UNIVERSITY OF TORONTO

DEPARTMENT OF CIVIL ENGINEERING

Reducing the Bias in Contractor Prequalification Using Data Envelopment Analysis

by

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*A THESIS SUBMITTED IN CONFORMITY WITH THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF APPLIED SCIENCE
GRADUATE DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF TORONTO*

0-612-53379-4

ABSTRACT

THESIS TITLE: Reducing the Bias in Contractor Prequalification Using Data Envelopment Analysis

DEGREE: Master of Applied Science

YEAR OF CONVOCATION: 2000

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UNIVERSITY: University of Toronto

Data Envelopment Analysis (DEA) is a linear programming tool that can handle multiple inputs and outputs in a non-parametric fashion. DEA provides an unbiased analysis of Decision Making Units (DMUs). It can provide a more sophisticated alternative to prequalification systems as well as eliminate any subjectivity from the decision-maker. A three-stage model, employing an output-oriented variable returns-to-scale DEA model, is proposed and compared against an established model. The three stages involve receiving a letter of required bonding, followed by the DEA analysis, and ending by reducing the amount of prequalified contractors to a predetermined amount, referred to as shortlisting. The DEA model produced average efficiencies between 70 and 85 percent for the seven contracts evaluated. Many of the top and bottom contractors received similar rankings in each of the two models. DEA should be a welcomed addition to the construction industry.

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank Professor Brenda Yvette McCabe for her constant support, patience, input, guidance, as well belief in myself throughout this research project.

I would also like to also extend a special thanks to the employees at MGP Project Managers, especially, Tony Nicholls, Sam Vaskov, Hank Edamura, Cecil Holtrop, Trevor Slimmon, Paul Stein, Donna Concalves, and Agnes Konca.

I would also like to thank Professor K. D. Pressnail for being the second reader of this thesis.

In addition I would also like to thank Alfea Carusoni for her help, constant support, patience, love and complete understanding of the frustrations experienced at times.

I would like to mention the help and input received from Peter Pilateris and Sandra Vela, without them this project would not have been completed as thoroughly.

Finally I would like to acknowledge the friendship of my classmates in the construction management group at the University of Toronto.

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1

1.0 INTRODUCTION

This introductory chapter will present an outline of this thesis report. Along with presenting an outline, it will serve as an introduction to many of the major issues that will be covered in this report. General principles will be discussed here as well as reasons for the undertaking of such a topic and why there may be such an interest in a new system for contractor prequalification. The main objectives as well as corresponding solution methodologies are also presented. Finally, the end of the chapter will provide a breakdown for the organization for the remainder of this report.

1.1 Background

The construction industry today is the largest industry in the United States of America (Carty, 1995). It is a highly competitive industry with a tremendous amount of risk. Most aspects of life that involve a large amount of risk and uncertainty are often accompanied by large rewards when carried out successfully. Such is not always the case in the construction industry. With profit to sales ratios in the range of 2 to 5 percent (Pilateris, 2000), the reward may sometimes not seem worth the risk of entering the tendering process. However, it is this competitive nature of the construction industry that drives companies to tighten budgets, fast track schedules, and increase productivity. It is this competition that can be indirectly related to advances in the technological sector of the construction industry. Companies are forced to become innovative to remain in the market. Cheaper and more efficient solutions are constantly being sought to become the lowest bidder, while still making a profit.

The awarding of contracts by an owner often goes to the lowest bidder, especially in publicly funded contracts. The bidding system has a set of rules that have been established over a number of years to maintain credibility and integrity. To be able to submit a tender on a particular project, contractors often go through a prequalification stage. It is this prequalification stage that is the focus of this report.

The prequalification process selects contractors based on their qualifications and allows them to move to the next stage of tender preparation and submission. However, this process is often carried out by one individual or a small like-minded group, which makes it very difficult to eliminate biases in the selection process. When a contract is being issued by an owner, the owner or their consultant will set out a bunch of guidelines as well as request certain materials that are deemed necessary to carry out the prequalification stage. After the closing date, the prequalification contracts will be assessed and the prequalified contractors will be notified to prepare a tender on the particular project.

Owners and project managers often employ different prequalification systems. Some systems are based on the contractor's historical track record with the particular owner or project manger, while others may be based on the special characteristics of the project involved. For instance one would not want a company bidding on a hydroelectric dam if they have not built one before. Some projects are so enormous that few contractors would be able to handle them.

Contractor prequalification is one of the earliest stages of the tendering process and an aspect of the system that has always been under heavy scrutiny. Prequalification is a process that identifies the contractors that are believed incapable of completing the project on time, on budget, and according to specifications, and prevents them from submitting a tender. It involves a wide range of criteria for which information supplied by the contractors is often qualitative, subjective, and imprecise. The process remains largely an art where subjective judgment, based on the individual's experience, becomes an essential part of the process (Russell and Skibniewski, 1988).

The prequalification system developed in this research will attempt to eliminate the subjectivity from the process. This is made possible through a relatively new analysis tool known as Data Envelopment Analysis (DEA). DEA was created in 1978, and has been gaining popularity ever since. It has the ability to handle multiple inputs and multiple outputs, which makes it a very versatile tool and one that is gaining momentum especially in the Information Technology Sector. By entering in all the inputs and outputs into a given model, DEA will compute the efficiency of any given Decision Making Unit (DMU) using a complex ratio analysis. The DMUs, in our case the contractors, are compared to one another and the most efficient ones are used as a threshold. Inputting contractor data, based on real figures and experiences, into DEA will help in eliminating the subjectivity or the bias from the prequalification process.

All prequalification systems have the same basic steps. Figure 1.1 shows a flow chart of a typical prequalification process. The evaluation criteria will differ from one project manager to another, causing concern for many contractors in the industry. Factors such as experience, track records, bondability issues, safety records, and staff available are often looked at in most prequalification systems. These factors are often placed in a weighted-score system to evaluate and compare the contractors.

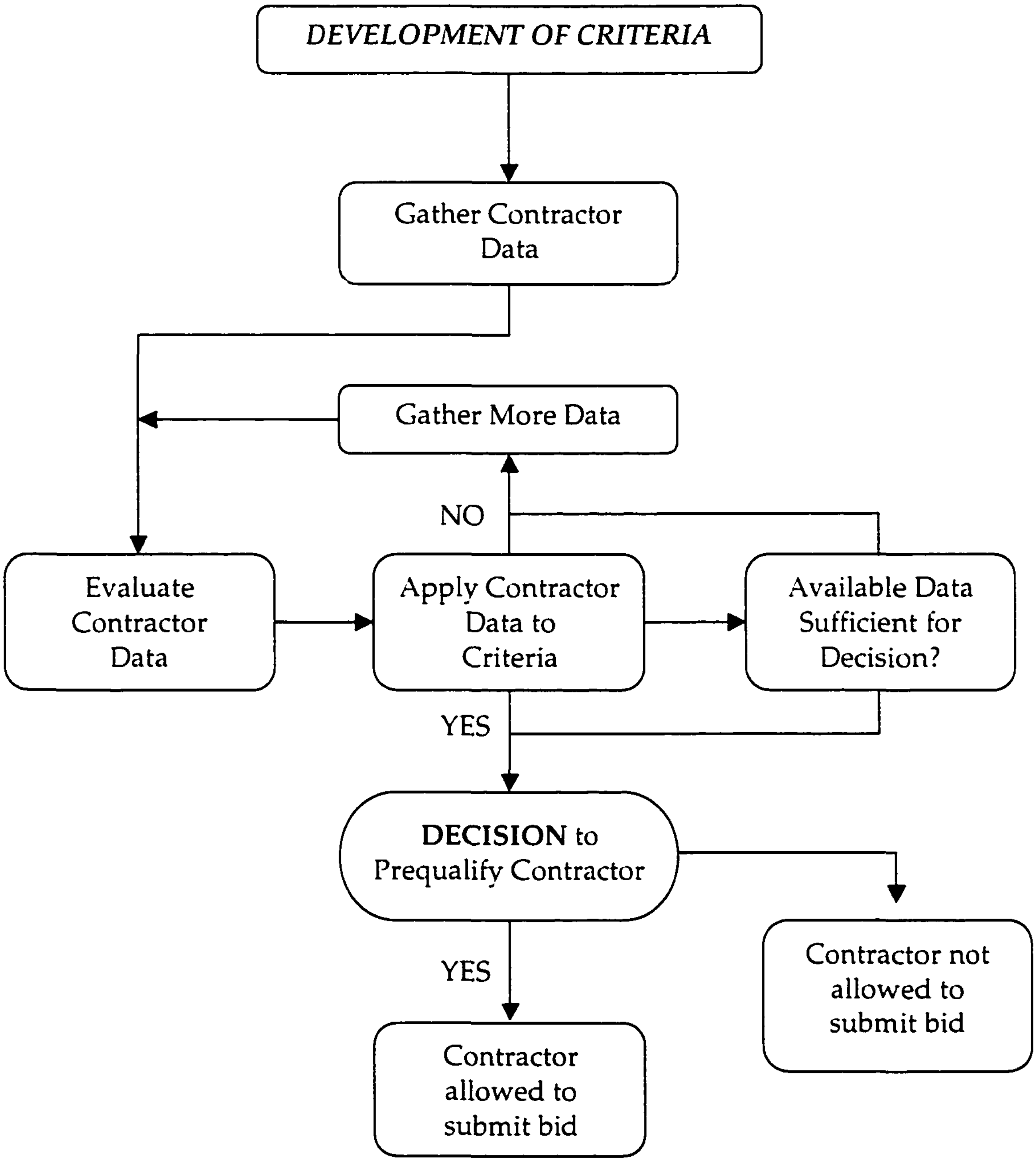


Figure 1.1: Flow Diagram of Contractor Prequalification Process (Russell and Skibniewski, 1988).

1.2 Research Motivations

The construction industry is one of the largest global industries as it makes up a significant fraction of the Gross National Product (GNP) in Canada (Gong, 1999). The area of owner-contractor prequalification has received a minimal amount of attention by the industry in the past. This lack of attention has resulted because owners have neglected contractor prequalification, relying instead on the surety companies that bond contractors, to prequalify contractors (Russell, 1994). The prequalification process was put in place in hopes that it would benefit the contractor as much as the owner. The owner will hopefully weed out the contractors that may be incapable of carrying out the contract properly, while on the other hand, contractors will not have to waste their time and money preparing a tender if they are not prequalified.

1.3 Objectives

The primary objective of this research is to develop a contractor prequalification model using DEA that may be used in the construction industry. The second objective is to introduce DEA to the construction research community and to the construction industry. The third objective is to determine whether DEA may also be used as a shortlisting tool to limit the number of contractors bidding on a contract.

1.4 Solution Approach

The prequalification model system presented here is a three-stage approach, which involves 1) bonding, 2) DEA, and 3) shortlisting. Contractor prequalification data were obtained from seven contracts. The ranking of the DEA and the owner's weighted score were compared to determine how the two methods compare.

1.5 Thesis Contributions

The main contributions of this research are:

- This is the first study that uses Data Envelopment Analysis to evaluate the efficiency of contractors in the construction industry, in particular the prequalification stage of the tendering process.
- The development of an automated prequalification model that will produce similar results to an established model.
- A three-stage model that can be used in any prequalification situation.

1.6 Thesis Organization

The structure of this thesis will be presented in the following chapters as described below:

- Chapter 2 is a review of literature on the tendering process in the construction industry. In particular the prequalification system will be looked at and the benefits and disadvantages of such a system will be examined. A discussion of prequalification versus postqualification will also be looked at from both an owner's perspective as well as a contractor's perspective. The chapter will also discuss the total cost of the tendering process and the importance of including a prequalification system.
- Chapter 3 will discuss several of the models that are currently described in the literature as well as other models that are currently in use in the construction industry.
- Chapter 4 will present the background information on Data Envelopment Analysis (DEA). A technical discussion will be presented on the two major models employed in this report. All related terminology associated with DEA will also be presented.
- Chapter 5 will present the three-stage model proposed for prequalification, which will attempt to eliminate any subjective judgment from the system as well as an established model which is currently being used in industry. The first stage of the new model deals with the ability of the contractor to obtain the proper amount of bonding or not. The second stage will involve a DEA

model that will rank the contractors based on productive efficiency scores. The third stage will discuss a concept known as "shortlisting", which involves selecting a predetermined number of contractors once again based on the top efficiency scores.

- Chapter 6 provides a detailed analysis of the results of both models presented and will compare the two models. The measure of comparison will be the ranking systems from each model. Some statistical work will also be done on the DEA model presented in order to ensure a good correlation among the data presented.
- Chapter 7 provides conclusions for the report as well as offers recommendations for future work to be performed in the same field.

2

2.0 CONTRACTOR PREQUALIFICATION

This chapter provides a comprehensive overview of the prequalification phase of the tendering process in the construction industry. The chapter will discuss the pertinent issues along with the benefits and shortcomings associated with the prequalification stage. Competitive bidding is also discussed along with the advantages and disadvantages of awarding any contract to the lowest bidder. A discussion on prequalification versus postqualification, surety bonding, and alternative financing is also presented. The chapter concludes with a discussion on prequalification criteria currently in use in the industry.

2.1 Contractor Prequalification

Contractor Prequalification is a process used to determine a candidate's competence or ability to meet the specific requirements for the performance of a task (Russell and Skibniewski, 1990). The process of contractor prequalification involves the analysis of quantitative and qualitative data by an individual or a group of individuals. Due to the subjective and resource intensive nature of the process, the task is usually reserved for one individual in senior management with many years of experience in the construction industry.

2.1.1 Publicly Funded Projects Versus Private Ownership

The contract award procedures used on publicly and privately funded projects are often significantly different. Privately funded projects are governed by rules established by the owner and the consultant. The private owner generally has full discretion over the tendering process and may choose to adopt, modify, or waive the public bidding system. Public owners, on the other hand, must follow strict guidelines in the award of contracts to avoid accusations of favouritism with public funds (Rankin et al., 1996). Large-scale privately funded projects more often than not will also employ some sort of prequalification process since in any given area there are not too many contractors that will have the experience or the capacity to handle such a large project. Prequalification systems for government funded projects may vary considerably from region to region or from project to project if they are used at all.

Public projects involving expenditure of taxpayers' money require that the contractor obtain appropriate surety contract bonds. There are several types of bonds that may be required for a contractor to proceed on a project. Surety bonding functions as a risk-transfer mechanism that protects labour and material suppliers on public and private projects in addition to the general public (Russell, 1994). It also protects the owner from liens. Public agencies need to be accountable for decisions that will affect the outcome of a project. Contract failure or a breach of a contract leading to litigation often brings to the forefront the importance of screening contractors from the beginning.

An inexperienced owner may make a rash decision and decide to skip the prequalification stage of the tendering process and simply select the low bidder in an attempt to cut the budget. However, such decisions may end up costing more if the low bidder proves to be incompetent and cannot or will not carry out the contract successfully. At the same token, it is not uncommon for quality and safety to be sacrificed by a contractor who suddenly realizes that their low bid will not make a profit. This situation will create tension between the contractor and the owner and will almost always lead to disputes or even litigation, which will prove more costly than having a qualified contractor. One advantage that a private owner may have over a public owner is that a private owner, even after prequalifying, does not necessarily have to select the lowest bidder.

2.1.2 *The Lowest Bid Award System*

In the Lowest Bid Award System, tenders are received from contractors and are analyzed by an owner or project manger to determine the contractor with the lowest bid. The Lowest Bid Award System is the cornerstone of the North American construction industry. It encourages competition among contractors so that they may be awarded the contract and it indirectly drives technological changes in the industry. Contractors are always looking for more efficient ways to increase productivity or to somehow gain that edge over another contractor in order to reduce costs so that they may be awarded the contract.

This system is supposed to be advantageous to an owner but such is not always the case. There are also many negative impacts associated with the Lowest Bid Award System. Gong (Gong, 1999) lists seven major factors that should concern those associated with the system, especially the owners. The seven factors cited by Gong are described next. It should be noted that these circumstances do not always occur, but occur often enough to make many owners cautious.

2.1.2.1 *Inadequate Assumptions*

The Lowest Bid Award System is intended to drive competition in the construction industry and ultimately provide an owner with the best possible value available in the market. One of the downfalls to this nodon is the assumption that all contractors bidding will have the capacity, resources, and experience to see that the contract is carried out properly. Inexperienced contractors may win the bid and may even complete the job on time and on budget. However, the quality of work or materials may not always meet specifications. Sometimes portions of the work are overlooked to allow the contractor to meet the specified budget and still make a profit. Situations like this can lead to delays or costly litigation.

2.1.2.2 *Too Many Bidders*

A large number of bidders on any contract will undoubtedly drive the competition up amongst contractors, which should be beneficial to the owner. This will generally occur on smaller scale projects since there are more small to medium sized contractors than large contractors in any given area. The downside for the owner is that it may drive away some of the better contractors, since they may not want to waste time or the effort for such a competitive contract. Some contractors may submit bids that are extremely high so they are not awarded the contract. This may be done as a polite gesture to the owner from the contractor to indicate to the owner that they are still interested in future work but may be currently overloaded. The consequence is that there may be only a few serious contractors left, some of who may be inexperienced or not qualified for the job. The contractor that will be awarded the contract in such a scenario will probably stand to make a minimal profit margin or no profit at all.

Contractors may initiate many change orders in an attempt to recover their profit. Contractors know that they have the owners at their mercy and that this is their opportunity to make a profit since the owner is not going to kick them off the site and bring in a new contractor. A lot of contractors rely on these change orders for their profit.

2.1.2.3 *Too Few Bidders*

The flip side to the problem of having too many bidders is having too few bidders. An owner will generally have a good estimate of the project cost, from a private consultant or its own team of architects and engineers. As a result of the absence of competition, an owner may receive tenders that are significantly higher than expected.

2.1.2.4 *Cost of the Tendering Process*

To maximize the likelihood of being awarded a contract, it is not uncommon for contractors to bid on almost every contract that they can. Success rates of being awarded a contract are often in the range of 10 percent or less. Contractors are seldom compensated for their efforts during the tendering process. On large-scale design-build projects such as the SkyDome in Toronto, Ontario, the three losing contractors were given an honorarium of about $750,000.00 for their efforts, which is still only a fraction of the cost of tendering. The cost of tendering is unavoidable; however one can realize the repercussions of consistently not being awarded a contract. The cost is often higher than the profit margins in the construction industry.

2.1.2.5 *Legal Aspect*

The legal aspects of the Lowest Bid Award System are more applicable to the open bidding process where any and all contractors are allowed to submit a bid. In some jurisdictions in North America, owners are legally bound to select the lowest bid. If they do not, there will be legal implications and consequences, unless there are specific clauses in the contract stating otherwise. In the case of Ron Engineering vs. the Ministry of the Environment, Ron Engineering was the lowest bidder. However they had made a $750,000.00 mistake in their bid price; they tried to revoke their tender. The case went all the way to the Supreme Court of Canada where it was ruled that they had forfeited their tender deposit once they withdrew their bid. This re-emphasizes the concept that the lowest bidder may be a mistaken bidder and not always the most appropriate choice since their bids may sometimes be low due to oversights or omissions.

2.1.2.6 *Contractor's Failure*

The Lowest Bid Award System may sometimes bring about unrealistic estimates from contractors to win the contract. Contractors may overestimate the productivity of a particular activity, which may end up costing more in the end. Labour is the most risky aspect of construction. If overzealous estimators are consistently optimistic in their anticipated productivity rates then this may lead to cost overruns on a project and to eventual contractor failure due to bankruptcy. This can result in irreversible financial damages to an owner.

2.1.2.7 *Unilateral Owner's Decision*

In the Lowest Award Bid System, the contract is awarded to the contractor with the lowest bid and not necessarily the lowest responsible bid. The owner has not assessed the contractor's experience or reviewed references from previous projects. Prequalifying contractors would reduce or eliminate incompetent, underfinanced, and inexperienced contractors from consideration. On the contractor's side, it works as a form of external auditing and recognition of the contractor's ability (Bubshait and Al-Gobali, 1996).

2.1.2.8 *Summary*

The seven factors are all contributing factors to a recognition that implementation of some sort of screening process of the contractors is needed. This is where a prequalification system can complement the Lowest Bid Award System in an open bidding process. Competitive bidding will be looked at in the next section, followed by a discussion on the prequalification system. Advantages and disadvantages from an owner's perspective as well as a contractor's perspective are also considered.

2.1.3 *Competitive Bidding*

Competitive bidding is an approach widely used to obtain and select contractors for construction projects. It is a hallmark of the free-enterprise system. Through the competitive-bidding process, private and public owners attempt to maximize competition to attain the best value for their money. Competitive bidding has been criticized for placing emphasis on award to the lowest bidder, which frequently generates disputes and litigation (Russell, 1990b). Russell (Russell, 1990b) defined the term *lowest responsible bidder* to include both bid responsiveness and bidder responsibility. This definition or criteria for selecting a contractor on any given contract makes sense theoretically, however it may still cause problems since an element of subjectivity on behalf of the owner is being introduced. This may lead to a protest of the contract award from either a contractor or a taxpayer.

2.1.3.1 *Concerns with Competitive Bidding*

Concerns and disputes often arise from the competitive bidding process whether dealing with a public owner or a private owner. Russell (Russell, 1990b) grouped these concerns into six distinct categories, which are described below. All six categories can be summarized with the term *lowest responsible bidder,* which Russell also talked about.

2.1.3.1.1 Rejection of Bidders

The owner can exercise the right to reject some or all bids for whatever reason believed appropriate. The owner's justification for rejecting some or any of the bids will always be a topic of great debate, especially in areas where they are legally bound to accept the lowest bid.

2.1.3.1.2 Mistake in Contractor's Bid

Errors made by the contractor in the preparation of the bid submittal can lead to problems when awarding the contract. This was exactly the case that occurred in Ron Engineering vs. the Ministry of the Environment. An owner cannot legally accept a tender knowing that there is an error in it, as this is one of the main clauses that constitute a legally bound contract.

2.1.3.1.3 Responsive Bid

Disagreement as to whether the bid conforms to the requirements outlined in the solicitation is often a topic of lengthy debate. An owner can disqualify a tender if he or she feels that it is does not follow the specifications that were outlined in the owner's proposal. If the tender put forth by the contractor does not meet the scope nor the schedule that is outlined, an owner can choose to not accept the contract, even though it may be lowest bid.

2.1.3.1.4 Responsible Bidder

There may be disagreement of whether the contractor has the resources and capability necessary to perform the required work. If a contractor has bid on a job that they may not be familiar with in terms of size or scope then an owner can reject the tender. For instance, if a contractor is the lowest bidder on a 20 million-dollar project, but has never completed a project worth more than one million dollars, there is a higher probability that the contractor will have major problems on such a contract. Another scenario can arise if a contractor who specializes in excavation wins a contract involving the design and construction of a bridge. There will once again be a higher probability of failure or producing sub-standard work in such a case.

2.1.3.1.5 Protest of Contract Award

The contractor or taxpayer may object to the contract award process. This can occur if others feel that a contractor has been awarded a contract unjustly, maybe because they know the owner or the owner owes them a favour. This will create tension among the contractors who were not awarded the contract especially if it is felt that the contractor may be incapable of carrying out the contract properly.

2.2 Existing Approaches

This section presents a comparison of prequalification against three other systems that have been used in the construction industry. Prequalification will be compared against postqualification as well as surety bonding and alternative financing.

2.2.1 Prequalification Versus Postqualification

Postqualification is an open bidding process whereby the qualification of the bidders is evaluated after the submission of tenders. Any contractor can use the drawings and specifications to prepare and submit a tender. All tenders are reviewed and the lowest bid is evaluated to make sure it has been prepared correctly and responsibly. The owner must have confidence in the contractor that the project can be completed on time and on budget according to the specifications and scope of the project. If there is serious doubt, then the next lowest bid will be evaluated and the same procedure repeated until the owner or the project manger feels that they are satisfied with their selection. Russell (Russell, 1994) prepared a table comparing the two contractor evaluation methods. The comparison can be seen in Table 2.1.

Table 2.1: Comparison Between Prequalification and Postqualification (Russell, 1994).

Criteria	*Prequalification*	*Postqualification*
Timing of Analysis	Early	Late
Time Available for Analysis	More	Less
Impact on Field Construction Starting Date	Low	High
Potential Impact on Contractor Reputation	Positive	Negative
Impact on Competition	Positive	Possibly Negative
Disqualification Complicated by Knowledge of Who is the Low Bidder	No	Yes
Depth of Analysis	Extensive	Extensive
Amount of Owner's Effort and Required Resources	Large	Small
Burden of Proof (Data Collection)	Owner	Contractor
Efficient use of Contractor's Resources	Yes	No
Efficient use of Owner's Resources	Yes	May or May not

Early timing of analysis means that prequalification is typically performed three weeks to three months before bids are submitted. *Late* timing means analysis is performed after contractor bids have been submitted. *More* time available means one week to several months. *Less* time available means several hours to several days. *Low* impact on the starting date of construction means that the evaluation of all bidders must be performed before the invitation to bid is issued. *High* impact on the starting date of construction means that a potential delay from evaluating each low bidder's qualification can occur, particularly when the low bidder is not qualified. *Negative* impact on a contractor's reputation means it can possibly lead to embarrassment if the low bidder is disqualified. A *positive impact on competition* means if all contractors are qualified to perform the work associated with the project, then more qualified contractors are likely to participate in the bidding process. A *negative impact on competition* means that qualified contractors might not participate if unqualified bidders are involved in the bidding process. A *yes* in the "Disqualification complicated by knowledge of who is the low bidder" column means the question of responsibility may be decided in a more favourable manner with ample time for consideration and investigation of contractor claims. *Depth of analysis* depends upon construction type, project complexity, expertise of owner's staff, and resources available. A *Large* amount of effort and required resources from the owner refer to high costs including a prequalification engineer, maintenance of prequalification records, processing of information, issuing of prequalification certificates (for public owners), and office-storage space. *Efficient use of contractor's resources* means that unqualified contractors are spared the costs of preparing a bid that may have ultimately been rejected. *Inefficient use of contractor's resources* means that disqualified contractors have expended valuable resources in preparing their bids. *Efficient use of owner's resources* means that resources expended early in the contract awarding process can contribute to successful construction execution by minimizing potential disputes and disagreements. *May or may not be* means that the ability of the project owner to ensure that the contractor has the qualification to perform the work is diminished (Russell, 1994).

In a postqualification system, contractors invest a lot of time and money in preparing a tender. If there are twenty contractors bidding on the same project, then the likelihood of being awarded the contract decreases dramatically based on probability since each would have a 5 percent chance of obtaining the contract. A prequalification system would reduce the overall cost of the tendering process as well as admit only qualified contractors to submit a bid. Although postqualification is often done, it is very difficult to turn down the lowest bid and accept a higher price because of performance doubts.

2.2.2 *Prequalification Versus Surety Bonding*

Surety bonds are different from insurance coverage. Surety companies do not expect to pay out against bonds. The bonding company simply acts as a guarantor that the project will be completed. The owner is acquiring protection from the bonding company in the event that the contractor cannot live up to the contract. If this occurs and the surety completes the contractual obligations using their own funds then the bonding company will expect the contractor to pay the money back. In essence, it is like an insurance scheme since when a contractor defaults to the owner, they usually default to the bonding company as well. Gong (Gong, 1999) identified eight different types of bonds, which are presented below.

2.2.2.1 *Bid Bond*

Bid Bond guarantees the good faith of the Principal (contractor) when bidding on a tender or contract for a specific job. If the contractor is awarded a project, the bid bond states that the contractor will enter into a contract within the specified time frame. If the contractor refuses to do so, then the surety will pay the owner the difference between the contractor's low bid and the next lowest bid.

2.2.2.2 *Consent of Surety or Agreement to Bond*

Consent of Surety or Agreement to Bond is also used when a Principal is bidding on a tender or contract. It is used as a promise or agreement that if the Principal is awarded the contract, the Surety will issue the required Bonds to the Obligee on behalf of the Principal within the time frame designated.

2.2.2.3 *Performance Bond*

Performance Bond guarantees the actual performance of the contract to the Principal, in accordance with its specified terms, conditions and specification for the price as stated by the principal. Often this will include a maintenance period after substantial completion of the job.

2.2.2.4 *Labour and Material Payment Bond*

Labour and Material Payment Bond guarantees claimants as defined in the bond wording, are paid for both labour and materials used on the contract if the Principal defaults. The claimants named are usually subcontractors and suppliers.

2.2.2.5 *Supply Bond*

Supply Bond guarantees the supply of materials or services as named in the contract by the Principal to the Obligee. As stated, this Bond is for supply only, which differs from the Performance bond.

2.2.2.6 *Maintenance Bond*

Maintenance Bond guarantees maintenance of a contract for faulty workmanship and defective materials after final acceptance of the performance of the contract between the Principal and the Obligee. The time frame is noted within the format of the Bond.

2.2.2.7 *Release of Lien Bond*

Release of Lien Bond is a financial guarantee, which is executed on behalf of the Principal and filed in the Provincial Court to guarantee that the funds are available to the claimants if the court deems the lien valid.

2.2.2.8 *Release of Holdback Bond*

Release of Holdback Bond is a financial guarantee in the amount of the holdback as specified in the contract by the Obligee. It protects the Obligee against lien claimants after the early release of holdback to the Principal.

Bonding companies rely more on quantitative financial analysis as opposed to prequalification, which relies on an individual's judgment and experience in the construction industry. An experienced decision maker is often more valuable than a bunch of numbers from a surety company. Surety companies do their research on the industry and on individual contractors, which is why owners often feel that this can take the place of a good prequalification system.

2.2.3 *Prequalification Versus Alternative Financing*

Alternative financing is defined as the substitution of cash, certificates of deposits, letters of credit, government securities or personal suretyship for corporate surety bonds (Gong, 1999). This approach is not as popular nor as common as surety or postqualification. Instead of receiving a third party guarantee of the financial stability of the contractor, the contractor is achieving the same thing on their own. By putting money up front or providing credit from a financial institution, the contractor is showing they can support the contract.

2.3 Benefits and Shortcomings to the Prequalification Process

The main benefit to the prequalification process is to ensure that the contractors that bid are qualified and have the capacity to do the work. An additional benefit is the reduction of the number of contractors that are allowed to submit a tender. The aim of the prequalification system is to eliminate all unqualified contractors as well as those that may be perceived as not capable of performing the task on time, budget, and scope. However, a prequalification system requires time to develop and research, which incurs an extra cost. Most prequalification systems, if not all, have a high degree of subjectivity, which brings about controversy and creates tension in the industry. The most common prequalification system is usually created using some form of a weighted factor system, which introduces subjectivity when trying to decide the weights and the scores. Contractors not accepted during the prequalification stage will save themselves the cost and time of preparing a tender. Russell (Russell, 1994) presented a list of benefits and shortcomings to the prequalification process from both the owner's perspective as well as the contractors'. These issues are presented in the next section.

2.3.1 *Benefits from an Owner's Perspective*

Prequalification provides an opportunity to screen contractors that do not have sufficient qualifications or experience to execute the contract to the satisfaction of the owner. Quality is a huge issue in the construction industry, and usually owners or project mangers will have some sort of quality assurance program present in the project. There is a difference between a contractor being able to complete a project and being able to complete the project to an industry standard.

An owner is able to identify contractors who are willing to submit a bid or proposal. The screening process of the prequalification system will also help to minimize the probability of large delays or contractor failure in the project. Another benefit of obtaining only the eligible bidders is that now the owner's team will have fewer tenders to evaluate, which can save a lot of time and money, allowing the field construction of the project to begin sooner than otherwise might occur. Any savings in the tendering process can be advantageous to the owner in the end.

2.3.2 *Shortcomings from an Owner's Perspective*

The cost of developing, implementing, and evaluating objective contractor prequalification criteria and evaluating contractors is an added expense to the tendering process. It may be worthwhile to note that, without the implementation of a contractor prequalification system, a contract may end up costing an owner much more in claims and litigation if an unqualified contractor is selected. The difficulty is of developing quantifiable criteria, applicable for a given project circumstance that allows accurate, sound, and consistent decisions to be made. Many systems have been developed over the years, differing from area to area and project to project.

When the number of bidders are reduced and competition is restricted, a higher project mark-up can be the consequence. As a result the owner may incur a higher project cost. There is a perception (albeit not proven) that there is an inverse relationship between the number of contractors bidding on a job and the mark-up that contractors will charge for the project.

2.3.3 *Benefits from the Contractor's Perspective*

Contractors are assured that projects will maintain a realistic relationship to sound engineering and construction practices as well as economic conditions, when an owner undertakes prequalification. This will help prevent unqualified contractors from introducing uncertainty into the bidding process. Bidders will be spared the expense of preparing the estimate or proposal and the embarrassment of disqualification in postqualification. Such a situation can give a contractor a bad name or reputation in the industry.

A contractor may not be prequalified if the owner or project manger feels that they are incapable of carrying out the project due to capacity reasons. This protects the contractor from being awarded contracts that may be too large for them to handle. The qualified contractors that are left will also benefit because there will be fewer contractors bidding on the same project, thus reducing the amount of competition.

2.3.4 *Shortcomings from the Contractor's Perspective*

The biggest shortcoming of the prequalification system may not be the theory behind it, but rather the implementation of the system. The element of subjectivity has always been a cause for concern as some contractors may feel that the potential of introducing biases into the bidding process is too high.

Some companies feel that they have an added expense in trying to improve public relations as well as the companies' image to gain subjective points in the prequalification process and secure themselves a spot in the bidding process. Unfortunately this is the reality of the prequalification process or any system that has a human element of decision making involved.

2.4 Prequalification Criteria

Prequalification criteria vary from model to model and are usually owner specific in every project. However, the most important criteria appear in most models in some form. One of the most important steps of the prequalification process is the actual data collection technique. Russell (Russell, 1994) illustrated a normalized distribution of owner-contractor prequalification data collection techniques, which is shown in Figure 2.1. Contractor questionnaires tend to dominate the data collection techniques as the preferred approach. It is also probably one of the easiest to conduct. The reviewer must assume that all the information is correct. This can be overcome by the request for references, which also seems to be standard practice.

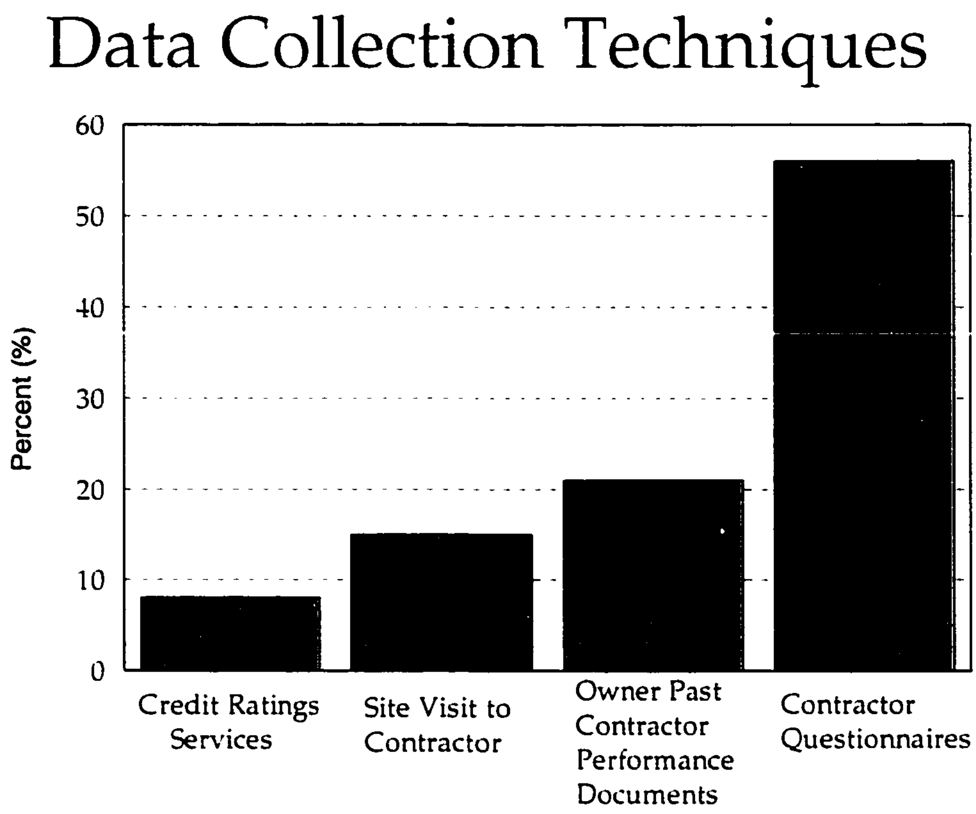


Figure 2.1: Normalized Distribution of Owner-Contractor Prequalification Data Collection Techniques (Russell, 1994).

Russell (1994) also broke down the major factors that were contained within the questionnaires since it was the most popular approach. He came up with six major factors, which also incorporate many other minor factors. A normalized distribution of factors which owners collect data can be seen in Figure 2.2. Contractor stability and experience seem to be the two most prominent factors that owners are concerned about.

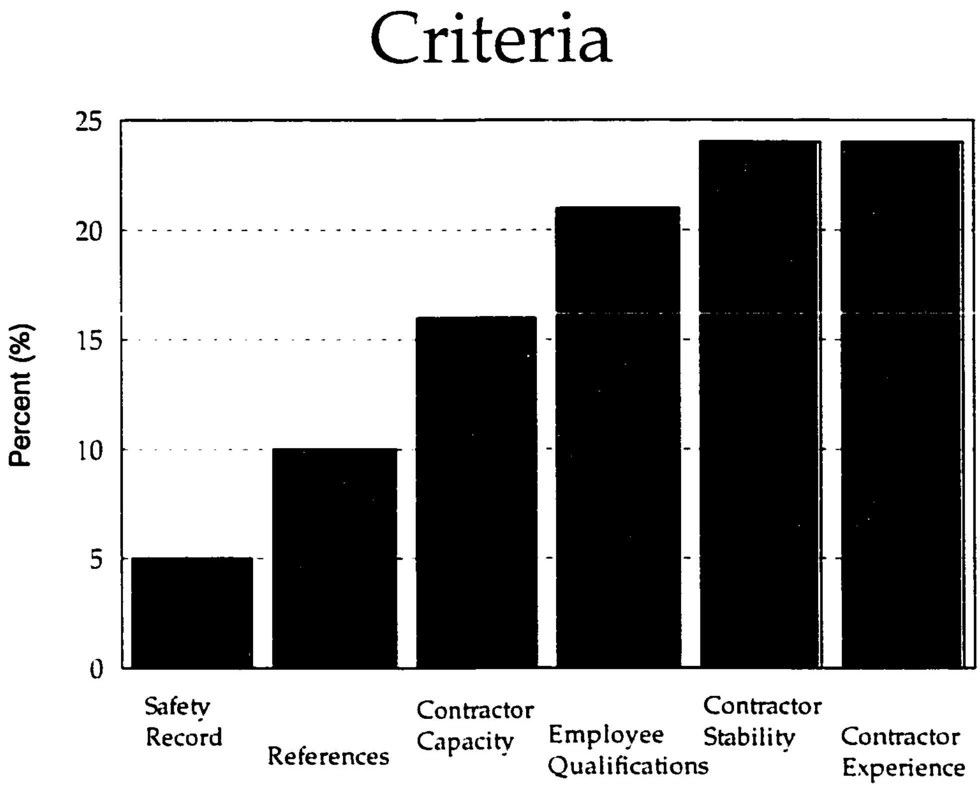


Figure 2.2: Normalized Distribution of Factors Which Owners Collect Data (Russell, 1994).

Russell broke down these factors into several more specific requirements. Gong (1999) also presented and discussed ten similar prequalification criteria in a heuristic manner. Holt et al. (1994) presented 5 major categories, which were further subdivided to produce a total of 21 specific categories. Holt's divisions will be used here to present the criteria that are often used in a prequalification questionnaire. A prequalification questionnaire called CCDC 11 from the Canadian Construction Document Committee (CCDC 1996) is shown in Appendix A.

2.4.1 *Contractor's Organization*

Elements of the contractor's organization will often show the stability of any reputable company. This category has been broken down into six specific characteristics, which are discussed next.

2.4.1.1 *Size of Organization*

There is usually a correlation between the size of a contracting organization and its resource capability (Holt et al., 1994). Size is an important parameter that should be looked at by owners, since it is important to determine whether or not a company has the resources or the capacity to complete the project to the specifications of the owner. Factors such as maximum financial capability as well as a company's average annual value of construction are measures of the size of a company. Number of employees is also an important factor, which will be looked at separately.

2.4.1.2 *Age of Organization*

Age used to be a major indication of a company's success. It was felt that if a company has survived a great number of years that they will have dealt with economic booms as well as recessions. Age was also associated with experience and a contractor's knowledge in the industry. Such is not the case in the industry any more. In today's industry, it is not uncommon for companies, such as Canadian Highways International Corporation in Southern Ontario, to be set up for specific projects. However, the employees, especially the principals, themselves may have tremendous experience in the industry. It is still important for a company to have tested the current company for a minimum period. Three years is a respectable yardstick that is often used.

2.4.1.3 *Image of Organization*

It is important to spend money on public relations to increase their company's image. Image is a subjective area, which is why companies will go great measures to ensure a healthy company image. Memberships in local and national associations will often aid in enhancing a company's image. It is a general fact that local owners will have an idea of who may be capable of doing the job correctly based on the image, reputation, and word of mouth in the industry.

2.4.1.4 *Quality Control Policy*

Implementation of a quality control policy is voluntary in many areas. A company that has adopted a quality control policy will more than likely gain favourable points with an owner. This exhibits that a company is genuinely interested in achieving consistent, industry standard quality. A company with such a policy has invested the time and money to produce and implement such a document. This can give a company a slight edge over other competitors.

2.4.1.5 *Health and Safety*

Companies with poor safety and health records are often frowned upon in the industry. No one would like to deal with a company that is renowned for causing bodily injury as well as not providing a safe environment for their employees to work in and carry out every day activities. In Ontario, an owner can be charged under the Ontario Health and Safety Act if a construction worker is killed on their site. Therefore it is prudent for an owner to be concerned about this issue.

2.4.1.6 *Litigation Tendency*

A corporate tendency for litigation is difficult to assess, since it is not always known if the contractor is the defendant or the plaintiff. It is also difficult to actually assess the truth in all claims and disputes. Perhaps a contractor worked for an owner who placed a lot of claims, it should not be held against them. In general, if there are a lot of claims submitted by a contractor and it is a repeated occurrence, it may say something about the contractor. Some contractors rely solely on claims and change orders to make a profit on a project, which may not be favourable with an owner. Cost overruns are often associated with litigation tendencies as well.

2.4.2 *Financial Considerations*

There are three specific points that may be associated with financial considerations. In general, financial stability of a company is imperative to the success of a company. A company's ability to pay its bills on time, as well as a company's reputation with their financial institution are just some of the things that must be considered when evaluating any company.

2.4.2.1 *Ratio Analysis*

Assets to liabilities and other financial ratios are factors that are considered in this section. Interest cover is the amount of interest a company has to pay on its long and short-term loans as a ratio of its pretax profits. A ratio of less than 2.0 for interest cover is a danger sign (Holt et al., 1994). This is not a very popular criterion in Canada but is implemented in Great Britain. An analysis of assets and liabilities would probably be a quick look approach to analyze a company's financial situation.

2.4.2.2 *Bank Reference*

A contractor's relationship in a financial institution is important for them to establish credit and capacity, which is essential in the construction industry. Three years with a financial institution is often used as a guideline in terms of developing a respectable reputation. A contractor who is constantly switching banks or surety companies is probably not gaining the confidence of such institutions. Banks will have detailed financial standings of a contractor and can provide a reference at any time for a contractor.

2.4.2.3 *Supplier and Manufacturer References*

Three years can be used a measuring stick in terms of a contractor's history with the suppliers and manufacturers. The suppliers are the people that provide all the necessary material for the construction industry. Unsettled accounts and outstanding balances would not be looked on as favourable from an owner's perspective. A good relationship with the suppliers can prove to be a necessity. Outstanding balances can delay the delivery of building material to future projects until accounts from past projects are closed, which can cause delay in the project.

2.4.3 *Management Resource*

The efficiency of management to assess a situation and make quick educated decisions can help a company thrive. Four key elements are looked at in this section. Management procedures as well as experience and the ability to communicate with others are all favourable attributes to have.

2.4.3.1 *Qualification of Company Owners*

Smaller companies will often have owners involved in the management and operation of the company. Larger companies will tend to have shareholders as owners who will not have an interest in day to day operations. Owners who are involved in the day to day operations of the company have a vested interest in the success in the company and will probably spend a lot more time and energy insuring the company's success.

2.4.3.2 *Qualification of Key Personnel*

Site management is viewed as being crucial to a successful project outcome, particularly the profitability of the contract (Holt et al., 1994). Technical expertise is important in management for the success of a company. Knowledge can be acquired through a formal institution or knowledge can be embedded through experience. Either method can produce similar results. It is important for management to understand the specifications of the job as well as procedures that can optimize labour activities.

2.4.3.3 *Key Personnel: Years with Company*

Experience is the single most important attribute a company can have based on its most important employees. Employees who stay many years with the same company are a benefit to a company compared to someone with the same amount of experience but spread out over a number of companies. The former will understand the company's structure and organization as well as procedures a lot better than a new employee of the company will. Experience is not something that becomes more valued as it increases. Older employees may not be as flexible in changing company policies and younger employees may just not have enough exposure to be considered self-sufficient. Somewhere in the middle of these two extremes is generally regarded as most desirable.

2.4.3.4 *Formal Training Regime*

It is important for management to adopt a formal training regime to pass on to employees. It is important to keep everyone in the company working together so that operations will run smoother in the field as well as at management levels. It can be a great benefit to mangers to encourage field and office managers to take courses and seminars to keep management tools and techniques current with the rest of the industry.

2.4.4 *Past Experience*

Past experience can determine whether a contractor will be qualified to bid or not. Most contractors will rank similarly in prequalification systems with the exception of past experience and size. Types of projects are all factors to be considered here. There are three key points that are discussed in this section to illustrate this notion.

2.4.4.1 *Type of Projects Completed*

Similar projects with respect to nature, scope, and size, are integral parts of the prequalification criteria that can determine whether a contractor is qualified for this project. Some contractors have a specialty in the field of construction such as excavation, foundations, industrial buildings, or high-rise buildings. Some contractors will only use a specified contractual method as construction such as design build, which may not be desirable for the particular owner on that project.

2.4.4.2 *Size of Projects Completed*

This particular category can be associated with the capacity of a contractor to be able to handle the size of the project. It may also mean a contractor's ability to handle the smaller scale projects and not just the larger ones to fit the needs of the project being looked at. It demonstrates a contractor's experience and ability to allocate and spread its resources in an effective manner.

2.4.4.3 *National or Local Experience*

A contractor should be familiar with the local by-laws as well as any national legislation that may affect the specifications of a project. Some owners may also want a particular contractor to employ local labour as part of the contract. A contractor who is not familiar with area trades may find it difficult to deal with local issues. Contractors who are flexible and willing to adapt will prove to be a great asset to the owner.

2.4.5 *Past Performance*

Past performance is also another indication of a contractor's capability. References from previous jobs can prove to be the single most important parameter in this category. There are four specific points that will be looked at here to evaluate this criterion.

2.4.5.1 *Failure to have Completed a Contract*

Contracts can end prematurely without default by either party. This is known as frustration in legal terms (Marston, 1996) and can occur if a contractor was building an extension on a school and the school burned down for some unforeseen reason. This is not anyone's fault. Ideally it would be important to know that a contractor has fulfilled all of his or her obligations in completing the contract as specified and agreed upon. Frequent incomplete contracts by a contractor would not be looked on favourably by an owner.

2.4.5.2 *Schedule Overruns*

Sometimes factors such as weather or unforeseen ground conditions can cause schedule overruns, which are not the fault of the contractor. A contractor can provide all the information on schedule overruns and the person conducting the prequalification can evaluate the reasons for their validity and circumstances.

2.4.5.3 *Cost Overruns*

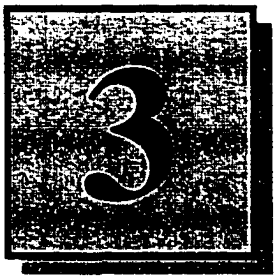
Cost overruns can often be associated with schedule overruns, since it can be said that time is money in the construction industry. Once again, reasons for cost overruns should be provided and evaluated by an experienced individual in the industry. No contractor is in business to lose money. so it can be safe to assume that a contractor who is consistently losing money on contracts may be doing something wrong in the office or the field.

2.4.5.4 *Quality of Work*

Quality of work can be determined from references from owners provided by the contractor. Generally speaking, if a previous client is satisfied with the work that they received from the contractor, he or she will probably be willing to provide a good reference. Inspecting completed projects can also show actual quality achieved. This is a cumbersome process, and most prequalification systems will probably rely on references.

2.5 Summary

All the criteria just described in Section 2.4 came from a prequalification system developed by Holt et al. (1994). The prequalification system can be seen in Appendix B of this report. This system was used to present the different criteria, which may be in the prequalification system. As stated earlier, most systems will involve some version of these criteria. The only other major issue that may be missing from these criteria for a North American system would be the issue of bonding. The surety industry is highly regarded in North America, as some owners will simply use this criterion as a sole means of prequalifying contractors. Chapter Three will present a number of prequalification models. These models have been found in the literature and may or may not have been implemented in industry.



3.0 CONTRACTOR PREQUALIFICATION MODELS

This chapter presents a review of contractor prequalification models found in the literature and/or in industrial practice. The models ranged from weighted systems to neural networks. Benefits as well as shortcomings of the models are discussed. The last two models will provide a prelude to DEA since they are more concerned with efficiency.

3.1 Dimensional Weighting Procedure - Qualifier-1

Russell and Skibniewski (1990) developed a model, which incorporates a dimensional weighting procedure. The model parameters are based on the factor analysis results, which were obtained from a questionnaire. Two terms are essential in the model: composite decision factor (CDF) and decision factor (DF). A CDF represents a single underlying construct made of interrelated DF. A DF can be defined as a criterion that could be used to evaluate candidate contractors. The linear prequalification model is formalized by Equation 3.1:

$$AR_k = \sum_{i=1}^{n} W_i \left[\sum_{j=1}^{m_i} (w_{ij})(R_{ijk}) \right] \tag{3.1}$$

where AR_k is the aggregate weighted rating of candidate contractor k;

n is the number of composite decision factors (CDF);

W_i is the weight of the CDF i, described on a scale from 0.0 to 1.0 for i = 1, 2, 3, to n;

m_i is the number of DF describing the CDF i;

w_{ij} is the weight of the decision factor (DF) j, describing the CDF i on a scale from 0.0 - 1.0, where the summation of w_{ij} = 1.0 for j = 1, 2, 3, to m_i and for i = 1, 2, ..., n;

and R_{jk} is the rating of the DF j describing the CDF i on a scale from 1.0 - 10.0 (1.0 is unsatisfactory, 10.0 is excellent) for candidate contractor k.

The weights of the CDFs for public owners and private owners or construction mangers are shown in Tables 3.1 and 3.2. They were determined from the data obtained from the questionnaires.

Table 3.1: Weights of CDFs for Public Owners (Russell, 1990).

Weights of CDFs for Public Owners		
CDF Name	CDF Index	Weight (W_i)
Financial Capability	1	0.21
Performance	2	0.16
Type of Contractor	3	0.16
Third-Party Evaluation	4	0.15
Capacity for Assuming New Projects	5	0.14
Percentage of Work Performed	6	0.13
Location	7	0.05

Table 3.2: Weights of CDFs for Private Owners (Russell, 1990).

Weights of CDFs for Private Owners / Construction Managers		
CDF Name	CDF Index	Weight (W_i)
Financial and Experience	1	0.14
Failed Performance	2	0.13
Performance	3	0.13
Capacity for Assuming New Projects	4	0.12
Management	5	0.11
Bonding	6	0.11
Location	7	0.09
Resources	8	0.09
Safety	9	0.08

The higher the rating the contractor obtains, the higher the chance of qualifying for the bidding process. The weights were developed using linear programming, and represent an average. It is the intentions of the authors that the program will reduce the effort required to perform this analysis and the subjectivity involved in the decision making process.

Russell and Skibniewski state a few shortcomings of this model. First, the model is dependent upon the user's ability to process the contractor data. Second, a low score in one section can be offset with a high score in another section. Third, the Qualifier - 1 model suffers from an inability to adequately represent the risk profile of the decision maker and the uncertainty associated with the data collected on candidate contractors (Russell and Skibniewski, 1990). Finally, the model has combined criteria with dissimilar units of measure, which is not favourable since it is a difficult task for the individual performing the analysis. Due to these shortcomings in this preliminary research, the authors improved the model to compensate for these drawbacks.

3.2 Hierarchical Dimensional Weighting of Decision Factors - Qualifier-2

Qualifier-2 attempts to answer the shortcomings of Qualifier-1 (Russell et al., 1990b). The program consists of three primary decision points:

1. **Initial prequalification decision** - an evaluation of the candidate's references, reputation, and failed contract history.

2. **Second prequalification System** - comparison of the candidate's ability to perform relative to the subject project requirements.
3. **Decision based on the CDF for financial stability** - to evaluate the financial condition and longevity of the candidate contractor (Russell, 1990b).

The model is based on decisions that are formulated in a linear fashion, each one dependent on the other, hence the term decision hierarchy. Contractors must meet the decision criteria to proceed to the next step of the model. Another important change in this model is the ability of the owner or the project manager to assign the weights of the CDFs and DFs. These can change from project to project and will be a reflection of the importance on criteria for that project.

Like Qulaifier-1, Qualifier-2 also calculates an aggregate score for the contractors and ranks the contractors based on this score. The major improvement on Qualifier-1 was the addition of a knowledge-based expert system, which has made this system a success after trials were run in industry.

A stochastic decision model has also been developed by randomizing the variable AR, instead of making it a fixed number (Russell et al., 1990a). A normal distribution is then used to describe the AR.

3.3 Fuzzy Set Prequalification Model

Even with the success of Qualifier-1 and Qualifier-2, there is still the element of not being able to include uncertainties. Fuzzy set theory was applied to address such uncertainty and enhance the contractor evaluation process (Elton et al., 1994). Prequalification systems often involve two types of uncertainty. The first may be seen in the form of descriptive references or qualitative criteria from contractors. The second can be seen as the uncertainty of the data provided by the contractor. For instance, a contractor who had a cost overrun on a previous project may have a different reason for this than the one that may be presented by the owner of that particular project. There is also a degree of uncertainty associated with the decision-makers involved in such a system. The use of fuzzy sets seems like a logical choice for contractor prequalification systems since they can handle ambiguous qualitative information, which dominates the prequalification process.

The fuzzy number ~7 (read as "about 7") can be said to be an average of a range of numbers. It can be called the most likely number in the range or the number that a majority of people would assign to the issue.

A bounded bell-shaped function, referred to as a π-curve, was used in Elton et al.'s (1994) analysis since it was felt that this best represented the industry. This was combined with Monte Carlo Simulation to establish the prequalification model. The weights were all given relative values as demonstrated earlier, while assuring that their total came to unity. The fuzzy set was established and the procedure was repeated many times through Monte Carlo Simulation. A utility model for comparing fuzzy numbers was developed by Juang et al. (1987) and was therefore used in this prequalification process. Equation 3.2 represents the model:

$$CPRI = \frac{(A_L - A_R + 1)}{2} \tag{3.2}$$

where CPRI is a non-fuzzy utility, entitled the Contractor Prequalification Ranking Index, A_L is the area bounded by the universe and to the left of the membership function of the resulting fuzzy set and A_R is the area bounded by the universe to the right of the membership function. The results produce CPRI that range from 0 to 1, where a higher score indicates an increased desire to prequalify the contractor.

In theory, fuzzy logic makes tremendous sense and would seem to be the logical choice for any prequalification system. It resembles the human decision making process since it includes a certain degree of uncertainty and distributes the weights accordingly. It provides a consistent methodology, which aids the prequalification process. The major drawback to this model is the number of parameters as well as a mathematical background needed to run the analysis. It may be too technical for some and as a result has not gained widespread acceptance in the industry.

3.4 Cluster Analysis

The principal task of cluster analysis is to reduce an original set of data into a series of smaller classes. By analyzing these sub-sets, one can establish contractor sets with similar attributes. The best sub-set established will then be given an invitation to tender (Holt, 1996). The method considers contractor attribute scores for the entire original set and uses an algorithm to group them. The output of the analysis is a tree diagram (a dendogram), this being a graphical "structure" showing contractors that are similar to each other in the hierarchical tree as distinct branches. Hence one is able to detect the distinct clusters (branches) being sought and interpret them. The most straightforward way of establishing degree of difference (distance) between contractors is to compute Euclidean distances via Equation 3.3:

$$D_{ij} = \sqrt{\left\{ \sum_{k=1}^{p} \left(x_{ik} - x_{jk} \right)^2 \right\}} \qquad (3.3)$$

where D_{ij} is the distance between two points i and j; x_{jk} is the value of the kth variable for the jth entity, and p is the number of variables (attributes) considered (Holt, 1996). Cluster Analysis can handle a large number of data points and groups similar sub-sets together, which seems like a good idea for a prequalification system. This graphical approach will allow for an easy interpretation of the results.

3.5 Hypertext Decision Support Prequalification Model

AbouRizk and Chehayeb (1995) developed this model primarily to help decision makers in the weight assigning process for the different criteria. Using multiattribute decision making method (MADM) decision-makers will find it easier to compare two factors with respect to each other in terms of importance rather than give an importance weight to a larger number of factors. This will eliminate biases and present a more structured approach for determining the relative weights of importance (AbouRizk and Chehayeb, 1995). All the previous models discussed in this section as well as many others involve the decision maker to assign the weight values to the different criteria used in the process. This model allows one to assign weights based on the adjacent factor.

The comparison of criteria is achieved in a square matrix n x n. Factor i would be compared to factor j, its adjacent factor, and subsequently a value is assigned that reflects the importance of one to the other. After developing the matrix, the weight of each factor is computed against all the other factors in the system using eigenvectors. The aggregate weight of a contractor is developed from the initial n x n matrix and the importance of the individual factors in the whole system. The total score of an interested contractor is calculated as a percentage of all the possible factors. This allows for easy comparison of one contractor to another.

Computer software was also developed to ease the calculations involved in this process. The software can convert existing text into hypertext, therefore making it user friendly. The software also has the ability to store, retrieve, analyze, as well as categorize all the prequalification contracts from a database.

This system also provides a structured system to prequalification and does indeed reduce the amount of bias present in the system; however, there is still a certain degree of bias that can be associated with the weight assignments when comparing one factor to another.

3.6 Contractor Prequalification Process (CPP)

Contractor Prequalification Process (CPP) is a user-friendly personal computer program that was created by Gong (1999) at the University of Toronto. It is a three-stage model that applies the hierarchical framework discussed in Qualifier-2 and uses fuzzy logic as its basis for its mathematical calculations. This program makes it easy to enter information as well as store it in a database to use for future reference. One shortcoming of the program is the use of an external equation solver to calculate eigenvectors and eigenvalues. The software will otherwise perform all necessary steps needed after the information is inputted. The software was tested with a large degree of success against a manual method of prequalifying contractors.

3.7 Neural Network Prequalification Model

Hanna et al. (1997) created a neural network prequalification model and prototype software. Neural networks are systems that have a learning ability, which is why they are often termed artificial intelligence. They can learn from historical data and will hone their knowledge with the input of more data, a process referred to as training or learning.

The biggest disadvantage to neural networks is that a large historical database is required. Due to the reluctance of many contractors to give up data, it is often difficult to obtain enough quality data to train a system. If the data were stored in a database from particular projects and then used again in the future, there may be a larger degree of success for this type of model.

3.8 Ratio Analysis

Simple ratios have historically been used to perform efficiency measurements, especially when comparing identical inputs and outputs to one another. It is easy to say that one machine producing 30 units an hour is half as efficient as a machine that is producing 60 units an hour; however, other relevant factors are overlooked such as capital costs and maintenance costs. If the efficiency were measured as units produced per dollar of maintenance of capital investment, the other machine may appear more efficient, but again other important factors such as time will be left out of the analysis. The obvious solution to this problem is to amass many ratios for the problem. However, this will result in some machines proving more efficient than other machines depending on different ratios and scenarios. This ambiguity makes ratio analysis ineffective in efficiency evaluations (Sexton, 1986).

Another problem that may not be accounted for in the ratio analysis is the fact that comparing costs from different geographical areas is very unfair and will skew the analysis. This shortcoming, unlike the previous one, can be compensated for by making certain adjustments such as including multipliers or weights.

3.9 Multiple Regression

Multiple regression analysis to model the output level of a particular problem as a function of various inputs addresses the shortcoming of ratio analyses by allowing several input variables to be included in the model. Such an analysis produces an estimated relationship that can be used to compute the predicted output level of a particular unit, given its input levels (Sexton, 1986). Any data that lies above the relationship that has been established will be deemed relatively efficient, since it is producing more output than the model predicts given the particular set of inputs. Following the same logic it can be said that any data below the established relationship will be deemed relatively inefficient since it is producing less output than the input levels lead us to believe. In this analysis, the efficiency of a problem can easily be tied to the residuals of a particular dilemma (Sexton, 1986).

As with ratio analysis, multiple regression analysis has its problems. Although there are multiple inputs, the analysis can only handle one output. This drawback is a major reason for the creation of DEA, since it can handle multiple outputs and inputs. Another major issue with multiple regression analysis is that it measures efficiency relative to average performance rather than the best performance. Hence it provides little direct information concerning the magnitude of efficiency gains that are possible at various production units within the sample. Thirdly, and finally, regression analysis requires the parametric specification of a production function, that is, an equation detailing how inputs are combined to produce outputs. Due to the specification of this technique, an important source of error is introduced into the analysis, which weakens the model. As a result, multiple regression analysis is often inadequate for the analysis of efficiency (Sexton, 1986).

Due to the shortcomings of the previous mentioned tools for analyzing efficiency, researchers developed a new tool known as DEA to handle the problem.

3.10 Summary

This chapter presented a look at nine models found in literature concerning prequalification. Most of the models are trying to achieve the same goal in providing an unbiased system to the industry.

There are common elements in all models, such as the evaluation criteria and need for accurate data as well as the need to establish weights for the different criteria being used. The idea of such systems is to reduce the bias that is present, as well as to minimize the amount of subjectivity that can be injected into a system from a decision-maker.

The next chapter will introduce the basic concepts associated with Data Envelopment Analysis (DEA) and will provide some background information on how the concept has been developed.

4

4.0 BACKGROUND ON DATA ENVELOPMENT ANALYSIS (DEA)

This chapter will cover the basic concepts of Data Envelopment Analysis (DEA). A brief history of DEA will be presented, followed by a description of the overall concept of DEA. More detail will then be explored, as a few existing models will be presented along with a technical discussion on each one. Input-oriented and output-oriented models will be explained along with the different possible types of envelopment surfaces that are currently being used. Translation of data is also briefly discussed.

4.1 What DEA Is

DEA stands for Data Envelopment Analysis. It is a non-parametric linear programming tool or technique, which creates virtual weights to calculate the efficiency of a particular process or operation to convert inputs to outputs. DEA optimizes on each observation with the objective of calculating a discrete piecewise frontier determined by the data. In a parametric analysis, the single optimized regression equation is assumed to apply to each data point (Charnes et al., 1994).

DEA does not introduce any bias into the system, which is the primary focus of this study. DEA has not yet been applied in the construction industry to the knowledge of the author; however, it is being investigated for this purpose at the University of Toronto. It is felt that with proper modeling and testing that DEA prequalification can become an industry standard. DEA relies heavily on the accuracy of its data, which seems like a simple concept. However, it is often difficult to collect all the data from contractors. This is a simple issue that could cause a problem in any prequalification system. Since DEA is a complex ratio analysis, dividing by zero is not an option, which makes it difficult to enter values for contractors whose information is not complete. If the criteria were subjective, then the individual can make assessments of the contractor based on his or her prior experiences with the contractor. The idea behind DEA would require a thorough job by contractors in preparing their documents as well as the omission of those that are not willing to provide all the data needed for the analysis. DEA may not be the answer to all the problems associated with prequalification but it may be a step in the right direction to eliminating subjectivity in the process. The absence of such a system in the construction industry provides an ideal research opportunity to explore the possibilities of eliminating subjectivity as well as introducing the construction world to a wonderful data analysis tool known as Data Envelopment Analysis.

4.2 History of DEA

A paper written by Farrell (Farrell, 1957) has often been credited with laying the foundation for DEA. Farrell established a model that was able to measure the technical efficiency of a single input/output. Although a significant breakthrough in terms of measuring technical efficiency, the model was not without limitations. Most situations in life that require analysis or some sort of comparison between data involve more than one input and output. In order to handle this shortcoming, Charnes, Cooper, and Rhodes (Charnes et al., 1978) generalized Farrell's model to allow it to handle the analysis of multiple inputs and outputs. The model was named the CCR model after the initials of its authors and quickly became known as the first model developed and the first paper written on the subject of DEA.

One of the major advantages of DEA is that it focuses on the individual observations as represented by the "n" optimizations (one for each observation) required in DEA analysis. This is in contrast to the focus on the averages and estimation of parameters that are associated with single-optimization statistical approaches (Charnes et al., 1994).

Since the inception of the CCR model, many models have followed and many articles have been written. Such rapid growth and widespread (and almost immediate) acceptance of the methodology of DEA is testimony to its strength and applicability (Seiford and Thrall, 1990). Since the CCR, the most significant model established has been the BCC model (Banker et al., 1984), named after its authors Banker, Charnes, and Cooper. This model was developed in 1984 and it introduces a new separate variable which makes it possible to determine whether operations were conducted in regions of increasing, constant or decreasing returns to scale (in multiple input and multiple output situations).

Along with the BCC model there have been two other notable models that have been established. They are the Additive Models and the Multiplicative Models. The CCR and BCC models will be discussed in detail while the Additive and Multiplicative models will be mentioned briefly. An explanation of all technical and relevant terms involving DEA will also be presented.

4.3 Terminology and Acronyms in DEA

There are many acronyms and related terminology encountered in the study of DEA that need to be clearly defined. The aim of this section is to relieve the reader of any ambiguity that may exist with any terms mentioned.

DMU. A DMU is a decision-making unit. This is the unit variable that is being analyzed. The inputs and outputs of each unit are determined to create a working model. In this report, the contractors will become the DMU's. Many tenders will be looked at but the DMU will always be the contractors that are bidding on the job. The inputs and outputs will come from the contractors and these will be used to set up the necessary models.

Efficiency. The efficiency of a production unit is a comparison between observed and optimal values of its output and input. The comparison can take the form of the ratio of observed to maximum potential output obtainable from the given input, or the ratio of minimum potential to observed input required to produce the given output, or some combination of the two (Lovell, 1993).

Productivity. The productivity of a production unit is the ratio of its output to its input. Productivity varies due to differences in production technology, differences in the efficiency of the production process, and differences in the environment in which production occurs (Lovell, 1993).

Technical Efficiency. Technical efficiency can be defined as a contractor's ability to maximize their outputs from the given set of inputs or to use minimal inputs for an allotted amount of outputs. This, of course, can be generalized to any DMU, but for the purpose of this report, it will be defined in a contractor context. Weiss defines a firm (or DMU) as technically inefficient if it uses excessive inputs or produces too little outputs with the inputs used. Technical efficiency can further be decomposed into pure technical efficiency and scale efficiency. A firm is scale efficient if inputs and outputs are not allocated in proportion to the correct input and output ratios (Weiss, 1991).

Envelopment Surfaces. The initial task of DEA is to determine which of the set of DMUs, as represented by observed data, form an empirical production function or envelopment surface. Each of the various models for data envelopment analysis (DEA) seeks to determine which of the n decision-making units determine an envelopment surface. This envelopment surface is referred to as the empirical production function or the efficient frontier (Ali and Seiford, 199).

4.4 DEA Theory and Methodology

The concepts and models that will be presented throughout this section are taken from Charnes et al., 1994. This section will also present the guiding principles in each of the BCC and CCR models.

4.4.1 *Theoretical and Empirical Production Frontier*

The production function determines the relationship between the consumption of resources (inputs) and the production of outputs within a DMU. It forms a boundary for the maximum or ultimate production possibility set, also referred to as the *production* or *theoretical frontier* as shown in Figure 4.1 (Vela, 2000). Assuming that this theoretical frontier is known or can be established, then it is possible to measure the efficiency of a production unit. More often than not, these theoretical relationships are not well defined or readily available and as a result observational data become heavily relied upon. These observational data can then be transformed into an empirical frontier or envelopment surface to estimate the efficiency of a DMU. Figure 4.1 illustrates this concept in the two dimensional case. DEA can handle more than two dimensions, but graphical representation becomes difficult.

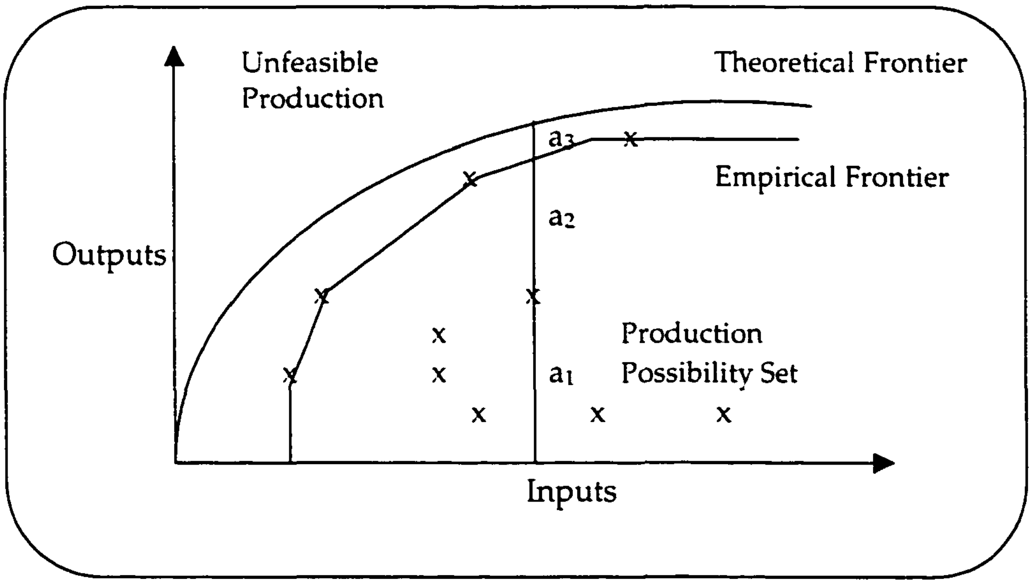


Figure 4.1: Theoretical and Empirical Production Frontiers.

One can define absolute efficiency as the distance from the production unit to the theoretical frontier shown in Figure 4.1 as $a_1/(a_1+a_2+a_3)$. Relative efficiency can be defined as the distance from the production unit to the empirical frontier as shown in Figure 4.1 as $a_1/(a_1+a_2)$. Any production unit on the empirical frontier is considered 100 % relative efficient. In a multiple dimensional analysis DEA becomes a performance ratio of weighted outputs to weighted inputs. The idea of the empirical frontier ensures that all observed units will have an efficiency either equal to or less than one.

4.4.2 Components of Efficiency Evaluation

Two essential components comprise efficiency evaluation in Data Envelopment Analysis. These components provide a framework for classifying the various DEA models with respect to (i) the form of envelopment surface, and (ii) the orientation or projection path of inefficient units to the envelopment surface (Vela, 2000).

There are two envelopment surfaces upon which three of the four major DEA models are based. They are known as *constant returns-to-scale* (CRS) and *variable returns-to-scale* (VRS) surfaces. The CCR model employs a CRS envelopment surface, which assumes that an increase in inputs results in a proportionate increase in the output levels. The BCC model and the Additive model produce a VRS envelopment surface, which assumes that an increase in inputs will result in either an increase or decrease in outputs not necessarily proportional to the increase in inputs. Therefore, these two models can be said to relax the constant returns-to-scale assumption. Figure 4.2 below illustrates the two envelopment surfaces. Once again this example is restricted to the two-dimensional case or the single input-single output model, however, the concepts can be applied to a multidimensional case.

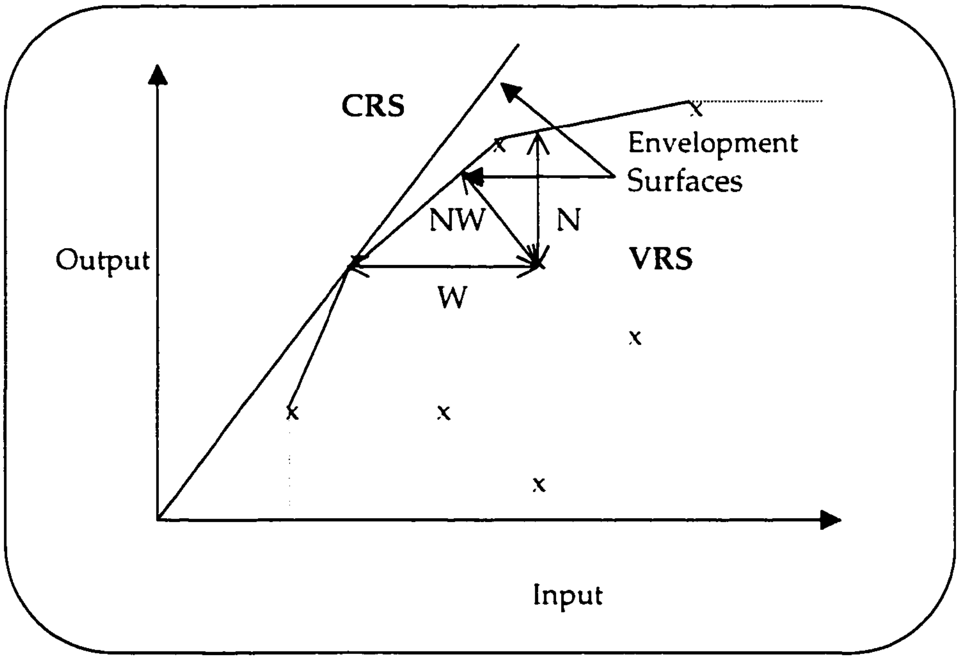


Figure 4.2: DEA Envelopment Surfaces.

Two movements that can be found in either the CCR model or the BCC model are described as being *input-oriented* or *output-oriented*. The other movement is simply a combination of these two movements and can be observed in the Additive model. Input-oriented models strive to maximize the proportional decrease in input variables while at the same time remaining in the envelopment surface. In other words, input-oriented models are trying to achieve a "westerly" movement towards the envelopment surface in order to become efficient. By contrast, the output-oriented model is trying to maximize the proportional increase in the output variables while once again remaining in the envelopment surface. Once again this model is trying to achieve a "northerly" movement towards the envelopment surface in order to become efficient. Lastly, the additive model is a combination of the input-oriented and the output-oriented models. It simultaneously performs a reduction in the inputs and an increase in the outputs all in the direction of the envelopment surface. The Additive model selects the point on the envelopment surface that maximizes the distance in the "northwesterly" direction (Charnes et al., 1994). However, the Additive model is only restricted to the Variable returns-to-scale (VRS) case, whereas the input-oriented and the output-oriented are not. A graphical representation of the three projection movements can be seen in Figure 4.3. Since the additive model can only support a VRS envelopment surface, the illustration on the next page utilizes a VRS envelopment surface.

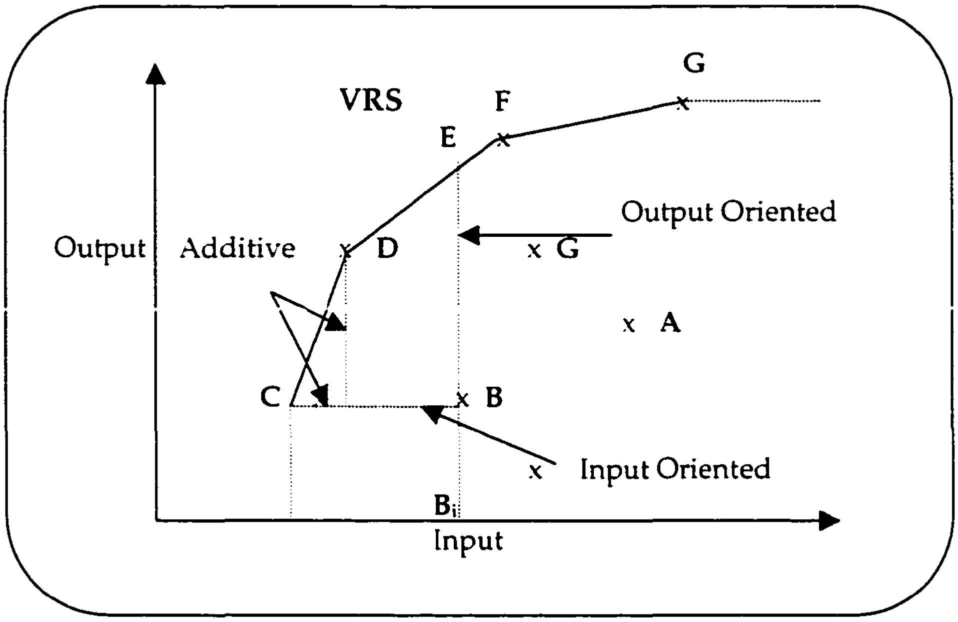


Figure 4.3: Projection Paths to a VRS Envelopment Surface.

4.4.3 *Scale and Translation Invariance*

The basic DEA models exhibit the properties of scale and translation invariance, both of which influence the manipulation of input and output values for DEA analysis (Ali and Seiford, 1990). Since only the relative scores of all the DMUs are measured, scaling all the variables proportionally will not affect the efficiency rating of any particular DMU. This is what is known as *scale invariance.* When dealing with input-oriented or output-oriented models, a translation of the inputs or the output by any coefficient should not have any affect on the efficiency ratings of any particular DMU. This is often referred to as *translation invariance.* The CCR model is only scale invariant while the BCC model is both scale and translation invariant.

4.5 Mathematical Formulation, Notation, and Models

This next section will deal with the different types of models and their mathematical formulation.

4.5.1 *The BCC Model*

The BCC model was created in 1984 and is a slight variation of the CCR model. Like the CCR model the BCC model can either be used as an input oriented or an output oriented model.

4.5.1.1 *Input Oriented BCC Model*

The dual linear programs for the BCC model with an input orientation are given below.

$$\begin{aligned} \min_{\theta,\lambda,s^+,s^-} \quad & z_0 = \theta - \varepsilon \cdot \vec{1} s^+ - \varepsilon \cdot \vec{1} s^- \\ s.t. \quad & Y\lambda - s^+ = Y_0 \\ & \theta X_0 - X\lambda - s^- = 0 \\ & \vec{1}\lambda \geq 1 \\ & \lambda, s^+, s^- \geq 0 \end{aligned} \tag{4.1}$$

The above equation is said to be in its *primal form* or as it is more commonly known its *envelopment form*. The (scalar) variable θ is the (proportional) reduction applied to all inputs of DMU_0 (the DMU being evaluated) to improve efficiency. This reduction is applied simultaneously to all inputs and results in a radial movement towards the envelopment surface. The variable ε is a non-

Archimedean (infinitesimal) constant whose presence in this primal objective function effectively allows the minimization over θ to pre-empt the optimization involving the slacks, which are the variables s^+ and s^- in Equation 4.1. These two slack variables are associated with the outputs and the inputs respectively. As a result, the optimization process can be viewed as a two-stage process that begins with the maximal reduction of the inputs. The second stage involves the movement onto the efficient frontier, which is achieved by the slack variables. The vector λ identifies the reference set of efficient DMUs, where all units are compared and contrasted.

It is also possible to formulate and solve the same problem in linear programming via a *dual problem*. The solution to the dual problem will provide the same information as the primal model. The dual model, which is more commonly known as the *multiplier form*, is constructed by assigning a dual variable, as the name implies, to each constraint in the envelopment form and constructing a new model on these variables. The multiplier form of the input-oriented BCC model is presented in Equation 4.2.

$$\max_{\mu,\nu} \quad w_0 = \mu^T Y_0 + u_0 \tag{4.2}$$

$$\begin{aligned} s.t. \quad & \nu^T X_0 = 1 \\ & \mu^T Y - \nu^T X + u^0 \vec{1} \le 0 \\ & -\mu^T \le -\varepsilon \cdot \vec{1} \\ & -\nu^T \le -\varepsilon \cdot \vec{1} \\ & u_0 \; free \end{aligned}$$

The dual problem yields an alternative geometric interpretation. In this problem one is searching for the closest supporting hyperplane, i.e., $\mu Y_0 + u_0 = w_0$ with maximal w_0. μ and ν are the sets of input and output weights or *multipliers*, respectively, that will produce the normal vector to the supporting hyperplane. The variable u_0 is an indicator of scale economies, where $u_0 > 0$ identifies decreasing returns-to-scale, $u_0 < 0$ identifies increasing returns-to-scale, and $u_0 = 0$ would indicate a constant returns-to-scale which is more characteristic of the CCR model.

For a DMU to be deemed technically efficient, the optimal values of both the primal and dual objective must satisfy the condition $w_0 = z_0 = 1$. $\theta = 1$ is necessary, however not sufficient, for a DMU to be technically efficient. The slacks s^+ and s^-, must be zero, i.e., $\theta = 1$, $X\lambda = x_0$, $Y\lambda = y_0$. The linear program is repeated for each DMU in the sample to identify two subsets of units: DMUs, which are technically efficient and form the VRS envelopment surface and those which are deemed inefficient and enveloped by the previously determined surface. The radial projection of the inefficient point onto the frontier is estimated as (θ x_0, y_0).

DMUs 1 through 4 have established the VRS envelopment surface in Figure 4.4 and are therefore deemed technically efficient. DMU 7 is obviously inefficient with θ (efficiency) < 1 and output slacks of 0. To make this unit efficient, it requires both a proportional decrease in input and an increase in output which is equivalent to the slacks S_I and S_o shown in Figure 4.4. DMU 5 and DMU 6 are also inefficient and require a proportional decrease in their inputs to become efficient. This time no increase in outputs is required since there are no slacks associated with those DMUs.

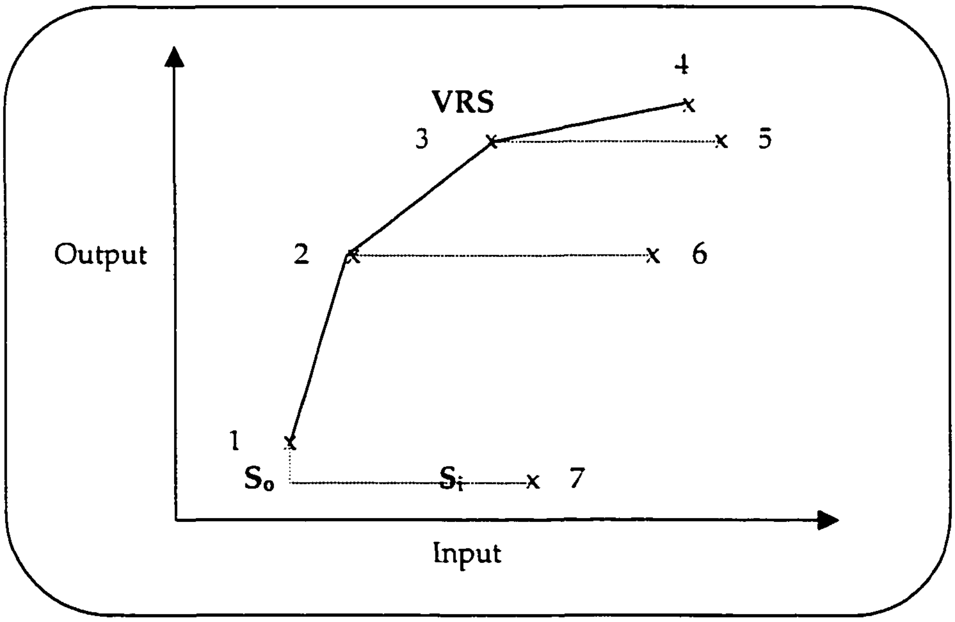


Figure 4.4: Envelopment surface for the BCC Input-Oriented Model.

4.5.1.2 *Output Oriented BCC Model*

Input oriented models focus on the reduction of the input of a DMU while holding the output constant until it reaches the envelopment surface. An output-oriented model attempts the converse by focusing to increase the output of a DMU without affecting the input to make the unit efficient. The envelopment form of the linear program of the BCC output oriented model is as follows:

$$
\begin{aligned}
\max_{\phi,\lambda,s^+,s^-} \quad & z_0 = \phi + \varepsilon \cdot \vec{1} s^+ + \varepsilon \cdot \vec{1} s^- \\
s.t. \quad & \phi Y_0 - Y\lambda - s^+ = 0 \\
& X\lambda + s^- = X_0 \\
& \vec{1}\lambda = 1 \\
& \lambda, s^+, s^- \geq 0
\end{aligned}
\tag{4.3}
$$

The multiplier form or the dual problem of the above linear program in equation 4.3 can be seen in Equation 4.4:

$$
\begin{aligned}
\min_{\mu,\nu,\nu_0} \quad & q_0 = \nu^T X_0 + \nu_0 \\
s.t. \quad & \mu^T Y_0 = 1 \\
& -\mu^T Y + \nu^T X + \nu_0 \vec{1} \geq 0 \\
& \mu^T \geq \varepsilon \cdot \vec{1} \\
& \nu^T \geq \varepsilon \cdot \vec{1} \\
& \nu_0 \; free
\end{aligned}
\tag{4.4}
$$

The biggest difference between the input oriented BCC and the output oriented BCC is that the linear program now maximizes on ϕ to achieve a proportional output increase. The output oriented model (Equation 4.4) attempts via ϕ to achieve as much expansion of Y_0 as the constraints will allow. In the dual problem the objective is to find a supporting hyperplane (i.e., a hyperplane that lies on or above all the DMUs) that minimizes the vertical distance from the hyperplane to the DMU being analyzed. A two-dimensional graphical representation of the BCC output oriented model can be seen in figure 4.5. DMU 1 through DMU 4 lie on the envelopment surface and are therefore considered to be technically efficient. DMU 5 and DMU 6 are inefficient but have no slacks which means that only an increase in outputs will project them onto the envelopment surface and make them efficient. DMU 7 is inefficient with $\phi > 1$ and an input slack. Consequently, it will require a proportional augmentation in output followed by a reduction in input by an amount that is equivalent to the input slack to become efficient.

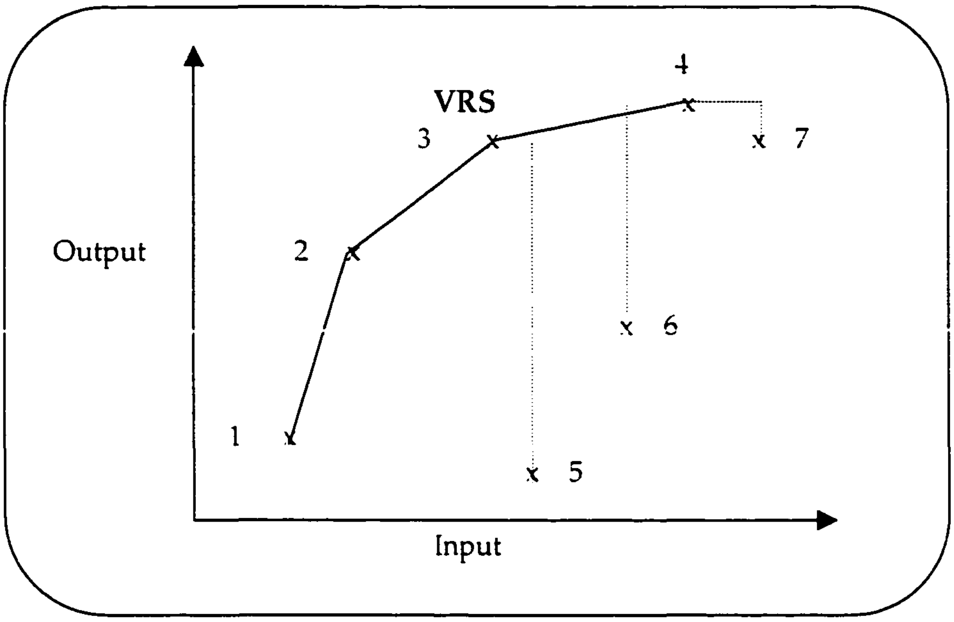


Figure 4.5: Envelopment surface for the BCC Output-Oriented Model.

One other point of note is that a DMU is characterized as efficient with an output orientation if and only if it is characterized as efficient with an input orientation applied to the same data.

4.5.2 CCR Ratio Form

The essential characteristic of the CCR ratio construction is the reduction of the multiple-output-multiple-input situation (for each DMU) to that of a single "virtual" output and a single "virtual" input. For a DMU, the ratio of this single virtual output to single virtual input provides a measure of efficiency that is a function of the multipliers (Charnes et al., 1994). According to Charnes et al.

(1978), the measure of the efficiency of any DMU is obtained as the maximum of a ratio of weighted outputs to weighted inputs subject to the condition that the similar ratios for every DMU be less than or equal to unity. In mathematical terms,

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}, \qquad (4.5)$$

subject to:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1.0;$$

which has variable constraints of:

$$j = 1, \ldots, n,$$
$$u_r, v_i \geq 0;$$
$$r = 1, \ldots, s;$$
$$i = 1, \ldots, m.$$

In this particular equation, which is the foundation of subsequent DEA models, y_{rj} and x_{ij} (all positive) are the known outputs and inputs respectively of the j^{th} DMU and the u_r and v_i are the variable weights determined by the solution of this problem (Charnes et al., 1978).

A DMU is deemed efficient relative to all other units in the group if, and only if, z_0 is equal to one. All other DMUs will be deemed inefficient. For an inefficient unit, the solution identifies corresponding efficient units (i. e. efficient with the same weights), which are said to form a peer group for the inefficient unit (Boussofiane et al., 1991).

4.5.3 *The CCR model*

The formulation of the BCC model is very similar to the CCR model. As a result the formulation of the CCR model will not be explained in great detail in this section. Instead the major differences will be noted.

The CCR and BCC models can be used as an input-oriented model or an output-oriented model. The major difference between the two models is the shape of the envelopment surface. The CCR model uses a constant returns-to-scale (CRS) envelopment surface, while the BCC model, uses a variable returns-to-scale (VRS) envelopment surface, which is probably more applicable to the construction industry.

As mentioned, the input-oriented and output oriented CCR models have similar formulations to that of the BCC models. The input-oriented CCR model is obtained by removing the convexity constraint, seen in Equation 4.6, from the primal form and the variable u_0 from the multiplier form of the BCC linear program.

$$\vec{1}\lambda = 1 \tag{4.6}$$

The absence of the convexity constraint creates the CRS envelopment surface and therefore produces a linear relationship with the efficient DMUs, which always begins at the origin. There is no longer a convex combination of the efficient DMUs, which is characteristic of the VRS envelopment surface. Generally speaking, the CRS envelopment surface will generate a larger production possibility set but will tend to produce less efficient DMUs as well as lower efficiency scores for the inefficient units. The VRS envelopment surface is often said to "envelop the data more tightly."

The same features that distinguish the input-oriented CCR to the input-oriented BCC also distinguish the output-oriented CCR from the output-oriented BCC. Once again the convexity constraint in equation 4.6 is removed from the envelopment form and the variable u_0 is removed from the multiplier form. Figure 4.6 illustrates the differences between the CCR and the BCC model as represented in a two-dimensional graph.

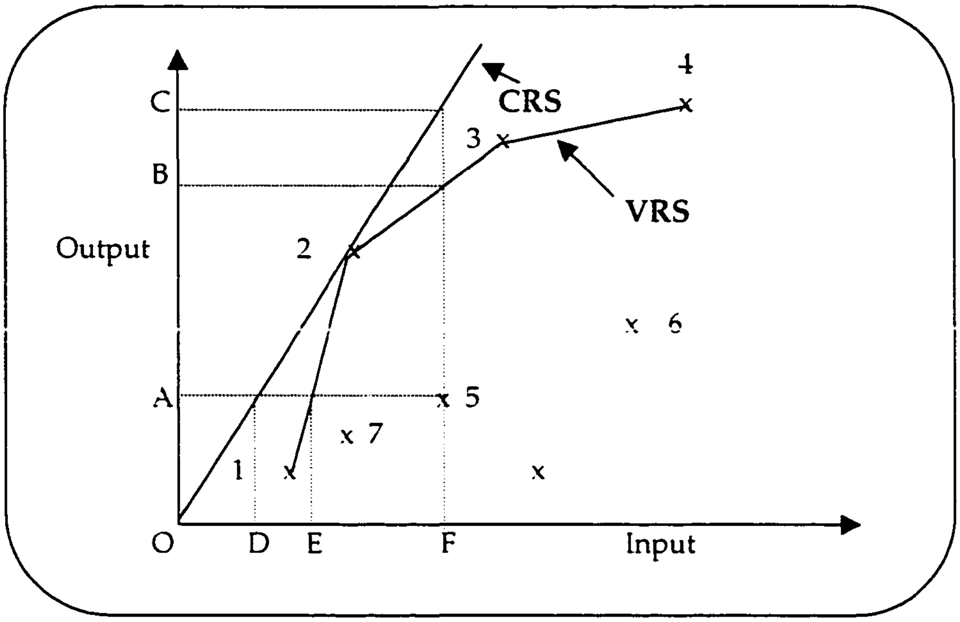


Figure 4.6: Comparison of the BCC and CCR Models.

In an input-oriented BCC model, a VRS envelopment surface would be employed and DMU 5 would be projected onto the VRS envelopment surface at point (A, E). However, if the model were output-oriented then DMU 5 would be projected at point (B, F). If a CCR was being utilized for the analysis, then a CRS envelopment surface would be employed and for an input-oriented CCR model DMU 5 would be projected onto point (A, D). For an output-oriented CCR model DMU 5 would be projected onto point (C, F).

The next stage in understanding and interpreting DEA results is the calculation of the efficiency scores. Efficiency may be broken down into three different categories: pure technical efficiency, which is for the BCC model, overall technical efficiency, which is for the CCR model, and scale efficiency which is a ratio of the CCR model over the BCC model. The calculations of these efficiencies based on Figure 4.6 are presented in Table 4.1 for both the input-oriented and output-oriented models.

Table 4.1: Determination of Efficiency Scores.

Efficiency	*Input Orientation*	*Output Orientation*
Pure Technical (BCC)	OE / OF	OB / OA
Overall Technical (CCR)	OD / OF	OC / OA
Scale (CCR / BCC)	OD / OE	OC / OB

An inefficient DMU is always compared to the set of closest efficient DMUs on the envelopment surface. The efficient DMUs that are directly in front of and behind the inefficient DMU are referred to as the peer group for that particular DMU. Of course these will change depending on the orientation of the model. Referring to DMU 5 in Figure 4.6, the peer group for that particular DMU in the input-oriented BCC model would be DMU 1 and DMU 2. For the output-oriented BCC model the peer group for DMU 5 would be DMU 2 and DMU 3.

The CCR model and the BCC model, along with their two orientations are the four most predominant models that are used in DEA. These four models have also laid the foundation for which any future models have or will be developed. The next two models, the additive and the multiplicative, will not be discussed here since they will not be used in this report.

Like all software in the market, DEA requires the input of data to produce an analysis. There are four basic requirements that ensure the proper use of DEA. They are:

- A set of similar DMUs. In this research, the DMUs are different contractors bidding on the same tender.
- A set of inputs from each DMU.
- A set of outputs from each DMU.
- A sufficient number of DMUs to appropriate degrees of freedom. This is probably the most important step. A sufficient amount is equal to three times the total number of inputs and outputs together.

This last criterion can be met by controlling the number of outputs and inputs, or by controlling the total number of DMUs available. Since it is unlikely that there will be more than 15 or 20 contractors bidding on the same contract, the total number of outputs and inputs for any given model is limited to approximately 4 or 5. This will be discussed in Chapter 5 when the models are discussed in much more detail. Once a model has been established, the technique will identify efficient DMUs by maximizing a given set of outputs for a given set of inputs, or vice versa by minimizing inputs for a given combination of outputs.

The next chapter will present two models: an established model, as well as a three-stage model proposed in this research involving Data Envelopment Analysis. The two models will be presented with all their criteria. The data from the established model will be used in the proposed model in order to compare the two and see if comparable results are achievable. The ranking systems from each model will be used as the measuring stick for both models when comparing them. Chapter six will present the analysis as well as a discussion on any anomalies between the two systems. It is hoped that comparable results will be achieved from the new unbiased, non-objective, proposed model.

5

5.0 ESTABLISHED AND PROPOSED MODELS

This chapter will present the two prequalification models that will be used for the analysis of the data. The two models will be referred to as the established model and the proposed model. The established model is currently being used in practice, while the proposed model is the three-stage DEA model that was developed in this research. Both models will be discussed in this chapter, along with their criteria, advantages, and disadvantages. The analysis of both models will be discussed in the next chapter.

5.1 The Established Model

The established model is based on a score out of 50 and allots a certain amount of points for each category. In essence, this is a weighted system since the criteria that were felt to be more important were allotted more points than other criteria. This is very much like making every category out of the same score and then multiplying it by some weight, which is consistent with many of the models that were found in literature. The owner or the project manger from the established model requested from interested contractors a list of five specific items to be submitted with their prequalification packages. The list included the following five items:

1. A completed Canadian Standard Form of Contractor's Qualification Statement (CCDC Form 11), which includes a list of similar projects, completed in the last five years, with client and consultant references. The CCDC Form 11 can be found in Appendix A.

2. Resumes of supervisory personnel to be assigned to the project.

3. A letter from Bonding Company stating the contractor's capacity to obtain Bid, Performance, and Payment Bonds with a minimum established bonding capacity.

4. A Certificate of Clearance from the Workplace Safety and Insurance Board (WSIB, formerly the WCB).

5. A current CAD-7 Calculations Safety Record from the WSIB (a measure used in Ontario, which will be explained later).

After the closing date, the decision-maker would extract the necessary data for input to the 50 point weighted score system. The contractors that were prequalified were then allowed to submit tenders. The criteria of the system follow along with the points allotted per section.

5.1.1 Type of Company (4 points)

Four points were awarded to an incorporated company, three to a partnership, and two to an individual or registered company (sole-proprietor). The existence of a corporation as separate and apart from its shareholder-owners, and the basic premise that a corporation's liabilities are its own and not those of it shareholders, has long been recognized by the courts. This separate existence provides a strong incentive for individuals to incorporate rather than carry on as sole proprietors or as partners, as the personal assets of sole proprietors and partners remain vulnerable to business creditors (Marston, 1996).

5.1.2 *Average Annual Value of Construction (6 points)*

Six points are awarded to a company that produces an average of at least 5 million dollars worth of construction over the last five years. Four points are awarded to a company that produces anywhere on average between three and five million dollars worth of construction over the last five years. One point is awarded to a company that produces on average between two and three million dollars worth of construction over the last five years. Finally no points are awarded to a company that has produced an average of less than two million dollars worth of construction over the last five years.

Owners want to make sure that a company has the capacity to carry out such a contract. These values can change from contract to contract, depending on the size of the contract. If the contract were worth 20 million dollars, then the owners would probably increase the values accordingly. The idea is to determine who has the resources and the capacity to carry out such a project successfully.

5.1.3 *Financial References (4 points)*

This section aims at understanding a company's financial standing and their references. Four points are allotted for a company providing a bank as its financial reference, whereas three points are allotted to a company that has a bonding company as its financial reference. Most companies have both a bank and a bonding company as a financial reference and will provide both in their prequalification contracts. No points are awarded to those contractors that fail to provide any financial references at all. This category almost cancels itself out since everyone will more than likely attain full marks. It is very difficult to conduct business without the aid of a banking institution. With the way pay schedules run in the construction industry, one needs credit lines from a bank.

5.1.4 Completed Projects in the Last Five Years (3 points)

Contractors who have not had recent work may not be familiar with the methods utilized in the construction industry and as a result may produce unreliable bid prices. This information is requested in the CCDC Form 11. CCDC 11 only has room for four entries. Some contractors keep a database of their completed projects and can print out the list to include it with their prequalification packages. It is sometimes difficult to compare one contractor to another when one contractor submits four completed projects while another submits twenty. There is nothing stopping a contractor from providing more information and such contractors should not be penalized. So the contractors that keep a database of contracts will normally reflect higher marks especially in the experience category. Even still, a contractor who fills all four spots of the CCDC Form 11 will receive the maximum of three points in this category.

A contractor who has only completed anywhere between one and three contracts will receive one point. A company that has not completed any projects over the last five years will receive a score of minus four. This is one of a few categories in this prequalification system that penalizes contractors for unfavourable submissions. This is unique to this system since not many other prequalification systems discussed will remove points from a contractor.

5.1.5 *Related Projects (With References, 10 points)*

This is among the most important criterion in any prequalification system. This can be seen by the number of points awarded to contractors who attain full marks. Contractors may receive any value between zero and ten. The points are decided upon by the decision maker that is carrying out the process. Contractors with good experience and references could be awarded a maximum of ten points, which is twenty percent of the total points awarded in this system. Contractors with some experience will be awarded five points. The points are based on references as well as the similarity of completed projects in the past. A contractor who provides no information or has no experience will receive a value of minus ten, which would almost eliminate them from being prequalified altogether.

Experience is one of the most tell tale signs of a contractor's capability and competence. Examining whether a contractor has completed the jobs on time and on budget are important parameters in estimating a contractor's experience.

5.1.6 Key Personnel Assigned to Projects (5 points)

A maximum of five points can be awarded in this category. Values can range from zero to five. Key personnel can be entered in the CCDC Form 11 or resumes can be provided. Once again this category involves a high level of subjectivity and can introduce a bias into the system, although number of years of service is objective. Positions within the company are evaluated when dealing with key personnel assigned to the project. A company should have a few leading people in the company entered in this section. This sixth section of this prequalification system concludes the part of this system where data can be obtained from the CCDC Form 11.

5.1.7 Personnel Resumes (2 points)

This criterion is a simple decision that can be regarded as a Boolean decision. A contractor who supplies resumes of their personnel will receive two points. Those that do not provide resumes will not receive any score in this section. Resumes are important in assessing an individual's experience, which the contractor has assigned to the particular project. A decision maker can get a feel for the type of experience the few key individuals assigned to the project have. This category does not involve any sort of subjective decisions to be carried out.

5.1.8 Letter of Required Bonding (10 points)

Along with experience, this is the most important criterion that a contractor meets to be prequalified to bid. A contractor who submits a letter from a bonding company with the appropriate amount will receive ten marks, which is also once again a total of twenty percent of the maximum score. Contractors who submit letters from bonding companies with insufficient amounts will receive a grade of zero. A contractor who does not submit any letter or information at all concerning bonding will receive a grade of minus 5.

Bonding companies often have a prequalification system of their own to issue bonds to qualified contractors. Bonding company systems usually involve financial data. Owners and project mangers will often use bonding companies to prequalify contractors for the project. A contractor failing this category will almost undoubtedly have no chance of being prequalified.

5.1.9 WSIB Clearance Certificate (2 points)

This category is also a Boolean decision. A contractor who provides a WSIB Clearance Certificate will receive two points. Contractors who fail to do so for whatever reason will receive a mark of zero. Contractors with poor safety ratings or unpaid premiums may find it difficult to obtain the Certificate. Sometimes contractors simply forget to provide them and will not be awarded the two points.

5.1.10 CAD – 7 Report (4 points)

The Workplace Safety and Insurance Board (WSIB) issues what is called a CAD-7 Experience Rating for Ontario construction contractors. The system looks at a number of different factors such as the size of the company, number of man-hours per year, and the number of time-loss injury claims per year. The report produces two basic numbers. The first is the rating factor, which is indicative of the size of the company. This number will range from 0.15 – 1.00. The second number is the firm performance index, which is indicative of a company's safety rating. This number can range from –2.000 to 1.000, where 1.000 is the best rating. Figure 5.1 illustrates the range of values and their associated qualitative values for the Firm Performance Index.

COST INDEX B	+	FREQ. INDEX C	÷ 2 =	PERF. INDEX P	
+1.000		+1.000		+1.000	Best
+0.800		+0.800		+0.800	Better Than Average
+0.600		+0.600		+0.600	
+0.400		+0.400		+0.400	
+0.200		+0.200		+0.200	
0.000		0.000		0.000	Average
-0.200		-0.200		-0.200	Worse Than Average
-0.400		-0.400		-0.400	
-0.600		-0.600		-0.600	
-0.800		-0.800		-0.800	
-1.000		-1.000		-1.000	
-1.200		-1.200		-1.200	
-1.400		-1.400		-1.400	
-1.600		-1.600		-1.600	
-1.800		-1.800		-1.800	
-2.000		-2.000		-2.000	Worst

Figure 5.1: Range of Values for Firm Performance Index (CSAO, 2000).

Companies with a firm performance index between 0 and 1 will receive a rebate, while those with a value between 0 and –2.000 will be levied a surcharge.

Companies in good standing with the decision maker will receive a maximum of four points. Those with an average standing will be assessed a score of 2, while those in poor standing or providing no information at all will receive a score of 0. It should be noted here that the good, average, and poor standings assessed in this section by the decision maker do not necessarily reflect those presented in Figure 5.1. Safety is an important issue while on site.

Responsible contractors will often take extra precautions as well as establish an internal safety procedure to ensure a safe working environment for their workers. Table 5.1 shows a summary of the criteria used in the established model.

Table 5.1: Summary of Criteria from Established Model.

EVALUATION CRITERIA
CRITERIA
Type of Company
Corporation (4), Partnership (3), Individual (2)
Average Annual Value of Construction
Over 5 M (6), 3 - 5 (4), 2 – 3 (1), less than 2 (0)
Financial References
Bank (4), Bonding Co. (3), None (0)
Completed Projects in Last Five Years
4 or more (3), 1 to 3 (1), or NIL (-4)
Related Projects (with references)
Good Experience (10), some experience (5)
or NIL experience or no info provided (-10)
Key Personnel Assigned to Projects (5 Max)
Personnel Resumes
Resumes (2), None (0)
Letter of Required Bonding
Yes (10), Not Sufficient (0), None (-5)
WCB Clearance Certificate
Yes (2), No Information (0)
CAD - 7 Report
Good Standing (4), Average (2), Poor or no info. (0)

5.2 University of Toronto Contractor Prequalification Model (UTCPM)

UTCPM is a three-stage model that is based on Data Envelopment Analysis (DEA). This model tries to mirror the established model presented in the previous section. The criteria are similar, except that scoring is not used i.e. real values are extracted from the data that the contractors provided. For example, the actual monetary value of all projects completed in the last five years is used instead of assigning it a relative grade value. A graphical representation of the model can be seen in Figure 5.2.

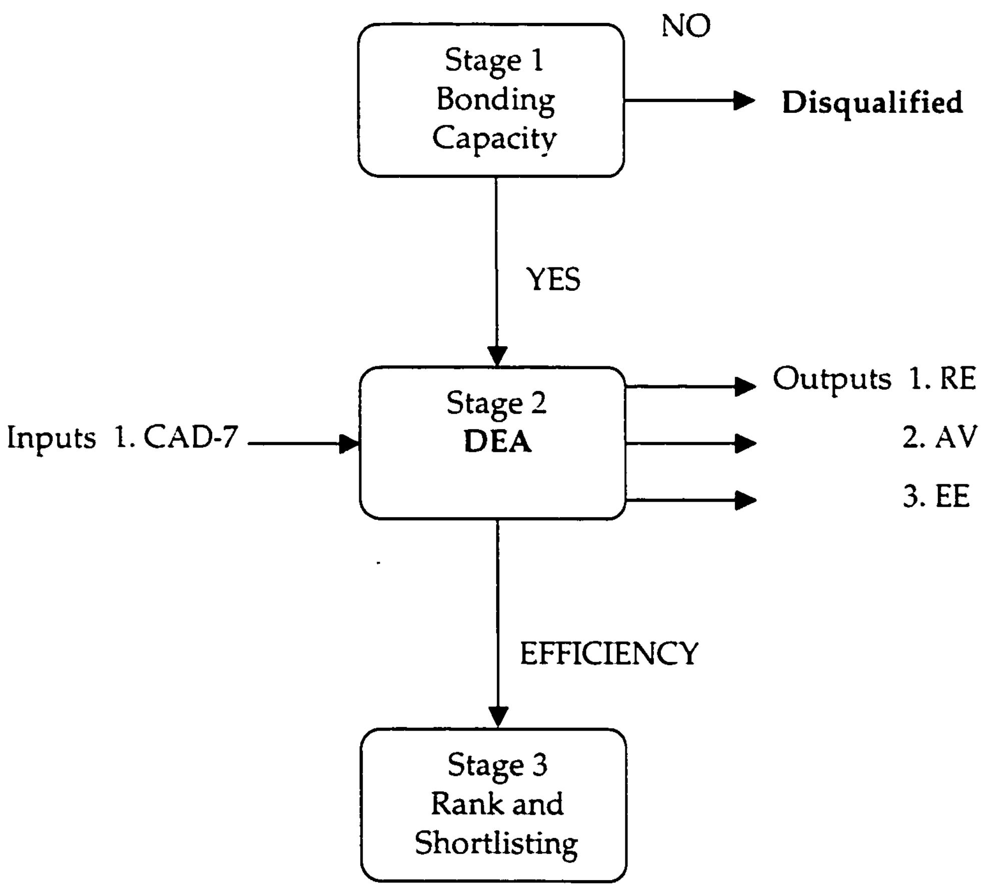


Figure 5.2: Graphical Representation of UTCPM (RE = Relevant Experience, AV = Average Annual Value of Construction, and EE = Employee Experience).

All the data used in this model were taken from the established model's prequalification contracts. A total of seven contracts were used for testing since that is all that was available from the project manager on the established model. The two models will then be tested against one another and their ranking systems will be compared.

5.2.1 *Stage I – Letter of Required Bonding*

Instead of allotting ten points for a contractor's ability to receive the letter of required bonding, UTCPM will simply disqualify any contractor who is unable to receive the appropriate bonding amount for the project. If a contractor cannot be get a bond, then the surety does not feel that the contractor can carry out the project successfully. Many owners use this as their sole means of evaluating prequalification packages submitted by contractors.

5.2.2 *Stage II – Data Envelopment Analysis (DEA)*

The second stage of this model is the implementation of a DEA model to rank the remaining contractors. Many combinations of inputs and outputs have been tried for this model through a trial and error procedure as well as discussions with industry experts. The final model involves one input and three outputs. DEA has one limiting parameter. The number of DMUs required for any given model must be equal or more than the sum of all inputs and outputs multiplied by three. Since the lowest number of contractors in any of the seven contracts is thirteen, it was decided to restrict the number of inputs and outputs to four. The four criteria chosen as well as the ones not chosen are explained in the following section.

5.2.2.1 *CAD-7 Report*

Safety is a major issue on any project. The combination of the WSIB Clearance Certificate and the CAD – 7 report were allotted a total of six points on the established system and so once again it was felt that it was important. The measure that was used here was the company's Firm Performance Index Number, since it is the most indicative of safety records. Instead of using values between 1.000 and –2.000, the values were simply increased by a factor of 3 to range from 1.000 to 4.000. This was done to accommodate DEA since it cannot handle zeros due to its ratio analysis calculations. Instead of 4.000 being the best rating, 1.000 was given the best rating to minimize this factor and make it an input.

5.2.2.2 *Average Annual Value of Construction*

This number was used due to its importance in reflecting capacity as well as experience in the field. If a company has not been in operation for five years, then the projects in years presented were averaged. This time the actual monetary value is used in the analysis. Another major reason for the selection of this criterion is because it was allotted a relatively high weight of six points out of fifty or 12% in the established system. This value was used as an output, since it should be maximized.

5.2.2.3 *Related Experiences*

This category was chosen for its importance, which can also be seen in the established system since it was given a total of 10 points. This is probably the most important parameter that can be evaluated in a prequalification system. The sum of all project values that are related to the project in question were totaled to one monetary value, which was also used in the DEA analysis as an output, since it is a factor that should be maximized.

5.2.2.4 *Employee Experience*

This criterion was chosen because it is key in a project's success. The combination of key personnel assigned to project and personnel resumes account for seven points in the system, which is also a significant amount. The total number of years of experience by a company's employees was added up to produce a single value, which was used in the analysis. This factor too was an output since it is felt that total experience should be maximized when looking at the whole company.

5.2.2.5 *Factors Not Used*

The type of company was not used since it is difficult to quantify and almost every contractor evaluated was a corporation, which would cancel out each other in the analysis. The same can be said about financial references. It is difficult to quantify, and every single contractor received the maximum score in this category, which made it a non-issue. Completed projects in the last five years was only allotted three points in the established model and it was felt as though this value was close to five times the average annual value of construction. Personnel resumes can be incorporated in the same category as the experience since that is where the information came from. Most companies had no trouble in being awarded these two points anyway. Letter of required bonding was taken care of in Stage I. The Clearance Certificate was only allotted two points and once again most contractors did not have trouble with this. The CAD-7 was more indicative of safety and indirectly can be grouped with the Clearance Certificate since they are issued from the same agency.

5.2.2.6 *Model Used*

The model used was a BCC model with three outputs and one input. It was felt that the variable-returns-to-scale was more indicative of the construction industry. Both input-oriented and output-oriented results of the BCC and CCR model were looked at for the analysis.

5.2.3 *Stage III – Shortlisting*

Shortlisting is a term often used by decision makers that assists them in reducing the number of prequalified contractors. The decision maker should determine the number of contractors that he or she wants to bid on the particular project. This will cut the cost of the tendering process, from both the owner's perspective and the shortlisted contractors' perspective. For example if the predetermined number of contractors to place a bid is set at five, then only the top five contractors plus ties in the DEA analysis will be allowed to place a bid. This will reduce the time spent in analyzing tenders submitted by prequalified contractors.

5.3 Summary

This chapter presented the two models that will be used in the analysis and comparison in the next chapter. All contractor data can be seen in Appendix C of this report. There are seven contracts that are used in the analysis. A project manager performed the established model analysis, while the DEA analysis is performed by the author. The analysis of the established model with its criteria broken down can be seen in Appendix D of this report, while the ranking system of the established model can be seen in Appendix E of this report. Chapter Six will present the results of the analysis and the comparison as well as discuss the pertinent issues associated with the interpretation of the results.

6

6.0 RESULTS AND ANALYSIS

This chapter presents the results of the DEA analysis. The results from the established model can be found in Appendix D of this report. A project manager in the Southern Ontario Region carried out the analysis on the established model. The ranking systems of each model will be compared to the other and any notable differences will be discussed. Some contractors could not be put through the DEA analysis due to missing information. The BCC input and output-oriented models will be looked at as well as the CCR input and output-oriented model. All four are presented so comparisons can be made.

6.1 DEA Results and Statistical Analysis

Seven contracts were evaluated using the DEA analysis. This was all the data available from the project manager. The project manager initially evaluated the seven contracts. Data were then extracted from the contracts submitted and run through a DEA analysis. A program called ProDEA© was used for the analysis. This software was created at the Centre for Management of Technology and Entrepreneurship at the University of Toronto. The number of contractors ranged from twelve to nineteen in each of the seven contracts, and many were the same for each contract. Special codes were developed to protect the contractor's privacy.

A few key notes should be made concerning the data at this time. Contractors that did not have all their data present were not included in the analysis, except for contractors that were missing their CAD-7 Reports. Contractors who were missing the CAD-7 report were given a score of 4.000, which is the worst possible safety rating for the DEA Analysis. A few contractors had contracts that were in American dollars. These contracts were multiplied by a value of 1.5 to transform it into Canadian dollars.

6.1.1 Contract A

The results from contract A are presented in Table 6.1.

Table 6.1: DEA Analysis of Contract A.

DMU	Contract A Model Efficiencies			
	BCC Input	BCC Output	CCR Input	CCR Output
1	0.351	2.083	0.189	5.299
2	0.994	2.490	0.343	2.914
3	1.000	1.500	0.210	4.760
4	0.257	2.129	0.134	7.453
5	0.495	2.045	0.266	3.761
6	1.000	1.000	0.316	3.160
7	0.893	1.207	0.796	1.257
8	1.000	1.000	1.000	1.000
9	0.253	1.563	0.175	5.702
10	1.000	1.000	1.000	1.000
11	0.539	1.253	0.487	2.052
12	1.000	1.000	0.869	1.151
13	1.000	1.000	0.570	1.755
14	0.988	1.052	0.755	1.325
15	0.251	5.779	0.052	19.179
16	0.989	1.075	0.614	1.628
Mean	0.751	1.698	0.486	3.962
Standard Deviation	0.324	1.197	0.320	4.507
Max	1.000	5.779	1.000	19.179
Min	0.251	1.000	0.052	1.000
# of Efficient DMUs	6	5	2	2
% of DMUs	37.5	31.25	12.5	12.5

To refresh the reader, BCC analyses variable returns-to-scale, whereas CCR models constant returns-to-scale. The BCC model is believed to be more representative of the construction industry because of its variable returns-to scale production frontier. One can notice by looking at Table 6.1 that the CCR generated fewer efficient units, which was expected since it is not felt that the relationships in the model follow a linear relationship. In input-oriented BCC model, the average overall efficiency of the candidate contractors is 75.1%. This number implies that the group of contractors could have produced their output with approximately 24.9% less input if they are operating on the variable returns-to-scale envelopment surface.

The BCC output-oriented model was chosen as the model that is going to be used in the ranking comparison. Output-oriented models maximize the proportional increase in the output vector while remaining within the envelopment surface. This was done because the model was dominated by outputs, which normally have the greatest affect on whether or not a contractor will be prequalified.

Table 6.2 shows a comparison of the established model with UTCPM. In this particular contract, two contractors produced the same exact ranking while eight others were within three ranks of one another. The orange in the chart symbolizes an exact match, while the blue denotes that a contractor was within three ranking positions in each system. This convention will be used throughout this chapter. This particular contract was very interesting since there were many contractors tied with 44 points in the established system causing a seven way tie for third place. As a result two other contractors would fall within three ranking points of one another.

Table 6.2: Comparison of Ranking for Contract A.

CONTRACT A				
	Established		UTCPM	
ID NUMBER	*Mark / 50*	*Rank*	*DEA Efficiency*	*Rank*
A – 8	48		1.000	
A – 9	45	2	1.563	11
A – 15	44	3	5.779	16
A – 14	44	**3**	1.052	**6**
A – 13	44	**3**	1.000	**1**
A – 10	44	**3**	1.000	**1**
A – 11	44	3	1.253	9
A – 12	44	**3**	1.000	**1**
A – 7	44	3	1.207	8
A – 6	43	10	1.000	1
A – 5	43	**10**	2.045	**12**
A – 4	42	**12**	2.129	**14**
A – 3	42	**12**	1.500	**10**
A – 16	41	14	1.075	7
A - 2	39		2.490	
A - 1	37	**16**	2.083	**13**

6.1.2 Contract B

The results from contract B are presented in Table 6.2.

Table 6.3: DEA Analysis of Contract B.

DMU	*Contract B Model Efficiencies*			
	BCC Input	*BCC Output*	*CCR Input*	*CCR Output*
1	0.880	1.061	0.623	1.605
2	0.327	2.049	0.285	3.509
3	0.917	1.041	0.810	1.235
5	1.000	1.000	0.639	1.565
6	1.000	1.000	1.000	1.000
7	0.239	1.289	0.165	6.045
9	1.000	1.000	1.000	1.000
10	0.536	1.437	0.408	2.448
11	0.364	1.202	0.239	4.186
12	0.927	1.050	0.636	1.571
13	0.499	1.033	0.298	3.352
14	0.734	1.412	0.705	1.419
15	1.000	1.000	1.000	1.000
16	0.455	2.787	0.337	2.966
17	1.000	1.000	1.000	1.000
18	0.453	2.146	0.373	2.681
Mean	0.708	1.344	0.595	2.286
Standard Deviation	0.287	0.529	0.302	1.437
Max	1.000	2.787	1.000	6.045
Min	0.239	1.000	0.165	1.000
# of Efficient DMUs	5	5	4	4
% of DMUs	31.25	31.25	25	25

In this particular contract, the BCC model produced one more efficient unit and demonstrated a stronger relationship than the CCR model. This reiterates the fact that the BCC model is more indicative of the construction industry. Table 6.4 shows the comparison of the BCC output oriented model with the established system.

This particular contract produced three exact matches and nine others that were within three ranks in each system. Two contractors were not used in the analysis due to incomplete submitted information. 75% of contractors fell within three spots of one another in each system, which shows a good correlation between the two systems. Contractors 6 and 17 were given a three out of ten for experience by the decision maker, however, the DEA analysis showed them as efficient units based on UTCPM. In this case the two systems yielded completely different results. Based on experience, the decision maker felt that the contractors did not have the proper experience to carry out the job. According to the data submitted by the contractor and inputted into DEA, they were deemed efficient. This is one instance where the two systems do not agree.

Table 6.4: Comparison of Ranking for Contract B.

CONTRACT B				
	Established		UTCPM	
ID NUMBER	*Mark / 50*	*Rank*	*DEA Efficiency*	*Rank*
B – 4	50	1		
B – 5	50		1.000	
B – 9	50		1.000	
B – 3	49	4	1.041	7
B – 15	49	4	1.000	1
B – 13	48		1.033	
B – 16	48	6	2.787	16
B – 14	47	8	1.412	12
B – 8	44	9		
B – 6	41	10	1.000	1
B – 17	41	10	1.000	1
B – 1	40	12	1.061	9
B – 12	40	12	1.050	8
B – 18	40	12	2.146	15
B – 2	39	15	2.049	14
B – 10	39	15	1.437	13
B – 11	37	17	1.202	10
B – 7	35	18	1.289	11

6.1.3 Contract C

The results from UTCPM for contract C are presented in Table 6.5. The BCC model produced more efficient units again, including over half of the DMUs on the input-oriented model. Note that contractor 5, 6, and 8 were efficient in all of the analysis.

Table 6.5: DEA Analysis of Contract C.

DMU	Contract C Model Efficiencies			
	BCC Input	BCC Output	CCR Input	CCR Output
1	0.253	4.765	0.097	10.351
2	1.000	1.703	0.226	4.424
3	1.000	2.180	0.109	9.140
4	0.379	3.907	0.179	5.598
5	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000
7	0.651	2.418	0.389	2.572
8	1.000	1.000	1.000	1.000
9	0.963	1.094	0.596	1.678
10	0.486	3.544	0.249	4.014
11	0.572	3.289	0.304	3.293
12	1.000	1.000	0.352	2.841
13	1.000	1.149	0.367	2.724
14	1.000	1.000	0.548	1.823
Mean	0.807	2.075	0.458	3.676
Standard Deviation	0.277	1.303	0.326	2.918
Max	1.000	4.765	1.000	10.351
Min	0.253	1.000	0.097	1.000
# of Efficient DMUs	8	5	3	3
% of DMUs	57.1	35.7	21.4	21.4

Table 6.6: Comparison of Ranking for Contract C.

CONTRACT C				
	Established		UTCPM	
ID NUMBER	*Mark / 50*	*Rank*	*DEA Efficiency*	*Rank*
C – 6	50		1.000	
C – 8	50		1.000	
C – 9	48	3	1.094	6
C – 12	48	3	1.000	1
C – 3	42	5	2.180	9
C – 4	41	6	3.907	13
C – 2	40	7	1.703	8
C – 10	40	7	3.544	12
C – 7	38	9	2.418	10
C – 5	37	10	1.000	1
C – 11	35		3.289	
C – 1	32	12	4.765	14
C – 13	32	12	1.149	7
C – 14	30	14	1.000	1

The comparison of ranking systems for contract C can be seen in Table 6.6. Contractors 5 and 14 were given a poor rating in the experience section as well as the section on key personnel assigned to the project, yet were deemed efficient through UTCPM. In this particular contract this seems to be an anomaly.

Contractor 14 was also penalized for not producing 2 million dollars worth of construction a year. It lost six points in the established system and therefore was not given a good score in the experience section. DEA results show this contractor is efficient and because of the VRS envelopment surface, it did not discriminate against size, which the established system did.

6.1.4 Contract D

The results for contract D are presented in Table 6.7. Over half of the DMUs in the BCC input oriented model were deemed efficient, which is double the number of efficient units that were produced using the CCR model. The means of the four analyses shown in Table 6.7, appear to be higher than the previous contracts, indicating that the contractors are relatively similar. A comparison of UTCPM and the established system is shown in Table 6.8.

Table 6.7: DEA Analysis of Contract D.

DMU	Contract D Model Efficiencies			
	BCC Input	BCC Output	CCR Input	CCR Output
1	1.000	1.000	1.000	1.000
2	0.994	1.332	0.642	1.558
3	1.000	1.000	1.000	1.000
4	1.000	1.000	0.940	1.064
5	0.515	2.264	0.419	2.385
6	0.363	2.660	0.246	4.065
7	1.000	1.000	0.691	1.447
8	0.868	1.023	0.850	1.177
9	0.849	1.313	0.681	1.468
10	0.689	2.011	0.490	2.043
11	0.493	2.753	0.287	3.489
12	1.000	1.000	1.000	1.000
13	1.000	1.000	0.997	1.003
14	1.000	1.019	0.305	3.281
15	1.000	1.000	1.000	1.000
Mean	0.851	1.425	0.703	1.799
Standard Deviation	0.224	0.652	0.291	1.035
Max	1.000	2.753	1.000	4.065
Min	0.363	1.000	0.246	1.000
# of Efficient DMUs	8	7	4	4
% of DMUs	53.3	46.7	26.7	26.7

Table 6.8: Comparison of Ranking for Contract D.

CONTRACT D				
	Established		UTCPM	
ID NUMBER	*Mark / 50*	*Rank*	*DEA Efficiency*	*Rank*
D – 13	50		1.000	
D – 4	50		1.000	
D – 9	50	1	1.313	10
D – 2	50	1	1.332	11
D – 5	48	5	2.264	13
D – 8	48	5	1.023	9
D – 12	48	5	1.000	1
D – 11	48	5	2.753	15
D – 3	46	9	1.000	1
D – 15	46	9	1.000	1
D – 7	44	11	1.000	1
D – 6	42	12	2.660	14
D – 14	42	12	1.019	8
D – 10	41	14	2.011	12
D – 1	40	15	1.000	1

This particular contract did not do well in the comparison of systems at first glance. All the contractors scored 40 or more in the established system and eleven of them scored extremely well in the DEA analysis. Even though contractors nine and two did not appear to do especially well in UTCPM, they are not very far from becoming efficient and achieving a number one ranking. In the established system, contractors 3 and 15 ranked ninth with scores of 46 out of 50. This is very close to perfect, which is what they got from UTCPM. Contractor 3 lost all its marks in the established system from the CAD-7 report, which means they probably did not submit one. With good standing, they would have received a perfect grade. Contractor 15 did not submit resumes and lost 2 points for this and another two points for key personnel, which can be said to be related. If they had submitted their resumes, they may have also got a perfect score, which is why UTCPM deemed them efficient.

6.1.5 Contract E

The UTCPM analysis for contract E can be seen in Table 6.9. Over 30% of the DMUs in the BCC models were deemed efficient. This number drops to half for the CCR models. The averages are also high, which shows a strong relationship between the data. Contractors 1, 3, and 11 are efficient throughout the analysis.

Table 6.9: DEA Analysis for Contract E.

DMU	Contract E Model Efficiencies			
	BCC Input	BCC Output	CCR Input	CCR Output
1	1.000	1.000	1.000	1.000
2	1.000	1.000	0.921	1.086
3	1.000	1.000	1.000	1.000
4	0.500	2.066	0.276	3.620
5	0.752	2.000	0.382	2.614
6	1.000	1.000	0.986	1.014
7	1.000	2.274	0.440	2.274
8	1.000	1.000	0.751	1.331
9	0.999	1.619	0.618	1.619
10	0.751	1.952	0.508	1.967
11	1.000	1.000	1.000	1.000
12	0.567	1.815	0.416	2.404
13	0.677	1.603	0.456	2.191
14	0.809	2.428	0.409	2.442
15	0.772	1.798	0.447	2.235
16	0.700	1.885	0.483	2.069
17	0.700	1.649	0.580	1.723
18	0.497	2.685	0.190	5.276
19	0.863	1.343	0.643	1.556
Mean	0.820	1.638	0.606	2.022
Standard Deviation	0.181	0.537	0.262	1.052
Max	1.000	2.685	1.000	5.276
Min	0.497	1.000	0.190	1.000
# of Efficient DMUs	7	6	3	3
% of DMUs	36.8	31.6	15.8	15.8

A comparison of ranking between the established system and UTCPM for contract E can be seen in Table 6.10.

Table 6.10: Comparison of Ranking for Contract E.

CONTRACT E				
	Established		UTCPM	
ID NUMBER	*Mark / 50*	*Rank*	*DEA Efficiency*	*Rank*
E - 2	50		1.000	
E - 3	50		1.000	
E - 6	50		1.000	
E - 8	50		1.000	
E - 10	50	1	1.952	14
E - 12	50	1	1.815	12
E - 14	50	1	2.428	18
E - 15	50	1	1.798	11
E - 11	49	9	1.000	1
E - 17	49	9	1.649	10
E - 1	47	11	1.000	1
E - 13	47	11	1.603	8
E - 16	47	11	1.885	13
E - 18	46	14	2.685	19
E - 19	45	15	1.343	7
E - 5	43	16	2.000	15
E – 9	43	16	1.619	9
E – 7	42	18	2.274	17
E – 4	40	19	2.066	16

Over half of the contractors were within three ranks of one another between the two systems. Contractor 11 received a ninth ranking in the established system even though it received a score of 49 out of 50. It lost the one point based on key personnel assigned to the project, however, UTCPM deemed it efficient and gave it a number one ranking. Although they seem far apart, they actually are not. A pattern can be noticed in the comparison of rankings. There are several matches toward the top and bottom of the list, which seems to occur in most contracts. The middle contractors, when examined more carefully can often be justified for mismatches in ranks. Usually it comes down to the subjectivity of the decision maker.

6.1.6 Contract F

The DEA Analysis for contract F can be seen in Table 6.11. Five out of twelve contractors were deemed efficient through the BCC model as opposed to two using CRS envelopment surface. Contractors 1 and 6 are efficient in all analyses. The comparison of ranking from UTCPM and the established system can be seen in Table 6.12. 33% of the contractors placed within three ranks between the two systems. Contractors 10 and 6 lost all their marks in the established system through experience and key personnel assigned to the project, which are two highly subjective categories. If not for these two judgment calls, they would receive a perfect score and UTCPM's efficiency rating would easily justifiable. This contract had the lowest number of matching ranking between the two systems.

Table 6.11: DEA Analysis for Contract F.

DMU	Contract F Model Efficiencies			
	BCC Input	BCC Output	CCR Input	CCR Output
1	1.000	1.000	1.000	1.000
2	1.000	1.000	0.775	1.290
3	0.465	4.758	0.149	6.725
4	0.667	2.087	0.383	2.610
5	1.000	1.000	0.976	1.025
6	1.000	1.000	1.000	1.000
7	0.400	1.676	0.280	3.573
8	0.932	1.292	0.617	1.621
9	0.904	1.327	0.740	1.352
10	1.000	1.000	0.292	3.424
11	0.636	3.937	0.240	4.160
12	0.434	2.102	0.275	3.641
Mean	0.786	1.848	0.561	2.618
Standard Deviation	0.248	1.249	0.327	1.758
Max	1.000	4.758	1.000	6.725
Min	0.400	1.000	0.149	1.000
# of Efficient DMUs	5	5	2	2
% of DMUs	41.7	41.7	16.7	16.7

Table 6.12: Comparison of Ranking for MBP Contract.

CONTRACT F				
	Established		UTCPM	
ID NUMBER	*Mark / 50*	*Rank*	*DEA Efficiencies*	*Rank*
F – 1	**50**		1.000	
F – 8	**50**	1	1.292	6
F – 2	**48**	**3**	1.000	**1**
F – 4	**48**	3	2.087	9
F – 9	**48**	3	1.327	7
F – 12	**47**	6	2.102	10
F – 3	**46**	7	4.758	12
F – 5	**46**	7	1.000	1
F – 6	**44**	9	1.000	1
F – 10	**40**	10	1.000	1
F – 7	**38**	**11**	1.676	**8**
F – 13	**36**	12		
F – 11	**26**	**13**	3.937	**11**

6.1.7 Contract G

The DEA results for contract G can be seen in Table 6.13. Almost half of the contractors were scored as efficient in the BCC model as opposed to just over 10% in the CCR model. An average of 80% for the BCC input oriented can be compared to the 51% generated from the CCR input-oriented model.

Table 6.13: DEA Analysis for Contract G.

DMU	Contract G Model Efficiencies			
	BCC Input	BCC Output	CCR Input	CCR Output
1	1.000	1.000	1.000	1.000
2	1.000	1.000	0.620	1.613
3	0.832	1.865	0.524	1.908
4	0.999	1.024	0.371	2.695
5	1.000	1.000	1.000	1.000
6	0.657	1.322	0.561	1.783
7	1.000	1.000	0.938	1.066
8	0.337	2.966	0.143	6.971
9	0.254	2.281	0.141	7.103
10	0.681	1.667	0.477	2.098
11	1.000	1.000	0.320	3.128
12	1.000	1.000	0.440	2.274
14	0.460	2.119	0.274	3.649
15	1.000	1.000	0.920	1.087
18	1.000	1.038	0.235	4.256
19	0.591	2.724	0.270	3.705
20	0.599	1.809	0.404	2.475
Mean	0.789	1.518	0.508	2.812
Standard Deviation	0.263	0.667	0.294	1.875
Max	1.000	2.966	1.000	7.103
Min	0.254	1.000	0.141	1.000
# of Efficient DMUs	7	7	2	2
% of DMUs	41.2	41.2	11.8	11.8

Table 6.14: Comparison of Ranking for Contract G.

CONTRACT G				
	Established		UTCPM	
ID NUMBER	*Mark / 35*	*Rank*	*DEA Efficiencies*	*Rank*
G - 1	35		1.000	
G – 7	35		1.000	
G – 5	35		1.000	
G – 2	35		1.000	
G – 11	35		1.000	
G – 4	35	1	1.024	8
G – 6	35	1	1.322	10
G - 10	35	1	1.667	11
G - 18	35	1	1.038	9
G - 19	35	1	2.724	16
G - 20	33	11	1.809	12
G - 3	32	12	1.865	13
G - 9	31	13	2.281	15
G - 12	31	13	1.000	1
G - 15	31	13	1.000	1
G - 16	31	13		
G - 17	31	13		
G - 8	29		2.966	
G – 14	28	19	2.119	14
G – 13	25	20		

The comparison of the two ranking systems for contract G can be seen in Table 6.14. The established ranking was not carried out in its entirety and as a result was scored out of 35 instead of 50, which produced a lot of ties. Contractor 13 was ranked 20 in the established model and lost all of its 10 points because it did not submit the required bonding. This eliminated this contractor from UTCPM since this is the first stage of the model. This contractor was otherwise perfect and as a result was deemed efficient in a trial run and would have been prequalified had they submitted the required bonding. In UTCPM, such a contractor is not permitted past step 1 without the proper required bonding. Contractor 15 lost four points in the established system because it did not submit their CAD-7 which would have otherwise given them a perfect score like they received in UTCPM.

It can also be seen that for the BCC output-oriented model, the number of efficient DMUs ranged from 31.3% to 46.7%. These numbers may seem high but can be anticipated due to the number of decision making units that are present in the analysis. The total number of DMUs for any contract ranged from 12 to 19 contractors, which is not a lot of data points by DEA standards. Having said that, it is also representative of the situation that occurs in the construction industry. Another way of looking at the data is to score the difference in ranks between the two models.

6.2 Prequalifying Contractors and Shortlisting

The third stage of UTCPM involves shortlisting and/or selecting the number of prequalified contractors allowed to submit a tender for the project. In the established system, the cut-off for prequalification varies from one contract to another. It will not always be a set number. It will depend on the number of contractors in the analysis and the range of scores obtained. It is much easier to set a mark in UTCPM, such as 1.5 in the output-oriented BCC model. Any contractor with an efficiency of less than 1.5 would be prequalified. The top eleven contractors in contract D and the top eight contractors in contract F were prequalified in the established system. The remaining five contracts are estimated in Table 6.15 along with the number of contractors that would be shortlisted in UTCPM based on an efficiency of 1.5 or less. The prequalified contractors in the established model were decided upon by judgment based on the range of scores except for the two green boxes, which were actual results. The results are fairly similar although it is important to note that the contractors that would be prequalified in each system are all the same. The biggest difference came in contract E where the 7 contractors that would be prequalified were all deemed efficient. The next best score was larger than 1.5. The established system may have yielded twice the amount of contractors allowed to submit a tender. Establishing a benchmark before the analysis is performed in UTCPM is critical in eliminating any subjectivity in the whole process. It might be better to determine the number of contractors that will be prequalified, which is closer to the shortlisting process. Allowing the contractors know how many will be shortlisted will encourage them to participate.

Table 6.15: Recommended Prequalified Contractors in Both Systems.

Contract	*Total DMUs*	*Prequalified in Established System*	*Percent of DMUs (%)*	*Prequalified in UTCPM*	*Percent of DMUs (%)*
A	16	12	75.0	10	62.5
B	18	9	50.0	13	72.2
C	14	8	57.1	7	50.0
D	15	**11**	73.3	11	73.3
E	19	15	78.9	7	36.8
F	13	**8**	61.5	7	53.8
G	20	12	60.0	10	50.0

6.3 Summary

As mentioned the biggest shortcoming concerning DEA and the prequalification of contractors is the number of DMUs as well as the fact that it is a relative procedure. All the contractors in the group may be awful but still receive efficiency scores of 1.0. This cannot be overcome since these are real situations in the construction industry and low numbers of participants may surface in any contract. Typical DEA studies involve hundreds to thousands of DMUs and as a result the concern of limiting the number of inputs and outputs is a non-issue. Limiting the inputs and outputs in this project was a major concern. Comparing two systems while being allowed a certain number of inputs and output required severely limiting the criteria selected, which would otherwise not be necessary. These may not necessarily have been the best criteria for prequalification, but they were the best criteria to meet the established model.

Table 6.16 summarizes the results of section 6.1. Contractors that were within three spots in the two systems varied from 26.7% to 75%. It is quite difficult to develop a non-biased system that matches exactly a biased system, so the results are encouraging. It is hoped that UTCPM will be a basis upon which future non-biased systems may be developed.

Table 6.16: Summary of Rank Comparison.

Contract	*Total DMUs*	*Exact Matches*	*Within 3 Spots*	*Total*	*Percent*
A	16	2	8	10	62.5
B	16	3	9	12	75.0
C	14	3	5	8	57.1
D	15	2	2	4	26.7
E	19	4	6	10	52.6
F	12	1	3	4	33.3
G	18	6	3	9	50.0

The results of four different DEA evaluation algorithms were presented but only the BCC output-oriented model was used for the comparison to the industry system. The average efficiency for each model ranged from 70 to 85 percent in the BCC input-oriented model, which shows a strong relationship between the DMUs, i.e. that they have relatively similar qualifications.

The main reasons why ranks were different between the two prequalification systems (the established and UTCPM) were discussed. Contractors who cannot get the appropriate bonding for the specified contract are not put through the DEA analysis in this proposed model. The established model produced many ranking ties since one is dealing with a discrete scoring system out of 50. DEA produces ties only in its number one ranking since these are all efficient units on the frontier. After the number one ranking, the efficiency scores are a continuous variable so it is highly unlikely that ties will be produced.

Application of the DEA model was successful, especially since it was not expected that the two systems would produce exactly similar results. UTCPM produces a non-subjective, unbiased system, which will hopefully be looked upon favourably in the construction industry.

7

7.0 CONCLUSIONS AND RECOMMENDATIONS

This chapter concludes the main findings from this research as well as suggests the direction that future research may be carried out. The main findings of the three-stage proposed model will be discussed with its many advantages and disadvantages. The comparison of the two models will also be discussed and finally the chapter will end with a discussion on the future of DEA models and DEA in general in the construction industry. Prequalification may not be the only place that DEA may be of use in the construction sector since there are many decisions that are subjective in nature and may be deemed biased.

7.1 Conclusions

A comprehensive overview of the owner-contractor prequalification system was presented along with its advantages and disadvantages as well as alternative measures. The system was looked at from an owner's perspective as well as a contractor's perspective and weighed the benefits with the shortcomings. A set of criteria that is often used in the construction industry was also presented to understand all the factors that go into a prequalification decision. Every single criterion will not be found in every prequalification model available in industry as well as literature but most of them will frequently arise in many of the models.

This work also provided a look at other current models discussed in literature, and implemented in the industry. Models range from systems subjectively assigning weights to different criteria to others developing a weighting methodology. Fuzzy logic was introduced as an alternative to definitive weighting, while neural networks were used to train a system on historical data. All models are striving for the same ultimate goal, to assist the decision maker.

An extensive literature review was also carried out on the subject of Data Envelopment Analysis (DEA) and its possible role in the construction industry. Three types of models were discussed: the BCC model, the CCR model, and the Additive model. The different envelopment surfaces and orientations were also discussed.

This research successfully demonstrated an alternate model for assessing the prequalification process of contractors using current data in the construction industry. Contractor prequalification can be seen as an important factor to the success of a project. Although it initially consumes resources, it may save an owner a great deal of money and resources when carried out properly. It may also save contractors time and money by discouraging unqualified contractors from preparing and submitting a bid. There is an obvious need for contractor prequalification in the construction industry, however, it is difficult to find a system that is acceptable to everyone since there is usually a high degree of subjectivity associated with any system. To address this concern a three-stage model involving the use of Data Envelopment Analysis was presented as an alternative to traditional prequalification weighted scoring systems.

The University of Toronto Contractor Prequalification Model (UTCPM) was proposed as an alternative to the traditional established system. The first stage requires contractors to submit the surety's letter of prequalification. The second stage is the DEA analysis involving one input and three outputs that were decided upon by comparing the model to an established model. The third stage involves a concept known as "shortlisting", where the decision maker reduces the number or prequalified contractors down to a predetermined number. This model was compared to an established 50 point weighted model developed by a project manger in the Southern Ontario region.

The DEA analysis of the seven contracts produced averages of between 70 and 85 percent efficiencies with the number of efficient decision making units ranging from 31 to 47 percent on the BCC output-oriented model. The ranking systems of both models produced many similar results especially at the top and the bottom of the ranking lists, which suggests that these contractors are in the correct place. The results in the middle are sometimes fuzzier and can often be explained by looking at both systems. The number of contractors that were within three ranking points in each system ranged from 27 to 75 percent depending on the contract. The results seemed to get better as the number of contractors prequalifying for the project increased.

This is the first time DEA is being introduced to the construction industry and can said to have a successful introduction although there is still much needed work. DEA has 3 disadvantages. First, one requires data (Number of contractors) that is at least three times the sum of all the inputs and outputs. In construction, the number of contractors will generally govern this relationship. This can be offset by the fact that DEA will produce the most non-subjective, unbiased decision in the prequalification process. The second disadvantage is that the analysis is a batch process, i.e. all contractors are analyzed as a group. If a late prequalification submission is received, then the entire analysis will have to be rerun. Thirdly, the analysis is relative only to the group, and a contractor's score may change if it is combined into a different group. It may be possible to establish a false set of ideal contractors to use in the model that can then set a standard level.

7.2 Recommendations

As this work unveils trends and recent developments in the prequalification process, it also illustrates the need and desire by industry to develop an unbiased system. This research also highlights the need for additional work on DEA in the construction industry. The following research areas are recommended to increase the value and worth of DEA in the construction industry:

- A DEA model should be developed without trying to compare it any system exactly, instead criteria should be developed through expert opinion and literature.
- The importance of quality data in any DEA analysis is crucial. Interpretations often had to be made concerning ambiguities that were presented by contractors.
- A special standard package should be developed for the prequalification process. Any contractor not providing all the necessary data or not adhering to the guidelines should automatically be disqualified.
- More data needs to be investigated and perhaps other systems used as reference points.

- Decision makers will not want to run through DEA manually, and although there is a number of different software to handle DEA, one should be developed, perhaps through Visual Basic, that is user friendly and specific to the construction industry.
- A database of all the information used in the DEA analysis should be maintained to look for improvements in selecting different criterion as well as ways to improve existing models. This would be an excellent way to test and refine objective indicators and compare scores on actual projects. This can lead to acceptance in the industry.

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STANDARD CONSTRUCTION DOCUMENT – CCDC 11 - 1996

CONTRACTOR'S QUALIFICATION STATEMENT

This document is intended to provide information on the capacity, skill, and experience of the Contractor. Applicant may supplement information requested with additional sheets if required.

Project Number: ________________

Project Title and Location: ____

____

1. **Submitted to:**

   Firm Name: ____

   Address: ____

   Phone: ________________ Fax: ________________ E-mail: ________________

2. **Submitted by:**

   Firm Name: ____

   Address: ____

   Phone: ________________ Fax: ________________ E-mail: ________________

3. **Legal Structure of Contractor:**

   Year Established: _____ Joint Venture _

   Corporation _ , Partnership _ , Registered _ , Sole Proprietor _ , Other: ________________

   Names and Titles of Officers, Partners, Principal: ________________________

   ____

   ____

   ____

4. **Financial References**

   a. Bank Name: ____

      Location: ____

      Contact Person(s): ____

      Phone: ________________ Fax: ________________ E-mail: ________________

   b. Bonding Company: ____

      Location: ____

      Contact Person(s): ____

      Phone: ________________ Fax: ________________ E-mail: ________________

5. **Annual value of construction work for the past five years**

Year	Value	Year	Value	Year	Value
_____	$ ______________	_____	$ ______________	_____	$ ______________
_____	$ ______________	_____	$ ______________		

6. **Principal projects completed in the past five years. Listed in Appendix A.**
7. **Similar or related projects completed. Listed in Appendix B.**
8. **Major construction projects underway this date. Listed in Appendix C.**
9. **Key office personnel proposed for the project, attach resume of qualifications and experience:**

   (e.g. Principal in Charge, Project Manager, Estimator, etc)

Name	Title / Position
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

10. **Key site personnel proposed for the project, attach resume of qualifications and experience:**

    (e.g. Project manager, Superintendent, Foreman, etc)

Name	Title / Position
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

I declare that the information provided is true and correct to the best of my knowledge.

____ _______________

name and title of contact person *date*

Project Title and Location: ______________________________

____

Description: ______________ Project Value: $ ______________

Owner: ______________ Date Completed: ______________

Refer to: ______________ Phone: ________ Fax: ________

Consultant: ______________________________

Refer to: ______________ Phone: ________ Fax: ________

Project Title and Location: ______________________________

____

Description: ______________ Project Value: $ ______________

Owner: ______________ Date Completed: ______________

Refer to: ______________ Phone: ________ Fax: ________

Consultant: ______________________________

Refer to: ______________ Phone: ________ Fax: ________

Project Title and Location: ______________________________

____

Description: ______________ Project Value: $ ______________

Owner: ______________ Date Completed: ______________

Refer to: ______________ Phone: ________ Fax: ________

Consultant: ______________________________

Refer to: ______________ Phone: ________ Fax: ________

Project Title and Location: ______________________________

____

Description: ______________ Project Value: $ ______________

Owner: ______________ Date Completed: ______________

Refer to: ______________ Phone: ________ Fax: ________

Consultant: ______________________________

Refer to: ______________ Phone: ________ Fax: ________

Project Title and Location: ______________________________

____

Description: ______________ Project Value: $ ______________

Owner: ______________ Date Completed: ______________

Refer to: ______________ Phone: ________ Fax: ________

Consultant: ______________________________

Refer to: ______________ Phone: ________ Fax: ________

Project Title and Location: ______________________________

____

Description: ______________ Project Value: $ ______________

Owner: ______________ Date Completed: ______________

Refer to: ______________ Phone: ________ Fax: ________

Consultant: ______________________________

Refer to: ______________ Phone: ________ Fax: ________

Project Title and Location: ______________________________

____

Description: ______________ Project Value: $ ______________

Owner: ______________ Date Completed: ______________

Refer to: ______________ Phone: ________ Fax: ________

Consultant: ______________________________

Refer to: ______________ Phone: ________ Fax: ________

Project Title and Location: ______________________________

____

Description: ______________ Project Value: $ ______________

Owner: ______________ Date Completed: ______________

Refer to: ______________ Phone: ________ Fax: ________

Consultant: ______________________________

Refer to: ______________ Phone: ________ Fax: ________

Major construction projects underway as of the date of submission. **APPENDIX C**

Project Title and Location: ______________________________

____

Description: ____________________ Project Value: $____________________

Scheduled Completion Date: ____________ Percent Completed: ____ %

Owner: ______________________________

Refer to: ____________________ Phone: __________ Fax: __________

Consultant: ______________________________

Refer to: ____________________ Phone: __________ Fax: __________

Project Title and Location: ______________________________

____

Description: ____________________ Project Value: $____________________

Scheduled Completion Date: ____________ Percent Completed: ____ %

Owner: ______________________________

Refer to: ____________________ Phone: __________ Fax: __________

Consultant: ______________________________

Refer to: ____________________ Phone: __________ Fax: __________

Project Title and Location: ______________________________

____

Description: ____________________ Project Value: $____________________

Scheduled Completion Date: ____________ Percent Completed: ____ %

Owner: ______________________________

Refer to: ____________________ Phone: __________ Fax: __________

Consultant: ______________________________

Refer to: ____________________ Phone: __________ Fax: __________

Project Title and Location: ______________________________

____

Description: ____________________ Project Value: $____________________

Scheduled Completion Date: ____________ Percent Completed: ____ %

Owner: ______________________________

Refer to: ____________________ Phone: __________ Fax: __________

Consultant: ______________________________

Refer to: ____________________ Phone: __________ Fax: __________

PREQUALIFICATION ANALYSIS SHEETS (HOLT ET AL., 1994)

PREQUALIFICATION ANALYSIS SHEETS.

NB. ✎ = descriptive insertion required by practitioner. ✍ = numeric insertion required by practitioner.

V1 SIZE.

(A) Approx. maximum required financial commitment by contractor to proposed project = 2 x [contract sum/contract period (months)].

(B) Approx. contractor capacity = (current assets – current liabilities + one half non-current assets [exc goodwill] – non-current liabilities) x 50%

Is (A) equal to, or less than (B) for contractor? **YES**: then score **1.0** **NO**: then score **zero**

Total V1 score ✍ ____________

V2 AGE.

Has the company been trading under the same company name within the construction sector for at least three years? **YES**: then score **1.0** **NO**: then score **zero**

Total V2 score ✍ ____________

V3 IMAGE.

Has the contractor supplied details of company membership of specialist trade associations? Award 0.5 for each membership (maximum score = 1) for which such membership is considered by the practitioner as complimenting this contractors' image. (**No membership = no score**).

V3a. Association 1. (score worth 0.5) ✎............................score:✍...............

V3b. Association 2. (score worth 0.5) ✎............................score:✍...............

Total V3 score ✍ ____________

V4 QUALITY CONTROL POLICY.

V4a). Does the company have appropriate QA registration to B.S. 5750? If answer is **YES**: then V4 score = 1.0 and go to V5. If answer is **NO**: go to V4b;

V4b). Does the company state that it intends to apply for appropriate QA registration to BS 5750 within the next six months? If answer is **YES**: then V4 score = 0.5 and go to V5. If answer is **NO**: score zero

Total V4 score ✍ ____________

V5 HEALTH AND SAFETY POLICY.

NB. FOR QUESTIONS V5a to V5h; YES = 0.1 & NO = ZERO

V5a. Has the company formulated an internal safety policy in accordance with section 2(3) of HASWA 1974?

score:✍...............

V5b. If so are the company's' H&S objectives clearly laid down within? score:✍...............

V5c. Does the document state that H&S are to be given the highest priority in all aspects of the works? score:✍...............

V5d. Does the document describe duties of employees and management with regard to H&S? score:✍................

V5e. Does the company have a permanent H&S Debt.'?
score:✍................

V5f. If so have its' representatives the power to stop dangerous activities?
score:✍................

V5g. Do directly employed operatives receive H&S awareness or first aid training? score:✍................

V5h. Do site management receive H&S awareness or first aid training? score:✍................

NOTE CHANGE IN SCORE VALUES: FOR QUESTIONS V5j & V5k; YES = ZERO & NO = 1.0.

V5j. Has the company been served with an improvement or prohibition Notice by the HSE over the last 5 years (Yes = zero No = 0.1) score:✍................

V5k. Has the company had a fatal accident on any site under its' control within the last 5 years (Yes = zero No = 0.1)
score:✍................

Total V5 score ✍ ____________

V6. LITIGATION TENDENCY.

What point on the following scale best represents the contractors litigation tendency? See comments relating to scale;

Point on scale.	*Comments.*
1.0.	The contractor is involved with multiple legal actions and observation of V20 indicates that the contractor has a strong claims consciousness.
5.0.	The contractor has a current legal action with an employer and observation of both references under V20 indicates up to 50% cost overrun due to contractor claims.
10.0.	The contractor has NO current legal actions and observation of V20 shows NO indication of cost overrun due to claims by the contractor.

1........2........3........4........5........6........7........8........9........10

N.B. V6 score = point on scale divided by 10 ie., 8/10 = 0.8

Total V6 score ✍ ___________

V7; RATIO ANALYSIS OF ACCOUNTS.

V7a.* Is current ratio score above critical limit of 1.0?...(Yes; 0.167 No; zero)...... score:✍................

V7b. If answer is yes to V7a; has current ratio remained stable or exhibited improvement over last 3 years figures?...(Yes; 0.167 No; zero).... score:✍................

V7c.* Is NA/CL ratio score above critical limit of 1.0?......(Yes; 0.167 No; zero).... score:✍................

V7d. If answer is yes to V7c; has NA/CL ratio remained stable or exhibited improvement over last 3 years figures?...(Yes; 0.167 No; zero).... score:✍................

V7e.* Is interest cover above critical limit of 2.0?......(Yes; 0.167 No; zero).... score:✍................

V7f. If answer is yes to V7e; has interest cover remained stable or exhibited improvement over last 3 years figures?...(Yes; 0.167 No; zero).... score:✍................

* *figures extracted from last full years trading accounts.*

Total V7 score ✍ ___________

V8; BANK REFERENCE.

V8a. Has the company been with its bank for a minimum 3 years? If **No** score **zero** and go to V9. If **YES** go to **V8b;**

V8b. Mirror the contractor's Bank reference on the following scale where; 1 represents a poor reference and 10 represents an excellent reference.

The end of the scale reflects poor reference, ie., one that does not instil confidence in the contractor company	Score of 5 reflects median response; neither excellent nor poor	The end of the scale represents reference which instils confidence in the contractor

1........2........3........4........5........6........7........8........9........10

N.B. V8 score = point on scale divided by 10 ie., 8/10 = 0.8

Total V8 score ✍ ____________

V9; TRADE REFERENCE.

V9a. Mirror the contractor's trade reference (Nr. 1) on the following scale where; 1 represents a poor reference and 10 represents an excellent reference.

The end of the scale reflects poor reference, ie., one that does not instil confidence in the contractor company	Score of 5 reflects median response; neither excellent nor poor	The end of the scale represents reference which instils confidence in the contractor

1........2........3........4........5........6........7........8........9........10

V9b. Mirror the contractor's trade reference (Nr. 2) on the following scale where; 1 represents a poor reference and 10 represents an excellent reference.

The end of the scale reflects poor reference, ie., one that does not instil confidence in the contractor company	Score of 5 reflects median response; neither excellent nor poor	The end of the scale represents reference which instils confidence in the contractor

1........2........3........4........5........6........7........8........9........10

Point on scale 9a✍.............Added to Point on scale9b✍.............Equals sub total ✍........... Sub total divided by 20 equals V9 score.

Total V9 score ✍ ____________

V10; TURNOVER HISTORY.

V10a. Has the company shown turnover contraction during the *period?..............................(Yes = zero No = 0.25).... score:✍................

V10b. Has the company fallen below the critical limit Of 1.0 (current ratio) during the *period? (Yes = zero No = 0.25).... score:✍................

V10c. Has the company shown a decline in ROCE on any previous year for the *period?....(Yes = zero No = 0.25).... score:✍................

V10d. Has the company held the critical limit of 50% capital gearing during the *period?...(Yes = zero No = 0.25).... score:✍................

**period = last 3 trading years*

Total V10 score ✍ ____________

V11; QUALIFICATION OF COMPANY OWNERS.

Insert the variable (performance) scores as indicated, then add & divide by four to establish mean.

V11a. Turnover (From V10 score) ✍................

V11b. Time (From V19 score) ✍................

V11c. Cost (From V20 score) ✍................

V11d. Quality (From V21 score) ✍................

Sub total✍................

Sub total divided by 4 = V11 score

Total V11 score ✍ ____________

V12; QUALIFICATION OF KEY PERSONNEL.

V12a. What %* of contractors' key personnel hold a construction related Degree?................. ✍.........% x 0.25 = ✍................

V12b. What %* of contractors' key personnel are between the age of 30 – 40 years old?........ ✍.........% x 0.25 = ✍................

V12c. What %* of contractors' key personnel are corporate members of the CIOB or the ICE? ✍.........% x 0.25 = ✍................

V12d. What %* of the contractors' key personnel have overseas construction management experience? ✍.........% x 0.25 = ✍................

**expressed as a decimal.*

Total V12 score ✍ ____________

V13; YEARS WITH COMPANY – KEY PERSONNEL.

V13. What percentage of management have been with the company since leaving school and remained in the company's employ for between 12 and 22 years? (Percentage expressed as a decimal equals variable score).

Total V13 score ✍ ____________

V14; FORMAL TRAINING REGIME.

V14a. Does the company operate a formal training regime (internal or external) to promote academic qualification of its managers? (Yes = 0.5 No = zero) score:✍............

V14b. Does the company operate an internal system of inter-departmental experience to its managers?.. (Yes = 0.5 No = zero) score:✍...........

Total V14 score ✍ ____________

V15; EXPERIENCE – TYPE OF PROJECTS.

V15. Has the contractor provided details (to the satisfaction of the practitioner) of a contract completed within the last 2 years for each of the (broad) work types V15a – V15d described by the practitioner below? Practitioners choice of work types shown (✎);

V15a. ✎.............................. (Yes = 0.25 No = zero)...... score:✍...............
V15b. ✎.............................. (Yes = 0.25 No = zero)...... score:✍...............
V15c. ✎.............................. (Yes = 0.25 No = zero)...... score:✍...............
V15d. ✎.............................. (Yes = 0.25 No = zero)...... score:✍...............

Total V15 score ✍ ____________

V16; EXPERIENCE – SIZE OF PROJECTS.

V16a. Has the contractor experienced execution of a contract of similar size ( ) to the proposed project within the last 3 years? (Yes = 0.5 No = zero)....
score:✍...............

V16b. Is the proposed project of a size ( ) most often undertaken by the contractor company?.................................. (Yes = 0.5 No = zero)...
score:✍...............

Total V16 score ✍ ____________

V17; NATIONAL OR LOCAL CATCHMENT.

Has the contractor supplied the address of one contract (min. contract period 2 months & executed within the last 2 years) which falls within any of the following regions? *(regions defined by the counties each encompasses).*

V17a. **Scottish Region**..................... (Yes; 0.1 No; zero)..
✍...............

V17b. **Northumbrian Region.** Northumberland, Tyne and Wear, Durham, Cleveland, North Yorkshire (Yes; 0.1 No; zero)..
✍...............

V17c. **North West Region.** Cumbria, Lancashire, Greater Manchester, Merseyside, Cheshire............(Yes; 0.1 No; zero)..
✍...............

V17d. **Yorkshire Region.** West Yorkshire, Humberside, South Yorkshire, Derbyshire. .... (Yes; 0.1 No; zero)..
✍...............

V17e. **Welsh Region.** Gwynedd, Clwyd, Dyfed, Powys, West Glamorgan, Mid Glamorgan, South Glamorgan, Gwent... (Yes; 0.1 No; zero)... ✍...............

V17f. **Severn Trent Region**. Shropshire, Staffs, Notts, Leics, West Mids, Hereford & Worcestershire Warwickshire (Yes; 0.1 No; zero)...
✍................
V17g. **Anglian Region**. Lincolnshire, Cambridgeshire, Norfolk, Northamptonshire, Suffolk, Bedfordshire, Essex................ (Yes; 0.1 No; zero)... ✍................
V17h. **South West Region**. Cornwall, Devon... (Yes; 0.1 No; zero)... ✍................
V17j. **Wessex Region**. Gloucestershire, Avon, Wiltshire, Somerset, Dorset. .... (Yes; 0.1 No; zero)...
✍................
V17k. **Thames & Southern Region**. Oxfordshire, Bucks, Herts, Greater London, Berkshire, Kent, Surrey, Hamps, W. Sussex, E. Sussex. .... (Yes; 0.1 No; zero)... ✍................

Total V17 score ✍ ___________

V18; FAILURE TO HAVE COMPLETED A CONTRACT.
Has the contractor ever failed to complete a contract (ie., achieve termination by performance) without having just reason, such as frustration or mutual agreement? If answer is **No** : score 1.0 If answer is **Yes** : score zero and go to V19

Total V18 score ✍ ___________

V19; OVERRUNS – TIME.
V19a. *(reference No' 1)*. From analysis of the information supplied by Referee Nr. 1 did the contractor complete the contract by the completion date? **IF YES** THEN SCORE 0.5 AND GO TO V19c **IF NO** THEN SCORE ZERO AND GO TO V19b.
V19b. (reference No' 1 continued). From analysis of the information supplied was the time overrun; i) Entirely due to contractor's fault = zero, ii) Only partly due to contractor's fault = 0.25, iii) Not in any way attributable to contractor then score 0.5
score:✍................
V19c. *(reference No'* 2). From analysis of the information supplied by Referee Nr. 2 did the contractor complete the contract by the completion date? **IF YES** THEN SCORE 0.5 then add total score for this variable. **IF NO** THEN SCORE ZERO AND GO TO V19d.
V19d. (reference No' 2 continued). From analysis of the information supplied was the time overrun; i) Entirely due to contractor's fault = zero, ii) Only partly due to contractor's fault = 0.25, iii) Not in any way attributable to contractor then score 0.5
score:✍................

Total V19 score ✍ ____________

V20; OVERRUNS - COST.

V20a. Referee no' 1. Did the contract overrun on cost ie., cost more than the original contract sum? **If answer is no** then score the contractor 0.5 and go to V20b.. score:✍...............

If Answer is yes then;
what approx. percentage of the overrun was attributable to the contractor making contractual claims?
(a)..........%
Now deduct (a) (as a decimal) from 1.0 and multiply by 0.5 =score:✍...............
V20b. Referee no' 2. Did the contract overrun on cost ie., cost more than the original contract sum? **If answer is no** then score the contractor 0.5 and add up V20 total.
If Answer is yes then;
what approx. percentage of the overrun was attributable to the contractor making contractual claims?
(b).........%
Now deduct (b) (as a decimal) from 1.0 and multiply by 0.5 =score:✍...............

Total V20 score ✍ ____________

V21; PAST PERFORMANCE - QUALITY ACHIEVED.

V21a. (Referee No' 1) What was the rating given by referee number 1 regarding the quality of finished product?

The end of the scale represents a poor quality product in terms of workmanship. workmanship.	A score of 5 represents acceptable quality of workmanship.	This end of the scale represents outstanding quality of

1.......2........3........4........5........6........7........8........9........10

V21b. (Referee No' 2) What was the rating given by referee number 2 regarding the quality of finished product?

The end of the scale represents a poor quality product in terms	A score of 5 represents acceptable quality of	This end of the scale represents outstanding

of workmanship. workmanship. quality of workmanship.

1........2........3........4........5........6........7........8........9........10

Point on scale 21a✍......Added to Point on scale 21b✍.......Equals sub total✍.........

Sub total divided by 20 equals V21 score.

Total V21 score ✍ ____________

CONTRACTOR DATA

Contract A

Company ID	A - 1	A - 2	A - 3	A - 4	A - 5	A - 6
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	5	1.8	1.2	8	2.4	1.8
	6	1.06	1.6	10	4.3	2.1
	9	2.4	2.55	10	5.2	3
	7.9	1.6		12	11	3.5
	9.7	1.8		10	9.5	3.9
Sum	**37.6**	**8.66**	**5.35**	**50**	**32.4**	**14.3**
Average	7.52	1.732	1.783333333	10	6.48	2.86
Related Work ($\$ \times 10^6$)	3.400647	1.82159666	0.56	14.69	9.23	5.67
Current Workload ($\$ \times 10^6$)	1.663	1.77762261	2.15	6.587	3.05	3.9178
Last Five Years ($\$ \times 10^6$)	4.011	2.60409216	2.08	10.84	9.23	5.196
Employee Experience (years)	120	81	48	113	121	72
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓		✓	✓
Rating Factor	1.000	0.326	0.150	N / P	0.798	0.150
Firm Performance Index	-0.901	0.994	1.000	N / P	-0.046	1.000

Contract A

Company ID	A - 7	A - 8	A - 9	A - 10	A - 11	A - 12
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	70	7	7	116	30	32.61528
	61	3	6.5	140	25	27.035898
	69	3.5	6	185.8	27	25.378465
	69	1.7	6	183	24	34.745785
	60	3.687108	5	211	23	18.248612
Sum	**329**	**18.887108**	**30.5**	**835.8**	**129**	**138.02404**
Average	65.8	3.7774216	6.1	167.16	25.8	27.604808
Related Work ($\$ \times 10^6$)	47.9	11.75	1.9	252.9033713	2.178	14.165
Current Workload ($\$ \times 10^6$)	22.2	3.11	9.5	1022	10.531191	11.99353
Last Five Years ($\$ \times 10^6$)	43	16.095	4.8	149	32.595	99.806515
Employee Experience (years)	159	238	160	119	196	250
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	1.000	0.218	N / P	1.000	1.000	1.000
Firm Performance Index	0.579	0.995	N / P	0.298	-0.036	0.587

Contract A

Company ID	A - 13	A - 14	A - 15	A - 16
Type of Company	Registered	Corporation	Registered	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	3	60.298	7.5	2.815147
	3	49.431	4.5	2.379408
	6.3	42.368	3.9	1.69478
	5	44.452	3.2	4.746158
	2.5	42.584	2.9	4.357059
Sum	19.8	239.133	22	15.992552
Average	3.96	47.8266	4.4	3.1985104
Related Work ($\$ \times 10^6$)	3.63348376	104.248546	2.925	60.5034
Current Workload ($\$ \times 10^6$)	4.497187	62.869683	6.65	0.5
Last Five Years ($\$ \times 10^6$)	2.8712566	94.239982	3.07	16.2404
Employee Experience (years)	132	117	43	105
Bank	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓
Rating Factor	0.431	1.000	N / P	0.168
Firm Performance Index	0.998	0.712	N / P	0.841

Contract B

Company ID	B - 1	B - 2	B - 3	B - 4	B - 5	B - 6
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	2.815147	5.9	131	N / P	20	9.861035
	2.379408	5.6	127	N / P	20	5.689798
	1.69478	5.1	149	N / P	17.5	5.456062
	4.746158	3.956	150	N / P	15	5.068872
	4.357059	3.845	111	N / P	9	
Sum	**15.992552**	**24.401**	**668**		**81.5**	**26.075767**
Average	3.1985104	4.8802	133.6		16.3	6.51894175
Related Work ($\$ \times 10^6$)	60.8484	9.877	27.75	N / P	28.2	11.8
Current Workload ($\$ \times 10^6$)	1.4	2.082959	8.855	16.27	4.9	4.9
Last Five Years ($\$ \times 10^6$)	16.5854	7.746	20	54.675	30.1	11.8
Employee Experience (years)	105	61	89	67	125	70
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	0.168	0.746	1.000	1.000	0.294	0.150
Firm Performance Index	0.841	0.994	0.784	0.210	1.000	0.671

Contract B

Company ID	B - 7	B - 8	B - 9	B - 10	B - 11	B - 12
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($ x 10^6^)	4	23	140	6.235	9.5	18
	3.1	25	202	5.343	11	13
	3.8	16	134	5.673	5.2	11
	3.1	11	84	5.57	4.3	10
	2.5	23	79	5.94	2.4	8
Sum	**16.5**	**98**	**639**	**28.761**	**32.4**	**60**
Average	3.3	19.6	127.8	5.7522	6.48	12
Related Work ($ x 10^6)	4.03	N / P	199.8	0.917	9.23	44.1
Current Workload ($ x 10^6)	5.34	43.661538	13	3.33	5.35	4.8
Last Five Years ($ x 10^6)	5.81	166.82659	199.8	3.414	9.23	49
Employee Experience (years)	97	81	61	87	104	109
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	0.634	1.000	1.000	1.000	0.798	0.150
Firm Performance Index	-0.756	0.572	0.355	0.999	-0.046	0.981

Contract B

Company ID	**B - 13**	**B - 14**	**B - 15**	**B - 16**	**B - 17**	**B - 18**
Type of Company	Corporation	Corporation	Corporation	Corporation	Registered	Corporation
Annual Value of Construction Over Five Years ($ x 10^6)	3.975	123.6	23	115	202	19
	5.938	83.6	18	105	220	16
	7.856	75.2	18	75	234	14
	7.724	68.8	25	55	253	9
	7.665	43	32	45	235	12.5
Sum	**33.158**	**394.2**	**116**	**395**	**1144**	**70.5**
Average	6.6316	78.84	23.2	79	228.8	14.1
Related Work ($ x 10^6)	6.697488	130.9	166.350423	16.25	30.8	35
Current Workload ($ x 10^6)	5.935	107.018	6.478	23.401	51.9	34.8
Last Five Years ($ x 10^6)	3.925	130.9	18	26.8	1272	16.9
Employee Experience (years)	121	33	35	13	69	43
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓		✓	✓		✓
Rating Factor	1.000	1.000	1.000	1.000	1.000	N / P
Firm Performance Index	0.094	0.500	0.986	0.571	0.686	1.000

Contract C

Company ID	C - 1	C - 2	C - 3	C - 4	C - 5	C - 6
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($ x 10^6)	5.4	3.969763	1.10371	0.5	116	21.2
	5.2	5.526237	1.116776	1.1	140	26.5
	5.3	4.922975	1.248337	1.4	185.8	25.9
	5.2	4.991317	1.427819	1.8	183	16.1
	6.3	4.285493	1.492541	3.6	211	15.5
Sum	**27.4**	**23.695785**	**6.389183**	**8.4**	**835.8**	**105.2**
Average	5.48	4.739157	1.2778366	1.68	167.16	21.04
Related Work ($ x 10^6)	7.1548	0.52	0.605	3.806	352.614334	7.2
Current Workload ($ x 10^6)	2.3412963	0.265	0.329	0.345	115.2	10.395
Last Five Years ($ x 10^6)	22.775208	21.265	0.605	3.806	1068.2	43.78
Employee Experience (years)	81	46	24	103	113	409
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	N / P	0.842	0.150	0.163	1.000	1.000
Firm Performance Index	N / P	1.000	1.000	-0.651	0.298	0.146

Contract C

Company ID	C - 7	C - 8	C - 9	C - 10	C - 11	C - 12
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($ x 10⁶)	12.5	36	4.952435	7.8	7.92194551	6
	13.5	41	2.022617	4.7	4.7114922	12
	15.1	42	1.06854	5.6	1.68709029	12
	17.2	42	0.962684	8.6	4.3775083	10
	18.5	32.6	0.091051	7.024	7.832805.43	10
Sum	**76.8**	**193.6**	**9.097327**	**33.724**	**18.6980363**	**50**
Average	15.36	38.72	1.8194654	6.7448	4.674509075	10
Related Work ($ x 10^6)	2.2	132.903385	1.069	8.352	20.181913.59	0.728
Current Workload ($ x 10^6)	2.05	12.325	1.114	3.875	0.405062.41	0.997
Last Five Years ($ x 10^6)	2.633	6.77	8.525	13.331	11.69091645	0.728
Employee Experience (years)	128	221	147	110	108	67
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	1.000	1.000	1.000	1.000	1.000	0.150
Firm Performance Index	0.341	0.565	0.882	-0.088	0.186	1.000

Contract C

Company ID	C - 13	C - 14
Type of Company	Corporation	Sole Proprietor
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	2.55	2.85
	1.6	1.534
	1.2	1.46
		0.66
		0.29
Sum	**5.35**	**6.794**
Average	1.783333333	1.3588
Related Work ($\$ \times 10^6$)	1.2	1.4355
Current Workload ($\$ \times 10^6$)	0.62	1.737675
Last Five Years ($\$ \times 10^6$)	2.08	2.385
Employee Experience (years)	81	121
Bank	✓	✓
Bonding Company	✓	✓
Letter of Required Bonding	✓	✓
WCB Clearance Certificate	✓	✓
Rating Factor	0.150	0.150
Firm Performance Index	1.000	1.000

Contract D

Company ID	D - 1	D - 2	D - 3	D - 4	D - 5	D - 6
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	2.815147	14.5	71	131	25	4
	2.379408	11.3	82	127	20	3.1
	1.69478	10.6	103	149	24	3.8
	4.746158	9.3	110	150	22	3.1
	4.357059	9.4	108	111	19	2.5
Sum	**15.992552**	**55.1**	**474**	**668**	110	16.5
Average	3.1985104	11.02	94.8	133.6	22	3.3
Related Work ($\$ \times 10^6$)	60.8484	0.03	10	34.141402	2.153	4.247
Current Workload ($\$ \times 10^6$)	1.4	6	25.7	8.855	4.9	5.34
Last Five Years ($\$ \times 10^6$)	16.5854	1.905	42.75	22.4	7.4	6.11
Employee Experience (years)	105	80	232	78	100	86
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	0.168	1.000	1.000	1.000	N / P	0.634
Firm Performance Index	0.841	0.986	-0.046	0.784	0.010	-0.756

Contract D

Company ID	D - 7	D - 8	D - 9	D - 10	D - 11	D - 12
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	6.235	80	97	24.9	16	7.2
	5.343	75	74	24.6	12	3.958037
	5.673	75	54	15.962	10	4.037952
	5.57	70	24	12.81	8	4.105722
	5.94	70	40	12.85	6	2.597869
Sum	**28.761**	**370**	**289**	**91.122**	**52**	**21.89958**
Average	5.7522	74	57.8	18.2244	10.4	4.379916
Related Work ($\$ \times 10^6$)	0.917	27.775996	38.9827965	4.65	9.75	11.9
Current Workload ($\$ \times 10^6$)	3.33	20.616	85.42158	10.8	4.7	3.5387
Last Five Years ($\$ \times 10^6$)	3.5064	11.4	69.644443	36.625	7.7	8.001
Employee Experience (years)	87	173	45	87	69	127
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	1.000	1.000	1.000	1.000	0.798	0.150
Firm Performance Index	0.999	0.092	0.648	0.522	-0.046	1.000

Contract D

Company ID	D - 13	D - 14	D - 15
Type of Company	Corporation	Corporation	Registered
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	191	5.5	202
	217.5	5	220
	295	4.5	234
	266.5	4	253
	324.5	2.5	235
Sum	**1294.5**	**21.5**	**1144**
Average	258.9	4.3	228.8
Related Work ($\$ \times 10^6$)	11	7.567	30.8
Current Workload ($\$ \times 10^6$)	15.32	3.92	51.9
Last Five Years ($\$ \times 10^6$)	74	7.567	1277
Employee Experience (years)	57	34	69
Bank	✓	✓	✓
Bonding Company	✓	✓	✓
Letter of Required Bonding	✓	✓	✓
WCB Clearance Certificate	✓		✓
Rating Factor	1.000	0.150	1.000
Firm Performance Index	0.509	1.000	0.686

Contract E

Company ID	E - 1	E - 2	E - 3	E - 4	E - 5	E - 6
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($ x 10^6)	131	20	176	20.07	5.068872	116
	127	20	123	21.36	5.456062	140
	149	17.5	111	18.009	5.689798	185.8
	150	15	119	20.64	9.861035	183
	111	9	109	22.887		211
Sum	**668**	**81.5**	**638**	**102.966**	**26.075767**	**835.8**
Average	133.6	16.3	127.6	20.5932	6.51894175	167.16
Related Work ($ x 10^6)	14.61	19.041489	634.4	22.7	11.8	221.0878943
Current Workload ($ x 10^6)	8.855	1.834	N / P	29.922	4.9	115.2
Last Five Years ($ x 10^6)	25.59	28.4	4.35	22.7	11.8	90.4
Employee Experience (years)	92	124	52	67	70	129
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	1.000	0.294	1.000	1.000	0.150	1.000
Firm Performance Index	0.784	1.000	0.891	-0.020	0.671	0.298

Contract E

Company ID	E - 7	E - 8	E - 9	E - 10	E - 11	E - 12
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($ x 10^6)	0.8	68	6.235	97	10.5	32
	1.5	81	5.343	74	10	45
	2	86	5.673	54	9	65
	3.5	100.3	5.57	24	8	73
		79	5.94	40	7	76
Sum	**7.8**	**414.3**	**28.761**	**289**	**44.5**	**291**
Average	1.95	82.86	5.7522	57.8	8.9	58.2
Related Work ($ x 10^6)	0	18.325	0.917	106.033301	6.3	149.101405
Current Workload ($ x 10^6)	1.94586	55.69	3.33	85.42158	18.5	21.15
Last Five Years ($ x 10^6)	2.638264	27.78	3.414	67.704293	9.6	22.558
Employee Experience (years)	62	55	87	59	141	66
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	0.150	1.000	1.000	1.000	0.150	1.000
Firm Performance Index	1.000	1.000	0.999	0.648	1.000	0.197

Contract E

Company ID	E - 13	E - 14	E - 15	E - 16	E - 17	E - 18
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	24.9	100	2.5	115	45	4.5
	24.6	75	4.5	105	65	6
	15.962	50	9.8	75	65	7
	12.81	30	18.3	55	70	6
	12.85	25	17.4	45	80	4
Sum	**91.122**	**280**	**52.5**	**395**	**325**	**27.5**
Average	18.2244	56	10.5	79	65	5.5
Related Work ($\$ \times 10^6$)	9.75	64.02	10.981915	18.021	6.9	11.578215
Current Workload ($\$ \times 10^6$)	10.8	69.2	9.163	13.6	49	6.353475
Last Five Years ($\$ \times 10^6$)	35.6	71.912	17.4035	10.415	39.5	12.01306
Employee Experience (years)	87	36	78	35	81	52
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	1.000	1.000	1.000	1.000	1.000	0.846
Firm Performance Index	0.522	0.754	0.704	0.571	0.555	-0.012

Contract E

Company ID	E - 19
Type of Company	Corporation
Annual Value of Construction Over Five Years ($ x 10^6)	2.815147
	2.379408
	1.69478
	4.746158
	4.357059
Sum	**15.992552**
Average	3.1985104
Related Work ($ x 10^6)	4.156
Current Workload ($ x 10^6)	1.4
Last Five Years ($ x 10^6)	22.5604
Employee Experience (years)	105
Bank	✓
Bonding Company	✓
Letter of Required Bonding	✓
WCB Clearance Certificate	✓
Rating Factor	0.168
Firm Performance Index	0.841

Contract F

Company ID	F - 1	F - 2	F - 3	F - 4	F - 5	F - 6
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	192	469	40.3	595.644	70	1747.828
	205.9	527	32.5	623.134	68	1828.632
	172.2	668	31.7	738.8	65	1712.805
	89.8	720	34.5	766	63	1310.816
	55	605	23.5	753	50	1132.147
Sum	**714.9**	**2989**	**162.5**	**3476.578**	**316**	**7732.228**
Average	142.98	597.8	32.5	695.3156	63.2	1546.4456
Related Work ($\$ \times 10^6$)	544.04	404.413	17.5	63.8	18.382278	107.085981
Current Workload ($\$ \times 10^6$)	212.2	623.9	15.2	318.2	43.376424	282
Last Five Years ($\$ \times 10^6$)	2029.9	1132.8	49.6	608.7	148.143787	654.67364
Employee Experience (years)	248	181	52	88	215	179
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	1.000	1.000	1.000	1.000	1.000	1.000
Firm Performance Index	0.448	0.043	-0.192	0.205	0.621	0.573

Contract F

Company ID	F - 7	F - 8	F - 9	F - 10	F - 11	F - 12
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($ x 10^6)	200	42.584	70	23	23.579563	7.92194551
	149	44.452	61	22.5	16.378132	4.7114922
	210	42.368	69	21.2	12	1.68709029
	144	49.431	69	20.8	12.42	4.3775083
	136	60.298	60	6.8	12	7.83280543
Sum	**839**	**239.133**	**329**	**94.3**	**76.377695**	**26.53084173**
Average	167.8	47.8266	65.8	18.86	15.275539	5.306168346
Related Work ($ x 10^6)	299.346	104.248546	64.5	21.86504197	13.40838526	37.74526347
Current Workload ($ x 10^6)	502.9495	62.869683	22.2	9.123374	5.76865	1.60727375
Last Five Years ($ x 10^6)	614.8	94.239982	42.9	21.9614579	28.06143993	18.00307467
Employee Experience (years)	114	127	168	47	63	118
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	1.000	1.000	1.000	0.635	1.000	0.978
Firm Performance Index	-1.286	0.712	0.579	0.993	0.360	-0.689

Contract F

Company ID	F - 13
Type of Company	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	40
	36
	28
	35
	24
Sum	163
Average	32.6
Related Work ($\$ \times 10^6$)	1.763253
Current Workload ($\$ \times 10^6$)	26.62686
Last Five Years ($\$ \times 10^6$)	30.112245
Employee Experience (years)	N / P
Bank	✓
Bonding Company	✓
Letter of Required Bonding	✓
WCB Clearance Certificate	✓
Rating Factor	1.000
Firm Performance Index	0.518

Contract G

Company ID	G - 1	G - 2	G - 3	G - 4	G - 5	G - 6
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	123	12	27	5.068	116	30
	192	14	29	5.456	140	30
	205.9	14	26	5.689	185.8	25
	172.2	18	28	9.861	183	27
	89.8	18	26	14.5	211	24
Sum	782.9	76	136	40.574	190	136
Average	156.58	15.2	27.2	8.1148	167.16	27.2
Related Work ($\$ \times 10^6$)	20.56	7.35	6.6	18.04	301.892867	2.178
Current Workload ($\$ \times 10^6$)	191.2	1.2	0	2.3	115.2	15.5145
Last Five Years ($\$ \times 10^6$)	1025.08	8.4	6.6	18.04	1068.2	52.451
Employee Experience (years)	267	131	136	70	110	202
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	1.000	0.866	1.000	0.150	1.000	1.000
Firm Performance Index	0.724	0.990	0.760	0.995	0.583	0.279

Contract G

Company ID	G - 7	G - 8	G - 9	G - 10	G - 11	G - 12
Type of Company	Corporation	Corporation	Corporation	Corporation	Corporation	Corporation
Annual Value of Construction Over Five Years ($ x 10^6)	32.399533	48.5	18	65	18.5	6.2
	32.61528	41	10	70	23	3.9
	27.035898	28	12	61	22.5	3.5
	25.378465	24	10	69	22.2	3
	34.745785	21	10	69	20.8	2.1
Sum	152.174961	162.5	60	334	107	18.7
Average	30.4349922	32.5	12	66.8	21.4	3.74
Related Work ($ x 10^6)	13.906777	23.12	16.3	36	21.865041	5.67
Current Workload ($ x 10^6)	0	13.3	5.487	14.3	1.31824	1.3
Last Five Years ($ x 10^6)	121.807413	27.225	12.383	66.9	21.961457	9.3424
Employee Experience (years)	232	81	113	147	56	92
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	1.000	0.823	N / P	1.000	0.669	0.200
Firm Performance Index	0.818	-1.056	N / P	0.369	0.996	1.000

Contract G

Company ID	G - 13	G - 14	G - 15	G - 16	G - 17	G - 18
Type of Company	Corporation	Corporation	Corporation	Corporation	Registered	Corporation
Annual Value of Construction Over Five Years ($ x 10^6^)	16	9.5	70	40	202	10.5
	11	11	68	40	220	11
	17	5.2	65	36	234	12.5
	21.5	4.3	63	38	253	13.775
	24	2.4	50	35	235	12.8
Sum	**89.5**	**32.4**	**316**	**189**	**1144**	**60.575**
Average	17.9	6.48	63.2	37.8	228.8	12.115
Related Work ($ x 10^6)	21.3	9.23	N / P	17.117952	30.8	8.67
Current Workload ($ x 10^6)	7.6	1.16	41.707304	16.14855	51.9	0.22
Last Five Years ($ x 10^6)	31.9	9.23	1056.715242	30.112245	1272	8.54
Employee Experience (years)	103	126	231	N / P	86	46
Bank	✓	✓	✓	✓	✓	✓
Bonding Company	✓	✓	✓	✓	✓	✓
Letter of Required Bonding	✓	✓	✓	✓	✓	✓
WCB Clearance Certificate	✓	✓	✓	✓	✓	✓
Rating Factor	0.150	1.000	1.000	1.000	1.000	1.000
Firm Performance Index	1.000	-0.197	0.557	0.360	-0.026	0.998

Contract G

Company ID	G - 19	G - 20
Type of Company	Corporation	Corporation
Annual Value of Construction Over Five Years ($\$ \times 10^6$)	40	42
	27	35
	25	29.8
	25	28.7
	25	31
Sum	142	166.5
Average	28.4	33.3
Related Work ($\$ \times 10^6$)	7	14.209
Current Workload ($\$ \times 10^6$)	8.235	18.245
Last Five Years ($\$ \times 10^6$)	19.4	19.125
Employee Experience (years)	98	146
Bank	✓	✓
Bonding Company	✓	✓
Letter of Required Bonding	✓	✓
WCB Clearance Certificate	✓	✓
Rating Factor	1.000	1.000
Firm Performance Index	0.265	0.251

CONTRACTOR PREQUALIFICATION ANALYSIS – ESTABLISHED SYSTEM

Contract A

EVALUATION CRITERIA	A - 1	A - 2	A - 3	A - 4	A - 5
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (5), 2 - 3 (1), less than 2 (0)	6	0	0	6	5
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	0
Related Projects (with references)					
Exc. Experience (8 - 10), G. Contractor experience (5 - 7)	8	8	9	9	10
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	0	2	4	4	4
Personnel Resumes					
Resumes (2), None (0)	0	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	0	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	0	4	4	0	2

Contract A

EVALUATION CRITERIA	A - 6	A - 7	A - 8	A - 9	A - 10
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (5), 2 - 3 (1), less than 2 (0)	1	6	5	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Exc. Experience (8 - 10), G. Contractor experience (5 - 7)	9	5	10	10	5
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	4	4	4	4	4
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	4	4	0	4

Contract A

EVALUATION CRITERIA	A - 11	A - 12	A - 13	A - 14	A - 15
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	2	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (5), 2 - 3 (1), less than 2 (0)	6	6	5	6	5
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Exc. Experience (8 - 10), G. Contractor experience (5 - 7)	5	5	10	5	10
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	4	4	2	4	4
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	4	4	4	0

Contract A

EVALUATION CRITERIA	A - 16
CRITERIA	
Type of Company	
Corporation (4), Partnership (3), Individual (2)	4
Average Annual Value of Construction	
Over 5 M (6), 3 - 5 (5), 2 - 3 (1), less than 2 (0)	5
Financial References	
Bank (4), Bonding Co. (3), None (0)	4
Completed Projects in Last Five Years	
4 or more (3), 1 to 3 (1), or NIL (-4)	3
Related Projects (with references)	
Exc. Experience (8 - 10), G. Contractor experience (5 - 7)	9
or NIL experience or no info provided (-10)	
Key Personnel Assigned to Projects (5 Max)	0
Personnel Resumes	
Resumes (2), None (0)	0
Letter of Required Bonding	
Yes (10), Not Sufficient (0), None (-5)	10
WCB Clearance Certificate	
Yes (2), No Information (0)	2
CAD - 7 Report	
Good Standing(4), Average (2), Poor or no info. (0)	4

Contract B

EVALUATION CRITERIA	B - 1	B - 2	B - 3	B - 4	B - 5
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	4	4	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)	6	3	9	10	10
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	3	3	5	5	5
Personnel Resumes					
Resumes (2), None (0)	0	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	4	4	4	4

Contract B

EVALUATION CRITERIA	B - 6	B - 7	B - 8	B - 9	B - 10
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	4	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)	3	3	5	10	3
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	3	3	4	5	3
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	0
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	0	4	4	4

Contract B

EVALUATION CRITERIA	B - 11	B - 12	B - 13	B - 14	B - 15
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	6	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)	3	3	10	10	9
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	3	2	5	4	5
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	0	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	0	4	2	4	4

Contract B

EVALUATION CRITERIA	B - 16	B - 17	B - 18
CRITERIA			
Type of Company			
Corporation (4), Partnership (3), Individual (2)	4	4	4
Average Annual Value of Construction			
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	6	6
Financial References			
Bank (4), Bonding Co. (3), None (0)	4	4	4
Completed Projects in Last Five Years			
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3
Related Projects (with references)			
Good Experience (10), some experience (5)	10	3	5
or NIL experience or no info provided (-10)			
Key Personnel Assigned to Projects (5 Max)	3	3	2
Personnel Resumes			
Resumes (2), None (0)	2	2	2
Letter of Required Bonding			
Yes (10), Not Sufficient (0), None (-5)	10	10	10
WCB Clearance Certificate			
Yes (2), No Information (0)	2	2	0
CAD - 7 Report			
Good Standing(4), Average (2), Poor or no info. (0)	4	4	4

Contract C

EVALUATION CRITERIA	C - 1	C - 2	C - 3	C - 4	C - 5
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	4	0	0	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	1	1	No Dates	No Dates	3
Related Projects (with references)					
Good Experience (10), some experience (5)					
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)					
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	0	4	4	0	4

Contract C

EVALUATION CRITERIA	C - 6	C - 7	C - 8	C - 9	C - 10
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	6	6	0	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)					
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)					
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	2	4	4	2

Contract C

EVALUATION CRITERIA	C - 11	C - 12	C - 13	C - 14
CRITERIA				
Type of Company				
Corporation (4), Partnership (3), Individual (2)	4	4	4	2
Average Annual Value of Construction				
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	6	0	0
Financial References				
Bank (4), Bonding Co. (3), None (0)	4	4	4	4
Completed Projects in Last Five Years				
4 or more (3), 1 to 3 (1), or NIL (-4)	3	No Dates	3	3
Related Projects (with references)				
Good Experience (10), some experience (5)				
or NIL experience or no info provided (-10)				
Key Personnel Assigned to Projects (5 Max)				
Personnel Resumes				
Resumes (2), None (0)	2	2	2	2
Letter of Required Bonding				
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10
WCB Clearance Certificate				
Yes (2), No Information (0)	2	2	2	2
CAD - 7 Report				
Good Standing(4), Average (2), Poor or no info. (0)	2	4	4	4

Contract D

EVALUATION CRITERIA	D - 1	D - 2	D - 3	D - 4	D - 5
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	4	6	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)	6	10	10	10	10
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	3	5	5	5	5
Personnel Resumes					
Resumes (2), None (0)	0	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	4	0	4	2

Contract D

EVALUATION CRITERIA	D - 6	D - 7	D - 8	D - 9	D - 10
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	4	6	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)	8	7	10	10	3
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	5	4	5	5	3
Personnel Resumes					
Resumes (2), None (0)	2	0	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	0	4	2	4	4

Contract D

EVALUATION CRITERIA	D - 11	D - 12	D - 13	D - 14	D - 15
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	4	6	4	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)	10	10	10	7	10
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	5	5	5	4	3
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	0
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	0	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	2	4	4	4	4

Contract E

EVALUATION CRITERIA	E - 1	E - 2	E - 3	E- 4	E - 5
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	6	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)	8	10	10	5	5
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	4	5	5	4	3
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	4	4	0	4

Contract E

EVALUATION CRITERIA	E - 6	E - 7	E - 8	E - 9	E - 10
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	0	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)	10	9	10	5	10
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	5	4	5	3	5
Personnel Resumes					
Resumes (2), None (0)	2	2	2	0	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	4	4	4	4

Contract E

EVALUATION CRITERIA	E - 11	E - 12	E - 13	E - 14	E - 15
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	6	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)	10	10	9	10	10
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	4	5	3	5	5
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	4	4	4	4

Contract E

EVALUATION CRITERIA	E - 16	E - 17	E - 18	E - 19
CRITERIA				
Type of Company				
Corporation (4), Partnership (3), Individual (2)	4	4	4	4
Average Annual Value of Construction				
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	6	6	4
Financial References				
Bank (4), Bonding Co. (3), None (0)	4	4	4	4
Completed Projects in Last Five Years				
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3
Related Projects (with references)				
Good Experience (10), some experience (5)	8	10	10	8
or NIL experience or no info provided (-10)				
Key Personnel Assigned to Projects (5 Max)	4	4	5	4
Personnel Resumes				
Resumes (2), None (0)	2	2	2	2
Letter of Required Bonding				
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10
WCB Clearance Certificate				
Yes (2), No Information (0)	2	2	2	2
CAD - 7 Report				
Good Standing(4), Average (2), Poor or no info. (0)	4	4	0	4

Contract F

EVALUATION CRITERIA	F - 1	F - 2	F - 3	F - 4	F - 5
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
10 - 15 M (2), 5 - 10 M (1), less than 5 M (0)	2	2	2	2	2
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (14), some experience (5)	14	14	12	12	12
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	5	5	5	5	3
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	2	2	4	4

Contract F

EVALUATION CRITERIA	F - 6	F - 7	F - 8	F - 9	F - 10
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
10 - 15 M (2), 5 - 10 M (1), less than 5 M (0)	2	2	2	2	2
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (14), some experience (5)	8	8	14	12	6
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)	5	3	5	5	3
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	0	4	4	4

Contract F

EVALUATION CRITERIA	F - 11	F - 12	F - 13
CRITERIA			
Type of Company			
Corporation (4), Partnership (3), Individual (2)	4	4	4
Average Annual Value of Construction			
10 - 15 M (2), 5 - 10 M (1), less than 5 M (0)	2	1	2
Financial References			
Bank (4), Bonding Co. (3), None (0)	4	4	4
Completed Projects in Last Five Years			
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3
Related Projects (with references)			
Good Experience (14), some experience (5)	3	14	5
or NIL experience or no info provided (-10)			
Key Personnel Assigned to Projects (5 Max)	2	5	2
Personnel Resumes			
Resumes (2), None (0)	2	2	0
Letter of Required Bonding			
Yes (10), Not Sufficient (0), None (-5)	0	10	10
WCB Clearance Certificate			
Yes (2), No Information (0)	2	2	2
CAD - 7 Report			
Good Standing(4), Average (2), Poor or no info. (0)	4	2	4

Contract G

EVALUATION CRITERIA	G - 1	G - 2	G - 3	G - 4	G - 5
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	6	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	?	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)					
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)					
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	4	4	4	4

Contract G

EVALUATION CRITERIA	G - 6	G - 7	G - 8	G - 9	G - 10
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	6	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	1	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)					
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)					
Personnel Resumes					
Resumes (2), None (0)	2	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	4	0	?	4

Contract G

EVALUATION CRITERIA	G - 11	G - 12	G - 13	G - 14	G - 15
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	4	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	4	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	?	3
Related Projects (with references)					
Good Experience (10), some experience (5)					
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)					
Personnel Resumes					
Resumes (2), None (0)	2	0	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	0	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	2	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	4	4	0	?

Contract G

EVALUATION CRITERIA	G - 16	G - 17	G - 18	G - 19	G - 20
CRITERIA					
Type of Company					
Corporation (4), Partnership (3), Individual (2)	4	2	4	4	4
Average Annual Value of Construction					
Over 5 M (6), 3 - 5 (4), 2 - 3 (1), less than 2 (0)	6	6	6	6	6
Financial References					
Bank (4), Bonding Co. (3), None (0)	4	4	4	4	4
Completed Projects in Last Five Years					
4 or more (3), 1 to 3 (1), or NIL (-4)	3	3	3	3	3
Related Projects (with references)					
Good Experience (10), some experience (5)					
or NIL experience or no info provided (-10)					
Key Personnel Assigned to Projects (5 Max)					
Personnel Resumes					
Resumes (2), None (0)	0	2	2	2	2
Letter of Required Bonding					
Yes (10), Not Sufficient (0), None (-5)	10	10	10	10	10
WCB Clearance Certificate					
Yes (2), No Information (0)	0	2	2	2	2
CAD - 7 Report					
Good Standing(4), Average (2), Poor or no info. (0)	4	2	4	4	2

CONTRACTOR PREQUALIFICATION RANKING – ESTABLISHED SYSTEM

CONTRACT A			
Number	*Contractor ID Number*	*Mark / 50*	*Rank*
1	A - 8	**48**	1
2	A - 9	**45**	2
3	A - 15	**44**	3
4	A - 14	**44**	3
5	A - 13	**44**	3
6	A - 10	**44**	3
7	A - 11	**44**	3
8	A - 12	**44**	3
9	A - 7	**44**	3
10	A - 6	**43**	10
11	A - 5	**43**	10
12	A - 4	**42**	12
13	A - 3	**42**	12
14	A - 16	**41**	14
15	A - 2	**39**	15
16	A - 1	**37**	16

CONTRACT B			
Number	*Contractor ID Number*	*Mark / 50*	*Rank*
1	B - 4	**50**	1
2	B - 5	**50**	1
3	B - 9	**50**	1
4	B - 3	**49**	4
5	B - 15	**49**	4
6	B - 13	**48**	6
7	B - 16	**48**	6
8	B - 14	**47**	8
9	B - 8	**44**	9
10	B - 6	**41**	10
11	B - 17	**41**	10
12	B - 1	**40**	12
13	B - 12	**40**	12
14	B - 18	**40**	12
15	B - 2	**39**	15
16	B - 10	**39**	15
17	B - 11	**37**	17
18	B - 7	**35**	18

CONTRACT C			
Number	*Contractor ID Number*	*Mark / 50*	*Rank*
1	C - 6	**50**	1
2	C - 8	**50**	1
3	C - 9	**48**	3
4	C - 12	**48**	3
5	C - 3	**42**	5
6	C - 4	**41**	6
7	C - 2	**40**	7
8	C - 10	**40**	7
9	C - 7	**38**	9
10	C - 5	**37**	10
11	C - 11	**35**	11
12	C - 1	**32**	12
13	C - 13	**32**	12
14	C - 14	**30**	14

CONTRACT D			
Number	*Contractor ID Number*	*Mark / 50*	*Rank*
1	D - 2	**50**	1
2	D - 4	**50**	1
3	D - 9	**50**	1
4	D - 13	**50**	1
5	D - 5	**48**	5
6	D - 8	**48**	5
7	D - 12	**48**	5
8	D - 11	**48**	5
9	D - 3	**46**	9
10	D - 15	**46**	9
11	D - 7	**44**	11
12	D - 6	**42**	12
13	D - 14	**42**	12
14	D - 10	**41**	14
15	D - 1	**40**	15

Note: Top Eleven Contractors were Prequalified.

CONTRACT E			
Number	*Contractor ID Number*	*Mark / 50*	*Rank*
1	E - 2	**50**	1
2	E - 3	**50**	1
3	E - 6	**50**	1
4	E - 8	**50**	1
5	E - 10	**50**	1
6	E - 12	**50**	1
7	E - 14	**50**	1
8	E - 15	**50**	1
9	E - 11	**49**	9
10	E - 17	**49**	9
11	E - 1	**47**	11
12	E - 13	**47**	11
13	E - 16	**47**	11
14	E - 18	**46**	14
15	E - 19	**45**	15
16	E - 5	**43**	16
17	E - 9	**43**	16
18	E - 7	**42**	18
19	E - 4	**40**	19

CONTRACT F			
Number	*Contractor ID Number*	*Mark / 50*	*Rank*
1	F - 1	50	1
2	F - 8	50	1
3	F - 2	48	3
4	F - 4	48	3
5	F - 9	48	3
6	F - 12	47	6
7	F - 3	46	7
8	F - 5	46	7
9	F - 6	44	9
10	F - 10	40	10
11	F - 7	38	11
12	F - 13	36	12
13	F - 11	26	13

Note: Top Eight Contractors were Prequalified.

CONTRACT G			
Number	*Contractor ID Number*	*Mark / 35*	*Rank*
1	G - 1	**35**	1
2	G - 4	**35**	1
3	G - 5	**35**	1
4	G - 2	**35**	1
5	G - 6	**35**	1
6	G - 7	**35**	1
7	G - 10	**35**	1
8	G - 11	**35**	1
9	G - 18	**35**	1
10	G - 19	**35**	1
11	G - 20	**33**	11
12	G - 3	**32**	12
13	G - 9	**31**	13
14	G - 12	**31**	13
15	G - 15	**31**	13
16	G - 16	**31**	13
17	G - 17	**31**	13
18	G - 8	**29**	18
19	G - 14	**28**	19
20	G - 13	**25**	20