SELECTION OF CONTRACTOR USING ANALYTICAL HIERARCHY PROCESS (AHP)

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SUPERVISOR'S DECLARATION

I hereby declare I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the award of Bachelor of Civil Engineering.

_____

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Full Name   :

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Projek-projek pembinaan sedang berjalan pesat di Malaysia dan telah menjadi salah satu faktor penting dalam menyumbang peningkatan ekonomi negara. Kerana itu, pemilihan kontraktor merupakan aspek penting dalam sektor pembinaan terutamanya bagi klien atau pihak yang melibatkan keperluan untuk mengupah kontraktor terbaik untuk mengurus dan menyelesaikan projek mereka dalam masa dan kos yang diberikan juga dengan kualiti yang baik. Selain itu, tanpa menggunakan kaedah yang sesuai dalam pemilihan kontraktor, ia pasti akan menjejaskan penyelesaian keseluruhan projek. Dalam kajian ini, saya melakukan penyelidikan mengenai penggunaan proses hierarki analisis (AHP) sebagai model sokongan keputusan untuk memilih kontraktor. AHP membolehkan keputusan membina sebagai hierarki dan setiap kriteria boleh dinilai dengan skala keutamaan (dari 1 hingga 9) yang ditentukan oleh pakar dalam bidang pembinaan. Tujuan kajian ini adalah untuk mengenal pasti kriteria utama yang digunakan oleh pelanggan dalam pemilihan kontraktor juga menentukan kriteria pemberat dengan menggunakan kaedah AHP dari amalan semasa di Malaysia. Selain itu, kaedah ini adalah salah satu kaedah yang perlu untuk mengurangkan risiko kegagalan projek disebabkan prestasi kontraktor yang lemah.

ABSTRACT

Construction projects are now progressing rapidly in Malaysia and have been as one of an important factor in contributing increasing economic country. Because of that, contractor selection is an important aspect in construction sector especially for client or parties involve that need to hire the best contractor to manage and complete their project within time and cost given also with good quality. Furthermore, without a suitable method use in selection of contractor, it for sure will affect the completion of whole project. In this study, I am doing research about the use of the analytical hierarchy process (AHP) as a decision support model to select contractor. The AHP allows constructing decision as hierarchies and each criterion can be evaluated through weighted determined by the expert in construction field. The purpose of this study is to develop the main criteria used by client in selection of contractors also identify the weighted criteria by using AHP method from current practice in Malaysia. Besides, this method is one of the decision-making that is necessary to eliminate the risks of project failure due to poor contractor's performance.

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LIST OF SYMBOLS

AHP   Analytical Hierarchy Process

MOF   Garis Panduan Penilaian Tender (Kementerian Kewangan Malaysia)

CIDB   Construction Industry Development Board

W   Weighted

CI   Consistency Index

RI   Random Index

CR   Consistency Ratio

GMM   Geometric Mean Method

CHAPTER 1

INTRODUCTION

1.1   Introduction

In the midst of the globalization era we can see that the construction sector is very important to meeting the current modernization of Malaysia. Where the construction sector is one of the most important factors contributing to the country's economic growth of infrastructure, building and becoming a developed nation. Standing strong skyscrapers, high-rise buildings in Malaysia can be concluded that Malaysia is on track to make the country a developed nation in southeastern Asia and is respected. The increase in contribution to buildings will lead the growth of investment in our country but behind the successful and complete project depends on parties that involved managing, controlling the flow and management of project in adequate manner with respective specification. This matter is evidenced by the statistics of the gross production rate released by The Office of Chief Statistician Malaysia Department of Statistics, Malaysia on 10 July 2017 this year. The compound annual growth rates stated that the gross output in construction sector has grown from 14.3 per cents to rm177.9 billion in 2015 as compared to rm91.3 billion in 2010.

For the performance of the construction sector through statistics on Economic Census of Construction Sector conducted in 2016 for reference year 2015 state that a total of 40,558 establishments were involved in this census with compound annual growth rate of 12.9 per cents as compared to 22,140 establishments of 2010. The positive growth is recorded for the overall performance of the construction sector in 2015 that give a good impact on economic Malaysia.

From the performance that are stated above can we conclude that from civil engineering sector, the need to manage information systematically, efficiently are very

important because competition now very high. As recommended by the minister of work, Dato' Seri Samy Vellu said:

"Whether we like it or not, we have to go global. Going global is a necessity and not a choice anymore if we want our construction industry to grow in the next millennium. "

Cost, time, quality and safety are the main element in construction where the contractors need to take it as the important thing during delivery the project given. So, the best example of choosing a contractor is that they concerned with the elements mentioned during the construction. Failure to select a competent contractor properly can lead to problems for the entire project. Selecting the best criteria for contractors by Multi-criteria decision making (MCDM) techniques where used Analytical Hierarchy Process (AHP) method. AHP allows decision to be constructed as hierarchies and each criterion can be assigned to a preference scale that is determined by the decision makers. AHP is a form that comparisons are made by priority-ranking model which the success factors identified in sequential manner, criteria with the highest score is deemed the best.

In Malaysia, this kind of ranking model is important because without a suitable and precise method in selection of contractors, it will affect the completion of project. It becomes quite popular for using AHP-based approach due to its simple and systematic implementations steps. Whatever the selection method is, the significance of three criteria which is time, cost and quality should be considered.

1.2   Problem Statement

The decline in the construction industry occurred around 2005 to 2006 with a rate of negative 5.1%. There was a reduction in the number of projects and many bankrupts' contractors *(CIDB News, 2005)*. In Malaysia, issues faced for selection of contractor where they do not emphasizing an important aspect in the delivery of construction projects where it linked to project success, in term of time schedule, cost, and quality. Besides, the overall project quality and owner satisfaction is relevant to the contractor performing the work. Contractor need to understand the procedures for obtaining government, private projects or tenders. Many of them are blacklisted because they cannot afford financial risk and responsibility given to complete the projects, also demand in price from chosen contractors when come from closed tender.

From observation, it is found that the contractors with insufficient financing where most of them do not have sufficient capital to finance their undertakings. Then, lack of experience and skills in technical or through management in construction phase which contractor unable to complete the project given according to agreed costs and time scheduled. Also, their quality performance for previous project that give them positive or negative impact. However, this study will identify the best criteria or factors that are important during selection of contractors using Analytical Hierarchy Process (AHP) where a theory of measurement through pair wise comparisons and relies on the judgments of experts to derive priority scales was applied.

1.3 Objective

The overall aim of this research is:

> ➢ To identify and study the main criteria in selection of contractor.

> ➢ Identify the weighted criteria by using Analytical Hierarchy Process.

1.4   Scope of study

This study focusing to the issue contractor selection problem for construction industry in Malaysia. The important aspect in the delivery of construction projects where it related to project success and finish within time, cost and quality is about the good selection of contractors. Through method uses which is analytical hierarchy process (AHP) we can find out the ranking review from the expert in construction industry to identify important criteria affecting the choice of contractors and best possible alternatives for the project that can be develop.

1.5   Significant of study

This study has been conducted in order to identify the best criteria that emphasized from parties involve in construction industry for selection of contractor**.** Through this research, various information and view from expert that involve had been found and obtained based on the feedback from the survey questionnaires form (through Google form).

Besides, from this study we conclude that the best criteria needed to select proper contractor. Without a proper method for select the competent contractor, it will affected the performance overall project. So, the issues which is always arise in construction industry can be solve and increase chances of project delivery within cost, time also quality.

1.6   Methodology

This research will be carried on through a few stages:

As mention in figure 1.1, the result of research 'Selection of Contractor uses Analytical Process (AHP)' is gathered from distributing the questionnaires to expert in the respective field. The proposed method to evaluate the selection of contractors in this study is based on a multi-criteria decision making tool (MCDM) called the analytical hierarchy process (AHP). This step to develop a hierarchy of criteria and to identify all possible alternatives. AHP uses comparison where a decision maker is required to compare all alternatives with respect to evaluation criteria.
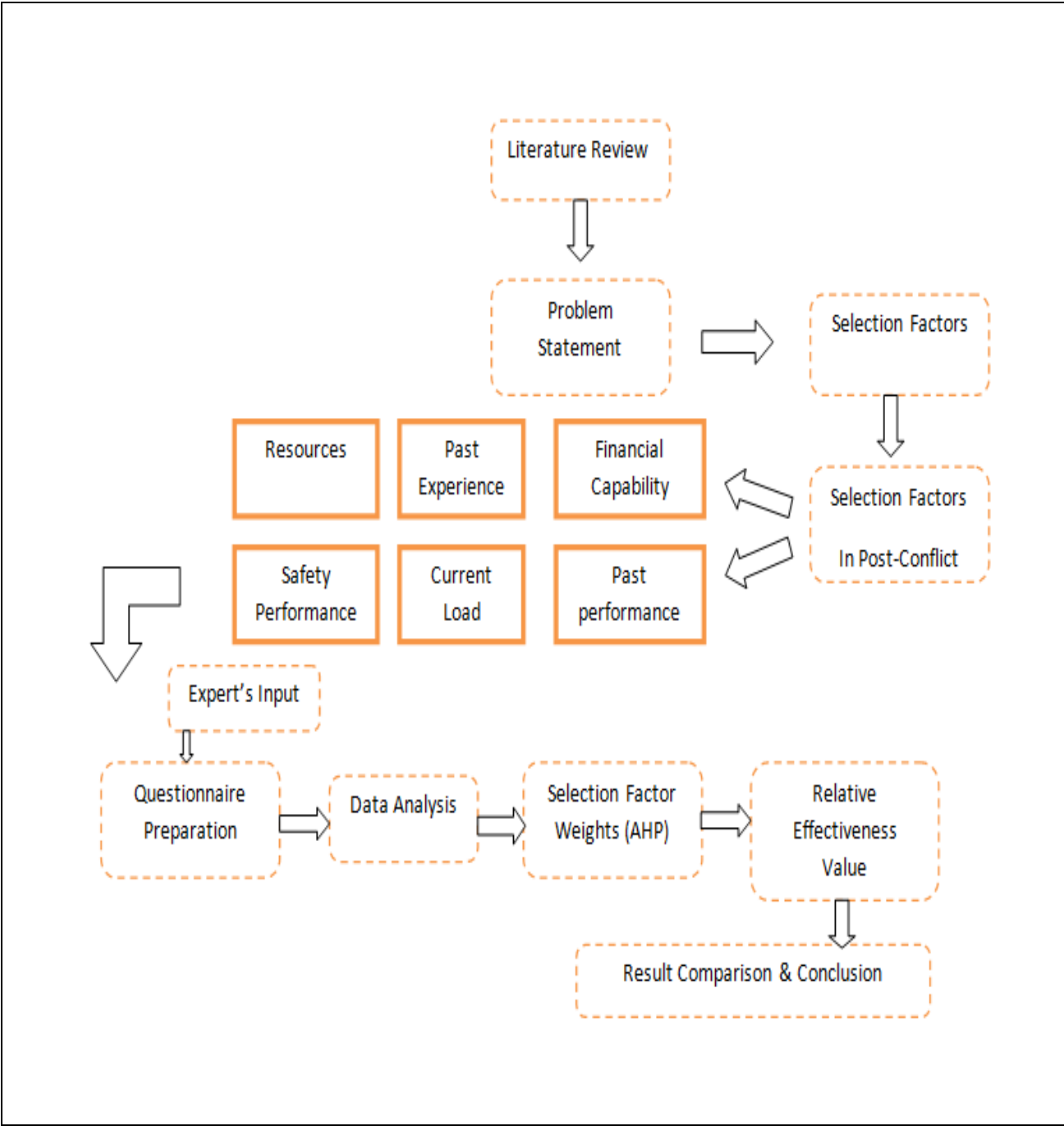
Figure 1.1   Flowchart of Methodology

CHAPTER 2

LITERATURE REVIEW

2.1   Introduction

In this challenging era, to get successful project construction we need to manage the flow or process in an effective manner. The demands from clients, competition, and regulatory agencies have been growing rapidly *(Crowley & Hancher, 1995)*. Hence, a failure to properly manage them can lead to problems for the entire project and construction team. Various studies have shown that overall project quality and owner satisfaction is directly related to the contractor performing the work *(Cheung, Maloney, Russell, & Jaselskis, 2006 ; 2002 ; 1992)*. Without care about people criteria and expertise in hiring contractors can be problematic during run the project given. The selection of a proper construction contractor increase chances of successful completion of a construction project *(Alhazmi & McCaffer, 2000)*. The selection of contractors is an important aspect in the delivery of construction projects and is linked to project success, in the terms of schedule, cost, and quality *(Hatush & Skitmore, 1998)*.

To choose capable construction contractor is one of the important aspect faced by the client or parties involve who wishes to achieve successful complete projects outcomes. This type of tasks is challenging, because construction industry is rapid growth and competitive around the world. *(Kangari & Bakheet, 1994)* agree that the probability of construction failure is quite high for individual contractors, and it is important for project owners to confront and manage these risks if they wish to achieve good project results.

In the other words, we need to find the decision making tools where we can seek the best of the satisfactory options to be the best solution to the problem *(Simon, 2003)*.

However, failure to make effective decision leads to poor, ineffectual and wrong decisions *(Drucker, 2001)*. For the alternative decision making tools that suitable to use for selection of contractor based on criteria chosen is Analytical Hierarchy Process (AHP) which will provide a solution for the complex problem in more systematic and effective way.

> *To solve the problem we must determine the weights of the criteria where the larger value can be indicate or more preferred as an importance factor to select a contractors. According to (Taylor, 2004) there are several ways of assigning weights to criteria that is by ranking, rating or by developing pair wise comparison. This type of selection can identify the contractor whom the client can confidently entrust and be responsibility to project given.*

2.2   Contractor

A contractor is a person or company that performs work on a contract basis. They responsible for providing all of material, labor, equipments (such as engineering vehicles and tools) and services necessary for the construction of the project. Contractors include sub-contractors that carry out, manage or control the flow of construction work. With this important phase in construction, contractor that hired by client must have the skills, experience, knowledge also organizational capability to carry out the work safely and environmentally for public used. During this construction phase the people that close to the risk of injury and ill health is contractor and their worker. Therefore, contractor have an important role in planning, staffing, managing and monitoring their work until they complete the project given also ensure any risks are controlled.

> *(Zaini & Haron, 2010), defines contractors as the most powerful and carry ultimate responsibility, in both internal and external aspects, for the firm and its investment capital. In this sense, the contractor is a body consisting of company director general and commercial manager of private companies.*

Contractors who is responsible to manage the project must make sure the client aware about their duties under Design and Management Regulations 2015, (CDM 2015) before starts work plan, monitor all work carried out by themselves and their workers also taking into account the problem or risks that will arise which might be affected public. Achieving client satisfaction was identified as a key factor to measure construction project success *(Parfitt & Sanvido, 1993)* an done of the most important challenges facing the construction industry in the 1990s *(Torbica and Stroh, 2001)*.

> *Two sets of requirements have to be fulfilled in order to achieve client satisfaction. Firstly, to get client needs translated into a design, which specifies technical characteristics, functional performance criteria and quality standards. Secondly, to get the project completed within a specified time and in the most cost effective manner (Bowen et al., 1999). Clients are most likely to be satisfied when the final product matches or exceeds their expectations (Ahmed, R. Kangari, & Hudson, 1995 ; 1999).*

> *Furthermore, as a good contractor they need to make sure that all their workers they employ or appoint have the skills, experience or was training to carry out the work with ethic and safety. Besides, contractor needs to provide appropriate supervision and instructions to their workers to ensure they do the works with the specifications given. In the award of construction services, the ultimate project quality and client's satisfaction correlates directly to the quality of the selected contractor performing the services (Kumaraswamy. M. & Anyuur. A., 2008)(E.J. & J.S, 1992).*

2.2.1 Category of Contractor

According to Government of Malaysia (2012) started from 15 October 2012, the limitation of acquisition value for the government work for the building work / civil / mechanical and electrical are shown in the Table 2.1 and Table 2.2 below:

Table 2.1   Limit of building/civil/mechanical work cost (CIDB,2015a)

Registration Grade	Limitation of acquisition work value (RM)
G1	Less than 200,000.00
G2	200,001.00 to 500,000.00
G3	500,001.00 to 1,000,000.00
G4	1,000,001.00 to 3,000,000.00
G5	3,000,001.00 to 5,000,000.00
G6	5,000,001.00 to 10,000,000.00
G7	More than 10,000,000.00

Table 2.2   Limit of electrical work cost (CIDB,2015a)

Registration Grade	Limitation of acquisition work value (RM)
G1	Until 200,000.00
G2	Until 500,000.00
G3	Until 1,000,000.00
G4	200,001.00 to 3,000,000.00
G5	200,001.00 to 5,000,000.00
G6	200,001.00 to 10,000,000.00
G7	More than 200,001.00

2.3   Issue in selection of contractors

The Malaysian newspaper *(Utusan Online, 2015)* stated that the issue of class Gred1 and Gred2 contractors was less that the government's project would be a source of surrender to the concessionaires causing the source of income to be affected. In addition, the decline in the construction industry occurred around 2005-2006 showing a -5.1% rate of project reductions and many bankrupted contractors *(CIDB News, 2005)*. In addition, the industry is always facing chronic problems such as time overrun, cost overrun, poor safety and poor quality *(Nahmens & Ikuma, 2009)*.

Issues that arise during the selection of contractors in Malaysia are because they do not understand the procedures for obtaining projects or tenders for both government

and private sectors. Many contractors have been blacklisted for not being able to take on financial risks and are responsible for the work to be given. In addition, for a closed bid price demand from chosen contractor, clients need to be more careful in selecting contractors who can full fill their needs. Therefore, the current contractor needs to have a strong finance to carry out a project and be able to complete the project according to the time and price set. Having a good reputation will give a positive impact to the client choosing a suitable contractor for building construction.

Furthermore, evaluation to select contractors in government depends on "Tender Evaluation Guidelines Division of Government Finance Ministry of Malaysia", *(Jan2008 edition).* Through the guidelines evaluation of contractors, the weighted to select the best contractor based on two criteria is 50% from financial capabilities and 50% from technical (include work experience, technical staff and plant & equipment. From above issue we can observe that actually the weighted must more percent in technical criteria where contain more important aspect in selection of contractors.

Other than that, *(Utusan Online, 2017)* state issue raised include impractical construction design and the quality of breeding work is unsatisfactory. Where consultants failed to ensure contractors complied with the design provided as in the case of elevator mains not in size. Besides, consulting company also had no experienced staff at the project site for monitoring purposes resulting in a lot of work being carried out not according to specifications.

2.4   Qualified contractor

In Malaysia to be a contractor and undertake a contracting job, a person or company is required to register and obtain the following certificates (chapter 5 contractor registration):

- Construction Industry Development Board (CIDB)- to allow the contractor to undertake construction jobs based on registered Class/Grade. The certificates are issued by CIDB.

- SPKK (Sijil Perolehan Kerja Kerajaan) or Governement Procurement Working Certificate- allow contractors to participate in government projects that they are qualified for. The certificate is issued by CIDB.

- STB (Sijil Taraf Bumiputera) or Bumiputea Status Certificate- allow contractors to participate in government projects which are allocated for Bumiputera contractors only. The certificate is issued by Bahagian Pembangnan Kontraktor & Usahawan (BPKU).

- Registration with other agencies/corporation e.g. TNB, Telekom, JKR, UTM, Petronas, SPAN- allows local contractors/suppliers to participate in procurement activities of the respective agencies. The certificate is issued by the relevant agencies.

Effective 20 July 1995, it is mandatory for all contractors, both local and foreign to register with the Construction Industry Development Board of Malaysia CIDB or Lembaga Pembangunan Industri Pembinaan Malaysia (LPIPM) before undertaking or completing any construction work in Malaysia except those who have been given exemption under Section 40(1) of the Construction Industry Development Board Act 1994. Anyone who undertakes to carry out and complete any construction work without registering as a registered contractor with the CIDB commits an offence under the Act and if convicted may be fined up to fifty thousand ringgit.

2.4.1   Contractor registration requirement and procedures with CIDB

Construction Industry Development Board of Malaysia (CIDB) established in 1994 which the CIDB 520 Act is an act to form the CIDB. It is implemented to offer CIDB expertise relevant to the local construction industry and other related matters. In the amendment of Act 520, involve three main points which first is improved construction quality through the registration of building personnel, skills certification and competence. Secondly is quality assurance of building materials through standardization and compliance and third placement of responsibility to manage and

ensure building safety and construction work during or after construction work on contractors and site managers.

In Malaysia to start a construction related business as contractor they need to apply CIDB license. For registration of contractors as per the Act, they cannot undertake any construction works unless they are registered also hold a valid certificate of registration issue by CIDB. Besides, non-registration will get fine not exceeding RM 50,000.00. There has restriction that need to follow which the contractor is not allowed to execute any construction works outside his registered category as stated in table 2.1 and table 2.2.

2.4.2   Tender evaluation guidelines MOF

Procurement by tenders, tender value limit for all procurement whether work, supply or services of more than RM 200,000 a year shall be tendered. For work before any work tender is invited, the Agency shall:

    a. Development of all the RM 200,000 under work turnover to class F contractors.

    h. Work tenderizes must be made among companies registered with the Contractor Service Center (PKK) and the Malaysian Industrial and Building Development Board (CIDB) according to the following classes and grades.

Table 2.3

	PUSAT KHIDMAT KONTRAKTOR (PKK)
CLASS	PROJECT VALUE
A	More RM10,000,000
B	RM5,000,001 until RM10,000,000
C	RM2,000,001 until RM5,000,000
D	RM500,001 until RM2,000,000
E	RM200,001 until RM500,000
F	More RM2000,000

Table 2.4

	LEMBAGA PEMBANGUNAN INDUSTRI DAN PEMBINAAN MALAYSIA (CIDB)
GRED	PROJECT VALUE
7	RM10,000,000 above
6	To RM10,000,000
5	To RM5,000,000
4	To RM3,000,000
3	To RM1,000,000
2	To RM500,000
1	To RM100,000

For the electrical work of the invitation should be made among companies registered with PKK according to the following class shown in table 2.5:

Table 2.5

CLASS	FINANCIAL LIMIT
I	More to RM200,000
II	To RM1,000,000
III	To RM500,000
IV	To RM200,000

2.4.3   Tender evaluation has been made in the following stage

a) First stage – prefix evaluation

Is a basic assessment in which all tenderers will be analyzed in terms of minimum perfection (3% of project costs) and current work performance.

b) Second stage – assessment of technical and financial capabilities

Tenders tend to be evaluated in detail which is in technical and financial capabilities. All tenderers will be evaluated in terms of financial position, work experience, technical staff also equipment capabilities.

c) Third stage – rating assessment of tenderes who pass technical and financial capabilities.

The tender evaluation committee will certify the tender that has satisfied the requirements and passed the preliminary also second level assessment. A scoring system was introduced to determine the capabilities of the tenderer and at the same time minimized the subjective elements.

7.6   Berikut adalah senarai petender yang telah lulus dalam ketiga-tiga peringkat penilaian berserta markah yang diperoleh dalam penilaian yang dilakukan:

BIL	KOD PETENDER	HARGA (RM)	TEMPOH SIAP (MINGGU)	MARKAH PENILAIAN			PERAKUAN J/K PENILAIAN
				Kew. (markah min. - 20)	Tek. (markah min. - 13)	Jumlah (markah min. - 45)	
1.	12/15	20,451,334.50	60	40	15	55	Lulus
2.	10/15	20,600,878.00	60	50	42	92	Lulus
3.	6/15	21,160,000.46	60	50	30	80	Lulus
4.	11/15	21,266,574.45	60	46	32	78	Lulus
5.	14/15	21,270,087.00	60	32	22	54	Lulus
-	-	22,561,900.00 (Ang. Jabatan)	-	-	-	-	-
6.	3/15	22,699,559.59	60	50	43	93	Lulus
7.	2/15	23,462,890.30	60	50	19	69	Lulus
8.	4/15	23,699,505.50	60	35	35	70	Lulus
9.	9/15	24,786,905.66	60	50	45	95	Lulus
10.	15/15	26,443,709.16	60	30	22	52	Lulus
11.	13/15	27,780,680.00	60	50	40	90	Lulus

Figure 2.1   Example evaluation of contractor within two criteria in government (Financial Capabilities 50% and Technical 50% by MOF).

2.5　Criteria of contractor

In selection of contractors generally clients need to select best criteria in order to get best results in term of cost, time and quality for their project. (Hatush & Skitmore, Construc. Manage. Econ, 1997) *focused on identifying universal criteria for prequalification and bid evaluation. Their result show that the most common criteria considered by clients are those pertaining to financial soundness, technical ability, management capability and health and safety performance of contractors as shown in figure 2.2:*

Based on figure 2.2 and information from professionals in Malaysian construction industry, a list of 14 criteria influencing selection of main contractor was produced. In construction management researches, questionnaires are mostly used to collect factual and perceptive responses.

Table 1: Criteria for selection main contractor from literature review

Main contractor selection criteria	Previous study			
	Topcu (2004)	Palaneeswaram and Kumaraswamy (2001)	Skimore (1999)	Holt *et al.* (1995)
Financial stability	√	√	√	
Background of company	√	√	√	
Technical capacity		√	√	
Cost	√	√	√	√
Performance	√			
Standard of quality	√	√	√	√
Occupational health and safety	√	√	√	
Time performance	√	√	√	√
Management capability	√			
Failed contract	√			
Progress of work	√			
Human resource management			√	
Level of technology	√			
Relationship with client		√	√	
Relationship with sub-contractors	√			
Fraudulent activity	√			
Competitiveness	√			

Figure 2.2

Criteria below state by Michael Almeida to get a weighted scale in selection of contractors:

- Financial Capability – involves contractor's sound financial position and profitability, here is considered minimum average annual construction turnover within the last five years.

- Past Performance – past client's levels of satisfaction with the quality of previous works and maintenance services during defects liability period by the contractors in the past five years.

- Past Experience – minimum value of contracts which are similar to the proposed works and which were successfully completed within the last five years.

- Resources – availability of competent personnel, owned major plants and equipments for construction.

- Current Workload – construction activities which are underway, on-going and nearing completion.

- Safety Performance – safety performance/ accidents rate in the past five years.

2.6   Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) is "a theory of measurement through pair wise comparisons and relies on the judgments of experts to derive priority scales" *(Saaty, 2008). (Ibbs & Chih, 2011)* stated that the first steps of AHP are to develop a hierarchy of criteria and to identify all possible alternatives. AHP uses a pair wise comparison procedure whereby a decision maker is required to compare all alternatives with respect to evaluation criteria in turn.

> *(Zala & Bhatt, 2011) Analytic Hierarchy Process is an effective decision making technique based on multi-criteria decision making methodology (MCDM). It consider the human judgment, experience, perception and feelings in the decision making process. This research focus on d e v e l o p i n g a theoretical selection model based on the AHP approach. It help decision maker to select the most appropriate contractor against a number of contractors with various alternatives. The Analytic Hierarchy Process was chosen for this study based on following reason:*

a) The ability of AHP to incorporate tangible and intangible factors in a systematic way.

b) It able to solve constructed problems in a variety of decision making situation, ranging from the simple personal decisions to the complex capital intensive decision.

c) The problem is broken down in a logical fashion from the large elements to smaller elements.

d) It works by examining judgments made by decision makers and measure the consistently of those judgments.

e) It does not required numerical judgment from the decision maker.

How do decision makers assign value to intangible criteria? To solve the problem the weights of the criteria must be determined because criteria are not equally important. By determining the weight of the criteria a value can thus be assigned to the criteria to indicate its importance relative to the other criteria under consideration. The larger the weight the more the important or preferred the criterion. Decision makers will then be able to identify the best alternative and order the alternatives in rank of preference (Nizamuddin, Dayang, & Adam, World academy of scince, engineering and technology, 2012). According to (Taylor B. W., 2004) there are several ways of assigning weights to criteria, that is by ranking, rating or by developing pair wise comparison.

2.6.1 Applying AHP method

(Saaty, 1987 ; 1994 ; 2001) developed the following steps for applying the AHP:

a) Define the problem and determine its goal.

b) The hierarchy from the top (the objectives from a decision-maker's viewpoint) through the intermediate levels (criteria on which sub sequent levels depend) to the lowest level which usually contains the list of alternatives.

c) Construct a set of pair wise comparison matrices(size n x n) for each of the lower levels with one matrix for each element in the level immediately above by using the relative scale measurement shown in **Table 2.6**. The pair-wise comparisons are done in terms of which element dominates the other.

d) There are n (n-1) / judgments required to develop the set of matrices in step 3. Reciprocals are automatically assigned in each pair-wise comparison.

e) Hierarchical synthesis is now used to weight the eigen vectors by the weights of the criteria and the sum is taken over all weighted eigen vector entries corresponding to those in the next lower level of the hierarchy.

f) Having made all the pair-wise comparisons, the consistency is determined by using the eigen value, Imax , to calculate the consistency index, CI as follows: C.I.= (Imax-n) / (n-1) where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (CR) of CI with

the appropriate value. The CR is acceptable, if it does not exceed 0.10. If it is more, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.

g) Steps (d-f) are performed for all levels in the hierarchy.

h) The pair-wise comparison matrices were formulated base from Saaty's 9-point priority scale measurement as shown in Table 2.6 below:

Table 2.6

Importance	Explanation
1	Equally preferred
2	Equally to moderately preferred
3	Moderately preferred
4	Moderately to strongly preferred
5	Strongly preferred
6	Strongly to very strongly preferred
7	Very strongly preferred
8	Very to extremely strongly preferred
9	Extremely preferred

2.6.2 Consistency Index and Consistency Ratio

We need to check the consistency of the result. When many pair wise comparisons are performed, some inconsistencies may typically arise. The AHP incorporates an effective technique for checking the consistency of the evaluations made by the decision maker when building each of the pair wise comparison matrices involved in the process (Saaty, 1980). Consistency Index (CI) is obtained by used formula:

$$CI = \frac{x - m}{m - 1}.$$

1.1

A perfectly consistent decision maker should always obtain CI=0, but small values of inconsistency may be tolerated. In particular, if

$$\frac{CI}{RI} < 0.1$$

1.2
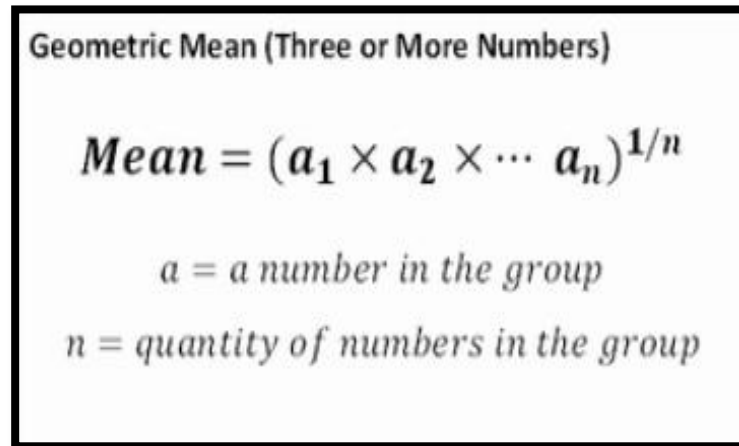
The inconsistencies are tolerable, and a reliable result may be expected from the AHP. In RI is the Random Index shown in table 2.7:

Table 2.7   Random Consistency Index

m	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

If the value of Consistency Ratio is smaller or equal to 10%, the inconsistency is acceptable. If the Consistency Ratio is greater than 10%, we need to revise the subjective judgment *(Saaty, 1980).*

2.6.3 Geometric Mean

Geometric Mean (Three or More Numbers)

$$Mean = (a_1 \times a_2 \times \cdots a_n)^{1/n}$$

$a = a$ number in the group

$n =$ quantity of numbers in the group

Figure 2.3   Formula

Figure 2.3 above shown the formula of geometric mean where are well-known approaches to deriving information from pair-wise comparison matrices in decision making process *(Tomashevskii, 2015)*. This tool can be generalized to group decision making.

The Geometric Mean Method (GMM) decision support tool, which has all components of a standard measuring tool, is composed of pair-wise comparisons as an initial measuring procedure *(Tomashevskii, 2015)*.

CHAPTER 3

METHODOLOGY

3.1   Introduction

All the objective can be obtained with the methodology flow process which is important. Besides, methodology flow process is used to conduct a research. Through this chapter, we are going to review the method used in this research in order to obtain data information and also to achieve objective of the research.

The methodology is important in collecting data which is necessary in statistical analysis for this research. Six main criteria involved in contractor selection were collected from the previous researcher journal questionnaire *(Almeida, 2016)*. A questionnaire survey was conducted to expert parties that involve in construction field in Malaysia. The survey was used as data information to get the weighted scale using Analytical Hierarchy Process (AHP) for which criteria is more important through selection of contractor.

So, the whole project will run smoothly and completed within time, cost and quality expected. Figure 3.0 shows the framework structure being objective is on the highest level (level 0) with the criteria on lower level (level 1) respectively.
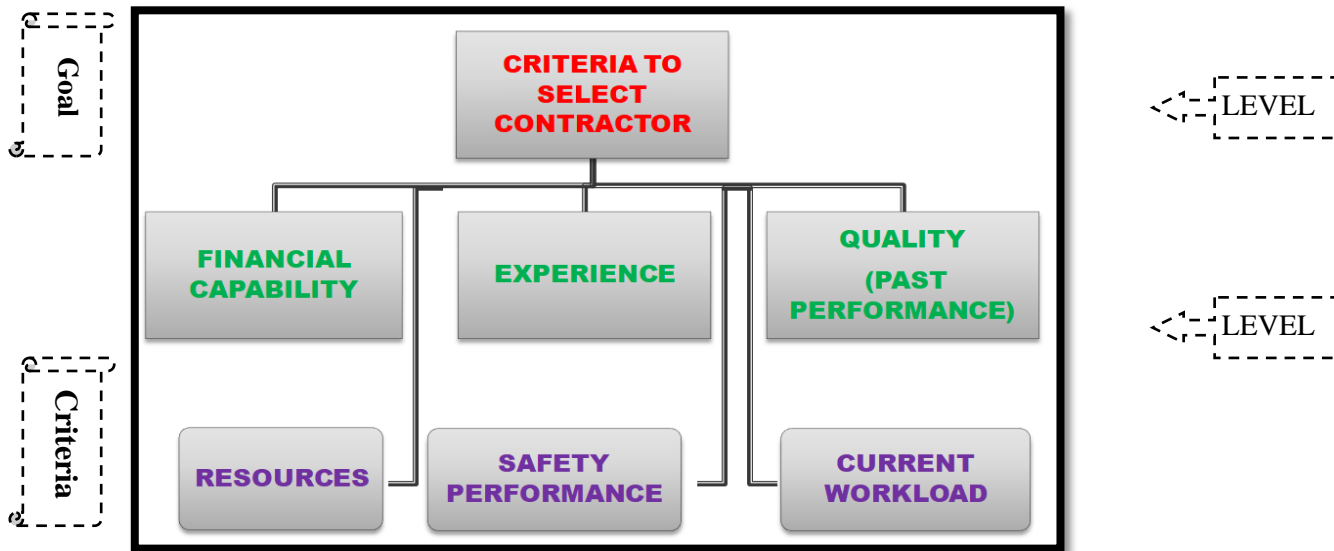
Figure 3.1   Framework Structure

The pair-wise comparison matrices were formulated base from Saaty's 9-point priority scale measurement as shown in Table 2.6 above:

3.2   Decision Making

To select the most qualified and capable contractor that can complete project given, AHP technique was used. From the hierarchy structure there have six criteria for chosen contractor:

- Financial Capability
- Past Performance
- Past Experience
- Resources
- Current Workload
- Safety Performance

All the criteria were evaluated with respect to the objective research, which want to develop the main criteria to select contractor. Comparison rank will access via surveys, which were distributed to expert parties that involve in construction sector or areas.

3.2.1 Consistency

It is necessary to check whether they are consistent or not if judgments have been entered. The idea of consistency is best illustrated in example that state: If you prefer a banana twice as much than apple and apple twice as much than an orange; how much would you prefer banana with respect to an orange? Some inconsistency is expected and allowed in AHP analysis. Since the numeric values are derived from the subjective preferences of individuals, it is impossible to avoid some inconsistencies in the final matrix of judgments. The question is how much inconsistency is acceptable. For this purpose, AHP calculates a consistency ratio (CR) comparing the consistency index (CI) of the matrix in question (the one with our judgments) versus the consistency index of a random-like matrix (RI). A random matrix is one where the judgments have been entered randomly and therefore it is expected to be highly inconsistent. More specifically, RI is the average CI of 500 randomly filled in matrices. *(Saaty T. L., 2012)* provides the calculated RI value for matrices of different sizes. In AHP, the consistency ratio is defined as CR where CR = CI/RI. *(Saaty T. L., 2012)* has shown that a consistency ratio (CR) of 0.10 or less is acceptable to continue the AHP analysis. If the consistency ratio is greater than 0.10, it is necessary to revise the judgments to locate the cause of the inconsistency and correct it, *(J.Alonso, 2006)*.

Table 3.2   Random Consistency Index

Number of things	1	2	3	4	5	6	7	n
number of comparisons	0	1	3	6	10	15	21	$\dfrac{n(n-1)}{2}$

3.3   Making Final Decision

This is the phase that now possible to make a decision after above steps have been completed in AHP analysis. Through this, we can compare the overall priorities obtained and whether the differences are large enough to make a clear choice. It is also necessary to analyze the consistency of judgments. From this analysis, we can express our recommendation to get better results.

3.4   Questionnaire

For data collection, questionnaire was used to get a weighted scale through pair-wise comparison criteria which in Analytical Hierarchy Process (AHP) method. The survey was conducted through Google Form which questionnaire distributed to experts parties in respective field, particularly in construction. Therefore, selecting the most competent and qualified contractor to complete the project in respect of time, cost and quality.

In brief, the selection models developed in this research have five major steps as stated below:

Step 1. Identify the main criteria options

Step 2. Define the Selection of Contractor in AHP method

Step 3. Assign Relative Importance Weights to Selection Factors

Step 4. Score the Criteria options by assigning them Relative Effectiveness Value

Step 5. Calculate the weighted score of selection factors in relation to the main criteria   options

Step 6. Select the best criteria needed that have highest weighted score.

The questionnaire was structure in 2 different sections (Google Form):

i.   **Section 1** : Personal Particular

This section is to gained personal particular information from expert parties involve in respective field. It focuses on the personal background which included the respondent name (not compulsory), gender, experience in field, position also company or organization profile.

ii.   **Section 2** : Selection of comparison between main criteria given

This section focused on the pair wise comparison matrices between six main criteria to find which most weighted scale among them through questionnaire is. The questionnaire is distributed to expert parties that involve in construction sector or areas. It formulated based from Saaty's 9-point priority scale measurement as shown in Table 3.2 below. From data analysis (through matrices), the more weighted score of criteria it will selected as the best criteria needed to choose contractors.
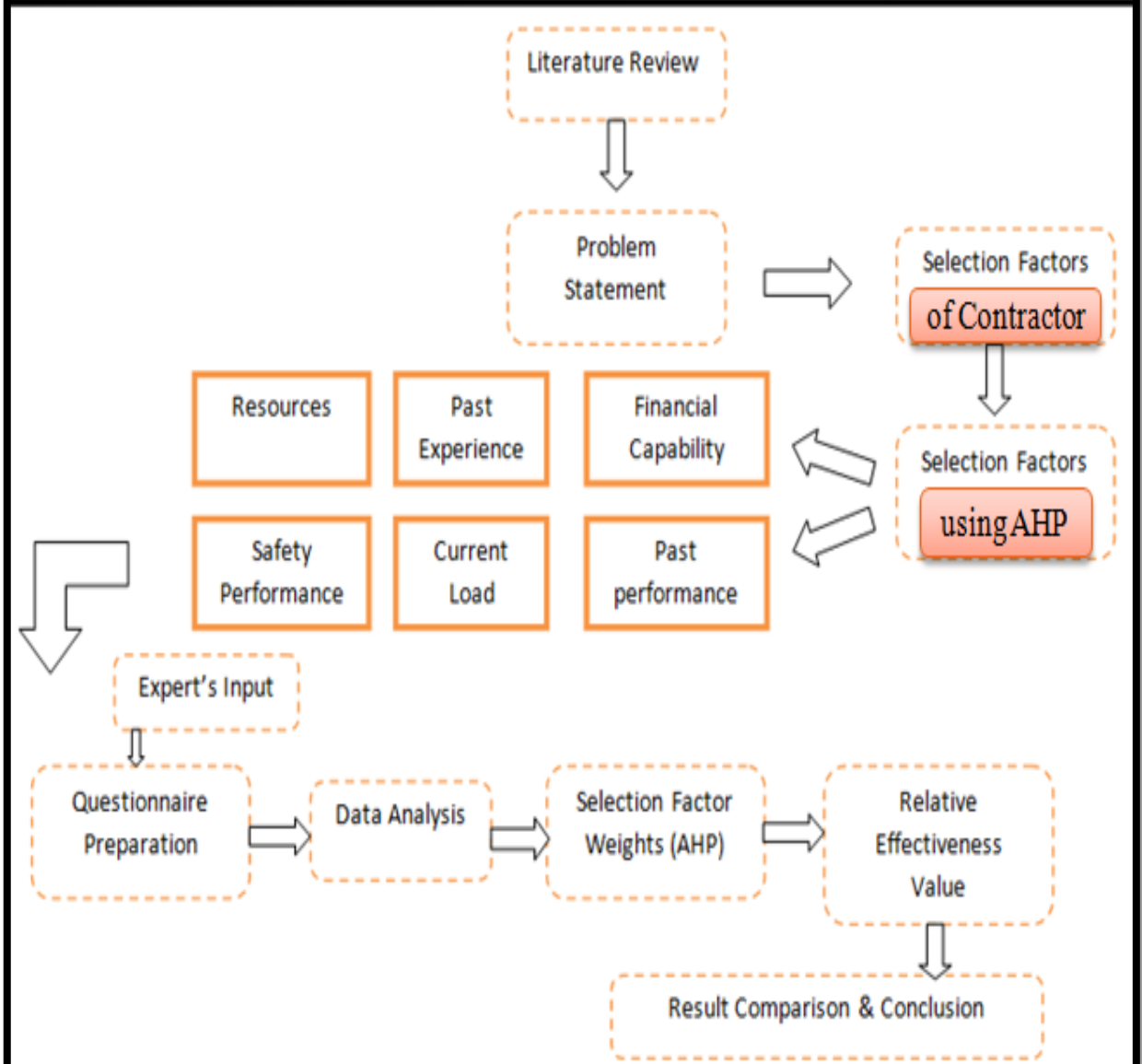
Figure 3.2   Shows the Flow Chart of Methodology

CHAPTER 4

RESULTS AND DISCUSSION

4.1   Introduction

All the data in this research were collected through questionnaire (in google form). This questionnaire purpose is focused on the main criteria needed to select the best contractor in Malaysia and based on comparison in scale, we will find which criteria are more weighted through calculation of matrices.

In this research all the data were analyzed and the result will be presented by using pie chart, graph and bar chart. The main purpose analyzing the data collected is to get result which can achieve the objectives of the research.

This chapter is divided into two sections which consist of:

1. Section 1 : Personal Particular
2. Section 2 : Comparison of Criteria to Select Contractor (in scale)

4.2   Questionnaire Collection

The questionnaire has been distributed through Google form to various types of company and organization in construction field. However, only 13 set of questionnaire were managed to get response and filled accordingly.

Table 4.1   Number of Responses

|	Timestamp	Name (not compulsory)	Gender	Experience (years)	Position	Company / Organization
1						
2	1/7/2018 22:29:53	Laila Maliqei	Female	1	Engineering assistant	Consultant
3	1/7/2018 23:44:28		Male	0.8	Resident architect	Architectural Firm
4	1/8/2018 13:34:23		Male	12	Resident architect	Consultant
5	1/8/2018 14:28:12		Female	28	Engineer	Consultant
6	1/8/2018 17:27:23	Raihana Hazali	Female	10	Admin	Consultant
7	1/8/2018 21:31:32	Nurul	Female	2	Draughtperson	Authority
8	1/10/2018 16:02:53	Azila	Female	6	Civil & structural engineer	Consultant
9	1/11/2018 14:42:14		Male	4	Site supervisor	Authority
10	1/11/2018 17:37:18	JAZMI BIN MOHAMED JABAR	Male	20	MANAGING DIRECTOR	Architectural Firm
11	3/12/2018 11:07:42		Female	10	Engineer	Authority
12	3/12/2018 11:10:24		Male	20	Site engineer	Authority
13	4/3/2018 20:30:29	HARMUNI	Female	3	engineer	Consultant
14						
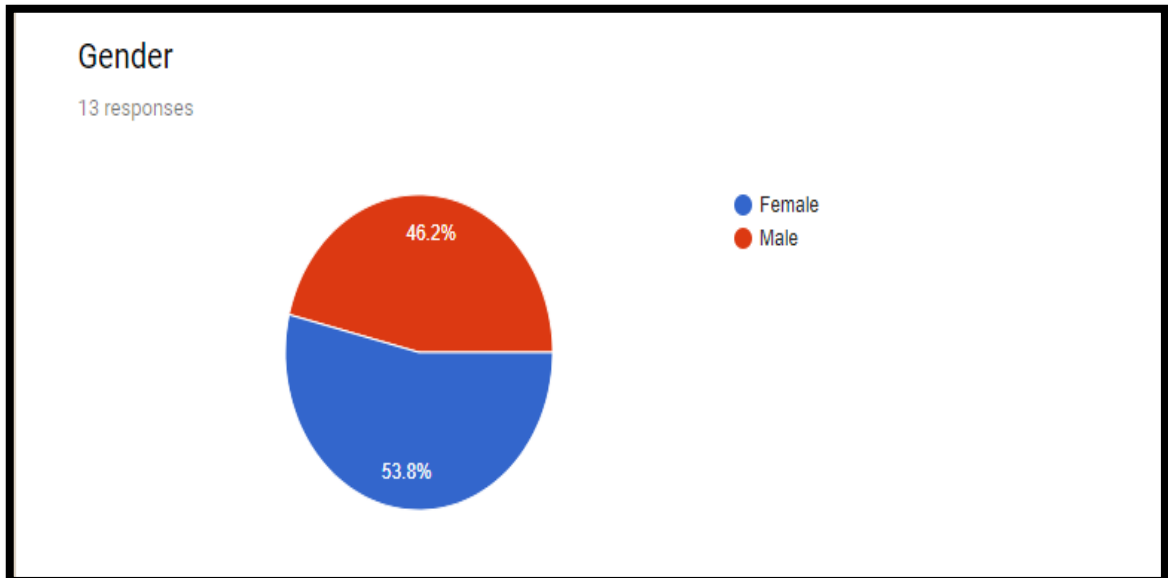
Figure 4.1   Percentage of Gender

4.3   Responses

According to (Saaty, 1980), in case of AHP analysis there are no pre-set rules to determine the acceptable sample size of experts. One expert judge may be sufficient unless political practicality requires that several judges from different constituencies are necessary. In AHP methods it is a special case where there no limit responses needed to get a weighted for result of our analysis which using matrices means that to obtain valid and consistent judgments of questionnaire. This is because when using analytic hierarchy process, the expert person in construction industry will involve. Besides, a judge is experienced and well versed in an area, he or she can be sufficient to provide the judgments instead of diluting his accuracy with the participation of others who may not be as good (Saaty & Ozdemir, 2015)

It is very different when one collects judgments in the AHP. Generally, AHP applications are concerned with three different ways to frame the pair wise comparison questions. The first is to ask which of the pair of elements is more dominant or important with respect to an attribute or criterion, the second is to ask which is the more likely outcome as in the presidential elections and the third is to ask which element is preferred with respect to the attribute, recognizing that preference is entirely. We believe that the preference question can be answered by sampling as is done in statistics, and any judge can be free to express his or her preference. Validation with respect to what can happen out there is of no consequence in preference choices. Answering both importance and likelihood questions requires what is known as expert knowledge in the subject in which the decision is made (Saaty & Ozdemir, 2015).

What is particularly useful in the AHP is that the judges themselves can be assigned priorities that make the judgments of a high priority judge count more than those with lower priority. This is done by raising their individual judgments to the power or the respective judges' priorities, then taking the geometric mean, thus extending more weight to those judges that are believed to have more expert knowledge. It is done not according to sample size as in taking statistics about preference, but according to how much and how well they know the subject, based on some criteria such as education, years of experience and etc (Saaty & Ozdemir, 2015).

4.4   Personal Particular

In Section 1 of the questionnaire, the respondents were asked to fill in their personal particular. All compulsory to fill it but for name is not compulsory. The personal particulars of the respondents are shown in the next discussion.

4.4.1   Designation

Based on the questionnaire, the designation that involved were expert that involved in construction industry which is client, contractor, consultant, architect, government or others. Most of respondents that answered the questionnaire were engineers and least was architect. They all must have a certain level of professional knowledge and ability to give an opinion in the questionnaire.
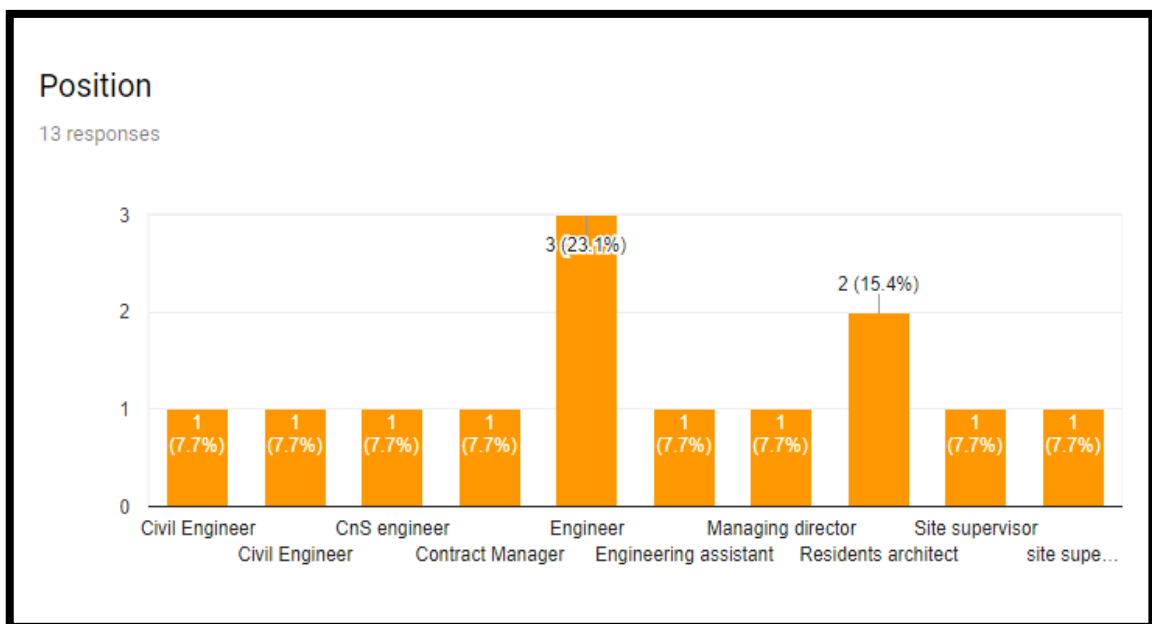
Figure 4.2   Respondents Designation

4.4.2   Type of Company

Through this research, the questionnaire had been distributed to various types of company in different type of field in construction industry. This had been done in order to gain information about the main criteria needed to select the contractor and get the result through weighted solution.

From the respondent of the questionnaire, the most response comes from C&S Company. The amounts of respondents were followed by C&S (50%), Developer (client 26%), Architectural Firm (16%) and Authority (8%).
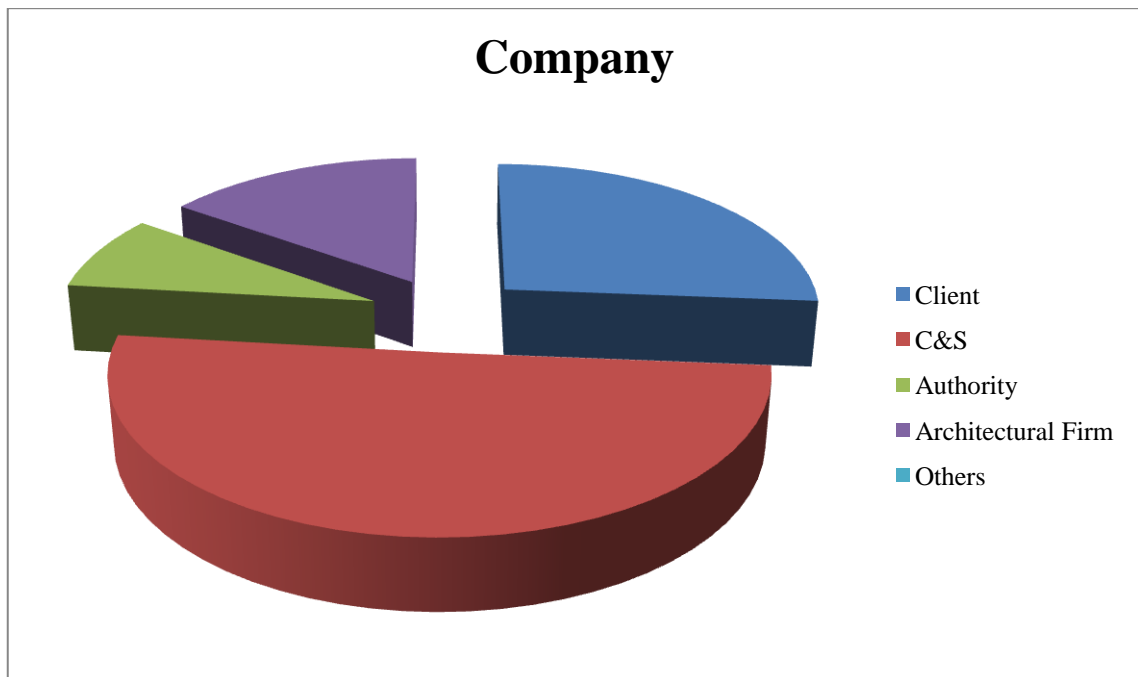
Figure 4.3   Types of Company

4.4.3 Duration Individual had Experience in Construction Field

The respondents were asked about the duration of their experience in construction industry. Most of the respondents have an experience in this field from five years and above which means they are expert through this industry.

Figure 4.4   Experiences of Individuals in Construction Industry

4.5 Level of Knowledge on choosing the Best Criteria (Contractor)

In Section 2, the knowledge about what are the best Criteria needed in Selection of Contractor was asked. Besides, their answer (in scale) will calculate used AHP method to find which criteria more weighted and the best to select contractor.

4.6   Weighted Criteria

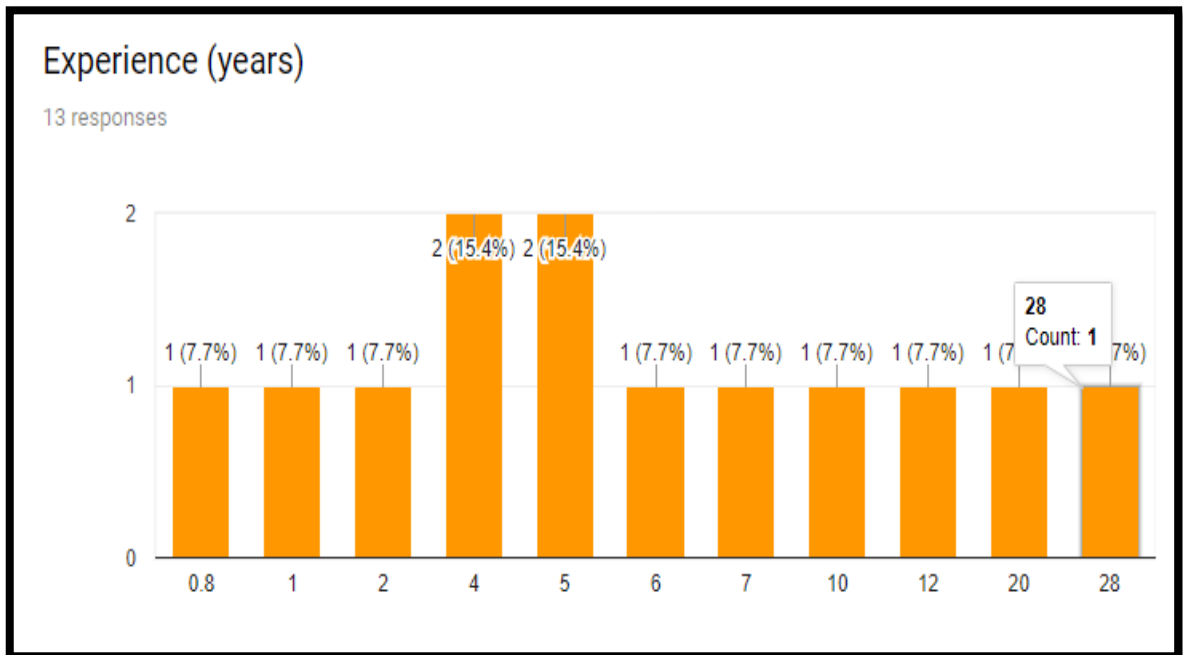The result weighted (priority vector) from the calculation of matrices in excels give which criteria are more preferred from expert in construction industry to select the best contractor in Malaysia. Table 4.2 shown the result weighted (matrices) in excels.

From the table 4.2 below (through 13 respondents) it can be shown that the result is more weighted in criteria of Financial Capability needed to select contractor. Follow criteria of Past Performance, Past Experience, Resources, Current Workload and Safety Performance.

Table 4.2

Criteria / Respondent	Financial	Past Performance	Past Experience	Resources	Current Workload	Safety Performance
1.	0.4716	0.2486	0.1581	0.0835	0.0318	0.0064
2.	0.5024	0.2573	0.1238	0.0756	0.0356	0.0053
3.	0.5107	0.2429	0.1303	0.0742	0.0347	0.0073
4.	0.5389	0.2347	0.1135	0.0709	0.0351	0.0068
5.	0.4578	0.2642	0.1528	0.0876	0.0307	0.0068
6.	0.4584	0.2556	0.1652	0.0581	0.0566	0.0060

7.	0.4433	0.2405	0.1847	0.0845	0.0402	0.0068
8.	0.4460	0.2727	0.1730	0.0596	0.0413	0.0074
9.	0.4598	0.3141	0.1063	0.0879	0.0262	0.0057
10.	0.4964	0.2428	0.1477	0.0835	0.0248	0.0048
11.	0.5029	0.2370	0.1491	0.0769	0.0297	0.0044
12.	0.5300	0.2096	0.1548	0.0664	0.0331	0.0060
13.	0.4970	0.2728	0.1440	0.0278	0.0278	0.0060

4.6.1   Consistency Index and Consistency Ratio

After get the weighted result, we need to check the consistency of the result. Once judgments have been entered, it is necessary to check that they are consistent *(Saaty, 1980)*. Since the calculation of the consistency ratio was calculate by using manual excels which it is easily performed.

a) Prof Saaty proved that for consistent reciprocal matrix, the largest Eigen value is equal to the number of comparison, or $\lambda_{sum} = n$ (eq.1).

b) Prof Saaty also proposed that we use this index by comparing it with the appropriate one called Random Consistency Index (RI).

c) For value of n is equal to 6 of criteria selected from AHP method (refer table 4.3).

d) Consistency Ratio is a comparison between CI and RI in (eq. 2).

e) By using manual excels calculation, the consistency ratio is easily performed. The result as shown in table 4.4 below.

The inconsistencies are tolerable, and a reliable result may be expected from the AHP. In RI is the Random Index shown in table 4.3:

Table 4.3   Random Consistency Index

m	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

If the value of Consistency Ratio is smaller or equal to 10%, the inconsistency is acceptable. If the Consistency Ratio is greater than 10%, we need to revise the subjective judgment *(Saaty, 1980)*. From table 4.4 shown that only 8 respondent (red colour) was acceptable for consistency ratio which is <10% and other 5 respondent are rejected because the consistency ratio >10%.

Table 4.4   Result of Consistency

Criteria / Respondent	Consistency Index	Consistency Ratio (<10%)
1.	0.0428	0.0342
2.	0.0071	0.0058
3.	0.0586	0.0473
4.	0.0860	0.0693
5.	0.0147	0.0119
6.	0.0847	0.0689

7.	0.0435	0.0351
8.	0.0331	0.0267
9.	0.1718	0.1386
10.	0.2020	0.1629
11.	0.2648	0.2136
12.	0.1671	0.1348
13.	0.1381	0.1114

4.6.1.1 **Comparison Weighted**

For comparison weighted result in selection of contractor from journal that I refer *(Almeida, 2017)* state that Financial Capability (0.497) is most important criteria in selection of good contractor in construction industry in Malaysia. Followed by Past Performance (0.200), Resources (0.089), Safety Performance (0.085), Current Workload (0.070) and Past Experience (0.063). Otherwise, their consistency ratio is 0.086 which is less <0.10 that are acceptable. Through my result for this topic we can refer table 4.2 above (average value from 13 respondents) shows that the most important criteria to select contractor is Financial Capabilities. Other than that, follow by Past Performance, Past Experience, Resources, Current Workload, and Safety Performance. Furthermore, for consistency ratio refer in table 4.4 shown that only 8 respondents was acceptable which means that their CR <0.10 and other than that their CR>0.10 was rejected.

4.6.1.2 Geometric Mean

In AHP, we used geometric mean rather than arithmetic mean because it involves reciprocal value during matrices. When use geometric mean instead of arithmetic mean you are preserving ratios instead of intervals *(James, 1968)*. Afterwards the weighted geometric mean method (WGMM) could be used to obtain the group judgment for each entry of the comparison matrices *(Saaty, Forman, & Peniwati, 1989;1998)*. Hereby, the arithmetic mean should not be used which is due to the non-reciprocity (power conditions) of the collective pair wise comparison matrices *(Aczel & Saaty, 1983)*. Table 4.5 shown the result that get from 8 respondents which their consistency is accepted.

Table 4.5   Geometric Mean

Criteria	Geometric Mean
Financial Capability	0.4776
Past Performance	0.2518
Past Experience	0.1483
Resources	0.0735
Current Workload	0.0376
Safety Performance	0.0066

CHAPTER 5

CONCLUSION

5.1 Introduction

In this chapter, for the conclusion and recommendation will be discussed properly. Conclusion about all objectives of the research which mention in chapter 1 will be briefly discussed. Furthermore, through the analysis and observation of the result in chapter 4, all the objectives meet its requirement. Besides, some recommendation was listed to get the best criteria needed to select contractor in Malaysia.

5.2 Conclusion

For overall, there are three (2) objectives which have been achieved to conclude for this study. There are:

i. To identify and study the main criteria in selection of contractor.

ii. Identify the weighted criteria by using Analytical Hierarchy Process.

5.2.1 Objective 1: To identify and study the main criteria in selection of contractor

For this final project, the first objective was achieved through the literature review in chapter 2. From there, the information shows that selection of contractor is an important in construction industry nowadays in Malaysia. This is because to avoid project given not completed within time and cost also with standard quality.

5.2.1 Objective 2: Weighted criteria using AHP method

In identify what is more weighted criteria needed in selection of contractor by using Analytic Hierarchy Process, some information was gathered through literature review. *(Saaty & Brunnelli, 2012;2015)* Through AHP method we can develop a model for the decision where break down the decision into hierarchy of goals and criteria. Furthermore, we derive the priorities (weights) for the criteria to select the best contractor. The importance criteria are compare pair wise with respect to the desired goal to derive their weights. After that, check the consistency of judgments which means that it is a review of the judgments is done in order to endure a reasonable level of consistency.

5.3 Making a Final Decision

Once all steps have been completed, the decision possible to make in our AHP analysis. Comparison will be make with overall weighted (priorities) obtained and know the differences weights large enough to make a clear choice. From the result analysis in chapter 4 the best criteria needed to select the contractor is Financial Capability. Follow with Past Performance, Past Experience, Resources, Current Workload and Safety Performance. It is also necessary to analyze the results of the consistency judgments where *(Saaty, 1980)* state that consistency ratio need to smaller or equal to 10% (0.1) the inconsistency is acceptable. If the consistency ratio is greater than 10%, we need to revise the subjective judgment (means that their judgment not

accepted). Through result analysis in chapter 4 shown that from 13 respondent only 8 respondent get consistency ratio < 10% (accepted) and 5 respondent have >10% consistency ratio (where rejected). In addition, the Geometric Mean for every criteria with only 8 respondents (who are accepted) for financial capability 0.4776, past performance 0.2518, past experience 0.1483, resources 0.0735, current workload 0.0376 and safety performance 0.0066.

5.4 Summarized Responses

As we can see that, it is not necessary for number acts as a reliable measure of wisdom and sanity. *(Saaty & Ozdemir, 2015)* state that to engage judges to help with a decision should not be a random matter. One needs to know the area of expertise needed to make that decision and select a judge or judges that have both knowledge and practical experience with the matter. In this case one expert judge may suffice unless political expediency requires that several judges from different constituencies are necessary. In that case one might select several judges if they are available.

5.5   Recommendation

From the analysis and personal side view, there are several recommendations to manage criteria needed in selection of the best contractor in construction industry:

a) In Malaysia, for construction industry we must be exposed to what the important criteria need to select the good contractor even in authority or private sector.

b) All future engineers must be informed well about the standards from JKR of the criteria needed in selection of contractor in Malaysia.

c) Authority and parties involve in construction industry should identify the other important criteria need to select the contractor where the project given will completed within cost and time also follow standards quality which has been set.

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Section 1 of 2

Selection of Contractor (Main Criteria) Survey

As part of my research thesis for Final Years Project at the University Malaysia Pahang, i am conducting a survey for topic "Selection of Contractor using Analytical Hierarchy Process (AHP). AHP method using a set of criteria for a decision making that derive ratio scales from paired comparisons.Choose only one (1) answer for every questions. I will appreciate if you could complete the following table. Any information obtained in connection with this study that can be identified with you will remain confidential.

Name (not compulsory)

Short answer text

Gender *

○ Female

○ Male

QUESTIONS   RESPONSES   12

Experience (years) *

Short answer text

Position *

Short answer text

Company / Organization *

○ Client

○ C&S

○ Authority

○ Architectural Firm

○ Other...

Questionnaire (Survey Data)

(LEFT SIDE SCALE) VS (RIGHT SIDE SCALE)

How much more important do you think
Financial Capability is than Past Performance in
selection criteria of Construction Contractor?

Multiple choice grid

Rows	Columns	
1. Financial Capability VS Past Performance	○ 9	×
2. Add row	○ 7	×
	○ 5	×
	○ 3	×
	○ 1	×
	○ 3	×
	○ 5	×

How much more important do you think Financial Capability is than Past *
Experience in selection criteria of Construction Contractor?

	9	7	5	3	1	3	5	7	9
Financial ...	○	○	○	○	○	○	○	○	○

How much more important do you think Financial Capability is than *
Resources in selection criteria of Construction Contractor?

	9	7	5	3	1	3	5	7	9
Financial ...	○	○	○	○	○	○	○	○	○

How much more important do you think Financial Capability is than Current *
Workload in selection criteria of Construction Contractor?

	9	7	5	3	1	3	5	7	9
Financial ...	○	○	○	○	○	○	○	○	○

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How much more important do you think Financial Capability is than Safety performance in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Financial ...	○	○	○	○	○	○	○	○	○

How much more important do you think Past Performance is than Past Experience in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Past Perf...	○	○	○	○	○	○	○	○	○

How much more important do you think Past Performance is than Resources in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Past Perf...	○	○	○	○	○	○	○	○	○

How much more important do you think Past Performance is than Current Workload in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Past Perf...	○	○	○	○	○	○	○	○	○

How much more important do you think Past Performance is than Safety Performance in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Past Perf...	○	○	○	○	○	○	○	○	○

How much more important do you think Past Experience is than Resources in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Past Expe...	○	○	○	○	○	○	○	○	○

How much more important do you think Past Experience is than Current Workload in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Past Expe...	○	○	○	○	○	○	○	○	○

How much more important do you think Past Experience is than Safety Performance in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Past Expe...	○	○	○	○	○	○	○	○	○

How much more important do you think Resources is than Current Workload in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Resource...	○	○	○	○	○	○	○	○	○

How much more important do you think Resources is than Current Workload in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Resource...	○	○	○	○	○	○	○	○	○

How much more important do you think Resources is than Safety Performance in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Resource...	○	○	○	○	○	○	○	○	○

How much more important do you think Current Workload is than Safety Performance in selection criteria of Construction Contractor? *

	9	7	5	3	1	3	5	7	9
Current W...	○	○	○	○	○	○	○	○	○

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