applies)

Financial department		Director	
Tendering department		Project manager	
Others, please specify			

12. How do you appraise the decision criteria for contractor selection?

Based on experience		Statistic analysis	
Professional judgement		Rating with weight	
Rating without weight		No evaluation	
Others, please specify			

13. How does your organization perform a final decision to select a contractor to execute a project?

Based on lowest price		Familiarity with contractor	
Based on multi criteria			
Others, please specify			

14. Who is responsible for performing the final selection of a contractor to execute a project?

Director		Bid awarding committee	
Tendering department		Senior project manager	
Others, please specify			

15. Does the current process for the selection of a contractor lead to award contract to an inappropriate contractor?

Yes		No	

16. What are the problems associated with current awarding process? (check all that applies)

Poor project performance		Cost overruns	
Contractor bankruptcy		Project will be delayed	
Number of claims increases			
Others, please specify			

17. What are the advantages associated with the current process for contractor selection? (check all that applies)

Perform contract awarding process quickly		Minimize the bid evaluation cost.	
Minimize bid evaluation time		Only classified contractor can be participated in the contract	
Only qualified contractor can be participated in contract			
Others, please specify			

18. Have you ever heard about the implementation of a decision support system in the evaluation of contractors?

Yes		No	
Others, please specify			

19. Have you ever heard about the analytical hierarchy process as a tool for assessment of contractors?

Yes		No	
Others, please specify			

20. Does your organization implement any decision support system in the evaluation or selection of a contractor?

Yes		No	
Others, please specify			

Section III: Criteria for contractor evaluation

1. Does your organization use the following criteria during the evaluation and selection process of a contractor?

   Please feel free to add any criteria that your organization uses during evaluating and selecting more than the following that are mentioned in the table below to enhance the research .

No.	Criteria	Yes	No
1	Contractor financial stability		
2	Contractor past Performance (performance record)		
3	Contractor technical expertise		
4	Contractor managerial Capability		
5	Contractor current workload (Capacity)		
6	Contractor safety records		
7	Operation & equipment resources possess by contractor		
8	Bid price		
9	Contractor home office location		
10	Familiarity of contractor with geographical location of project		
11	Quality control system implemented by contractor		
12	Past penalties on contractor		
13	Familiarity of owner with contractor		
14	Contractor submitted complete bid documents including bonds, zakah clearance, financial offer, etc		
15	Environmental management strategies adopted by contractor to reduce impact of construction on environment		
16	Contractor classification		
Other (please specify)			
17			
18			
19			

Section IV: Pair-wise comparison between criteria

In this part your input is very essential to determine the importance of each criterion and sub-criteria with respect to others. The influence of each criterion on the overall decision based on scale of 1 to 9 is needed. The table below illustrates the meaning for each point on the scale.

Points scale	Description
1	Equally importance
3	Moderately importance
5	Strongly importance
7	Very strongly importance
9	Extremely importance
2,4,6,8	Intermediate values, for example, a value of 6 means that the degree of importance is between strongly importance which is (5) and very strongly importance which is (7).

Example: To perform pair-wise comparison between each two criteria, please put tick (✓) in the right box as illustrated in the example below.
In this example the respondent ,when comparing financial stability with safety records believes that financial stability is strongly more important than safety records, so that the respondent puts tick (✓) under 5 adjacent to financial stability. Whereas, when comparing financial stability with technical expertise, the respondent believes that technical expertise is moderately more important than financial stability, therefore the respondent puts tick (✓) under 3 adjacent to the technical expertise.

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria
Financial stability					✓													Safety records
Financial stability											✓							Technical expertise

1. Please perform pair-wise comparison between the criteria based on your judgment and experience in contractor selection and evaluation.

A. Decision Criteria for Contractor Evaluation and Selection in Saudi Arabia

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria
Contractor financial stability																		Contractor past Performance
Contractor financial stability																		Contractor technical expertise
Contractor financial stability																		Contractor managerial Capability
Contractor financial stability																		Contractor current workload (Capacity)
Contractor financial stability																		Contractor safety records
Contractor financial stability																		Operation & equipment resources possess by contractor
Contractor financial stability																		Bid price
Contractor financial stability																		Contractor home office location
Contractor financial stability																		Familiarity of contractor with geographical location of project
Contractor financial stability																		Quality control system implemented by contractor
Contractor financial stability																		Past penalties on contractor
Contractor financial stability																		Familiarity of owner with contractor
Contractor financial stability																		Complete bid documents submitted by contractor
Contractor financial stability																		Contractor classification

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria
Contractor past Performance																		Contractor technical expertise
Contractor past Performance																		Contractor managerial Capability
Contractor past Performance																		Contractor current workload (Capacity)
Contractor past Performance																		Contractor safety records
Contractor past Performance																		Operation & equipment resources possess by contractor
Contractor past Performance																		Bid price
Contractor past Performance																		Contractor home office location
Contractor past Performance																		Familiarity of contractor with geographical location of project
Contractor past Performance																		Quality control system implemented by contractor
Contractor past Performance																		Past penalties on contractor
Contractor past Performance																		Familiarity of owner with contractor
Contractor past Performance																		Complete bid documents submitted by contractor
Contractor past Performance																		Contractor classification
Contractor technical expertise																		Contractor managerial Capability
Contractor technical expertise																		Contractor current workload (Capacity)
Contractor technical expertise																		Contractor safety records
Contractor technical expertise																		Operation & equipment resources possess by contractor

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria
Contractor technical expertise																		Bid price
Contractor technical expertise																		Contractor home office location
Contractor technical expertise																		Familiarity of contractor with geographical location of project
Contractor technical expertise																		Quality control system implemented by contractor
Contractor technical expertise																		Past penalties on contractor
Contractor technical expertise																		Familiarity of owner with contractor
Contractor technical expertise																		Complete bid documents submitted by contractor
Contractor technical expertise																		Contractor classification
Contractor managerial Capability																		Contractor current workload (Capacity)
Contractor managerial Capability																		Contractor safety records
Contractor managerial Capability																		Operation & equipment resources possess by contractor
Contractor managerial Capability																		Bid price
Contractor managerial Capability																		Contractor home office location
Contractor managerial Capability																		Familiarity of contractor with geographical location of project
Contractor managerial Capability																		Quality control system implemented by contractor
Contractor managerial Capability																		Past penalties on contractor
Contractor managerial Capability																		Familiarity of owner with contractor

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria
Contractor managerial Capability																		Complete bid documents submitted by contractor
Contractor managerial Capability																		Contractor classification
Contractor current workload (Capacity)																		Contractor safety records
Contractor current workload (Capacity)																		Operation & equipment resources possess by contractor
Contractor current workload (Capacity)																		Bid price
Contractor current workload (Capacity)																		Contractor home office location
Contractor current workload (Capacity)																		Familiarity of contractor with geographical location of project
Contractor current workload (Capacity)																		Quality control system implemented by contractor
Contractor current workload (Capacity)																		Past penalties on contractor
Contractor current workload (Capacity)																		Familiarity of owner with contractor
Contractor current workload (Capacity)																		Complete bid documents submitted by contractor
Contractor current workload (Capacity)																		Contractor classification
Contractor safety records																		Operation & equipment resources possess by contractor
Contractor safety records																		Bid price
Contractor safety records																		Contractor home office location
Contractor safety records																		Familiarity of contractor with geographical location of project

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria
Contractor safety records																		Quality control system implemented by contractor
Contractor safety records																		Past penalties on contractor
Contractor safety records																		Familiarity of owner with contractor
Contractor safety records																		Complete bid documents submitted by contractor
Contractor safety records																		Contractor classification
Operation & equipment resources possess by contractor																		Bid price
Operation & equipment resources possess by contractor																		Contractor home office location
Operation & equipment resources possess by contractor																		Familiarity of contractor with geographical location of project
Operation & equipment resources possess by contractor																		Quality control system implemented by contractor
Operation & equipment resources possess by contractor																		Past penalties on contractor
Operation & equipment resources possess by contractor																		Familiarity of owner with contractor
Operation & equipment resources possess by contractor																		Complete bid documents submitted by contractor
Operation & equipment resources possess by contractor																		Contractor classification
Bid price																		Contractor home office location
Bid price																		Familiarity of contractor with geographical location of project
Bid price																		Quality control system implemented by contractor

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria
Bid price																		Past penalties on contractor
Bid price																		Familiarity of owner with contractor
Bid price																		Complete bid documents submitted by contractor
Bid price																		Contractor classification
Contractor home office location																		Familiarity of contractor with geographical location of project
Contractor home office location																		Quality control system implemented by contractor
Contractor home office location																		Past penalties on contractor
Contractor home office location																		Familiarity of owner with contractor
Contractor home office location																		Complete bid documents submitted by contractor
Contractor home office location																		Contractor classification
Familiarity of contractor with geographical location of project																		Quality control system implemented by contractor
Familiarity of contractor with geographical location of project																		Past penalties on contractor
Familiarity of contractor with geographical location of project																		Familiarity of owner with contractor
Familiarity of contractor with geographical location of project																		Complete bid documents submitted by contractor
Familiarity of contractor with geographical location of project																		Contractor classification
Quality control system implemented by contractor																		Past penalties on contractor

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria
Quality control system implemented by contractor																		Familiarity of owner with contractor
Quality control system implemented by contractor																		Complete bid documents submitted by contractor
Quality control system implemented by contractor																		Contractor classification
Past penalties on contractor																		Familiarity of owner with contractor
Past penalties on contractor																		Complete bid documents submitted by contractor
Past penalties on contractor																		Contractor classification
Familiarity of owner with contractor																		Complete bid documents submitted by contractor
Familiarity of owner with contractor																		Contractor classification
Complete bid documents submitted by contractor																		Contractor classification

2. If you add other criteria to that mentioned in section III of this questionnaire, please perform pair-wise comparison between the criteria added and those mentioned.

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria

Decision criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision criteria

Thank you

VITA

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