CONTRACTOR PREQUALIFICATION PRACTICES IN BANGLADESH

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Contractor Prequalification Practices in Bangladesh

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ABSTRACT

Like many developing economies, the construction industry in Bangladesh is vital to its economic development and growth. However, the Bangladeshi construction industry is plagued by unethical practices, sub-standard construction work, and the inability of local contractors to partake in internationally funded (lucrative) contracts (as general contractors). A contractor prequalification process is proposed to address the problems facing the industry.

In this work, an extensive literature review was used in combination with research surveys, statistical analyses of the literature and survey results, and the analytical hierarchy process to develop sets of factors and criteria pertinent to contractor prequalification/selection. A five-level framework involving regulatory verification, project-specific validation, performance evaluation, state-of-the-art best practices, and capacity assessment was developed to address the problem. This research developed innovative practices that could be used for the prequalification of contractors in Bangladesh and a method for implementing a recommended system for evaluating and prequalifying contractors.

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DEDICATION

To my parents; brothers; sisters; and, especially, my elder brother,

Mohammad Syful Islam Molla

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LIST OF EQUATIONS

LIST OF ABBREVIATIONS

ASCE……..American Society of Civil Engineers

CPTU……..Central Procurement Technical Unit

CR……..Initial Consistency Ratio

FY……Fiscal Year

GDP……...Gross Domestic Mean

Min……..Minimum

Max…….Maximum

NDSU……..North Dakota State University

LCL……..Lower Control Limit

PPR……Public Procurement Rules

RII……Relative Importance/Impact Index

UCL……..Upper Control Limit

USAID……United States Agency for International Development

LIST OF SYMBOLS

g……Group Number

i……..Row Number

j…….……Column Number

k…….Size of Likert Scale

K ……Cohen Kappa Coefficient or Agreement Index

n……Total Number of Factor

n_1……..Number of Responses with “Very High Impact”

n_2 ……Number of Responses with “High Impact”

n_3 ……Number of Responses with “Moderate Impact”

n_4 ……Number of Responses with “Little Impact”

n_5 ……Number of Responses with “No Impact”

N……Total Number of Responses Counted on Each Likert Scale Category

P_e ……Expected Proportion of Agreement

P_j ……..Marginal Distribution of Agreement

P_m ……Maximum Proportion of Agreement

P_o ……Observed Proportion of Agreement

R……Total Number of Respondents

TI……Total Importance of a Factor

λ_{max}.....Eigen Value

$\bar{\lambda}_{max}$ ……Average Eigen value

α ……Confidence Level

α_1.....Allowable Consistency Ratio

$.....United States Currency

μ……..Statistical Mean Value

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1. INTRODUCTION

1.1. Background

The European Commission Asia Investment Facility (2001) reported that Bangladeshi contractors are being used as subcontractors by international contractors for major internationally funded projects. Studies have shown that Bangladeshi contractors are not considered to be as capable as other contractors when evaluated during the prequalification process for international projects. Studies also showed that Bangladeshi contractors are not capable of satisfying the prequalification criteria specified by foreign contractors.

Khan and Rasheduzzaman (2008) discussed the Bangladeshi bidding process in a *Transparency International Bangladesh* report. They stated that the last two governments were not capable of managing the bidding process, resulting in a power crisis in Bangladesh. Bidders, journalists, and decision makers complained, and some individuals initiated lawsuits about the corrupt bidding processes in Bangladesh.

Khan and Rasheduzzaman (2008) stated that the Official Secret Act of 1923 created a method for secret bid evaluations. As a result of this act, the bidding process, the bid evaluation process, and the evaluation criteria used for bids are not allowed for disclosed to the bidder, the media, and the general public.

One of the studies performed by Ullah (2000) found that the Bangladeshi government did not include the construction industry in its economic plan until the year 2000. No initiative was undertaken to evaluate the construction industry although, at the end of the twentieth century, gross domestic product (GDP) was forecasted to be between 6.2% and 7%. Although there are approximately 25,000 local contracting firms classified as class one, two, or three, most contractors were not competitive with foreign contractors. Bhattacharya, the executive director at the Center for Policy Dialogue Bangladesh (2003), stated that the Bangladeshi housing sector, which is part of the construction industry, is now expanding compared to earlier decades.

According to Khan and Rasheduzzaman (2008), several issues that have been raised by the World Bank and that are part of the bidding process are as follows (Khan and Rasheduzzaman, 2008):

- Poor advertising
- Short bidding period
- Poor specifications
- Nondisclosure of selection criteria

- Awarding contracts by a lottery
- One-sided contract documents
- Negotiating with all bidders
- Rebidding without adequate grounds
- Corruption and outside influences
- Other miscellaneous irregularities.

Khan and Rasheduzzaman's studies also showed that bidders get frustrated due to several complexities and interventions (2008):

- Inefficiencies in order to attaining final approvals
- Delayed processes
- Complications and the increased costs to bid on projects.

Therefore, there is a need to establish a fair and transparent set of factors that could be used to select contractors. This study has developed standard practices to prequalify contractors in Bangladesh and has outlined methods for implementing the recommended system.

1.2. Problem Statement

Contractor prequalification is a multivariate decision-making process which could be used to pre-select contractors who are then asked to submit bids for projects, work, goods, and services in the construction industry. Decision inputs from owners and consultants (based on agreements between the two groups about a particular criterion) could influence decisions during the prequalification process.

The contractor prequalification process is a multi-variable decision support system that requires input from varied qualitative and quantitative information. Construction projects are risky, and there are always uncertainties present for each project. A systematic, contractor-prequalification process would reduce the risks and uncertainties. The early stage of the bidding process is the prequalification phase. The prequalification process could be used for any type of project work, goods, or services.

Enshassi *and Nayrab* (2010) stated that bidding decisions can affect business success, which means that the resulting output is based on decision inputs. Elyamany (2010) stated that large contractors with more experience are competing against small contractors and that small contractors could bid lower prices. Therefore, when the bid specifications and the contract require the selection of the lowest cost bidder, project performance and quality could be jeopardized.

Hatush and Skitmore (1997) explained the necessity of contractor selection. They indicated that the contractor prequalification, evaluation, and selection process as well as the criteria used are elementary even though project complexity and client needs have increased during the last two decades. Bubshait and Al-Gobali (1996) stated that bid evaluation is one of the most vital functions in project management. Proper contractor selection affects the project's success or failure. They also stated that owners and contractors benefit from an effective bid-evaluation method. With a proper bid-evaluation system, owners would be able to select competent, financially capable, and experienced contractors. Contractors would be able to decide whether they should bid on projects. Russell (1996) stated that the best prices, with a higher-quality contractor, could be obtained by practicing appropriate contractor-evaluation techniques.

In order to evaluate the bid prequalification process for the Bangladeshi construction industry, the most important criteria that influence the contractor's bid prequalification process need to be identified. The criteria are based on agreements between owners and consultants because these two parties are usually responsible for the bid decision making process. This study developed standard practices for the contractor bid prequalification process in Bangladesh as well as methods for implementing recommendations to create a fair and transparent system for contractor evaluations.

1.3. Research Objective

The primary objectives of this research were to identify the criteria used by consultants and owners to select contractors, to create a weighted model, and to develop a decision model hierarchy framework (DMHF) using an analytical hierarchy process (AHP)for the contractor's bid prequalification process in the Bangladeshi construction industry. The specific goals of the research are as follows:

- Identify the factors that should be considered during the contractor's bid prequalification phase
- Study the statistical significance of each bid prequalification criterion and its relative importance index and ranking
- Identify the contractor's bid prequalification criteria based on mutual agreement between owners and consultants
- Compare the results obtained in Bangladesh with the results from the United States and Saudi Arabia

- Develop a weighted model of clustered bid prequalification criteria using an analytical hierarchy process
- Develop a decision model hierarchy framework for the contractor's bid prequalification process.

1.4. Research Methodology

The research was conducted in ten main phases. Phases one and two included the development of research goals, research proposals, and a literature review. Phase three included the data collection and analysis procedures. Phases four to ten were designed to achieve each research objective.

- Phase One: Identifying the research objectives and developing the research plan
- Phase Two: Conducting a thorough literature review related to contractors' bid prequalification, bid evaluation, contract selection, and assessment
- Phase Three: Developing a questionnaire to investigate the criteria that should be considered to help minimize the risk and uncertainty in the bid process, and to conduct a survey to determine outcomes for the research objectives
- Phase Four: Performing a detailed statistical analysis of the survey data using Minitab statistical software and Microsoft Office software
- Phase Five: Determining the relative importance index and ranking for the surveyed bid prequalification criteria
- Phase Six: Determining the surveyed bid prequalification criteria based project owners and consultants' mutual agreements
- Phase Seven: Comparing the results obtained in Bangladesh with results from the United States and Saudi Arabia based on the relative importance index and clustering
- Phase Eight: Developing a weighted model for each cluster using an analytical hierarchy process method
- Phase Nine: Developing a decision model hierarchy framework for contractors' bid prequalification processes
- Phase Ten: Discussing the results, conclusions, and recommendations for the Bangladeshi construction industry and the thesis.

1.5. Research Contributions

This study provides a framework with a set of criteria for selecting contractors during the bid prequalification stage. There are many groups inside and outside the engineering and construction industry that will benefit from this research, including clients; contractors; government agencies; academia; industry experts; and members of the engineering and construction community, especially the Bangladeshi construction industry. This study also provides the bid prequalification criteria recommended for construction work, design and build infrastructure service. The bid prequalification criteria are also recommended for unit price, negotiated, design-build/turnkey, sealed bid, and construction-management contracts for private and/or public projects. This research developed a weighted model using an analytical hierarchy process, and the decision model hierarchy framework can contribute to developing national standards and guidelines for the contractors' bid prequalification.

1.6. Outline of the Thesis

Apart from this chapter, there are five other chapters and two appendixes.

- Chapter 2 presents the Literature Review for the contractors' bid prequalification process in Bangladesh, global practices, and the existing research.
- Chapter Three is the Research Methodology.
- Chapter Four presents the data analysis and results. It includes the questionnaire design, the methods of analysis, an analysis of the results, and a discussion of the results.
- Chapter Five discusses the proposed and developed weighted model and decision model hierarchy framework for the contractor's bid prequalification process.
- Chapter Six presents the conclusions and recommendations for the Bangladeshi construction industry as well as recommendations for further studies.
- Appendix A supplements these chapters, and it contains the questionnaire.
- Appendix B supplements these chapters, and it contains the appendix tables.

2. LITERATURE REVIEW

2.1. Definition of the Bid Prequalification Process

Bid prequalification is a preliminary stage in the bidding process where it is determined if a bidder has the ability to meet the specific qualifications required to complete the construction project. During the prequalification process, potential contractors, suppliers, bidders, or vendors are screened on the basis of factors such as experience, financial ability, managerial ability, reputation, work history, etc. A list of qualified bidders is then developed, and it is used to send the invitation-to-bid documents.

Minchin, Jr. and Smith (2001) stated that bid prequalification was consistently undefined. They also quoted Nettleton's (1948) definition: "prequalification as the determination of the responsibility of each contractor to satisfactorily undertake and complete a certain construction project before the issuing of plans, specifications, and proposals. It is an extension of the principle applied to the professions of law, medicine, and engineering in which persons must have a certain understanding of appropriate theory and applicable experience to be licensed for business" (Minchin, Jr. and Smith, 2001, p. 6).

2.2. Responsibility of the Bidders

The main aspect of bid prequalification is to identify highly responsible contractors who could be invited to bid on projects. Minchin, Jr. and Smith (2001) stated that irresponsible bidders are not able to show the skills required to undertake the project. They also included information from Thomas *et al.* (1985) about the responsibility of bidders (Minchin, Jr. and Smith, 2001, p. 7):

- Financial strength and resources of the contractor
- Documented skill of the contractor and subcontractors on previous contracts
- Judgment, which includes financial and construction management
- Overall experience in the construction industry as well as experience of the key personnel who execute the work
- Integrity of the officers to ensure they have not been involved in previous wrongdoing or contract crimes
- Previous performance, which evaluates the contractor's quality of construction and ability to complete the project within the goals of time, quality and cost
- Ownership of equipment or the ability to rent or lease equipment needed to perform the project.

- Ability to perform in accordance with the contract
- Ability to acquire bonding from an established and reputable surety
- Conformity to the goals and objectives of affirmative action plans" (Minchin Jr. and Smith, 2001).

Therefore, before awarding a contract, a systematic contractor bid prequalification-and-evaluation process may facilitate scrutiny of the contractor based on several requirements, such as financial stability, resources, capability, regulatory information, state-of-art best practices, performance, etc. The acceptability of bidders could be demonstrated through a background check which includes factors in their bid prequalification, such as financial situation, resources, experience, claims history, etc.

2.3. Necessity of Bid Prequalification

First, it is necessary to understand why the contractor bid prequalification should be adopted. In this regard, advantages and disadvantages of contractor bid prequalification are studied. There are several advantages for contractor bid prequalification. Minchin, Jr. and Smith (2001) stated that the prequalification process has both advantages and disadvantages that have been discussed by Lower (1982), Hauf (1976), Nettleton (1948), and Russell (1996). The following advantages for bid prequalification are given by Minchin, Jr. and Smith (2001, p. 8):

- The prequalification process will create a level playing field for bid competition, where small, medium and large contractors can submit bids
- Identify and remove incompetent bidders and prepare a qualified list of bidders
- Produce a structured and organized system
- Substantially increase both bid process handling time and cost
- Eliminate bias issues of the lowest price bid award system
- Identify competent, successful, qualified and quality contractors.

It can be seen that, by using a bid prequalification process for contractors, project owners could benefit in several ways. Owners may be able to identify competent, successful, qualified, and quality contractors before awarding any contract. Owners could produce an efficient system to reduce bid processing time and cost, including bias elimination.

2.4. Influence of the Construction Industry in the Global Economy

Bangladesh did not consider the construction industry as an individual sector until 2000. Currently, the construction industry is considered a sub sector of the industry sector for Bangladesh's national budget. Therefore, it is necessary to look at how the construction industry is contributing to the global economy.

According to the World Economic Forum's Construction and Engineering report (2008) , the world economic recession changed the business environment into a zero-investment game. As their demands increase, cost-oriented owners who work internationally create hardships for engineering and construction companies. A 2006 CEO survey indicated that engineering and construction business environments are changing significantly. Currently, this sector is operating and searching for long-term goals and multi-stakeholdership. In order to respond to customers' demands, these industries have been proactively preparing long-term plans even though a majority of the risks are unknown. The 2006 CEO survey showed that, for the first time, more than 50% of the world's population lives in urban area.

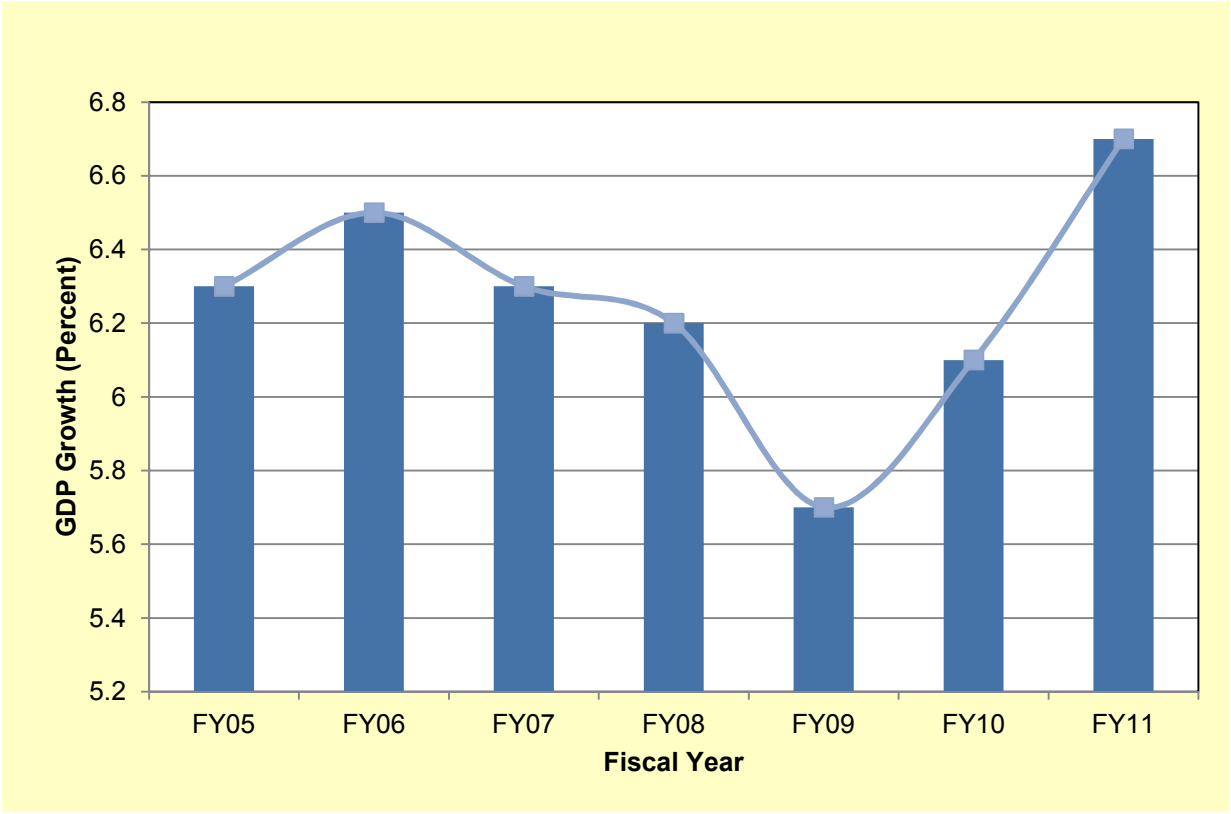
Infrastructure development depends mainly on a community's population and economic growth. Earlier studies by the World Economic Forum's Construction and Engineering report (2008) suggest that, in developing countries, 71% of the population will live in urban areas by the year 2020, that will create increased demand for engineering and construction industry sources. The Economy Watch (2010) stated that the construction industry is an important sector and one of the biggest industries in the world economy. The construction industry contributes approximately 10% to the global GDP, and approximately 7% of the total employed population is employed in this sector. The United Nations (2012) states that the construction sector is experiencing strong economic growth in developing countries. Therefore, the previously mentioned studies show that the engineering and construction industry has a major influence on the world economy and is contributing significantly.

2.5. Influence of the Construction Industry on Bangladesh's Economy

In a previous section, it was shown that the construction industry is contributing significantly to the global economy. In order to see how Bangladesh's economy is influenced by its construction industry, a literature review was conducted.

The United States Agency for International Development (2010) stated that the Bangladeshi economy had a slight increase in private investment primarily due to the construction sector. After the global financial crisis, the Bangladesh Bank (2011) declared that Bangladesh's economy received some positive momentum during fiscal year 2011 due to investment and strong domestic demand. However, rising global food and fuel prices, deteriorating remittances, an increased reserve drawdown, and stock market volatility and its potential impact on the banking sector were all short-term risks for the Bangladeshi economy.

Table 2.1 and Figure 2.1 show that, according to the Bangladesh Bureau of Statistics (Bangladesh Bank 2011), the GDP was the highest at 6.7% in fiscal year 2011, which is 0.6% higher than fiscal year 2010. In fiscal year 2010, strong growth was experienced in the industrial service sector.



Data Source: Bangladesh Bureau of Statistics (Bangladesh Bank, 2011)

Figure 2.1. Bangladesh's Real GDP Growth

Table 2.1 shows that the construction sector is part of the industry sector. The industry sector, which contributed 30.4% of the GDP, exhibited a robust growth of 8.2% in fiscal year 2011, compared to 6.5% in fiscal year 2010. This robust growth was caused by strong growth in the manufacturing and construction subsectors which recorded growth of 9.5% and 6.4%, respectively, in fiscal year 2011, compared to 6.5% and 6.0% in fiscal year 2010. The accelerating growth was mainly due to investments in large- and medium-scale industries.

Table 2.1. Sector Gross Domestic Product Growth in Bangladesh from 2008 to 2011

SL	Main Category	Second-Level Category	Third-Level Category	2008	2009	2010	2011
1	Agriculture			3.2	4.1	5.2	5.9
		Agriculture and		2.9	4.1	5.6	4.8
			Crops and horticulture	2.7	4.0	5.1	5.0
			Animal Farming	2.4	3.5	3.4	3.5
			Forest and related services	5.5	5.7	5.2	5.4
		Fishing		4.2	4.2	4.2	5.4
2	Industry			6.8	6.5	6.5	8.2
		Mining and quarrying		8.9	9.8	8.8	4.9
		Manufacturing		7.2	6.7	6.5	9.5
			Large and medium scale	7.3	6.6	6.0	10.4
			Small scale	7.1	6.9	7.6	7.3
		Power, gas, and water supply		6.8	5.9	7.3	6.0
		Construction		5.7	5.7	6.0	6.4
3	Services			6.5	6.3	6.5	6.6
		Wholesale and retail trade		6.8	6.2	5.9	6.1
		Hotel and restaurants		7.5	7.6	7.6	7.6
		Transport, storage and communication		8.6	8.0	7.7	7.9
		Financial		8.9	9.0	11.6	9.4
			Monetary	8.4	9.1	10.5	8.8
			Insurance	10.0	8.4	14.9	11.1
			Other financial intermediation	12.5	11.1	15.1	10.8
		Real estate, renting, and business activities		3.8	3.8	3.9	4.0
		Public administration and defense		6.2	7.0	8.4	9.6
		Education		7.8	8.1	9.2	9.5
		Health and social		7.0	7.2	8.1	8.3
		Community, social and personal services		4.6	4.7	4.7	4.8
		Gross Domestic Product Growth		**6.2**	**5.7**	**6.1**	**6.7**

Data Source: Bangladesh Bureau of Statistics Data (Bangladesh Bank, 2011)

2.6. Bangladesh's Construction Industry Problem

The European Commission Asia Investment Facility (2001) reported that Bangladeshi contractors are being used as subcontractors by international contractors for major internationally funded projects. Studies illustrated that Bangladeshi contractors are not considered to be as capable as other contractors during the prequalification-process evaluations for international projects. Studies also showed that Bangladeshi contractors are not capable of competing with the specific prequalification criteria set by foreign contractors.

Khan and Rasheduzzaman (2008) discussed the Bangladeshi bidding process in a *Transparency International Bangladesh* report. They stated that the last two governments were not capable of carrying out bidding processes and that this failure created a power crisis in Bangladesh. Bidders, journalists, and decision makers complained, and some individuals initiated lawsuits about the corrupt bidding process in Bangladesh.

Khan and Rasheduzzaman (2008) stated that the Official Secret act of1923 created a gap or path for secret bid evaluations. With this act, the bidding process, evaluation process, and evaluation criteria are not allowed to be disclosed to the bidder, the media, and citizens.

One of the studies by Ullah (2000) found that the Bangladeshi government did not include the construction industry in economic plans until the year 2000. There have not been any new initiatives uncovered in the construction industry, although, at the end of the twentieth century, gross domestic product (GDP) was forecast to be 7%. Although there were a total of 25,000 local contracting firms, classified as class one, two or three, Bangladesh contractors were not able to compete with foreign contractors. Due to a lack of accurate data, the exact number of contracting firms was impossible to estimate.

Bhattacharya, the Executive Director at the Center for Policy Dialogue Bangladesh (2003), stated that the Bangladeshi housing sector, which is part of the construction industry, is growing. It is challenging to obtain accurate data in Bangladesh.

According to Khan and Rasheduzzaman (2008), several issues that have been raised by the World Bank (2005) and that are part of the bidding process are as follows (Khan and Rasheduzzaman, 2008, p. 28):

- Poor advertising
- Short bidding period
- Poor specifications
- Nondisclosure of selection criteria
- Awarding contracts by a lottery
- One-sided contract documents
- Negotiating with all bidders
- Rebidding without adequate grounds
- Corruption and outside influences
- Other miscellaneous irregularities.

Khan and Rasheduzzaman's (2008) studies also showed that bidders get frustrated due to several complexities and interventions:

- Inefficiencies in order to attaining final approvals
- Delayed processes
- Complications and costs for bidders.

The Literature Review revealed several issues about the Bangladeshi construction industry's contractor bid-prequalification, evaluation, and selection-process problems. It can be seen that the addressed issues originate from the owner's side. Therefore, there is a need to establish a standard, fair-and-transparent process that could be used to select contractors.

2.7. Recent Disasters in the Bangladeshi Construction Industry

Besides the owner-side originating issues for the bid prequalification, evaluation, and selection process, there were some issues resulting from contractors' performance and quality work. Recent collapses of several building structures led to an investigation report that found contractor failure. In this regard, Shafi (2010), during a roundtable discussion about the implementation of Bangladesh's National Building Code, discussed a recent disaster in the Bangladesh construction industry which included the following cases.

Case One: According to Shafi (2010), the Collapse of the Spectrum/Shahriyar Sweater Factory in Bangladesh, where 64 workers were killed and 80 persons were injured on April 11, 2010. *The Daily Star*, one of the newspapers in Bangladesh, reported the investigation officer for the case, Sub-Inspector Anwar Hossain of the Detective Branch of the Police, stated that, based on the Bangladesh University of

Engineering and Technologies expert reports, the factory structure failed mainly due to inadequate concrete work. Chief Engineer Emdadul Islam of Rajuk said the building collapsed due to overloading, the faulty laying of the foundation, and an improper use of construction materials. The building was constructed without permission from the Rajuk authority (Shafi, 2010).

Case Two: On June 1, 2010, Begun Bari, a five-story building, collapsed onto three tin-shed houses in the Tejgaon area at night, resulting in the deaths of 23 people. *The Daily Star* (2010) reported the main causes as faulty construction, supervision, and maintenance of the building. No rules or codes were followed by the contractor during construction. The building was also constructed using poor-quality materials (The Daily Star, 2010).

Case Three: According to Shafi (2010), during the Nimtoli Tragedy on June 3, 2010, a fire spread to 8 nearby structures and over 20 stores, killing 120 people at Nawab Katra in Nimtoli. It was also reported that 32 structures in the Nimtoli area were constructed without following the design requirements.

Case Four: In the collapse of the six-story building, Shankhari Bazar on June 10, 2004, nineteen people were killed, and 30 were injured. The building collapsed due to its age, which was approximated to be 200 years. A total of 91 buildings in the same location have been identified as having similar vulnerabilities (Shafi, 2010).

Case Five: A five-story building, Phoenix Garments, collapsed on February 25, 2006, killing 21 people. Faulty construction was the main reason for the collapse. The building was constructed without a construction permit (The Daily Star, 2004).

It can be seen that the Bangladeshi construction industry is plagued by unethical practices and sub-standard construction work. Therefore, to identify the flaws in Bangladesh's existing contractor prequalification process, it is necessary to review the entire process thoroughly.

2.8. Contractor Prequalification Practices in Bangladesh

The Bangladeshi government has *Public Procurement Rules of 2008 (PPR)* that replaced the *Public Procurement Act of 2006* to regulate the procurement of construction services in Bangladesh. The Bangladeshi procurement rules of 2008 apply to any government, semi-public, or private projects. In

order to implement PPR 2008, the following entities from the Central Procurement Technical Unit of Bangladesh need to be considered (Central Procurement Technical Unit, 2008, p. 13):

- Procurement of Goods, Works, or Services using public funds by a company registered under the Companies Act of 1994 (Act No. 18 of 1994).
- Procurement of Goods, Works, or Services under a loan, credit, or grant agreement or under any other agreement with a development partner or with a foreign state or an organization, provided that if there is anything to the contrary in any such agreement entered into, the provision of that agreement shall prevail.

According to government public notification, the Central Procurement Technical Unit (2008), when exercising powers conferred under sections 67 and 130 of the Public Procurement Act of 2006, the Central Procurement Technical Unit (CPTU) has the highest authority for implementing, monitoring, and controlling projects. The Central Procurement Technical Unit has developed a standard format for contract documents. Government departments, such as the Roads and Highways Department, Local Government and Engineering Department, Public Works Department, the Bangladesh Power Development Board, etc., use standard policies for contractor prequalification as outlined by the CPTU.

According to Bangladesh's existing laws, procuring entities may use prequalification procedures on large and complex projects, including projects that have the following characteristics:

- Construction >$5.0 Million
- Maintenance work >$0.5 Million
- Supplying and installing plant and equipment >$2.15 Million
- Designing and building infrastructure >$5.0 Million
- Custom designed equipment >$0.5 Million
- Management contractors >$5.0 Million

During the prequalification process, the following items from the CPTU should be considered (Central Procurement Technical Unit, 2008, p. 43):

A. Professional and Technical Capacity
    - Professional registration details and certificates

- Technical facilities, machinery availability, quality performance measure, and Research and Development opportunities
- Supplying material details with samples
- Technical and supervisory personnel plan

B. Financial Capacity

- Banking arrangements
- Statement of Transactions
- Annual Turnover

C. Legal Capacity

- Affidavit of declaration for claims and history
- Tax and Value Added Taxes certificate

It is an evident that the existing policies have some threshold frequency in terms of the contract amount for bid prequalification which includes six project categories: 1) construction, 2) maintenance, 3) designing and building infrastructure, 4) management contractors, 5) supplying and installing plants and equipment, and 6) custom designed equipment. According to PPR 2008, prequalification is not mandatory for any category. It can be seen that project categories 1, 3, and 4 may be applicable for contractor prequalification when the contract amount is more than $5 million, which seems to be an abnormality in the current prequalification system. Again, it is clear that government agencies are evaluating on the basis of limited requirements/criteria for the contractors, such as professional and technical ability, financial capacity, and legal capacity. This existing PPR 2008 lacks detail and a systematic contractor prequalification process.

2.9. Literature Review

In order to conduct the research investigation, it was necessary to study Bangladeshi and global practices for the bid prequalification process. Several prequalification systems and bid evaluation procedures are used globally, involving the development and consideration of a wide range of decision criteria that are used to evaluate the overall suitability of contractors. A review of the literature revealed the existence of various criteria, different information types, and different assessment methods.

The National Research Council (1994) of the United States stated that, by the middle of the nineteenth century, the U.S. government officials authorized criteria for prequalifying contractors during the bidding process in order to protect public funds, eliminate corruption, develop an efficient system, and prevent mismanagement. Studies showed that the majority of states use either prequalification or postqualification of contractors during the bidding process. The set of attributes used to evaluate a prospective contractor are financial capability (financial strength of the contractor at the time of qualification and the ability to obtain a bid, and performance and payment bonds for specific projects), managerial and technical ability, past experience (ownership of equipment or the ability to rent or lease the equipment needed to perform the project, managerial ability to provide the required labor or materials, the experience of key supervisory personnel, technical ability to perform, skills, and overall experience), performance evaluation (attitude, cooperation, and performance on state Department of Transportation projects; quality performance; and the ability to finish projects on time), and business practices of the principles to ensure that they or the company has not been involved in previous wrongdoing or infractions of agency policy. The National Research Council of the United States also mentioned that more than 75% of state Departments of Transportation are at least evaluating the financial and managerial strength of prospective contractors which also includes checking the debarment list maintained by the Federal Highway Administration. On the other side, the American Association of State Highway Officials, the Associated General Contractors (AGC), and the Bureau of Public Roads are following standard practices when selecting contractors (National Research Council, 1994).

Kumaraswamy (1996) investigated the bid evaluation criteria used in the Hong Kong construction industry. First, he categorized the criteria and then divided them into subcriteria. The major divisions were finance (financial stability and financial capacity), technology (techno-ware, info-ware, org-ware, and human-ware), personnel (managerial, supervisory, and operational skills), and experience (general work, specialized work, local/regional experience, and partners and subcontractors).

Assaf and Jannadi (1994) stated that, if any contractor is not qualified in the areas of experience, skill, integrity, and is not responsible or able to arrange financing in order to complete a job, then the result will be unsatisfactory, leading to the development of the multi-criteria decision model. The factors

used in their multi-criteria decision model for contractor bid prequalification and selection in Saudi Arabia were financial stability, experience, references, past performance, current workload, staff availability, manpower resources, company organization, office location, experience in the geographic location of the project, quality performance, failure to complete contracts, procurement experience, safety consciousness, and claim attitude (Assaf and Jannadi, 1994).

Bubshait and Al-Gobali (1996) identified the criteria for bid prequalification and ranked the criteria that should be considered in prequalification practices for semipublic and private projects in Saudi Arabia. Their results indicated that the criteria used to evaluate the process include contractor's experience, financial stability, past performance, quality performance, project-management capabilities, contractor failure records, management-staff availability, and contractor capacity. The results were compared with the United States and found to be similar. Sixteen factors were identified, and then grouped and ranked based on a relative importance index.

The Queensland, Australia, Department of Public Works (2011) used a best value for money concept. The idea is that the bidder who is most beneficial and produces higher returns for the investment will probably be awarded the project. In some cases, such as complex bid evaluation, the Department of Public Works use warranted commissioning of a probity auditor (Queensland, Australia, Department of Public Works, 2011).

Hatush and Skitmore (1997) discussed the bidding criteria that are used in the United Kingdom. There, contractors' capabilities have to be justified and verified for whether they are able to complete the work before they are awarded the project. In the United Kingdom, the bidding process has three basic stages: 1) general information, 2) prequalification, and 3) bid evaluation. General information is the administrative information relating to a contractor's company detail, the scope of work offered by the firm, technical resources and references, existing insurance, taxation details, financial information, subcontracting, race relations, plants and equipment, and health and safety. During the bid prequalification stage, the United Kingdom agencies verify technical resources and references, financial criteria, health-and-safety policies, existing insurance, taxes, subcontracting, and race relations (Hatush and Skitmore, 1997).

Russell and Skibniewski (1988).stated that, depending on project requirements, the client frames and performs the bid-prequalification process. He or she incorporates several factors, such as management, safety, location, performance, resources, finances, experience, failed performance, bonding, and the capacity for assuming a new project, when choosing the most qualified contractor and avoiding construction failure.

The Department of Treasury and Finance, Tasmania (1999) utilized a weighted bid-evaluation process rather than awarding the bid to the lowest-priced bidder so that the Department of Treasury and Finance are able to achieve the best value for their money. Five project criteria were used. During the non-price item evaluation, significant price differences were detrimental to the bidder. Bid-evaluation guidelines were developed using weighted criteria for buildings and services, and the most important evaluations were for the areas of experience, past performance, technical skills, management skills and systems, resources, methodology, and cost.

Shen *et al.* (2003) proposed a decision-support process in order to select contractors for a competitive bid using computer-aided applications. Utilizing computer-aided support systems allows the owners to sort suitable bidders, based on the bidders' strengths and weaknesses, during the bid-prequalification stage. Searching through the bidders' weaknesses helps determine suitable contactors. Lai *et al.* (2004) included six main perspectives about bid evaluations: 1) degrees of responsiveness; 2) construction organization; 3) contractor reputation and competence; 4) bid prices, amounts used for each of three materials (steel, cement, and lumber); 5) range for minimizing cost; and 6) thorough verification. Lai et al. stated that the Chinese government frustrated to eliminate corruption in the construction industry (Lai *et al*., 2004).

Lam *et al.* (2005) reported 17 factors that should be considered during the bid evaluation process: 1) quality standard, 2) time, 3) construction scheme, 4) the quality guarantee system, 5) safety, 6) plans for the labor force and the amount of main equipment and materials used, 7) the construction schedule and its guarantee measure, 8) level of qualification, 9) reputation, 10) level of qualifications for the project manager, 11) experience with similar projects, 12) qualified and excellent percentage of projects in the last two years, 13) percentage of on-time completions, 14) bid prices, 15) amount of materials, 16) plan

for cost minimization, and 17) points for a comprehensive check and evaluation. They stated that the bid-evaluation process, using these 17 factors, was non-linear, uncertain, and subjective, complicating the problems. Therefore, they proposed a principal component analysis method. By this method, a large number of interdependent variables with their co-linearity and dimensionality could be reduced.

Salama *et al.* (2006) surveyed criteria for the selection of contractors and bid evaluations in Egypt. Currently, government projects in Egypt are regulated through Act 89/1998, which recommends using a point system to evaluate contractors based on technical and financial requirements. Act 89/1998 was not mandated to Egyptian agencies to enable them follow the order. Bid evaluation criteria were also unmentioned. Therefore, Salama *et al*. conducted the research by providing project managers and professionals in Egypt with recommendations about suitable criteria for more accurate evaluations, both technically and financially, of construction bids. They used criteria for contractors' bid prequalification, such as experience with similar projects, resources, financial status, the firm's structure and organization, the firm's capacity, projects in progress, and the firm's claim history. Again, for the technical evaluation, Salama *et al.* used quality control/quality assurance systems, adequacy of technical supervision, availability of equipment, method statements and the proposed schedule, the experience of key personnel, and the percentage of subcontracted work. For the financial evaluation, Salama *et al.* used bid price, bid price/consultant or fair estimate, schedule of payments, percentage of payments, financial stability, financial status, financial strength, credit history, and claim history.

El-Sawalhi *et al.* (2007) included both qualitative and quantitative information in the bid prequalification process. Genetic-Neural Networks (GNN) was proposed in order to develop a state-of-the-art method for contractor bid prequalification. They suggested seven main prequalification criteria: 1) financial stability, 2) management and technical ability, 3) experience, 4) historical non-performance, 5) resources, 6) quality, and 7) health and safety.

Abdelrahman *et al.* (2008) researched rational and flexible best-value procurement strategies based on performance by the Minnesota Department of Transportation. Abdelrahman *et al.* stated that the idea of best-value strategies is being increasingly used by federal and state agencies. Strategically, the best-value concept created additional value for every dollar. They proved that quality performance is a

better indicator of a suitable contractor, which eventually could be used to award contracts instead of the lowest price. They considered price, schedule, financial and bonding requirements, past experience, safety record/plan, key personnel and their qualifications, utilization of small businesses, subcontractor plans, management/organization plan, quality management, proposed design alternate, technical proposal responsiveness, and environmental considerations in the best-value procurement strategy (Abdelrahman *et al.*, 2008).

Turskis (2008) stated that it is important to be aware of the bidder's financial, technical, and general qualitative, quantitative, or verbal information before awarding a project. Using the most preferable technique, feasible alternatives could be identified. This method could also be defined as the multi-variable contractor ranking method. Although the lowest price is a vital factor in selecting the bidder, there are other non-price items which play an important role. One of the case studies that was conducted focused on factors such as a history of reasonable bid-price submissions, work history, bid responsiveness, quality-control plans, contractor staffing plans, subcontractor plans, cooperation with other contractors, the management team, scheduling, environmental plans, safety concerns, warranty responsiveness, job-site management, claims, workload, and manpower plans.

Plebankiewicz (2009) stated that only competitive bidders could be identified through the contractor prequalification process. Plebankiewicz proposed a model using the Fuzzy Sets Theory that has many criteria, such as financial standing, technical ability, management capability, health and safety, and reputation.

Lam *et al.* (2009) stated the necessity of using a prequalification process for both contractors and owners, especially with complex and large projects. The prequalification process proactively serves as a safeguard for both parties. Considering the complexity of projects and the prequalification process, Lam *et al.* proposed a Support Vector Machine (SVM) method for best-value procurement. The attributes of the decision input variables identified through extensive knowledge-mining in support vector machining were financial strength and resource, previous performance, past experience, human resources, equipment resources, safety and health aspects, environmental considerations, quality management, current workload, management capacity, and claim history.

Padhi and Mohapatra (2010) researched the Indian government's bidding process which includes a three-step procedure before awarding a project. At first, general information and claim histories for the bidders are evaluated. Second, agencies assess and score the bidders based on criteria related to past work performance, availability of resources, and the financial status of the bidders. The top-determined three bidders are selected at the second step, and offers bid submissions where the ultimate offer goes to the lowest bidder.

The Minister of Finance, Democratic Republic of Timor (2012), stated that, in order to do long-term business, selecting contractors based only on bid prices would be an inaccurate method. Again, depending on costs, benefits, and alternative solutions, the valuation of money could be compared. The government of Timor considers technical capability or professional competence, commercial analysis, industry or local development, and financial analysis as the four major evaluation criteria.

Lam and Yu (2011) developed an advanced Multiple Kernel Learning (MKL) method based on subjectivity, non-linearity, and multi-variant bid prequalification with the goal of higher precision. Their MKL methods performed better than their earlier Support Vector Machine methods. The attributes of the decision input variables identified through extensive knowledge-mining using support vector machining were financial strength, past performance, past experience, human resources, equipment resources, safety and health aspects, environmental considerations, quality management, current workload, management capacity, and claim history.

2.10. Historical Development of Contractor Bid Prequalification and Evaluation Methodologies

To identify the factors that should be considered during contractor prequalification, it was necessary to review the current contractor evaluation methods, existing research on prequalification among organizations and countries, and the work cited most frequently about contractor prequalification. In order to achieve this objective, factors were identified by using a tabulated process. The process was classified into four steps and described in this section.

At first step, in order to determine which factors to use for contractor prequalification, it was necessary to identify the factors that are currently being used in different organizations and countries. Table 2.2 lists the chronological development of contractor evaluation methods. A literature study

covering the period from 1985 to 2012 was conducted, and the results are summarized in Appendix Table B.1. Various methods were used in different locations. Some approaches are fuzzy set, dimensional weighting aggregations (DWA), knowledge-based systems (KBS), time/cost approaches, multi-parameter bidding systems, multi-attribute analysis (MAA), artificial neural networks (ANN), scoring systems, analytical hierarchy processes (AHP), performance-based scoring, PERT models, cluster analysis, MAGNET systems, hybrid models, bid distribution models, simulated annealing, case based reasoning (CBR), outliers and goodness of fit Tests, unit price methods, integer programming, AHP-SMART, rational approaches, weighing criteria, and best value of money.

Table 2.2 was created to classify important attributes, or factors, for contractor selection that have been used with the different methodologies identified in this research. Some of them are mentioned in Table 2.2, and some are missing due to the unavailability or limited access to research materials. However, selected attributes, such as uncertainty, bid price, construction time, quality of previous work, organization and management structure, work experience, financial capability, technical ability, technology offered, similar type of project experience, quality assurance, workload, local knowledge, safety performance, reputation, references, resources, methodologies, mark-up ratio, historical non-performance, and warranty, are used in each modeling approach. A majority of the models, except for fuzzy logic and the Hybrid Mutli-Criteria Model, utilize a few attributes from the factors mentioned in Table 2.2. These factors have been used from 1985 to 2012 (Table 2.2).

Table 2.2. Existing Methodologies for Bidders' Prequalification

Year	Source	Country	Attributes	Modeling Approach
1985	Nguyen	Australia	Uncertainty in prequalification	Fuzzy Set Prequalification
1990	Russell and Skiniewski	USA	Subjective judgment decision	Dimensional Weighting Aggregation
1990	Russell *et al.*	USA	Heuristic decision	Knowledge Based System
1991	Ellis	USA	Bid Prices and Construction Time	Time/Cost Approach
1992	Herbsman	USA	Bid Amount, time of execution, and quality of previous work	Multi-parameter Bidding System
1994	Holt *et al.*	UK	Many decision parameters with several outcomes	Multi-Attribute Analysis
1994	Taha	USA	Based on algorithms	Artificial Neural Networks
1994	Transportation Research Board	USA	Organization and Management, Work Experience, Financial Capability, and Technical Ability	Scoring Systems
1995	Munaif	Saudi Arabia	Multi-variable judgmental decision	Analytical Hierarchy Process
1996	Kumaraswamy	Hong-Kong	Financial status, technology offered, and experience in handling similar types of projects.	Performance-Based Scoring
1997	Hatush and Skitmore	UK	Time, cost, and quality	PERT Model for Contractor Prequalification
1997	Hatush and Skitmore	UK	Quality Assurance, Workload, Experience on similar projects , experience with the owner, financial stability, local knowledge, and	Point Scoring System
1998	Holt	UK	Quoted cost, quality of work, and completion time	Cluster Analysis
1998	Hatush and Skitmore	UK	Quoted bid price, financial soundness, technical ability, management capabilities, safety performance, and reputation.	Multi-Attribute Utility Theory
1999	Deng	Australia	Quoted cost, technical capability, services and references from the government officials.	Fuzzy-Analytic Hierarchy Process

(Continued)

Table 2.2. Existing Methodologies for Bidders' Prequalification (Continued)

Year	Source	Country	Attributes	Modeling Approach
1999	Dept of Treasury and Finance	Tasmania	Relevant experience, appreciation of the task, past performance, management and technical skills, resources, management systems, methodology, and price	Weighted Criteria Method
1999	Khosrowshahi	UK	Judgmental decision whether qualified or disqualified	Artificial Neural Networks
1999	Collins *et al.*	USA	Cost, Task coverage, temporal feasibility and risk estimation	MAGNET System/ Simulated Annealing
2000	Lam *et al.*	Hong-Kong	Based on algorithms	Artificial Neural Networks
2001	Al-Harbi	UAE	Experience in handling similar types of projects, financial stability, quality performance, manpower resources, equipment resources, and current workload.	Analytic Hierarchy Process
2001	Seydel and Olson	USA	Mark-Up ratio, ratio of actual to estimated cost, ratio of lowest competing bid to the bidder's cost estimate, profit maximization, volume maximization,	Hybrid Multi-criteria Method
2001	Ng	Hong-Kong	Expert judgment	Case-Based Reasoning
2002	Mahdi	Kuwait	Multi-variable judgmental decision	Analytical Hierarchy Process
2002	Skitmore	Australia	Identification of auction outliers	Outliers and Goodness-of-Fit
2004	Topcu	Turkey	Quoted cost, quality of work, and completion time	Analytic Hierarchy Process
2004	Lai *et al.*	China	Contractor organization structure, firm honor and competence, quoted bid price, and amount of materials used.	Multi-Attribute Analysis
2006	Missbauer and Hauber	Austria	Bid price	Integer Programming
2006	Wang *et al.*	Taiwan	Conversion of all the attributes to price	Unit-price based

(Continued)

Table 2.2. Existing Methodologies for Bidders' Prequalification (Continued)

Year	Source	Country	Attributes	Modeling Approach
2007	Nabil *et al.*	UK	criteria: Financial stability, management and technical ability, experience, historical non-performance, resources, quality, health and safety	Hybrid Model: Combining AHP, Neural Network, Genetic Algorithm
2007	Lambropoulos	Greece	Quoted cost, quality of work, and completion	Multi-Attribute utility theory
2008	Conti and Naldi	Italy	Detection of anomalous bids and	Average Bid Criteria or Bid Distribution Model
2009	Padhi and Mohapatra	India	Quoted bid price, financial status, available physical resources, amount of work done, service during warranty period, co-operation and coordination	Fuzzy- Analytic Hierarchy Process (AHP)-SMART
2009	Zhang	Hong-Kong	Concessionaire's capability and predicted future performance	Fuzzy Logic System
2010	Elyamany	USA	Based on history of construction quality and long-term performance	Rational Approach
2011	Department of Queensland	Australia	Price, non-price criteria: project specific, methodology, contractor resources strategy	Weighted Criteria and Best Value of Money
2012	Ministry of Finance	Timor Leste	Technical capability or professional competence of contractor, commercial analysis, industry or local development, financial analysis	Two Envelope Tendering System (Scoring and Best Value of Money)

Data Source: El-Sawalhi 2007, Hatush and Skitmore 1997, Padhi and Mohapatra 2010, Skitmore 2002, Lai et al. 2004, Conti and Naldi 2008.

In Appendix Table B.1, a total of 228 factors were initially identified. It was discovered that some factors had the same functions but used different terminology. There were a lot of factors with different terminology, but having the same function, used in various publications and locations. Therefore, it was first necessary to collect the bid-prequalification factors with different terminology but the same meaning, which are presented in Appendix Table B.1 in order to facilitate the research objective. Based on the tabulation method, the 228 factors in Appendix Table B.1 were reduced to the 186 factors that are in Appendix Table B.2.

The literature used in this research was found in the American Society of Civil Engineers (ASCE), Science Direct, Web of Science, the NDSU Library, and on the Internet in other online databases. Findings for the third step are presented in Table 2.3. A total of 18 major factors containing 165 minor factors were identified during the Literature Review. A chronological analysis of Table 2.3 was done, and it is presented in Appendix Table B.3. At the end of Table 2.3, and Appendix Tables B.3 and B.4, all factors were ranked in accordance with the total number of responses for each individual factor. The major factors are:

- General Information and Registration Details
- Experiences
- Project Specific
- References
- Management and Organization
- Resources
- Finance
- Methodology
- Quality Assurance and Quality Control Plan
- Safety
- Communication
- Work Schedules
- Claim History
- Capabilities
- Subcontracting
- Estimation
- Strategic Business Plans
- Bid Specific

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria

Category	Factor/Criteria	Science Direct										Web of Science					ASCE												Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al.(19)	El-Sawalhi et al.(26)	Plebankiewicz (27)	Lam et al.(13)	Padhi and Mohapatra	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al. (11)	Lam et al.(17)	Turskis (53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007		
General Information & Registration Details	Validity of Registration Details								X				X								X				X							X					5	16
	Attitude, cooperation and performance						X	X							X															X					X		5	16
	Board of Directors																				X																	1	20
	Customer service, including whole of life servicing and maintenance		X																																	X		2	19
	Qualification Grade												X																									1	20
	Familiarity with regulating authorities																							X														1	20
	Ownership and substance of the business												X																X								X	3	18
	Age of shareholders																												X									1	20
	Past record in dealings with this authority																																				X	1	20
	Length of time in business		X			X	X			X	X						X	X				X		X		X	X			X							12	9
	Size of business										X											X				X	X											4	17
	Length of time company controlled by current management																X																					1	20
	Largest project performed in past 5 years																X	X																				2	19
	Past and current performance		X	X		X	X					X		X	X	X	X		X	X			X					X				X	X	X	X	X	20	4

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE											Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al.(19)	El-Sawalhi et al.(26)	Plebankiewicz (27)	Lam et al.(13)	Padhi and Mohapatra	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al.(11)	Lam et al.(17)	Turskis(53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007		
Experiences	Qualified and excellent percentage of project in recent 5 years				X																											X					2	19
	General works experience	X																																			1	20
	Specialist work experience	X																																			1	20
	Partners / sub-contracts experience	X			X																																2	19
	Recent completed project																								X												1	20
	Type of work want to do or did					X				X	X							X				X		X		X						X					8	13
	Past performance in owner's previous project																				X																1	20
	Size of project-experience					X				X	X											X		X		X											6	15
	Classes of work performed in each project																								X												1	20
	Number of projects-experience					X				X																											2	19
	Work performed with own forces																			X																	1	20
	Business coverage																										X										1	20
	Experience in the region					X																															1	20
	Length of time in business					X																															1	20

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE										Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al.(19)	El-Sawalhi et al.(26)	Plebankiewicz (27)	Lam et al.(13)	Padhi and Mohapatra	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al.(11)	Lam et al.(17)	Turskis (53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007		
Project Specific	Type of work want to do or did					X																										X						2	19
	Number of projects-experience					X																																1	20
	Expertise in similar projects			X	X			X	X															X	X								X		X			8	13
	Largest similar project performed in past five years																X																					1	20
	Understanding of objectives & identify key issues							X																														1	20
	Experience in geographic location of project	X				X				X	X	X					X			X	X	X		X		X												11	10
References	Company image-historical non-performance					X																																1	20
	Company reputation			X														X				X				X	X		X										6	15
	Appreciation of the task				X			X					X																						X				4	17
	Community consultation																																	X				1	20
	References											X					X	X		X	X				x				X		X			X	X				10	11
	Good relationship with stakeholders		X							X														X			X			X								5	16
	Good relationship with pas projects owners																							X														1	20
	Client satisfaction-historical non-performance					X				X																												2	19

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE												Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al.(19)	El-Sawalhi et al.(26)	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al.(11)	Lam et al. (17)	Turskis (53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007	Count	Rank
Management and Organization	Management and technical skills and capability		X	X		X				X	X			X	X	X	X			X	X	X		X		X			X	X	X	X		X	X			20	4
	Quality management system									X																												1	20
	Leader's personality and capability																										X											1	20
	Qualification of owners/contractor																					X				X												2	19
	Design & Consultant management																						X											X				2	19
	Environmental sustainability							X			X		X		X	X							X				X							X				8	13
	Handover management																																	X				1	20
	Programming of works																																	X				1	20
	Subcontractor management														X																			X				2	19
	Waste management										X				X																			X				3	18
	Project management		X					X															X							X				X				5	16
	Project control procedures																X			X			X															3	18
	Plant management																										X											1	20
	Contract management																										X											1	20
	Substance abuse policy																X			X																		2	19
	Site management							X			X				X												X						X	X				6	15
	Standard of subcontractors' works in past projects																							X														1	20

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE										Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al.(19)	El-Sawalhi et al.(26)	Plebankiewicz (27)	Lam et al.(13)	Padhi and Mohapatra	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al.(11)	Lam et al.(17)	Turskis(53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007		
	User group/client management																																	X				1	20
	Contractor organization and Plan			X		X		X		X		X					X			X	X		X				X		X		X		X				13	8
	Logistic and supply chain management																										X											1	20
	Purchasing expertise, material handling and control											X									X																	2	19
	Key managerial, supervisory and operational personnel experience and availability	X	X				X	X			X	X		X	X	X	X			X			X				X	X		X	X	X	X	X		X		20	4
	Personnel back-up strategy							X																					X					X				3	18
	Key trade package																																	X				1	20
	Amount of work performed with own forces																X																					1	20
	Techno-ware Technology availability	X																																				1	20
	Info-ware Technology knowledge and availability	X									X		X													X	x											5	16
	Org-ware Technology availability	X																																				1	20
	Human-ware Technology availability	X																																				1	20

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE												Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al.(19)	El-Sawalhi et al.(26)	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al. (11)	Lam et al. (17)	Turskis (53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007	Count	Rank
Resources	Ownership of equipment or the ability to rent or lease equipment needed to perform the job																															X						2	19
	Workforce resources and availability		X	X	X				X	X	X	X				X	X			X	X			X					X	X			X					15	7
	Equipment resources and availability		X	X			X		X	X	X		X	X		X	X			X	X								X	X	X	X	X	X				18	5
	Equipment operational experience																						X															1	20
	The quantities, capabilities, and condition of the contractor's owned or rented equipment																						X	X	X													3	18
	Availability of product and price information of labor, materials, plants, and other resources																										X											1	20
	Availability of testing equipment as quality assurance																							X														1	20
	Equipment repair and maintenance		X																		X		X				X											4	17
	Finance arrangement																							X										X				2	19
	Life cycle cost																																	X				1	20
	Quality of financial statement																												X									1	20

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE											Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al.(19)	El-Sawalhi et al.(26)	Plebankiewicz (27)	Lam et al.(13)	Padhi and Mohapatra	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al.(11)	Lam et al.(17)	Turskis(53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007		
Finance	construction experience of accountant																												X								1	20
	Accounting method																												X								1	20
	Current commitments																							X													1	20
	Capital																							X													1	20
	Current & fixed assets																							X													1	20
	Net worth																							X													1	20
	Range of reducing cost				X																																1	20
	Financial stability & soundness	X	X	X		X	X		X	X		X		X	X	X	X			X	X		X		X		X	X	X	X		X	X			X	X	24	3
	Previous financial penalties	X																														X						2	19
	Currency of records of employees																															X						1	20
	Credit rating and history		X			X				X	X		X									X			X	X			X				X					10	11
	Solvency																					X	X			X												3	18
	Liquidity (current ration)									X												X	X	X		X			X									6	15
	Turnover History					X	X				X											X		X		X				X								7	14
	Overruns: cost										X															X			X									3	17
	Bank arrangement		X			X																X				X			X	X								6	15
	Debit ratio					X	X															X	X			X				X								6	15
	Owned financial funds																													X								1	20
	previous claims and past judgments																												X								1	20
	Payment score																												X								1	20
	Profitability					X	X															X	X			X		X	X	X								8	13
	Statement of methodology							X																X				X				X						5	16

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE											Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al.(19)	El-Sawalhi et al.(26)	Plebankiewicz (27)	Lam et al.(13)	Padhi and Mohapatra	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al.(11)	Lam et al.(17)	Turskis(53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007		
Methodology	Technical proposal responsiveness														X													X									2	19
	Environmental considerations.															X												X									2	19
	Build-ability/Maintainability												X																				X				2	19
	Functionality																																X				1	20
	Use of local industry																																X				1	20
	Specialized knowledge of particular construction method										X													X													2	19
	Incorporation of best practice																																X				1	20
Quality	Quality management, control & assurance system		X	X	X	X	X			X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X		X	X		X	X		X	X	28	1
	Achievement of quality level (e.g., ISO: 14000)																							X														1	20
	Quality performance					X																				X					X							3	18
Safety	Health & Safety performance and plan		X	X	X	X	X			X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X	X	x	X	X		X				27	2
	Security																		X																			1	20
Communication	Communication																						X				X							X				3	18
	Documentation Management										X												X											X				3	18
	Inadequately staffed reception arrangements for telephone message at head office																															X					1	20

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE																Others					Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al. (19)	El-Sawalhi et al. (26)	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Neto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al. (11)	Lam et al. (17)	Turskis (53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sommez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007		
Working Schedule	Schedule of project				X			X			X				X				X					X			X	X					X				9	12
	Schedule of resources														X																			X				2	19
	Construction scheme				X																																	1	20
	Scheduling of Cost Control										X										X																	2	19
	Overruns: time										X															X			X									3	18
	Construction scheduling guarantee measure				X										X																							2	19
	Projects completed on time									X																												1	20
	Project completed on budget									X																												1	20
	Ability to complete the project on time																																			X		1	20
	Percentage of keeping time promise				X																																	1	20
	History of claims						X		X	X	X	X		X	X	X					X				X						X	X	X			X	X	15	7
	Contractor failure to complete a project		X			X	X		X	X	X	X					X	X			X	X		X	X	X				X	X	X					17	6
	Contract not renewed due to failure to perform	X																														X					2	19
	Current claims in court or arbitration																								X													1	20
	Prequalification and disqualification history with any agency																								X													1	20
	Litigation tendency										X											X				X												3	18
	Engaged in fraudulent activity																	X																				1	20

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE											Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
	Year	Kumaraswamy(30) 1996	Hatush and Skitmore 1998	Al-Harbi 2001	Lai et al.(19) 2004	El-Sawalhi et al.(26) 2007	Plebankiewicz (27) 2009	Lam et al. (13) 2009	Padhi and Mohapatra 2010	Nieto-Morote and Ruz-Vila 2012	Azahrani and Emsley 2012	Assaf and Jannadi (4) 1994	Shen et al.(11) 2003	Lam et al.(17) 2007	Turskis(53) 2008	Lam and Yu(1) 2011	Russell and Skibniewski 1990	Russell 1990	Herbsman and Ellis 1992	Potter and Sanvidor 1995	Bubshait and Al-Gobali 1996	Sonmez et al. 2002	Palaneeswaran and Kumaraswamy 2005	Singh and Tiong 2006	Abudayyeh et al. 2007	Li et al. 2007	Lu et al. 2008	Elyamany 2010	Marsh and Fayek 2010	Nguyen 1985	Russell 1996	Hatush and Skitmore 1997	Salama et al. 2006	Australia 2000	Tasmania 1999	NCHRP 1994	Timor 2007		
Claim History	Ineligibility to bid on public works because of breaching any of the environmental or labor codes																								X												1	20
	Has the contractor ever been debarred in a certain jurisdiction area by a governmental agency																	X						X													2	19
	Claim and dispute resolving skills																										X										1	20
	Knowledge and expertise on law																										X										1	20
	Declined invitations, or did not submit a bid on at least three occasions in the previous 12months	X																													X						2	19
	Current workload			X								X		X	X	X	X			X	X		X	X					X			X						12	9
	Unbonded At Risk work																												X									1	20
	available surety credit																												X									1	20
	amount of current uncompleted work-on-hand																X	X																				2	19
	largest of amount of uncompleted work-on-hand																	X																				1	20

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE																	Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36						
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al.(19)	El-Sawalhi et al.(26)	Plebankiewicz (27)	Lam et al.(13)	Padhi and Mohapatra	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al.(11)	Lam et al.(17)	Turskis (53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007	Count	Rank
Capability	Ability to obtain a bid, performance, payment bond; bonding capacity		X								X				X		X	X		X					X											X		8	13
	Capacity of firms																X			X																			2	19
	Technical ability to perform the job in terms of contract																																			X		1	20
	Amount of work performed earlier																				X																	1	20
	Capacity to add this project																							X							X							2	19
	Ability to meet essential and desirable requirements of the bid																																				X	1	20
	availability of liability and workers' compensation insurance policies																								X													1	20
	The maximum amount of work that can be performed by the contractor's own workforce																								X													1	20
	Key Man life insurance																												X									1	20
	Risk management (including insurance, and use of authorized sub-contractors)																							X			X			X							X	4	17
	Percentage subcontracted Work																																X					1	20

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE											Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al.(19)	El-Sawalhi et al.(26)	Plebankiewicz (27)	Lam et al.(13)	Padhi and Mohapatra	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al.(11)	Lam et al.(17)	Turskis (53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayeh et al.	Li et al.	Lu et al.	Ryamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007		
Subcontracting	Utilization of small business																											X									1	20
	Subcontractor prequalification process																												X									1	20
	Management of subcontractors																												X									1	20
	Reputation of subcontractors to be used for the project																							X														1	20
	Subcontractor Plan														X													X										2	19
Estimation	Fair Estimation														X																		X					2	19
	Schedule of payments				X																												X					2	19
	Advance payment		X																														X					2	19
Business	Location of home office & man-power accommodation											X					X			X	X										X						X	6	15
	Regional and district development opportunities																																				X	1	20
	Training activities or programs supported by the bidder or sustainable development of human resources																						X			X	X										X	4	17
	the contractor's time and cost saving considerations																							X														1	20
	Post business attitude																							X														1	20
	Innovate method					X		X		X			X																					X				5	16

(Continued)

Table 2.3. Results from the Literature Review on the Most Frequently Cited Factors/Criteria (Continued)

Category	Factor/Criteria	Science Direct										Web of Science					ASCE										Others				Organization				Count	Rank
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
		Kumaraswamy(30)	Hatush and Skitmore	Al-Harbi	Lai et al. (19)	El-Sawalhi et al. (26)	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Neto-Morote and Ruz-Vila	Alzahrani and Emsley	Assaf and Jannadi (4)	Shen et al. (11)	Lam et al. (17)	Turskis (53)	Lam and Yu (1)	Russell and Skibniewski	Russell	Herbsman and Ellis	Potter and Sanvidor	Bubshait and Al-Gobali	Sonmez et al.	Palaneeswaran and Kumaraswamy	Singh and Tiong	Abudayyeh et al.	Li et al.	Lu et al.	Elyamany	Marsh and Fayek	Nguyen	Russell	Hatush and Skitmore	Salama et al.	Australia	Tasmania	NCHRP	Timor		
	Year	1996	1998	2001	2004	2007	2009	2009	2010	2012	2012	1994	2003	2007	2008	2011	1990	1990	1992	1995	1996	2002	2005	2006	2007	2007	2008	2010	2010	1985	1996	1997	2006	2000	1999	1994	2007		
Strategic	Strategic awareness and perspective																										X										1	20
	Matching strategy to a company's situation																										X										1	20
	Strategy implementation																										X										1	20
	Suitability of organization structure																										X										1	20
	Motivation and job satisfaction																										X										1	20
	Technological innovation ability																										X										1	20
	Sustainable development of technology and R&D																										X										1	20
	Market research and planning																										X										1	20
Bid Specific	Bidding Strategy																										X										1	20
	Experiences in bidding																										X										1	20
	Bidding resources																										X										1	20
	Business plan																										X										1	20
Total		13	18	11	13	25	13	13	7	22	27	14	12	9	20	12	24	11	5	18	20	19	21	34	16	24	37	12	28	19	13	17	16	31	6	10	12		

3. RESEARCH METHODOLOGY

3.1. Introduction

The objective of the research was to identify and analyze factors that affect the contractors' bid prequalification process in Bangladesh to help improve the performance of both contractors and owners. This chapter discusses the methodology that was used for this research investigation. The methods used to accomplish the research include the following techniques: a review of the literature related to contractors' bid prequalification; a questionnaire survey used to gather data; data collection and data analysis; a detailed statistical analysis; a determination of the relative importance index and rank; determine a mutual agreement between project owners and consultants; a comparison of results obtained in Bangladesh with results from the United States and Saudi Arabia; the development of a decision-model hierarchy framework; and a discussion of the results, conclusions, and recommendations for Bangladesh's construction industry.

This chapter discusses the research's methodology and design, the research population and samples, the questionnaire design, the data-collection process, and the statistical data analysis. The content validity and the pilot study are also presented in this chapter.

3.2. Research Tasks

The research consisted of 10 main phases. Figure 3.1 summarizes the research phases:

- Phase One: Identify the research problem and objectives, and develop the research plan.
- Phase Two: Conduct a thorough literature review related to contractors' bid prequalification, evaluation, selection, and assessment.
- Phase Three: Develop a questionnaire to investigate the criteria to consider that minimize risk and uncertainty, and conduct a survey to collect data.
- Phase Four: Perform a detailed statistical analysis of the data collected using the Minitab statistical software and MS Office software.
- Phase Five: Determine the relative importance index, and rank the surveyed prequalification criteria.

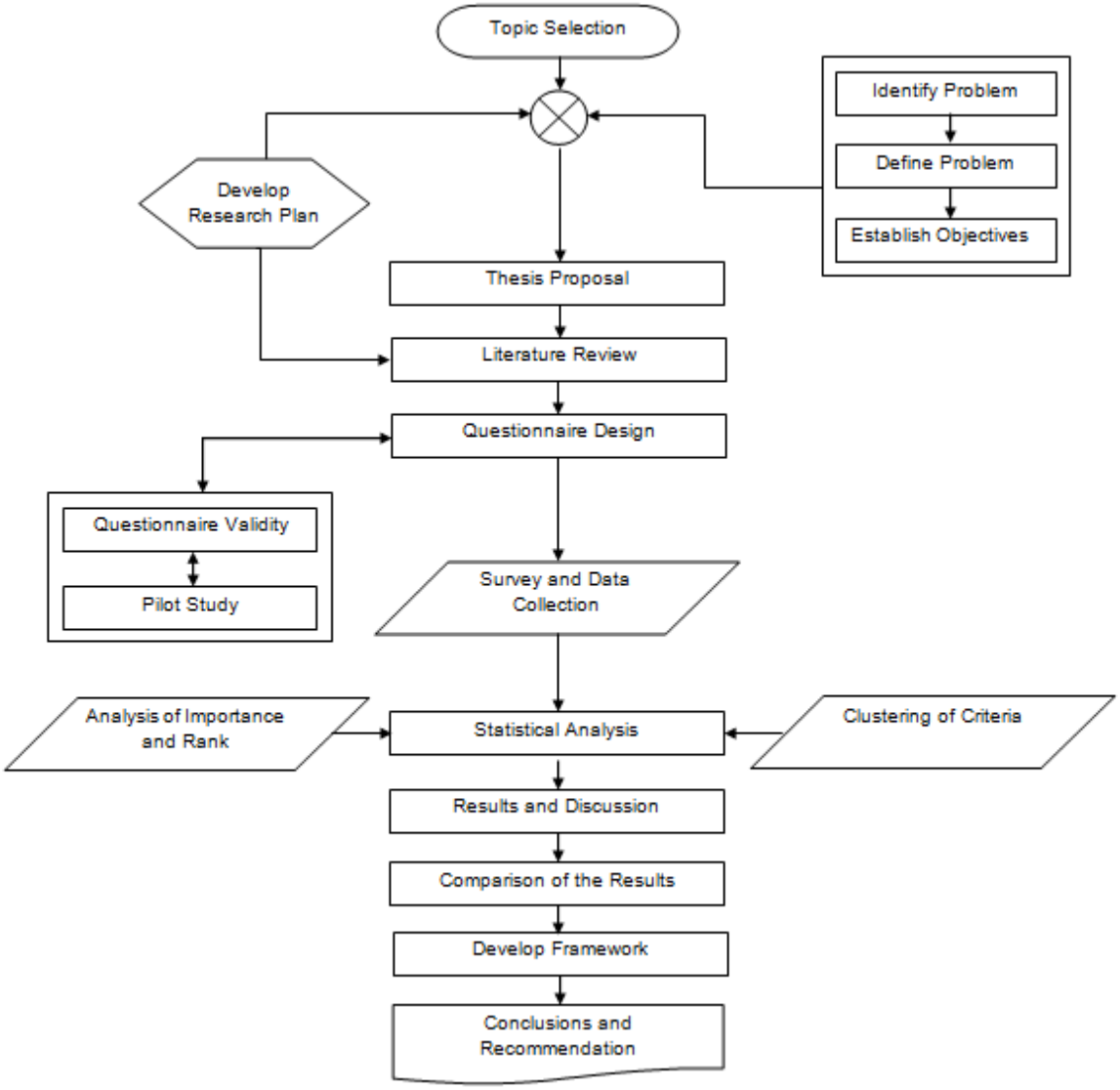


Figure 3.1. Research Methodology Flow Chart

- Phase Six: Determine clustering for the surveyed bid prequalification criteria based on project owners and consultants' mutual agreement.
- Phase Seven: Compare the results obtained in Bangladesh with the results from the United States and Saudi Arabia based on the relative importance index and clustering.
- Phase Eight: Develop a weighted model for each cluster using analytical hierarchy process methods.

- Phase Nine: Develop a decision model hierarchy framework for the contractors' bid prequalification process so that users can effectively use the process.
- Phase Ten: Discuss the results, and provide conclusions and recommendations for Bangladesh's construction industry.

3.3. Statistical Validity of the Factor(s)

From the Literature Review, it was determined that a total 165 factors should be considered during the contractors' bid prequalification phase. At the end of Table 2.3, all 165 factors were ranked in accordance with each author's opinion. Then, all factors were sorted and presented in Appendix Table B.4. The highest number of responses in Table 2.3 was 26 for health and safety performance and plan, which was ranked as the first criterion. A total of 87 factors received just one author's opinion, which was ranked as the least-responded criteria. In order to design a good questionnaire, a statistical analysis was conducted.

3.3.1. Goodness-of-Fit Test

For 164 degrees of freedom, the observed chi-square value was 1036.42, and the P-Value was found to be less than <0.005. Therefore, it was inferred that, for the 99.995% significance level, the null hypothesis was rejected, and it could be stated that all factors do not have the same significance.

3.3.2. Descriptive Statistics

Using MS Excel, Appendix Table B.4 was analyzed as presented in Table 3.1. From a skewness of 2.76, which is closest to 3 in Table 3.1, and the Pareto plot in Figure 3.2, it is inferred that the distribution pattern of factors is positively skewed.

Table 3.1. Descriptive Statistics

Mean	3.38		Kurtosis	7.98
Standard Error	0.36		Skewness	2.76
Median	1		Range	25
Mode	1		Minimum	1
Standard Deviation	4.62		Maximum	26
Sample Variance	21.33		Sum	557
Count	165			

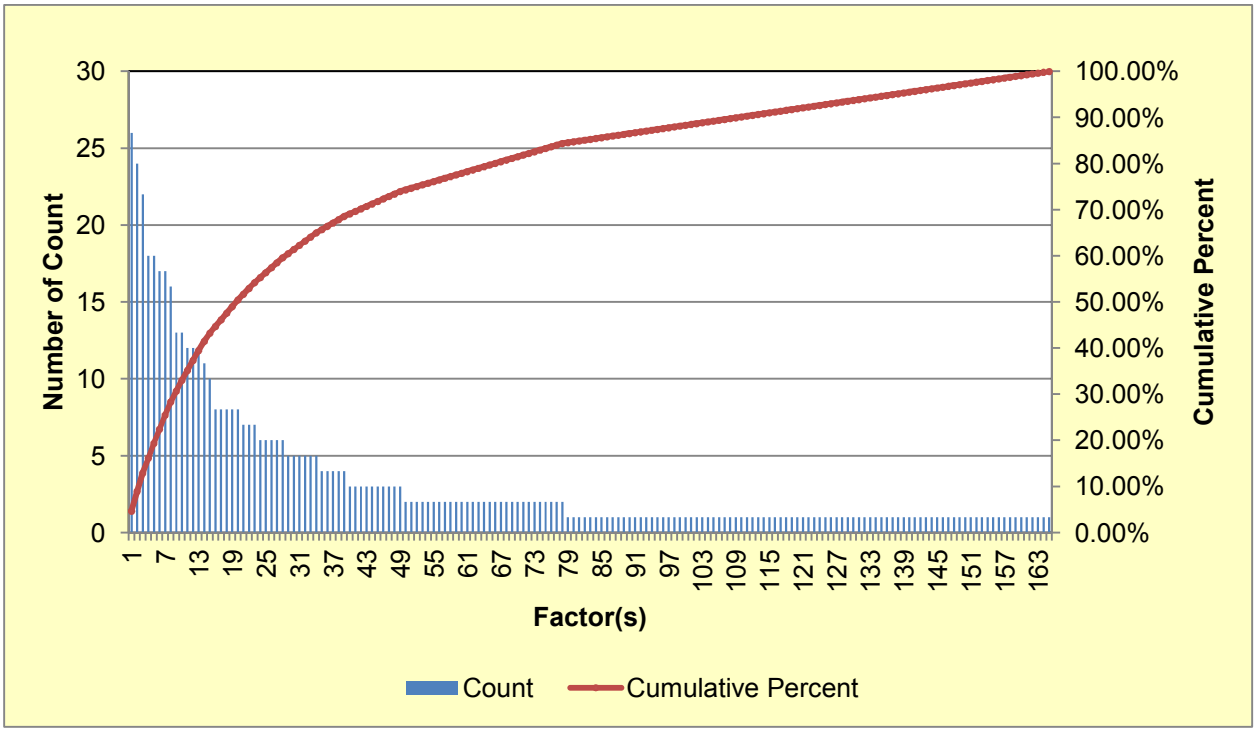


Figure 3.2. Pareto Plot of Identified Factors

3.3.3. Outlier Analysis

As shown in Table 3.2, the quartile analysis of the identified factors revealed that 75% of the factors are below a count of 3 and that 25% of the factors are above a count of 3. Therefore, 50% of the factors are above the count of 1.

Table 3.2. Quartile Analysis

Quartile No.	Count	Quartile	Percentile Function	Count	Approximate
0	1	Same as MIN	0	1	
1	1	1st Quartile	0.25	1	25% of the values are below the counting of 1 and 75% of the values are above the counting of 1
2	1	2nd Quartile same as Median	0.5	1	50% of the values are above the counting of 1
3	3	3rd Quartile	0.75	3	75% of the values are below the counting of 3 and 25% of the values are above the counting of 3
4	26	Same as MAX	1	26	

3.3.4. Normality Probability Plot

Using the normal distribution theory, the confidence interval is $\mu \pm 3\sigma$ = (3.38 ± 3*4.62) = (-10.48, 17.24), which indicates that no single factor could be eliminated because all the lower-ranking factors are within these boundaries. From the normality probability plot shown in Figure 3.3, it could be concluded that the data are not normally distributed because the graph is not an S-curve.

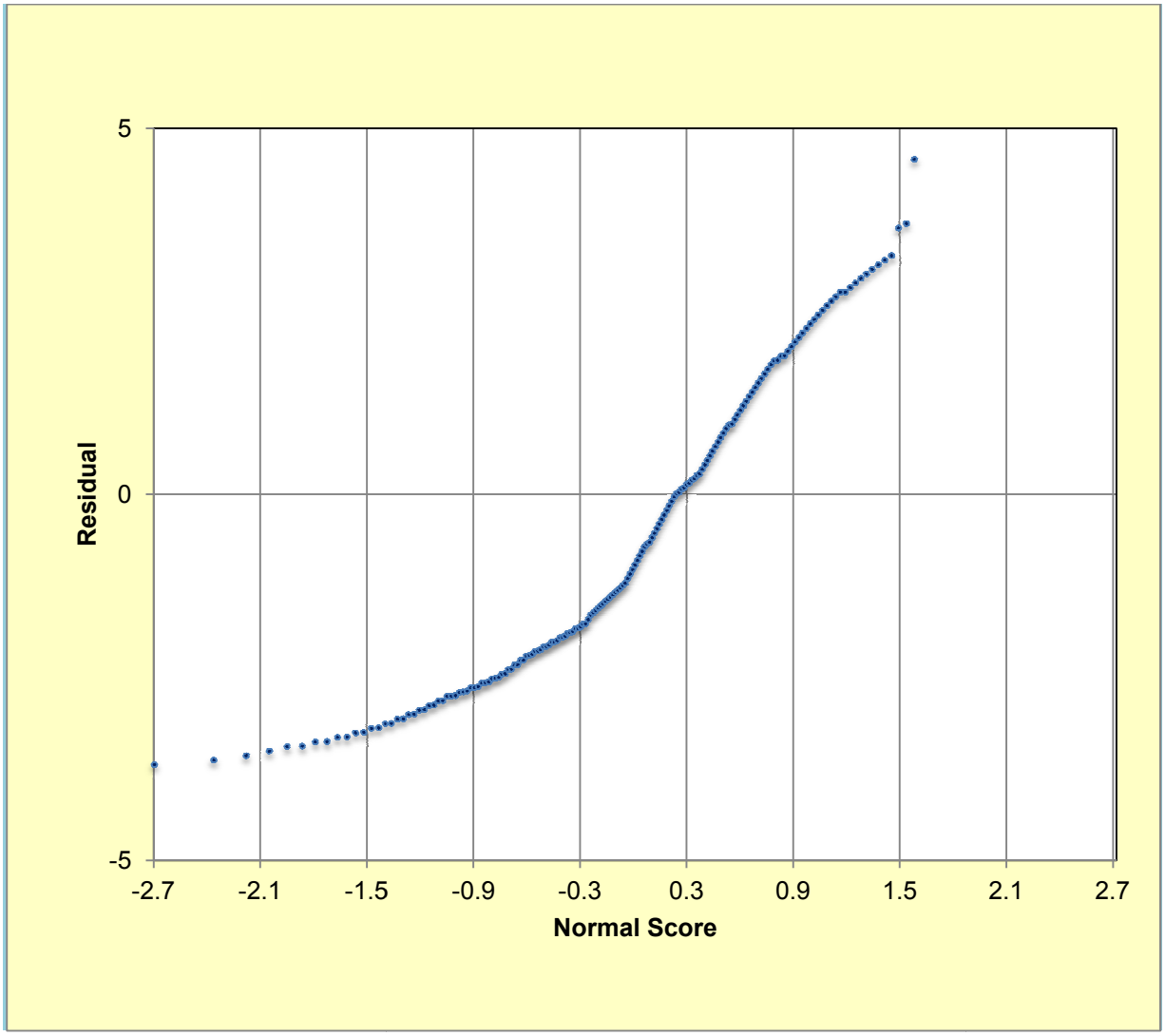


Figure 3.3. Normality Probability Plot

3.3.5. Statistical Control Chart and Major Group Analysis

The factors could be controlled statistically in order to systematically reduce the variability. A total of 18 major groups were analyzed and are presented in Table 3.3. The analysis showed that the lower control limit (LCL) was equal or greater to 2.27. The LCL value represented factors that have a total count of at least 3, and they should be in the control chart. On the other hand, the upper control limit (UCL) was 18.07. The indirect outcome of this analysis was finding the upper-counted factor. Therefore, UCL should not be considered in this study. Finally, a total of 49 factors are displayed in Table 3.3 and Figure 3.4.

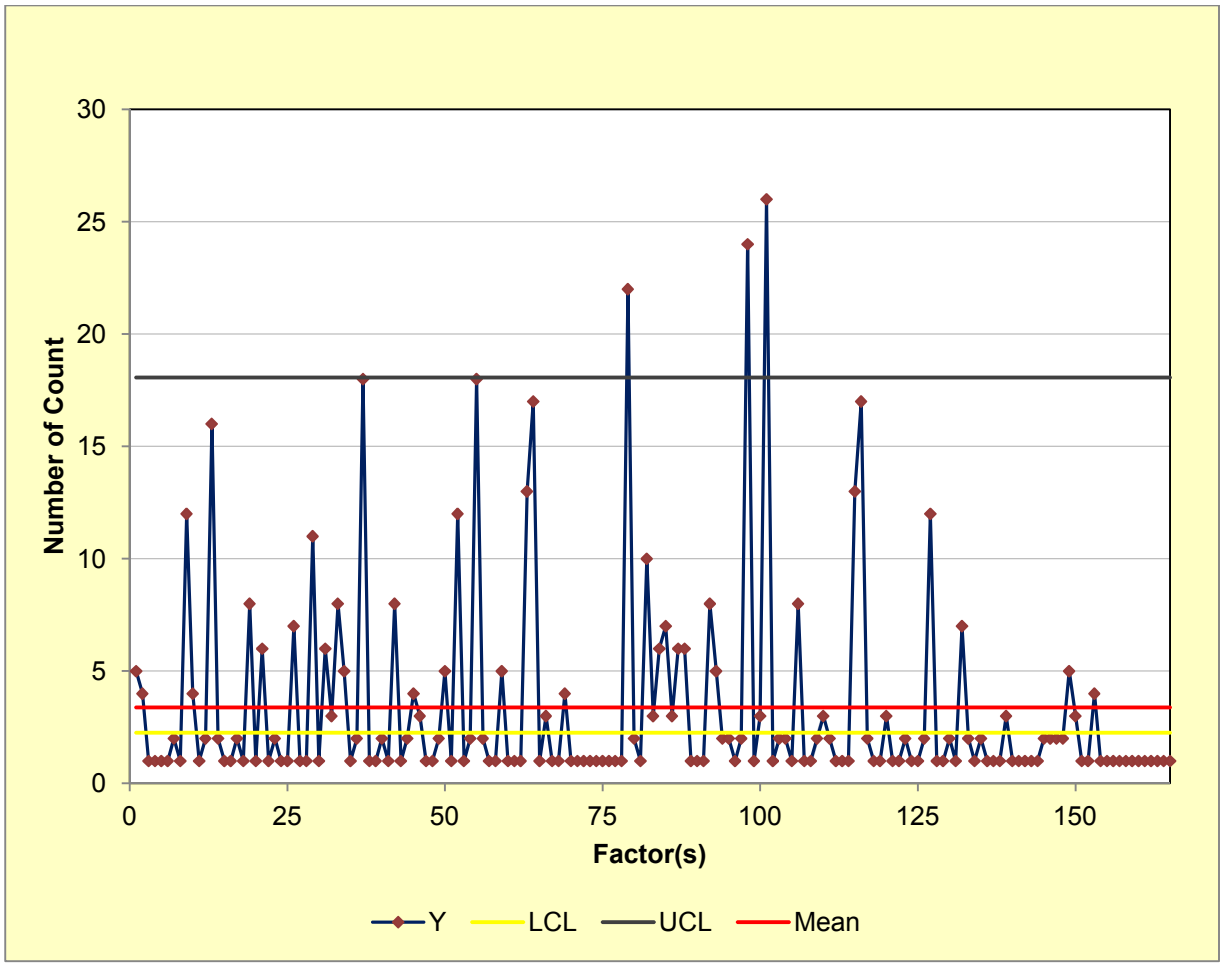


Figure 3.4. Statistical Control Chart

Table 3.3. X-Bar and R-charts Control Variable

Major Factor	Code	Minor Factor Count																							Mean	Range
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
General Information and Registration Details	F1	5	4	1	1	1	1	2	1																2.00	4
Experiences	F2	12	4	1	2	16	2	1	1	2	1	8	1	6	1	2	1	1							3.65	15
Project Specific	F3	7	1	1	11																				5.00	10
References and Appreciation	F4	1	6	3	8	5	1	2																	3.71	7
Management and Organization	F5	18	1	1	2	1	8	1	2	4	3	1	1	2	5	1	12	1	2						3.67	17
Resources	F6	18	2	1	1	5	1	1	1	13	17	1	3	1	1	4									4.67	17
Finance	F7	1	1	1	1	1	1	1	1	1	22	2	1	10	3	6	7	3	6	6	1	1	1	8	3.74	21
Methodology	F8	5	2	2	1	2																			2.40	4
Quality Assurance and Quality Control Plan	F9	24	1	3																					9.33	23
Safety	F10	26	1																						13.50	25
Communication	F11	2	2	1																					1.67	1
Working Schedule	F12	8	1	1	2	3	2	1	1	1															2.22	7
Claims History	F13	13	17	2	1	1	3	1	1	2	1	1	2												3.75	16
Capability	F14	12	1	1	2	1	7	2	1	2	1	1	1	3											2.69	11
SubContracting	F15	1	1	1	1	1	2																		1.17	1
Estimation	F16	2	2	2																					2.00	0
Strategic Business Plan	F17	5	3	1	1	4	1	1	1	1	1	1	1	1											1.69	4
Bid Specific	F18	1	1	1	1																				1.00	0
Total																									67.86	183

3.4. Research Population, Location, and Sample Size

The targeted population for the research consisted of experts, engineers, project designers, and project managers from diverse organizations (public, semi-public, private, and others) who have experience with contractor selection projects in Bangladesh. The questionnaire was given to establishments and individuals residing in Bangladesh. The targeted sample was 30. A random survey invitation was forwarded to the populations. The populations were classified according to their specialty as follows:

- Government and Public Agency
- Private Owner
- General Contractor
- Project Designer and Consultant
- Project Manager
- Subcontractor
- Supplier
- Academic or Professional

3.5. Sample Characteristics

The public clients were those individuals who were working on public projects in Bangladesh. Some of the institutions were as follows: the Ministry of Housing and Public Works, local government engineering departments, Roads and Highway Departments, the Ministry of Local Government and Rural Development, the House and Building Research Institute, the Public Works Department, the Department of Architecture, the Urban Development Directorate, the Dhaka Development Authority (RAJUK), the Chittagong Development Authority, the Khulna Development Authority, the Transparency International-Bangladesh, the Bangladesh Power Development Board, the Bangladesh Water Development Board, the Dhaka Water Supply and Sewerage Authority, the Bangladesh Association of Construction Industry, the Engineering Institution of Bangladesh, the Bangladesh University of Engineering and Technology, the Real Estate and Housing Association of Bangladesh, the Khulna University of Engineering and Technology, the Rajshahi University of Engineering and Technology, and the Ahsanullah University of Science and Technology. Private clients were chosen from the online database of the Bangladeshi Yellowpages.

3.6. Data Collection

A questionnaire was chosen as the data-collection method for this research because a questionnaire is a widely used technique. Abdal-Hadi (2010) quoted, “Questionnaires have been widely used for descriptive and analytical surveys in order to find out the facts, opinions and views (Naoum, 1998). It enhances confidentiality, supports internal and external validity, facilitates analysis, and saves resources” (Abdal-Hadi, 2010, p,34).

The data were collected in a standardized format using an online survey from samples of the population. The standardized form allowed the researcher to determine statistical inferences about the data.

3.7. Questionnaire Design

Abdal-Hadi (2010, p. 34) quoted, “The good design of the questionnaire is a key to obtaining good survey results and warranting a high rate of return (Chan and Chan 2002).” The survey was designed and modified to determine the common criteria used for contractors’ bid prequalification and ranking the criteria. The questionnaire contained 76 prequalification criteria. The respondents selected options from five possible answers representing varying degrees of impact on bid prequalification, using a scale of one to five. A response of one meant that the criterion had no impact on the bid prequalification; two meant it had little impact; three meant it had moderate impact; four meant it had high impact; and five meant it had very high impact. The relative impact/importance index of each survey response was calculated using equation 3.1. Abdal-Hadi (2010) stated that this equation is widely used in the construction industry for human-subject observation studies.

$$\frac{5(n_1) + 4(n_2) + 3(n_3) + 2(n_4) + 1(n_5)}{5(n_1 + n_2 + n_3 + n_4 + n_5)} \tag{3.1}$$

where n_1 = Number of Responses with “Very High Impact,” n_2 = Number of Responses with “High Impact,” n_3 = Number of Responses with “Moderate Impact,” n_4 = Number of Responses with “Little Impact,” and n_5 = Number of Responses with “No Impact.”

A questionnaire was administered to determine the subjects' opinion regarding factors affecting contractors' bid prequalification decisions in Bangladesh. A four-page questionnaire (found in Appendix A) was accompanied by a cover letter and sent to the survey participants. The cover letter indicated the research objectives explained that the results of the questionnaire would be used to determine contractors' prequalification practices in Bangladesh. The questionnaire had four sections to help accomplish the research objectives.

- Section One: This section contained general questions, such as the industry sector, type of contract, type of project handled, and information about the population.
- Section Two: This section contained a total of 76 factors ranked using a 5-point Likert scale.
- Section Three: This section contained opinions from the population regarding five other factors that should be included but were not listed in the survey.
- Section Four: This section contained voluntary general background information about the population.

3.8. Institutional Research Board Compliance

This research included human subjects. In order to protect the rights, safety, and welfare of all individuals participating in this research, complying with Institutional Research Board guidelines was required. These protections ensured that the survey recruitment procedure was fair, that subjects were sufficiently informed and able to make a voluntary choice, and that their privacy and confidentiality were ensured.

3.9. Questionnaire Validity and Pilot Study

The content of the questionnaire was validated during a review by the thesis adviser and committee members. Based on their comments, some factors were modified or deleted. All factor modifications were discussed and approved by the adviser, and then, the questionnaire was finalized to include 76 factors. Abdal-Hadi (2010, p.44) quoted, "All questions should initially be piloted; completed by a small sample of respondents (Fellows and Liu, 1977)." Therefore, a pilot study was conducted before the survey was administered in order to provide a trial for the questionnaire, which involves testing the question wording, identifying ambiguous questions, testing the techniques being used to collect data,

measuring the effectiveness of the standard invitation to respondents, and testing and quality checking the survey in accordance with the Institutional Research Board compliance procedures. Some objectives of the pilot test process were as follows:

- Confirming that the questionnaire is simple and easy to understand
- Sending the survey through an NDSU email account
- Forwarding the survey through a secured site (HTTPS)
- Confirming that the survey invitation did not get sent to spam folders
- Securing the respondent's IP address
- Checking the thank-you page after survey completion
- Finishing a partially completed survey
- Receiving anonymous responses
- Measuring the survey's completion time
- Generating a user-formatted report, as well as filtering and downloading individual or summary responses from SurveyMonkey's web features
- Downloading responses at any time
- Complying with the Institutional Research Board guidelines.

4. DATA COLLECTION, ANALYSIS, RESULTS, AND DISCUSSION

4.1. Introduction

This chapter discusses the collected data and the results obtained from the online questionnaire that received 71 responses, including 40 project owners, 21 consultants, and 9 contractors. Section two presents information about the respondents. Section three contains the calculated relative importance index and the rankings for the overall group or in between the group prequalification criteria. Section four presents the statistical significance of the criteria. Section five shows the clustering of the prequalification criteria based on the owners and the consultants' agreement. Section six compares the results obtained in Bangladesh with results from the United States and Saudi Arabia.

4.2. Respondent Information

This section provides general information about the respondents in terms of the major industry types, contract type, project type, organization type, years of experience, and position held. This section also presented the graphical and statistical analysis about the respondents.

4.2.1. Type of Work of the Respondents

Figure 4.1 shows that the following individuals participated in the survey: 34.3% (24) private owners, 22.9% (16) government and public agencies, 18.6% (13) project designers, 8.6% (6) general contractors, 5.7% (4) project managers, 5.7% (4) academic professionals, 2.9% (2) subcontractors, and 1.4% (1) suppliers. Only one respondent skipped this question. None of the respondents selected "other type of organization."

Figure 4.2 shows other characteristics of survey participants: 56.34% (40) owners, 29.58% (21) consultants, and 12.68% (9) contractors. Figure 4.3 shows that 56% (40) of the respondents performed private projects and that 34% (24) of the respondents performed public projects. Only one respondent skipped this question. Two respondents selected "other type of project," and these two respondents worked on both private and public projects.

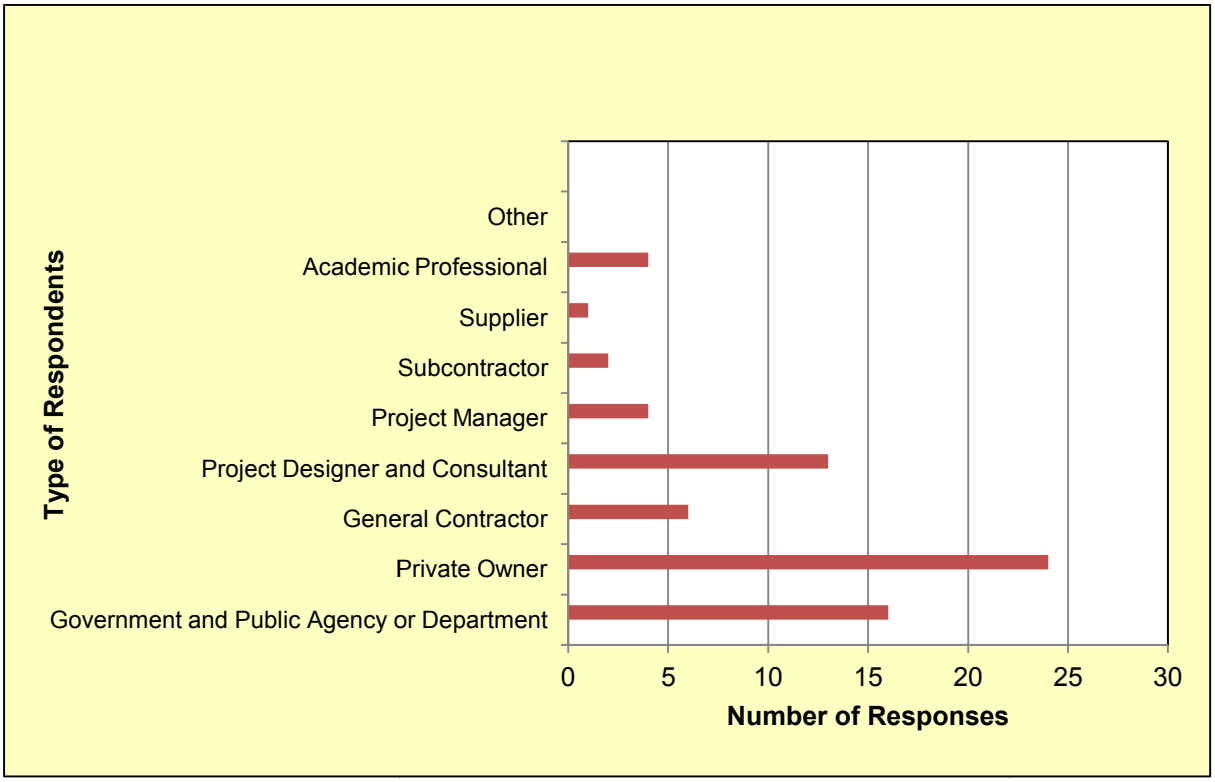


Figure 4.1. Type and the Percent of Respondents

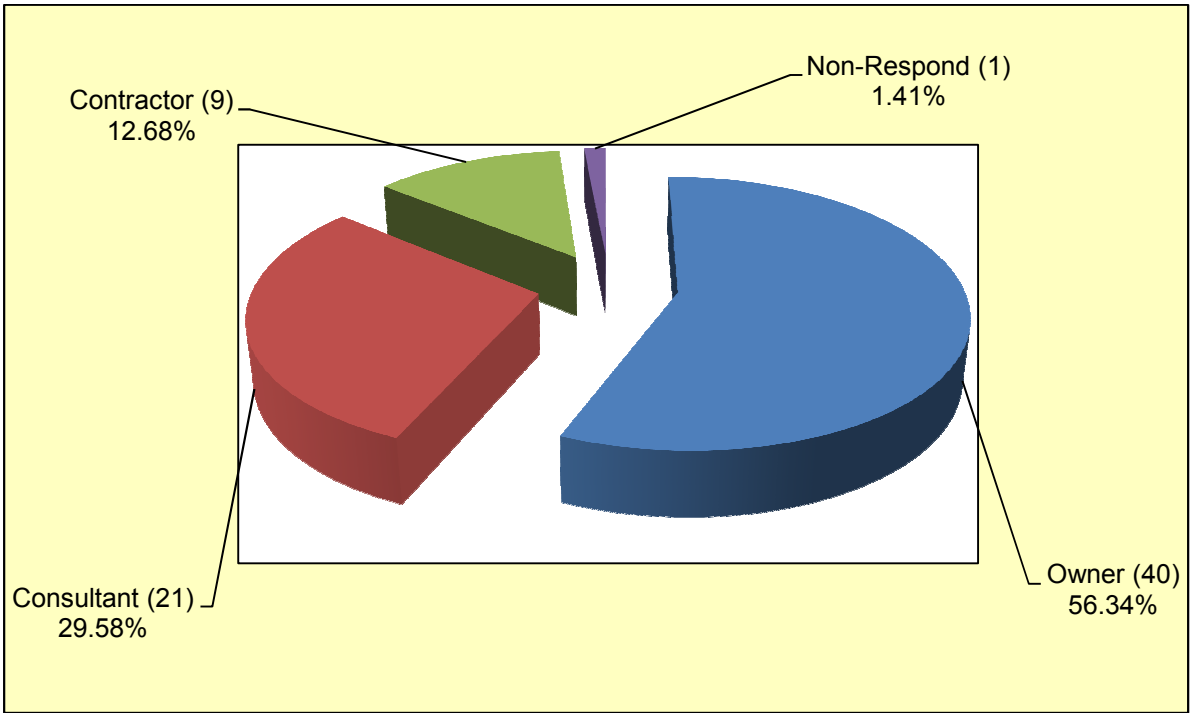


Figure 4.2. Combined Percentile of Respondents

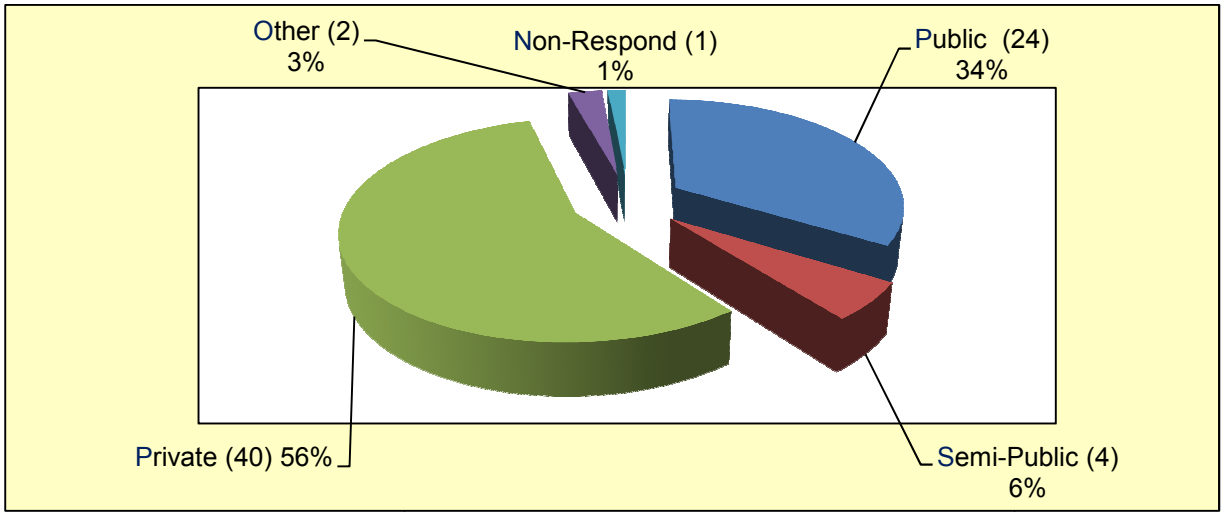


Figure 4.3. Type of Project Performed by Respondents

4.2.2. Type of Industry of the Respondents

Figure 4.4 shows that 43% (30), 31% (22), 6% (4), 9% (6), 1% (1), 0% (0), and 10% (7) of the respondents were directly associated with construction, design and building infrastructure, maintenance works, management contractors, supply and installation of plants and equipment, custom designed equipment, and other construction industry work. Only one respondent skipped this question. Ten percent of the respondents answered “other type of industry” because they were involved with academia and mentoring in the construction industry.

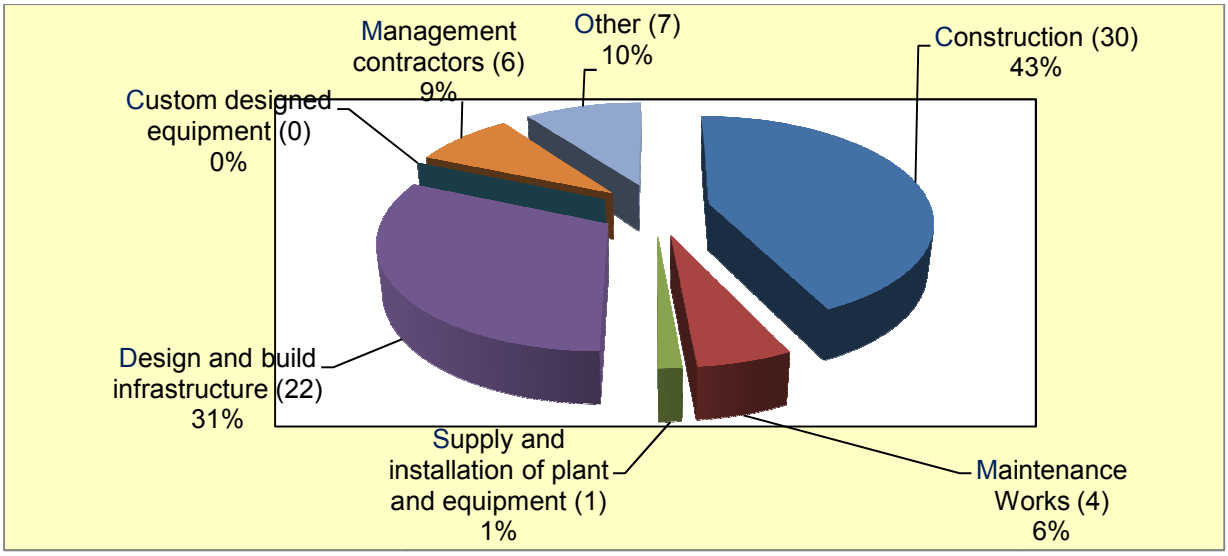


Figure 4.4. Type of Industry of Respondents

4.2.3. Type of Contract Performed by the Respondents

Table 4.1 shows that the highest five contract types were unit price, 23.2% (16); negotiated contract, 18.8% (13); design-build/turnkey, 15.9% (11); sealed bid, 10.1% (7); and construction management, 8.7% (6). Only two respondents skipped this question. There were no respondents involved with cost plus percentage of cost contracts.

Table 4.1. Type of Contract Performed by Respondents

Contract Type	Number of Responses	Percentage of Responses
Lump Sum	4	5.8%
Sealed Bid	7	10.1%
Negotiated	13	18.8%
Unit Price	16	23.2%
Design-Build (DB)/Turnkey	11	15.9%
Construction Management	6	8.7%
Management	2	2.9%
Construction Manager At Risk (CMAR)	1	1.4%
Cost Plus Fee	2	2.9%
Cost Plus Percentage of Cost	0	0.0%
Design-Bid-Build (DBB)	2	2.9%
Job Order Contract (JOC)	3	4.3%
Guaranteed Maximum Price (GMP)	2	2.9%
Other	0	0.0%
Answered Questions		**69**
Skipped Questions		**2**

4.2.4. Position and Years of Experience of the Respondents

Table 4.2 shows that, of 71 respondents, only 48% (34 respondents) provided their position and years of experience. Only 47% (33) of the respondents provided their organization's name.

Table 4.2. General Information of Respondents

Answer Options	Percentage of Responses	Number of Responses
Position Held	100.0%	34
Years of Experiences	100.0%	34
Organization	97.1%	33
Answered Question		**34**
Skipped Question		**37**

Table 4.3 shows that 47% (16) were related to engineering positions, 21% (7) of the respondents were CEOs/managing directors, 9% (3) of the respondents were in academia, and 24% (8) of the respondents were in management positions. Forty-five percent of the respondents were in key positions that provide quality information. Table 4.4 shows that 68% (23) of the respondents have more than 5 years of experience with their organization and that 32% (11) of the respondents have less than 5 years of experiences in that organization.

Table 4.3. Position of Respondents in Their Organization

Position of Respondent	**Number of Responses**	**Percentage of Responses**
Engineering	16	47%
CEO/Managing Director	7	21%
Academic	3	9%
Management	8	24%
	Answered Questions	**34**
	Skipped Questions	**37**

Table 4.4. Years of Experience for Respondents in Their Organization

Years of Experience	**Number of Responses**	**Percentage of Responses**
Less than 5 years	32%	11
More than or equals 5 years	68%	23
	Answered Questions	**34**
	Skipped Questions	**37**

4.3. Factor(s) Influencing the Bid Prequalification Processes in Bangladesh

This part consists of the results and a discussion about the factors that influence the bid prequalification processes in Bangladesh's construction industry. A total of 76 factors (extracted from the Literature Review) were classified into 17 major divisions:

- General Information and Registration Details
- Experience
- Project Specific
- References
- Management and Organization
- Resources
- Finance
- Methodology

- Quality Assurance and Quality Control Plan
- Safety
- Communication
- Work Schedule
- Claim History
- Capability
- Subcontracting
- Estimating
- Strategic Business Plan

The overall relative importance index is shown by the radar charts in Figures 4.5 and 4.6 for the major groups and individual factors. In Figure 4.5, a total of 17 radial lines represent the relative importance index of their respective groups. In Figure 4.6, a total of 76 radial lines represent the relative importance index of each minor factor. The average relative importance index is also incorporated into the chart in order to emphasize each group/factor's relative position.

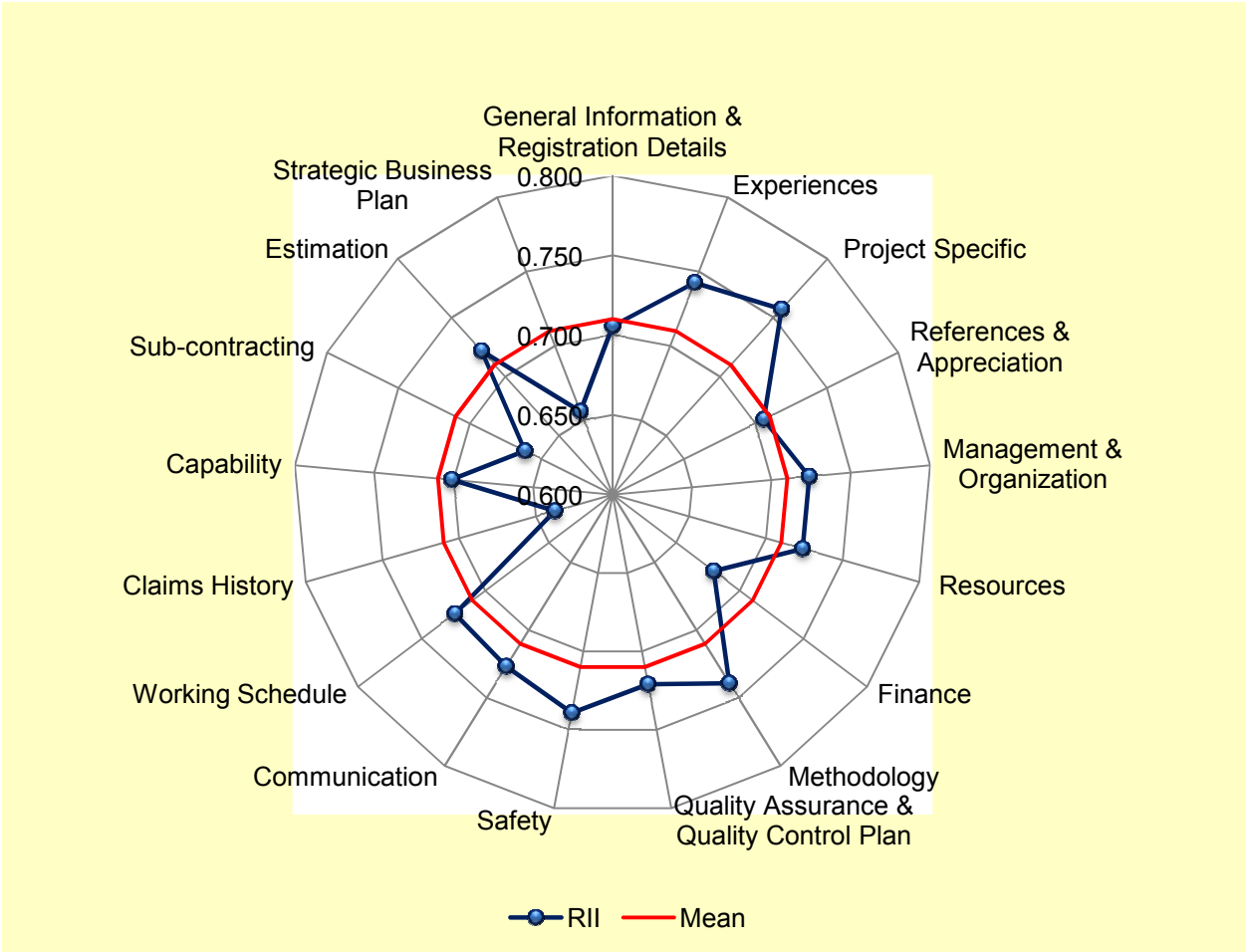


Figure 4.5. Radar Chart of Major Factor(s) Relative Importance Index

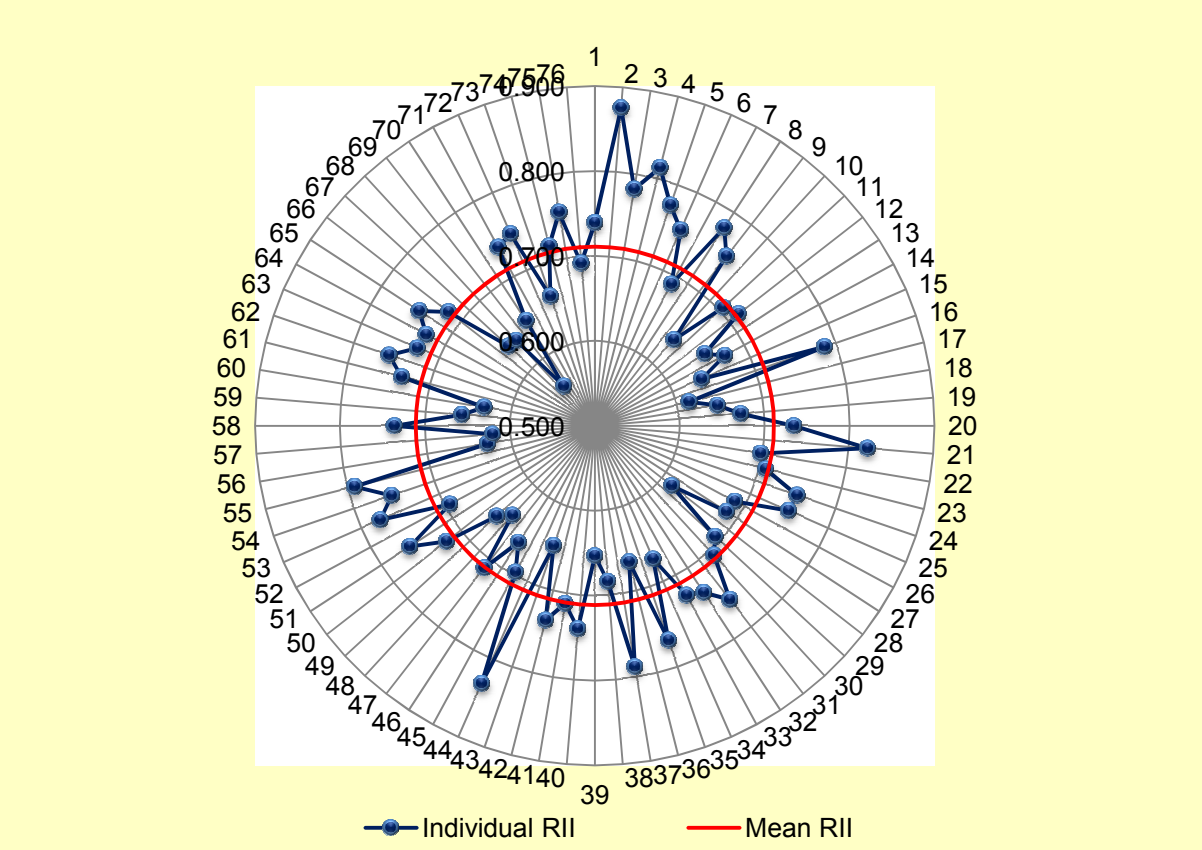


Figure 4.6. Radar Chart of Minor Factor(s) Relative Importance Index

4.3.1. Factor(s) Related to General Information and Registration Details

Table 4.5 shows the respondents' opinions regarding the factors related to the contractors' general information and registration details. The factors' RIIs are as follows:

Table 4.5. Factor(s) Related to General Information and Registration Details

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Attitude, cooperation and performance	11	27	15	1	1	55	0.767	12	1
2	Validity of registration details	6	23	18	4	3	54	0.693	40	2
3	Ownership and substance of the business	2	18	23	4	2	49	0.657	52	3

1. "Attitude, cooperation and performance" with RII equals 0.767, and the rank equals 1 in the "General Information and Registration Details" group and 12 in the overall group.

2. “Validity of registration details” with RII equals 0.693, and the rank equals 2 in the “General Information and Registration Details” group and 40 in the overall group.
3. “Ownership and substance of the business” with RII equals 0.657, and the rank equals 3 in the “General Information and Registration Details” group and 52 in the overall group.

4.3.2. Factor(s) Related to Experience

Table 4.6 shows the respondents’ opinions regarding the factors related to contractors’ experience details. The factors’ RII are as follows:

Table 4.6. Factor(s) Related to Experiences

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Area of specialization	13	27	15	1	0	56	0.786	7	1
2	Past and current performance	14	24	16	2	0	56	0.779	9	2
3	Qualified and excellent percentage of project performed in recent 5 years	10	22	17	0	1	50	0.760	13	3
4	Size of project-experience	8	26	19	1	0	54	0.752	18	4
5	Large scale(largest amount) project performed in past five years	6	25	15	4	1	51	0.722	30	5
6	Length of time in business	6	20	26	3	0	55	0.705	36	6
7	Partners / sub-contracts experience	4	18	24	3	0	49	0.694	39	7
8	Size of business	1	21	28	5	0	55	0.665	49	8

1. “Area of Specialization” with RII equals 0.786, and the rank equals 1 in the “Experience” group and 7 in the overall group.
2. “Past and Current Performance” with RII equals 0.779, and the rank equals 2 in the “Experience” group and 9 in the overall group.
3. “Qualified and Excellent Percentage of Project Performed in Recent five years” with RII equals 0.760, and the rank equals 3 in the “Experience” group and 13 in the overall group.
4. “Size of Project Experience” with RII equals 0.752, and the rank equals 4 in the “Experience” group and 18 in the overall group.
5. “Large Scale (Largest Amount) of Project Performed in Past Five Years” with RII equals 0.722, and the rank equals 5 in the “Experience” group and 30 in the overall group.

6. “Length of Time in Business” with RII equals 0.705, and the rank equals 6 in the “Experience” group and 36 in the overall group.
7. “Partners/Sub-contracting Experiences” with RII equals 0.694, and the rank equals 7 in the “Experience” group and 39 in the overall group.
8. “Size of Business” with RII equals 0.665, and the rank equals 8 in the “Experience” group and 49 in the overall group.

4.3.3. Factor(s) Related to Project Specific Requirements

Table 4.7 shows the respondents’ opinions regarding factors related to the project-specific requirements. The factors’ RII are as follows:

1. “Expertise in Similar Projects” with RII equals 0.822, and the rank equals 1 in the “Project Specific” group and 3 in the overall group.
2. “Number of Similar Projects Experience” with RII equals 0.776, and the rank equals 2 in the “Project Specific” group and 10 in the overall group.
3. “Experience in Geographic Location of Project” with RII equals 0.674, and the rank equals 3 in the “Project Specific” group and 46 in the overall group.

Table 4.7. Factor(s) Related to Project Specific Requirements

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Expertise in similar projects	15	31	7	1	0	54	0.822	3	1
2	Number of similar projects experience	10	25	14	1	0	50	0.776	10	2
3	Experience in geographic location of project	4	20	23	6	1	54	0.674	46	3

4.3.4. Factor(s) Related to References and Appreciation

Table 4.8 shows the respondents’ opinions regarding the factors related to contractors’ references and appreciation. The factors’ RIIs are as follows:

1. “Client Satisfaction-Historical Non-Performance” with RII equals 0.753, and the rank equals 1 in “References and Appreciation” group and 17 in the overall group.
2. “Company Reputation” with RII equals 0.749, and the rank equals 2 in the “References and Appreciation” group and 19 in the overall group.

3. “Good Relationship with Stakeholders” with RII equals 0.707, and the rank equals 3 in the “References and Appreciation” group and 35 in the overall group.
4. “References” with RII equals 0.615, and the rank equals 4 in the “References and Appreciation” group and 64 in the overall group.

Table 4.8. Factor(s) Related to References and Appreciation

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Client satisfaction- historical non-performance	12	23	11	2	3	51	0.753	17	1
2	Company reputation	6	33	13	2	1	55	0.749	19	2
3	Good relationship with stakeholders	8	23	20	1	4	56	0.707	35	3
4	References	7	8	26	10	4	55	0.615	64	4

4.3.5. Factor(s) Related to Management and Organization

Table 4.9 shows the respondents’ opinions regarding factors related to the contractor’s managerial and organizational setup. The factors’ RIIs are as follows:

Table 4.9. Factor(s) Related to Management and Organization

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Management and technical skills and capabilities	17	30	9	2	0	58	0.814	4	1
2	Qualification of contractor	15	18	15	1	0	49	0.792	5	2
3	Project management	10	27	11	1	0	49	0.788	6	3
4	Site management	13	24	12	3	2	54	0.759	14	4
5	Project control procedures	6	28	12	3	1	50	0.740	21	5
6	Purchasing expertise, material handling and control	6	29	9	5	1	50	0.736	24	6
7	Contractor organization and plan	8	21	22	5	0	56	0.714	33	7
8	Environmental sustainability	8	15	20	8	5	56	0.646	57	8
9	Waste management practices	9	12	13	9	7	50	0.628	62	9
10	Substance abuse policy	6	15	13	6	8	48	0.621	63	10

1. “Management and Technical Skills and Capabilities” with RII equals 0.814, and the rank equals 1 in the “Management and Organization” group and 4 in the overall group.
2. “Qualification of Contractor” with RII equals 0.792, and the rank equals 2 in the “Management and Organization” group and 5 in the overall group.

3. “Project Management” with RII equals 0.788, and the rank equals 3 in the “Management and Organization” group and 6 in the overall group.
4. “Site Management” with RII equals 0.759, and the rank equals 4 in the “Management and Organization” group and 14 in the overall group.
5. “Project Control Procedure” with RII equals 0.740, and the rank equals 5 in the “Management and Organization” group and 21 in the overall group.
6. “Purchasing Expertise, Material Handling and Control” with RII equals 0.736, and the rank equals 6 in the “Management and Organization” group and 24 in the overall group.
7. “Contractor Organization and Plan” with RII equals 0.714, and the rank equals 7 in the “Management and Organization” group and 33 in the overall group.
8. “Environmental Sustainability” with RII equals 0.646, and the rank equals 8 in the “Management and Organization” group and 57 in the overall group.
9. “Waste Management Practices” with RII equals 0.628, and the rank equals 9 in the “Management and Organization” group and 62 in the overall group.
10. “Substance Abuse Policy” with RII equals 0.621, and the rank equals 10 in the “Management and Organization” group and 63 in the overall group.

4.3.6. Factor(s) Related to Resources

Table 4.10 shows the respondents’ opinions regarding factors related to the contractor’s resources. The factors’ RIIs are as follows:

1. “Key Managerial, Supervisory and Operational Personnel Experience and Availability” with RII equals 0.775, and the rank equals 1 in the “Resources” group and 11 in the overall group.
2. “Workforce Resources and Availability” with RII equals 0.753, and the rank equals 2 in the “Resources” group and 17 in the overall group.
3. “Equipment Resources and Availability” with RII equals 0.752, and the rank equals 3 in the “Resources” group and 18 in the overall group.
4. “Info-Ware, Knowledge of Technology and Availability” with RII equals 0.735, and the rank equals 4 in the “Resources” group and 26 in the overall group.

Table 4.10. Factor(s) Related to Resources

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Key managerial, supervisory and operational personnel experience and availability	8	35	11	2	0	56	0.775	11	1
2	Workforce resources and availability	11	22	20	2	0	55	0.753	17	2
3	Equipment resources and availability	15	19	19	5	0	58	0.752	18	3
4	Info-ware, knowledge of technology and availability	8	26	17	3	1	55	0.735	26	4
5	The quantities, capabilities, and condition of the contractor's owned or rented equipment	5	24	16	4	1	50	0.712	34	5
6	Equipment repair and maintenance	2	20	25	3	0	50	0.684	45	6
7	Personnel back-up strategy	2	20	20	4	3	49	0.657	52	7

5. "Quantities, Capabilities, and Condition of the Owned or Rented Equipment" with RII equals 0.712, and the rank equals 5 in the "Resources" group and 34 in the overall group.
6. "Equipment Repair and Maintenance" with RII equals 0.684, and the rank equals 6 in the "Resources" group and 45 in the overall group.
7. "Personnel Back-Up Strategy" with RII equals 0.657, and the rank equals 7 in the "Resources" group and 52 in the overall group.

4.3.7. Factor(s) Related to Finance

Table 4.11 shows the respondents' opinions regarding factors related to contractor finances. The factors' RIIs areas are as follows:

Table 4.11. Factor(s) Related to Finance

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Financial stability and soundness	11	32	12	2	0	57	0.782	8	1
2	Bank solvency	7	24	15	4	0	50	0.736	24	2
3	Turnover History	3	28	19	3	2	55	0.698	37	3
4	Liquidity (current ration)	5	21	22	7	0	55	0.687	43	4
5	Bank arrangement / financing	5	23	18	6	2	54	0.685	44	5
6	Profitability	7	17	23	5	3	55	0.673	47	6
7	Overruns: cost in past projects	4	12	27	4	2	49	0.649	55	7
8	Credit rating and history	3	20	18	10	3	54	0.637	60	8
9	Previous financial penalties	6	15	15	9	5	50	0.632	61	9
10	Debit ratio	1	16	27	6	4	54	0.615	64	10

1. “Financial Stability and Knowledge” with RII equals 0.782, and the rank equals 1 in the “Finance” group and 8 in the overall group.
2. “Bank Solvency” with RII equals 0.736, and the rank equals 2 in the “Finance” group and 24 in the overall group.
3. “Turnover History” with RII equals 0.698, and the rank equals 3 in the “Finance” group and 37 in the overall group.
4. “Liquidity (Current Ration)” with RII equals 0.687, and the rank equals 4 in the “Finance” group and 43 in the overall group.
5. “Bank Arrangement/Financing” with RII equals 0.685, and the rank equals 5 in the “Finance” group and 44 in the overall group.
6. “Profitability” with RII equals 0.673, and the rank equals 6 in the “Finance” group and 47 in the overall group.
7. “Overruns: Cost in Past Projects” with RII equals 0.649, and the rank equals 7 in the “Finance” group and 55 in the overall group.
8. “Credit Rating and History” with RII equals 0.637, and the rank equals 8 in the “Finance” group and 60 in the overall group.
9. “Previous Financial Penalties” with RII equals 0.632, and the rank equals 9 in the “Finance” group and 61 in the overall group.
10. “Debit Ratio” with RII equals 0.615, and the rank equals 10 in the “Finance” group and 64 in the overall group.

4.3.8. Factor(s) Related to Methodology

Table 4.12 shows the respondents’ opinions regarding factors related to contractors’ work methodology. The factors’ RIIs are as follows:

1. “Specialized Knowledge of Particular Construction Method” with RII equals 0.756, and the rank equals 1 in the “Methodology” group and 15 in the overall group.
2. “Technical Proposal Responsiveness” with RII equals 0.735, and the rank equals 2 in the “Methodology” group and 25 in the overall group.

3. “Statement of Methodology/Constructability” with RII equals 0.727, and the rank equals 3 in the “Methodology” group and 28 in the overall group.

Table 4.12. Factor(s) Related to Methodology

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Specialized knowledge of particular construction method	7	25	18	0	0	50	0.756	15	1
2	Technical proposal responsiveness	6	25	15	2	1	49	0.735	25	2
3	Statement of methodology / constructability	7	25	15	4	1	52	0.727	28	3

4.3.9. Factor(s) Related to Quality-Assurance and Quality-Control Plans

Tale 4.13 shows the respondents’ opinions regarding factors related to contractors’ quality-assurance and quality-control plans. The factors’ RIIs are as follows:

1. “Quality Management, Control and Assurance System” with RII equals 0.876, and the rank equals 1 in the “Quality Assurance and Quality Control Plan” group and 1 in the overall group.
2. “Quality Performance” with RII equals 0.831, and the rank equals 2 in the “Quality Assurance and Quality Control Plan” group and 2 in the overall group.

Table 4.13. Factor(s) Related to Quality Assurance and Quality Control Plan

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Quality management, control and assurance system	32	16	10	0	0	58	0.876	1	1
2	Quality performance	16	27	8	0	0	51	0.831	2	2

4.3.10. Factor(s) Related to Health and Safety

Table 4.14 shows the respondents’ opinions regarding factors related to contractors’ safety performance and plans. The factors’ RIIs are as follows:

1. “Health and Safety Performance and Plans” with RII equals 0.739, and the rank equals 1 in the “Health and Safety” group and 22 in the overall group.

Table 4.14. Factor(s) Related to Health and Safety

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Health and Safety performance and plan	17	15	16	6	2	56	0.739	22	1

4.3.11. Factor(s) Related to Communication

Table 4.15 shows the respondents' opinions regarding factors related to the contractors' communication methods. The factors' RIIs are as follows:

1. "Communication" with RII equals 0.728, and the rank equals 1 in the "Communication" group and 27 in the overall group.
2. "Documentation Management" with RII equals 0.725, and the rank equals 2 in the "Communication" group and 29 in the overall group.

Table 4.15. Factor(s) Related to Communication

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Communication	9	20	16	4	1	50	0.728	27	1
2	Documentation Management	9	23	12	5	2	51	0.725	29	2

4.3.12. Factor(s) Related to Work Schedules

Table 4.16 shows the respondents' opinions regarding factors related to contractors' work schedules. The factors' RIIs are as follows:

Table 4.16. Factor(s) Related to Work Schedule

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Scheduling of Cost Control	9	23	13	3	1	49	0.747	20	1
2	Schedule of project	15	15	18	6	1	55	0.735	26	2
3	Construction scheduling guarantee measure	6	23	15	4	1	49	0.718	31	3
4	Overruns: schedule in past projects	5	20	19	6	0	50	0.696	38	4

1. “Scheduling of Cost Control” with RII equals 0.747, and the rank equals 1 in the “Working Schedule” group and 20 in the overall group.
2. “Schedule of Project” with RII equals 0.735, and the rank equals 2 in the “Working Schedule” group and 26 in the overall group.
3. “Construction Scheduling Guarantee Measure” with RII equals 0.718, and the rank equals 3 in the “Working Schedule” group and 31 in the overall group.
4. “Overruns: Schedule in Past Projects” with RII equals 0.696, and the rank equals 4 in the “Working Schedule” group and 38 in the overall group.

4.3.13. Factor(s) Related to Claim History

Table 4.17 shows the respondents’ opinions regarding factors related to a contractor’s claim history. The factors’ RIIs are as follows:

Table 4.17. Factor(s) Related to Claim History

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Contractor failure to complete a project	16	14	13	10	5	58	0.690	42	1
2	Litigation tendency	4	18	20	6	2	50	0.664	50	2
3	Contract not renewed due to failure to perform	7	15	13	4	8	47	0.638	59	3
4	History of claims of contractor	5	16	21	6	5	53	0.638	59	3
5	Has the contractor ever been debarred in a certain jurisdiction area by a governmental agency	9	14	13	3	10	49	0.637	60	4
6	Declined invitations, or did not submit a bid on at least three occasions in the previous 12months	3	8	19	14	5	49	0.559	65	5

1. “Contractor Failure to Complete a Project” with RII equals 0.690, and the rank equals 1 in the “Claims History” group and 42 in the overall group.
2. “Litigation Tendency” with RII equals 0.664, and the ranks equals 2 in the “Claims History” group and 50 in the overall group.
3. “Contract Not Renewed Due to Failure to Perform” with RII equals 0.638, and the rank equals 3 in the “Claims History” group and 59 in the overall group.
4. “History of Claims of Contractor” with RII equals 0.638, and the rank equals 4 in the “Claims History” group and 59 in the overall group.

5. “Debarment of Contractor from any Jurisdiction Area by a Governmental Agency” with RII equals 0.637, and the rank equals 5 in the “Claims History” group and 60 in the overall group.
6. “Declining Tendency” with RII equals 0.559, and the rank equals 6 in the “Claims History” group and 65 in the overall group.

4.3.14. Factor(s) Related to Capability

Table 4.18 shows the respondents’ opinions regarding factors related to a contractor’s capability. The factors’ RIIs are as follows:

Table 4.18. Factor(s) Related to Capability

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Capacity to add this project	8	25	12	3	1	49	0.747	20	1
2	Capacity of firms	6	26	14	2	1	49	0.739	23	2
3	Risk management (including insurance, and use of authorized subcontractors	10	17	16	5	2	50	0.712	34	3
4	Ability to obtain a tender, performance, payment bond; bonding capacity	6	23	20	4	1	54	0.707	35	4
5	Current workload	4	17	26	6	2	55	0.655	53	5
6	Amount of current uncompleted work-on-hand	3	17	22	5	3	50	0.648	56	6

1. “Capacity to Add this Project” with RII equals 0.747, and the rank equals 1 in the “Capability” group and 20 in the overall group.
2. “Capacity of Firms” with RII equals 0.739, and the rank equals 2 in the “Capability” group and 23 in the overall group.
3. “Risk Management” with RII equals 0.712, and the rank equals 3 in the “Capability” group and 34 in the overall group.
4. “Bonding Capacity” with RII equals 0.707, and the rank equals 4 in the “Capability” group and 35 in the overall group.
5. “Current Workload” with RII equals 0.655, and the rank equals 5 in the “Capability” group and 53 in the overall group.
6. “Amount of Current Uncompleted Work-on-Hand” with RII equals 0.648, and the ranks equals 6 in the “Capability” group and 56 in the overall group.

4.3.15. Factor(s) Related to Subcontracting

Table 4.19 shows the respondents' opinions regarding factors related to contractors' subcontracting. The factors' RIIs are as follows:

1. "Subcontracting Plan" with RII equals 0.661, and the rank equals 1 in the "Subcontracting" group and 51 in the overall group.

Table 4.19. Factor(s) Related to Subcontracting

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Subcontractor plan	2	20	20	5	2	49	0.661	51	1

4.3.16. Factor(s) Related to Estimating

Table 4.20 shows the respondents' opinions regarding factors related to contractors' estimating and payment methods. The factors' RIIs are as follows:

1. "Schedule of Payments" with RII equals 0.755, and the rank equals 1 in the "Estimating" group and 16 in the overall group.
2. "Use of Fair Estimation Methods" with RII equals 0.718, and the rank equals 2 in the "Estimating" group and 32 in the overall group.
3. "Advance Payment" with RII equals 0.692, and the rank equals 3 in the "Estimating" group and 41 in the overall group.

Table 4.20. Factor(s) Related to Estimating

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Schedule of payments	10	22	14	2	1	49	0.755	16	1
2	Use of fair estimating methods	7	23	14	2	3	49	0.718	32	2
3	Advance payment	9	17	15	6	3	50	0.692	41	3

4.3.17. Factor(s) Related to the Strategic Business Plan

Table 4.21 shows the respondents' opinions regarding factors related to the contractor's strategic business plan. The factors' RIIs are as follows:

1. "Location of Home Office and Manpower Accommodation" with RII equals 0.671, and the rank equals 1 in the "Strategic Business Plan" group and 48 in the overall group.
2. "Use of Innovative Practices" with RII equals 0.653, and the rank equals 2 in the "Strategic Business Plan" group and 54 in the overall group.
3. "Training Activities" with RII equals 0.643, and the rank equals 3 in the "Strategic Business Plan" group and 58 in the overall group.

Table 4.21. Factor(s) Related to the Strategic Business Plan

SL.	Minor Factor	Very High	High	Moderate	Low	None	Total	RII	Overall Rank	Between Group
1	Location of home office and manpower accommodation	5	19	24	7	1	56	0.671	48	1
2	Use of innovative practices	3	15	24	6	1	49	0.653	54	2
3	Training activities or programs supported by the bidder or sustainable development of human resources	3	18	20	7	3	51	0.643	58	3

4.4. Statistical Analysis of Factor(s)

Different statistical analyses were performed using Minitab 15 and Microsoft Office software. The statistical result is summarized in Section 4.4.1.

4.4.1. Descriptive Statistics of Category Analysis

The following statistical analysis shown in Table 4.22 used Minitab to find the mean for categorical analysis. The mean relative importance index was 0.7036 for the consultants' group, 0.7259 for the owners' group, 0.7107 for the overall category, and 0.7184 for both the owner and consultant categories. The results showed that the owners have a higher RII than the consultants. The result also showed that the standard deviation of the mean was the same for all categories, 0.06. The maximum RII for the consultants was 0.900, and it was 0.894 for the owners.

Table 4.22. Descriptive Statistics Output from Minitab

Var	Category	Mean	StDev	Variance	Minimum	Maximum	Median	Skewness	Kurtosis
RII	Both Owner and Consultant	0.71843	0.06015	0.00362	0.56190	0.89600	0.72223	0.16	0.30
	Consultant	0.70357	0.06364	0.00405	0.58667	0.90000	0.69333	0.77	0.60
	Overall	0.71074	0.05866	0.00344	0.55918	0.87586	0.71314	0.11	0.00
	Owner	0.72586	0.06259	0.00392	0.53333	0.89412	0.73218	-0.24	0.39

4.4.2. Statistical Analysis of Relative Importance Index

The individual value plot shown in Figure 4.7 and the box plot in Figure 4.8 indicate that each respondent category has a different mean relative importance index, where the means for owners, consultants, overall, and both owners and consultants were 0.7259, 0.7038, 0.7107, and 0.7184, respectively. The individual value plot in Figure 4.7 indicates that the RII distribution for all categories is the same.

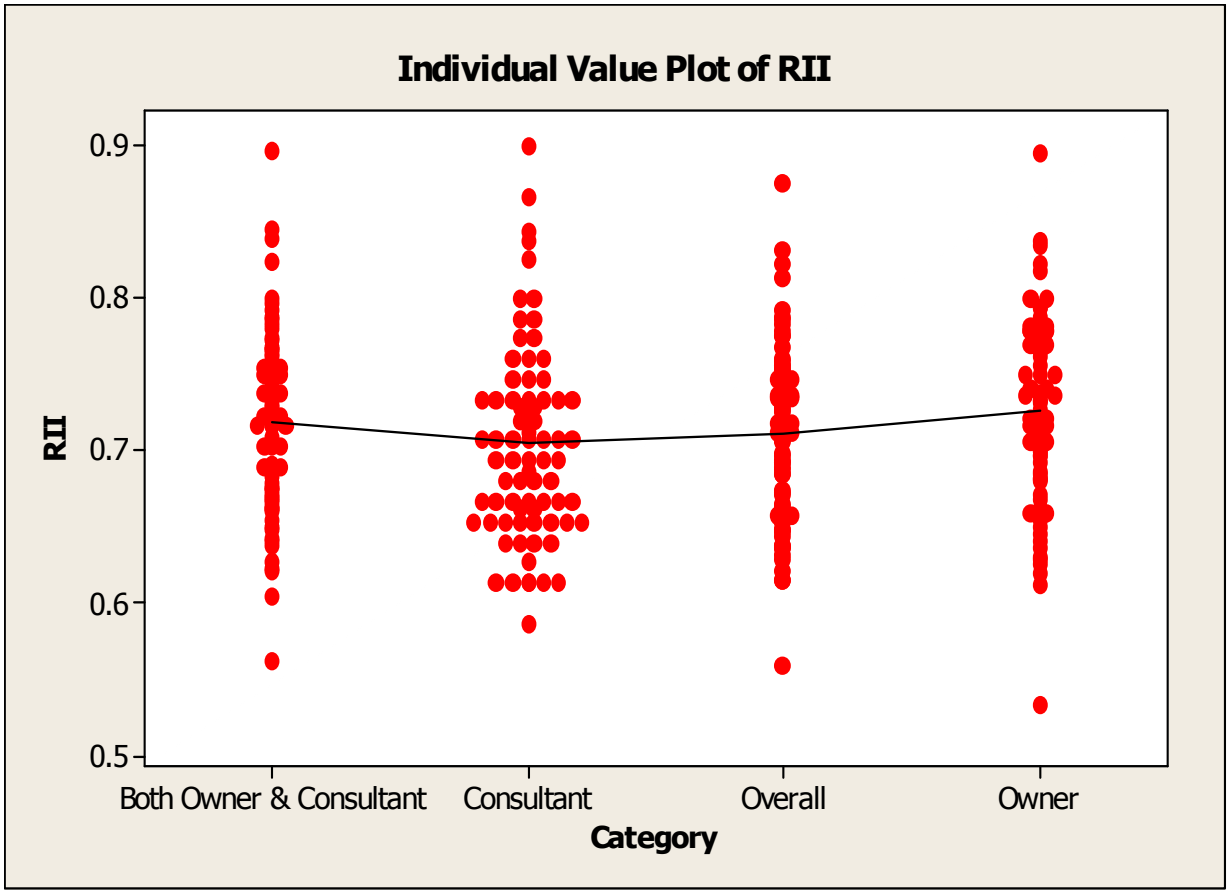


Figure 4.7. Individual Value Plot of Relative Importance Index

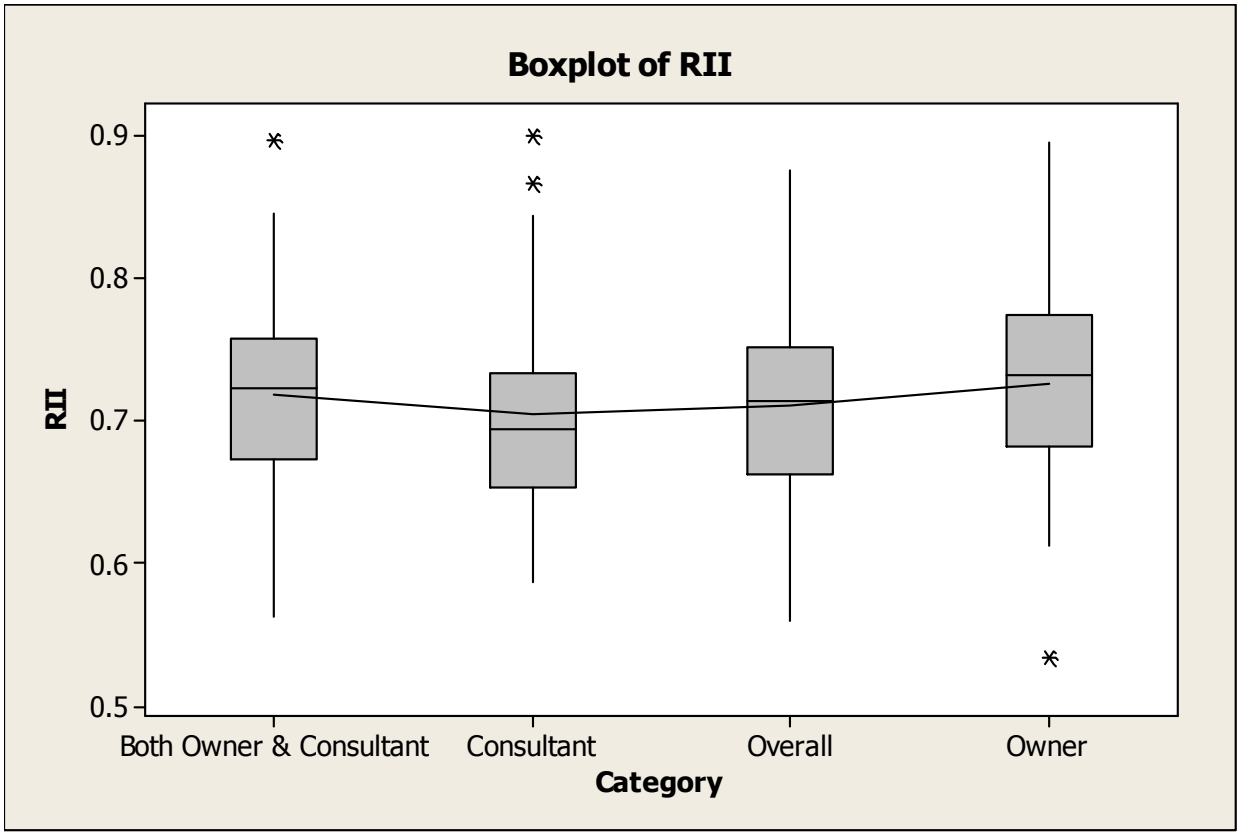


Figure 4.8. Box Plot of Relative Importance Index

The box plot in Figure 4.8 is the methodology of descriptive measures and is based on quartiles of the RII values. It shows that all RII values are on the interquartile range except the four observations which are the outliers. Only the minor factor "Declined invitations, or did not submit a bid for three consecutive times," with RII of 0.533 for owners' category, falls below the lower quartile.

As seen in the individual value plot and the box plot, the means for each category of respondents are different. The mean RIIs were as follows:

- Owner: 0.7259
- Consultant: 0.7036
- Both Owner and Consultant: 0.7184
- Overall: 0.7107

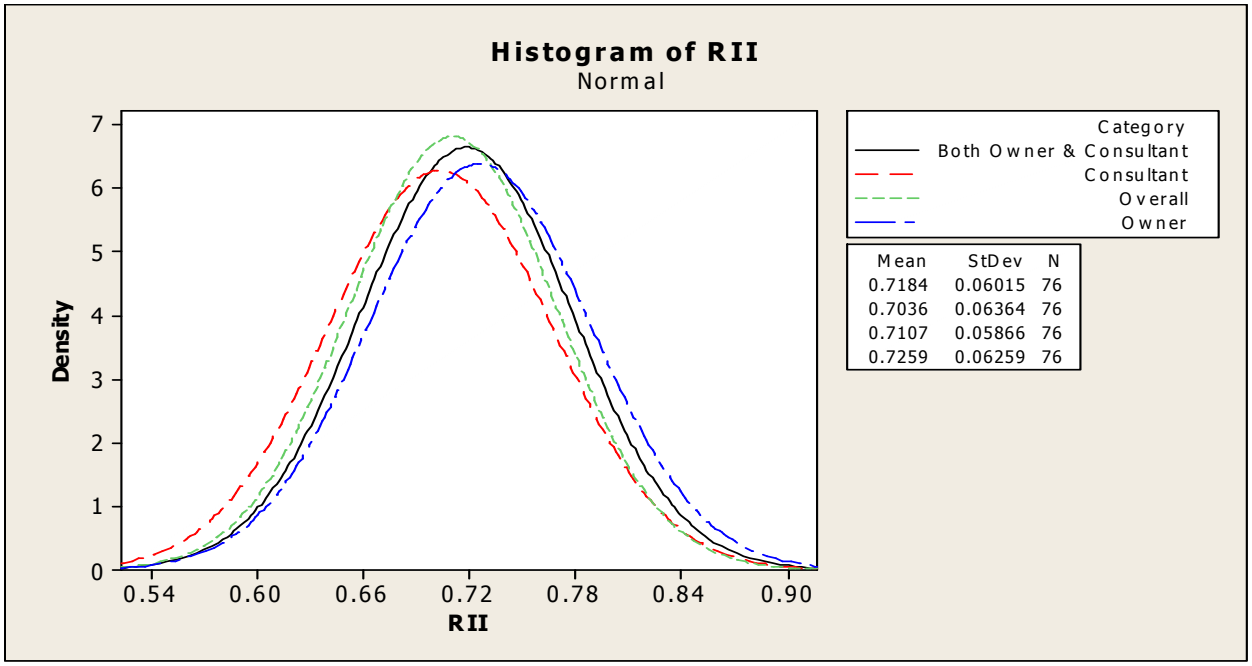


Figure 4.9. Histogram of Relative Importance Index

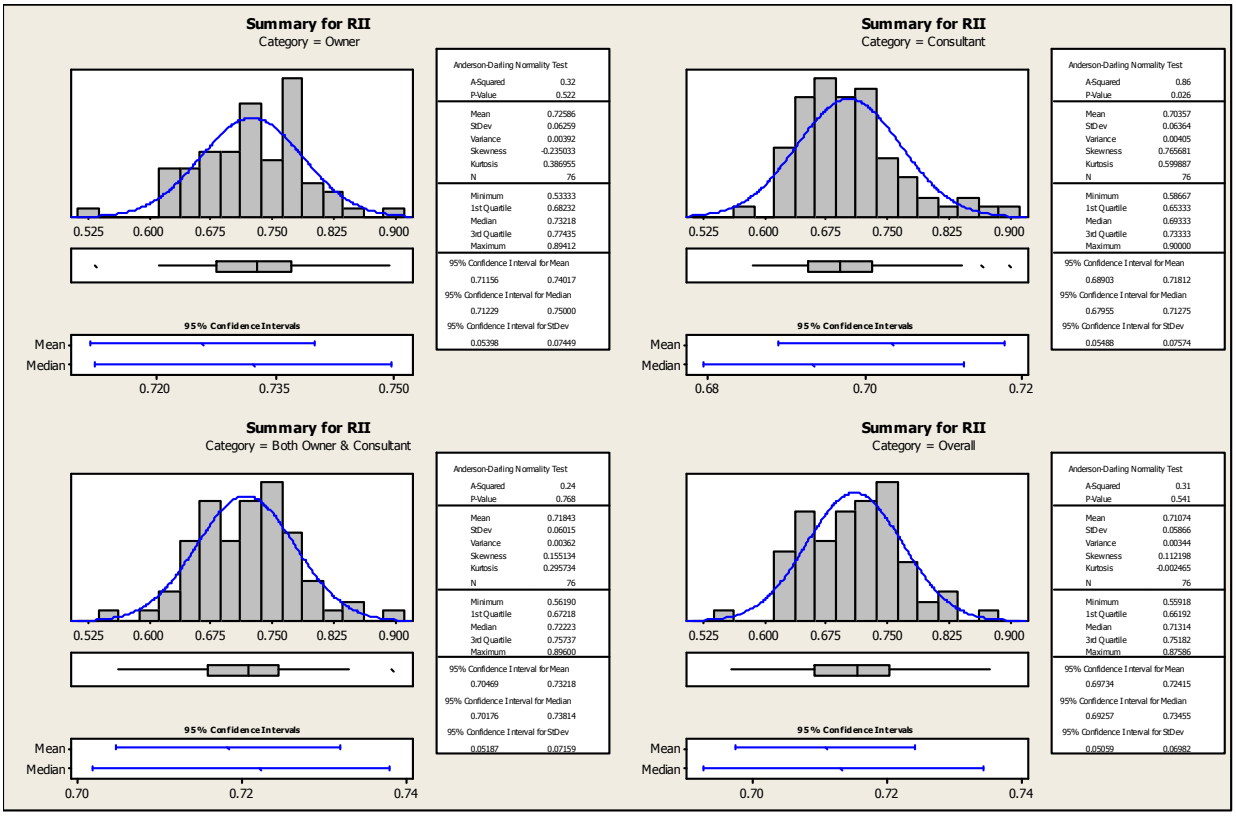


Figure 4.10. Individual Histogram of Relative Importance Index

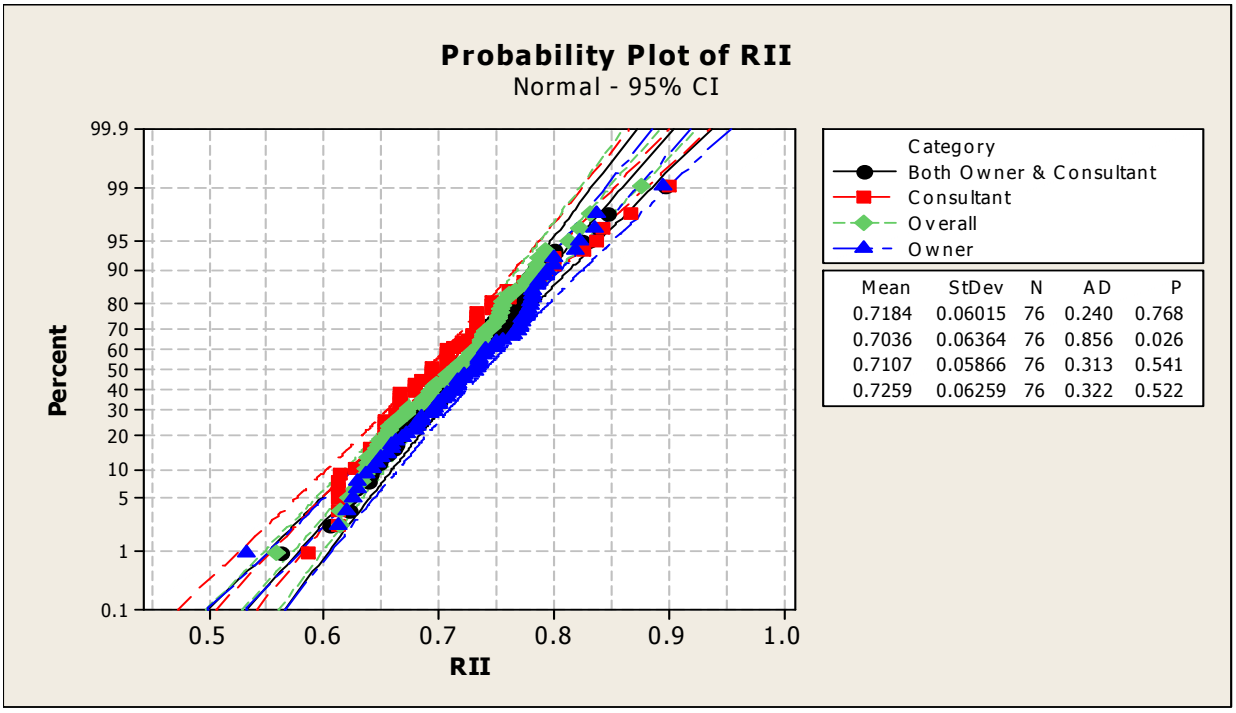


Figure 4.11. Probability Plot of Relative Importance Index

The group RII histogram, shown in Figure 4.9, indicates that owners, consultants, both owners and consultants, and the overall category were different in their mean RIIs with a similar RII spread. It was determined that neither group had a smaller or larger difference in the mean and the distribution. The individual RII histogram, shown in Figure 4.10, and the RII probability plot in Figure 4.11 show that the RII for each category was normally distributed, as illustrated by the distribution curves that exhibited the same pattern.

4.4.3. Statistical Significance of the Relative Importance Index

In order to statistically analyze the RII, two-sample t-tests were conducted as shown in the Minitab output (Table 4.23 and Figure 4.12). In the test result shown in Figure 4.12, the p-value (0.031) provided sufficient evidence that the average RII for each category was different when $\alpha = 0.05$ (95% confidence interval).

Table 4.23. Two-Sample t-Test for Owner RII-vs-Consultant RII

	N	Mean	StDev	SE Mean
Owner RII	76	0.7259	0.0626	0.0072
Consultant RII	76	0.7036	0.0636	0.0073
Difference = mu (Owner RII) - mu (Consultant RII)				
Estimate for difference: 0.0223				
95% CI for difference: (0.0021, 0.0425)				
T-Test of difference = 0 (vs not =): T-Value = 2.18 P-Value = 0.031 DF = 150				
Both use Pooled StDev = 0.0631				

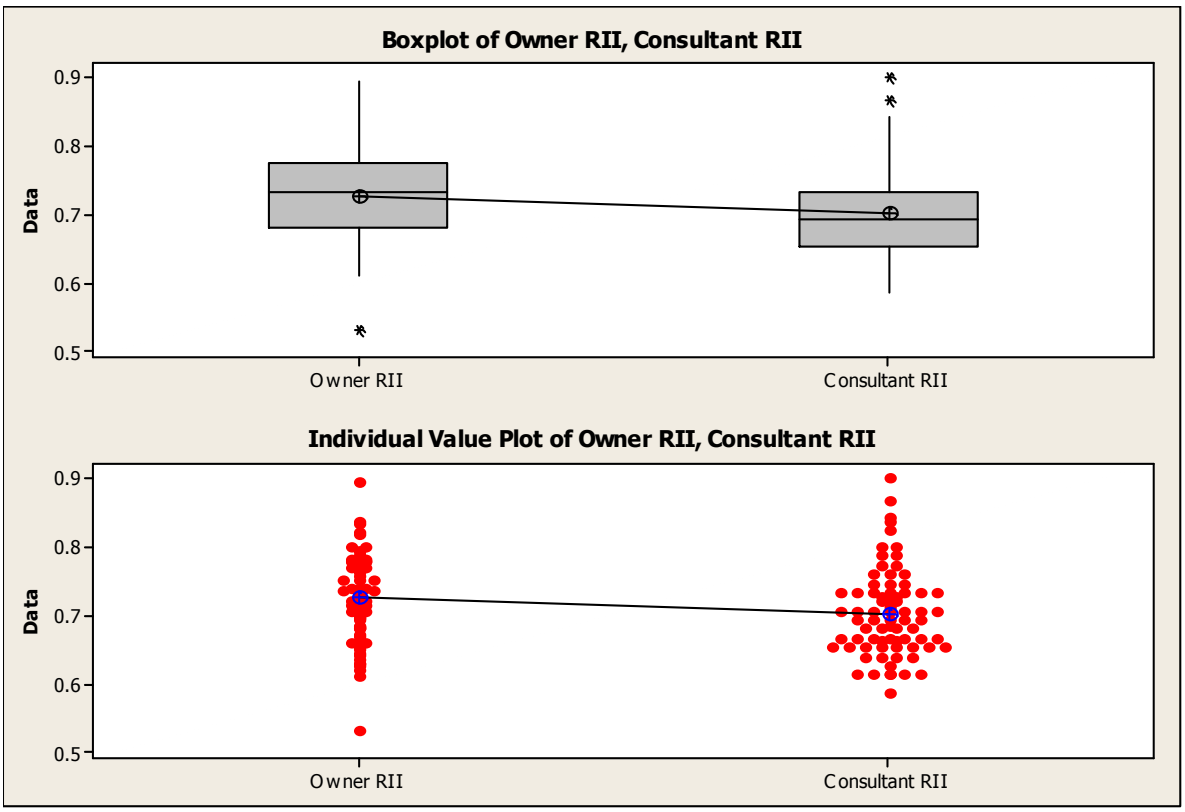


Figure 4.12. Two-Sample t-Test for Relative Importance Index

Therefore, both groups had significantly different RII means. The owners had a larger RII mean of 0.7259 compared to the consultants' RII mean of 0.7036. It can be inferred that the individual factor RII was different, too. Therefore, it was necessary to rank each individual factor for each population category in accordance with the RII values.

4.4.4. Statistical Significance of Ranking

4.4.4.1. Ranking Technique

The data could be ranked as described by Conover (1999). Conover used a technique for the Mann-Whitney test for ranking data. The data consist of two random samples. Let $X_1, X_2, \ldots\ldots\ldots, X_n$ denote the random sample of size n from population 1, and let $Y_1, Y_2, \ldots\ldots\ldots, Y_m$ denote the random sample size of m from population 2. Assign ranks 1 to n + m to the relative importance index from largest to smallest (Conover, 1999).

4.4.4.2. The Mann-Whitney Test

Conover (1999) stated that the following assumptions should be used with the Mann-Whitney test:

1. Both samples are random samples from their respective populations.
2. In addition to independence within each sample, there is mutual independence between the two sample sets.
3. The measurement scales are at least ordinal.

Table 4.24. Mann-Whitney Test and CI: Owner Low 1st Rank and Consultant Low 1st Rank

	N	Median
Owner Low 1st Rank	76	42.50
Consultant Low 1st Rank	76	26.00
Point estimate for ETA1-ETA2 is 10.00		
95.0 Percent CI for ETA1-ETA2 is (2.00,17.00)		
W = 6527.5		
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0086		
The test is significant at 0.0086 (adjusted for ties)		

Based on the Conover (1999) assumptions and using Minitab, the Mann-Whitney test is conducted, and the results are shown in Tables 4.24 and 4.25. The results illustrate that the p-value (0.0086) is smaller than the level of significance, α=0.05. Therefore, it could be inferred that there was a significant difference between the owners' and consultants' mean ranking.

Table 4.25. Mann-Whitney Test and CI: Owner High 1st Rank and Consultant High 1st Rank

	N	Median
Owner High 1st Rank	76	34.50
Consultant High 1st Rank	76	52.00
Point estimate for ETA1-ETA2 is -10.00		
95.0 Percent CI for ETA1-ETA2 is (-17.00,-3.00)		
W = 5095.5		
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0081		
The test is significant at 0.0081 (adjusted for ties)		

4.4.4.3. Scatter Plot of the Rankings

The points on the scatter plot in Figure 4.13 exhibit a reciprocal linear pattern for all four respondent categories. The regression line for each category is approximately similar, suggesting that the proximity of ranking to category with respect to RII does not affect the ranking.

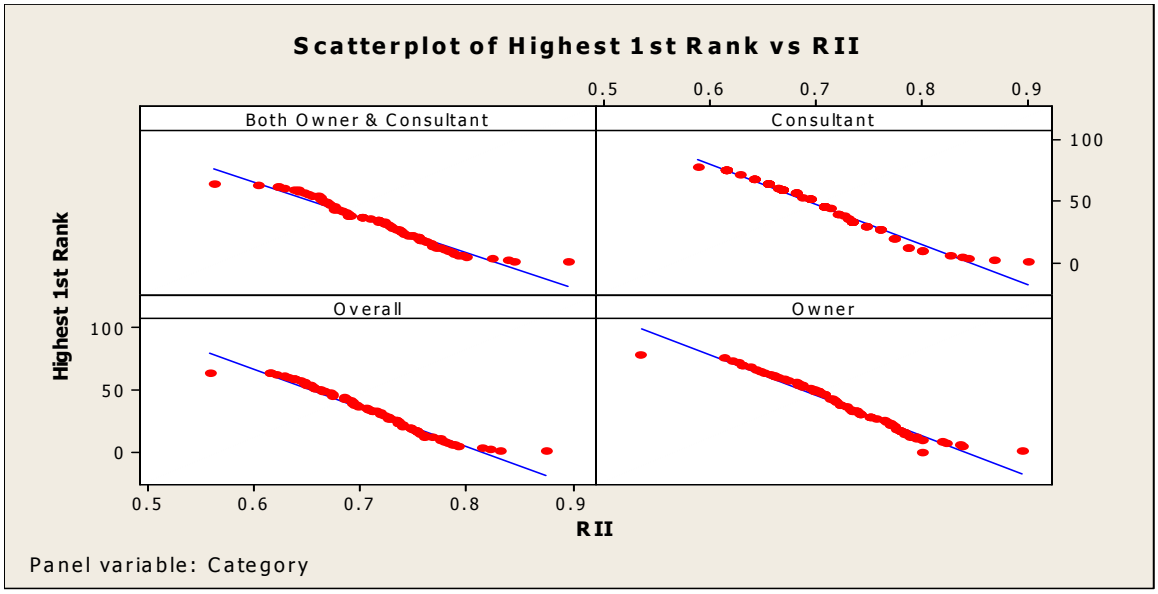


Figure 4.13. Scatter Plot of Ranking

4.5. Agreement between Two Independent Rater Groups

At this point, it was clear which factors had a high relative importance index and which did not. It was shown that the same factor could vary for different rater groups. Therefore, in order to categorize the 76 factors, it was necessary to group these factors based on agreement between the owner and consultant groups. Usually in the contractors' prequalification phase, the owners and consultants are

responsible for evaluating contractors. Therefore, this study only considered two population groups, the owners and the consultants.

For example, a group of owners may be evaluated against a group of consultants or against a group of experts; each group classifies the same item set on a categorical scale. Likewise, agreement could be established between two respondent groups. Vanbelle (2009) found a dearth of theoretical work related to calculating the agreement between two respondent groups. The traditional practice of consensus categorical analysis would help solve this problem.

4.5.1. Consensus Procedure

Vanbelle (2009) stated that the intuitive consensus procedure could be applied for categorical, ordinal-scale data without any verification of theoretical proof. Therefore, in order to establish an agreement index for two rater groups, a case of two raters could be used (Vanbelle, 2009). In order to determine the agreement index, the following procedures for two rater groups was used by Vanbelle (2009).

In this case, the objective was to quantify the agreement index for each individual factor between the owner and consultant groups. In order to achieve the desired outcomes, the followings steps were taken using Microsoft Excel:

1. Classifying the 76 factors on a 5-point Likert or “Summative” scale, very high, high, moderate, low, and none, in accordance with each rater’s response.
2. Summarizing the 76 factors on a 5-point Likert scale (k = 5), very high, high, moderate, low, and none, in accordance with each group of owners and consultants.
3. Separating each individual factor into a two-way classification table using 5 x 5 sizes for each Likert scale.
4. Calculating the distribution of the summarized responses and expressing them in terms of proportions using equation 4.1.

$$P_{ij,g} = \frac{n_{ij,g}}{R_g} \tag{4.1}$$

where $P_{ij,g}$ is the distribution of the summarized responses for each group of raters, i = row number, j = column number, R = total number of respondents on a specified group, and g = group number.

5. Determining the observed proportion of agreement using equation 4.2.

$$P_o = \frac{1}{N} \sum_{i=1}^{N} \sum_{j=1}^{N} P_{ij,1} P_{ij,2} \tag{4.2}$$

where P_o = observed proportion of agreement and N = total number of responses counted for each Likert-scale category.

6. Determining the marginal classification distribution of the group of raters by using equation 4.3.

$$P_j = \frac{1}{N} \sum_{i=1}^{k} P_{ij} \tag{4.3}$$

where P_j = marginal distribution of agreement; $j = 1,.....,k$.

7. Determining the expected proportion of agreement using equation 4.4.

$$P_e = \sum_{j=1}^{k} P_{j,1} P_{j,2} \tag{4.4}$$

where P_e = expected proportion of agreement.

8. For each item, the highest observed proportion of agreement was chosen, which led to the maximum proportion of observed agreement using equation 4.5.

$$P_m = \frac{1}{N} \sum_{i=1}^{N} j_{(max)} P_{ij} \tag{4.5}$$

where P_m = maximum proportion of agreement.

9. Finally, an agreement index (Cohen's kappa coefficient) was calculated using equation 4.6.

$$K = \frac{P_o - P_e}{P_m - P_e} \tag{4.6}$$

where K = Cohen kappa coefficient or agreement index.

4.5.2. Results of the Consensus Approach

The commonly cited scale presented by Viera and Garrett (2005) is being used to interpret the kappa value. It is shown in Table 4.26.

Vanbelle (2009) said, “To define the agreement index, Cohen (1960) considered the observed proportion of agreement after that the proportion of agreement expected by chance is removed from consideration. The result is then scaled to obtain a value 1 when agreement is perfect, a value 0 when agreement is only due to chance and negative values when observed agreement is lower than agreement expected by chance” (Vanbelle, 2009, p. #).

Table 4.26. Interpretation of Kappa Scale

Kappa Value	Agreement
<0	Less than Chance Agreement
0.01-0.20	Slight Agreement
0.21-0.40	Fair Agreement
0.41-0.60	Moderate Agreement
0.61-0.80	Substantial Agreement
0.81-0.99	Almost Agreement

Cohen’s kappa coefficient, or agreement index, between the two groups was K_{max}= 0.13. Each of the 76 factors was examined, and the lower value of the kappa coefficient ranged from a negative value to 0.40. The majority of the observed kappa values were found to be from less-than-a-chance agreement to moderate agreement. Some factors, which had high RIIs, showed a high percentage of overall observed agreement with low kappa values. Lantz and Nebenzahl (1996) researched the high levels of observer agreement with low kappa values paradox. They stated that, even though Feinstein and Cicchetti (1990) first raised this paradox, they failed to provide systematic methods for determining solutions. Therefore, the prevalence and bias-adjusted kappa methods developed were used in this study to calculate the adjusted kappa values, but the observed adjusted kappa value did not improve significantly. Later, an extension of the Cohen (1960) method was used by Fleiss (1971). In this

approach, the expected proportion of agreement was divided by k (k-1)/2 for each cell, where k = the value of the Likert scale. Adopting this formula, this study showed significant improvement in justifying the agreement. According to Biswas (2006), the overall percentage of agreement is not able to address the problem where a difference between positive and negative percentage of agreement exist. Therefore, reporting a positive percent agreement (PPA) in lieu of the overall agreement would overcome this problem. Higher kappa values may contain higher values of negative agreement. Therefore, the factors, which had a higher positive percent agreement index compared to negative percent agreement index was only then considered for each Likert scale. Later factors were categorized in terms of the kappa interpretation scale.

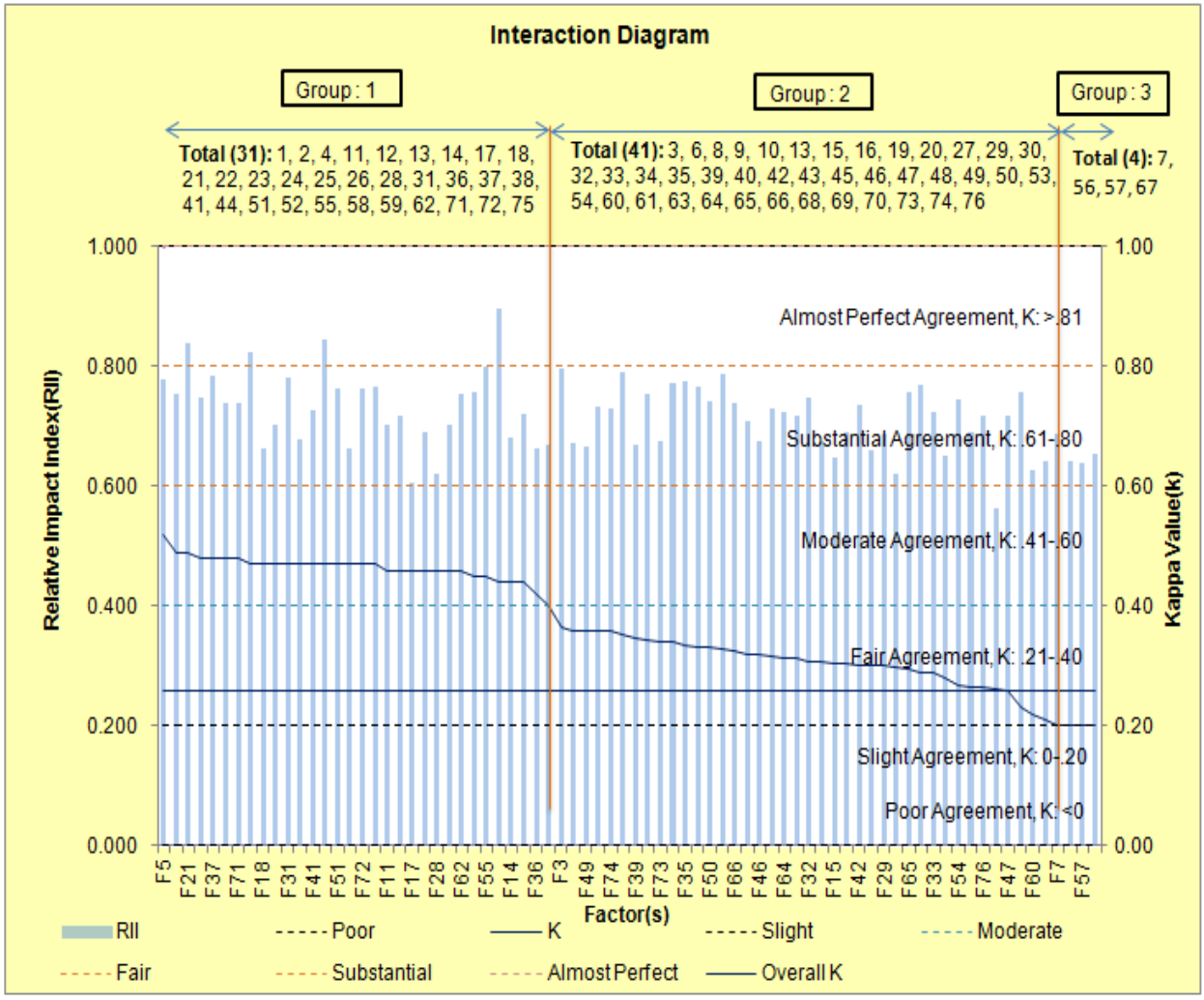


Figure 4.14. Interaction Diagram of Factor Grouping

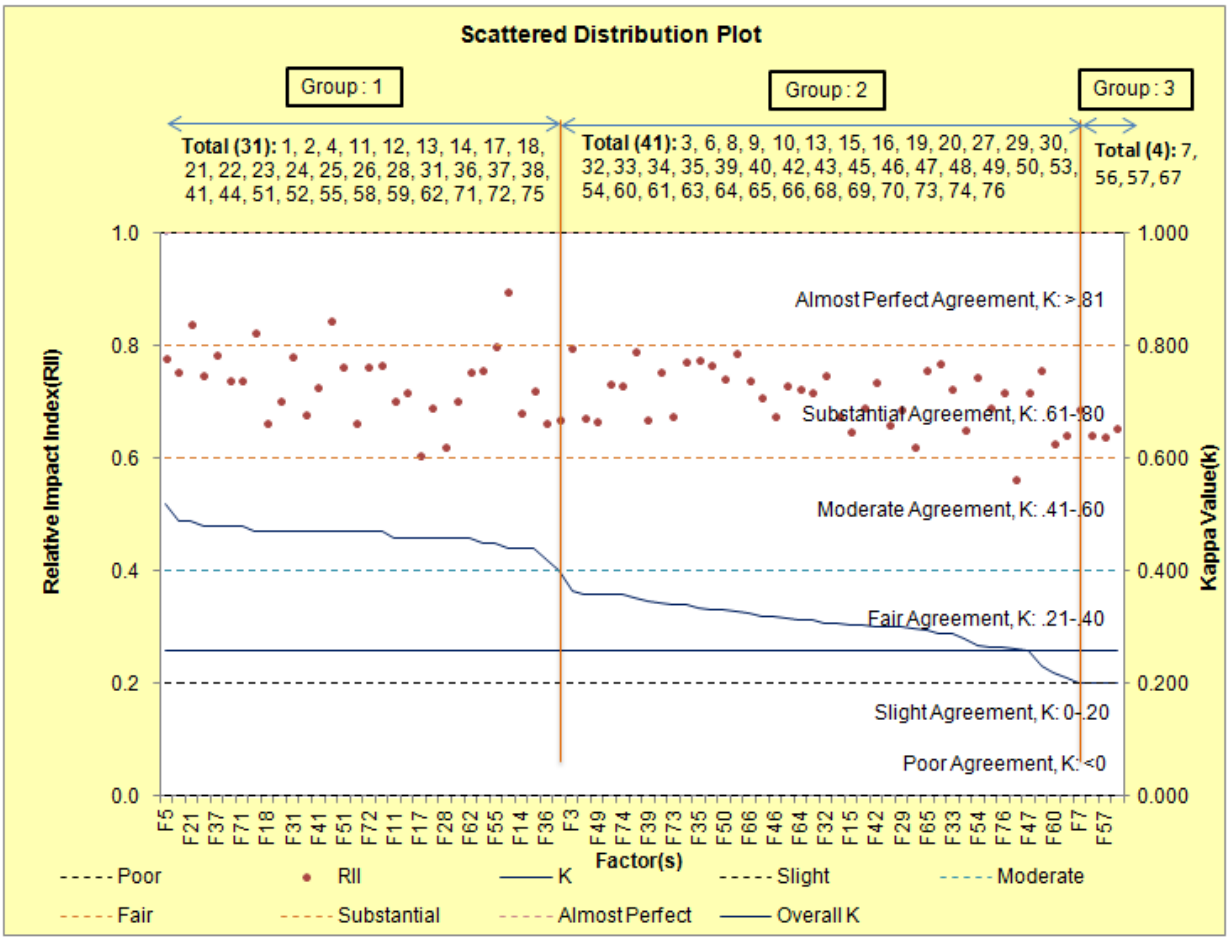


Figure 4.15. Scattered Distribution Plot for Factor Grouping

The interaction diagram in Figure 4.14 and the scattered distribution plot in Figure 4.15 present the final group. Both figures show that a total of 76 factors were classified into 3 major groups based on the agreement between owners and consultants and on the kappa values. Group one contained a total of 31 factors wherein owners and consultants agreed moderately. Factors which were under each specified group were presented in the graph. Group two contained a total of 41 factors where the owners and consultants fairly agreed. Only four factors were identified in group three, representing slight agreement between owners and consultants. Finally, each group was sorted with respect to the highest and lowest RII.

4.6. Comparison of the Results among Bangladesh, the United States, and Saudi Arabia

In order to compare to results obtained from this study with the results obtained by Bubshait and Al-Gobali (1996) and Russell (1988) results was used. The questionnaire was analyzed, and the relative impact index (RII) of each criterion was calculated using equation 4.7 that was only adopted for this section of the study because Bubshait and Al-Gobali (1996) and Russell (1988) used this equation to calculate the RII. For this purpose, it was not necessary to collect different data sets. Equation 4.7 indicated that a response of zero meant the criterion had no impact on bid prequalification; one meant little impact; two meant moderate impact; three meant high impact; and four meant very high impact.

The relative impact index (RII) given by Bubshait and Al-Gobali (1996) is as follows:

$$\frac{4(n_1)+3(n_2)+2(n_3)+1(n_4)+0(n_5)}{4(n_1+n_2+n_3+n_4+n_5)}, \qquad (4.7)$$

where n_1 = Number of Responses with "Very High Impact," n_2 = Number of Responses with "High Impact," n_3 = Number of Responses with "Moderate Impact," n_4 = Number of Responses with "Little Impact," and n_5 = Number of Responses with "No Impact."

4.6.1. Comparison Table Formation

Only 16 of the 76 factors' minor factors were tabulated in Table 4.27 to compare the results. Table 4.27 contains data for Saudi Arabia and the United States of America which were presented by Bubshait and Al-Gobali (1996).

Bubshait and Al-Gobali (1996) arranged the prequalification criteria into four groups:

- Group One (G1): an impact index greater than 3.5
- Group Two (G2): an impact index between 3 and 3.5
- Group Three (G3): an impact index between 2.5 and 3
- Group Four (G4): an impact index between 2 and 2.5

4.6.2. Discussion of Comparison Studies

- The study of Bangladesh included a total of 17 major factors and 76 minor factors, about Bubshait and Al-Gobali and Russell only considered 16 bid prequalification criteria.

Table 4.27. Comparison Table of Relative Importance Index

SL	Decision Factor	Bangladesh			Kingdom of Saudi Arabia*			United States of America*		
			Weight	Rank		Weight	Rank		Weight	Rank
1	Quality management, control and assurance system	G2	3.379	1	G2	3.365	4	G2	3.360	5
2	Management and technical skills and capabilities	G2	3.069	4	G2	3.317	5	G2	3.030	6
3	Financial stability & soundness	G3	2.912	8	G1	3.619	2	G1	3.631	2
4	Past and current performance	G3	2.893	10	G1	3.746	1	G1	3.655	1
5	Key managerial, supervisory and operational personnel experience and availability	G3	2.875	11	G2	3.175	7	G3	2.918	8
6	Attitude, cooperation and performance	G3	2.836	12	G2	3.429	3	G1	3.530	4
7	Workforce resources and availability	G3	2.764	17	G3	2.968	10	G3	2.553	11
8	Size of project-experience	G3	2.759	18	G3	2.730	13	G4	2.200	14
9	Equipment resources and availability	G3	2.759	18	G3	2.825	11	G4	2.110	15
10	Capacity of firms	G3	2.708	22	G2	3.063	8	G3	2.991	7
11	Contractor organization & plan	G3	2.571	31	G3	2.984	9	G4	2.357	12
12	Contractor failure to complete	G4	2.448	39	G2	3.200	6	G1	3.560	3
13	Experience in geographic location of project	G4	2.370	43	G4	2.254	15	G4	2.210	13
14	Location of home office & manpower accommodation	G4	2.357	45	?	1.952	16	?	1.460	16
15	Current workload	G4	2.273	49	G3	2.603	14	G3	2.673	10
16	References	G4	2.073	61	G3	2.746	12	G3	2.808	9

*Source: Bubshait and Al-Gobali (1996)

- Table 4.27 indicated that studies in Bangladesh were far different in weight and ranking compared to results for Saudi Arabia and the United States. For example, the quality management, control, and assurance system was ranked 1st in Bangladesh, 4th in Saudi Arabia, and 5th in the United States. Reference factors were ranked 61st in Bangladesh, 12th in Saudi Arabia, and 9th in the United States.
- Rankings of the criteria were compared with the earlier studies and were found to be statistically significantly different.
- The results obtained from Bangladesh revealed new factors which were not available in the earlier studies performed by both Bubshait and Al-Gobali (1996) and Russell (1988).
- The earlier studies by Bubshait and Al-Gobali (1996) and Russell (1988) did not designate the different populations: whether the respondents were owners, consultants, or contractors.

- In the study of Bangladesh, an agreement index between owners and consultants was used in the RII and the grouping for all factors. Agreement-index techniques were not conducted by Bubshait and Al-Gobali (1996) or Russell (1988).
- There were no statistical justifications for classifying the factors into four groups with the earlier studies. For the study of Bangladesh, all factors were classified according to their kappa value and agreement index, which were divided into three groups with specific objectives.
- The earlier studies did not suggest any group of factors which had an impact index less than 2.0. For example, earlier studies did not include the location of the home office as a factor in any of their groups. This factor had an impact index of 2.357 in Bangladesh, which identified the factor's necessity. Therefore, earlier groupings suggested by the other authors should not be followed. For instance, with international bidding, someone who has a good portfolio may win the bid in Bangladesh, but he only has a business office in China. Then, the question is about how this factor will affect successful project completion and minimize risk. The location of the home office factor may affect project complexity. Therefore, all minor factors should be checked and included in the decision-making process, which was not done in the earlier studies of Bubshait and Al-Gobali (1996) and Russell (1988).
- Health and safety were ranked, overall, as 22nd in Bangladesh, but the earlier studies did not include this factor.
- The previous studies did not discuss how to tie group and individual factors into real-time problems. In order to achieve this outcome in the Bangladeshi study, the analytical hierarchy process (AHP) was adopted to calculate the weight of the individual factors or groups. A detailed framework was also provided to evaluate contractors during the bid-prequalification stages.

Therefore, it might be inferred that there was a significant difference in the results obtained from the Bangladesh studies compared to results from Saudi Arabia and the United States. The study in Bangladesh was more detailed, statistically significant, and reasonably ranked, and it included more specific objectives for each individual or group factor, which, eventually, might be suitable and acceptable to identify contractors' bid prequalification factor(s).

5. PROPOSED FRAMEWORK FOR THE BID PREQUALIFICATION PROCESS

5.1. Introduction

One of the main aspects of this research was to develop a framework for the Bangladeshi contractors' prequalification process in accordance with the owners and consultants' agreement on the survey responses and identified factor(s). This chapter is divided into two more sections.

- The second section determines/establishes the individual/group weights of the surveyed factors using the analytical hierarchy process (AHP) techniques for the proposed framework.
- The third section discusses and develops a framework so that owners/consultants are able to follow the systematic method for decision making about/screening of contractors, which would eventually be a decision model/framework for the contractors' bid prequalification process in Bangladesh's construction industry.

5.2. Necessity of the Bid Prequalification Framework for Bangladesh's Construction Industry

Potter (1994) developed a design-build prequalification system (DBPS) and identified key factors. Potter (1994, p. ii) stated, "The DBPS model is proven as a valid framework for organizing the prequalification attributes of outside design/build teams." The major limitation of that model was based on project constraints, such as public-scrutiny issues and private-sector constraints, and was applicable only for public-sector design/build projects.

Potter (1994) also stated, "Russell *et al.* (1990) presented a decision model for construction prequalification which provides preliminary screening, contractor resources analysis and project specific criteria analysis. He expands on this model to provide a decision framework for this process" (p.27). Plotter extended Russell *et al.*'s (1990) framework. Russell *et al.*'s (1990) decision framework was based on a limited number of factors that were discussed in the last chapter.

Gransberg and Riemer (2009) developed a performance-based, three-tiered construction contractor prequalification framework for the United States Transportation Research Board. The three-tier framework consisted of an administrative, performance-based, and project-specific prequalification process. In their framework, they included a limited number of factors without any further details or standard components for that group. Another drawback of their framework was that they did not include

any minor factors which could become important depending on the project conditions. Therefore, the unavailability of a suitable framework for Bangladesh's construction industry, a literature review, statistical analysis of surveyed data, and a discussion of owner and consultant responses suggest that a new knowledge and an appropriate framework for the contractors' prequalification processes is needed for the Bangladeshi construction industry.

5.3. Analytical Hierarchy Process Model of Contractors' Bid Prequalification

Before discussing the framework, the analytical hierarchy process model is explained in order to facilitate decision making. The AHP technique could be used to identify a qualified single or a list of contractors. There are 76 factors, but there might be even more, depending on the project uniqueness and requirements, and the conditions during bid competition. AHP has been used to select the most qualified contractor(s). Applying AHP, decision makers might be able to identify the most qualified contractor in a logical, transparent way (that could be verified).

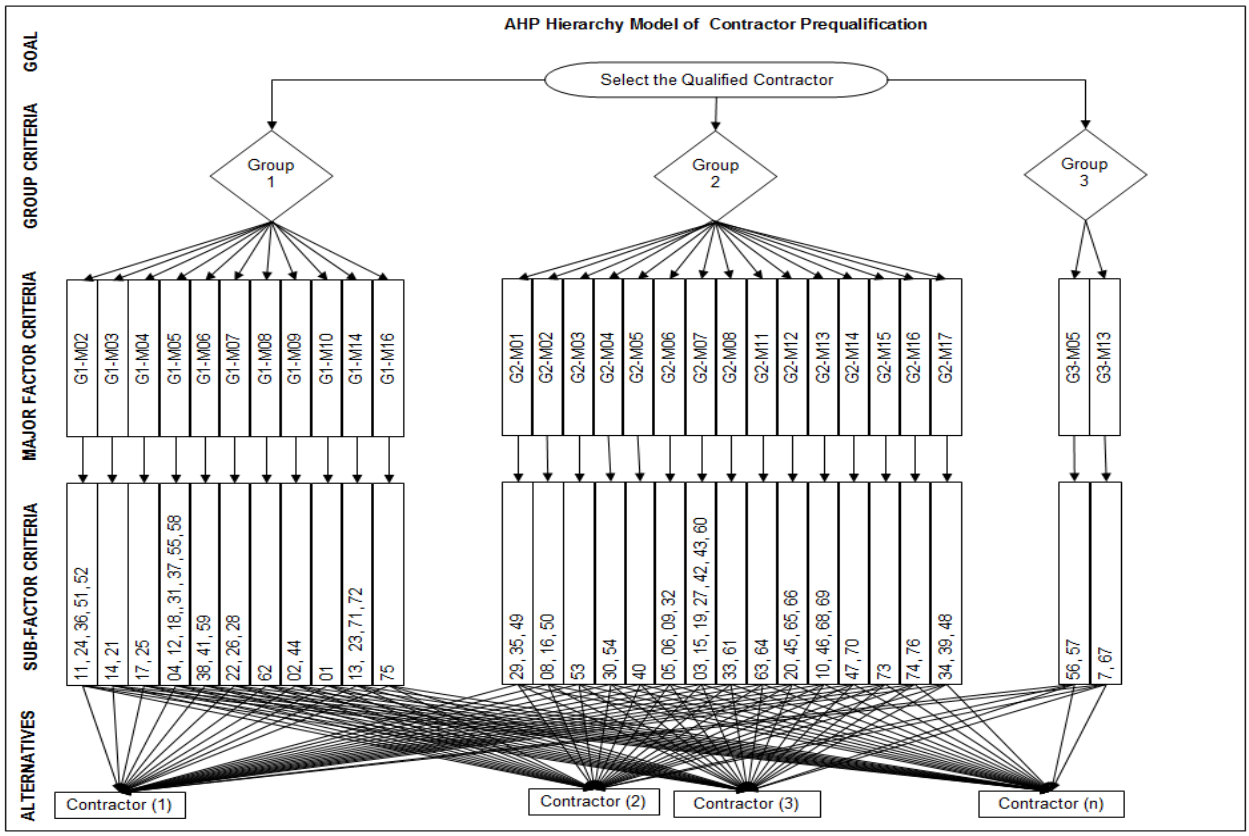


Figure 5.1. AHP Hierarchy Model for Contractors' Prequalification

Figure 5.1 shows the AHP hierarchy at the end of the decision-making process. The three identified groups are included based on the agreement index of the owners and consultants. For each group, there are several factors presented as major-factor criteria. Group one contains 11 major-factor criteria and 31 minor-factor criteria where the owners and consultants moderately agreed. Group two contains a total of 15 major-factor criteria and 41 minor-factor criteria where owners and consultants fairly agreed. Again, only two major-factor and four minor-factor criteria are identified in group three which was agreed to slightly by owners and consultants. At the end of the decision level, a pair-wise comparison of each contractor is done for each pair-wise comparison of an individual group, major factor, and minor factor, which is graphically represented by a series of arrows from minor factor to each contractor in Figure 5.1. Details of the AHP algorithm are described later.

5.3.1. Procedure for Establishing Weights for AHP

5.3.1.1. Step 1. Develop the Judgmental Ranking Criteria for the Decision Maker

A pair-wise judgmental comparison scale for the decision makers was developed for each item in accordance with importance. Because one of the main objectives of this research was to propose a framework for the entire Bangladeshi construction industry, responses from the participants were used as a pair-wise comparison for each item. In order to accomplish this objective, the questionnaire was designed as a Likert/ordinary scale of very high, high, moderate, low, or no importance.

5.3.1.2. Step 2. Calculation of Total Importance

Calculating of the total importance for each item was done using equation 5.1

$$TI_{(Factor)} = 5(n_1) + 4(n_2) + 3(n_3) + 2(n_4) + 1(n_5) \quad , \qquad (5.1)$$

where TI=Total Importance, n_1 = Number of respondents answering "Very High Importance," n_2 = Number of respondents answering “High Importance,” n_3 = Number of respondents answering “Moderate Importance,” n_4 = Number of respondents answering “Low Importance,” and n_5 = Number of companies answering “None Importance.”

To show an example of moderate agreement between the consultant and owner groups (G1), a major factor criterion (M02: Experience) under G1 was chosen. The M02 major group consisted of five minor factors (F11, F24, F36, F51, and F52). For (F11: Length of time in business minor) factors, the

collected responses were filtered based on owner and consultant data (Table 5.1). The total importance of minor factor F11 was calculated using equation 5.1. The total importance of the M02 group was obtained by summing all the total importances of each factor. Similarly, total importance for the rest of the 10 major-factor criteria for group G1 was calculated, and they are shown in Table 5.2.

Table 5.1. Collected, Filtered Responses for the G1-M02 Category

Factor of Group G1- M02	Very High	High	Moderate	Little	None	Total	Total Importance
F11	5	17	22	3	0	47	165
F24	7	22	17	0	0	46	174
F36	1	18	23	5	0	47	156
F51	9	19	14	0	1	43	164
F52	4	16	21	2	0	43	151
						Total	810

Table 5.2. Collected, Filtered Responses for the G1-Major Factor Criteria

	1	2	3	4	5	6	7	8	9	10	11
Major Factor Criteria	**M02**	**M03**	**M04**	**M05**	**M06**	**M07**	**M08**	**M09**	**M10**	**M14**	**M16**
Total Importance	810	350	318	1209	441	470	162	410	185	638	161

5.3.1.3. Step 3. Formation of the Pair-Wise Comparison Matrix

A single pair-wise comparison matrix for each criterion was created. For example, Table 5.3 represents the pair-wise comparison matrix for the G1 major factor criteria.

Table 5.3. Pair-Wise Comparison Matrix for G1-Major Factor Criteria

	1	2	3	4	5	6	7	8	9	10	11	12
	M02	**M03**	**M04**	**M05**	**M06**	**M07**	**M08**	**M09**	**M10**	**M14**	**M16**	**Total**
M02	1.00	2.31	2.55	0.67	1.84	1.72	0.49	1.98	4.38	1.27	5.03	23.23
M03	0.43	1.00	1.10	0.29	0.79	0.74	0.21	0.85	1.89	0.55	2.17	10.04
M04	0.39	0.91	1.00	0.26	0.72	0.68	0.19	0.78	1.72	0.50	1.98	9.12
M05	1.49	3.45	3.80	1.00	2.74	2.57	0.73	2.95	6.54	1.89	7.51	34.68
M06	0.54	1.26	1.39	0.36	1.00	0.94	0.27	1.08	2.38	0.69	2.74	12.65
M07	0.58	1.34	1.48	0.39	1.07	1.00	0.28	1.15	2.54	0.74	2.92	13.48
M08	0.20	0.46	0.51	0.13	0.37	0.34	0.10	0.40	0.88	0.25	1.01	4.65
M09	0.51	1.17	1.29	0.34	0.93	0.87	0.25	1.00	2.22	0.64	2.55	11.76
M10	0.23	0.53	0.58	0.15	0.42	0.39	0.11	0.45	1.00	0.29	1.15	5.31
M14	0.79	1.82	2.01	0.53	1.45	1.36	0.38	1.56	3.45	1.00	3.96	18.30
M16	0.20	0.46	0.51	0.13	0.37	0.34	0.10	0.39	0.87	0.25	1.00	4.62
Total	6.36	14.73	16.21	4.26	11.69	10.97	3.10	12.57	27.86	8.08	32.01	147.83

Any value in Table 5.3 was calculated using a comparison of one major factor over another from Table 5.2. For example, in Table 5.3, at the first row and second column value was found by dividing the total importance of M02 in Table 5.2 with the total importance of M03, which was equal to 2.31. Each cell value in Table 5.3 could be interpreted as each row item over each column item. Using a similar method, the rest of the cell values were calculated.

5.3.1.4. Step 4. The Formation of the Synthesized Matrix for the Factor Criteria

A synthesized matrix could be obtained from a pair-wise matrix comparison by dividing each comparison value of the pair-wise matrix by its column total. For example, Table 5.4 represents the synthesized matrix for Table 5.3 of the pair-wise matrix. In Table 5.4, the first row value (0.157) was calculated by dividing the first row value of Table 5.3 (1.00) with the column total (6.36) from same table. With a similar method, the rest of the cell values were calculated.

Table 5.4. Synthesized Matrix for G1-Major Factor Criteria

	M02	M03	M04	M05	M06	M07	M08	M09	M10	M14	M16	Priority Vector
M02	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157	15.72%
M03	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	6.79%
M04	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	6.17%
M05	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	23.46%
M06	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	8.56%
M07	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	9.12%
M08	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	3.14%
M09	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	7.95%
M10	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	3.59%
M14	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	0.124	12.38%
M16	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	3.12%

5.3.1.5. Step 5. Averaging Priority Vector

The priority vector could be obtained by finding the row averages of the synthesized matrix in Table 5.4. For example, in Table 5.4, the first-row average for the G1-M02 factor, the priority vector, shows 15.72%. Similarly, all values are calculated for the other factors. Table 5.5 shows the priority vectors derived from Table 5.4.

Table 5.5. Priority Vector of G1-Major Factor Criteria

Group	Priority Vector
M02	15.72%
M03	6.79%
M04	6.17%
M05	23.46%
M06	8.56%
M07	9.12%
M08	3.14%
M09	7.95%
M10	3.59%
M14	12.38%
M16	3.12%

5.3.1.6. Step 6. Estimating the Initial Consistency Ratio

The Consistency Ratio (CR) signifies the consistency of a decision-maker's judgment using a pair-wise comparison. The Consistency Ratio matrix could be obtained by multiplying the pair-wise comparison matrix with the priority vector matrix.

Table 5.6. Initial Consistency Ratio of the G1-Major Factor Criteria

Group	Consistency Ratio
M02	1.587
M03	0.686
M04	0.623
M05	2.369
M06	0.864
M07	0.921
M08	0.317
M09	0.803
M10	0.362
M14	1.250
M16	0.315

In the previous example, the pair-wise comparison matrix is 11 x 11; the priority vector matrix is 11 x 1. Because the first matrix's column size and the second matrix's row size are the same, their multiplication is possible. The results are in Table 5.6.

5.3.1.7. Step 7. Estimating the Eigen Value λ and λ_{max}

Dividing the initial consistency ratio with the corresponding priority vector produces the Eigen value matrix. Table 5.7 shows the Eigen value, λ, for the G1-major factor criteria for contractors' prequalification. Again, λ_{max} is the average of all the elements. For example, in the earlier case, λ_{max} is 10.10.

Table 5.7. Eigen Value of the G1-Major Factor Criteria

Group	Eigen Value (λ)
M02	10.10
M03	10.10
M04	10.10
M05	10.10
M06	10.10
M07	10.10
M08	10.10
M09	10.10
M10	10.10
M14	10.10
M16	10.10

5.3.1.8. Step 8. Consistency Testing

Based on Alonso and Lamata (2006), a consistency test for judgment was conducted. With the earlier example, the total number of major factors (n=11) in group G-1 and the Eigen value λ_{max} = 10.10 (from step 7), the error matrices (0.90) were calculated using of equation 5.2. The average Eigen value (26.12) was calculated using equation 5.3.

$$\text{Error}_{(\text{matrices})} = n - \lambda_{max} \tag{5.2}$$

$$\bar{\lambda}_{max} = 2.7699(n) - 4.3513 \tag{5.3}$$

$$\text{Error}(n) = \bar{\lambda}_{max} - n \tag{5.4}$$

where λ_{max} is the Eigen value, n is the total number of factors,and $\bar{\lambda}_{max}$ is the average Eigen value.

The average Error(n) was calculated (15.12) using equation 5.4. By dividing $Error_{(matrices)}$ with $Average_{(matrices)}$, the consistency ratio (-0.06) was found, which was less than the allowable consistency ratio of 0.10. Test results proved that, at α_1=0.10, the judgments were consistent among the respondents. Therefore, the priority vector could be calculated as the weights of the G1-Major factor criteria as presented in Table 5.8.

Table 5.8. Weights of the G1-Major Factor Criteria

Group	Major Factor	Weight
M02	Experience	15.72%
M03	Project Specific	6.79%
M04	References and Appreciation	6.17%
M05	Management and Organization	23.46%
M06	Resources	8.56%
M07	Finance	9.12%
M08	Methodology	3.14%
M09	Quality Assurance and Quality Control Plan	7.95%
M10	Safety	3.59%
M14	Capability	12.38%
M16	Estimation	3.12%

5.3.2 Weights of the Group Criteria, Major-Factor Criteria, and Minor-Factor Criteria

Using a similar approach to Section 5.3.1, each group's main-factor and minor-factor criteria weights were determined. Figures 5.2 to 5.4 show the weights for the contractors' prequalification process in Bangladesh's construction industry. These figures show weights of 42.04%, 55.25%, and 4.71% for groups one, two, and three, respectively. As already discussed, group one is based on moderate agreement between owners and consultants; group two is based on a fair agreement between owners and consultants; and group three is based on slight agreement for owners and consultants. All 17 major factors and 76 minor factors are included in the weighted framework. Any of these weights could be adjusted, depending on the project requirements and the owners/consultants' choices. Group two carries more weight due to the fact that it included 41 of the 76 minor factors.

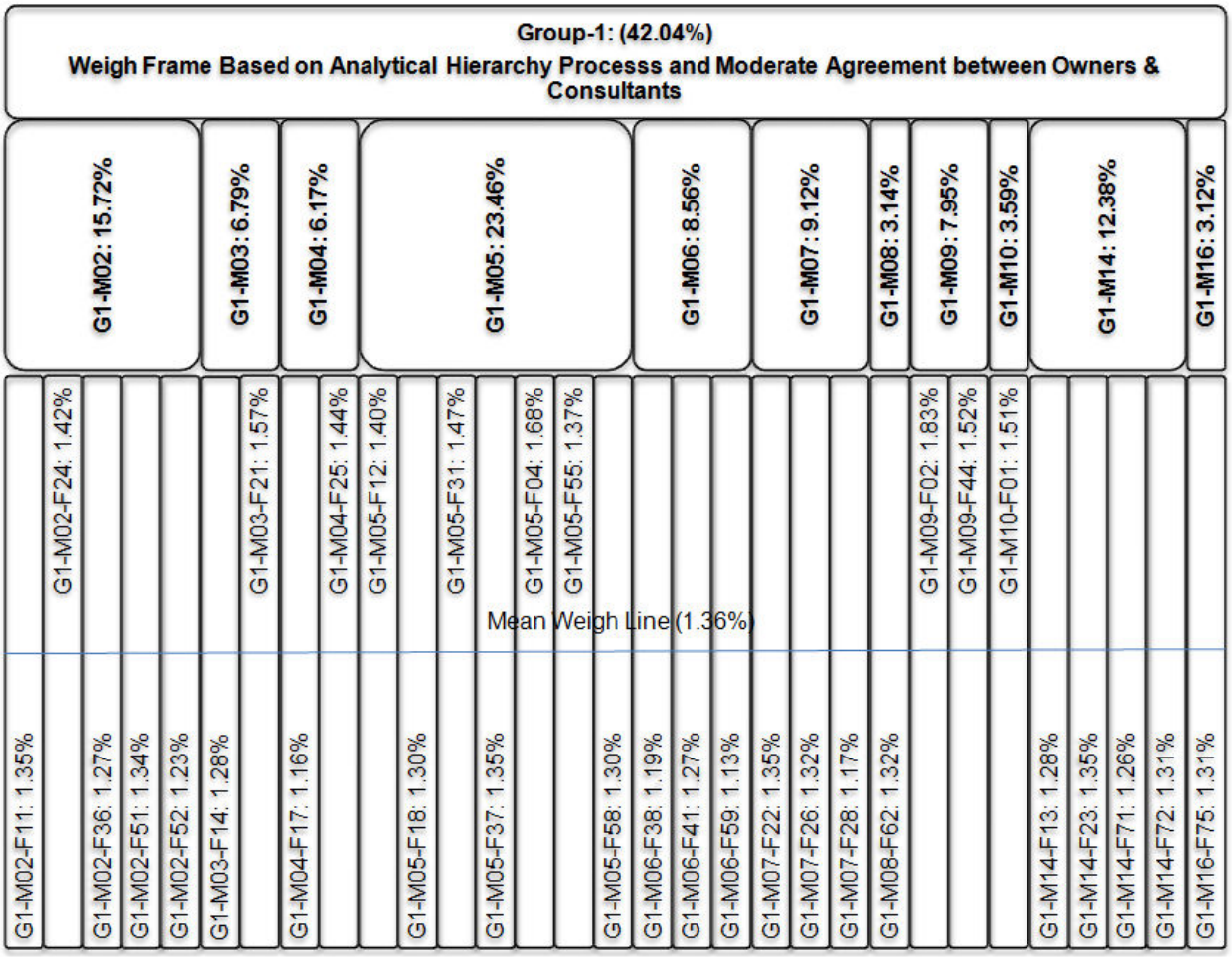


Figure 5.2. Calculated Weights of Group-1, Major Factor, and Minor Factor

The major factor criteria for group one in Figure 5.2 could be ranked according to their weight from highest to lowest:

1. Management and organization, weight 23.46% of 42.04%.
2. Experience, weight 15.72% of 42.04%.
3. Capability, weight 12.38% of 42.04%.
4. Finance, weight 9.12% of 42.04%.
5. Resources, weight 8.56% of 42.04%.
6. Quality assurance and quality control plan, weight 7.95% of 42.04%.
7. Project specific, weight 6.79% of 42.04%.
8. References and appreciation, weight 6.17% of 42.04%.

9. Safety, weight 3.59% of 42.04%.
10. Methodology, weight 3.14% of 42.04%.
11. Estimation, weight 3.12% of 42.04%.

Again, there are 31 minor factors in group one. Instead of ranking all 31 factors, only 10 factors above the mean weight (1.36%) in group one are ranked according to their weight from highest to lowest:

1. Quality management, control, and assurance system, weight 54.63% of 7.95% of 42.04%.
2. Management and technical skills and capabilities, weight 17.04% of 23.46% of 42.04%.
3. Expertise in similar projects, weight 55.14% of 6.79% of 42.04%.
4. Quality performance, weight 45.37% of 7.95% of 42.04%.
5. Health and safety performance and plan, weight 3.59% of 42.04%
6. Site management, weight 14.89% of 23.46% of 42.04%.
7. Company reputation, weight 55.35% of 6.17% of 42.04%.
8. Size of project experience, weight 21.48% of 15.72% of 42.04%.
9. Contractor organization and plan, weight 14.23% of 23.46% of 42.04%.
10. Qualification of contractor, weight 13.90% of 23.46% of 42.04%.

The major-factor criteria for group two in Figure 5.3 could be ranked according to their weight from highest to lowest:

1. Finance, weight 16.87% of 55.25%.
2. Resources, weight 11.26% of 55.25%.
3. Working schedule, weight 9.90% of 55.25%.
4. Experience, weight 8.30% of 55.25%.
5. Claim history, weight 8.29% of 55.25%.
6. General information and registration details ,weight 7.35% of 55.25%.
7. Strategic business plan, weight 6.88% of 55.25%.
8. References and appreciations, weight 5.12% of 55.25%.
9. Communication, weight 4.84% of 55.25%.
10. Methodology, weight 4.79% of 55.25%.

11. Estimation, weight 4.70% of 55.25%.
12. Capability, weight 4.53% of 55.25%.
13. Project specific, weight 2.54% of 55.25%.
14. Management and organization, weight 2.48% of 55.25%.
15. Subcontracting, weight 2.18% of 55.25%.

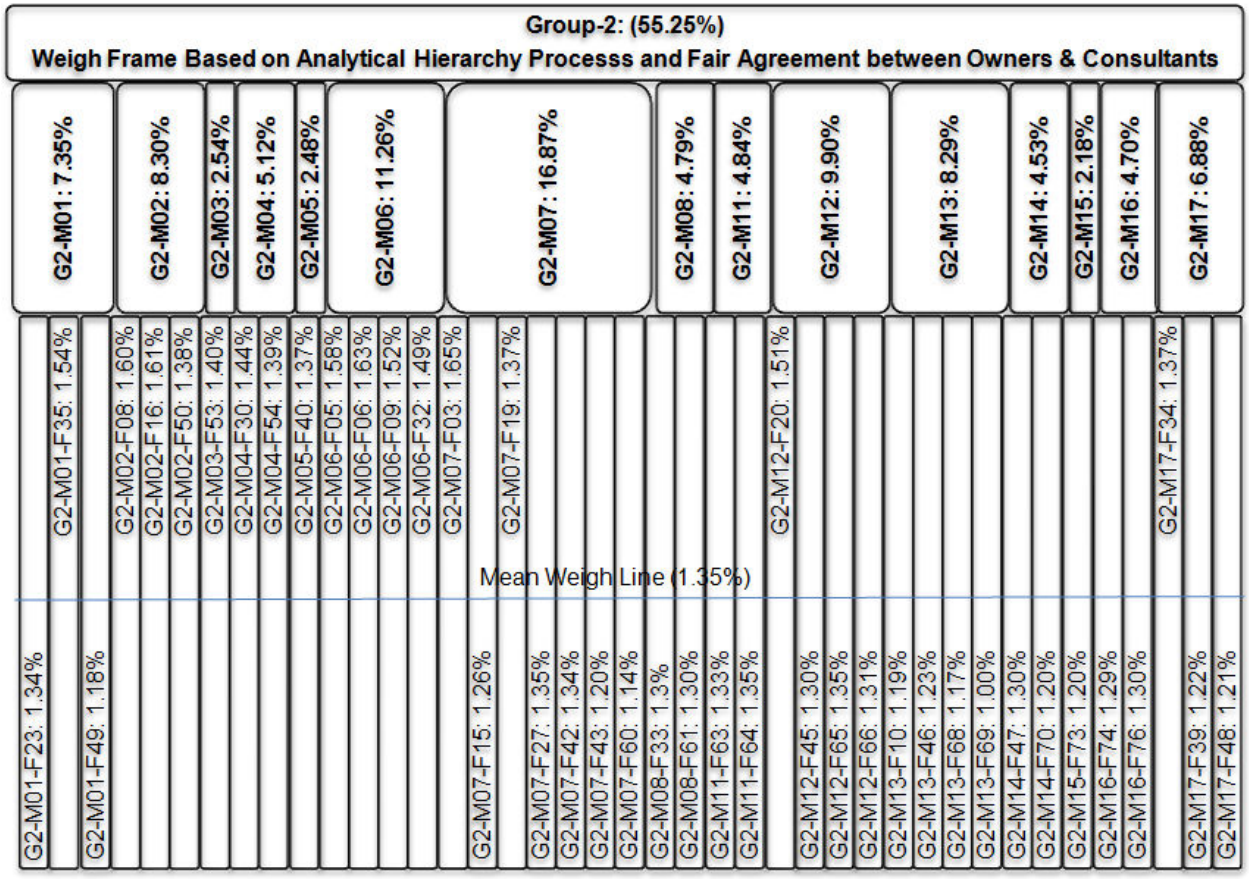


Figure 5.3. Calculated Weights of Group-2, Major Factor, and Minor Factor

Again, there are 41 minor factors in group two. Instead of ranking all 41 factors, only 16 factors which are above the mean weight (1.35%) in group two are ranked according to their weight from highest to lowest:

1. Financial stability and soundness, weight 17.74% of 16.87% of 55.25%.
2. Equipment resources and availability, weight 26.12% of 11.26% of 55.25%.
3. Area of specialization, weight 35.06% of 8.30% of 55.25%.

4. Past and current performance, weight 34.87% of 8.30% of 55.25%.
5. Key managerial, supervisory, and operational personnel experience and availability, weight 25.44% of 11.26% of 55.25%.
6. Attitude, cooperation, and performance, weight 37.92% of 7.35% of 55.25%.
7. Workforce resources and availability, weight 24.49% of 11.26% of 55.25%.
8. Schedule of project, weight 27.55% of 9.90% of 55.25%.
9. Info-ware, knowledge of technology, and availability, weight 23.95% of 11.26% of 55.25%.
10. Good relationship with stakeholders, weight 50.90% of 5.12% of 55.25%.
11. Number of similar project experiences, weight 100% of 2.54% of 55.25%.
12. Client satisfaction and historical non-performance, weight 49.10% of 5.12% of 55.25%.
13. Large-scale (largest amount) project performed in past five years, weight 30.07% of 8.30% of 55.25%.
14. Profitability, weight 14.74% of 16.87% of 55.25%.
15. Location of home office and accommodation, weight 36.08% of 6.88% of 55.25%.
16. Project-control procedures, weight 100% of 2.48% of 55.25%.

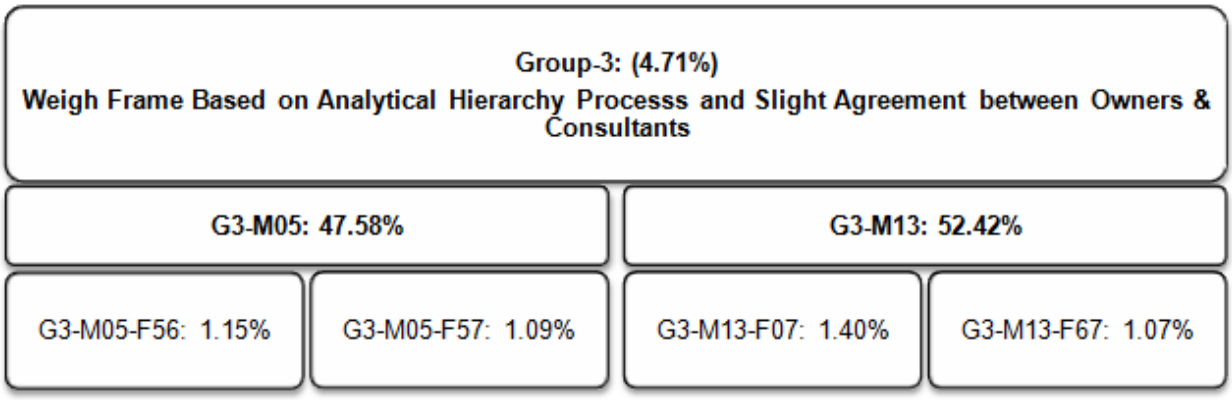


Figure 5.4. Calculated Weights of Group-3, Major Factor, and Minor Factor

The major-factor criteria for group three in Figure 5.4 could be ranked according to their weight from highest to lowest:

1. Claim history, 52.42% of 4.71%.
2. Management and organization, weight 47.58% of 4.71%.

Again, there are only four minor factors in group three, and they could be ranked according to their weight from highest to lowest:

1. Contractor failure to complete a project, weight 56.77% of 52.42% of 4.71%.
2. Waste-management practices, weight 51.27% of 47.58% of 4.71%.
3. Substance abuse policy, weight 48.73% of 47.58% of 4.71%.
4. Contract not renewed due to failure to perform, weight 43.23% of 52.42% of 4.71%.

5.4. Decision Model Hierarchy Framework for Contractors' Bid Prequalification

Figures 5.5 and 5.6 graphically present the main decision model hierarchy framework for the contractor prequalification process for Bangladesh's construction industry. The framework was developed on the basis of 76 individual factors, 17 major factor categories, and 3 major groups based on the owners

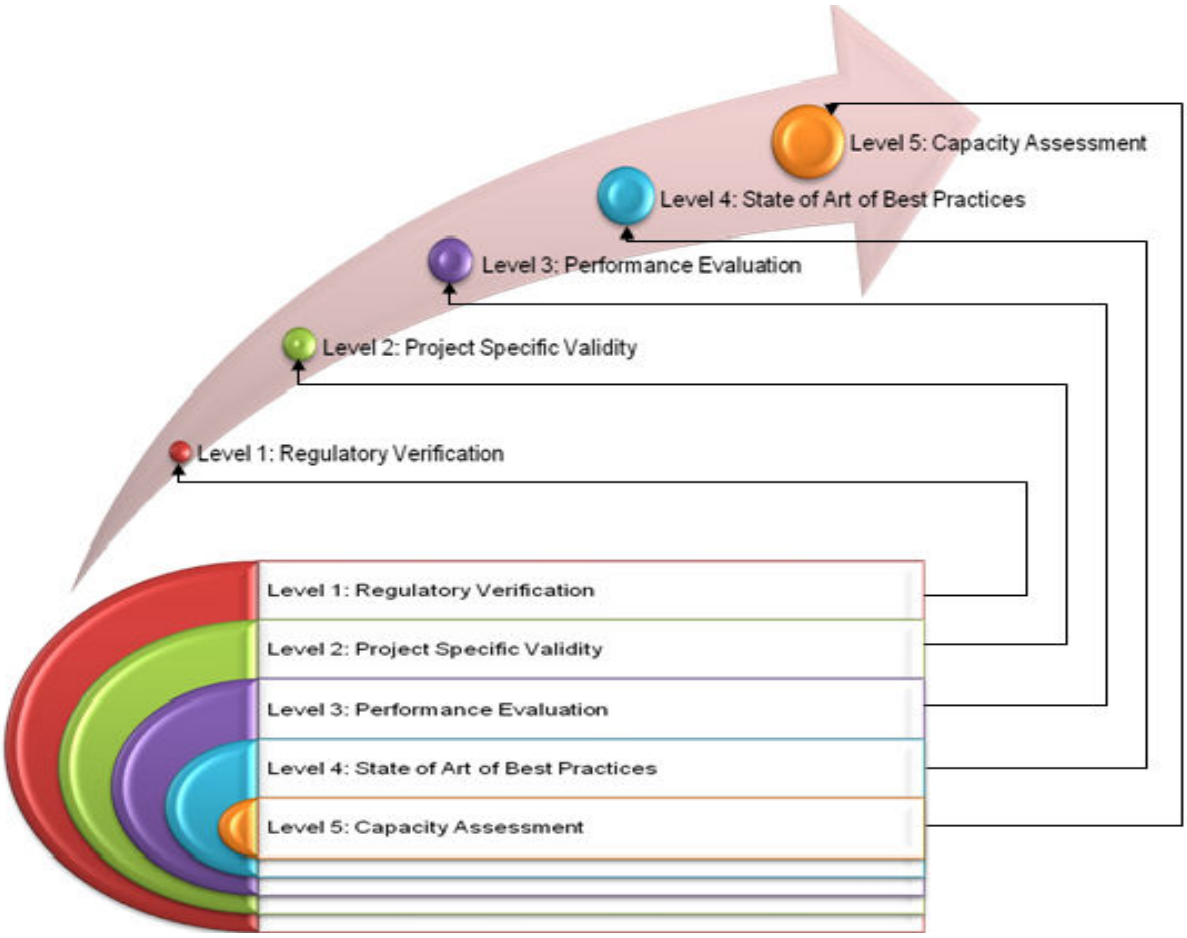


Figure 5.5. Main Levels of the Decision Model Hierarchy Prequalification Framework

and consultants' agreement index. Because another objective of this study was to determine the weighted percentile for each factor, category, or group using the analytical hierarchy process (AHP) concept and the consistency index, the detailed framework breakdown is described.

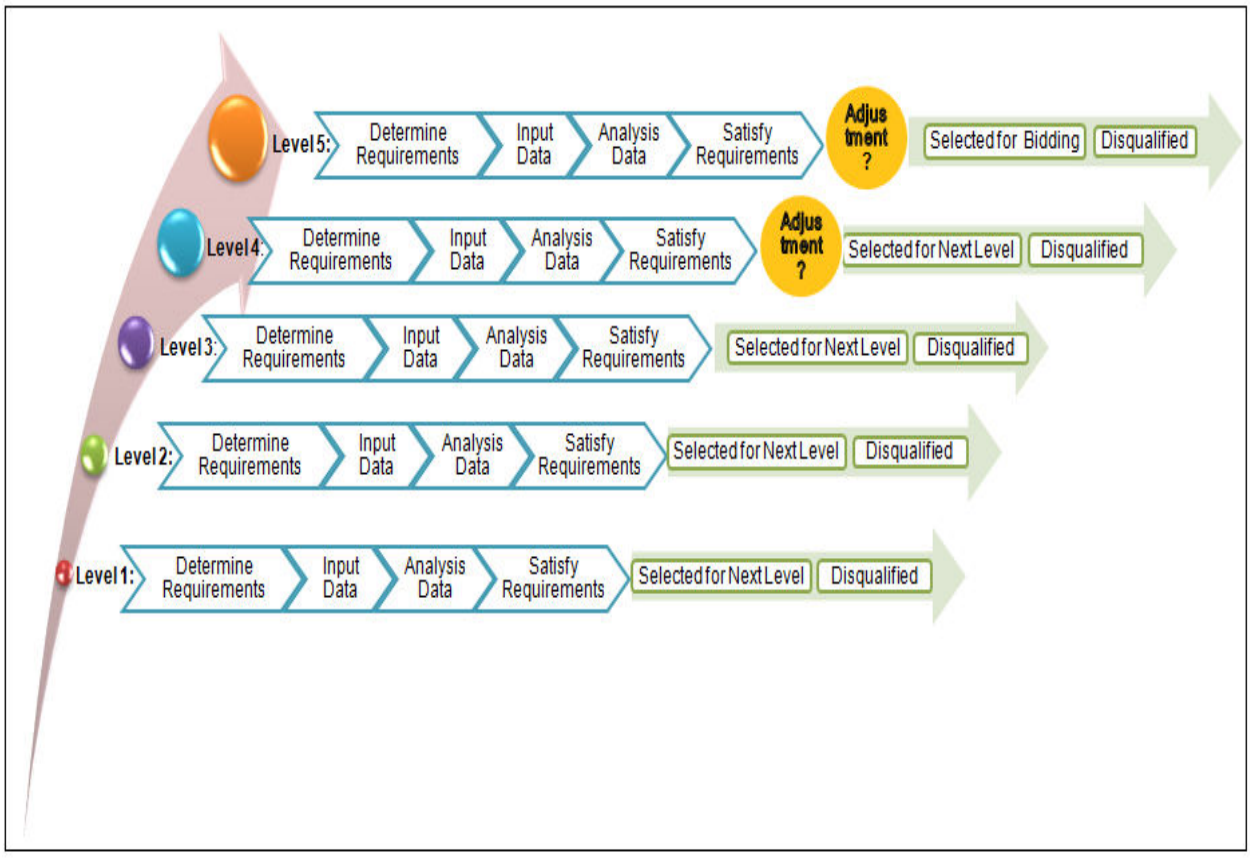


Figure 5.6. Process for the Main Decision Model Hierarchy Prequalification Framework

In order to develop a simple framework and save time during the contractors' bid prequalifcation process, a limited number of activity levels could be incorporated rather than 17 consecutive activities for the 17 major factors. The 17 major factors can be categorized into 5 divisions. The major-factor characteristics indicate each category's formation. Therefore, the prequalification framework is classifed into five activity levels depending on the major-factor characteristics:

1. Level 1: Regulatory Requirements
2. Level 2: Project-Specific Validity
3. Level 3: Performance Evaluation
4. Level 4: State-of-Art-the Best Practices

5. Level 5: Capacity Assessment

The five activity levels were designed to follow successive activities. The user of this proposed framework could start from the first-level regulatory requirement activity in order to prequalify a contractor and could choose individual requirements at each level. Users could set and determine their own requirements. The framework includes several decision points for users to check the necessity of any level. After starting from the beginning, the process guides users on how to complete the prequalification process. At all levels, some common activities, such as determining requirements, input data, analysis data and satisfy requirements, have to be performed as shown in Figure 5.6. After completing each level, a qualified (or disqualified) list of contractors could be identified. Two optional adjustment decision points are proposed in levels four and five. The framework for the individual levels is presented in Figures 5.7 to 5.11.

The contractor bid prequalification framework includes Figures 5.7 to 5.11. The regulatory verification level as shown in Figure 5.7, investigate the major factor general information and registration details. The general information and registration details include the validity of registration details; attitude, cooperation, and performance; and the substance of the business. Before choosing/inputting the minor factors, minimum requirements for each factor need to be established. After a pair-wise comparison and the AHP process analysis described earlier for all the bidders, owners/consultants need to check for satisfaction of the minimum requirements. Cross checking these requirements produces two different lists of bidders: qualified or disqualified. No adjustment is proposed at this level. For example, if a bidder has no license or an invalid license, then the bidder has to be eliminated in the first stage. Only the qualified bidders go to the second level of prequalification.

The second level includes project-specific validity as shown in Figure 5.8. Project-specific validity determines the project-specific requirements and the methodology of the work requirements. Project-specific requirements determine and analyze the previous experience in the geographic location, expertise in similar projects, and the number of similar projects factors. Work methodology requirements are used to determine and to analyze the methodology statement, technical proposal responsiveness, and bidders' specialized knowledge. Before choosing/inputting the minor factors, the minimum

requirements for each factor need to be established. After a pair-wise comparison and the AHP process analysis described earlier, all the bidders are checked for satisfaction of the minimum requirements. Cross checking these requirements produces two different lists of bidders: 1) qualified or 2) disqualified. No adjustment is proposed at this level. For example, if the project owner and consultants want the bidder as a binding requirement, such as the contractor must have similar experience, then they could easily sort the bidders by whether they are qualified. Only the qualified bidders go to the third level of prequalification.

Levels three to five are presented in Figures 5.9 to 5.11 and as described in the previous two levels. The only exception is that levels four and five include an adjustment of the minimum requirements for the decisions.

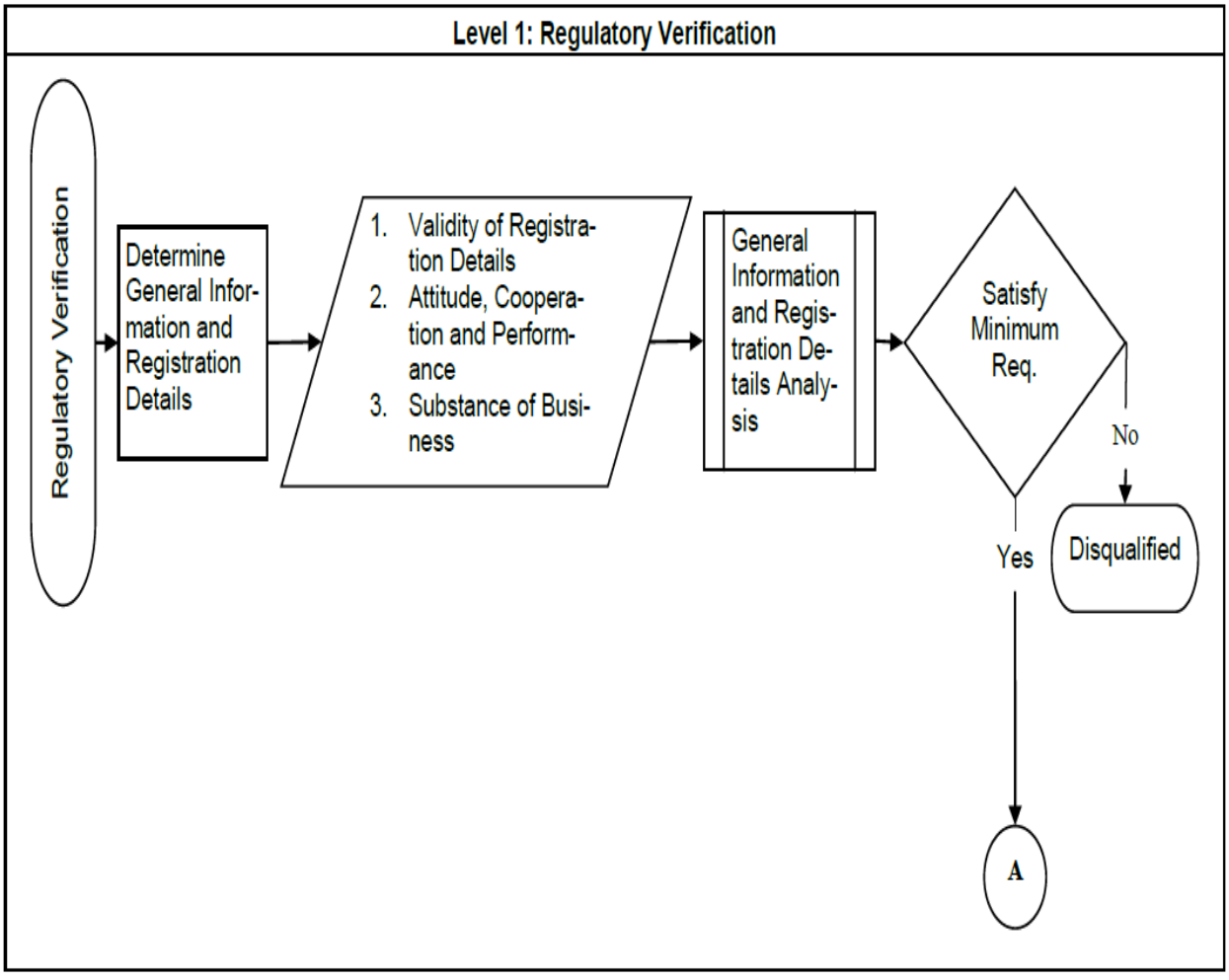


Figure 5.7. Framework for Regulatory Verification

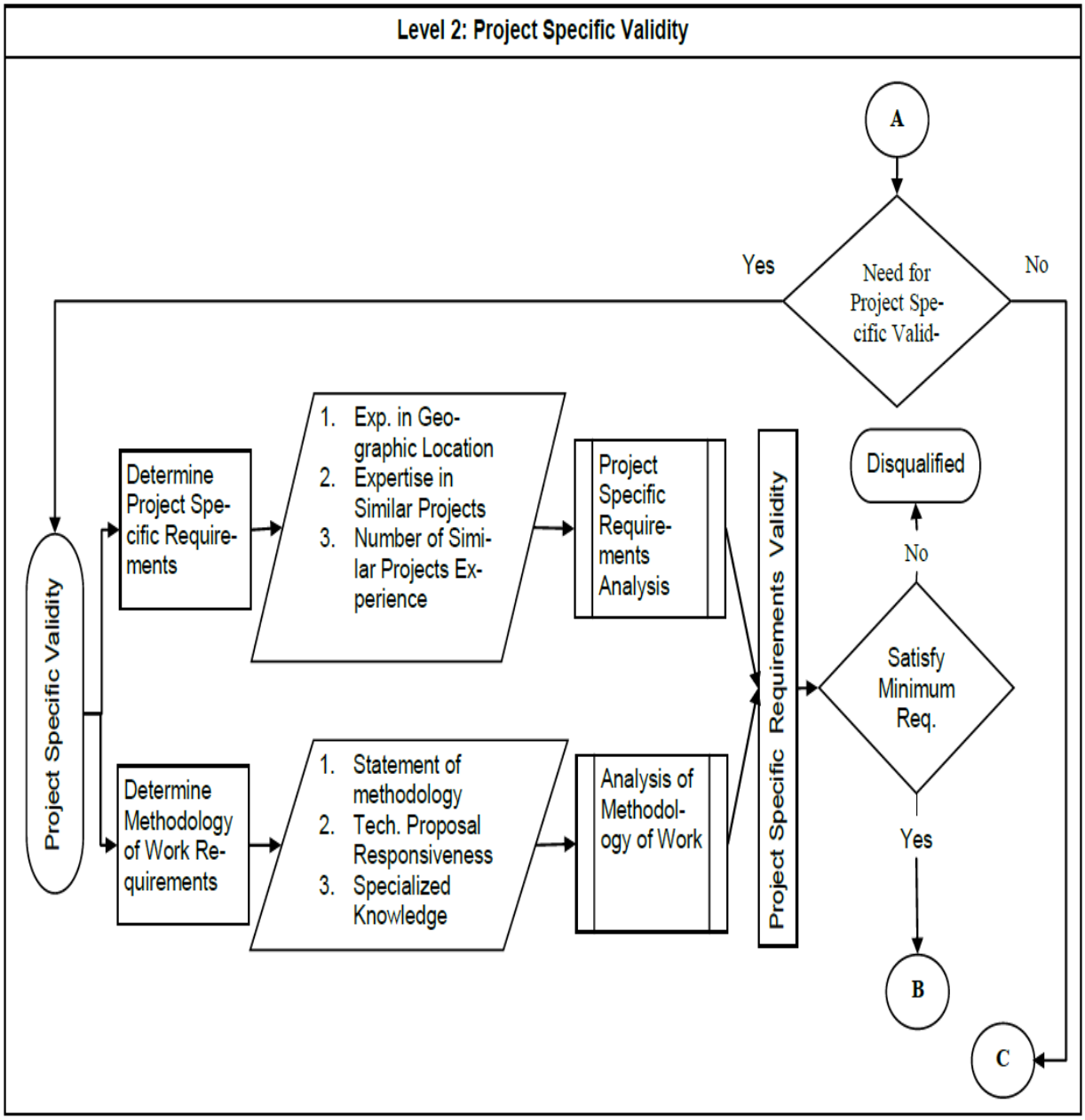


Figure 5.8. Framework for Project-Specific Validity

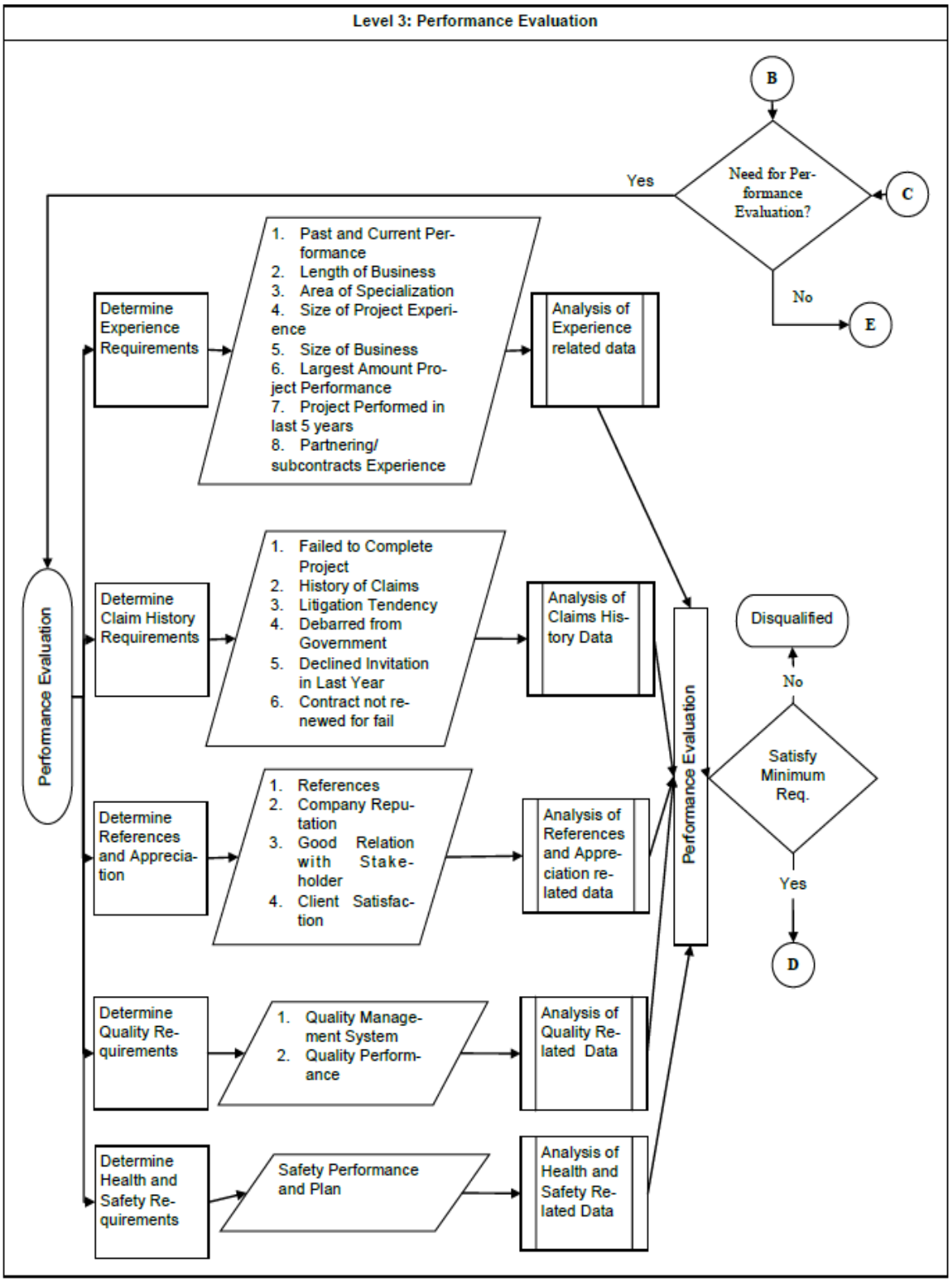


Figure 5.9. Framework for Performance Evaluation

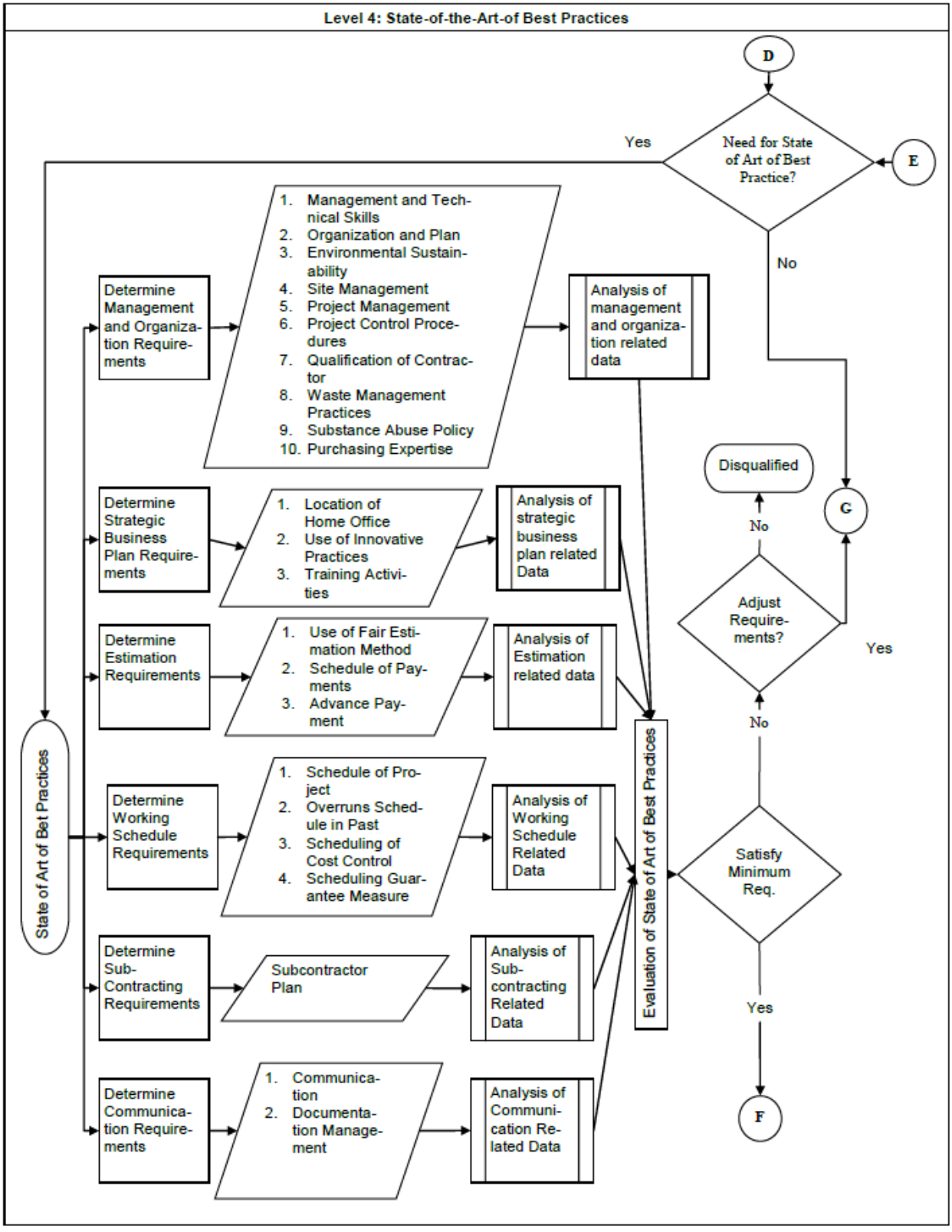


Figure 5.10. Framework for State-of-the-Art Best Practices

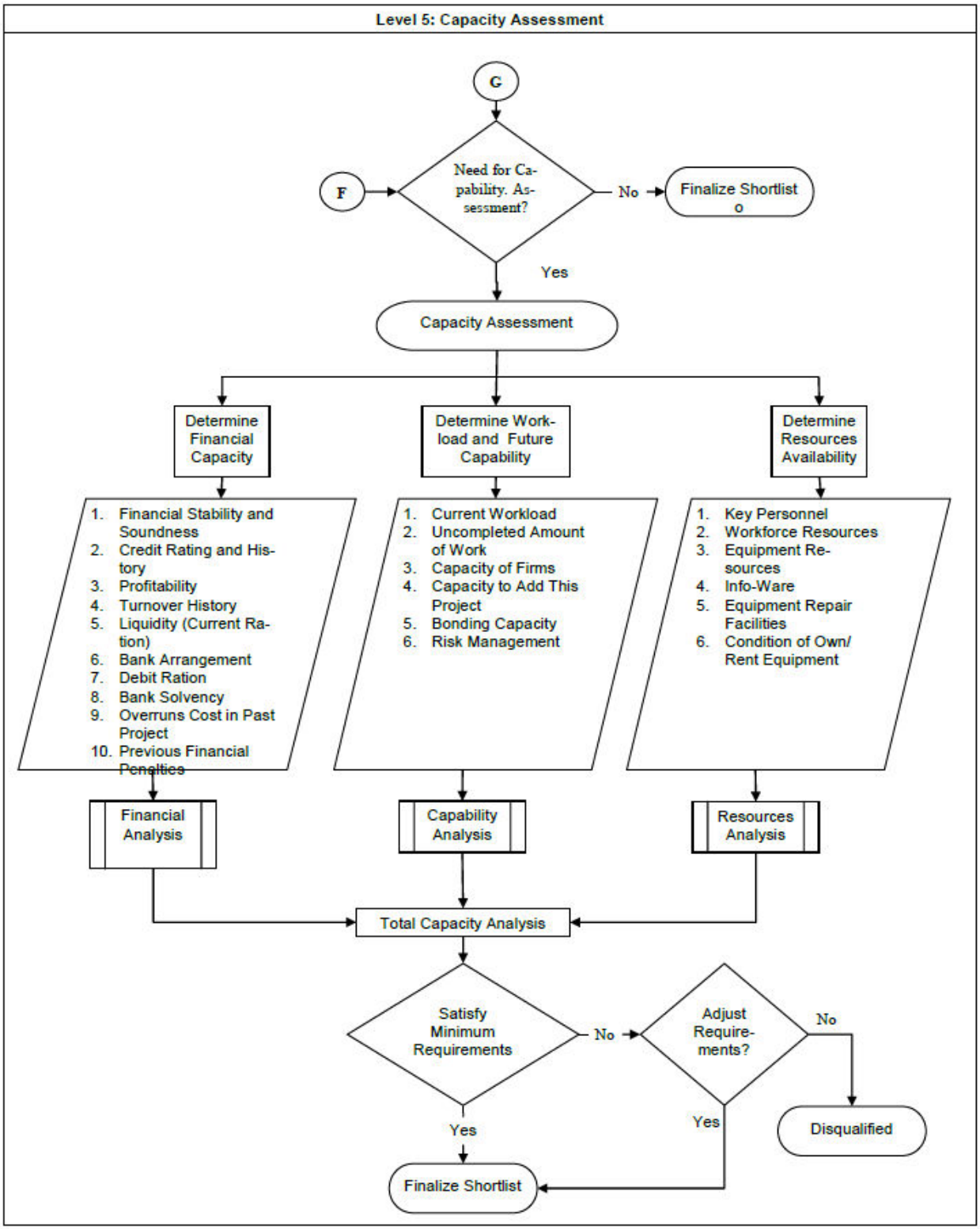


Figure 5.11. Framework for Capacity Assessment

6. SUMMARY, CONCLUSIONS, AND RECOMMENDATION

6.1. Introduction

This chapter summarizes and describes the research conclusions, recommendations for project owners and consultants, recommendations for further study, and limitations of the research for the Bangladeshi construction industry.

6.2. Summary and Conclusions

Prequalification, a multivariate, decision-making process, is used to select a set of potential contractors who could be asked to bid on a construction project. Prequalification is a preliminary, systematic method based on criteria defined by owners (and/or consultants) to preselect a set of contractors who bid for projects, work, goods, and services in the engineering, procurement, and construction industries. If a contractor is determined to be a potential bidder and has the ability to meet the specific qualifications required for completing the construction project, the contractor in question is invited to bid on the project. In the prequalification process, decision inputs based on agreements between owners and consultants about a particular criterion could influence prequalification decisions.

The six goals of this dissertation were to identify the contractors' bid prequalification factors, or criteria, which could form the basis of the current prequalification practices, to study the statistical significance of each bid prequalification criterion and its relative importance and ranking, to identify the contractors' bid prequalification criteria based on mutual agreement between owners and consultants, to compare results obtained in Bangladesh with results from the United States and Saudi Arabia, to develop a weighted model of clustered bid prequalification criteria using the analytical hierarchy process, and to develop a decision model hierarchy framework to implement the study results.

6.2.1. Research Goal One

A comprehensive Literature Review was performed with Science Direct, Web of Science, ASCE, NDSU Library, and others. Prequalification factors and criteria were compiled and analyzed by reviewing the 24 prequalification systems and bid-evaluation procedures that exist globally (available research on prequalification among organizations and countries, and the work cited most frequently about contractor prequalification). The review of published literature from 1985 to 2012 revealed that a total of 5 to 37

minor factors were considered during the contractors' bid prequalification evaluation and selection process.

A total of 18 major factors, containing a total of 165 minor factors, were identified during the Literature Review. The major factors are general information and registration details, experiences, project specific, references, management and organization, resources, finances, methodology, quality-assurance and quality-control plans, health and safety plans, communication, work schedules, claim history, capabilities, estimation, strategic business plans, subcontracting, and bid specific.

Ranks were assigned to the counts (the number of times a factor/criterion occurs in the literature) and presented in tables. Examples of the criteria with the highest ranking were health and safety plans, quality-assurance and quality-control plans, financial stability and soundness, management and technical skills capability, personnel experience and availability, equipment resources and availability, contractor failure to complete a project. A total of 87 factors received just one author's opinion, which was ranked as the lowest rank, 18.

Hypothesis testing indicated that the contractors' bid prequalification criteria have significant differences in importance at a 99.995% confidence interval. A total of 17 major factors and 49 minor factors were identified as important factors using the control-chart statistics.

6.2.2. Research Goal Two

A research survey was developed, subjected to IRB approval, tested and validated, and conducted online. The questionnaire contained 17 major factors and 76 minor factors (gleaned from analyzing the literature about the prequalification of contractors). The survey yielded a total of 71 responses: 40 from project owners, 21 from consultants, 9 from contractors, and 1 with non-responded..

The relative importance index as well as the ranking of the major groups and individual factors were shown as radar charts in Figures 4.5 and 4.6, and Tables 4.5 to 4.21. The major groups had significantly different relative importance indexes. The proximity of ranking to each group with respect to relative importance index did not affect the ranking. However, there was a significant difference in the responses between the owners and consultants. The factors were ranked using a categorical, ordinal-

scale measurement of each factor, which may affect the results. A mutual agreement index between owners and consultants was established as part of this research.

The contractors' top-ranked bid prequalification criteria were quality management, quality performance, expertise with similar projects, project management, technical skills and capabilities, contractor qualification, project management, area of specialization, financial stability and soundness, past and current experience, number of similar project experiences, etc. The contractor's quality management, control, and assurance system had the highest RII of 0.876 and ranked first overall. The contractor's low-ranked bid prequalification criteria were debarment, previous financial penalties, waste-management practices, substance abuse policy, debit ratio, etc. The contractor's tendency not to submit a bid had the lowest RII of 0.559 and was ranked 5 of 65.

6.2.3. Research Goal Three

The results of the research survey (with about 76 minor factors) were classified into 3 groups based on the mutual agreement index between owners and consultants. The first group had moderate agreement; the second group had fair agreement; and the third group had slight agreement. The interaction diagram in Figure 4.14 and the scattered, distributed plot in Figure 4.15 present the final group.

The most important group (group one) contained a total of 31 factors wherein owners and consultants agreed moderately. Group one included such items as quality management, quality performance, health and safety, expertise with similar projects, qualification, project management, capacity to add the project, company reputation, organizational plans, turnover history, current workload, experiences in the geographic location, references, etc.

Group two (where the owners and consultants had fair agreement) contained a total of 41 factors. The group included financial stability, workforce resources and availability, equipment resources and availability, area of specialization, communication, bank arrangement, subcontractor plans, litigation tendency, etc.

Only four factors were identified in the least important group (group three) which had slight agreement between the owners and consultants. Group three included contractors' failure to complete a

project, waste-management practices, substance abuse policy, and contract not renewed due to a failure to perform.

6.2.4. Research Goal Four

For this goal, the results obtained in Bangladesh were compared with results from the United States and Saudi Arabia. There was a significant difference about the relative importance index and ranking in the results obtained from the Bangladeshi studies when compared to the results obtained from Saudi Arabia and the United States. The study in Bangladesh was more detail oriented, statistically significant, and reasonably ranked, and it included more specific objectives for each individual or group factors, which eventually might be suitable and acceptable to identify contractors' bid prequalification criterion factor(s). Both the research studies conducted in the United States and Saudi Arabia followed Russell's (1988) approach.

6.2.5. Research Goal Five

The fifth goal was to develop a weighted model of clustered bid prequalification using an analytical hierarchy process. The contractors' bid prequalification criteria weights were 42.04%, 55.25%, and 4.71% for groups one, two, and three, respectively. Figures 5.2 to 5.4 showed the weights for the contractors' prequalification process in Bangladesh's construction industry. The consistency test showed that the weights for contractors' bid prequalification based on judgments were consistent among the respondents, strengthening the acceptance of this proposed criteria.

It was discovered group one includes 11 major factors. The weight of group one's major-factor criteria were experience (15.72%), project specific (6.79%), references and appreciation (6.17%), management and organization (23.46%), resources (8.56%), finances (9.12%), methodology (3.14%), quality-assurance and quality-control plans (7.95%), health and safety (3.59%), capability (12.38%), and estimation (3.12%).

It was also found that group two included 15 major factors (wholly or partially). Their weights were capability (4.53%), claim history (8.29%), communication (4.84%), estimation (4.70%), experience (8.30%), finance (16.87%), general information and registration details (7.35%), management and organization (2.48%), methodology (4.79%), project specific (2.54%), references and appreciation

(5.12%), resources (11.26%), strategic business plan (6.88%), subcontracting (2.18%), and work schedule (9.90%).

Group three had two items which could be classified as major factors. The weighted major-factor criteria for group three were management and organization (47.58%) and claim history (52.42%).

6.2.6. Research Goal Six

In this section, a five-level and/or decision model hierarchy framework for the contractors' bid prequalification process was performed. Figures 5.5 to 5.11 incorporated findings for the entire research project. A five-level hierarchy framework for the contractors' bid prequalification process was developed. The framework represented the work accomplished in research goals two to five as well as which could be implemented in an organized and systematic way. The framework was developed on the basis of statistically significant (76) individual factors, 17 major factor categories, and 3 major groups based on the owners and consultants' agreement index. The five-level decision model hierarchy frameworks included the regulatory requirement, project-specific validity, performance evaluation, state-of-art-the best practices, and the capacity assessment.

The regulatory verification level of the contractor bid prequalification framework only included the determination of general information and registration details major factor related information. The project-specific validity contained two major factors, the project-specific requirement and the methodology of work requirement. The performance evaluation level contained five major factors: experience, claim history, references and appreciation, quality, and health and safety requirement. State-of-the-Art-of best practices included six major criteria: management and organization, strategic business plan, estimation, work schedule, subcontracting, and communications. The final-level capacity assessment included three major factors: finance, capability, and resources.

6.3. Recommendations

6.3.1. Recommendation for Bangladesh's Construction Industry

The research results should be disseminated in Bangladesh and may be have to be turned into legislation. The prequalification criteria should be recommended for construction work, and design and build infrastructure types of work. The prequalification criteria can also be recommended to the

management, supply and installation of plants and equipment, custom-designed equipment, or other types of work. Prequalification criteria might be recommended for unit-price, negotiated, design-build/turnkey, sealed-bid, and construction-management contracts. The five-level decision model hierarchy framework (DMHF) described and presented in the thesis from Figure 5.7 to 5.11 could be recommended for contractors' prequalification decision-making processes.

6.3.2. Recommendation for Future Research

Case studies could be performed in order to validate the proposed weighted criteria for the identified factors and developed framework. A comparison study using methods other than the analytical hierarch process (AHP) could be performed, which could eventually facilitate Bangladeshi construction industry contractors' prequalification process in a better way. Software/tools could be developed for Bangladesh so that users could easily utilize the step-by-step decision process. The contractors' perspective about the prequalification factors and processes could be incorporated so that their judgment/agreement could be compared against the owners/consultants. Using contract size in terms of amount might be applied to develop a platform so that the necessity of contractor prequalification could be justified. A unified global perspective for the contractors' prequalification process could be created.

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APPENDIX A. SURVEY QUESTIONNAIRE

CONTRACTOR PREQUALIFICATION PRACTICES IN BANGLADESH

Research Intent

Dear Participants:

This research is being conducted by Mohammad Mofigul Islam Molla, under the supervision of Dr. Eric Asa. Mr. Molla is a graduate student in the Department of Construction Management and Engineering at North Dakota State University, Fargo, North Dakota, United States of America.

Contractor prequalification is a major decision point where a number of unqualified contractors could be eliminated from the list of potential contractors. In view of the economic potential, the state of the construction industry, limited past research in construction, recent collapse of building structures and other factors, it may be necessary to establish a set of factors to be used to select the best set of potential contractors who could submit bids to construction projects in the near future. The aim of this research is to identify a set of factors/criteria used for the prequalification of potential contractors for construction projects in Bangladesh. The information and data collected in this research would be used to develop an effective prequalification process for construction projects in Bangladesh.

You are kindly invited to participate in this research study. The criteria for participating in the study is that you must be 18 years of age or older; able to access the internet; have prior experience in contractor selection processes or the construction industry in Bangladesh (construction and consulting firms, local institutions or ministries, municipalities, implementing agencies, international agencies); and/or specifically working in construction, maintenance, supply and installation of plant and equipment, infrastructure design and building, custom designed equipment, management consultation or other related types of work.

It would take about 10-15 minutes to complete the entire survey. It would be greatly appreciated if you could take the time to complete the survey. To complete the survey, please click on the link at the bottom of the page. Your participation is entirely voluntary, and you may change your minds or quit participating at any time, with no penalty. However, your assistance would be greatly appreciated in making this a meaningful study. You may opt out of receiving email invitations to take surveys which are sent by the creators of this survey via SurveyMonkey. If you decide to complete this survey, you may print off this screen and keep this for your records.

If you wish to receive a copy of the research document or have any questions, please email Dr. Eric Asa at Eric.Asa@ndsu.edu or Mr. Mohammad M. Molla at mohammad.molla@my.ndsu.edu, or call 915-996-0916.

Your participation is greatly appreciated. To proceed to the survey, please click next.

Sincerely,

Eric Asa, Ph.D., Associate Professor.

Contractor Prequalification Survey Questionnaire

PART 1: GENERAL QUESTIONS

1. Which industry sector would you associate yourself with the most?

☐ Construction Works
☐ Maintenance Works
☐ Supply and installation of plant and equipment
☐ Design and build infrastructure
☐ Custom designed equipment
☐ Management contractors
☐ Other

Other (please specify)

2. What type of contract do you more often use to perform your projects?

☐ Lump Sum
☐ Sealed Bid
☐ Negotiated contract
☐ Unit Price
☐ Design-Build (DB)/Turnkey
☐ Construction Management Contract
☐ Management Contract
☐ Construction Manager At Risk (CMAR)
☐ Cost Plus Fee
☐ Cost Plus Percentage of Cost
☐ Design-Bid-Build (DBB)
☐ Job Order Contract (JOC)
☐ Guaranteed Maximum Price (GMP)
☐ Other

Other (please specify)

3. What type(s) of project(s) have you handled most?

☐ Public
☐ Semi-Public
☐ Private
☐ Other

Other (please specify)

4. Which of the following best describes your organization's role?

☐ Government and Public Agency or Department
☐ Private Owner
☐ General Contractor
☐ Project Designer and Consultant
☐ Project Manager
☐ Subcontractor
☐ Supplier
☐ Academic Professional
☐ Other

Other (please specify)

PART 2: IMPORTANCE OF PREQUALIFICATION FACTOR

Prequalification is a preliminary stage in a bidding process where it is determined if a bidder has the ability to meet the specific qualifications required to complete the construction project. During prequalification of potential contractors, suppliers, bidders or vendors are screened on the basis of factors such as experience, financial ability, managerial ability, reputation, work history, and others. A of qualified bidders is then developed and it is used to send the invitation-to-bid documents.

The following factors or criteria deal with pre-qualifying a contractor. What impact does each of the factors have on the successful prequalification of a contractor?

Type of Factor(s)	Importance				
	Very High	High	Moderate	Little	None
Health and Safety performance and plan	☐	☐	☐	☐	☐
Quality management, control and assurance system	☐	☐	☐	☐	☐
Financial stability and soundness	☐	☐	☐	☐	☐
Management and technical skills and capabilities	☐	☐	☐	☐	☐
Key managerial, supervisory and operational personnel experience and availability	☐	☐	☐	☐	☐
Equipment resources and availability	☐	☐	☐	☐	☐
Contractor failure to complete a project	☐	☐	☐	☐	☐
Past and current performance	☐	☐	☐	☐	☐
Workforce resources and availability	☐	☐	☐	☐	☐
History of claims of contractor	☐	☐	☐	☐	☐
Length of time in business	☐	☐	☐	☐	☐
Contractor organization and plan	☐	☐	☐	☐	☐
Current workload	☐	☐	☐	☐	☐
Experience in geographic location of project	☐	☐	☐	☐	☐
Credit rating and history	☐	☐	☐	☐	☐
Area of specialization	☐	☐	☐	☐	☐
References	☐	☐	☐	☐	☐
Environmental sustainability	☐	☐	☐	☐	☐
Profitability	☐	☐	☐	☐	☐
Schedule of project	☐	☐	☐	☐	☐
Expertise in similar projects	☐	☐	☐	☐	☐
Turnover History	☐	☐	☐	☐	☐
Ability to obtain a tender, performance, payment bond; bonding capacity	☐	☐	☐	☐	☐
Size of project-experience	☐	☐	☐	☐	☐
Company reputation	☐	☐	☐	☐	☐
Liquidity (current ration)	☐	☐	☐	☐	☐
Bank arrangement / financing	☐	☐	☐	☐	☐
Debit ratio	☐	☐	☐	☐	☐
Validity of registration details	☐	☐	☐	☐	☐
Good relationship with stakeholders	☐	☐	☐	☐	☐
Site management	☐	☐	☐	☐	☐
Info-ware, knowledge of technology and availability	☐	☐	☐	☐	☐
Statement of methodology / constructability	☐	☐	☐	☐	☐
Location of home office and manpower accommodation	☐	☐	☐	☐	☐
Attitude, cooperation and performance	☐	☐	☐	☐	☐
Size of business	☐	☐	☐	☐	☐

Type of Factor(s)	Importance				
	Very High	High	Moderate	Little	None
Project management	☐	☐	☐	☐	☐
Equipment repair and maintenance	☐	☐	☐	☐	☐
Use of innovative practices	☐	☐	☐	☐	☐
Project control procedures	☐	☐	☐	☐	☐
The quantities, capabilities, and condition of the contractor's owned or rented equipment	☐	☐	☐	☐	☐
Bank solvency	☐	☐	☐	☐	☐
Overruns: cost in past projects	☐	☐	☐	☐	☐
Quality performance	☐	☐	☐	☐	☐
Overruns: schedule in past projects	☐	☐	☐	☐	☐
Litigation tendency	☐	☐	☐	☐	☐
Risk management (including insurance, and use of authorized subcontractors	☐	☐	☐	☐	☐
Training activities or programs supported by the bidder or sustainable development of human resources	☐	☐	☐	☐	☐
Ownership and substance of the business (secured business)	☐	☐	☐	☐	☐
Large scale(largest amount) project performed in past five years	☐	☐	☐	☐	☐
Qualified and excellent percentage of project performed in recent 5 years	☐	☐	☐	☐	☐
Partners / sub-contracts experience	☐	☐	☐	☐	☐
Number of similar projects experience	☐	☐	☐	☐	☐
Client satisfaction- historical non-performance	☐	☐	☐	☐	☐
Qualification of contractor	☐	☐	☐	☐	☐
Waste management practices	☐	☐	☐	☐	☐
Substance abuse policy	☐	☐	☐	☐	☐
Purchasing expertise, material handling and control	☐	☐	☐	☐	☐
Personnel back-up strategy	☐	☐	☐	☐	☐
Previous financial penalties	☐	☐	☐	☐	☐
Technical proposal responsiveness	☐	☐	☐	☐	☐
Specialized knowledge of particular construction method	☐	☐	☐	☐	☐
Communication	☐	☐	☐	☐	☐
Documentation Management	☐	☐	☐	☐	☐
Scheduling of Cost Control	☐	☐	☐	☐	☐
Construction scheduling guarantee measure	☐	☐	☐	☐	☐
Contract not renewed due to failure to perform	☐	☐	☐	☐	☐
Has the contractor ever been debarred in a certain jurisdiction area by a governmental agency	☐	☐	☐	☐	☐
Declined invitations, or did not submit a bid on at least three occasions in the previous 12months	☐	☐	☐	☐	☐
Amount of current uncompleted work-on-hand	☐	☐	☐	☐	☐
Capacity of firms	☐	☐	☐	☐	☐
Capacity to add this project	☐	☐	☐	☐	☐
Subcontractor plan	☐	☐	☐	☐	☐
Use of fair estimation methods	☐	☐	☐	☐	☐
Schedule of payments	☐	☐	☐	☐	☐
Advance payment	☐	☐	☐	☐	☐

Please include other factor(s) that you think might be considered in pre-qualifying contractors.

Factor 1 (Specify): _____

Factor 2 (Specify): _____

Factor 3 (Specify): _____

Factor 4 (Specify): _____

Factor 5 (Specify): _____

Please rank these factors in the order of importance:

Type of Factor(s)	Importance				
	Very High	High	Moderate	Little	None
Factor 1	☐	☐	☐	☐	☐
Factor 2	☐	☐	☐	☐	☐
Factor 3	☐	☐	☐	☐	☐
Factor 4	☐	☐	☐	☐	☐
Factor 5	☐	☐	☐	☐	☐

<u>You may skip this section. However your assistance would be greatly appreciated in making this a meaningful study.</u>

Person completing this questionnaire:

Position Held: _____

Years of Experiences : _____

Organization : _____

We do appreciate and thank you very much for your participation in our study. If you have any questions, please call Mohammad Mofigul Islam Molla at +1-915-996-0916 or email: mohammad.molla@my.ndsu.edu.

APPENDIX B. ANALYSIS TABLES

Table B.1. Contractor Prequalification Factors with Similar Terminology

SL.	Factors/Criteria	Tasmania (1999)	Australia (2000)	Lal *et al.* (2004)	Padhi and Mohapatra (2009)	Kumaraswamy (1995)	Skitmore (2002)	Salama *et al.* [2006]	NCHRP [1994]	Bubshait and Al-Gobali (1996)	Abdelrahman *et al.* (2008)	Russell (1988)	Timor (2007)	El-Sawalhi *et al.* (2007)
1	Relevant experience	X												
2	Appreciation of the task	X												
3	Past performance	X												
4	Management and technical skills	X												
5	Resources	X												
6	Management system	X												
7	Methodology	X												
8	Price	X												
9	Build ability/maintainability		X											
10	Community consultation		X											
11	Consultant management		X											
12	Design management		X											
13	Environmental sustainability		X											
14	Handover management		X											
15	Innovation		X											
16	Programming of works		X											
17	Safety		X											
18	Subcontractor management		X											
19	Use of local industry		X											
20	Waste management		X											
21	Communication		X											
22	Construction management		X											
23	Cost management		X											
24	Documentation management		X											
25	Functionality		X											
26	Incorporation of best practice		X											
27	Life cycle costs		X											
28	Quality management		X											
29	Site management		X											
30	Supporting equipment and systems		X											
31	User group/client management		X											
32	Key managerial and supervisory personnel		X											
33	Key team members (including their resumes)		X											
34	Key trade package		x											
35	A project organization chart		X											
36	Schedule of project and manpower		X											
37	Management structures, roles, reporting relationship		X											
38	Past and current performance		X											
39	Personnel back-up strategy		X											
40	Referees		X											
41	Quality standard			X										
42	Time			X										
43	Construction scheme			X										
44	Quality guarantee system and its measure			X										

(Continued)

Table B.1. Contractor Prequalification Factors with Similar Terminology (Continued)

SL.	Factors/Criteria	Tasmania (1999)	Australia (2000)	Lai *et al.* (2004)	Padhi and Mohapatra (2009)	Kumaraswamy (1995)	Skitmore (2002)	Salama *et al.* [2006]	NCHRP [1994]	Bubshait and Al-Gobali (1996)	Abdelrahman *et al.* (2008)	Russell (1988)	Timor (2007)	El-Sawalhi *et al.* (2007)
45	Safety measure			X										
46	Plans for labor force and the amounts used of main equipment and materials			X										
47	Construction scheduling plan and its guarantee measure			X										
48	Level of qualification			X										
49	Honor title for the project earned by the firm			X										
50	Level of qualification of project manager			X										
51	Expertise in similar projects			X										
52	Qualified and excellent percentage of project in recent two years			X										
53	Percentage of keeping time promise			X										
54	Bid price			X										
55	Amounts used of three materials			X										
56	Range of reducing cost			X										
57	Registration details				X									
58	Lawsuit filed				X									
59	Complains raised against them				X									
60	Quantum of similar work done in the past				X									
61	Availability of physical resources				X									
62	Financial status (liquid assets)				X									
63	Financial stability					X								
64	Financial capacity –general and present					X								
65	Technoware technology					X								
66	Infoware technology					X								
67	Orgware technology					X								
68	Humanware technology					X								
69	Managerial personnel					X								
70	General works experience					X								
71	Specialist work experience					X								
72	Local/regional experience					X								
73	Partners/sub-contracts experience					X								
74	General information						X							
75	Type of work want to do or could						X							
76	Previous financial penalties						X							
77	Any termination/employment determined under the terms of contract						X							
78	Contract not renewed due to failure to perform						X							
79	Suitability and competence of potential employees						X							
80	Skills, qualification and experience of manpower						X							
81	Staffing levels						X							
82	Currency of records of employees						X							
83	Name, address and details of work carried out recently other than this authority						X							
84	Contract carried out for the client in last 3 years						X							

(Continued)

Table B.1. Contractor Prequalification Factors with Similar Terminology (Continued)

SL.	Factors/Criteria	Tasmania (1999)	Australia (2000)	Lai *et al.* (2004)	Padhi and Mohapatra (2009)	Kumaraswamy (1995)	Skitmore (2002)	Salama *et al.* [2006]	NCHRP [1994]	Bubshait and Al-Gobali (1996)	Abdelrahman *et al.* (2008)	Russell (1988)	Timor (2007)	El-Sawalhi *et al.* (2007)
85	Main plant and equipment owned by the company						X							
86	Work performance of last 5 years						X							
87	Experience						X							
88	Claims						X							
89	Declined invitations, or did not submit a tender on at least three occasions in the previous 12months						X							
90	Inadequately staffed reception arrangements for telephone message at head office						X							
91	Inadequate plant resources						X							
92	Site/head office management						X							
93	Financial criteria						X							
94	Health and safety policy						X							
95	Experience in similar project							X						
96	Resources: personnel, equipment, facilities							X						
97	Financial status							X						
98	Firms structure and organization							X						
99	Firms capacity: project in progress							X						
100	Firms history of claims							X						
101	Quality control/quality assurance systems							X						
102	Adequacy of technical supervision							X						
103	Availability of equipment							X						
104	Method statement and proposed schedule							X						
105	Experience of key personnel							X						
106	Percentage subcontracted work							X						
107	Bid price							X						
108	Fair estimation							X						
109	Schedule of payments							X						
110	Advance payment							X						
111	Financial stability, soundness							X						
112	Financial strength							X						
113	Credit rating							X						
114	History of claims							X						
115	Financial strength								X					
116	Ability to obtain a bid, performance, payment bond								X					
117	Ownership of equipment or the ability to rent or lease equipment needed to perform the job								X					
118	Managerial ability to provide the required labor or material and the experience of key personnel								X					
119	Technical ability to perform the job in terms of contract								X					
120	Skills								X					
121	Overall experience								X					
122	Attitude, cooperation and performance								X					
123	Quality of construction								X					
124	Ability to complete the project on time								X					

(Continued)

Table B.1. Contractor Prequalification Factors with Similar Terminology (Continued)

SL.	Factors/Criteria	Tasmania (1999)	Australia (2000)	Lai *et al.* (2004)	Padhi and Mohapatra (2009)	Kumaraswamy (1995)	Skitmore (2002)	Salama *et al.* [2006]	NCHRP [1994]	Bubshait and Al-Gobali (1996)	Abdelrahman *et al.* (2008)	Russell (1988)	Timor (2007)	El-Sawalhi *et al.* (2007)
125	Disputes and claims								X					
126	Government/official requirements									X				
127	Work experience									X				
128	Workforce availability and resources									X				
129	Equipment availability and resources									X				
130	Financial stability									X				
131	Board of directors													
132	Previous claims and disputes													
133	Management capability									X				
134	Contractor organization									X				
135	Location of home office and manpower accommodation									X				
136	Purchasing expertise, material handling, and control									X				
137	Scheduling cost control									X				
138	Equipment repair and maintenance									X				
139	Safety consciousness									X				
140	Quality assurance and quality control									X				
141	References									X				
142	Past performance in owner's previous project									X				
143	Contractor failure to complete a project									X				
144	Management staff available									X				
145	Capacity of contractor									X				
146	Amount of work performed earlier									X				
147	Current workload									X				
148	Experience in geographic location of project									X				
149	Price										X			
150	Schedule										X			
151	Financial and bonding requirements										X			
152	Past experience										X			
153	Safety record/plan										X			
154	Key personnel and their qualifications										X			
155	Utilization of small business										X			
156	Subcontractor plan										X			
157	Management/organization plan										X			
158	Quality management										X			
159	Proposed design alternate										X			
160	Technical proposal responsiveness										X			
161	Environmental considerations										X			
162	Control procedure over work performed											X		
163	Staff available											X		
164	Project management capabilities											X		
165	Company organization											X		
166	Safety performance											X		
167	Substance abuse policy											X		
168	Location of home office											X		

(Continued)

Table B.1. Contractor Prequalification Factors with Similar Terminology (Continued)

SL.	Factors/Criteria	Tasmania (1999)	Australia (2000)	Lai *et al.* (2004)	Padhi and Mohapatra (2009)	Kumaraswamy (1995)	Skitmore (2002)	Salama *et al.* [2006]	NCHRP [1994]	Bubshait and Al-Gobali (1996)	Abdelrahman *et al.* (2008)	Russell (1988)	Timor (2007)	El-Sawalhi *et al.* (2007)
169	Experience in geographic area of project											X		
170	References											X		
171	Past performance											X		
172	Quality performance											X		
173	Manpower resources											X		
174	Equipment resources											X		
175	Amount of work performed with own forces											X		
176	Financial stability											X		
177	Record of failure on past projects											X		
178	Experience record											X		
179	Bonding capacity											X		
180	Capacity of firm											X		
181	Capacity to add this project											X		
182	Ability to meet essential and desirable requirements of the tender												X	
183	Customer service, including whole of life servicing and maintenance												X	
184	Quality assurance												X	
185	Capacity to perform task												X	
186	Past performance												X	
187	Strategic issues (e.g. Location, network)												X	
188	Risk management (including insurance, and use of authorized subcontractors)												X	
189	Compliance to conditions of contract												X	
190	Conflicts of interest												X	
191	Ownership and substance of the business												Xx	
192	Financial strength of the business												X	
193	Past record in dealings with the government												X	
194	Level of skills and technology transfer												X	
195	Regional and district development opportunities												X	
196	Training activities or programs supported by the bidder												X	
197	Financial analysis													X
198	Credit rating													X
199	Turnover													X
200	Bank arrangement													X
201	Debit ratio													X
202	Liquidity													X
203	Profitability													X
204	Experience of staff													X
205	Management capability													X
206	Qualification of staff													X
207	Past performance													X
208	Quality performance													X
209	Company org													X

(Continued)

Table B.1. Contractor Prequalification Factors with Similar Terminology (Continued)

SL.	Factors/Criteria	Tasmania (1999)	Australia (2000)	Lai *et al.* (2004)	Padhi and Mohapatra (2009)	Kumaraswamy (1995)	Skitmore (2002)	Salama *et al.* [2006]	NCHRP [1994]	Bubshait and Al-Gobali (1996)	Abdelrahman *et al.* (2008)	Russell (1988)	Timor (2007)	El-Sawalhi *et al.* (2007)
210	Innovate method													X
211	Type of project –experience													X
212	Size of project-experience													X
213	Number of projects-experience													X
214	Experience in the region													X
215	Length of time in business													X
216	Company image-historical non-performance													X
217	Skilled manpower													X
218	Client satisfaction- historical non-performance													X
219	Record of failure- historical non-performance													X
220	Claims and litigation- historical non-performance													X
221	Equipment resources													X
222	Equipment manpower													X
223	Quality control													X
224	Quality policy													X
225	Quality assurance													X
226	Health and safety performance													X
227	Health and safety accountability													X
228	Injury and illness													X

Table B.2. Modified Factors of Contractor Prequalification

SL.	Factors/Criteria	Tasmania (1999)	Australia (2000)	Lai *et al.* (2004)	Padhi and Mohapatra (2009)	Kumaraswamy (1995)	Skitmore (2002)	Salama *et al.* [2006]	NCHRP [1994]	Bubshait and Al-Gobali (1996)	Abdelrahman *et al.* (2008)	Russell (1988)	Timor (2007)	El-Sawalhi *et al.* (2007)
1	A project organization chart		X											
2	Ability to complete the project on time								X					
3	Ability to meet essential and desirable requirements of the tender												X	
4	Ability to obtain a bid, performance, payment bond								X					
5	Adequacy of technical supervision							X						
6	Advance payment							X						
7	Amount of work performed earlier									X				
8	Amount of work performed with own forces											X		
9	Amounts used of three materials			X										
10	Any termination/employment determined under the terms of contract						X							
11	Appreciation of the task	X												
12	Attitude, cooperation and performance								X					
13	Availability of physical resources				X									
14	Bank arrangement													X
15	Board of directors									X				
16	Bonding capacity											X		
17	Build-ability/maintainability		X											
18	Capability													
19	Capacity of contractor									X		X		
20	Capacity to add this project											X		
21	Capacity to perform task												X	
22	Claims						X							
23	Claims and failure record													
24	Claims and litigation- historical non-performance													X
25	Client satisfaction- historical non-performance													X
26	Communication		X											
27	Community consultation		X											
28	Company image-historical non-performance													X
29	Company organization											X		X
30	Complains raised against them				X									
31	Compliance to conditions of contract												X	
32	Conflicts of interest												X	
33	Construction management		X											
34	Construction scheduling plan and its guarantee measure			X										
35	Construction scheme			X										
36	Consultant management		X											
37	Contract carried out for the client in last 3 years						X							
38	Contract not renewed due to failure to perform						X							
39	Contractor failure to complete a project									X				
40	Contractor organization									X				
41	Control procedure over work performed											X		
42	Cost management		X											
43	Credit rating							X						X
44	Currency of records of employees						X							
45	Current workload									X				
46	Customer service, including whole of life servicing and maintenance												X	
47	Debit ratio													X

(Continued)

Table B.2. Modified Factors of Contractor Prequalification (Continued)

SL.	Factors/Criteria	Tasmania (1999)	Australia (2000)	Lai *et al.* (2004)	Padhi and Mohapatra (2009)	Kumaraswamy (1995)	Skitmore (2002)	Salama *et al.* [2006]	NCHRP [1994]	Bubshait and Al-Gobali (1996)	Abdelrahman *et al.* (2008)	Russell (1988)	Timor (2007)	El-Sawalhi *et al.* (2007)
48	Declined invitations, or did not submit a tender on at least three occasions in the previous 12months						X							
49	Design management		X											
50	Disputes and claims								X					
51	Documentation management		X											
52	Environmental considerations										X			
53	Environmental sustainability		X											
54	Equipment availability and resources									X				
55	Equipment manpower													X
56	Equipment repair and maintenance									X				
57	Equipment resources											X		X
58	Estimation	X												
59	Experience						X							
60	Experience in geographic area of project									X		X		X
61	Experience in similar project							X						
62	Experience of key personnel							X						
63	Experience of staff													X
64	Experience record											X		
65	Expertise in similar projects			X										
66	Fair estimation							X						
67	Finance													
68	Financial stability and soundness				X	X	X	X	X	X	X		X	X
69	Firms capacity: project in progress							X						
70	Firms history of claims							X						
71	Firms structure and organization							X						
72	Functionality		X											
73	General information						X							
74	General works experience					X								
75	Government/official requirements									X				
76	Handover management		X											
77	Health and safety		X	X			X			X				
78	Health and safety accountability													X
79	Health and safety record/plan										X			
80	Health and safety performance											X		X
81	History of claims							X						
82	Honor title for the project earned by the firm			X										
83	Human-ware technology					X								
84	Inadequately staffed reception arrangements for telephone message at head office						X							
85	Incorporation of best practice		X											
86	Info-ware technology					X								
87	Injury and illness													X
88	Innovate method													X
89	Innovation		X											
90	Key managerial and supervisory personnel		X			X								
91	Key personnel and their qualifications										X			
92	Key team members (including their resumes)		X											
93	Key trade package		X											
94	Lawsuit filed				X									

(Continued)

Table B.2. Modified Factors of Contractor Prequalification (Continued)

SL.	Factors/Criteria	Tasmania (1999)	Australia (2000)	Lai *et al.* (2004)	Padhi and Mohapatra (2009)	Kumaraswamy (1995)	Skitmore (2002)	Salama *et al.* [2006]	NCHRP [1994]	Bubshait and Al-Gobali (1996)	Abdelrahman *et al.* (2008)	Russell (1988)	Timor (2007)	El-Sawalhi *et al.* (2007)
95	Length of time in business													X
96	Level of qualification			X										
97	Level of qualification of project manager			X										
98	Level of skills and technology transfer												X	
99	Local/regional experience					X								
100	Location of home office											X		
101	Location of home office and manpower accommodation									X				
102	Management													
103	Management and technical skills	X												
104	Management capability									X				X
105	Management staff available									X				
106	Management structures, roles, reporting relationship		X											
107	Management system	X												
108	Management/organization plan										X			
109	Managerial ability to provide the required labor or material and the experience of key personnel								X					
110	Manpower resources											X		
111	Method statement and proposed schedule	X						X			X			
112	Methodology													
113	Name, address and details of work carried out recently other than this authority						X							
114	Number of projects-experience													X
115	Org-ware technology					X								
116	Overall experience								X					
117	Ownership and substance of the business												X	
118	Ownership of equipment or the ability to rent or lease equipment needed to perform the job						X		X					
119	Partners/subcontracts experience					X								
120	Past and current performance		X											
121	Past experience	X									X	X	X	X
122	Past performance in owner's previous project									X				
123	Past record in dealings with the government												X	
124	Payments													
125	Percentage of keeping time promise			X										
126	Percentage subcontracted work							X						
127	Personnel back-up strategy		X											
128	Plans for labor force and the amounts used of main equipment and materials			X										
129	Previous claims and disputes									X				
130	Previous financial penalties						X							
131	Profitability													X
132	Programming of works		X											
133	Project management capabilities											X		
135	Purchasing expertise, material handling, and control									X				
136	Qualification of staff													X
137	Qualified and excellent percentage of project in recent two years			X										
138	Quality													
139	Quality management, control and assurance system		X	X				X	X	X	X	X	X	X
140	Quality performance											X		X

(Continued)

Table B.2. Modified Factors of Contractor Prequalification (Continued)

SL.	Factors/Criteria	Tasmania (1999)	Australia (2000)	Lai *et al.* (2004)	Padhi and Mohapatra (2009)	Kumaraswamy (1995)	Skitmore (2002)	Salama *et al.* [2006]	NCHRP [1994]	Bubshait and Al-Gobali (1996)	Abdelrahman *et al.* (2008)	Russell (1988)	Timor (2007)	El-Sawalhi *et al.* (2007)
141	Quantum of similar work done in the past				X									
142	Range of reducing cost			X										
143	Record of failure- historical non-performance													X
144	Record of failure on past projects											X		
145	References	X	X							X		X		
146	Regional and district development opportunities												X	
147	Registration details				X									
148	Relevant experience	X												
149	Resources	X												
150	Risk management (including insurance, and use of authorized subcontractors)												X	
151	Schedule of manpower		X											
152	Schedule of payments							X						
153	Schedule of project		X	X							X			
154	Scheduling of cost control									X				
155	Site management		X											
156	Site/head office management						X							
157	Size of project-experience													X
158	Skilled manpower													X
159	Skills								X					
160	Skills, qualification and experience of manpower						X							
161	Specialist work experience					X								
162	Staff available											X		
163	Staffing levels						X							
164	Strategic issues (e.g. Location, network)												X	
165	Strategy													
166	Subcontracting													
167	Subcontractor management		X											
168	Subcontractor plan										X			
169	Substance abuse policy											X		
170	Suitability and competence of potential employees					X								
171	Supporting equipment and systems		X				X	X						
172	Technical ability to perform the job in terms of contract								X					
173	Technical proposal responsiveness										X			
174	Techno-ware technology					X								
175	Training activities or programs supported by the bidder												X	
176	Turnover													X
178	Type of project –experience													X
179	Type of work want to do or could						X							
180	Use of local industry		X											
181	User group/client management		X											
182	Utilization of small business										X			
183	Waste management		X											
184	Work experience									X				
185	Work performance of last 5 years						X							
186	Workforce availability and resources									X				

Table B.3. Five Years Range's Chronological Analysis

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985	1990	1990	Sub-Total	1992	1994	1995	Sub-Total	1996	1996	1996	1997	1998	Sub-Total	2001	2002	2003	2004	2005	Sub-Total	2006	2006	2007	2007	2007	2007	2008	2008	2009	2009	2010	2010	2010	Sub-Total	2011	2012	2012	Sub-Total		
		Nguyen	Russell and Skibniewski	Russell	Sub-Total	Herbsman and Ellis	Assaf and Jannadi (4)	Potter and Sanvidor	Sub-Total	Kumaraswamy (30)	Bubshait and Al-Gobali	Russell	Hatush and Skitmore	Hatush and Skitmore	Sub-Total	Al-Harbi	Sonmez et al.	Shen et al. (11)	Lai et al. (19)	Palaneeswaran and Kumaraswamy	Sub-Total	Singh and Tiong	Salama et al.	El-Sawalhi et al. (26)	Lam et al. (17)	Abudayyeh et. al	Li et al.	Turskis (53)	Lu el at.	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Elyamany	Marsh and Fayek	Sub-Total	Lam and Yu (1)	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Sub-Total		
General Information and Registration Details	Validity of Registration Details	16									X		X		(2)			X			(1)					X					X			(2)					5	14
	Attitude, cooperation and performance	X			(1)																							X		X	X				(3)					4	15
	Board of Directors										X				(1)																									1	18
	Customer service, including whole of life servicing and maintenance													X	(1)																									1	18
	Qualification Grade																	X			(1)																			1	18
	Familiarity with regulating authorities																					X												(1)					1	18
	Owners hip and s ubstance of the business																	X			(1)												X	(1)					2	17
	Age of s hareholders																																	X	(1)					1	18
	Length of time in business	X	X	X	(3)									X	(1)		X				(1)	X		X			X		X	X				(5)		X	X	(2)	12	8
	Size of bus ines s																X				(1)						X		X					(2)			X	(1)	4	15
	Length of time company controlled by current management		X		(1)																																		1	18
	Largest project performed in past five years		X	X	(2)																																		2	17
	Past and current performance	X	X		(2)	X	X	X	(3)			X		X	(2)	X				X	(2)		X	X	X			X		X			X		(6)	X			(1)	16	6

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985 Nguyen	1990 Russell and Skibniewski	1990 Russell	Sub-Total	1992 Herbsman and Ellis	1994 Assaf and Jannadi (4)	1995 Potter and Sanvidor	Sub-Total	1996 Kumaraswamy (30)	1996 Bubshait and Al-Gobali	1996 Russell	1997 Hatush and Skitmore	1998 Hatush and Skitmore	Sub-Total	2001 Al-Harbi	2002 Sonmez et al.	2003 Shen et al. (11)	2004 Lai et al. (19)	2005 Palaneeswaran and Kumaraswamy	Sub-Total	2006 Singh and Tiong	2006 Salama et al.	2007 El-Sawalhi et al. (26)	2007 Lam et al. (17)	2007 Abudayyeh et. al	2007 Li et al.	2008 Turskis (53)	2008 Lu et al.	2009 Plebankiewicz (27)	2009 Lam et al. (13)	2010 Padhi and Mohapatra	2010 Elyamany	2010 Marsh and Fayek	Sub-Total	2011 Lam and Yu (1)	2012 Nieto-Morote and Ruz-Vila	2012 Alzahrani and Emsley	Sub-Total		
Experiences	Qualified and excellent percentage of project in recent 5 years												X		(1)				X		(1)																	2	17
	General works experience									X					(1)																								1	18
	Specialist work experience									X					(1)																								1	18
	Partners / sub-contracts experience									X					(1)				X		(1)																		2	17
	Recent completed project																									X								(1)					1	18
	Type of work want to do or did			X	(1)								X		(1)		X				(1)	X		X			X						(3)		X	X	(2)	8	11
	Past performance in owner's previous project										X				(1)																								1	18
	Size of project-experience																X				(1)	X		X			X							(3)		X	X	(2)	6	13
	Classes of work performed in each project																									X								(1)					1	18
	Number of projects-experience																							X										(1)		X		(1)	2	17
	Work performed with own forces							X	(1)																														1	18
	Business coverage																												X					(1)					1	18
	Experience in the region																							X										(1)					1	18

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985	1990	1990		1992	1994	1995		1996	1996	1996	1997	1998		2001	2002	2003	2004	2005		2006	2006	2007	2007	2007	2007	2008	2008	2009	2009	2010	2010	2010		2011	2012	2012			
		Nguyen	Russell and Skibniewski	Russell	Sub-Total	Herbsman and Ellis	Assaf and Jannadi (4)	Potter and Sanvidor	Sub-Total	Kumaraswamy (30)	Bubshait and Al-Gobali	Russell	Hatush and Skitmore	Hatush and Skitmore	Sub-Total	Al-Harbi	Sonmez et al.	Shen et al. (11)	Lai et al. (19)	Palaneeswaran and Kumaraswamy	Sub-Total	Singh and Tiong	Salama et al.	El-Sawalhi et al. (26)	Lam et al. (17)	Abudayyeh et. al	Li et al.	Turskis (53)	Lu el at.	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Elyamany	Marsh and Fayek	Sub-Total	Lam and Yu (1)	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Sub-Total		
	Length of time in business																							X											(1)				1	18
Project Specific	Type of work want to do or did												X		(1)									X											(1)				2	17
Project Specific	Number of projects-experience																							X											(1)				1	18
Project Specific	Expertise in similar projects															X			X		(2)	X	X			X					X	X			(5)				7	12
Project Specific	Largest similar project performed in past five years		X		(1)																																		1	18
Project Specific	Understanding of objectives & identify key issues																														X				(1)				1	18
Project Specific	Experience in geographic location of project		X		(1)		X	X	(2)	X	X				(2)		X				(1)	X		X			X								(3)		X	X	(2)	11	9
References	Company image-historical non-performance																							X											(1)				1	18
References	Company reputation			X	(1)											X	X				(2)						X		X				X	(3)				6	13
References	Appreciation of the task																	X	X		(2)										X			(1)				3	16
References	References		X	X	(2)		X	X	(2)		X	X			(2)											X							X	(2)				8	11
References	Good Relations hip with stakeholders	X			(1)									X	(1)							X						X						(2)		X		(1)	5	14
References	Good relations hip with pas projects owners																					X												(1)				1	18

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985 Nguyen	1990 Russell and Skibniewski	1990 Russell	Sub-Total	1992 Herbsman and Ellis	1994 Assaf and Jannadi (4)	1995 Potter and Sanvidor	Sub-Total	1996 Kumaraswamy (30)	1996 Bubshait and Al-Gobali	1996 Russell	1997 Hatush and Skitmore	1998 Hatush and Skitmore	Sub-Total	2001 Al-Harbi	2002 Sonmez et al.	2003 Shen et al. (11)	2004 Lai et al. (19)	2005 Palaneeswaran and Kumaraswamy	Sub-Total	2006 Singh and Tiong	2006 Salama et al.	2007 El-Sawalhi et al. (26)	2007 Lam et al. (17)	2007 Abudayyeh et. al	2007 Li et al.	2008 Turskis (53)	2008 Lu el at.	2009 Plebankiewicz (27)	2009 Lam et al. (13)	2010 Padhi and Mohapatra	2010 Elyamany	2010 Marsh and Fayek	Sub-Total	2011 Lam and Yu (1)	2012 Nieto-Morote and Ruz-Vila	2012 Azahrani and Emsley	Sub-Total		
	Client satisfaction-historical non-performance																							X										(1)		X		(1)	2	17
Management and Orgnization	Management and technical skills and capability	X	X		(2)			X	(1)		X	X	X	X	(4)	X	X				(2)	X		X	X		X	X					X	(6)	X	X	X	(3)	18	4
	Quality management system																																				X		(1)	1	18
	Leader's personality and capability																												X					(1)					1	18
	Qualification of owners/contractor																X				(1)						X							(1)					2	17
	Design & Consultant management																			X	(1)																		1	18
	Environmental sustainability																	X		X	(1)							X	X		X			(3)	X		X	(2)	8	11
	Subcontractor management																											X						(1)					1	18
	Waste management																											X						(1)			X	(1)	2	17
	Project management	X			(1)									X	(1)					X	(1)										X			(1)					4	15
	Project control procedures		X		(1)			X	(1)											X	(1)																		3	16
	Plant management																												X					(1)					1	18
	Contract management																												X					(1)					1	18
	Substance abuse policy		X		(1)			X	(1)																														2	17
	Site management																						X					X	X		X			(4)			X	(1)	5	14

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985	1990	1990		1992	1994	1995		1996	1996	1996	1997	1998		2001	2002	2003	2004	2005		2006	2006	2007	2007	2007	2007	2008	2008	2009	2009	2010	2010	2010		2011	2012	2012			
		Nguyen	Russell and Skibniewski	Russell	Sub-Total	Herbsman and Ellis	Assaf and Jannadi (4)	Potter and Sanvidor	Sub-Total	Kumaraswamy (30)	Bubshait and Al-Gobali	Russell	Hatush and Skitmore	Hatush and Skitmore	Sub-Total	Al-Harbi	Sonmez et al.	Shen et al. (11)	Lai et al. (19)	Palaneeswaran and Kumaraswamy	Sub-Total	Singh and Tiong	Salama et al.	El-Sawalhi et al. (26)	Lam et al. (17)	Abudayyeh et. al	Li et al.	Turskis (53)	Lu et at.	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Elyamany	Marsh and Fayek	Sub-Total	Lam and Yu (1)	Nieto-Morote and Ruz-Mla	Azahrani and Emsley	Sub-Total		
	Standard of subcontractors' works in past projects																					X												(1)				1	18
	Contractor organization and Plan		X		(1)		X	X	(2)		X	X			(2)	X				X	(2)			X					X		X		X	(4)		X		(1)	12	8
	Logistic and supply chain management																												X					(1)					1	18
	Purchasing expertise, material handling and control						X		(1)		X				(1)																									2	17
	Key managerial, supervisory and operational personnel experience and availability	X	X		(2)		X	X	(2)	X		X	X	X	(4)					X	(1)		X		X			X	X	X	X		X		(7)	X		X	(2)	18	4
	Personnel back-up strategy																														X			X	(2)					2	17
	Amount of work performed with own forces		X		(1)																																			1	18
	Techno-ware Technology availability									X					(1)																									1	18
	Info-ware Technology knowledge and availability									X					(1)			X			(1)								X						(1)		X	X	(2)	5	14
	Org-ware Technology availability									X					(1)																									1	18

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985	1990	1990	Sub-Total	1992	1994	1995	Sub-Total	1996	1996	1996	1997	1998	Sub-Total	2001	2002	2003	2004	2005	Sub-Total	2006	2006	2007	2007	2007	2007	2008	2008	2009	2009	2010	2010	2010	Sub-Total	2011	2012	2012	Sub-Total		
		Nguyen	Russell and Skibniewski	Russell		Herbsman and Ellis	Assaf and Jannadi (4)	Potter and Sanvidor		Kumaraswamy (30)	Bubshait and Al-Gobali	Russell	Hatush and Skitmore	Hatush and Skitmore		Al-Harbi	Sonmez et al.	Shen et al. (11)	Lai et al. (19)	Palaneeswaran and Kumaraswamy		Singh and Tiong	Salama et al.	El-Sawalhi et al. (26)	Lam et al. (17)	Abudayyeh et. al	Li et al.	Turskis (53)	Lu el at.	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Elyamany	Marsh and Fayek		Lam and Yu (1)	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley			
Resources	Human-ware Technology availability									X					(1)																							1	18
	Owners hip of equipment or the ability to rent or lease equipment needed to perform the job												X		(1)																							1	18
	Workforce res ources and availability	X	X		(2)		X	X	(2)		X			X	(2)	X			X		(2)	X	X								X			(2)	X	X	X	(3)	13	7
	Equipment resources and availability	X	X		(2)			X	(1)		X	X	X	X	(4)	X		X			(2)		X		X					X		X		X	(5)	X	X	X	(3)	17	5
	Equipment operational experience																			X	(1)																		1	18
	The quantities, capabilities, and condition of the contractor's owned or rented equipment																			X	(1)	X				X								(2)					3	16
	Availability of product and price information of labor, materials, plants, and other res ources																												X					(1)					1	18
	Availability of testing equipment																					X												(1)					1	18
	Equipment repair and maintenance										X			X	(2)					X	(1)								X					(1)					4	15
	Finance arrangement																					X												(1)					1	18

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985	1990	1990	Sub-Total	1992	1994	1995	Sub-Total	1996	1996	1996	1997	1998	Sub-Total	2001	2002	2003	2004	2005	Sub-Total	2006	2006	2007	2007	2007	2007	2008	2008	2009	2009	2010	2010	2010		2011	2012	2012			
		Nguyen	Russell and Skibniewski	Russell		Herbsman and Ellis	Assaf and Jannadi (4)	Potter and Sanvidor		Kumaraswamy (30)	Bubshait and Al-Gobali	Russell	Hatush and Skitmore	Hatush and Skitmore		Al-Harbi	Sonmez et al.	Shen et al. (11)	Lai et al. (19)	Palaneeswaran and Kumaraswamy		Singh and Tiong	Salama et al.	El-Sawalhi et al. (26)	Lam et al. (17)	Abudayyeh et. al	Li et al.	Turskis (53)	Lu el at.	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Elyamany	Marsh and Fayek		Lam and Yu (1)	Nieto-Morote and Ruz-Vila	Azahrani and Emsley			
Finance	Quality of financial statement																																X	(1)					1	18
	Construction experience of accountant																																X	(1)					1	18
	Accounting method																																X	(1)					1	18
	Current commitments																					X												(1)					1	18
	Capital																					X												(1)					1	18
	Current & fixed assets																					X												(1)					1	18
	Networth																					X												(1)					1	18
	Range of reducing cost																		X		(1)																		1	18
	Financial stability & soundness	X	X		(2)		X	X	(2)	X	X		X	X	(4)	X				X	(2)		X	X	X	X		X	X	X		X	X	X	##	X	X		(2)	22	3
	Previous financial penalties									X			X		(2)																									2	17
	Currency of records of employees												X		(1)																									1	18
	Credit rating and history													X	(1)		X	X			(2)		X	X		X	X							X	(5)		X	X	(2)	10	10
	Solvency																X			X	(2)						X								(1)					3	16
	Liquidity (current ration)																X			X	(2)	X					X							X	(3)		X		(1)	6	13
	Turnover History	X			(1)												X				(1)	X		X			X			X					(4)			X	(1)	7	12
	Overruns : cost																										X							X	(2)			X	(1)	3	16
	Bank arrangement	X			(1)									X	(1)		X				(1)			X			X							X	(3)					6	13
	Debit ratio	X			(1)												X			X	(2)			X			X			X					(3)					6	13
	Owned financial funds	X			(1)																																			1	18

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985	1990	1990		1992	1994	1995		1996	1996	1996	1997	1998		2001	2002	2003	2004	2005		2006	2006	2007	2007	2007	2007	2008	2008	2009	2009	2010	2010	2010		2011	2012	2012			
		Nguyen	Russell and Skibniewski	Russell	Sub-Total	Herbsman and Ellis	Assaf and Jannadi (4)	Potter and Sanvidor	Sub-Total	Kumaraswamy (30)	Bubshait and Al-Gobali	Russell	Hatush and Skitmore	Hatush and Skitmore	Sub-Total	Al-Harbi	Sonmez et al.	Shen et al. (11)	Lai et al. (19)	Palaneeswaran and Kumaraswamy	Sub-Total	Singh and Tiong	Salama et al.	El-Sawalhi et al. (26)	Lam et al. (17)	Abudayyeh et. al	Li et al.	Turskis (53)	Lu el at.	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Elyamany	Marsh and Fayek	Sub-Total	Lam and Yu (1)	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Sub-Total		
	Previous claims and past judgments																																X	(1)					1	18
	Payment score																																X	(1)					1	18
	Profitability	X			(1)												X			X	(2)			X			X			X			X	X	(5)					8	11
Methodology	Statement of methodology																					X	X								X		X		(4)					5	14
Methodology	Technical proposal responsiveness																											X					X		(2)					2	17
Methodology	Environmental considerations.																																X		(1)	X			(1)	2	17
Methodology	Build-ability/Maintainability																	X			(1)																			1	18
Methodology	Specialized knowledge of particular construction method																					X													(1)			X	(1)	2	17
Quality	Quality management, control & assurance system	X	X		(2)	X	X	X	(3)		X	X		X	(3)	X	X	X	X	X	(5)	X	X	X	X		X	X	X	X			X		(9)	X	X	X	(3)	24	2
Quality	Achievement of quality level (e.g., ISO: 14000)																					X													(1)					1	18
Quality	Quality performance											X			(1)									X			X								(2)					3	16
Safety	Health & Safety performance and plan	X	X		(2)	X	X	X	(3)		X	X	X	X	(4)	X	X	X	X	X	(5)	X		X	X		X	X	X	X			X	X	(9)	X	X	X	(3)	26	1
Safety	Security					X			(1)																															1	18
	Communication																			X	(1)								X						(1)					2	17

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985 Nguyen	1990 Russell and Skibniewski	1990 Russell	Sub-Total	1992 Herbsman and Ellis	1994 Assaf and Jannadi (4)	1995 Potter and Sanvidor	Sub-Total	1996 Kumaraswamy (30)	1996 Bubshait and Al-Gobali	1996 Russell	1997 Hatush and Skitmore	1998 Hatush and Skitmore	Sub-Total	2001 Al-Harbi	2002 Sonmez et al.	2003 Shen et al. (11)	2004 Lai et al. (19)	2005 Palaneeswaran and Kumaraswamy	Sub-Total	2006 Singh and Tiong	2006 Salama et al.	2007 El-Sawalhi et al. (26)	2007 Lam et al. (17)	2007 Abudayyeh et. al	2007 Li et al.	2008 Turskis (53)	2008 Lu el at.	2009 Plebankiewicz (27)	2009 Lam et al. (13)	2010 Padhi and Mohapatra	2010 Elyamany	2010 Marsh and Fayek	Sub-Total	2011 Lam and Yu (1)	2012 Nieto-Morote and Ruz-Vila	2012 Alzahrani and Emsley	Sub-Total		
Communication	Documentation Management																			X	(1)																		2	17
	Inadequately staffed reception arrangements for telephone message at head office												X		(1)																									1	18
Work Schedule	Schedule of project					X			(1)										X		(1)	X						X	X		X		X		(5)			X	(1)	8	11
	Schedule of resources																											X							(1)					1	18
	Construction scheme																		X		(1)																			1	18
	Scheduling of Cost Control										X				(1)																						X	(1)	2	17
	Overruns : time																										X							X	(2)			X	(1)	3	16
	Construction scheduling guarantee measure																		X		(1)							X							(1)					2	17
	Projects completed on time																																				X		(1)	1	18
	Project completed on budget																																				X		(1)	1	18
	Percentage of keeping time promise																		X		(1)																			1	18
	History of claims						X		(1)		X	X	X		(3)								X		X	X		X		X		X		(6)	X	X	X	(3)	13	7
	Contractor failure to complete a project	X	X	X	(3)		X		(1)		X	X	X	X	(4)		X				(1)	X		X		X	X			X		X		(6)		X	X	(2)	17	5
	Contract not renewed due to failure to perform									X			X		(2)																									2	17

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985 Nguyen	1990 Russell and Skibniewski	1990 Russell	Sub-Total	1992 Herbsman and Ellis	1994 Assaf and Jannadi (4)	1995 Potter and Sanvidor	Sub-Total	1996 Kumaraswamy (30)	1996 Bubshait and Al-Gobali	1996 Russell	1997 Hatush and Skitmore	1998 Hatush and Skitmore	Sub-Total	2001 Al-Harbi	2002 Sonmez et al.	2003 Shen et al. (11)	2004 Lai et al. (19)	2005 Palaneeswaran and Kumaraswamy	Sub-Total	2006 Singh and Tiong	2006 Salama et al.	2007 El-Sawalhi et al. (26)	2007 Lam et al. (17)	2007 Abudayyeh et. al	2007 Li et al.	2008 Turskis (53)	2008 Lu el at.	2009 Plebankiewicz (27)	2009 Lam et al. (13)	2010 Padhi and Mohapatra	2010 Elyamany	2010 Marsh and Fayek	Sub-Total	2011 Lam and Yu (1)	2012 Nieto-Morote and Ruz-Vila	2012 Alzahrani and Emsley	Sub-Total		
Claim History	Current claims in court or arbitration																									X								(1)				1	18
	Prequalification and disqualification history with any agency																									X								(1)				1	18
	Litigation tendency																X				(1)						X							(1)			X	(1)	3	16
	Engaged in fraudulant activity			X	(1)																																		1	18
	Eneligibility to bid on public works because of breaching any of the enviromental or labor codes																									X								(1)				1	18
	Has the contractor ever been debarred in a certain jurisdiction area by a governmental agency			X	(1)																	X												(1)				2	17
	Claim and dispute resolving skills																												X					(1)				1	18
	Knowledge and expertise on law																												X					(1)				1	18
	Declined invitations, or did not submit a bid on at least three occasions in the previous 12months									X			X		(2)																								2	17

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010													2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985	1990	1990		1992	1994	1995		1996	1996	1996	1997	1998		2001	2002	2003	2004	2005		2006	2006	2007	2007	2007	2007	2008	2008	2009	2009	2010	2010	2010		2011	2012	2012			
		Nguyen	Russell and Skibniewski	Russell	Sub-Total	Herbsman and Ellis	Assaf and Jannadi (4)	Potter and Sanvidor	Sub-Total	Kumaraswamy (30)	Bubshait and Al-Gobali	Russell	Hatush and Skitmore	Hatush and Skitmore	Sub-Total	Al-Harbi	Sonmez et al.	Shen et al. (11)	Lai et al. (19)	Palaneeswaran and Kumaraswamy	Sub-Total	Singh and Tiong	Salama et al.	El-Sawalhi et al. (26)	Lam et al. (17)	Abudayyeh et. al	Li et al.	Turskis (53)	Lu el at.	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Elyamany	Marsh and Fayek	Sub-Total	Lam and Yu (1)	Nieto-Morote and Ruz-Vila	Alzahrani and Emsley	Sub-Total		
Capability	Current workload		X		(1)		X	X	(2)		X				(1)	X				X	(2)	X	X		X			X					X	(5)	X			(1)	12	8
	Unbonded At Risk work																																	X	(1)					1	18
	Available surety credit																																	X	(1)					1	18
	Amount of current uncompleted work-on-hand		X	X	(2)																																			2	17
	Largest of amount of uncompleted work-on-hand			X	(1)																																			1	18
	Ability to obtain a bid, performance, payment bond; bonding capacity		X	X	(2)			X	(1)					X	(1)											X		X						(2)			X	(1)	7	12
	Capacity of firms		X		(1)			X	(1)																															2	17
	Amount of work performed earlier										X				(1)																									1	18
	Capacity to add this project											X			(1)							X												(1)					2	17
	Availability of liability and workers' compensation insurance policies																									X								(1)					1	18
	The maximum amount of work that can be performed by the contractor's own workforce																									X								(1)					1	18
	Key Man life insurance																																	X	(1)					1	18

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010												2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985	1990	1990		1992	1994	1995		1996	1996	1996	1997	1998		2001	2002	2003	2004	2005		2006	2006	2007	2007	2007	2007	2008	2008	2009	2009	2010	2010	2010		2011	2012	2012			
		Nguyen	Russell and Skibniewski	Russell	Sub-Total	Herbsman and Ellis	Assaf and Jannadi (4)	Potter and Sanvidor	Sub-Total	Kumaraswamy (30)	Bubshait and Al-Gobali	Russell	Hatush and Skitmore	Hatush and Skitmore	Sub-Total	Al-Harbi	Sonmez et al.	Shen et al. (11)	Lai et al. (19)	Palaneeswaran and Kumaraswamy	Sub-Total	Singh and Tiong	Salama et al.	El-Sawalhi et al. (26)	Lam et al. (17)	Abudayyeh et. al	Li et al.	Tunskis (53)	Lu el at.	Plebankiewicz (27)	Lam et al. (13)	Padhi and Mohapatra	Elyamany	Marsh and Fayek	Sub-Total	Lam and Yu (1)	Nieto-Morote and Ruz-Mla	Alzahrani and Emsley	Sub-Total		
	Risk management (including insurance, and use of authorized sub-contractors)	X			(1)																	X						X					(2)					3	16
Subcontracting	Percentage subcontracted Work																						X											(1)					1	18
Subcontracting	Utilization of small business																																X		(1)					1	18
Subcontracting	Subcontractor prequalification process																																	X	(1)					1	18
Subcontracting	Management of subcontractors																																	X	(1)					1	18
Subcontracting	Reputation of subcontractors to be used for the project																					X													(1)					1	18
Subcontracting	Subcontractor Plan																											X					X		(2)					2	17
Estim-ation	Fair Estimation																						X					X							(2)					2	17
Estim-ation	Shcedule of payments																					X	X												(2)					2	17
Estim-ation	Advance payment													X	(1)								X												(1)					2	17
	Location of home office & man-power accommodation		X		(1)		X	X	(2)		X	X			(2)																								5	14
	Training activities or programs supported by the bidder																			X	(1)						X		X					(2)					3	16

(Continued)

Table B.3. Five Years Range's Chronological Analysis (Continued)

Category	Factor/Criteria	1985-1990				1991-1995				1996-2000						2001-2005						2006-2010														2011-2012				Count	Rank
		1	2	3		4	5	6		7	8	9	10	11		12	13	14	15	16		17	18	19	20	21	22	23	24	25	26	27	28	29		30	31	32			
	Year	1985 Nguyen	1990 Russell and Skibniewski	1990 Russell	Sub-Total	1992 Herbsman and Ellis	1994 Assaf and Jannadi (4)	1995 Potter and Sanvidor	Sub-Total	1996 Kumaraswamy (30)	1996 Bubshait and Al-Gobali	1996 Russell	1997 Hatush and Skitmore	1998 Hatush and Skitmore	Sub-Total	2001 Al-Harbi	2002 Sonmez et al.	2003 Shen et al. (11)	2004 Lai et al. (19)	2005 Palaneeswaran and Kumaraswamy	Sub-Total	2006 Singh and Tiong	2006 Salama et al.	2007 El-Sawalhi et al. (26)	2007 Lam et al. (17)	2007 Abudayyeh et. al	2007 Li et al.	2008 Turskis (53)	2008 Lu el at.	2009 Plebankiewicz (27)	2009 Lam et al. (13)	2010 Padhi and Mohapatra	2010 Elyamany	2010 Marsh and Fayek	Sub-Total	2011 Lam and Yu (1)	2012 Nieto-Morote and Ruz-Vila	2012 Alzahrani and Emsley	Sub-Total		
Strategic Business	The contractor's time and cost saving considerations																					X													(1)					1	18
	Postbusiness attitude																					X													(1)					1	18
	Innovate method																	X			(1)			X						X				(2)		X		(1)	4	15
	Strategic awareness and perspective																												X						(1)					1	18
	Matching strategy to a company's situation																												X						(1)					1	18
	Strategy implementation																												X						(1)					1	18
	Suitability of organization structure																												X						(1)					1	18
	Motivation and job satisfaction																												X						(1)					1	18
	Technological innovation ability																												X						(1)					1	18
	Sustainable development of technology and R&D																												X						(1)					1	18
	Market research and planning																												X						(1)					1	18
Bid Specific	Bidding Strategy																												X						(1)					1	18
	Experiences in bidding																												X						(1)					1	18
	Bidding resources																												X						(1)					1	18
	Business plan																												X						(1)					1	18

Table B.4. Ranking of Factors

Sl.	Factors	Count	Rank
1	Health and safety performance and plan	26	1
2	Quality management, control & assurance system	24	2
3	Financial stability and soundness	22	3
4	Management and technical skills and capability	18	4
5	Key managerial, supervisory and operational personnel experience and	18	4
6	Equipment resources and availability	17	5
7	Contractor failure to complete a project	17	5
8	Past and current performance	16	6
9	Workforce resources and availability	13	7
10	History of claims of contractor	13	7
11	Length of time in business	12	8
12	Contractor organization and plan	12	8
13	Current workload	12	8
14	Experience in geographic location of project	11	9
15	Credit rating and history	10	10
16	Type of work want to do or did	8	11
17	References	8	11
18	Environmental sustainability	8	11
19	Profitability	8	11
20	Schedule of project	8	11
21	Expertise in similar projects	7	12
22	Turnover history	7	12
23	Ability to obtain a bid, performance, payment bond; bonding capacity	7	12
24	Size of project-experience	6	13
25	Company reputation	6	13
26	Liquidity (current ration)	6	13
27	Bank arrangement	6	13
28	Debit ratio	6	13
29	Validity of registration details	5	14
30	Good relationship with stakeholders	5	14
31	Site management	5	14
32	Info-ware technology knowledge and availability	5	14
33	Statement of methodology	5	14
34	Location of home office and manpower accommodation	5	14
35	Attitude, cooperation and performance	4	15
36	Size of business	4	15
37	Project management	4	15
38	Equipment repair and maintenance	4	15
39	Innovative method	4	15
40	Appreciation of the task	3	16
41	Project control procedures	3	16
42	The quantities, capabilities, and condition of the contractor's owned or	3	16
43	Solvency	3	16
44	Overruns: cost	3	16
45	Quality performance	3	16
46	Overruns: time	3	16
47	Litigation tendency	3	16
48	Risk management (including insurance, and use of authorized sub-	3	16

(Continued)

Table B.4. Ranking of Factors (Continued)

Sl.	Factors	Count	Rank
49	Training activities or programs supported by the bidder or sustainable development of human resources	3	16
50	Ownership and substance of the business	2	17
51	Largest project performed in past five years	2	17
52	Qualified and excellent percentage of project in recent 5 years	2	17
53	Partners / subcontracts experience	2	17
54	Number of projects-experience	2	17
55	Client satisfaction- historical non-performance	2	17
56	Qualification of contractor	2	17
57	Waste management	2	17
58	Substance abuse policy	2	17
59	Purchasing expertise, material handling and control	2	17
60	Personnel back-up strategy	2	17
61	Previous financial penalties	2	17
62	Technical proposal responsiveness	2	17
63	Environmental considerations.	2	17
64	Specialized knowledge of particular construction method	2	17
65	Communication	2	17
66	Documentation management	2	17
67	Scheduling of cost control	2	17
68	Construction scheduling guarantee measure	2	17
69	Contract not renewed due to failure to perform	2	17
70	Has the contractor ever been debarred in a certain jurisdiction area by a	2	17
71	Declined invitations, or did not submit a bid on at least three occasions in the previous 12months	2	17
72	Amount of current uncompleted work-on-hand	2	17
73	Capacity of firms	2	17
74	Capacity to add this project	2	17
75	Subcontractor plan	2	17
76	Fair estimation	2	17
77	Schedule of payments	2	17
78	Advance payment	2	17
79	Board of directors	1	18
80	Customer service, including whole of life servicing and maintenance	1	18
81	Qualification grade	1	18
82	Familiarity with regulating authorities	1	18
83	Age of shareholders	1	18
84	Length of time company controlled by current management	1	18
85	General works experience	1	18
86	Specialist work experience	1	18
87	Recent completed project	1	18
88	Past performance in owner's previous project	1	18
89	Classes of work performed in each project	1	18
90	Work performed with own forces	1	18
91	Business coverage	1	18
92	Largest similar project performed in past five years	1	18
93	Understanding of objectives and identify key issues	1	18
94	Company image-historical non-performance	1	18
95	Good relationship with pas projects owners	1	18

(Continued)

Table B.4. Ranking of Factors (Continued)

Sl.	Factors	Count	Rank
96	Quality management system	1	18
97	Leader's personality and capability	1	18
98	Design and Consultant management	1	18
99	Subcontractor management	1	18
100	Plant management	1	18
101	Contract management	1	18
102	Standard of subcontractors' works in past projects	1	18
103	Logistic and supply chain management	1	18
104	Amount of work performed with own forces	1	18
105	Techno-ware Technology availability	1	18
106	Org-ware Technology availability	1	18
107	Human-ware Technology availability	1	18
108	Ownership of equipment or the ability to rent or lease equipment needed to	1	18
109	Equipment operational experience	1	18
110	Availability of product and price information of labor, materials, plants, and	1	18
111	Availability of testing equipment as quality assurance	1	18
112	Finance arrangement	1	18
113	Quality of financial statement	1	18
114	Construction experience of accountant	1	18
115	Accounting method	1	18
116	Current commitments	1	18
117	Capital	1	18
118	Current and fixed assets	1	18
119	Net worth	1	18
120	Range of reducing cost	1	18
121	Currency of records of employees	1	18
122	Owned financial funds	1	18
123	Previous claims and past judgments	1	18
124	Payment score	1	18
125	Constructability/maintainability	1	18
126	Achievement of quality level (e.g., ISO: 14000)	1	18
127	Security	1	18
128	Inadequately staffed reception arrangements for telephone message at	1	18
129	Schedule of resources	1	18
130	Construction scheme	1	18
131	Projects completed on time	1	18
132	Project completed on budget	1	18
133	Percentage of keeping time promise	1	18
134	Current claims in court or arbitration	1	18
135	Prequalification and disqualification history with any agency	1	18
136	Engaged in fraudulent activity	1	18
137	Ineligibility to bid on public works because of breaching any of the	1	18
138	Claim and dispute resolving skills	1	18
139	Knowledge and expertise on law	1	18
140	Unbonded at risk work	1	18
141	Available surety credit	1	18
142	Largest of amount of uncompleted work-on-hand	1	18
143	Amount of work performed earlier	1	18
144	Availability of liability and workers' compensation insurance policies	1	18

(Continued)

Table B.4. Ranking of Factors (Continued)

Sl.	Factors	Count	Rank
145	The maximum amount of work that can be performed by the contractor's	1	18
146	Key man life insurance	1	18
147	Percentage of work subcontracted	1	18
148	Utilization of small business	1	18
149	Subcontractor prequalification process	1	18
150	Management of subcontractors	1	18
151	Reputation of subcontractors to be used for the project	1	18
152	The contractor's time and cost saving considerations	1	18
153	Post-business attitude	1	18
154	Strategic awareness and perspective	1	18
155	Matching strategy to a company's situation	1	18
156	Strategy implementation	1	18
157	Suitability of organization structure	1	18
158	Motivation and job satisfaction	1	18
159	Technological innovation ability	1	18
160	Sustainable development of technology, and Research and Development	1	18
161	Market research and planning	1	18
162	Bidding strategy	1	18
163	Experiences in bidding	1	18
164	Bidding resources	1	18
165	Business plan	1	18